Strategic Plan for DoD Test and Evaluation Resources

Department of Defense

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REPORT ON THE STRATEGIC PLAN FOR DoD TEST AND EVALUATION RESOURCES

DEPARTMENT OF DEFENSE

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1.0 INTRODUCTION

Section 196 of title 10, United States Code, as added by section 231 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Pub. L. No. 107-314 (2002) established the DoD Test Resource Management Center (TRMC) and requires the Director, among other tasking, to complete and maintain a biennial strategic plan reflecting the needs of DoD with respect to test and evaluation facilities and resources, including preparation of a report on the plan. The strategic plan has been completed and is attached. This report describes the review on which the plan was based, as well as a summary of the principal findings.

The plan was coordinated with the Director of Operational Test and Evaluation (DOT&E), the Secretaries of the military departments, and the heads of Defense Agencies with T&E responsibilities.

2.0 BACKGROUND

The TRMC was chartered with the issuance of DoD Directive DoDD 5105.71 in March of 2004 to: "plan for and assess the adequacy of the Major Range and Test Facility Base (MRTFB)... to provide adequate testing in support of development, acquisition, fielding, and sustainment of defense systems; and to maintain awareness of other T&E facilities and resources, within and outside the department, and their impacts on DoD requirements." As part of this mission, both the NDAA and the DoD Directive task the TRMC to develop, on a biennial basis, a strategic plan reflecting the needs of the department with respect to T&E resources and covering a period of ten years. This strategic plan is central to the TRMC mission and the associated budget certification process and, as such, it is designed to provide a roadmap for programming and budgeting for transforming the T&E infrastructure to meet the transformation needs of the department.

Section 196 of Title 10, United States Code states that the strategic plan will include the following six elements:

- An assessment of the T&E requirements of the Department for the period covered by the plan, which is addressed in Chapter 6.
- An identification of performance measures associated with the successful achievement of T&E objectives for the period covered by the plan, which is addressed in Chapter 3.

- An assessment of the T&E facilities and resources that will be needed to meet such requirements and satisfy such performance measures, which is addressed in Chapter 6.
- An assessment of the current state of the T&E facilities and resources of the department, which is addressed in Chapter 5.
- An itemization of acquisitions, upgrades, and improvements necessary to ensure that the T&E facilities and resources of the department are adequate to meet such requirements and satisfy such performance measures, which is addressed in Chapter 6.
- An assessment of the budgetary resources necessary to implement such acquisitions, upgrades, and improvements, which is addressed in Chapter 7.

Not all six elements were completely accomplished since the TRMC was partially staffed during the development of this plan. The progress in accomplishing the six elements is addressed in Chapter 7 of this strategic plan.

An inaugural strategic plan "Department of Defense T&E Resources" was developed and published in September 2003 by an interim staff from the Services and various OSD offices with T&E subject matter expertise.

This plan is the first one produced by permanent TRMC staff members, and it articulates the results of a comprehensive assessment of test resource needs.

The current plan represents a significant expansion of the inaugural strategic plan. Led by the permanent TRMC staff, this effort involved the cooperative efforts of numerous organizations within the DoD, and used a standing Strategic Plan Working Group (SPWG) to guide the development and maturing of the plan.

3.0 PURPOSE

This strategic plan provides a systematic approach to determining DoD's T&E resource and infrastructure needs. This plan is intended to be for the period from the time of submission in accordance with 10 U.S.C. 196(d)(3) through FY2017, but the focus is on FY2008 through FY2017 because of budget timing and Program Objective Memorandum (POM) constraints. It is on that period that this plan can have an impact. This plan reflects the planning aimed at achieving an Objective T&E Infrastructure by the end of this period. The first POM this plan can influence is that for FY2008.

This strategic plan represents an evolutionary progression from the inaugural strategic plan to one that can best answer the needs of future acquisition and test programs and associated warfighter requirements. This strategic plan will mature over time (in future editions) as the department's transformation initiatives mature and begin to bring new systems, tactics, techniques, and doctrine on line to meet joint warfighter needs.

4.0 SOURCES

A variety of sources were used to determine the T&E capabilities required to support the DoD. Sources at the national level include the President's Management Agenda, the National Security Strategy, and the National Military Strategy. Within the department, sources of guidance included the Strategic Planning Guidance and the goals set forth by the Under Secretary of Defense (Acquisition, Technology and Logistics); the vision, goals and objectives for DoD T&E community also shaped the strategic plan; Service and agency transformation roadmaps; and the T&E resource needs and solutions resulting from the Service-level T&E Executive Agent Reliance process.

5.0 OBJECTIVE T&E INFRASTRUCTURE

The end state test infrastructure that this and future biennial strategic plan updates will strive for is an adaptive, persistent, integrated, distributed, global T&E infrastructure that is capable of the following:

- providing robust, flexible T&E of systems & systems of systems
- providing capability to test next generation weapon, C4ISR, and IT systems
- providing connectivity capability between open air ranges, hardware in the loop facilities, installed system test facilities, battle laboratories, and training ranges
- using persistent connectivity to live, virtual, and constructive joint mission environments, and
- supporting informed, effective and timely transition of new capabilities to the joint warfighter.

6.0 KEY T&E CAPABILITY NEEDS

The key T&E capability needs were identified through an analytic process. The analysis identifies test capability needs in the near -, mid -, and far – terms. The analysis includes traceability matrices, roadmaps, test capability gaps, and provides issues and recommendations. The traceability matrices provide links to programs, high-level guidance, or concept drivers that will require a given test capability to be available at some future time and provide a rough estimate of its criticality.

The DoD T&E capability needs described in this plan are organized by the Reliance Areas used by the Service T&E Executive Agent process:

- Air Combat
- Armaments and Munitions
- Command, Control, Communications, Computers, Intelligence, and Reconnaissance (C4ISR)

- Common Range Instrumentation (CRI)
- Electronic Combat
- Land Combat
- Sea Combat
- Space Combat
- Test Environments
- Targets and Threat Systems.

To determine test capability needs and gaps that the Department should focus on in future investments, each area was analyzed in the context of T&E capability drivers extracted from the overarching national and departmental strategic guidance, and transformation strategies; the T&E infrastructure capabilities as they exist today; and the current T&E infrastructure investment strategies. T&E capability drivers that were extracted from the overarching strategy documents are identified in Chapter 4. Chapter 5 describes the current T&E infrastructure as it exists today, and Chapter 6 identifies test capability needs and any gaps resulting from the analysis.

- A test capability "need" is a T&E capability that is projected to be required in the future.
- A "test capability gap" is a test capability need that does not have a roadmap to provide that capability or provides it too late to support expected projects or programs.

The TRMC will work with the OSD stakeholders and service and agency representatives through the Strategic Planning Working Group (SPWG) to address these gaps and needs and develop an implementation plan and associated roadmaps over the next year.

7.0 Overarching Test Capability Modernization Strategy and Themes

Several dominant themes and focus areas emerged as a result of the analyses associated with this plan. These will require the ability to test individual platform performance, as we have done with our legacy systems, and also to test emerging new technology systems such as directed energy systems, unmanned systems, hypersonic weapon systems, larger footprint weapons, and information warfare non-kinetic systems. Additionally our T&E infrastructure must evolve to provide the ability to assess mission capability in the context of sensor-to-shooter kill chains and joint mission threads that integrate weapon and command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) systems using joint tactics and doctrine that cross-Service and even our allied partner lines.

8.0 TEST CAPABILITY GAPS SUMMARY

A summary view of the high-priority test capability gaps is presented below.

- **Air Combat**- Larger test areas to mitigate encroachment and support hypersonic air vehicles and global range UAVs. Improved avionics test capabilities to support transformational, net-centric systems and increased utilization of artificial intelligence.
- **Armaments and Munitions** – Larger test ranges for long-range precision strike weapons and miniaturized flight termination systems (FTS) to support smaller long-range precision strike weapons.
- **C4ISR** – End-to-end system of system stress loading from ISR assets to command facilities and eventually to engaging elements to assess the full effects of performance. Improved data link transmission and monitoring for accurate evaluation of interference, timing and true operational communication loading.
- **Common Range Instrumentation** – Non-intrusive, embedded miniaturized instrumentation, capabilities for integrating M&S (constructive and virtual) with live test, training, and experimentation events, compatibilities with the Test and Training Enabling Architecture (TENA) for sharing and co-use of M&S among test, training, and experimentation events.
- **Electronic Combat** – IR/UV missile warning system end-to-end testing to include multi-spectral band missile plume simulators and improved simulation ability.
- **Land Combat –** Chemical Biological test capability enhancements including a live agent test chamber to perform live CB agent testing of active standoff CB detectors.
- **Sea Combat** – Currently, there are no identifiable test capability gaps other than the supersonic seaskimming targets referenced in section 6.9. However, the adequacy of littoral/shallow water testing is a special interest item.
- **Space Combat** - Extended hypersonic flight corridors that are flexible, accessible and over land, water and littoral areas near the U.S. test ranges. Overseas/foreign test capabilities to support the global testing focus for Operational Responsive Space (ORS) and Ballistic Missile Defense System (BMDS).
- **Test Environments** – Sustainment of aero-thermodynamic and air breathing engine test capabilities to decrease maintenance failures and support future

system needs. Small scramjet engine test capability Mach 4-8 for hypersonic weapon systems development and large high-speed turbine engine test capability up to Mach 4.

- **Targets and Threats** –Development of a full-scale aerial target replacement for the QF-4 and development of supersonic sea-skimming aerial targets to meet new threat capabilities.

9.0 CONCLUSION

This plan represents a comprehensive assessment of the DoD T&E infrastructure and test capability needs and gaps. It is the foundation for future TRMC initiatives to collaborate with the Services and agencies to develop implementation plans, roadmaps, and associated business processes to transform the Department's T&E infrastructure within the confines of strategic guidance, policy, and fiscal constraints. Over the next year, the TRMC will collaborate with the OSD stakeholders and Service and agency representatives through the SPWG to address identified issues, test capability gaps, and test capability needs identified here.

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DIRECTOR'S FOREWORD

The Department of Defense (DoD) Test Resource Management Center (TRMC) completed the formal standup as a field activity under the Under Secretary of Defense (Acquisition, Technology & Logistics) in response to the requirements of section 196 of title 10, United States Code, as added by section 231 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Pub. L No. 107-314 (2002). The formal standup included the hiring of permanent staff and the selection of a Director. This "Strategic Plan for DoD Test and Evaluation Resources" responds to the requirements of section 196. It is the second plan and yet the first to be completed by the permanent staff, and it articulates the results of a comprehensive assessment of test resource needs. This plan is the result of cooperative efforts of numerous organizations within the Department of Defense and used a Strategic Planning Working Group (SPWG) to guide its development and maturation process.

Key to the strategic planning effort is having a vision for an objective T&E infrastructure that can be achieved via the combined efforts of all concerned. Moreover, this objective must support, and contribute to, the objectives of the Department of Defense and the President in keeping this country strong and safe. As we proceed into the 21st century, this commitment requires continuous re-examination of the role that the T&E community must play and a concerted effort to transform and modernize our ranges and facilities in the most efficient manner possible. Our vision is one of migrating our T&E capabilities to those that can provide the best possible support to our Combatant Commanders, and truly achieve a capability where we can say we do indeed "test as we fight".

Several dominant themes and focus areas emerged as a result of the analyses associated with this plan. These will require the ability to test individual platform performance, as we have done with our legacy systems, and also to test emerging new technology systems such as directed energy systems, unmanned systems, hypersonic weapon systems, larger footprint weapons, and information warfare non-kinetic systems. Additionally our T&E infrastructure must evolve to provide the ability to assess mission capability in the context of sensor-to-shooter kill chains and joint mission threads that integrate weapon and command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) systems using joint tactics and doctrine that cross Service and even our allied partner lines.

This strategic plan represents a critical step in an evolutionary progression that can best answer the needs of future acquisition and test programs and associated warfighter requirements. It will mature over time as the Department's transformation initiatives mature and begin to bring new systems, tactics, techniques, and doctrine on line to meet joint warfighter needs.

The objective test infrastructure that we envision is one which is adaptive, persistent, integrated, distributed, and global. As we migrate towards investing to meet joint objectives, our T&E infrastructure will be capable of providing robust, flexible T&E of systems and systems of systems, supporting informed, effective and timely transition of new capabilities to the joint warfighter.

This plan is the foundation for future TRMC initiatives to collaborate with the Services and agencies to develop implementation plans, roadmaps, and associated business processes to transform the department's T&E infrastructure within the confines of strategic guidance, policy, and fiscal constraints. TRMC will collaborate with our OSD stakeholders and Service and agency representatives through the SPWG to address issues, test capability gaps, and test capability needs identified. This collaborative process will yield a future T&E infrastructure that positions the Department for timely transition of future capabilities to the warfighter.

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LIST OF ACRONYMS

Acronym	Definition
USD (AT&L)	Undersecretary for Defense for Acquisition, Technology and Logistics
DUSD (AS&C)	Deputy Under Secretary of Defense for Advanced Systems and Concepts
C4ISR	Command, Control, Communications, Computers, Intelligence and Reconnaissance
2D-AESA	2-Dimensional Active Electronically Scanned Array
A/AM	Air-to-Air Missiles
A/SM	Air-to-Surface Missiles
AAALAC	Association for Assessment and Accreditation of Laboratory Animal Care
AAC	Air Armament Center
AADS	Airborne Active Denial System
AARGM	Advanced Anti-Radiation Guided Missile
ABL	Airborne Laser
ACAT	Acquisition Category
ACETEF	Air Combat Environment Test and Evaluation Facility
ACS	Aerial Common Sensor
ACTD	Advanced Concept Technology Demonstration
ADS	Advanced Deployable System
ADS	Active Denial System
ADS	Active Defense System
AEA	Airborne Electronic Attack
AEDC	Arnold Engineering Development Center
AEHF	Advanced Extremely High Frequency
AESA	Active Electronically Scanned Array
AEW	Airborne Early Warning
AF	Air Force
AFEWES	Air Force Electronic Warfare Evaluation

	Simulator
AFFTC	**Air Force Flight Test Center**
AFSPC	**Air Force Space Command**
AGS	**Alliance Ground Surveillance**
AHE	**Advanced Hawkeye**
AI	**Artificial Intelligence**
ALP	**AUTEC Lightening Protection**
AMF	**Airborne, Maritime & Fixed**
AMP	**Aircraft Modernization Program**
AMRAAM	**Advanced Medium-Range Air-to-Air Missile**
ANL	**Argonne National Laboratory**
AOC-WS	**Air Operations Center – Air- Weapons System**
APS	**Advanced Polar System**
APU	**Auxiliary Power Unit**
ARDEC	**Armaments Research, Development and Engineering Center**
ARH	**Armed Reconnaissance Helicopter**
ARMD	**Aeronautics Research Mission Directorate**
ARMS	**Anti-Radiation Missiles**
ASAS	**All Source Analysis System**
ASTE	**Armament Systems Test Equipment**
ASV	**Armored Security Vehicle**
AT&L	**Acquisition, Technology and Logistics**
ATACMS	**Army Tactical Missile System**
ATC	**Aberdeen Test Center**
ATEC	**Army Test and Evaluation Command**
ATEF	**Aircraft Test and Evaluation Facility**
ATIC	**Avionics Test and Integration Complex**
ATIN	**Army Test Integration Network**
ATL	**Advanced Tactical Laser**
ATR	**Atlantic Test Range**
ATR	**Advanced Test Reactor**
ATRC	**Advanced Test Reactor Critical Facility Reactor**
AUTEC	**Atlantic Undersea Test and Evaluation Center**

BAF	**Benefield Anechoic Facility**
BAMS	**Broad Area Maritime Surveillance**
BAT	**Brilliant Anti-armor Sub-munition**
BDA	**Battle Damage Assessment**
BLM	**Bureau of Land Management**
BMD	**Ballistic Missile Defense**
BMDS	**Ballistic Missile Defense System**
BMTC	**Ballistic Missile Technical Collection**
BoD	**Board of Directors**
BRAC	**Base Realignment and Closure**
BRP	**Basic Research Plan**
BSD	**Battlefield Situational Display**
C2	**Command and Control**
C2 IPS	**Command and Control Information Processing System**
CAOC	**Combined Air Operations Center**
CAP	**Combined Aggregate Program**
CAV	**Common Aero Vehicle**
CB	**Chemical and Biological**
CBDP	**Chemical and Biological Defense Program**
CBRNE	**Chemical, Biological, Radiological, Nuclear, and Enhanced**
CBU	**Cluster Bomb Unit**
CCAFS	**Cape Canaveral Air Force Station**
CCIC2S	**Combat Commanders Integrated Command & Control System**
CES	**Core Enterprise Service**
CIGTF	**Central Inertial Guidance Test Facility**
CIS	**Combat Intelligence System**
CITS	**Combat Information Transport System**
CLAWS	**Complimentary Low Altitude Weapon System**
CMM	**Cryptologic Mission Management**
CNI	**Communication, Navigation & Identification**
CNO	**Computer Network Operation**
COE	**Center of Excellence**

COI	**Communities of Interest**
CONOPS	**Concept of Operations**
COSIP	**Coherent Signal Processor**
COTS	**Commercial Off The Shelf**
CP	**Concrete Piercing**
CRI	**Common Range Instrumentation**
CRTC	**Cold Regions Test Center**
CS	**Combat Support**
CS	**Counter Space**
CSS	**Combat Service Support**
CTAPS	**Contingency Theater Automated Planning System**
CTD	**Concept Refinement and Technology Development**
CTEIP	**Central Test & Evaluation Investment Program**
CTOL	**Conventional Take Off and Landing**
CV	**Carrier Suitable Variant**
CVN	**Aircraft Carrier, Nuclear**
CWA	**Chemical Warfare Agent**
DAES	**Defense Acquisition Executive Summary**
DARPA	**Defense Advance Research Projects Agency**
DCAPES	**Deliberate & Crisis Action Planning & Execution Segments**
DCGS	**Distributed Common Ground System**
DCS	**Defensive Counter Space**
DDR&E	**Director, Defense Research and Engineering**
DE	**Directed Energy**
DET	**Directed Energy Test**
DHS	**Department for Homeland Security**
DIADS	**Digital Integrated Air Defense System**
DISA	**Defense Information Systems Agency**
DJC2	**Deployable Joint Command and Control**
DoD	**Department of Defense**

DoE	**Department of Energy**
DOT	**Department of Transportation**
DOT&E	**Director, Operational Test and Evaluation**
DPG	**Dugway Proving Ground**
DPICM	**Dual Purpose Improved Conventional Munitions System**
DREN	**Defense Research and Engineering Network**
DS	**Defense Support**
DT	**Development Testing**
DT&E	**Development Test & Evaluation**
DTAP	**Defense Technology Area Plan**
DTC	**Developmental Test Command**
DTCC	**Distributed Test Control Center**
DTRA	**Defense Threat Reduction Agency**
DTS	**Dynamic Targeting System**
DTTSG	**Defense Test and Training Steering Group**
DUSD (AS&C)	**Deputy Undersecretary (Advanced Systems & Concepts)**
DUSD (I&E)	**Deputy Undersecretary (Installations & Environment)**
DUSD (P&E)	**Deputy Undersecretary (Planning & Evaluation)**
DUSD (P&R)	**Deputy Undersecretary (Programs & Resources)**
E^3	**Electromagnetic Environmental Effects**
EA	**Executing Agent**
EC	**Electronic Combat**
ECBC	**Edgewood Chemical and Biological Center**
ECM	**Electromagnetic Countermeasures**
ECR	**Electronic Combat Range**
ECSS	**Expeditionary Combat Support System**
EFV	**Expeditionary Fighting Vehicle**
EGI	**Embedded GPS/INS**
EHF	**Extreme High Frequency**
EI	**Embedded Instrumentation**

EJSE	**Enhanced JTIDS system exerciser**
ELTR	**Eastern Launch and Test Range**
EMI/EMC	**Electromagnetic Interference and Compatibility**
EMP	**Electromagnetic Pulse**
EMT	**Electromagnetic Transients**
EMV	**Electromagnetic Vulnerability**
EMW	**Expeditionary Maneuver Warfare**
EOD	**Explosive Ordnance Disposal**
EPG	**Electronic Proving Ground**
EPTI	**Energy and Power Technologies Initiative**
ERAM	**Extended Range Active Missile**
ERGM	**Extended Range Gun Munitions**
ES	**Executive Secretariat**
ESD	**Electrostatic Discharge**
ESM	**Enterprise Service Management**
ESSM	**Evolved Sea Sparrow Missile**
ETIC	**Estimated Time for Completion**
EW	**Electronic Warfare**
FAB-T	**Family of Beyond Line-of-Site Terminals**
FBCB2	**Force XXI Battlefield Command Brigade and Below**
FCS	**Future Combat Systems**
FOERC	**Fiber Optic Enhanced Range Conductivity**
FORACS	**Forces Fleet Sensor and Weapons Accuracy and Check Site**
FRP	**Full Rate Production**
FTS	**Flight Termination Systems**
GATM	**Global Air Traffic Management**
GCCS-AF	**Global Command and Control System – Air Force**
GCCS-J	**Global Command and Control System – Joint**
GCSS	**Global Combat Support System**
GEMSIS	**Global Electromagnetic Spectrum Information System**

GEO	**Geosynchronous Earth Orbit**
GIG	**Global Information Grid**
GIG-BE	**Global Information Grid Bandwidth Expansion**
GLP	**Good Laboratory Practice**
GMD	**Ground Missile Defense**
GMLRS	**Guided Multiple Launch Rocket System**
GPS	**Global Positioning System**
GPS-III	**Global Positioning System III**
GWEF	**Guided Weapons Evaluation Facility**
HARM	**High Speed Anti-Radiation Missile**
HE	**High Explosive**
HEL	**High Energy Laser**
HELSTF	**High Energy Laser Systems Test Facility**
HERA	**High Explosive Rocket Assisted**
HEU	**Highly Enriched Uranium**
HHSTT	**Holloman High Speed Test Track**
HIMARS	**High Mobility Artillery Rocket System**
HITL	**Hardware-In-The-Loop**
HLR	**Heavy Lift Replacement**
HPM	**High Power Microwave**
HST	**Hypersonic Test**
HSV	**High Speed Vessel**
I&M	**Investment and Modernization**
IAMD	**Integrated Air and Missile Defense**
ICBM	**Inter-Continental Ballistic Missiles**
IED	**Improvised Explosive Device**
IFAST	**Integration Facility for Avionics Systems Testing**
INEL	**Idaho National Engineering Laboratory**
INS	**Inertial Navigation Systems**
InterTEC	**Interoperability Test & Evaluation Capability**
IO	**Information Operations**
IOC	**Initial Operational Capability**
IOT&E	**Initial Operational Test & Evaluation**

IPT	**Integrated Product Team**
IR/UV	**Infrared/Ultra-Violet**
IR/UV/RF	**Infrared/Ultra-Violet/Radio Frequency**
IRCC	**Inter-Range Control Center**
ISCN	**Integrated Satellite Control Network**
ISR	**Intelligence, Surveillance, and Reconnaissance**
ISTF	**Installed System Test Facilities**
ISTT	**Information Systems Technology Test**
ITSS	**Improved Thermal Sight System**
IVA	**Integrated Vulnerability Assessment**
JASSM	**Joint Air-to-Surface Standoff Missile**
JBPDS	**Joint Biological Point Detection System**
JBTDS	**Joint Biological Tactical Detection System**
JC2	**Joint Command & Control**
JCAD	**Joint Chemical Agent Detector**
JCBRAWM	**Joint Chemical, Biological and Radiological Agent Water Monitor**
JCPE	**Joint Collective Protective Equipment**
JDAM	**Joint Direct Attack Munition**
JDEP	**Joint Distributed Engineering Environment**
JDSETES	**Joint Distributed Systems Engineering and Test and Evaluation Strategy**
JEFX	**Joint Expeditionary Force Experiment**
JEM	**Joint Effects Model**
JERC	**Joint Experimentation Range Complex**
JFCOM	**Joint Forces Command**
JHSV	**Joint High Speed Vehicle**
JIM	**Joint Improvement and Modernization**
JITC	**Joint Interoperability Test Command**
JLENS	**Joint Land Attack Cruise Missile Defense Elevated Netted Sensors**
JLSCAD	**Joint Lightweight Standoff Chemical Agent Detector**
JLW155	**Joint Lightweight 155mm**
JMEM	**Joint Munitions Effectiveness Manual**

JNIC	**Joint National Integratration Center**
JNN	**Joint Network Node**
JNTC	**Joint National Training Capability**
JNTC-S	**Joint Network Transport Capability-Spiral**
JOEF	**Joint Operational Effects Federation**
JPACE	**Joint Protective Aircrew Ensemble**
JPALS	**Joint Precision Approach Landing System**
JPDS	**Joint Portable Decontamination System**
JSAM	**Joint Service Aircrew Mask**
JSCESM	**Joint Service Chemical Environment Escape Mask**
JSF	**Joint Strike Fighter**
JSGPM	**Joint Service General Purpose Mask**
JSLIST	**Joint Services Light Weight Integrated Suit Technology**
JSLSCAD	**Joint Service Lightweight Chemical Agent Detector**
JSMLT	**Joint Service Mask Leakage Tester**
JSOW	**Joint Standoff Weapon**
JTF	**Joint Test Facility**
JTIDS	**Joint Tactical Information Distribution System**
JTRS	**Joint Tactical Radio System**
JUCAS	**Joint Unmanned Combat Air System**
JVMF	**Joint Variable Message Format**
JWARN	**Joint Warning and Reporting Network**
JWSTP	**Joint Warfare Science and Technology Plan**
KEI	**Kinetic Energy Interceptor**
KMRSS	**Kwajalein Missile Range Support Ship**
LAIRCM	**Large Aircraft Infra-red Countermeasures**
LAV-25	**Light Armored Vehicle - 25**
LCMR	**Lightweight Counter Mortar Radar**
LCS	**Littoral Combat Ship**
LEU	**Low Enriched Uranium**
LHA	**Landing Ship-Attack**
LMRS	**Long-term Mine Reconnaissance System**

LOS	**Line of Sight**
LOSAT	**Line-of-Sight Anti-Tank**
LTRS	**Launch and Test Range System**
LVC	**Live, Virtual and Constructive**
LW	**Land Warrior**
M&S	**Modeling & Simulation**
M2CA	**Multi-Sensor Command & Control Aircraft**
MAGTF	**Marine Air Ground Task Force**
MAIS	**Major Automated Information System**
MANPADS	**Man-Portable Air Defense Missiles**
MARIAH	**Magnetohydrodynamics Accelerator Research in Advanced Hypersonics**
MATSS	**Mobile Aerial Target Support System**
MCL	**McKinley Climatic Laboratory**
MDA	**Missile Defense Agency**
MDAP	**Major Defense Acquisition Program**
MEADS	**Medium Extended Air Defense System**
MILSATCOM	**Military Satellite Communications**
MIRACL	**Mid-Infrared Advanced Chemical Laser**
MKV	**Multiple Kill Vehicle**
MLRS	**Multiple Launch Rocket System**
MMA	**Multi-mission Maritime Aircraft**
MOA	**Memorandum of Agreement**
MOOTW	**Military Operations Other Than War**
MOP	**Measures of Performance**
MOUT	**Military Operations in Urban Terrain**
MPF-F	**Maritime Positioning Force - Future**
MP-RTIP	**Multi-Platform Radar Technology Improvement Program**
MRTFB	**Major Range and Test Facility Base**
MS	**Mission Support**
MST	**Multi-Spectral Test**
MSTTE	**Multi-Spectral Test and Training Environment**
MTHEL	**Mobile Tactical High Energy Laser**
MUOS	**Mobile User Objective System**

MWR	**Morale Welfare Recreation**
N&S	**Needs and Solutions**
NAI	**National Aerospace Initiative**
NASA	**National Aeronautics and Space Administration**
NAVAIR	**Naval Air Systems Command**
NAVSEA	**Naval Sea Systems Command**
NAWCAD	**Naval Air Weapons Center-Aircraft Division**
NAWC-WD	**Naval Air Weapons Center-Weapons Division**
NBCRV	**NBC Reconnaissance Vehicle**
NBL	**New Brunswick Laboratory**
NCES	**Net-Centric Enterprise Services**
NCP	**Navy Capability Pillar**
NCW	**Network Centric Warfare**
NDA	**National Defense Education Act**
NDAA	**National Defense Authorization Act**
NDS	**National Defense Strategy**
NFAC	**National Full-Scale Aerodynamic Complex**
NLOS-C	**Non-Line of Sight Cannon**
NLOS-LS	**Non-Line-of-Sight Launch Systems**
NMS	**National Military Strategy**
NOAA	**National Oceanic and Atmospheric Administration**
NOC	**Naval Operating Concept**
NPOESS	**National Polar-Orbiting Operational Environmental Satellite System**
NR-KPP	**Net-Ready Key Performance Parameter**
NRO	**National Reconnaissance Office**
NRTF	**National Radar Cross Section Test Facility**
NSA	**National Security Agency**
NSPS	**National Security Personnel System**
NSS	**National Security Strategy**
NSSO	**National Security Space Office**
NTA	**Non-Traditional Agent**
NTS	**Nevada Test Site**

NUWC	**Naval Undersea Warfare Center**
NWCF	**Navy Working Capital Fund**
NWE	**Nuclear Weapon Effects**
OAR	**Open Air Range**
OASYS	**Off-Board Advanced Systems Stimulus**
OBI	**On-Board Instrumentation**
OBIS	**Observation Island**
OCS	**Offensive Counter Space**
ODSI	**Orbital Deep Space Imager**
OIPT	**Overarching Integrated Product Team**
OPAREAS	**Operating Areas**
ORNL	**Oak Ridge National Laboratory**
ORO	**Oak Ridge Operations**
ORS	**Operational Responsive Spacelift**
OSD	**Office of the Secretary of Defense**
OT	**Operational Test**
OT&E	**Operational Test & Evaluation**
OTA	**Operational Test Agency**
OTS	**Outdoor Test Site**
OUSD P&R	**Office of the Under Secretary of Defense for Personnel and Readiness**
PAFB	**Patrick Air Force Base**
PAM	**Pulse Amplitude Modulated**
PCM	**Pulse Code Modulation**
PCO	**Prospective Commanding Officer**
PEG	**Program Execution Guide**
PEO	**Program Executive Officer**
PGM	**Precision-Guided Munitions**
PMRF	**Pacific Missile Range Facility**
PNP	**Panamanian National Police**
POM	**Program Objective Memorandum**
PRIMES	**Preflight Integration of Munitions & Electronic Systems**
PSEF	**Propulsion Systems Evaluation Facility**
PWT	**Propulsion Wind Tunnel**

QDR	**Quadrennial Defense Review**
R&D	**Research and Development**
RAAF	**Royal Australian Air Force**
RACS	**Reliance Area Capabilities Summaries**
RAN	**Royal Australian Navy**
RCS	**Radar Cross Section**
RDT&E	**Research Development Test and Evaluation**
REBS	**Rapidly Emplaced Bridging System**
REP	**Resource Enhancement Program**
RERP	**Reliability Enhancement and Re-Engineering Program**
RF	**Radio Frequency**
RF/IR	**Radio Frequency/Infrared**
RLTR	**Responsive Launch and Test Range**
RM&S	**Reliability, Maintainability, and Sustainability**
RMA	**Reliability, Maintainability, Availability**
ROSA	**Radar Open Systems Architecture**
RPG	**Rocket-Propelled Grenades**
RRBL	**Ricketts Regional Biocontainment Laboratory**
RSI	**Radar System Improvement**
RTCA	**Real Time Casualty Assessment**
RTF	**Return To Flight**
RTIP	**Radar Technology Improvement Program**
RTS	**Ronald Reagan Ballistic Missile Defense Test Site**
S&T	**Science and Technology**
S/SM	**Surface-to-Surface Missile**
SADL	**Situational Awareness Data Link**
SAGG	**Seeker-Aided Ground Guidance**
SAM	**Surface-to-Air Missile**
SATCOM	**Satellite Communication**
SBR	**Space Radar**
SCC	**Submarine Commands Course**
SDB	**Small Diameter Bomb**
SDD	**System Development and Demonstration**

SDTS	**Self Defense Test Ship**
SET	**Spectrum Efficient Technology**
SFA	**Space Force Application**
SFE	**Space Force Enhancement**
SHF	**Super High Frequency**
SHOTS	**Stabilized High Accuracy Optics Tracking System**
SIAP	**Single Integrated Air Picture**
SIGINT	**Signals Intelligence**
SIIRCM	**Suite of Integrated Infrared Countermeasures**
SINCGARS	**Single Channel Ground and Airborne Radio System**
SKS	**Surveillance and Knowledge Systems**
SLAMER	**Stand-off Land Attack Missile Expanded Range**
SLBD	**Sea Lite Beam Director**
SLBM	**Submarine Launched Ballistic Missile**
SM	**Standard Missile**
SM-6	**Standard Missile-6**
SMART	**Science, Mathematics and Research for Transformation**
SMC	**Space and Missile Center**
SMC	**Space and Missile Systems Center**
SMC/GP	**Space and Missile Systems Center/Global Positioning**
SNM	**Special Nuclear Materials**
SNORT	**Supersonic Radar Ordnance Track**
SOCOM	**Special Operations Command**
SOJ	**Stand Off Jammer**
SPAWAR	**Space & Naval Warfare Systems Command**
SPG	**Strategic Planning Guidance**
SPO	**System Program Office**
SPWG	**Strategic Plan Working Group**
SRBM	**Short-Range Ballistic Missile**
SS	**Space Support**

SSA	**Space Situational Awareness**
STIL	**Systems Test & Integration Lab**
STOVL	**Short Take Off and Vertical Landing**
STTR	**Space Test and Training Range**
SUT	**Systems Under Test**
SUV	**Sport Utility Vehicles**
T&E	**Test and Evaluation**
T&E/S&T	**Test and Evaluation/Science and Technology**
TAMD	**Theater Air and Missile Defense**
TAWS	**Terrain Awareness Warning System**
TBMCS	**Theater Battle Management Core Systems**
TCA	**Transformational Communications Architecture**
TCAR	**Transatlantic Cooperative Alliance Radar**
TCAS	**Traffic Collision Avoidance System**
TCS	**Target Control System**
TE	**Test Environment**
TEMS	**Test and Evaluation Modeling and Simulation**
TENA	**Test and Training Enabling Architecture**
TESA	**Test and Evaluation Support Aircraft**
THAAD	**Terminal High Altitude Air Defense**
THOR	**Tera Hertz Operational Reachback**
TIM	**Toxic Industrial Material**
TM	**Telemetry Module**
TMD	**Tactical Missile Defense**
TOTO	**Tongue of the Ocean**
TRAG	**Test Resources Advisory Group**
TRMC	**Test Resource Management Center**
TRTC	**Tropic Regions Test Center**
TSAT	**The Transformational Satellite Communications System**
TSN	**Test Support Network**
TSPI	**Time Space Position Information**
TT&C	**Tracking, Telemetry and Commanding**
TTAP	**Test Technology Area Plan**

UAV	**Unmanned Aerial Vehicle**
UGV	**Unmanned Ground Vehicle**
UMTE	**Unmanned Threat Emitters**
UOC	**Urban Operations Complex**
URDC	**Underwater Range Data Communications**
USAKA	**United States Army Kwajalein Atoll**
USASMDC	**U.S. Army Space and Missile Defense Command**
USD(I)	**Under Secretary of Defense (Intelligence)**
USNS	**United States Naval Ship**
USW	**Undersea Warfare**
UTTR	**Utah Test and Training Range**
UUV	**Unmanned Undersea Vehicle**
VAFB	**Vandenberg Air Force Base**
VDS	**Vehicle Durability Simulator**
VISTA	**Variable Inflight Stability Training/Test Aircraft**
VTM	**Versatile Tracking Mounts**
VTOL	**Vertical Take Off Landing**
VXX	**Vertical Aircraft-Future**
WAS	**Wide Area Surveillance**
WCCS	**Wing Command and Control System**
WIR	**Woomera Instrumented Range**
WLTR	**Western Launch and Test Range**
WMD	**Weapons of Mass Destruction**
WPA	**Woomera Prohibited Area**
WSLAT	**Whole System Live Agent Testing**
WSMR	**White Sands Missile Range**
YPG	**Yuma Proving Ground**
YTC	**Yuma Test Center**

1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

1.1.1 Background

Section 231 of the Bob Stump National Defense Authorization Act (NDAA) for Fiscal Year 2003, Pub. L No. 107-314 (2002) enacted 10 U.S.C. 196 that directed the Department of Defense (DoD) to establish the Test Resource Management Center (TRMC) as a DoD Field Activity. TRMC was chartered with the issuance of DoD Directive DoDD 5105.71 in March of 2004 to: ”plan for and assess the adequacy of the Major Range and Test Facility Base (MRTFB)... to provide adequate testing in support of development, acquisition, fielding, and sustainment of defense systems; and to maintain awareness of other T&E facilities and resources, within and outside the department, and their impacts on DoD requirements.” As part of this mission, both the NDAA and the DoD Directive task the TRMC to develop, on a biennial basis, a strategic plan reflecting the needs of the department with respect to T&E resources and covering a period of ten years. This strategic plan is central to the TRMC mission and the associated budget certification process and, as such, it is designed to provide a roadmap for programming and budgeting for transforming the T&E infrastructure to meet the transformation needs of the department.

Section 196 of Title 10, United States Code states that the strategic plan will include the following six elements:

- An assessment of the T&E requirements of the Department for the period covered by the plan, which is addressed in Chapter 6.
- An identification of performance measures associated with the successful achievement of T&E objectives for the period covered by the plan, which is addressed in Chapter 3.
- An assessment of the T&E facilities and resources that will be needed to meet such requirements and satisfy such performance measures, which is addressed in Chapter 6.
- An assessment of the current state of the T&E facilities and resources of the department, which is addressed in Chapter 5.

- An itemization of acquisitions, upgrades, and improvements necessary to ensure that the T&E facilities and resources of the department are adequate to meet such requirements and satisfy such performance measures, which is addressed in Chapter 6.
- An assessment of the budgetary resources necessary to implement such acquisitions, upgrades, and improvements, which is addressed in Chapter 7.

Not all six elements were completely accomplished since the TRMC was partially staffed during the development of this plan. The progress in accomplishing the six elements is addressed in Chapter 7 of this strategic plan.

An inaugural strategic plan "Department of Defense T&E Resources" was developed and published in September 2003 by an interim staff from the Services and various OSD offices with T&E subject matter expertise.

This plan is the first one produced by permanent TRMC staff members, and it articulates the results of a comprehensive assessment of test resource needs.

The current plan represents a significant expansion of the inaugural strategic plan. Led by the permanent TRMC staff, this effort involved the cooperative efforts of numerous organizations within the DoD, and used a standing Strategic Plan Working Group (SPWG) to guide the development and maturing of the plan.

1.1.2 Purpose

This strategic plan provides a systematic approach to determining DoD's T&E resource and infrastructure needs. This plan is intended to be for the period from the time of submission in accordance with 10 U.S.C. 196(d)(3) through FY2017, but the focus is on FY2008 through FY2017 because of budget timing and Program Objective Memorandum (POM) constraints. It is on that period that this plan can have an impact. This plan reflects the planning aimed at achieving an Objective T&E Infrastructure by the end of this period. The first POM this plan can influence is that for FY2008.

This strategic plan represents an evolutionary progression from the inaugural strategic plan to one that can best answer the needs of future acquisition and test programs and associated warfighter requirements. This strategic plan will mature over time (in future editions) as the department's transformation initiatives mature and begin to bring new systems, tactics, techniques, and doctrine on line to meet joint warfighter needs.

1.2 SOURCES

A variety of sources were used to determine the T&E capabilities required to support the DoD. Sources at the national level include the President's Management Agenda, the National Security Strategy, and the National Military Strategy. Within the department, sources of guidance included the Strategic Planning Guidance and the goals set forth by the Under Secretary of Defense (Acquisition, Technology and Logistics); the vision, goals and objectives for DoD T&E community also shaped the strategic plan; Service and agency transformation roadmaps; and the T&E resource needs and solutions resulting from the Service-level T&E Executive Agent Reliance process.

1.3 OBJECTIVE T&E INFRASTRUCTURE

The end state test infrastructure that this and future biennial strategic plan updates will strive for is an adaptive, persistent, integrated, distributed, global T&E infrastructure that is capable of the following:

- providing robust, flexible T&E of systems & systems of systems
- providing capability to test next generation weapon, C4ISR, and IT systems
- providing connectivity capability between open air ranges, hardware in the loop facilities, installed system test facilities, battle laboratories, and training ranges
- using persistent connectivity to live, virtual, and constructive joint mission environments, and
- supporting informed, effective and timely transition of new capabilities to the joint warfighter.

1.4 KEY T&E CAPABILITY NEEDS

The key T&E capability needs were identified through an analytic process. The analysis identifies test capability needs in the near -, mid -, and far – terms. The analysis includes traceability matrices, roadmaps, test capability gaps, and provides issues and recommendations. The traceability matrices provide links to programs, high-level guidance, or concept drivers that will require a given test capability to be available at some future time and provide a rough estimate of its criticality.

The DoD T&E capability needs described in this plan are organized by the Reliance Areas used by the Service T&E Executive Agent process:

- Air Combat
- Armaments and Munitions

- Command, Control, Communications, Computers, Intelligence, and Reconnaissance (C4ISR)
- Common Range Instrumentation (CRI)
- Electronic Combat
- Land Combat
- Sea Combat
- Space Combat
- Test Environments
- Targets and Threat Systems.

To determine test capability needs and gaps that the Department should focus on in future investments, each area was analyzed in the context of T&E capability drivers extracted from the overarching national and departmental strategic guidance, and transformation strategies; the T&E infrastructure capabilities as they exist today; and the current T&E infrastructure investment strategies. T&E capability drivers that were extracted from the overarching strategy documents are identified in Chapter 4. Chapter 5 describes the current T&E infrastructure as it exists today, and Chapter 6 identifies test capability needs and any gaps resulting from the analysis.

- A test capability "need" is a T&E capability that is projected to be required in the future.
- A "test capability gap" is a test capability need that does not have a roadmap to provide that capability or provides it too late to support expected projects or programs.

The TRMC will work with the OSD stakeholders and service and agency representatives through the Strategic Planning Working Group (SPWG) to address these gaps and needs and develop an implementation plan and associated roadmaps over the next year.

1.4.1 Overarching Test Capability Modernization Strategy and Themes

Several dominant themes and focus areas emerged as a result of the analyses associated with this plan. These will require the ability to test individual platform performance, as we have done with our legacy systems, and also to test emerging new technology systems such as directed energy systems, unmanned systems, hypersonic weapon systems, larger footprint weapons, and information warfare non-kinetic systems. Additionally our T&E infrastructure must evolve to provide the ability to assess mission capability in the context of sensor-to-shooter kill chains and joint mission threads that integrate weapon and command, control, communications, computer, intelligence,

surveillance and reconnaissance (C4ISR) systems using joint tactics and doctrine that cross-Service and even our allied partner lines.

1.5 TEST CAPABILITY GAPS SUMMARY

A summary view of the high-priority test capability gaps is presented below.

- **Air Combat**- Larger test areas to mitigate encroachment and support hypersonic air vehicles and global range UAVs. Improved avionics test capabilities to support transformational, net-centric systems and increased utilization of artificial intelligence.
- **Armaments and Munitions** – Larger test ranges for long-range precision strike weapons and miniaturized flight termination systems (FTS) to support smaller long-range precision strike weapons.
- **C4ISR** – End-to-end system of system stress loading from ISR assets to command facilities and eventually to engaging elements to assess the full effects of performance. Improved data link transmission and monitoring for accurate evaluation of interference, timing and true operational communication loading.
- **Common Range Instrumentation** – Non-intrusive, embedded miniaturized instrumentation, capabilities for integrating M&S (constructive and virtual) with live test, training, and experimentation events, compatibilities with the Test and Training Enabling Architecture (TENA) for sharing and co-use of M&S among test, training, and experimentation events.
- **Electronic Combat** – IR/UV missile warning system end-to-end testing to include multi-spectral band missile plume simulators and improved simulation ability.
- **Land Combat –** Chemical Biological test capability enhancements including a live agent test chamber to perform live CB agent testing of active standoff CB detectors.
- **Sea Combat** – Currently, there are no identifiable test capability gaps other than the supersonic seaskimming targets referenced in section 6.9. However, the adequacy of littoral/shallow water testing is a special interest item.
- **Space Combat** - Extended hypersonic flight corridors that are flexible, accessible and over land, water and littoral areas near the U.S. test ranges. Overseas/foreign test capabilities to support the global testing focus for

Operational Responsive Space (ORS) and Ballistic Missile Defense System (BMDS).

- **Test Environments** – Sustainment of aero-thermodynamic and air breathing engine test capabilities to decrease maintenance failures and support future system needs. Small scramjet engine test capability Mach 4-8 for hypersonic weapon systems development and large high-speed turbine engine test capability up to Mach 4.
- **Targets and Threats** –Development of a full-scale aerial target replacement for the QF-4 and development of supersonic sea-skimming aerial targets to meet new threat capabilities.

1.6 CONCLUSION

This plan represents a comprehensive assessment of the DoD T&E infrastructure and test capability needs and gaps. It is the foundation for future TRMC initiatives to collaborate with the Services and agencies to develop implementation plans, roadmaps, and associated business processes to transform the Department's T&E infrastructure within the confines of strategic guidance, policy, and fiscal constraints. Over the next year, the TRMC will collaborate with the OSD stakeholders and Service and agency representatives through the SPWG to address identified issues, test capability gaps, and test capability needs.

2.0 INTRODUCTION

2.1 BACKGROUND

Section 231 of the Bob Stump National Defense Authorization Act (NDAA) for Fiscal Year 2003, Pub. L No. 107-314 (2002) enacted 10 U.S.C. 196 that directed the Department of Defense (DoD) to establish a DoD Test Resource Management Center (TRMC). The purpose of the organization is to: (1) review and provide oversight of budgets and expenditures for the Major Range and Test Facility Base (MRTFB) and other DoD test and evaluation (T&E) facilities, (2) to complete and maintain a strategic plan, (3) to review and certify the T&E budgets, and (4) to administer the Central Test and Evaluation Investment Program and the DoD T&E for Science and Technology program. This document is prepared in response to the requirement to develop a strategic plan in order to assess the adequacy of the Major Range and Test Facility Base (MRTFB) to provide adequate testing in support of development, acquisition, fielding, and sustainment of defense programs.

The Strategic Plan for DoD T&E Resources is to be completed at least biennially in coordination with representatives of the Director of Operational Test and Evaluation ,the Service Secretaries, and heads of Defense Agencies having T&E responsibilities. The plan is to provide:

- an assessment of T&E requirements for a period of ten years,
- the facilities and resources necessary to meet those requirements,
- an assessment of current T&E facilities,
- an identification of performance measures to evaluate successful achievement of the objectives of the plan
- identification of T&E infrastructure investments required to achieve T&E requirements and satisfy performance metrics and the budgetary resources required to acquire them

The first *Strategic Plan for Department of Defense Test and Evaluation Resources* was submitted on September 26, 2003. An addendum to that plan was completed in June, 2005 to support T&E resource planning for the FY2007 budget cycle. This document is TRMC's second strategic plan and projects the T&E capabilities necessary to support DoD needs at least a decade into the future.

2.2 PURPOSE

This strategic plan provides a systematic approach to determining DoD's T&E resource and infrastructure needs and a cogent and balanced investment plan for meeting those needs. This plan is intended to be for the period from the time of submission in accordance with 10 U.S.C. 196(d)(3) through FY2017, but the focus is on FY2008 through FY2017 because of budget timing and Program Objective Memorandum (POM) constraints. It is on that period that this plan can have an impact. This plan reflects the planning aimed at achieving an Objective T&E Infrastructure by the end of this period. The first POM this plan can influence is that for FY2008. This strategic plan represents an evolutionary progression from the current one to a plan that can best answer the needs of the future warfighter.

In proceeding along this evolutionary path, the plan discusses the T&E capabilities needed to answer near-term (FY2008 – FY2012) and midterm (FY2013-2017) needs. Once the plan is met, the capabilities that result will meet the objective infrastructure. The plan also considers, insofar as it is possible to do so, the DoD's long-term T&E needs, which extend the objective into yet an even more distant infrastructure to be covered by future plans.

2.3 METHODOLOGY

This section describes the logic and methodology used to develop the Strategic Plan, including the process of transforming our current infrastructure into a future one with its accompanying capability to perform test and evaluation (T&E). This process is represented in the conceptual model shown in Figure 2.1.

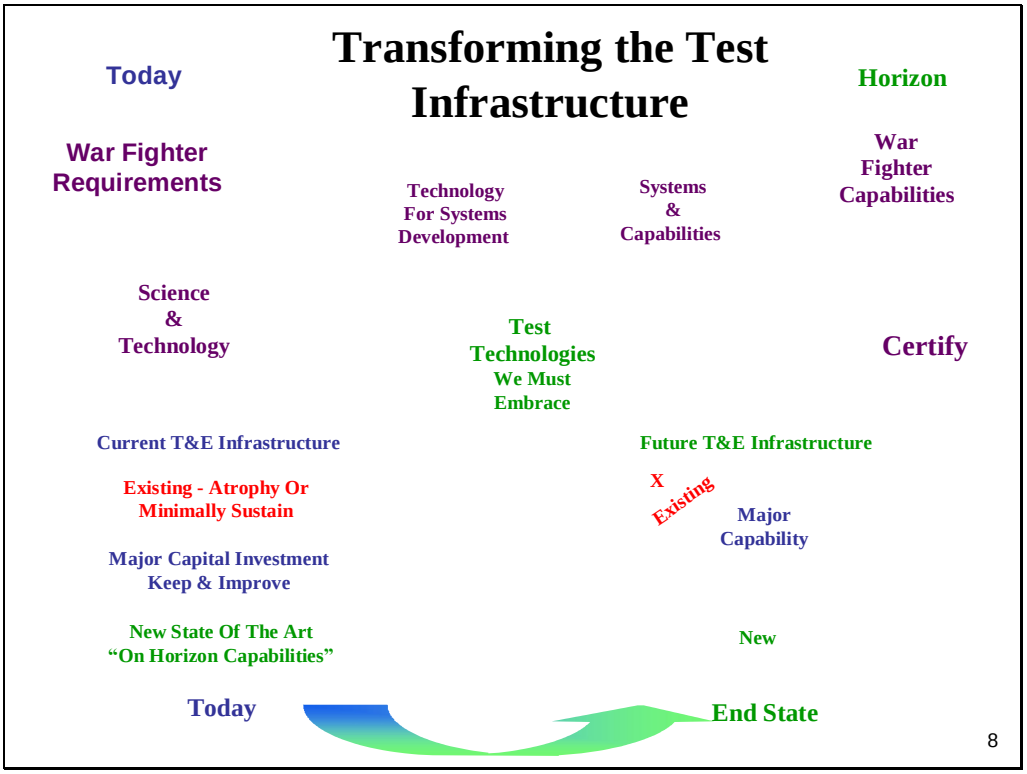

Figure 2.1—Conceptual Model for the Strategic Plan: Transforming Our Infrastructure

The model elaborates on the traditional logic of identifying needs, examining capabilities, identifying shortfalls, and building roadmaps to show how the shortfalls will be remedied as a function of time and resources. Starting with the upper left hand corner, the upper half of the figure shows the "pull" on the acquisition process represented by the *Warfighter Requirements*. It also represents the "push" on the acquisition process represented by *Science and Technology*. These two elements feed each other resulting in *Technologies for Systems Development*. Some of the technologies for systems development lead to acquisition of *Systems and Capabilities*. Using the technologies for systems development and the knowledge of the systems under development, *Test Technologies We Must Embrace* can be identified. The *Systems and Capabilities*, supported by the *Future T&E Infrastructure*, go on to be *Certified* and ultimately provide *Warfighter Capabilities*.

For the sake of simplicity the feedback loop that must exist between *War Fighter Capabilities* and *War Fighter Requirements* is omitted from the diagram. This process is

continuous. As the left side of the figure proceeds, *Systems and Capabilities* need to be tested, which started in a previous cycle of the process. This process is similar to that of the DoD's program/budget process. While one program/budget is being executed, others are being developed and reviewed.

The upper half of Figure 2.1 can be thought of as the traditional "needs" side of the equation while the lower half represents the "capabilities" side. This is the essence of the Strategic Plan: transforming the existing T&E infrastructure into the one required in the future. The current T&E infrastructure is broken into three parts: *Existing, Major Capital Investment*, and *New State of the Art*. We then show the action we intend for each part. The existing part will be allowed to "atrophy" or will be "minimally sustained." The *Major Capital Investment* will "Keep and Improve." The new state of the art will be expanded by searching for the "On Horizon Capabilities" This will permit the T&E of emerging weapons technology.

Both the "Major Capabilities" and the "New" portions of the future T&E infrastructure are fed from the *Test Technologies We Must Embrace*. To simplify the model, resources and resource allocation process are not shown. The logic of this conceptual model maps into the organization of the Strategic Plan.

2.4 HOW THE STRATEGIC PLAN IS ORGANIZED

The plan is organized into two parts: a main plan and appendix. In addition to an executive summary and an introduction, the main plan has six other chapters. Chapter Three describes the national-level policy documents that provide the high-level guidance to DoD, and it contains the T&E vision, goals, and objectives that TRMC has distilled from those documents. Chapter Four describes the T&E needs that DoD either has or will likely have before 2017. Chapter Five catalogs DoD's current capabilities, and Chapter Six compares the needs with extant capabilities and identifies gaps. Because the TRMC has only been in existence since FY2003, it has not been able to generate or assemble some portions of the information that 10 U.S.C. 196(d) requires be included in the plan. Chapter Seven identifies the shortfalls that will be addressed in subsequent strategic resource plans as well as where in the report that available information pertaining to requirement of 10 U.S.C. 196 can be found.

3.0 NATIONAL GUIDANCE, VISION, GOALS AND OBJECTIVES

This chapter describes the national guidance, contained in a series of national-level policy documents and describes the overarching T&E infrastructure that chart the course for the DoD over the next half-decade. These documents are important to the development of a strategic T&E resource plan because they heavily influence DoD and Service acquisition plans and programs. These plans and programs produce the materiel that the T&E community evaluates, which in large part determines the objective T&E infrastructure. Second, it describes the overarching T&E vision and the goals and objective that flow from it. The linkage among these guidance documents is portrayed in Figure 3.1

Figure 3.1—Guidance and Implications

3.1 NATIONAL GUIDANCE DOCUMENTS

3.1.1 President's Management Agenda

The overriding guidance for how the resources are managed and used in the DoD is identified within the "President's Management Agenda." As pertains to the DoD T&E infrastructure, this includes the five core elements of the Agenda; i.e., strategic management of human capital, competitive sourcing, improved financial performance, expanded electronic government, and budget and performance integration. Implications for the T&E infrastructure include application of tools such Lean Six Sigma, Balanced Scorecard, and Activity-Based Costing.

3.1.2 National Security Strategy

The emphasis on joint operations and global forward presence permeates the national guidance documents to influence how the Department of Defense (DoD) will transform for the 21st century. The highest-level strategy document issued by the U.S. Government is the *National Security Strategy* (NSS) of the United States. Authored by the National Security Council, it covers not only defense strategy but also all other aspects of the government federal, state, and local. As such, implications for the test community are only general and may be inferred from desired capabilities rather than specific Test and Evaluation (T&E) guidance.

The 2002 *National Security Strategy* (NSS) sets the transformation to joint operations and global forward presence in motion by stating, "innovation within the armed forces will rest on experimentation with new approaches to warfare, strengthening joint operations, exploiting U.S. intelligence advantages and taking full advantage of science and technology." The NSS aims to defeat threats to our nation, our allies, and our friends, and promote and preserve global peace, prosperity, and liberty. These goals aim to make the world safer in addition to our own country.

From the NSS, the SecDef has established a framework within which to balance risks among the strategic goals, and prioritized the top ten annual goals against which to measure the DoD's performance. The capabilities of the DoD T&E infrastructure will contribute to the performance measures for the realization of these goals. These risks and associated goals are as follows:

- Force Management Risk
- Manning the Force
- Operational Risk
- Successfully Pursue the Global War on Terrorism

- Strengthen Joint and Combined Warfighting
- Combat the Proliferation of Weapons of Mass Destruction
- Implement New Concepts for Global Engagement
- Improve Homeland Defense
- Institutional Risk
- Streamline DoD Processes
- Reorganize DoD to Deal With Pre-War Opportunities and Post-War Responsibilities
- Future Challenge Risk
- Transform the Joint Force
- Optimize Intelligence Capabilities

The Undersecretary for Defense for Acquisition, Technology and Logistics (USD (AT&L)) developed the following AT&L goals to align with the SecDef goals:

- Acquisition Excellence with Integrity
- Logistics: Integrated and Efficient
- Systems Integration and Engineering for Mission Success
- Technology Dominance
- Resources Rationalized
- Industrial Base Strengthened
- Motivated, Agile Workforce

These AT&L goals provide some implications for T&E. These implications include timely T&E capability upgrades to support new S&T/Acquisitions, analysis of existing T&E infrastructure for sustainment or termination and a new T&E enterprise that is responsive to support timely decisions. With these implications in mind, a set of DoD T&E goals are developed after a quick examination of other national documents.

3.1.3 National Defense Strategy

The *National Defense Strategy* (NDS) is based on the framework laid out in the *National Security Strategy*. The strategic objectives of the NDS include securing the United States from direct attack, securing strategic access while retaining global freedom of action, strengthening alliances and partnerships, and establishing favorable security conditions. These objectives will be accomplished through assuring our allies and friends, dissuading potential adversaries, deterring aggression, countering coercion, and defeating

adversaries. These objectives will be further implemented through active, layered defense, continuous transformation, using a capabilities-based approach, and managing risks.

Further, the NDS describes critical operational capabilities that include operating from global commons (space, international waters, airspace and cyberspace) and the ability to conduct net-centric operations. The strategy notes that this requires a fundamental shift in processes, policy and culture. It is clear from the strategy that a global force must operate in a net-centric fashion to implement a true joint operation.

3.1.4 National Military Strategy

With guidance from the NSS and NDS, the *National Military Strategy* (NMS) establishes the objectives of protecting the United States against attacks and aggression from external sources, preventing conflict and surprise attacks, and prevailing against adversaries. These objectives aim to assure our allies and friends, to dissuade and deter adversaries, aggression, and coercion, and to ensure that the Armed Forces remain ready to defend the United States. The NMS describes four implementation guidelines for the NDS. These include an active layered defense, continuous transformation, capabilities-based approach, and risk management. The NMS states that the future direction of military strategy will be to accommodate joint forces and prevent adversaries from using weapons of mass destruction (WMD). Accomplishing this goal will require new levels of interoperability and systems that are conceived of and designed with joint architectures and acquisition strategies in mind, i.e., "born joint."

3.1.5 Strategic Planning Guidance

The *Strategic Planning Guidance* (SPG) was released in March 2004 as a guide for DoD Components in a new Joint Capabilities Development Process. The SPG is "global" in nature and provides guidance to the Department of Defense for the next five or six years. The SPG further provides focused and timely strategic direction for DoD resource allocation decisions. Its priorities support the NDS and expand the risk guidance given to the DoD Components by directing a reduction or acceptance of risk.

The SPG provides three types of guidance. First, it provides overarching guidance that applies across the defense program, including planning assumptions, application of the Defense strategy and general risk guidance. Second, the SPG gives specific-by-exception planning and programming guidance organized by risk areas to achieve department goals and prepare for the next Quadrennial Defense Review (QDR). Finally, it outlines detailed guidance for the tasks directed in the SPG.

To carry out the Defense Strategy and develop the key operational capabilities required to implement future joint operating concepts, the DoD will pursue innovative research and development T&E programs. These programs include the Joint Test and Evaluation Program, the Joint Rapid Acquisition Program, the Transformation Initiative Program, and Joint Testing in Force Transformation.

3.2 DOD T&E VISION, GOALS AND OBJECTIVES

The goals and objectives of the FY2003 Strategic Plan for T&E Resources have been updated to reflect DoD priorities/goals and recent guidance in national level documents.

3.2.1 Vision

The DoD's vision for T&E facilities and resources is:

Department of Defense T&E Ranges and Facilities will be fully capable of supporting the Department with quality products and services in a responsive and affordable manner

3.2.2 Goals and Objectives

The analysis of the national-level documents and the vision for the T&E ranges and facilities concluded that three goals must be accomplished to reach the objective infrastructure needed to meet the DoD's needs. The three goals are as follows:

- Assess, sustain, and improve T&E capabilities to support DoD transformation, advancing technologies, and changing operational conditions.
- Ensure effective and economical acquisition, manning, and operational maintenance of T&E capabilities.
- Draw upon other capabilities to complement DoD T&E capabilities and avoid unnecessary duplication of resources.

The Measures of Performance (MOP) are under development, but initial MOPs are provided herein. More mature MOPs will be provided in subsequent plans.

Goal 1: Assess, sustain, and improve T&E capabilities to support DoD transformation, advancing technologies, and changing operational conditions.

- Objective 1: Identify T&E requirements of the department through collaboration with the S&T, acquisition, and operational communities.

Strategy and Means:
The TRMC will actively participate in meetings and planning activities with the S&T, acquisition, and operational communities to develop a comprehensive understanding of emerging technologies, current acquisition programs, and operational test and training requirements.

Measures of Performance:

- Active participation in meetings and workshops on a regular basis

- Objective 2: Assess the ability of current test capabilities to meet requirements and identify critical gaps.

Strategy and Means:
The TRMC will analyze requirement documents, determine impacts to test resources, monitor progress of development activities, and assess system resource adequacy. In the future, the overall T&E Reliance structure will be examined in order to determine the most effective way to filter and propagate T&E needs. Concurrently, existing Service-specific database inventories of T&E infrastructure capabilities will be reviewed with the goal to establish a consolidated database of all DoD assets.

Measures of Performance:

- Participation in T&E requirements processes on a regular basis.
- Creation of secure, electronic database that houses a complete inventory of T&E infrastructure capabilities.

- Objective 3: Sustain existing critical T&E facilities, capabilities, and equipment.

Strategy and Means:
To preserve and sustain DoD ranges and operational areas, lasting relationships must be built with state and local governments, land use communities, non-governmental organizations, and other stakeholders. Furthermore, legislation is being sought to protect the interests of the DoD ranges. The majority of these efforts are under the direct oversight of the Overarching Integrated Product Team (OIPT), which is co-chaired by DUSD (I&E), DUSD (P&R), and Deputy, DOT&E. The TRMC will proactively engage these organizations, monitor

legislative efforts, and continue to promote more open communication with non-government stakeholders in an effort to preserve our operational environment. TRMC will work with the Services and DUSD (I&E) to assess the data provided for the sustainment, restoration, and modernization of T&E facilities and, as necessary, work to facilitate the reduction in the recapitalization rate for T&E facilities.

Measures of Performance:

- Develop/establish Memorandums of Understanding, Memorandums of Agreement, Working Group Charters (as applicable), and IPTs.
- Recapitalization rate.

- Objective 4: Invest in new T&E capabilities to satisfy critical needs.

Strategy and Means:

TRMC will review the new T&E capability needs in this Strategic Plan with the Strategic Planning Working Group to determine the critical priorities. TRMC will then review the investments of all Services and Defense Agencies to ensure satisfactory solutions to these critical priorities are adequate.

Measures of Performance:

- Number of critical T&E capability needs that are adequately funded
- Number of solutions for critical T&E capability needs that deliver capability on time

- Objective 5: Invest in S&T initiatives that provide more effective T&E capability.

Strategy and Means:

TRMC's T&E / Science & Technology (T&E/S&T) program develops test technologies in parallel with advanced warfighter technologies. The T&E/S&T program's overarching goal is to provide the required T&E technologies in time to verify performance before these weapon systems enter production or are deployed to the warfighter. The focus areas within the T&E/S&T program, in conjunction with Service S&T efforts, identify the necessary technology for future T&E capability development.

Measures of Performance:

- Number of T&E test technologies that transition to T&E capability development programs
- Percentage of T&E/S&T projects progressing toward technical, financial, schedule and risk mitigation goals established for each project.

This goal and its supporting objectives map into the portion of the Strategic Plan that identifies the critical T&E needs, where those needs are not met, and what needs to be done to close the gap between needs and capabilities.

Goal 2: Ensure effective and economical acquisition, manning, and operational maintenance of T&E capabilities.

- Objective 1: Ensure the department's T&E capabilities are adequately and appropriately resourced in accordance with the T&E Strategic Plan.

  Strategy and Means:
  TRMC will review the DoD investments for capability needs identified in the T&E Strategic Plan and will work with the Services and Defense Agencies to ensure satisfactory solutions are funded adequately.

  Measures of Performance:
  - Capability needs adequately funded.

- Objective 2: Ensure customers of DoD test capabilities are charged appropriately.

  Strategy and Means:
  - TRMC will work closely with the Services to determine the charges that are appropriate and ensure any necessary additional guidance is documented in the Financial Management Regulation or other appropriate documents.
  - TRMC will perform assessments of the MRTFB activities to ensure compliance with the new charge policy and work with the Services to resolve any discrepancies.

  Measures of Performance:
  - Identification of additional guidance required by the Services.

- MRTFB activities are charging appropriately and consistently

- Objective 3: Ensure DoD T&E workforce is adequately staffed and receives training and education to address projected T&E requirements.

  Strategy and Means:
  Pursue a plan with department and field personnel offices to develop a high performance T&E workforce. Partner with the DDR&E Science, Mathematics and Research for Transformation (SMART) Scholarship program to supply highly-qualified engineers and scientists to the T&E technical workforce.

  Measures of Performance:
  - Establish milestones for plan development by FY2007.

This goal and its supporting objectives map into the portion of the Strategic Plan that identifies all T&E needs including sustainment and improvement. Yet it also maps to our assessment of the current T&E infrastructure in the Strategic Plan to include the workforce. This goal also addresses education and training of the workforce.

Goal 3: Draw upon other capabilities to complement DoD T&E capabilities and avoid unnecessary duplication of resources

- Objective 1: Partner and develop interoperability, data sharing, and standardized procedures with DoD training and experimentation.

  Strategy and Means:
  TRMC will implement an aggressive outreach program to fully integrate DoD's T&E resource and facility planning with other responsible test, training, and warfighter joint experimentation oversight activities to include the Defense Test and Training Steering Group (DTTSG), and Joint Forces Command (JFCOM). Participate in ongoing initiatives that will facilitate cross-service range use and interoperability among test and training ranges, and support the development of a standards-based live, virtual and constructive T&E capability.

Measures of Performance:

- Develop/establish Memorandums of Understanding, Memorandums of Agreement, Working Groups and IPTs.

- Objective 2: Partner with and leverage other Federal Agency T&E capabilities and investments where appropriate.

Strategy and Means:

TRMC will pursue constructive engagement with other DoD and non-DoD entities (eg., DOE, NASA, DARPA, NOAA, NSSO) in order to explore area of common interest with respect to test resources and capabilities, and identify other Federal T&E capabilities that fill DoD needs, improve efficiencies, or reduce costs.

Measures of Performance:

- Develop/establish Memorandums of Understanding, Memorandums of Agreement, Working Groups, and IPTs.

- Objective 3: Partner with and leverage DoD contractor and U.S. commercial T&E capabilities.

Strategies and Means:

TRMC will identify test capabilities of DoD contractor and U.S. commercial activities that can augment existing DoD capabilities, fill DoD capability needs, or supplant DoD capabilities that can not be sustained. TRMC will facilitate Service or Defense Agency efforts to gain access to needed non-DoD capabilities.

Measures of Performance:

- Develop/establish Memorandums of Agreement and Contracts

- Objective 4: Leverage international T&E capabilities and ensure security and test procedures are interoperable for data interchangeability.

Strategy and Means:

TRMC will partner with DOT&E to identify test capabilities of allied nations that can be used to fill DoD capability needs or satisfy limited use applications.

Measures of Performance:

- Develop/establish Memorandums of Agreement, Contracts, Security Guides.

This goal addresses TRMC's charge to set priorities for T&E investments. If a need can be dealt with by sharing a T&E facility with an organization outside DoD, it likely would be to the advantage of both organizations to do so. It would reduce the overall operations and maintenance cost of the host organization to have additional users, and it would save DoD the cost of establishing a new facility or upgrading an existing one to acquire the necessary capability.

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4.0 T&E CAPABILITY DRIVERS

4.1 INTRODUCTION

This chapter identifies and reviews the documents, programs, and other relevant sources of information that have a significant influence on any vision for the future DoD T&E infrastructure. Based on an analysis of these sources, the TRMC identified programs, systems and weapon capabilities that are anticipated within the near- (FY2008–FY2012), mid- (FY2013–FY2017), and far- (FY2018–FY2022) term. The primary focus is on the near and midterm, but the far term is included in preparation for future Strategic Plans. These capabilities, called "drivers," define the nature of the future infrastructure and help identify critical areas for investment of T&E resources.

To ensure that the T&E Resources Strategic Plan remains consistent with the national-level documents referred to in Chapter Three, a wide range of DoD and service policy and planning documents were reviewed from the following categories:

- National guidance documents
- DoD transformation documents
- DoD homeland defense and civil support
- Defense science and technology plans
- DoD technology programs
- DoD acquisition programs
- Other documents

This chapter is organized into the four major areas.

1) The documents reviewed in the above categories are described with the associated major implications for T&E capabilities.
2) Major acquisition programs likely to be in the system development phase during the timeframe of this plan are reviewed. The acquisition programs are included in order to anticipate their T&E needs. The acquisition programs are categorized into the ten T&E Reliance Panel areas that the Services use to define test resource needs and solutions (see Chapter Five): air combat, land combat, sea combat, space combat, armaments and munitions, C4I, common range instrumentation, electronic combat, target systems, and test environments.

3) The Test Technology Capability drivers derived from ongoing science and technology advances and DoD transformation thrusts are described. These drivers are not associated with any specific acquisition program but must nevertheless be considered because of their potential effect on the T&E infrastructure.
4) Several on-going department-wide initiatives are identified that will also "drive" T&E capability needs.

Describing T&E capability drivers in this way is important because the lead time required to budget for, design, construct, and activate major T&E capabilities that address new technology or complex testing capabilities generally requires actions to be initiated prior to the slated specific needs of a defined acquisition program.

4.2 NATIONAL AND SERVICE-LEVEL DOCUMENTS

The following documents were reviewed in preparation of the plan. (Full citations appear in the bibliography.)

4.2.1 National Guidance Documents

Addressed in Chapter Three, the review of national documents includes the NSS, NDS, NMS, and SPG.

4.2.2 DoD transformation documents

The transformation documents reviewed include the Transformation Planning Guidance approved by the Secretary of Defense and the Joint Forces Command Joint Transformation Roadmap. The review also included the Transformation Roadmaps of the Army, Navy, and Air Force, and the Training Transformation Plan developed by the Office of the Under Secretary of Defense for Personnel and Readiness (USD P&R).

Common themes that appear in the service plans are the latest technology areas and the joint operational concepts. The Air Force plan moves from a theater focus to a global one of rapidly projecting capability anywhere on the earth and in space. The Army plan leads to a strategically responsive and precision maneuver force that is dominant across the range of military operations. The Navy plan focuses on the Sea Power 21 concept, which is based on Sea Shield, Sea Basing, and Sea Strike. Department initiatives, such as joint T&E environment, combining testing and experimentation, and integrated training and T&E strategy will influence the Services in achieving their transformational objectives.

The critical component of the Training Transformation Plan that is of significant interest to the T&E community is the development of a Joint National Training Capability (JNTC). The JNTC will be capable of supporting Live, Virtual, and Constructive (LVC) events in which every level of warfare can be orchestrated within a joint context.

4.2.3 DoD Homeland Defense and Civil Support

The review included the Strategy for Homeland Defense and Civil Support, written by DoD, and the Department for Homeland Security (DHS) Strategic Plan—Securing Our Homeland, written by DHS.

The Strategy for Homeland Defense and Civil Support outlined five strategic goals for DoD: achieve maximum awareness of potential threats; deter, intercept, and defeat threats at a safe distance; achieve mission assurance; support civil authorities in minimizing the damage and recovering from domestic chemical, biological, radiological, nuclear, or high-yield explosive (CBRNE) mass casualty attacks; and improve national and international capabilities for homeland defense and security.

The DHS Strategic Plan—Securing Our Homeland outlines seven strategic goals: awareness, prevention, protection, response, recovery, service, and organizational excellence. Overall, the DHS strategy directs attention to the same technological developments mentioned in the service and Joint Forces Command strategies but adds more weight to such areas as CBRN defense, sensor technologies, high-altitude surveillance, and networked communications capabilities. The new emphasis on homeland defense raises the potential for new programs that will need to be tested, thus placing increased demands on DoD T&E infrastructure.

4.2.4 Defense Science and Technology Plans

Technological superiority, which has given the United States a military advantage, continues to be a cornerstone of our national military strategy. This advantage was gained from past S&T investments. Future warfighting capabilities will be determined by today's S&T investments. The literature reviewed in this category consisted of four documents: the Basic Research Plan (BRP), the Joint Warfare Science and Technology Plan (JWSTP), the Defense Technology Area Plan (DTAP), and the Test Technology Area Plan (TTAP). The BRP, JWSTP, and DTAP are published by the Director, Defense Research and Engineering (DDR&E). The TTAP, formerly published by the Director, Operational Test and Evaluation (DOT&E), will come under the purview of the TRMC in the future.

The BRP presents DoD objectives and investment strategy for DoD-sponsored basic research. It also presents the planned investment in the following 12 technical

disciplines composing the basic research program: atmospheric and space sciences, biological sciences, chemistry, cognitive and neural science, computer science, electronics, materials science, mathematics, mechanics, ocean sciences, physics, and terrestrial sciences.

The JWSTP identifies a broad range of future warfighting capabilities and objectives. It addresses the development of technology options to support the achievement of capabilities associated with the eight joint functional concepts: battlespace awareness, joint command and control, force application, protection, focused logistics, net-centric environment, joint training, and force management.

The DTAP presents DoD objectives and the applied research and advanced technology development investment strategy. DTAP documents the focus, content, and principal objectives of the overall DoD science and technology efforts. The focus is on the following 12 technology areas: air platforms, battlespace environments; biomedical; chemical/biological defense; ground and sea vehicles; human systems; information systems technology; materials/processes; nuclear technology; sensors, electronics, and electronic warfare; space platforms; and weapons.

The TTAP guides S&T investment and leveraging decisions within the T&E community. The nine focus areas are as follows: hypersonic test, spectrum efficient technology, multispectral test, embedded instrumentation, directed-energy test, information systems technology test, software test, modeling and simulation, and test range/facility technology improvements.

DDR&E Initiatives. DDR&E established four special interest initiatives: National Aerospace Initiative (NAI), which involves systems using hypersonic technology to access space and to achieve global reach; Energy and Power Technologies Initiative (EPTI); Surveillance and Knowledge Systems (SKS), and National Defense Education Program (NDEP).

4.2.5 DoD Technology Programs

Review in this area included several technology areas, such as hypersonics, directed energy, and net-centric operations initiatives.

4.2.6 Other documents

Other documents, reviewed included the Advanced Concept Technology Demonstration (ACTD) Plan written by Deputy Under Secretary of Defense for Advanced Systems and Concepts DUSD (AS&C) and the (Draft) FY2004 Defense Planning Guidance Test and Evaluation Task written by DOT&E. Another document that affects

planning and management processes that support the T&E infrastructure is the DoD Directive 3500.15, of January 10, 2003: Sustainment of Ranges and Operating Areas (OPAREAS). This directive establishes policy and assigns responsibilities under Title 10, U.S. Code, for the sustainment of test and training ranges and OPAREAS.

4.2.7 Summary of T&E Implications from the Document Review

Review of various planning documents revealed a number of common capability drivers. Although T&E capabilities are already in hand to address many of these drivers, in some cases, current capabilities may need to be improved to fully meet future requirements. Specific needs identified are addressed in Chapter Six.

Joint Operations. The various guidance and planning documents reinforce a theme that has received considerable attention in recent years—the need for net-centric joint operations. This theme has important implications for the T&E community because of the complexity and large scale of such operations. A critical component of this theme is training. Of particular interest for the T&E community is the development of a Joint National Training Capability (JNTC). When fully implemented, JNTC will provide Joint forces and the Services an array of Live, Virtual, and Constructive (LVC) training environments that can emulate virtually any joint warfighting condition in which such forces may be expected to operate. This is accomplished through networking a selected collection of interoperable training and test sites and facilities to fuse personnel, capabilities, doctrine, and technology to meet combatant commander and service training event requirements. Thus the JNTC will be capable of supporting events where every level of warfare can be orchestrated within a joint context to provide the best possible training for fostering the execution of seamless military operations. By 2009, the goal is to have the capability to train any element of unified commands, Services, or multinational and interagency units in the full joint warfighting context.

System of Systems. Another aspect of the emphasis on joint, network-centric operations, as identified in CJSCI 3170.01B is the need for a framework for life-cycle evaluation of systems and systems of systems in a joint operational environment. To accomplish this evaluation, a program manager's T&E strategy will now need to address the Development Test & Evaluation (DT&E) and OT&E requirements for joint missions into which such systems may expect to be integrated and employed. In describing these environments, a common standardized task-based language will be used to identify missions and operational tasks, including the specification of measures and conditions to be employed. To create an adequately sized test environment, a persistent robust networking infrastructure for systems engineering, DT&E, and OT&E is needed to

connect distributed LVC resources while also enabling real-time data sharing and archiving. In recognition of the potential for the JNTC to support testing as well, strategic partnerships must be established between DOT&E, AT&L, and service T&E communities with OUSD (P&R), JFCOM, and Service training communities to exploit opportunities to combine training exercises and test events within a common shared scenario. Combining exercises or test events requires establishment of a collaborative prioritization and vetting process to ensure that testing, training, experimentation, and mission rehearsal can be pursued in a common venue without impairing the specific objectives of the tester, trainer, experimenter, or operational commander.

Battlespace Awareness. All Services are working to improve their awareness of the battlespace. This is a key aspect of being able to carry out truly joint operations and involves comprehensive knowledge of both friendly and enemy locations and activities. Battlespace awareness includes logistic assets that will require focused logistics elements to be tested within the net-centric infrastructure. The main implications of the need for battlespace awareness for the T&E infrastructure include interoperability, sensor range, sensor performance, network/asset mobility and flexibility, and information timeliness, security, and ambiguity. This strategy requires that the future range infrastructure be globally larger, more flexible, and more integrated with future C4ISR initiatives. The infrastructure will use traditional and nontraditional T&E resources simultaneously across great distances to include command centers. The infrastructure must also be capable of handling greater amounts of data efficiently. It is important that as designs evolve for battlespace awareness the “testing” design becomes embedded in the future system designs.

Command and Control (C2). As is the case with battlespace awareness, C2 is an inherent aspect of joint operations. The main effect of the C2 capabilities on the T&E infrastructure is the problem of testing an integrated C2 system within the present T&E infrastructure. The major challenge in a collaborative information environment is the huge amount of data to evaluate resulting from the sharing of information and the networked computing environment. Also, a robust communication grid is necessary to connect the many elements for a joint C2 capability. Again, these are part of the design needed to ensure that C2 and T&E are “designed in” from the beginning. If we truly test as designed, then the design must possess some inherent test capability that allows information to be pushed and pulled for test purposes as well as operational ones.

Non-kinetic Test Capability. All Services are increasing their capabilities to mature the Computer Network Operation (CNO) elements of attack, defense, and

exploitation. Two aspects of CNO programs set them apart from their acquisition counterparts—their relative expense does not meet the ACAT cost thresholds, and their development time is measured in weeks or months rather than years. Yet CNO tools and weapons emanating from these programs are poised to fulfill department policy to mature Information Operations (IO) into a core military capability. Achieving a steady-state IO core capability requires kinetic and nonkinetic capabilities to be fully integrated, tested, and certified across a range of operational environments against multiple target sets. DoD is pursuing an Integrated IO Range by integrating and connecting geographically dispersed CNO test capabilities and supporting activities and associated processes into a multilevel security, virtual range capable of supporting experimentation, Research Development Test & Evaluation (RDT&E), training, and exercises. The IO Range will support the combat arms Reliance areas of air, land, sea and space combat, as well as electronic warfare and armaments/munitions.

Larger System "Footprints." The requirement for testing networked systems expands the space occupied by test systems, as does the expansion in the range of weapons and mobility of platforms. Expanding test footprints to encompass multiple ranges will require portable instrumentation systems and interoperable range systems and processes.

New Operational Environments. Urban warfare, shallow water (littoral) environments, space operations, and chemically and biologically toxic environments have all become more important concerns in recent years. T&E resources for testing in these environments will require new investments.

Robust, Adaptive, Asymmetric Threats. In recent years, new kinds of asymmetric threats have emerged. These include improvised explosive devices (IEDs), chemical and biological threats, and different types of electronic and information warfare attacks. Additional T&E investments will be required to support efforts to counter these threats.

New Military-Relevant Technologies. It has always been the case that the continuing evolution of S&T produces opportunities to develop and exploit new weapons and other military technologies. The innovative nature of these developments often means that new facilities and instrumentation must be developed to test them. Present technological challenges include hypersonic propulsion, biometrics, directed-energy weapons, robotics and unmanned vehicles, and mobile wireless networks. .

Greater Scope of Tests, Desire for Efficient Test Processes. Other T&E resource consequences arise from the larger scope of tests and a desire for more efficient and faster testing. These include the need for more and more capable real-time casualty

assessment (RTCA) instrumentation, greater data-processing capability, and embedded test instrumentation, as examples.

Weapons of Mass Destruction (WMD). The detection of and protection against WMD figured prominently in most of the documents reviewed. T&E capabilities required fall into four functional areas: general testing requirements, sensing or detecting chemical and biological agents employed by an opponent, shielding or protecting forces or population, and sustaining operations in a chemically or biologically contaminated environment.

4.3 MAJOR ACQUISITION PROGRAM AND RELIANCE PANEL AREA DRIVERS

The most critical driver of T&E resource needs is the portfolio of DoD acquisition programs, both those past Milestone B and those Concept Refinement and Technology Development (CTD) programs that will likely soon pass that decision point. For the purposes of this plan, the Programs considered are those Major Defense Acquisition (MDAP) programs and Major Automated Information System (MAIS) programs being monitored by the Defense Acquisition Executive Summary (DAES) process or on the OSD Oversight List, as well as those pre-MDAP developments, designated as efforts which may eventually become MDAP's as defined by 10 U.S.C. 2430. The focus will center on those programs that will have passed Milestone B but are not yet in Full Rate Production (FRP) or Initial Operational Capability (IOC) during the timeframe of this plan. Focusing on programs that are past Milestone B and before FRP allows the plan to concentrate on programmatic time periods where the majority of the T&E will take place.

4.4 COMBAT TEST CAPABILITY AREAS DRIVERS.

4.4.1 Air Combat

The air combat warfare area addresses the systems (both the actual weapon systems and their support systems) that project military power and achieve national objectives through airpower. These systems include not just the assets of the Air Force, but also those of the Army, Marine Corps, and Navy. Air combat capabilities encompass many diverse missions categorized by the following overarching, distinctive, transformational capabilities:

- Information Superiority: In terms of air combat, this capability encompasses reconnaissance aircraft as well as the information-gathering/management functions on other types of aircraft. In the past, the reconnaissance mission was accomplished mostly by manned aircraft but is now evolving more towards

UAVs. This testing overlaps heavily with the C4ISR and electronic combat Reliance areas. In manned and unmanned aircraft of all types, this will involve testing of sensors, targeting, electronic warfare, and data-linking subsystems

- Air Superiority: This requires the negation and penetration of enemy air defenses to clear the path for follow-on joint forces. It encompasses a wide range of air-combat related systems and technologies: manned and unmanned aircraft, electronic attack and countermeasures, "stealth," standoff weapons, directed-energy weapons, and many more. This capability also encompasses cruise missile detection and defense to protect the homeland and deployed forces. This type of testing involves air-to-air and air-to-surface weapons delivery as well as other systems performance.
- Precision Engagement: This refers to the capability to attack and destroy a target with incredible accuracy and minimal ordnance. Across the Services, this requires land or carrier-based deep strike, interdiction, or close-air-support by manned or unmanned systems. In terms of air combat testing, this area involves air-to-surface weapons delivery, munitions integration and employment and sensor integration.
- Global Attack: In the near term, this capability involves long-range bomber and attack aircraft dropping nuclear or conventional munitions, although these could be replaced in the future by hypersonic or space-based or near-space systems, or a combination of manned and unmanned systems employing munitions as well as directed-energy weapons. In terms of naval or marine forces, this capability would in many cases also require carrier-based aviation.
- Rapid Global Mobility: In simple terms relating to air vehicles, this is the use of transport aircraft to deploy personnel and materiel rapidly. For air vehicles, T&E efforts would encompass such subsystems as a new inflight refueling boom for existing tankers or an entirely new transport or tanker aircraft. This would include not just fixed-wing, rotary-wing, and hybrid (tilt-rotor, VTOL, STOVL) airlift aircraft and tankers, but also associated support and survivability systems. More subtly, deployed personnel and aircraft must be able to operate seamlessly with sister Services and allied forces in a variety of environments, such as austere "bare bases" and CBRNE environments. T&E along the latter lines would likely focus on basic aircraft performance and sustainability in extreme environments
- Agile Combat Support: Strictly speaking, this capability does not encompass any air combat missions or functions. Rather, it involves the readiness,

training, equipping, and sustainment of air combat forces. However, in testing of certain air combat systems, such logistical aspects may come into play and most certainly could drive test requirements, such as the need for certain types of maintenance facilities, for example.

Both current and future air combat systems upgrades, design, and development are being driven by Service transformation plans. Some common transformation efforts across the Services are:

- Net-centric warfare: This will be a technological enabler as well as a requirements driver for new tactics, techniques, and systems. Current fighter, attack, and bomber aircraft, for example, are being retrofitted with various datalinks and improved sensors, while new aircraft designs are incorporating them on the drawing board. Combatant commands are also devising new CONOPS and aerial force mixes predicated on interlinked aircraft. Testing will move from testing subsystems or aircraft in isolation to testing large formations of interlinked aircraft and ground systems, mirroring actual employment. Cooperative engagement and third-party targeting will also drive new systems and CONOPS.
- Multipurpose platforms: Legacy and future aircraft weapons designs are being tasked to perform more varied roles than in past years. The YF-22A Raptor, first designed as an air superiority tactical fighter, has been redesigned to also perform air-to-surface attack missions and has been redesignated the "F/A-22." Similar trends can be seen with the F-14, F-18, B-1, B-2, B-52, and in the plans for the F-35 JSF, the E-10A M2CA, and the P-8 MMA.
- Unmanned platforms: As artificial intelligence and net-centric technology enablers advance, we will see an increase in the types and numbers of UAVs being designed and fielded. Of particular note will be the increased use of "weaponized" UAVs in armed combat.

Summary of T&E capability drivers for air combat:

- System-of-systems and network- centric warfare test capabilities. These require extensive communications in a joint environment. For the T&E community, the challenge is developing a robust capability to test a wide

variety of networked systems simultaneously, capturing and analyzing an enormous amount of data.

- Distributed test capability (interlinked facilities, integrated LVC testing, standardized interfaces and formats)
- Hypersonic air vehicles test capabilities. Tracking and telemetry instrumentation improvements are required, as are increased footprints for testing and improved C2 response mechanisms, materials, and structures.
- Ability to stimulate and test advanced multispectral sensors.
- Ability to test improved low-observable systems. This will include not just our own Systems Under Test (SUTs) but also performance testing of our systems against low observable threats.
- Realistic air-to-air and surface-to-air threats, targets, and countermeasures.
- Standardized instrumentation (both in the aircraft as well as on the range) that is also flexible and tailorable. Where possible, instrumentation embedded in the system design should be pursued to avoid "add-on" modifications.

Planned MDAP/MAIS Air Combat Programs Within the Strategic Plan Time-frame

Pre-MDAP/MAIS

Joint Precision Approach Landing System (JPALS)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Joint Unmanned Combat Air System (Joint UCAS)—Air Force Initiative

Pre-MDAP, milestones to be determined.

KC-135 Tanker Replacement Program—Air Force Initiative

Pre-MDAP, milestones to be determined.

Armed Reconnaissance Helicopter (ARH) Program—Army Initiative

Pre-MDAP, milestones to be determined.

Future Cargo Aircraft Program—Army Initiative

Pre-MDAP, milestones to be determined.

Light Utility Helicopter Program—Army Initiative

Pre-MDAP, milestones to be determined.

Longbow Apache (AH-64D), Block III Program—Army Initiative

Pre-MDAP, milestones to be determined.

Heavy Lift Replacement (HLR) Helicopter (CH-53X) Upgrade Program—Marine Corps Initiative

Pre-MDAP, milestones to be determined.

Personnel Recovery Vehicle—Air Force Initiative

Pre-MDAP, milestones to be determined.

Near Term (FY2008 – FY2012)

USMC H-1. This program involves upgrades to the USMC H-1, the AH-1W Cobra attack helicopter, and the UH-1N light utility helicopter. The common elements of the two will be identical twin engines, drive trains, a new four-bladed rotor, tail sections, and integrated digital cockpits. In addition, the AH-1Z attack helicopter will feature upgraded targeting.

Milestone B—2006, IOT&E—2008, IOC—2008.

Presidential Support Helicopter VXX.The VXX will be the primary Presidential vertical-lift platform employed by Marine Helicopter Squadron One. The program will field two increments of capability. IOC will occur with the fielding of four Increment 1 aircraft in October 2009. Increment 2 aircraft satisfy all requirements. The VXX Program objective is to field Increment 2 capability as soon as practicable.

Milestone B—2008, IOT&E—2010, IOC—2009.

C-130 Aircraft Modernization Program (AMP). This program consolidates and installs mandated DoD navigation and safety modifications, the Global Air Traffic Management (GATM) systems, and other reliability, maintainability, and sustainability (RM&S) upgrades, including Traffic Collision Avoidance System (TCAS), Terrain Awareness Warning System (TAWS), replacement of APN-59 and APQ-175 radars, replacement of N-1/C-12 compass, dual autopilot, dual flight management systems and HF/UHF/VHF datalink.

Milestone C—2008, IOT&E—2008, FRP—2009.

C-5 Reliability Enhancement and Reengineering Program (RERP). This effort centers on replacing the current TF39 engines with more reliable, commercially available turbofan engines with increased takeoff thrust that comply with stage-three noise requirements. It also upgrades wing attach fittings, thrust reversers, auxiliary power units (APUs), electrical system, hydraulics, fuel system, fire suppression system, pressurization/air conditioning systems, landing gear, and airframe to increase payload capability.

Milestone B—2001, IOT&E—2008, FRP—2010.

Mid- Term (FY2013—FY2017)

Joint Strike Fighter (JSF) F-35. The F-35 Joint Strike Fighter (JSF) is the next-generation strike fighter aircraft for the U.S. Navy, Air Force, Marine Corps, and allies. There are three variants: the F-35A Conventional Takeoff and Landing (CTOL); F-35B Short-Takeoff and Vertical Landing (STOVL); and the F-35C Aircraft Carrier–Suitable Variant (CV).
Milestone B—2002, IOC—2012–2013 (USMC, USAF, USN versions).

4.4.2 Electronic Combat

Electronic combat (EC), also known as electronic warfare (EW) is the subset of military IO involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy across the broad range of radio frequency and optical bands. Tools to accomplish these tasks include radio frequency (RF) and infrared/ultra-violet (IR/UV) sensors, RF/IR jammers and expendable countermeasures, DE weapons using high-energy laser or high-power microwave, and antiradiation missiles (ARMS).

Electronic warfare T&E capabilities must keep pace with the advanced electromagnetic sensor and processing technologies incorporated into today's threat warning, geolocation, and self-protection countermeasures systems. EW systems have migrated from dedicated single-function designs to the development of integrated multipurpose EW suites tailored to platform-specific needs. The design trend has rapidly moved toward embedding traditional EW capabilities into host platform integrated mission avionics functions, where the inputs of multiple IR/UV/RF sensors are processed into fused target tracks for improved situational awareness, offensive weapons support, and defensive reaction. Advanced sensor track fusion technologies will support the evolution towards network-centric EW, in which cooperative engagement strategies leverage inputs from both on- and offboard sensors for precise location of target threats in near–real time.

Next-generation EW sensors will embody hyperspectral designs well beyond the correlated scene presentation abilities of DoD's current open-air-ranges (OAR), installed system test facilities (ISTF), and hardware in-the-loop laboratories. The T&E community will need even more robust and higher-fidelity stimulators, models, scene generation components, and calibration instrumentation to achieve the highly dynamic range and frame rates required to exercise fully sophisticated signal processing and sensor track fusion algorithms.

High-power microwave (HPM) and high-energy lasers (HEL) technologies are creating an entirely new class of directed-energy weapon systems that must be tested. Current directed-energy testing capabilities are fragmented, fixed, and not functionally

integrated. Existing directed-energy test infrastructure is neither adequate to support the full spectrum of testing (developmental, operational, and live-fire) required to develop U.S. directed-energy systems, nor able to test the survivability of already fielded U.S. weapons against the emerging directed-energy threat.

In the near term, a need exists to support more robust end-to-end testing of IR/UV missile warning and infrared countermeasures systems on the aircraft they are intended to protect. State-of-the-art missile attack warning systems incorporate target detection and declaration algorithms that account for both temporal and spatial attributes of a threat missile in flight. Multispectral band missile plume simulators are needed for both OAR and ISTF applications that can accurately represent dynamic threat missile characteristics in real-time.

OAR, ISTF, and Hardware-In-The-Loop (HITL) capabilities are needed to support open/closed-loop testing of radar warning receivers and jammers against advanced air-to-air and surface-to-air radar threats. Testing of state-of-the-art precision location and identification systems requires ISTFs with phase-coherent RF threat emitters. Testing of integrated EW suites and multispectral sensor track fusion requires OAR, ISTF, and HITL capabilities that provide high threat density RF/UV/IR scenes with precise band-to-band temporal and spatial synchronous correlation. Directed-energy test capability needs include HEL target interaction instrumentation, hardened flight termination systems, telemetry and target control, and simulators that can emulate real threat systems.

For the mid- and far term, new test technology solutions are needed to ensure that adequate developmental, live-fire, and operational test capabilities are available to support testing of the next generation of directed energy weapons. Innovative technical approaches are also needed to mitigate restrictions on open-air jamming at or near commercial or dual-use frequencies. For example, OAR/ISTF capabilities are needed for free-space testing of standoff jammers against radar and communication threats operating in the low-frequency bands (below 2 GHz). Network-centric operations will require that OAR and ISTF be populated with both friendly and threat force electronic orders of battle that support evaluation of systems designed to exploit information vulnerabilities of our adversaries and protect information in U.S. and allied force decision support systems.

EW capabilities are critical to testing of other major weapons programs including the F/A-22, F-35, Multimission Maritime Aircraft, Aerial Common Sensor, and the Army's Future Combat Systems. Additionally, EC programs that are below ACAT-1, such as the next-generation Large Aircraft Infrared Countermeasures (LAIRCM) System and spiral upgrades to the ALR-69A, are major near term test capability drivers.

Summary of T&E capability drivers for Electronic Combat:

- More robust, higher fidelity M&S
- Various specific directed energy technology to support development, live fire and operational testing
- Robust end-to-end testing of IR/UV missile warning and infrared countermeasures
- Multi-spectral band missile plume simulators
- Improved net-centric testing of electronic combat systems

Planned MDAP/MAIS Electronic Combat Programs Within the Strategic Plan Time-frame

Pre-MDAP/MAIS

B-52 Standoff Jammer (SOJ) Air Force Initiative

Pre-MDAP, milestones to be determined.

Near Term (FY2008 – FY2012)

EA-18G. This is the fourth major variant of the F/A-18 family of aircraft. It will replace the EA-6B and provide a capability to detect, identify, locate, and suppress hostile emitters.

Milestone B—2004, IOT&E—2008, FRP—2009.

4.4.3 Land Combat

Land combat addresses the individual systems and vehicles that fight on the ground. For purposes of this plan, chemical and biological systems are considered part of land combat. Traditionally, land combat includes direct-fire and indirect-fire weapons systems, C2 systems, combat support, and combat service support systems. The mission of land combat forces is to close with and destroy the enemy. Since September 11, 2001, the traditional battlefield has expanded to include the United States and its territories. Terrorist threats, such as car bombings and suicide bombers, are new factors in the land combat equation.

Transformation efforts focus on the mobility and agility of ground forces. The Army reoriented its focus to be lighter and more mobile than its current tank and infantry fighting vehicle based units. The centerpiece of this change is the Future Combat System (FCS). FCS is designed to provide a rapidly deployable, highly mobile, lethal land force with the ability to fight on arrival in theater. Forces will be networked to a system of

sensors so that commanders will be able to react and plan in real time. FCS units will be self-sustaining for limited periods of time, which will reduce the need for an immediate logistics or supply line. These capabilities are designed with the objective of providing the combatant commanders multiple options in any situation using a single force.

The advancements in technology that are being integrated into existing or planned land combat weapons systems are also needed in the instrumentation and modeling and simulation tools required to support T&E of these systems.

Summary of T&E capability drivers for land combat:

- Improved real-time casualty assessment particularly as it applies to non-line-of-sight and fast-moving airborne systems.
- Measuring performance particularly of dismounted and airborne warriors in urban terrain.
- Data buses with high transmission rates (up to 500 Mb/sec for video systems)
- New sensor stimulators specially associated with CB simulants.
- Improved synthetic environments, including hyper-spectral characterization and replication.
- New measurement capabilities comparable or greater than the capabilities of systems under development such as robotics, hypersonics, network performance.
- Protective ensemble testing methodology for chemical and biological testing
- Embedded instrumentation in such systems as munitions, robotics, vehicular systems, and networks to measure performance.
- Joint DT, OT, and training instrumentation and modeling and simulation environments such as common terrain and weather pictures.

Planned MDAP/MAIS Land Combat Programs Within The Strategic Plan Time-frame

Near Term (FY2008 – FY2012)

Land Warrior (LW). This is an integrated system used by the dismounted combat soldier for tactical operations. It includes weapons; laser rangefinder; visual displays; integrated load-carrying equipment with ballistic protection; helmet; speaker with microphone; computer; navigation; and radio.
Milestone B—1994, Milestone C—2007, IOT&E—2010, FRP —2010.

Expeditionary Fighting Vehicle (EFV). This vehicle is the successor to the Marine Corps' current amphibious vehicle. The EFV will provide the principle means of tactical surface mobility for the Marine Air-Ground Task Force (MAGTF) during both ship-to-objective maneuver and subsequent combat operations ashore. Milestone B—2001, Milestone C—2006, FRP—2012.

Near Term – Mid Term (FY2008 – FY2017)

Future Combat Systems (FCS). This is a system of systems composed of advanced, networked air- and ground-based combat and maneuver sustainment systems, unmanned ground and air vehicles, and unattended sensors and munitions. The soldier is the centerpiece, and the system includes 18 systems plus the network unattended ground sensors; two unattended munitions (Non-Line-of-Sight Launch System and Intelligent Munitions System); four classes of UAVs; six types of unmanned ground vehicles (UGVs), and eight manned ground vehicles (Infantry Carrier, C2 Vehicle., Mounted Combat System, Reconnaissance and Surveillance Vehicle, Non-LOS Cannon, Non-LOS Mortar, Recovery and Maintenance Vehicle, and a Medical Evacuation Vehicle).
Milestone B—2003, Milestone C—2013, FRP—2015.

4.4.4 Sea Combat

Sea combat needs to be viewed through a wide-angle lens as an extremely broad warfare area, primarily composed of Navy and Marine Corps elements augmented as necessary by other service and agency capabilities, that weaves together significant aspects of naval, air, land, space and electronic combat into a common, integrated warfare environment. Maritime forces are extensively employed in deterrence and in military operations other than war. Nevertheless, sea-based warfighting remains their fundamental mission. Simply put, such forces promote and defend national interests by maintaining maritime superiority, contributing to regional stability, conducting operations on and from the sea, seizing or defending advanced naval bases, and conducting such land operations as may be essential to the prosecution of naval campaigns. Four operational capabilities are the key components of modern naval warfare, battlespace dominance and power projection being the two most critical. The other two—command, control, and surveillance and force sustainment—are enabling components of the first two. The primary characteristics of today's naval forces are readiness, flexibility, self-sustainability, and mobility. These attributes permit naval forces to be expeditionary—that is, able to establish and maintain a forward-based, stabilizing presence. As indicated, the breadth of

sea combat is not just limited to surface and subsurface maritime forces but includes air, land, electronic, space, Special Forces, and chemical and biological elements as well.

- Littoral warfare—military combat in and near shallow water depths.
- Antisurface warfare—maritime warfare in which operations are conducted to destroy or neutralize enemy naval surface forces and merchant vessels.
- Antisubmarine warfare—operations conducted with the intention of denying the enemy the effective use of its submarines.
- Mine warfare —the strategic, operational, and tactical use of mines and mine countermeasures.
- Amphibious warfare (short of land combat) —employment of a combination of land and sea forces to take or defend a military objective ashore.
- Naval special warfare —a designated naval warfare specialty which conducts unconventional and counterguerilla warfare operations in the coastal, riverine, and maritime environments.
- Explosive ordnance disposal —explosive ordnance reconnaissance, identification, access and recovery, disposal of all conventional surface ordnance, underwater explosive ordnance, nuclear weapons, and diving related to Explosive Ordnance Disposal (EOD).

The Department of the Navy Transformation Plan has as its objective the transformation of the Navy–Marine Corps team, which will enable swift integration and leveraging of naval and joint capabilities to project forward-deployed multidimensional combat power. It will achieve this by facilitating the rapid deployment and flexible employment of joint capabilities through a family of afloat systems and resources. The resultant strategically agile team will be capable of providing quickly scalable combat capabilities that when coupled with the transformed capabilities of other Services and agencies ensures that joint force commanders have the right mix of forces to meet developing challenges.

Naval transformation centers upon a concept termed SeaPower 21. The varied naval capabilities associated with SeaPower 21 are being developed through four interdependent Navy Capability Pillars (NCP). They are Sea Shield, Sea Strike, Sea Base, and FORCEnet. Briefly these pillars encompass the following:

- Sea Shield—capabilities that extend precise and persistent naval defense not only throughout large maritime areas, but also deep overland to protect joint forces and allies ashore.
- Sea Strike—naval capabilities to project dominant and decisive offensive power from the sea in support of joint objectives.

- Sea Base—capabilities that allow naval forces to exploit the maneuver space provided by U.S. control of the sea.
- FORCEnet—a concept for networked, naval command and control by which naval forces will employ diverse and precise effects in support of joint and combined operations.

Future Naval Capability drivers needed to support Sea Power 21 will include several high-priority areas for research and development that should be expedited for rapid deployment to the fleet. These will have a direct influence on the development of the T&E infrastructure.

Summary of the T&E capability drivers for Sea Combat:

- Organic mine countermeasures—Systems that enable operational maneuver from the sea and ship-to-objective maneuver; support the movement of surface and subsurface combatants throughout the littoral penetration area; and ensure access to ports, harbors, sea lines of communication, and routes into ports
- Information distribution—Systems that provide jamming-resistant, wide-area communications on link network.
- Extending the littoral battlespace—Enhanced integrated communications, C2, sensors, and fire and targeting capability to enable rapid employment, maneuver, and fire support from the sea of dispersed units operating in an extended littoral battlespace.
- Time-critical strike—The ability to detect, localize, track, and neutralize time-critical targets before they can endanger Naval forces or move to new hide sites.
- Autonomous operations—The capability to perform missions using unmanned vehicles in dynamic and unstructured environments with greatly reduced need for human intervention. Autonomous operations include UAVs, Unmanned Undersea Vehicles (UUVs) and UGVs.
- Littoral antisubmarine warfare—The submarine threat facing expeditionary forces in the littorals will be small, quiet, and non-nuclear.
- Missile defense —Protecting Navy ships and ports from attacks by missiles or manned aircraft.
- Platform protection—Critical technologies for naval platforms to win or to avoid engagements with evolving threats as they project power from the sea.
- Integrated power system technology—Provides electrical power at an order of magnitude higher than current capabilities and will facilitate integration of

electric drive propulsion, sensors, and electric weapons systems with reduced impact on platform size, weight, and cost.

- Expeditionary logistics—The naval forces ability to logistically support their own tactical operations, drawing help only from such national assets as strategic lift, strategic intelligence, global command and control, and global navigation aids
- Warfighter protection—Providing Naval personnel with the best possible protection from operational threats and reduce mortality throughout the battlespace.

Planned MDAP/MAIS Sea Combat Programs Within The Strategic Plan Time-frame

Pre-MDAP/MAIS

Advanced Deployable System (ADS)—Navy Initiative

Pre-MDAP, milestones to be determined.

CG(X) Next-Generation Cruiser—Navy Initiative

Pre-MDAP, milestones to be determined.

Joint High-Speed Vessel (JHSV)—Navy Initiative

Pre-MDAP, milestones to be determined.

LHA(R) New Amphibious Assault Ship—Navy Initiative

Pre-MDAP, milestones to be determined.

Maritime Positioning Force—Future (MPF-F)—Navy Initiative

Pre-MDAP, milestones to be determined.

T-AOE(X) Fast Combat Support Ship—Navy Initiative

Pre-MDAP, milestones to be determined.

Near Term (FY2008 – FY2012)

***Virginia*-Class (SSN-774) Submarine.** This submarine replaces the fleet of SSN-688 Class submarine., The *Virginia*-class submarine is characterized by state-of-the-art stealth, enhanced features for special operations forces, and cost effective command, control, communication and intelligence capability.

Milestone II – 1995, IOT&E 2008, FRP – 2009.

Littoral Combat Ship (LCS). This vessel is relatively small, high-speed, maneuverable surface combatant. It is envisioned as a networked, agile, and stealthy

vessel that will operate in the near-land littoral region to ensure coastal access for U.S. forces.

Milestone B – 2007, IOT&E – 2009, FRP - 2008.

Standard Missile-6 (SM--6). This is an Extended-Range Active Missile (ERAM) that builds from the Navy's SM-2 Block IV and Integrated Vulnerability Assessment (IVA) development programs and is designed to provide ship self-defense, fleet area defense, and theater air defense for sea and littoral forces.

Milestone B—2004, IOT&E—2011, FRP—2011.

Mid-Term (FY2013 – FY2017)

Future Aircraft Carrier (CVN 21). This is the planned successor to the *Nimitz*-class (CVN 68) aircraft carrier.

Milestone B—2004, FRP—2015.

Land Attack Destroyers DD(X). This destroyer is an optimally crewed, multimission surface combatant designed to provide littoral dominance and fulfill volume firepower and precision strike requirements.

Milestone B—2005, IOT&E—2013, FRP—2013.

4.4.5 Space Combat

Space Combat encompasses the planning, execution, and reporting of T&E of spacecraft development, space ground-control and user equipment, launch vehicles, ballistic missile defense development, and missiles (nuclear/conventional/intercontinental/interregional, offensive and defensive).

The major mission areas for space combat include space force enhancement (SFE), counterspace (CS), space force application (SFA), space support (SS), mission support (MS) and ballistic missile defense (BMD).

The first five mission areas (SFE, CS, SFA, SS, and MS) fall under the auspices of the Air Force Space Command (AFSPC) as the executive agent for space combat. The last mission area (BMD) falls under the Missile Defense Agency (MDA) for the development of Ballistic Missile Defense System (BMDS).

AFSPC. The QDR 2001 directed that, “DoD will establish a space test range” (p. 36). The QDR further said: “In particular the Department will treat information operations, intelligence and space assets not simply as enablers . . . but rather as core capabilities” (p. 38) with the increasing emphasis on C4ISR data to enhance battlespace awareness and Global Positioning System (GPS) satellites for navigation, space assets of today are vital to our nation’s defense.

In response to QDR direction, the AFSPC has developed several space combat mission areas. Those areas are listed below and extracted from the AFSPC Strategic Plan for FY2006 and beyond (p. 2):

- SFE—capabilities that contribute to maximizing the effectiveness of military air, land, sea, and space operations.
- CS—capabilities to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while negating an adversary's ability to do the same.
- SFA—capabilities to execute missions with weapons systems operating from or through space and hold terrestrial targets at risk.
- SS—capabilities to provide critical launch and satellite control infrastructure and capabilities and technologies that enable the other mission areas to effectively perform their missions.
- MS—functional areas that cut across all mission areas and provide required infrastructure.

In the SFE mission area, the space radar and the "near-space" platforms are the two programs that provide the biggest challenge for space combat. The space radar will provide reconnaissance from space and a demonstration of a near-earth capability is planned for the FY2008 timeframe. The near-space platforms are a new set of tactical satellites at near-space orbit that provide capabilities that are responsive to the warfighter's needs and are a new initiative.

In the CS mission area the space situational awareness submission is matched with submissions of defensive counterspace and offensive counterspace. Together these three submissions provide a capability to protect our space assets from attack while denying an enemy use of their own space assets. Included in this CS area is the development of a Space Test and Training Range (STTR), where engineers and doctrine experts will formulate theories and concepts while allowing testers to evaluate new systems. The STTR will also provide space warriors the ability to hone their skills for the CS mission. The STTR currently leverages assets from other organizations to provide range control and instrumentation for all Services desiring to test, experiment, and exercise counterspace capabilities. The goals is to eventually transition from leveraging assets to dedicated assets and/or integrated assets on other ranges.

The SFA mission area includes the fielding of a common aero vehicle (CAV) (a hypersonic glide vehicle) that will be delivered via a land-based missile. Another possible future launch platform for CAV includes the Operationally Responsive Spacelift (ORS)

hybrid vehicle being developed to fulfill the requirement to perform space missions in narrow timeframes with multiple launches.

The SS mission area includes the use of the Integrated Satellite Control Network to control and monitor satellites plus the use of the Launch and Test Range System (LTRS) located at the eastern (Cape Canaveral AFS FL) and western range (Vandenberg AFB CA). This area also includes the development of a future Responsive Launch and Test Range (RLTR) to support such future space missions as the operational responsive space hybrid. The RLTR concept is expected to incorporate selected assets from the current LTRS, along with space-based, airborne, and mobile assets. It will afford shorter flight approval timelines with increased coverage and capacity.

The MS mission area provides the infrastructure, sustainment, security, and trained personnel to perform the space combat missions around the globe. They include such classic support functions as communications and information, logistics, medical and education.

MDA. An integrated BMDS capable of providing a layered defense for the homeland, deployed forces, friends, and allies against ballistic missiles is the keystone of MDA's development efforts to fulfill the BMD mission. The layered defense includes engagement at all phases of ballistic missile flight (boost, midcourse, and terminal) against various short-, medium-, and long-range ballistic missiles launched from any global region. The BMDS will be an integrated system of systems that will link C2, sensors, and engaging elements to form that layered defense.

The defense of the homeland mission mainly includes the Ground-Based Midcourse Defense system, Aegis BMD, various sensors, and a C2 Battle Management System all linked by various communication networks. There is limited terminal phase defense provided by Patriot and Theater High-Altitude Area Defense (THAAD) systems.

Defense of deployed forces will protect them against mainly theater ballistic missile attack, and that defense is provided by Patriot, THAAD and Aegis BMD. However, it is expected that Airborne Laser and Kinetic Energy Interceptor (KEI) will play an intercept role in the boost phase of flight for any ballistic missile.

Efforts in support of defense of our allies involves coalition partners and those that have chosen to participate in some form of ballistic missile defense. For instance, the Japanese have chosen recently to use Aegis BMD ships to defend against theater ballistic missile attack. Several allies are assisting the global defense with utilization of forward sensors and the future possibility of deployment of BMDS assets as they require.

One of the key challenges that MDA faces is ensuring that a robust test range infrastructure is in place to support operationally representative system-level tests during

all phases of flight at all threat ranges. The MDA approach has been to establish a broad-Pacific BMDS Test Bed. The BMDS Test Bed encompasses multiple DoD ranges located in the Pacific (e.g., Vandenberg AFB, NAWC-WD, Point Mugu, Reagan Test Site, and Pacific Missile Range Facility), the Kodiak Launch Complex, and other remote locations. Targets and interceptors may be launched from geographically separated locations in support of a single test; multiple ranges involved in the test may have instrumentation coverage responsibilities during various phases of flight; and data collection may be required in broad ocean areas between ranges. Efficient testing requires the various ranges and locations to be integrated and interoperable. The establishment of a broad-Pacific BMDS Test Bed requires many land-, air-, and sea-transportable instrumentation systems from the nation's test infrastructure as well as procurement of additional transportable systems. The use of transportable systems provides instrumentation coverage in remote locations and augments current range capabilities as well. In addition, the following target requirements are needed: a realistic booster for booster-phase defense systems and post-booster and re-entry vehicles are needed for mid-course and terminal defense systems.

This test bed is an integrated set of components widely dispersed among operationally realistic locations primarily along the Pacific rim. Some of the specific components of the test bed have independent utility. However, the test bed, as a whole, is designed to support development of missile defense elements and demonstrate an integrated, layered missile defense system. MDA will use the test bed over the next few years to validate the capability of the BMDS as additional midcourse, boost, and terminal elements, including supporting sensors and necessary BM/C2 and communications components are added to the system. The BMDS test bed includes prototypes and surrogates of the system elements as well as supporting test infrastructure to provide trajectory, sensing, intercept, and BM/C2 and communication scenarios that resemble conditions under which the system might be expected to operate. It will enable testing against faster, longer-range target missiles than we are using today, and it will allow us to test using different geometric, operational, and element configurations.

As the MDA design evolves with more C4ISR interactions and more global elements, the layered defense will cause greater stress on the future DoD test infrastructure. The ability to test Airborne Laser (ABL), as well as THAAD, Patriot PAC-3, Aegis BMD Standard Missile (SM)-3, numerous Ground Missile Defense (GMD) launch sites all in a network-centric design for defense of the United States and deployed forces is a significant challenge.

Summary of T&E capability drivers for space combat:

- C4ISR integration on all future ranges for seamless testing.
- Robust, wideband and portable telemetry to support global testing.
- Long-range, portable, multispectral ability to track large numbers of objects.
- Larger range space to facilitate global testing.
- Robust, responsive, and flexible space test infrastructure that is flexible to adapt to spiral developments easily.
- Linkage of several facilities in a persistent LVC network to facilitate net-centric testing.

Planned MDAP/MAIS Space Combat Programs Within The Strategic Plan Time-frame

Pre-MDAP/MAIS

Advanced Polar System (APS)—Air Force Initiative

Pre-MDAP, Milestones To Be Determined.

GPS III System—Air Force Initiative

Pre-MDAP, milestones to be determined.

Orbital Deep-Space Imager (ODSI)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Space Radar (SBR)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Operational Responsive Spacelift) –

Pre-MDAP, milestones to be determined.

Near Term (FY2008-FY2012)

Advanced Extremely High Frequency (AEHF). This is a joint service satellite communications system that provides global, secure, protected, and jam-resistant communications for high-priority military ground, sea, and air assets. The system consists of three satellites in geosynchronous earth orbit (GEO) with a ground-based mission control segment and user terminals.

Milestone B—2001, IOC—2010.

Mobile User Objective System (MUOS). This satellite communications network is designed to provide a worldwide, multiservice population of mobile and fixed-site terminal users with narrowband beyond-line-of-sight communications services.

Capabilities will include a considerable increase in narrowband satellite communications capacity and improvement in availability for small, disadvantaged terminals.
Milestone C—2002, IOT&E—2010, IOC—2009.

National Polar-Orbiting Operational Environmental Satellite System (NPOESS). This space-based system will provide capability for both civilian and military weather missions. It has four major segments: space segment; command, control, and communications (c3); interface data processing; and field terminals. The space segment consists of three satellites in sun-synchronous, near-polar orbits with multiple, complex sensors.
Milestone C—2002, IOT&E—2010, IOC—2012.

Near Term to Midterm (FY2008 – FY2017)

Transformational Satellite Communications System (TSAT). A five-satellite constellation will provide high-data-rate Military Satellite Communications (MILSATCOM) services with Internet-like capability. It extends the Global Information Grid (GIG) to deployed and mobile users worldwide.
Milestone B—2004, IOC—2015.

4.4.6 Armaments and Munitions

The armaments and munitions area addresses the many various weapons used to defend friendly forces and destroy enemy forces. Warfighting commanders need to destroy a selected target the first time, without wasting resources and while avoiding destruction of noncombatants, and they need to do so in all weather conditions, day or night, in extreme environments, against targets that may be concealed, armored, hardened, or protected by countermeasures. Land, sea, and air forces engaging in combat all make use of myriad armaments and munitions across a wide variety of missions. To describe any set of air, land, or sea combat missions and the various functional capabilities they entail would be unmanageable in this plan. However, all the Service transformation roadmaps and various planning documents rely on armaments and munitions to some degree, and the missions can be simply summed up as follows.

- Armaments and munitions achieve two overarching desired effects:
  - To defend and protect friendly joint forces from hostile threats
  - To destroy a hostile threat or target selectively as desired by the combatant commander.

- Armaments and munitions are used in many functions in a variety of missions in all warfare areas:
  - Air warfare: missiles, gun ammunition
  - Surface warfare: land and sea-based artillery, missiles (surface-launched and air-launched), gun ammunition, and countermeasures against the same.

Summary of the T&E capability drivers for Armaments and Munitions:

- Low-/Very Low-Observable technologies.
- Propulsion technologies for enhanced performance.
- Hypersonic-velocity weapon capabilities
- Advanced Materials and Energetic Materials Science.
- Environmental effects (simulation, networked).
- Multimode seekers, sensors, guidance, control, and fuzing systems.
- Weapons datalinks.
- Distributed test capability (interlinked facilities, integrated LVC testing, standardized interfaces and formats)
- Flexible, tailorable, standardized instrumentation on the test range or weapons delivery platform, or in the case of actual munitions, microminiaturized instrumentation capable of withstanding high-acceleration forces
- High-speed, high-fidelity, high-bandwidth telemetry and command-destruct systems
- Range instrumentation for smaller munitions, utilizing miniaturized Telemetry Instrumentation and Flight Termination Systems.
- Collateral damage avoidance and growing emphasis on increasing the accuracy of precision strikes.
- Urban warfare or military operations other than war considerations ("smart bullets," nonlethal antipersonnel/area-denial weapons, peacekeeping/riot control operations, etc.).
- Development of long-range precision strike capabilities.
- Exploratory cooperative efforts between the Department of Defense and Homeland Security in explosives characterization, personnel/vehicle armoring/protection, and weapons detection due to anti-terrorism and homeland security concerns with improvised explosives.

<u>Planned MDAP/MAIS Armaments and Munitions Programs Within The Strategic Plan Time-frame</u>

Near Term (FY2008 -FY2012)

Excalibur. This is a precision-guided extended-range family of artillery projectiles providing increased accuracy and reduced collateral damage. It will be compatible with the Future Combat Systems (FCS) Non-Line of Sight Cannon (NLOS-C) and the digitized Joint Lightweight 155-mm (JLW155) howitzer.
Milestone C —2006 (Block 1A1), 2007 (Block 1A2); Milestone B—2012 (Block 1B); IOT&E—2009, FRP 2009.

Guided Multiple-Launch Rocket System (GMLRS). The GMLRS consists of two variants of rockets fired from M270A1 MLRS or High-Mobility Artillery Rocket System (HIMARS launchers). The GMLRS Dual-Purpose Conventional Munitions System DPICM) variant carries 404 submunitions, while the GMLRS unitary rocket will have a single, 200-pound, high-explosive warhead. Both variants have enhanced accuracy and increased range.
Milestone B—2003, IOT&E—2008, FRP—2009.

Advanced Antiradiation Guided Missile (AARGM). This is a major improvement to the AGM-88 High-Speed Anti-Radiation Missile (HARM) inventory. It provides a new multimode guidance section and modified control section mated with existing HARM propulsion and warhead sections. IOC—2010.

Near Term – Mid Term (FY2008 – FY2017)

Combined Aggregate Program (CAP), Medium Extended Air Defense System (MEADS). MEADS is a mobile air and missile defense system for the protection of maneuver forces and fixed assets. The system provides area and point defense capabilities against multiple, simultaneous, 360-degree attacks by ballistic missiles, large-caliber rockets, fixed-wing and rotary-wing aircraft, UAVs, cruise missiles, tactical air-to-surface missiles, and antiradiation missiles.
Milestone B—2005, IOT&E, and FRP for 3 different increments—2010–2018.

4.4.7 C4ISR

Almost all new weapon systems will rely on and must be compatible with C4ISR systems. Thus, not only must new C4ISR systems undergo T&E but so also must all other weapon systems and their interfaces with new and in-service C4ISR systems. Network-Centric Warfare that employs dramatically enhanced quality and timeliness of information as well as fully transparent interoperability of both systems and organizations poses the greatest challenge for investment in T&E capability. It is enabled by a concept

called Net-Centricity intended to be a robust, globally interconnected, network environment (including infrastructure, systems, processes, and people) in which data are shared in a timely way and seamlessly among users, applications, and platforms. Net-centricity enables substantially improved military situational awareness and significantly shortened decision making cycles. Key net-centric initiatives include the Joint Tactical Radio System (JTRS), Global Information Grid Bandwidth Expansion (GIG-BE), Transformational Communications Architecture (TCA) SATCOM, Future Combat Systems, net-centric enterprise services, information assurance programs, and horizontal fusion. The ability to test systems of systems, such as FCS and BMDS in a network-centric design are core drivers.

Summary of the T&E capability drivers for C4ISR:

- Developing the necessary communications needed at the ranges to tie all system of systems elements to include Command Centers, Sensors and Intelligence assets
- Integration of IO in future joint tests and SOS tests
- Persistent, distributed and remotely monitored and controlled test capability that ties all system of systems elements for Live, Virtual, Constructive testing
- Improved M&S that includes evaluation of data latency, information operations, communications timing

Planned MDAP/MAIS C4ISR Programs Within the Strategic Plan Time-frame

Pre-MDAP/MAIS

Air Operations Center–Air- Weapons System (AOC-WS)—Air Force Initiative

Pre-MDAP, milestones to be determined.

B-2 SPIRIT AEHF SATCOM Capability (B-2 EHF)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Combat Commanders Integrated C2 System (CCIC2S)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Combat Information Transport System–Combatant (CITS)—Air Force Initiative –

Pre-MDAP, milestones to be determined.

Deliberate and Crisis Action Planning and Execution Segments ((DCAPES) - Air Force Initiative

Pre-MDAP, milestones to be determined.

E-10A–Multi-Sensor C2 Aircraft (MC2A)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Expeditionary Combat Support System (ECSS)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Family of Beyond-Line-of-Site Terminals—Air Force Initiative

Pre-MDAP, milestones to be determined.

Global Command and Control System–Air Force (GCCS-AF)—Air Force Initiative

Pre-MDAP, milestones to be determined.

Distributed Common Ground System–Army (DCGS-A)—Army Initiative

Pre-MDAP, milestones to be determined.

Global Combat Support System–Army (GCSS-A)—Army Initiative

Pre-MDAP, milestones to be determined.

Joint Land-Attack Cruise Missile Defense Elevated Netted Sensors (JLENS)—Army Initiative

Pre-MDAP, milestones to be determined.

Joint Network Transport Capability-Spiral (JNTC-S) Joint Network Node (JNN)—Army Initiative –

Pre-MDAP, milestones to be determined.

Airborne Early Warning (AEW)—Navy Initiative –

Pre-MDAP, milestones to be determined.

Ballistic Missile Technical Collection (BMTC)—Navy Initiative –

Pre-MDAP, milestones to be determined.

Broad-Area Maritime Surveillance (BAMS)—Navy Initiative

Pre-MDAP, milestones to be determined.

Cryptologic Mission Management (CMM) is a new National Security Agency (NSA) program. CMM will manage the signals intelligence resources that make up the Unified Cryptologic System that has been developed in response to requirements from the Intelligence Community.

Pre-MDAP, milestones to be determined

Global Electromagnetic Spectrum Information System (GEMSIS)—DISA Initiative

Pre-MDAP, milestones to be determined.

Joint C2 (JC2)—DISA Initiative

Pre-MDAP, milestones to be determined.

Net-Centric Enterprise Services (NCES)—ISA Initiative

Pre-MDAP, milestones to be determined.

Near Term (FY2008 – FY2012)

Aerial Common Sensor (ACS). ACS is a modified Embraer 145 regional jet. It will provide the Army and Navy's next-generation airborne, worldwide, self-deployable ISR capability.

Milestone B—2004, IOT&E—2009, FRP—2010.

Joint Tactical Radio System (JTRS). This is a family of common software-defined radios, forming the foundation of wireless communications. It will replace all existing tactical radios throughout the Services.

Milestone B—2004 (C5), 2005 Airborne, Maritime and Fixed (AMF); IOT&E—2009; FRP 2010 (C5 & AMF).

Cobra Judy. This system replaces the capability of the current U.S. Naval Ship (USNS) Observation Island (OBIS), its Cobra Judy radar suite, and other mission essential systems. It will collect foreign ballistic missile data in support of international treaty verification.

Milestone B—2004, IOT&E—2011, IOC—2011.

Near Term – Mid Term (FY2008 – FY2017)

E2C Advanced Hawkeye (AHE). This aircraft is an all-weather, twin-engine, carrier-based, AEW aircraft designed to extend task force defense perimeters. It is based on the E-2C Hawkeye 2000 configuration and is designed to improve battlespace target detection and situational awareness and support of Theater Air and Missile Defense (TAMD) operations.

Milestone B—2003, IOT&E—2012, FRP—2013.

Mid Term (FY2013 – FY2017)

Multimission Maritime Aircraft (MMA). This aircraft is the replacement system for the P-3C, Orion. The MMA system will sustain and improve the armed maritime and littoral ISR capabilities for U.S. Navy. It is based on a 737-800 ERX aircraft.

Milestone B—2004, IOT&E—2012, FRP 2013.

4.4.8 Target and Threat Systems

Title 10 of the US Code requires weapon systems testing to be conducted against operationally representative simulations of real-world threats. Real world threats can be represented in a variety of forms, including threat representative targets, threat simulators,

US and allied weapon system threat surrogates, actual foreign threat weapon system components, and digital threat models.

The leading-edge technologies incorporated in (Blue) weapon systems under test and corresponding improvements in the capabilities of emerging (Red) threats combine to drive requirements for higher-fidelity threat representative targets and simulations. Our understanding of T&E requirements in this area is constantly changing as intelligence information on emerging threat capabilities becomes available. As a result, the test capabilities needed to represent various classes of threats must quickly respond to both advanced technologies and a changing operational environment. For example, Operation Iraqi Freedom has increased emphasis on military operations in an urban environment, which drives a near-term requirement for realistic mobile land targets that can be hidden or quickly relocated.

Accurate threat representation depends on an adequate and comprehensive understanding of threat weapons systems and the performance characteristics of U.S. weapon systems against those threats. The technology drivers for target and threat system development include increases in sensor fidelity, the migration to multimode and multiband seekers, and the availability of onboard signal processing. Increased Blue system seeker resolution is driving threat representations to be presented with much more resolution as well as requiring countermeasure systems to be much more pervasive. Additionally, the ability of the both Red and Blue systems to change modes or bands are driving simulation and scene-generator performance to present accurate signature attribute emulation in more than one frequency band simultaneously (e.g., RF and IR). These advances mandate threat-representative performance and representative signatures across the frequency spectrum.

Summary of T&E Capability drivers for targets and threat:

- Accurate threat representations
- Improved M&S for higher fidelity threat representations
- Improved sensor fidelity and resolution for threat systems

4.4.9 Common Range Instrumentation

In addition to the combat test capability drivers, there are those that cut across several combat areas to recapitalize and modernize test capabilities, improve productivity and efficiencies, promote interconnectivity among ranges and facilities, and to facilitate sharing of resources across Services and Defense Agencies.

Common range instrumentation (CRI) pertains to classes of basic test capabilities common to the technical sustainability of, primarily, open-air test ranges and, thus, are not specific to a particular location or program. These needs address not only the support of advances in weapon system technologies and capabilities but also the necessity to recapitalize the aging and unsupportable test infrastructure capabilities and to transition technologies and developments from the T&E/S&T program and Central Test and Evaluation Investment Program (CTEIP) to test range and facility capabilities. One thrust is to ensure that improvements in technology and capabilities being developed and implemented at one location are shared and can be leveraged at other locations. These classes of capabilities primarily consist of the facilities and instrumentation that enable systems-under-test (SUTs) and range control facilities to produce repeatable results among ranges and to be interoperable among ranges to exchange, distribute, process, and analyze test data collected elsewhere. The primary CRI focus areas for T&E ranges are as follows:

- Time Space Position Information (TSPI)
- On-board instrumentation
- Telemetry
- Range control
- Data processing
- Telecommunications and timing
- Test and evaluation (T&E) support vehicles

Major drivers that will have the largest influence on investments in the common range instrumentation test capability area for open-air ranges will be: numerous types of hypersonic systems as identified in the National Aerospace Initiative program; multi-players and joint-players (personnel, equipment, net-centric operations) at ground and near-ground levels, such as FCS and MDA program elements; military operations on urban terrain; and directed-energy systems as identified in the directed-energy roadmap. Computer network operations are a major new driver for visualization instrumentation that reveals nonkinetic weapon route tracking from “trigger pull” to target; real-time weapon health and route disruptions; and effects assessment. Range and airspace constraints drive the need for mobile and interoperable instrumentation to address on- and off-range control of test participants and articles. New weapon capabilities and CONOPS are driving the need to score multiple, simultaneous weapon engagements. Smaller munitions are driving the need for miniaturized telemetry and flight termination systems. Drivers with less effect will be any program that will use only non–open air range

resources. In addition, existing test capabilities will need continuous upgrading of computers and instrumentation as they become obsolete or no longer repairable.

Summary of T&E capability drivers for CRI:

- Mobile and interoperable instrumentation for off-range test monitoring and control
- Miniaturized telemetry and flight terminations systems
- Computer and Instrumentation Obsolescence
- Computer network operations integration on ranges
- Hypersonics

4.4.10 Test Environments

Test environments, which replicate physical environments from sea-level to space; Mach numbers from subsonic to hypersonic speeds at the corresponding temperatures, pressures, and chemistry; climates that range from severe cold to extreme heat, present a full range of conditions from various types of radiation, capabilities support a wide-range of systems for all three Services and other DoD agencies.

Test environment capability needs to include recapitalization of the aging infrastructure and new test capabilities to support future military developments, such as air-breathing hypersonic propulsion systems. DoD Reliance on NASA for test environment support for certain performance regimes may also have to be addressed in the future if NASA continues to scale back its involvement in aeronautics facilities, which are core development capabilities for DoD.

Summary of T&E capability drivers for Test Environments:

- Hypersonic testing of air-breathing propulsion systems
- NASA termination of support for aeronautics test facilities
- Radiation testing for various systems

4.5 TECHNOLOGY TEST CAPABILITY DRIVERS

In addition to the combat area and cross-cutting programmatic drivers, advances in technology are likely to make the transition into combat capabilities for which supporting T&E infrastructure must be available.

Hypersonics. Hypersonic aircrafts, missiles, and spacelift systems will become instrumental in supporting the demand in DoD's global strike doctrine for quick and

accurate delivery of munitions. Success thus far in the development of current hypersonic systems stem in large part from the T&E infrastructure that nurtured their development. The next generation of hypersonic weapon systems offers unique advantages to the warfighter but challenges T&E capabilities in its development. Specifically, these new systems will employ air-breathing propulsion systems that cannot be adequately tested in existing MRTFB infrastructure. Furthermore, these systems will operate at much higher speeds and in more severe environments—at extreme temperatures and pressures.

Investments for hypersonic infrastructure need to be made now to develop hypersonic technologies that will lead to the acquisition programs needed by the warfighter.

Near Term (2008 – FY2012)

Supersonic Cruise Missile (Mach 3–5). This missile is to be compatible with fighter, bomber, ship, submarine, and ground launch. To achieve desired tactical utility, missiles are required to be launched at speeds of up to Mach 4

Hypersonic Cruse Missile (Mach 4-8). This missile has the same launch platform compatibility requirements as the supersonic cruise missile and has the same supportability and maintainability issues.

High Speed Aircraft (Mach 2-4). This aircraft is to capitalize on the full capability of emerging Versatile, Advanced, Affordable Turbine Engine technology. The baseline for this system is the SR-71, which nominally cruised at speeds above Mach 3

Mid term (FY2013 – FY2017)

Hypersonic Interceptor/Attack (Mach 8 -12). This is to be a surface launch vehicle that will provide a time-critical attack option. Ground-based infrastructure permits the use of hydrogen fuel to achieve a high specific impulse.

High-Speed Aircraft (Mach 3–6). – This aircraft is a regional hypersonic cruise vehicle, with cruise speed of Mach 3, or greater, (probably around Mach 4), and dash capability to Mach 6.

Far Term (FY2018 – FY2022)

Hypersonic Aircraft (Mach 4–7). This is envisioned as a Global Hypersonic Cruise Vehicle, capable of delivering a 12,000-pound payload anywhere in the world within two hours of launch.

Space Access (Mach 715). This two stage to orbit vehicle will have an estimated gross liftoff weight for the three payloads indicated of 100,000 pounds, less than 1 million pounds, and less than 2 million pounds.

Directed Energy. Directed-energy weapons technology comes from DoD's science and technology programs. Directed-energy weapons technology, particularly HEL and HPM are now emerging into Advanced Concept Technology Demonstrations (ACTD) and acquisition programs. Directed-energy weapons technology differs significantly from conventional kinetic munitions and presents a new set of challenges. Advancements in HEL and HPM have created a new class of weapon systems in which energy is placed on a target instantaneously, making traditional test techniques for evaluating conventional munitions (with flight times ranging from seconds to minutes) not applicable to directed-energy systems' T&E. New technology solutions are needed to ensure that adequate test capabilities are available when directed-energy acquisitions programs are ready to test.

Directed-energy system and component testing requires two principal assessments: weapon performance and interaction of energy and target. The current T&E infrastructure is based on effects testing or determining whether and when the target was destroyed. Detailed test data are required to understand directed-energy system performance so that the military utility can be maximized. The CTEIP-funded Directed Energy Study, DETEC T-SS was completed in 2003 and the final report tracked requirements and shortfalls to test directed-energy weapons in the future. The study concentrated on HEL and HPM capabilities for testing of current and future programs.

Most of the directed-energy programs were developed in the labs and have recently been making the transition into ACTDs. One program, the Airborne Laser, has moved into the acquisition phase. The list below gives examples of some of the unclassified programs:

Current:

- Advanced Tactical Laser (ATL) ACTD
- Active Denial System (ADS) ACTD

Future:

- Airborne Active Denial System (AADS) (potential ACTD in 2014)
- Airborne Electronic Attack (AEA) Concept (S&T only)

Key Network Centric Initiatives. Network Centric Warfare employs the benefits of dramatically enhanced quality and timeliness of information as well as fully transparent

interoperability of both systems and organizations. Net-Centricity is a robust, globally interconnected, network environment (including infrastructure, systems, processes, and people) in which data are shared promptly and seamlessly among users, applications and platforms. Net-centricity enables substantially improved military situational awareness and significantly shortened decision making cycles. A net-centric force can operate in a collaborative environment that improves efficiency and effectiveness of the force.

The solution of the tactical data link restrictions such as line of sight for Link 16 lies with a set of key net-centric initiatives to improve the communication infrastructure and transform the force to an Internet Protocol Version 6 approach where information is shared and can be pushed or pulled as needed. This protocol provides the ability for a greater number of network IP addresses to be connected, greater message security, and better tracking of equipment through digital tags. Those key net-centric initiatives include the JTRS, GIG-BE, Transformational Communications Architecture (TCA) SATCOM, net-centric enterprise services, information assurance programs and horizontal fusion.

The JTRS is intended to provide the operator with IP-based, self-managed beyond-line-of-sight mobile data and voice communications through the ability to move among various networks and use satellites for communication.

The GIG-BE provides an optical mesh IP network for up to 101 sites and is slated to become operational by FY2006. The GIG-BE provides a robust bandwidth for the future force to communicate. Note that by FY2008 the IP version 6 (IPv6) will be the standard for all military communication equipment that uses the GIG-BE.

The TCA SATCOM incorporates mobile/tactical users and global intelligence through optical cross links and EHF SATCOM IP links. The EHF SATCOM satellites are scheduled for a 2013 launch.

Net-centric enterprise services (NCES) will provide information and data services to all users of the GIG and tactical communication services supported by GIG transport services. The NCES will provide a common set of information capabilities to provide the awareness, confidentiality, integrity, availability, access, and delivery of information using the GIG. Communities of interest will be formed among GIG users to provide the basic ability to search NCES for desired information based on access privileges and authorization. The core enterprise services of NCES will be storage, mediation, collaboration, discovery, application, information assurance/security, messaging, user assistant and enterprise service management (ESM). NCES will create a new environment that supports posting data securely to common storage spaces, alerts authorized users of changes in relevant information or time-critical events that affect their survival or threaten the mission, provide users down to the last tactical mile with the capability to pull

information or data whenever they want, support secure interoperability with allies and coalition partners, and guarantee information assurance/security. NCES will be developed in two increments with an initial capability of increment 1 for all core enterprise services by FY2010 via three spirals and increment 2 in FY2013.

The Information Assurance Programs provide trusted computer networking and data services to all GIG users utilizing new encryption techniques. This will occur in three spirals with the third spiral finishing in FY2009 timeframe.

Horizontal fusion accelerates the operational implementation of this new GIG service oriented architecture to provide programs of records with the ability to modify their program to take advantage of this new capability. It is the program that pushes integration of all DoD programs to the GIG Service Oriented Architecture.

Additionally, various other service related programs are occurring in parallel to facilitate each service's ability to use the GIG Service Oriented Architecture. These include the Navy's FORCEnet, Army's LandWarNet, Air Force C2 Constellation and the Marine Corps Integrated Architecture Picture.

The result of all this development is that the future joint force will have several military advantages: knowing the location of friendly and enemy forces via increased situational awareness can result in new tactics; networked forces can operate with smaller units that can travel lighter with fewer platforms and carry fewer supplies; allows a Microsoft chat atmosphere from various sources to solve problems faster; and reduces the sensor-to-shooter time.

Summary of Joint Net-Centric Drivers for Test Infrastructure

- Revision of test communication infrastructure to include GIG-BE, TSAT, and JTRS capability at each major test facility.
- Requirement that all new "GIG-compliant" programs use a telemetry module (TM) to publish data handling capability where all telemetry data variables are to be published to the NCES Storage data services site. This would enable a future TM capability that is IP based and data are "pulled" as needed.
- Increased bandwidth data recording capability that is global in nature and compatible with GIG and NCES protocols and uses the data tagging ability of NCES.
- More accurate TM time standards to handle the reduced sensor-shooter timeframe.
- Reduction in latency time for TM data from shooter to facilitate test safety

Tactical Data Links. Several Tactical Data Links exist today that provide a networked approach for the joint force. Link 16 Tactical Data Link connects aircraft, ground units, and ships over one line-of-sight network link in theater. This allows the sharing of tactical tracks, situational awareness, and limited C2. In fact, this link is used today for coordination of operations in Operation Iraqi Freedom. Other existing tactical links include Link 11, Joint Variable Message Format (JVMF), and Situational Awareness Data Link (SADL). Efforts have been directed at developing a common architecture for networking future weapons. The ACTD, "Weapon Data Link Network," aims to provide this capability by FY2010–2011 and will incorporate pathfinder weapons.

4.6 DEPARTMENT-WIDE INITIATIVES

While still in various stages of development and implementation, other initiatives by the DoD will drive T&E capabilities:

Test and Training Range Transformation Initiatives. Several important parallel initiatives are underway within the DoD, all of which focus on various aspects of transforming our T&E and training infrastructure to provide distributed live, virtual, and constructive (LVC) capabilities to support engineering, developing, testing, and training in the evolving joint, network centric environment.

Deputy Secretary of Defense approved the "*Testing in a Joint Environment Roadmap*". The roadmap focuses on three areas that will affect the T&E infrastructure:

- Institutionalizing the need to test in realistic joint operational environments;
- Establishing persistent connectivity between battle labs, hardware-in-the-loop facilities, simulations, ranges and live force instrumentation; and
- Using this persistent connectivity to achieve robust LVC joint mission environments for joint experimentation, development, test, and training.

OSD/DOT&E is currently working with Joint Staff, OSD, Service, applicable Defense Agencies, and JFCOM stakeholders to develop and publish an Implementation Plan for this roadmap.

USD(AT&L) and ASD/NII have jointly sponsored a Joint Command, C4ISR Decision Support Center (DSC) Study called the *"Joint Distributed Systems Engineering*

and Test and Evaluation Strategy (JDSETES)" which is also on-going. It focuses on the following:

- Determining how the multiple distributed systems engineering and test initiatives underway throughout the DoD can be integrated to provide a joint distributed systems engineering T&E capability, including T&E of the Net-Ready Key Performance Parameter (NR-KPP).
- Determining what DoD guidance is needed to ensure that the diverse investments in systems engineering and test capabilities provide the integrated tools needed for the full community, including the war fighter, information technology (IT) engineers, program managers, systems engineers, and testers.
- Providing input to and complementing the Testing in a Joint Environment Roadmap planning efforts.

Joint Distributed Engineering Environment Plan (JDEP), based on Joint Staff and OUSD (AT&L) guidance, is an ongoing initiative and defined as a DoD-wide capability for Service and joint resources engineering, integration, and test resource to provide battlefield representative environments in support of developer, test, and warfighter requirements. JDEP is expected to provide comparable support to JC2 and NCES programs as well as the JFCOM's JBMC2 initiative.

Information Operations (IO) Range Initiative. QDR 2001 directed that IO, along with intelligence and space assets be a core capability and not just enablers. DPG FY2004–2009 directed the department to "Provide . . . analysis, testing, and training for more reliable IO capabilities (to include procedural controls, combat assessments and measures of effectiveness)." USD(I) and DOT&E sponsored a study to address the IO Range issue. This effort has been transitioned to JFCOM JNTC, and a program office is in the process of standing up to deliver an IO Range capable of supporting the requirements of experimentation, T&E, training, and exercises. The initial capability will attempt to link facilities from ten initial sites and establish IOC by July 2006. This phase will concentrate on a Computer Network Attack (CNA)/EW capability. The ten sites are Fort Meade; NAS Patuxent River; Cyber Warfare Center Lab at Fort Belvoir; Wright-Patterson AFB; Joint Research Analysis and Assessment Center at Redstone Arsenal; Lackland AFB; Sandia National Laboratory; Electronic Proving Ground at Fort Huachucha; NAS China Lake; and the Air Warfare Center at Nellis AFB. Additional sites will be added to expand IO Range capability until FY2011.

This effort, although focused on IO, will also address issues and capabilities similar to those being addressed in the aforementioned Testing in a Joint Environment Road Map

and JDSETES study—interconnecting distributed LVC facilities to create a "joint environment" for experimentation, testing, and training.

Lastly, JFCOM, through the Joint National Training Capability (JNTC) is focusing on the LVC issue as it applies to training. The Test and Training Roadmap focuses on several LVC training initiatives that parallel the LVC initiatives for testing. These include the following:

- Developing requirements analyses and development of the functional and technical requirements for the integrated LVC environment.
- Establishing interoperability between LVC training systems in support of defined "joint" force training requirements.
- Modernizing (provide interoperable instrumentation), sustaining, and protecting from encroachment maneuver areas, airspace, training ranges, and systems.
- Creating a highly adaptable mission rehearsal and joint training capability that is integrated with the Joint Technical Architecture.

JNTC is attempting to develop an overarching, open-architecture environment that will provide plug-and-play interoperability in a full range of LVC training. This LVC training will include an integrated live and synthetic environment, which will provide the foundation for a new, adaptable joint national training capability that will enhance the use of military testing areas and training ranges.

The four initiatives discussed above contain synergies that will enhance our ability to train as we fight, test as we fight, and engineer and develop our new systems to be "born joint." They are essential to DoD's transformation goals, and they need to be carefully integrated and synchronized as they evolve. The TRMC will play an active role in this synchronization effort.

Nuclear Weapons Effects. The *Report of Defense Science Board Task Force on Nuclear Weapons Effects Test, Evaluation, and Simulation,* April 2005, recommended: investments and divestments in T&E capabilities for nuclear weapons effects and that DoD, in conjunction with the Department of Energy (DoE), should work to develop an investment/divestment strategy. However, the overriding issue that must be resolved first is the establishment of a DoD position on the degree of hardening that weapon systems (including C4ISR) must have against electromagnetic pulse and other radiation effects. This position will drive both the capability and capacity needs for the DoD T&E infrastructure.

4.7 SUMMARY OF TEST CAPABILITY DRIVERS.

All the documents reviewed, advancements in technology, and capabilities of future weapons systems reveal that future forces will be fully integrated, expeditionary, networked, decentralized, adaptable, capable of agile decision making, and lethal. The future T&E infrastructure is key to testing and evaluating such systems so that the warfighter can meet all the future demands and have the attributes required to prevail in tomorrow's challenges.

The objective of the future T&E infrastructure for 2017 is to evolve current resources and infrastructure into a global environment that allows continuous testing among ranges and seamless use among stakeholders. Because of increasing encroachment issues, stakeholders include not only the testing community and government participants but also the surrounding community, state and local governments, regulators, and non-government organizations. This future T&E infrastructure should evolve into a suite of joint, interoperable capabilities that provide a full spectrum of sources to test current and new technologies and to test improved sensors, weapons, platforms, and C4ISR systems. The T&E infrastructure capabilities should evolve to an adaptive, persistent, integrated, distributed, global T&E system that is capable of providing robust, flexible T&E capabilities to support informative, effective, and timely transition of new capabilities to the warfighter.

Figure 4.1 below summarizes the test capability drivers and their linkage to combat and test capabilities. Chapter Six draws on these test capability drivers to identify test capability needs and roadmaps.

Test Capability Drivers	Test Capability Areas	Land Combat	Air Combat	Sea Combat	Space Combat	Missile Defense	Electronic Combat	Armament & Munitions	C4ISR	Common Range Inst	Target Systems	Test
Joint Operations		X	X	X	X	X	X		X	X	X	
System of Systems		X	X	X	X	X	X	X	X	X	X	
Battlespace Awareness		X	X	X	X	X	X		X	X	X	
Command and Control (C2).		X	X	X	X	X	X	X	X	X		
Non-Kinetic Test Capability		X			X		X		X	X	X	
Larger System "Footprints		X	X	X	X	X	X	X	X	X		
New Operational Environments		X	X	X	X	X	X	X	X	X	X	
Robust, Adaptive, Asymmetric Threats		X	X	X	X	X	X	X	X	X	X	
New Military-Relevant Technologies		X	X	X	X	X	X	X	X	X	X	
Greater Scope of Tests, Desire for Efficient Test Processes		X	X	X	X	X	X	X	X	X	X	
Weapons of Mass Destruction		X	X	X	X	X	X	X	X	X	X	
Major Defense Acquisition Program Drivers		X	X	X	X	X	X	X	X	X	X	
Hypersonics			X	X	X	X		X		X	X	
Directed Energy		X	X	X	X	X	X	X		X		
Network Centric Operations		X	X	X	X	X	X	X	X	X	X	
Test & Training Range Initiatives		X	X	X	X	X	X	X	X	X	X	
Information Operations					X		X		X	X	X	

Figure 4.1—Test Capability Drivers

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5.0 CURRENT T&E CAPABILITIES

5.1 OVERVIEW

The previous chapter outlined the drivers for T&E infrastructure, and this chapter describes current capabilities. An essential requirement for future planning of the T&E infrastructure is a comprehensive understanding of the capabilities available to DoD today. To fully evaluate the potential effects and the measure of risk associated with presumed capability shortfalls, the TRMC must have a full appreciation of the existing T&E infrastructure and how efficiently our investments are being used. This chapter provides the baseline information required to compare needs with capabilities. Specifically addressed are the planning and management functions of the T&E infrastructure as it exists today, the MRTFB T&E infrastructure, key non-MRTFB facilities and their associated major T&E capabilities, commercial and international test facilities, and other U.S. government test facilities.

5.2 T&E INFRASTRUCTURE PLANNING AND MANAGEMENT FUNCTIONS

The increasing complexity of the T&E of defense weapons systems over the past two decades requires changes and updates to the planning and management processes that support the T&E infrastructure. These changes keep our T&E capabilities current, and it is through them that requirements can be validated. The planning and management functions addressed in this strategic plan include the Military Services' T&E Executive Agent and Reliance, OSD's CTEIP and T&E/S&T program, the DoD Sustainable Ranges Integrated Product Team (IPT), and other unique, acquisition program specific infrastructure functions.

5.2.1 T&E Executive Agent and Reliance

In response to a 1989 Defense Management Review Decision, the Services proposed the establishment of a T&E Executive Agent Structure to be supported by T&E Reliance teams (Figure 5.1) consisting of technical experts in various fields. The proposed structure was approved by OSD and is still in place today. The purpose of the T&E Executive Agent Structure is to improve DoD multiservice T&E planning by promoting coordinated and centralized investment planning without impeding decentralized execution. The Board of Directors provides guidance and oversight of the process and is

comprised of the Vice Chiefs of each of the Services. The Board of Directors Executive Secretariat, primarily consisting of the Service T&E executives, coordinates and prioritizes the multiservice T&E requirements submitted from the Reliance teams and recommended to them by the Test Resources Advisory Group (TRAG). The Board of Directors Executive Secretariat ultimately forwards the joint T&E requirements to the TRMC for CTEIP funding consideration.

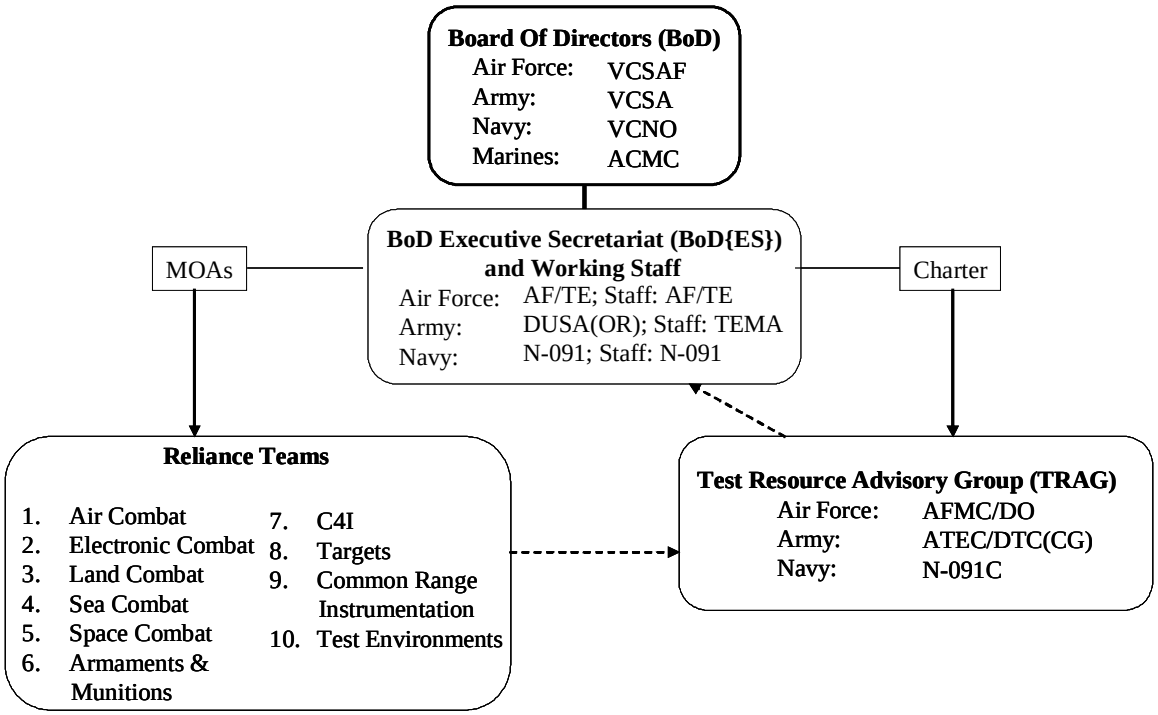

Figure 5.1—T&E Reliance Teams

The Reliance teams consist of functional experts from the Services who identify unwarranted T&E duplication, recommend improvements for test facility management, evaluate service T&E resource needs and solutions within the functional areas, and prioritize requirements. Each Reliance panel is chaired by a Service lead and, the roles, responsibilities, and Service commitments for each panel are identified in the Memorandum of Agreement (MOA) that exists between the BoD (ES) and the reliance teams. A brief description of each of the 10 Reliance panels follows:

1. **Air Combat**

   The Service lead rotates annually. Air combat includes fixed-wing/rotary-wing (manned, unmanned) aircraft, all related mission and support systems, and T&E support aircraft. The Air Combat Reliance Panel consists of tri-service fixed/rotary wing aircraft T&E and T&E support aircraft functional area experts.

2. **Electronic Combat**

   The Service lead rotates annually. Electronic combat T&E capabilities include resources used to evaluate electronic combat systems that span the entire electromagnetic spectrum that are both offensive and defensive in nature and include subsystems, technologies, and techniques for electronic warfare (EW) and suppression of enemy air defenses. DoD defines EW as any military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or attack the enemy.

3. **Land Combat**

   The Army leads the land combat Reliance panel. Land combat T&E capabilities include resources used to evaluate land vehicles, chemical warfare and chemical and biological defense, and smoke/obscurants. Chemical warfare and chemical and biological defense includes chemical retaliatory, incapacitating, and riot control agents and herbicides and their delivery systems; chemical and biological agent detection; identification and warning; individual protective items and clothing; collective protection; general chemical and biological threat assessment; and smoke/obscurants. Land systems include self-propelled or towed ground systems and supporting components as well as individual soldier systems.

4. **Sea Combat**

   The Navy is the sea combat panel lead. Sea combat systems encompass those that may be categorized as ship or ship/land/air extensions except those included under other Reliance panels. Sea combat systems also include undersea targets.

5. **Space Combat**

   The Air Force leads the space combat Reliance panel. Space and ballistic missile capabilities include DoD ground- and space-based test capabilities required to perform T&E of weapon systems and components in a duplicated or simulated space or ballistic missile environment, including

ground- and space-based testing infrastructures, and space and ballistic missile launch facilities and ranges.

6. **Armaments and Munitions**
   The Service lead rotates annually. Armaments and munitions include air-to-air, air-to-surface, surface-to-air, surface-to-surface missiles; guns/munitions; and electric guns. Excluded from this Reliance panel are ballistic missiles.
7. **Command, Control, Communications, Computers, and Intelligence (C4I)**
   The Service lead rotates annually. C4I systems include C4 (automated information systems) and intelligence systems or equipment that assists a commander in planning, directing, and controlling forces. Test elements include hardware, software, personnel, facilities, and procedures. Embedded software normally associated with non-C4I systems is excluded from this Reliance panel.
8. **Target Systems**
   The Service lead rotates annually. Target systems include air, land, and sea targets and target-related systems, including targets that simulate ballistic missiles. Thirteen subpanels support this Reliance area.
9. **Common Range Instrumentation (CRI)**
   The Service lead rotates annually. CRI includes instrumentation, equipment, and facilities related to time, space, positioning information, scoring systems, range control, range communication and telemetry, system-under-test data acquisition, and data processing. CRI draws support from eight subpanels.
10. **Test Environments**
    The Air Force leads the test environments Reliance panel. Test Environments T&E capabilities include nuclear weapons effects facilities, air-breathing engine facilities, environmental simulation facilities, supersonic sled tracks, non–air breathing propulsion facilities, and aerothermodynamic facilities. Six subpanels support the test environments panel.

The current Test Investment Review process focuses on investments with costs of $1 million or more in a single year or $5 million over the life of the project. The current process covers two categories of investments: those that address Service-specific requirements and those that are deemed joint and fulfill multi-service requirements.

Service-unique requirements are funded through the T&E investment money allocated for each Service, whereas investments that fulfill multi-service needs may be cooperatively funded by more than one Service or through the Central Test and Evaluation Investment Program (CTEIP). The joint Needs and Solutions (N&S) process provides a mechanism to identify, prioritize, and nominate joint solution candidates to OSD for potential CTEIP funding. The joint N&S process is illustrated in the T&E Executive Agent (EA) Investment Planning Process Timeline shown in Figure 5.2.

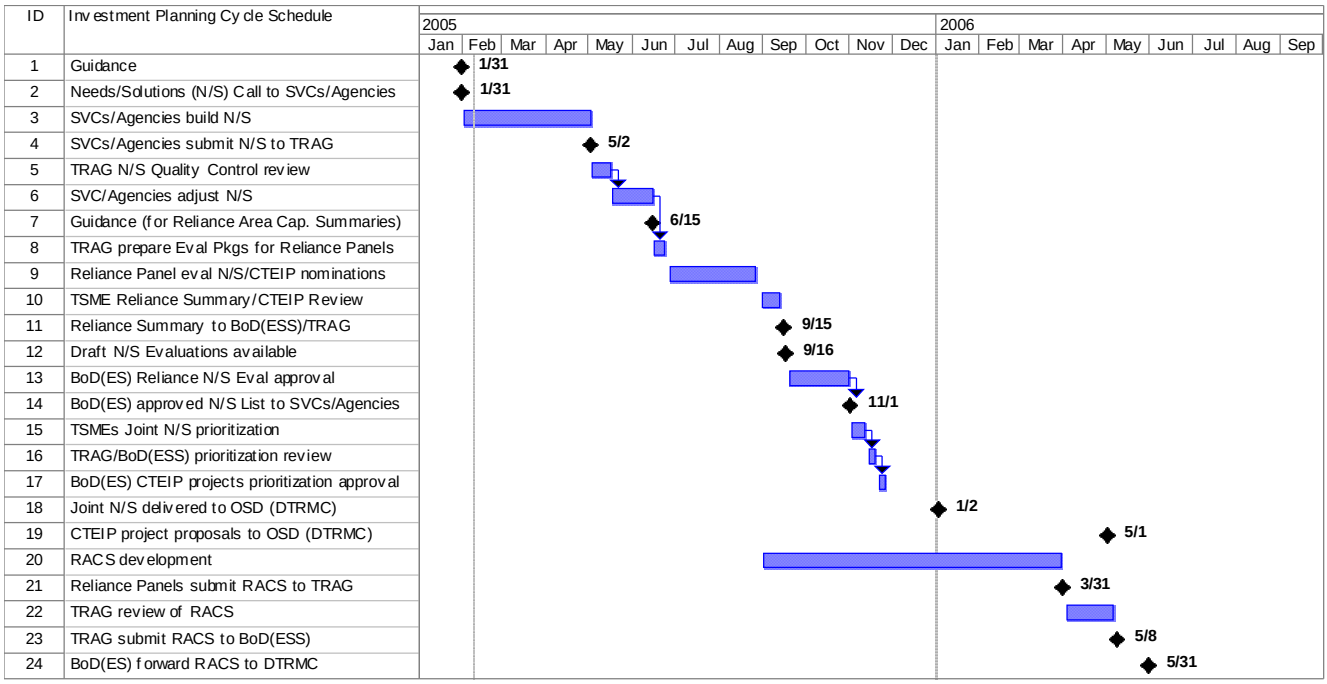

Figure 5.2—T&E Executive Agent Investment Planning Process Timeline

Projects that are deemed to address joint requirements can best be tracked by looking at tasks 9, 10, and 15-18 in Figure 5.2. Figure 5.3 illustrates the CTEIP nomination process.

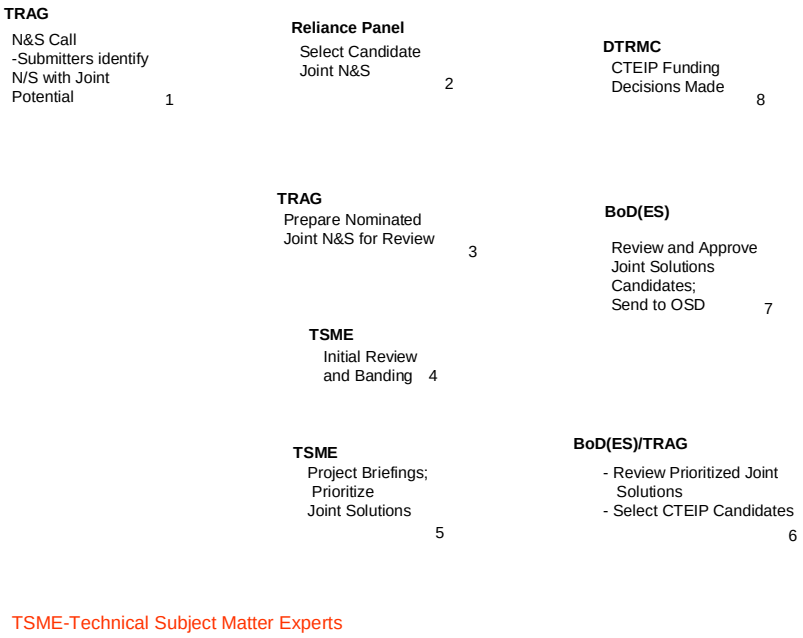

Figure 5.3—Joint Needs and Solutions Identification Process Activity Flow

5.2.2 CTEIP and T&E S&T

5.2.2.1 Central Test and Evaluation Investment Program

CTEIP was established by DoD, [1] which required that projects selected as CTEIP programs must be developmental in nature and geared toward multi-Service application. Furthermore, the CTEIP Program Execution Guide (PEG) specifies that the Services are responsible for budgeting for the procurement of any system or test capabilities developed under CTEIP. Other CTEIP objectives include increased interoperability to enable efficient interservice use of test assets, promotion of mobile test sites as an alternative to fixed facilities, and development, validation, and integration of modeling and simulation with open-air testing. The TRMC currently selects CTEIP projects from candidates

[1] Department of Defense Appropriations Act, 1991, Public Law No. 101-511, 104 Statute 1871 (1991). Senate Report No. 101-521, 101st Congress, 2nd Session (1991)

submitted by the Board of Directors Executive Secretariat or from initiatives proposed directly by the Office of the Secretary of Defense. In FY2005, the management and oversight of the CTEIP transitioned from DOT&E to TRMC. The TRMC will evaluate the Reliance process and the CTEIP selection process to ensure that they meet the vision and goals of the TRMC and determine if new processes and policies need to be incorporated.

Currently, CTEIP funds two programs: Joint Improvement and Modernization (JIM) and Resource Enhancement Program (REP). JIM projects represent investments that are critically needed for the integration of advanced technologies into the T&E infrastructure in order to test increasingly complex and sophisticated weapons systems. Eighty percent of CTEIP funding supports the development of JIM programs, and the typical project lifespan of a JIM effort is no more than five years. REP projects eliminate near-term shortfalls in operational test capabilities that require immediate development and funding. The need for these capabilities is generally not known sufficiently in advance of the operational test to be included in the Services' or Defense Agencies' normal programming and budgeting cycle. Funding the development of such capabilities as REP subprojects under CTEIP enables the T&E community to coordinate and integrate near-term test requirements with DoD-wide T&E investment planning. It also ensures that other programs that may have similar testing requirements are taken into consideration before investments are made. Twenty percent of CTEIP funding supports the development of REPs, and projects are typically no longer than two years.

5.2.2.2 Test and Evaluation/Science and Technology Program

The T&E/Science & Technology (T&E/S&T) program (program element was initiated in FY2002 as a cooperative effort by the DOT&E and the DDR&E to ensure that T&E supports the rapid development and fielding of new weapon systems. In FY2005, the T&E/S&T program transitioned from the DOT&E to the TRMC. This program fosters a robust T&E/S&T planning process to develop test technologies in parallel with advanced warfighter technologies in order to better support early user testing and help streamline the acquisition process.

The T&E/S&T program element allows test technologies to pace evolving weapons technology and is critical to ensuring that the capability exists to adequately test the advanced weapons systems that will be fielded in the future, including lethal and nonlethal weapons; intelligence, surveillance and reconnaissance systems; and information systems. To accomplish this, the T&E/S&T program:

- exploits new technologies and processes to meet important T&E requirements,

- expedites the transition of new technologies from the laboratory environment to the T&E community, and
- leverages commercial equipment and networking innovations to support T&E.

The T&E/S&T program's overarching goal is to provide the required T&E technologies in time to verify performance before advanced weapon systems enter production or are deployed to the warfighter. To identify T&E needs, the program leveraged the knowledge and experience of warfighters, S&T subject matter experts, and T&E subject-matter experts. These experts were brought together in a number of workshops and meetings in FY2002. During these forums, the participants focused on the T&E technology drivers contained in the Quadrennial Defense Review (QDR), Defense Planning Guidance, Defense Science and Technology Plans, and DDR&E Initiatives. Participants then identified the test capabilities that will be needed to test advanced weapon systems and conducted a gap analysis to identify the major shortfalls in the current T&E infrastructure. These shortfalls were further analyzed to determine which ones required S&T development for resolution. The majority of the shortfalls requiring S&T work are captured in nine focus areas:

- hypersonic test
- spectrum efficient technology
- multi-spectral test
- embedded instrumentation
- directed energy test
- information systems technology test
- software test
- modeling and simulation, and
- test range/facility technology improvements

The program initiated the first three focus areas (hypersonic test, spectrum efficient technology, and multispectral test) in FY2002 while the next two (embedded instrumentation and directed-energy test) were stood up in FY2003. Information systems technology test is being initiated in FY2005.

Currently, Service executing agents (EAs) lead each of the six active focus areas and their corresponding working groups, which are composed of Service T&E subject-matter experts and S&T subject-matter experts. The EAs and the working groups use the broad agency announcement process to solicit and select projects. A source selection committee led by the EA and consisting of the working group, contracting representatives,

and other subject-matter experts is formed to evaluate the proposals. Proposals are evaluated against criteria established by the program office and the EAs. The following criteria apply to all T&E/S&T projects:

- Potential for a technology to mitigate a militarily significant T&E risk or fulfill a militarily significant T&E need
- Appropriateness of proposed research for S&T (6.3) funding
- Potential for transition of the technology to a T&E capability through CTEIP, Service improvement and modernization programs, or acquisition programs
- Ability to support multi-Service requirements

The number and scope of active projects within the T&E/S&T program increases annually as the program continues to increase funding. Currently, the program has more than 40 projects in the six active focus areas. Each focus area addresses a particular risk area within the T&E community.

1. **Hypersonic Test (HST)—**The HST focus area is developing technologies to enable integrated T&E of high-fidelity propulsion systems and flight vehicles for air-breathing hypersonic systems. This includes enhancing ground, flight, and modeling and simulation testing techniques, as well as improving diagnostic capabilities.
2. **Spectrum Efficient Technology (SET)—**The SET focus area is developing technologies to enable T&E telemetry to use more efficient modulation techniques as well as more bands of the electromagnetic spectrum. This includes providing techniques for autonomous and adaptive spectrum use in L, S, superhigh-frequency (SHF), and non-radio frequency (optical) bands.
3. **Multi-Spectral Test (MST)—**The MST focus area is developing technologies that go beyond the single frequency infrared (IR) test capabilities that exist today to provide real-time, realistic end-to-end T&E of multispectral (multiband) and hyperspectral (hundreds of bands) sensors. This will enable DoD's T&E community to provide credible, accurate, and affordable testing of multi-spectral and hyperspectral sensors, seekers, and algorithms.
4. **Embedded Instrumentation (EI)—**The EI focus area is developing non-intrusive sensors, power sources and data storage technologies that can be embedded in systems under test to enable continuous and non-obtrusive T&E. This focus area is also developing architecture concepts for EI.

5. **Directed-Energy Test**—The DET focus area is developing technologies to enable T&E of High-Energy Laser (HEL) and High-Power Microwave (HPM) system performance and target interaction. This requires development of T&E capabilities that can measure the directed-energy weapon-target interaction without altering the directed-energy weapon's performance. The developed technologies must also be able to survive in the DE environment.
6. **Information Systems Technology Test (ISTT)**—The ISTT focus area will develop technologies that enable the T&E of information systems within complex network-centric environments. The technologies to be developed will address the T&E scenarios, technologies, and analysis tools required to ensure that information systems delivered to the warfighter provide an assured capability to acquire, verify, protect, and assimilate information necessary for battlefield dominance within a complex network-centric environment.

The T&E/S&T program remains a critical element in ensuring that T&E capabilities are developed and in place to support the development and fielding of advanced weapon systems.

5.3 TEST RANGES AND FACILITIES

T&E infrastructure consists of test ranges and facilities that support developmental and operational testing, commercial testing, and even training events. The OSD acquisition community uses several different types of test ranges and facilities to support the acquisition cycle. This T&E infrastructure consists of MRTFB, DoD non-MRTFB test ranges and facilities, other U.S. government test facilities, U.S. commercial test facilities, and international test ranges and facilities.

5.3.1 MRTFB

MRTFB T&E activities consist of test installations, facilities, and ranges that are regarded as national assets. The primary reason for sizing, operating, and maintaining these assets is to support the DoD T&E, including modeling and simulation, developmental testing, operational testing, and live-fire testing. The MRTFB facilities and ranges are also available to support non-DoD and commercial users on a reimbursable basis when workload permits.

In 1971, DoD recognized that certain strategic military test facilities and capabilities represented national assets and should be preserved. Because these assets supported development, testing, and deployment of U.S. warfighting capabilities, the DoD established the MRTFB management concept and set forth the governing policy in DoD Directive 3200.11.

This concept provides coordination among major test facilities, promotes multi-Service T&E asset utilization, reduces unnecessary duplication of T&E capabilities, and establishes budgetary priority at the department level. The TRMC performs oversight of the MRTFB in accordance with DoDD 3200.11. However, the Military Services and the DoD agencies remain the responsible parties for nominating T&E facilities for MRTFB consideration. Figure 5.4 shows the MRTFB's composition and each facility's location.

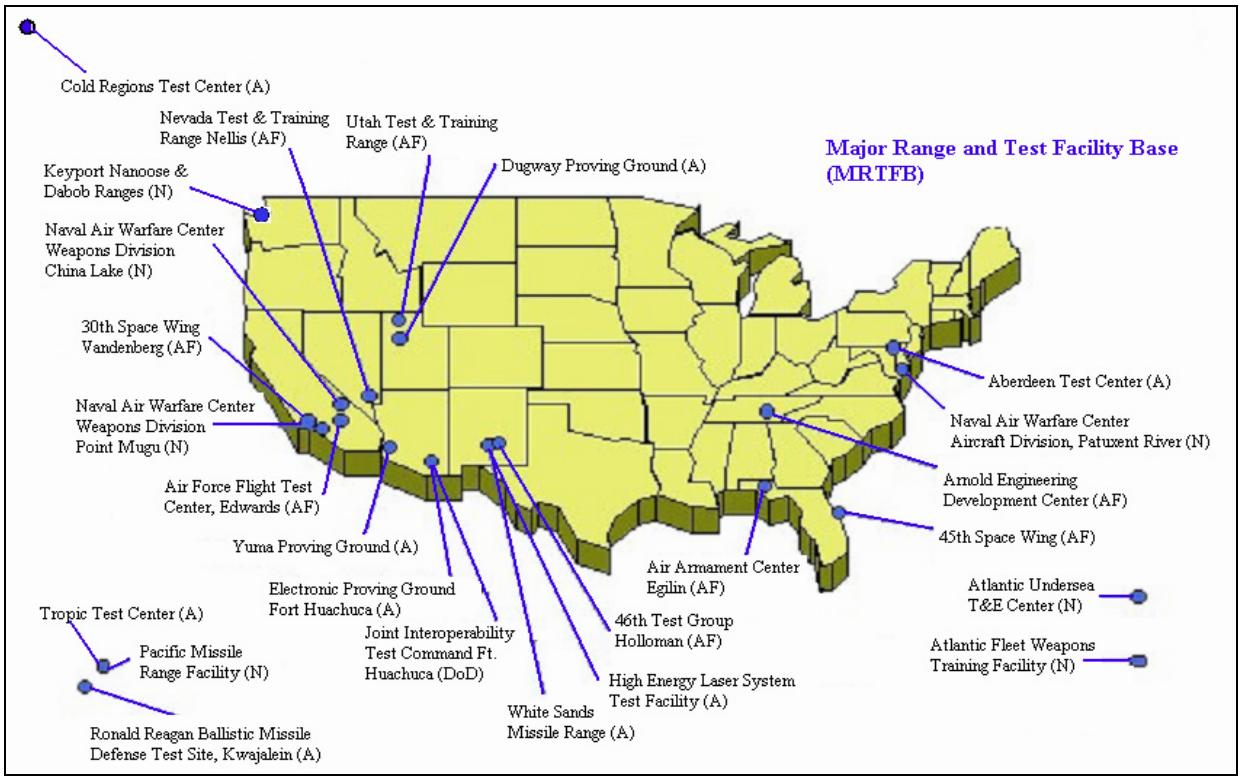

Figure 5.4—MRTFB Locations

The MRTFB consists of four elements:

1. **Human Resources**
   The skills and expertise needed to operate the T&E infrastructure and manage test processes.
2. **Natural Resources**
   The air, land, sea, and spectrum required to test current and future weapon systems using realistic footprints and tactics.
3. **Capital Equipment**
   The facilities, equipment, and instrumentation needed to test, measure, and report on weapon systems performance, effectiveness, and suitability.
4. **Processes**
   The actions and operations through which T&E are achieved. This may include test planning, investment and modernization (I&M) planning, managing test assets, operations and mission support, analysis and evaluation, reporting, and financial management and control.

Provided below is a description of the unique T&E capabilities that exist at each MRTFB, an overview of the testing conducted in FY2004, and an infrastructure outlook for each facility. In FY2004, DOT&E approved the inclusion of the Navy's Pacific Northwest Range Complex (Nanoose and Dabob Ranges) in Keyport, Washington, to the MRTFB beginning in FY2006. More complete descriptions of the individual MRTFB sites appear in Appendix A.

5.3.1.1 Aberdeen Test Center (ATC), Aberdeen Proving Ground, Maryland

Key and unique areas of capability: ATC is the Army lead test agency for land combat, direct fire, congressionally mandated live-fire testing, and manned and unmanned ground vehicles. ATC is a diverse, multipurpose, temperate-climate proving ground that encompasses 56,707 acres of land and water, including restricted airspace from "surface" to "unlimited". ATC encompasses 250 test ranges with 40 miles of vehicle test courses. ATC test facilities, instrumentation, simulators, and models support testing of both military weapons systems and their subsystems. Testing includes automotive endurance and performance; full-scale live-fire vulnerability, survivability, and lethality testing; soldier systems and support equipment; and electromagnetic interference, fire safety, and surface/underwater shock and explosives testing.

Testing in FY2004: ATC is one of two primary test centers used to support testing of the Army's Future Combat Systems (FCS). During FY2004, ATC continued to

test traditional Army systems equipped with enhanced technologies; these systems will remain part of ATC's workload in the future. Testing of transition systems, such as the Stryker Vehicle, began in FY2000. This testing has resulted in a workload increase of 30 percent through FY2004. It will continue through FY2007.

Infrastructure outlook: ATC is developing simulators to replace range testing. The first two phases of the three-phase, $38 million Roadway Simulator project, funded by CTEIP, were completed in FY2004. The third phase is scheduled to become operational in FY2005 and will give the ability to test large semitrailers and their prime movers. A Vehicle Durability Simulator (VDS) to test advanced platforms design reliability is funded for preliminary design. In FY2005, $2.5 million was received to initiate the VDS concept and construction, with completion expected in mid–FY2008. Other simulation facilities at ATC include vibration, accelerated corrosion, climate, and electromagnetic interference.

The new Climatic Firing Facility is scheduled to open in early CY06 and will permit test firing of full-sized weapon systems and operation of other military materiel under field weather conditions. The facility provides the capability to test from -65 degrees F to +165 degrees F and up to 100 percent relative humidity.

ATC is constructing a Distributed Test Control Center (DTCC) to support all future development and testing of systems including the Future Combat Systems (FCS). The DTCC will connect ATC test activities to the other DTC test centers through the Defense Research and Engineering Network (DREN). The DTCC will enable a distributed test environment that networks the specialties of all the test centers into a single test scenario to test advanced (e.g., FCS) concepts and technologies.

5.3.1.2 Dugway Proving Ground (DPG), Dugway Proving Ground, Utah

Key and unique areas of capability: DPG is the DoD primary chemical and biological (CB) test range. This remote and isolated installation, consisting of 800,000 acres of desert environment free from population encroachment and from threatened or endangered species, is ideally suited for conducting CB testing. DPG's principal mission is testing chemical and biological (CB) defense systems and performing nuclear, biological, and chemical survivability testing of defense materiel. DPG conducts exercises and advanced training in support of counterproliferation and consequence management associated with weapons of mass destruction. In addition, DPG tests smoke and obscurant systems, illumination devices, and insensitive munitions and final hazard classifications tests.

Testing in FY2004: In FY2004, DPG supported programs in CB defense, smoke, obscurants, and illumination munitions, Insensitive Munitions, and Final Hazard Classification testing; environmental characterization; and CB defense classes and training. Additionally, DPG supported a number of ACTD and operational exercises such as the Defense Support (DS) ACTD and technology test projects such as Agent Defeat, Equipment Decontamination and Expedient Personnel Decontamination System (Biological)

Infrastructure outlook: Test infrastructure for CB defense program systems in development meet minimal testing requirements, but in many cases are outdated, incapable of a high degree of reproducibility or precision, or otherwise inadequate to meet current schedule or quality requirements for operational evaluations. The development of all CB defense program materiel—from detectors, individual protective gear, and decontaminants—require test validation against actual chemical warfare agents (CWAs) in systems validated with animal models. Major infrastructure improvements are ongoing and should address most known shortfalls. A live agent chamber capable of supporting standoff CB detectors remains unprogrammed.

5.3.1.3 Electronic Proving Ground (EPG), Fort Huachuca, Arizona.

Key and unique areas of capability: EPG is the principal Army test center for developmental testing of such ground and airborne electronic systems as C4ISR and navigation systems, applicable mission packages on UAVs, and avionics systems. EPG has more than 9,600 square miles in and around Fort Huachuca. EPG tests distributed C4ISR and network-centric systems with emphasis on the testing of the electronic and C4I aspects of systems of systems. To encapsulate systems and networks under test with their expected information and computer communication environment, EPG developed the Virtual Electronic Proving Ground, which allows for testing in combined LVC simulation environments. Facilities include a full suite of capabilities that permits EPG to exploit its unique electromagnetic environment and test range to test systems and equipment that operate within and can be affected by the electromagnetic spectrum.

Testing in FY2004: During FY2004, EPG was heavily involved with testing systems related to the digitization of the Army. Tests include the Force XXI Battlefield Command Brigade and Below (FBCB2) Blue-Force Tracking, Stryker, Adaptive C4ISR node, Prophet Block 2/3, Tactical Internet Manager System, ISYSCON V4, Stryker Brigade Combat Team, support to the Central Technical Support Facility, All-Source Analysis System (ASAS), Miniature Airborne GPS Receiver, Joint Service Light NBC Reconnaissance System, Aerial Common Sensor component advanced development, Joint

Tactical Radio System–Cluster 1 (JTRS), Suite of Integrated Infrared Countermeasures (SIIRCM), Combat Survivor Evader, Locater, Defense Advanced GPS Receiver First Article Test, Secure En-route Communications Package–Improved, Tactical Operations Checkout testing of Tactical Command Centers, Army Battle Command System 6.4 Operational Test Support and FCS LSI TIE support.

Infrastructure outlook: The projected FY2005 workload at EPG will be more intense, requiring more days in the field and additional improved facilities, instrumentation and electromagnetic simulation capabilities. EPG's workload will be larger, more complex, and more difficult to execute.

5.3.1.4 High Energy Laser Systems Test Facility (HELSTF), White Sands Missile Range, New Mexico.

Key and unique areas of capability: In the 1980s, Congress directed the establishment of HELSTF for the testing of high-energy laser systems. This $800 million facility, operated by the U.S. Army Space and Missile Defense Command (USASMDC) is located within the White Sands Missile Range (WSMR), an instrumented test range that provides 3,200 square miles of controlled land area and 7,000 square miles of controlled airspace. This permits HELSTF to conduct live missile, rocket, artillery, mortar, and other dynamic high-energy laser engagement tests. HELSTF is an accredited predictive avoidance site (to support Mobile Tactical High Energy Laser (MTHEL) system testing) with the US Strategic Command Laser Clearinghouse. HELSTF is an approved above-the-horizon HEL test facility. HELSTF is also a center that can support ground-based laser T&E(tactical and developmental); and is a test site that can accommodate tactical battlespace laser systems. It includes the Mid-Infrared Advanced Chemical Laser (MIRACL) and its Sea Lite Beam Director (SLBD), the nation's highest power laser and only high-energy laser/beam director integrated system. Other lower-powered lasers, pointing and tracking systems, specialized optics, a 50-foot large vacuum chamber (which can simulate a space environment for conducting HEL tests), instrumented open-air target areas for full-scale target testing, an indoor instrumented test area for precise lethality testing, and meteorological measurement capabilities provide opportunities to conduct both laser and non-laser DE experiments. The SLBD also provides a passive optical sensor for obtaining target imagery during missile testing at WSMR.

Infrastructure outlook: Use of HELSTF has historically been relatively low, but it is a high-value test facility that provides unique capabilities for high-power laser testing. The importance of HELSTF has grown with forecasts of increased interest in directed-energy applications and with the potential for the Air Force (ABL and ATL) and Army

(MTHEL and SSHCL) tactical weapons development programs. HELSTF is preparing to support the CTEIP Directed Energy Test and Evaluation Capability program.

5.3.1.5 Ronald Reagan Ballistic Missile Defense Test Site (RTS) – Kwajalein Atoll, Republic of Marshall Islands.

Key and unique areas of capability: Located 2,300 miles southwest of Hawaii, RTS is a launch and reentry site for testing strategic antiballistic missile interceptor missiles and Intercontinental Ballistic Missiles (ICBM). RTS provides multilevel strategic and ballistic missile defense system testing, including system interoperability testing, sensor system research, developmental testing, space operations, including space object identification, space surveillance, commercial space launch, T&E operations, operational testing, T&E to characterize the performance of hypersonic systems and new foreign space launch tracking in support of the U.S. Strategic Command and NASA.

Range instrumentation includes four high-power, highly sensitive radar systems operating at seven defense-relevant frequencies. Tracking radars, telemetry, optical systems, and a large-area hydroacoustic missile impact scoring system complete the United States Army Kwajalein Atoll (USAKA) instrumentation suite. Because of its geographical location, the USAKA radars provide unique, around-the-clock first orbital coverage of most Chinese, Russian, Japanese, French Guinea, Indian, and other Asian continent launches within one hour after launch. The range sensors are integrated to a central control center via a high-speed, fiber-optic, intra-atoll network. Multiple target launch facilities sited around the atoll support intercept testing. Wake Island and Aur Atoll provide medium- and short-range target launch facilities. The airfield on the primary atoll, Kwajalein, handles all current U.S. air transport systems, and deep-water harbor facilities are available.

Testing in FY2004: RTS supported GMD, ICBM, Tactical Missile Defense (TMD) and space test programs.

Infrastructure outlook: The Army and MDA have made significant investments in RTS in the last few years, upgrading and modernizing four sophisticated radar and telemetry systems and state-of-the-art anti-missile launch facilities in Meck. In addition, the sea-based mobile telemetry and range safety platform, Kwajalein Missile Range Support Ship (KMRSS), is being upgraded to support the latest MDA missions. To meet the increasing bandwidth requirement, a submarine fiber optical cable network connecting Kwajalein to the Pacific basin optical cable network is under consideration.

5.3.1.6 White Sands Missile Range (WSMR), New Mexico.

Key and unique areas of capability: WSMR spans 3,420 square miles of land space and 10,026 square miles of contiguous air space (including extension areas). WSMR shares borders with Fort Bliss and Holloman AFB. The size, topography, small populations, and local community support renders WSMR virtually free of encroachment. The terrain ranges from high desert to wooded terrain at 4,000–9,000 feet MSL. WSMR provides a capability to develop, validate, and sustain advanced long-range systems through the near simultaneous launch, engagement (ground to exoatmospheric), and recovery of multiple large-scale targets and interceptors in a safe, secure, and diverse terrain environment. WSMR provides the engineering and science knowledge base, instrumentation, data acquisition, analysis, threat presentation, operational environments, survivability, and complex range operations for acquisition and sustainment of warfighter capabilities. WSMR includes overland restricted airspace, nuclear survivability test reactor, high-speed guidance and propulsion test track, unique low observables radar test facilities, open air jamming environments, and state-of-the-art control center. WSMR is the central network entry point for the Army T&E Command for distributed test and training through the Inter-Range Control Center (IRCC). WSMR acts as the inter-range control center for the ATEC Test Interoperability Network (TIN). WSMR is accessible via two major interstate highways and railroad systems, within 12 hours (ground) of the Pacific and Atlantic Oceans, accessible by air via Holloman AFB, Biggs Army Airfield and installations runways (up to 35,000'), and is a licensed spaceport.

Testing in FY2004: WSMR supports test programs for the Army, Navy, Air Force, Marine Corps, MDA, NASA, private industry, foreign military sales, and other governmental agencies. Army programs included Patriot, PAC-3, Army Tactical Missile System (ATACMS) Block I/II and Brilliant Antiarmor Submunition (BAT), Multiple-Launch Rocket System (MLRS), Guided MLRS, High-Mobility Artillery Rocket System (HIMARS), M1 System Enhancement Program, M3A2 Bradley, Stinger, Line-of-Sight Antitank (LOSAT) missile, and Viper Strike. Major Navy programs include the Evolved Sea Sparrow Missile (ESSM), Tactical Tomahawk, and Standard Missile (SM). Major Air Force programs include the High-Energy Airborne Laser, Advanced Medium-Range Air-to-Air Missile (AMRAAM), Joint Air-to-Surface Standoff Missile (JASSM), AIM-9x, Joint Direct-Attack Munition (JDAM), and Small-Diameter Bomb. WSMR also supports the Marine Corps Complimentary Low-Altitude Weapon System (CLAWS), DARPA Netfires, High Explosive Rocket Assisted (HERA) Theater Missile, liquid propellant rocket development, various UAV programs, NASA Space Shuttle Training, and NASA Research Rockets.

Infrastructure outlook: WSMR funding does not permit the timely replacement of outdated radars, optics, and telemetry systems with more modern and efficient systems. WSMR has begun a transition from film cameras to high-speed digital cameras but is not adequately funded to complete this work. WSMR's Cox Range Control Center is a state-of-the-art range control facility with full network centric capabilities. As an adjunct to the CRCC, WSMR is developing the IRCC as a major control center for distributed testing. WSMR is also completing a Test Support Network (TSN) to provide a secure, real-time network infrastructure throughout the entire range. Although the fiber backbone is in place, the TSN is not funded for complete last-mile of linkage to all required nodes and for full LAN/WAN support capability.

5.3.1.7 Yuma Proving Ground (YPG), Arizona.

Key and unique areas of capability: YPG, at more than 838,000 acres in size, is larger than Rhode Island and is the Army's natural environment tester. YPG oversees the activities of Yuma Test Center (YTC) and has satellite activities at the Cold Regions Test Center (CRTC) in Alaska and the Tropic Regions Test Center (TRTC) with locations in Panama, Hawaii and Honduras. YPG is predominantly bordered by other federal lands, has no urban encroachment and suffers no endangered species constraints. In addition to controlling the restricted airspace over its test ranges, YPG controls an additional 426,521 acres of restricted airspace bringing the total restricted airspace under YPG's control to over 1,264,000 acres. YTC has five UAV test facilities with seven runways between 2,000 and 6,000 feet in length. All facilities provide hangars and operations facilities to support multiple test aircraft and projects. With a large variety of weapons and laser firing ranges, the test range provides capability to support airframe, sensors, and weapons integration development for a variety of UAV systems.

The air cargo complex, located on Laguna Army Airfield, enables preparation of airdrop loads, maintenance, parachute packing, and air transport rigging. It has 43,000 square feet of interior space providing office space, maintenance bay, parachute pack bay, environmentally controlled drying tower, segregated storage for life support equipment and non-standard test items and a 40-ton bridge crane with 35 foot hook height. External facilities include a 48,000 square foot dedicated aircraft ramp, 100,000-pound capacity truck scale, secure and open storage yards and a 42,000-pound capacity aircraft loader.

YTC is the Army's largest desert-environment test center and contains the largest overland artillery firing range. It has 400 miles of test courses and trails used for testing prototype and operational military vehicle systems (both wheeled and tracked). YTC teams with ATC to conduct virtually all of DoD's vehicle and ground systems reliability

testing (temperate and desert) under the same strictly controlled test methodologies. YTC is also the DoD Reliance lead for ammunition lot acceptance testing. YTC conducts developmental testing of Army air-to-ground armament and target acquisition equipment as well as helicopter weapon subsystems and their integration into the air vehicle.

With a capability to conduct concurrent aircraft, artillery, ground vehicle, combat systems, and ammunition testing along with the extensive fixed and mobile instrumentation, range facilities and support systems, YTC can conduct joint Service combined arms test and training for all DoD Services, agencies, friendly foreign nations and private industry. DoD Reliance studies established YPG as the joint Services lead test agency for gun munitions (indirect fire) and electric gun and a specialty site for automotive testing. Developmental Test Command (DTC) named YPG the lead test center for overall UAV performance testing and support for UGV autonomous/semi-autonomous operations and armaments.

The Smart Weapons Test Range Complex supports testing of smart mines and countermine systems that operate on acoustic, magnetic, and seismic sensors and require isolated test sites so physical input to the sensors can be controlled. YTC's mine testing capabilities include projectile-delivered mines, specially prepared impact areas and the Mines, Countermine, and Demolition Test Complex.

The Joint Experimentation Range Complex facilitates rapid experimentation of sensor technologies for the detection and defeat of threats in an urban/rural environment. It has large, remote land/airspace, controlled access, urban and rural terrain, 14.1 miles of roadway and 227 buildings.

YPG's Integrated Test Management Facility allows on-the-fly data basing of test data and transmission to materiel and combat developers.

YTC's large, drive-in environmental firing chamber allows firing of large artillery weapons (up to eight-inch) at various elevations (more than 60 degrees) while being subjected to high or low extreme temperatures and humidity. It can accommodate a helicopter (without the engine running) while still being able to fire certain weapon systems. Temperature range of the chamber is -63-165 degrees F and humidity range is 5-100 percent in the 60-145 degrees F range.

The Range Digital Transmission System provides the capability to transfer data throughout the range through a fiber optic cable. It corrects problems of limited, antiquated cable plant and dependency on a large amount of microwave equipment. The capability includes 600 miles of fiber optic cable to more than 400 test sites.

Testing in FY2004: Current programs include CMS/C-RAM Demonstration, Light Armored Vehicle - 25 (LAV-25), Improved Thermal Sight System (ITSS), 120mm

Mortar Titanium Baseplate, FCS NLOS Cannon Demonstrator, Active Defense System (ADS), Lightweight Countermortar Radar (LCMR), M777 155mm Lightweight Howitzer, Stryker, XM8 Rifle, Improvised Explosive Devices (IEDs), Joint Precision Airdrop System, Precision Airdrop Technology Development, Low-Cost Aerial Delivery System – OT, Vigilante UAV - Hydra-70 Rocket Integration, Expendable UAV Systems, and Kiowa Warrior Block I Software Validation. In the area of unexploded ordnance remediation, continued development of laser cutting of high-explosive munitions and bio-remediation of explosive components showed promise for production quantities.
Infrastructure outlook: With a scheduled completion date in FY2006, the total cost of the improved digital transmission system is approximately $50 million. Requirements to test precision airdrops for guided parachute technologies require new approaches to telemetry and precision location instrumentation and will continue to drive future testing technology.

5.3.1.7.1 Cold Regions Test Center (CRTC), Fort Greeley, Alaska.

Key and unique areas of capability: CRTC is located in the interior of Alaska. Approximately 100 miles southeast of Fairbanks, CRTC is bordered primarily by state and federal land, experiences no physical or electromagnetic encroachment, and has no noise restrictions. CRTC covers 660,000 acres of Alaska's interior, which closely approximates subarctic conditions around the world. The climate at CRTC is characterized by long, cold winters and relatively short, mild summers. A normal year will have 56 inches of snowfall between mid October and mid April. The wintertime temperatures are variable, with long periods of subzero temperatures interspersed with milder periods. The wind speeds also vary, with long periods of light wind conditions interspersed with periods of heavy wind. The winter days are short, with only 4 hours and 10 minutes of daylight on December 21. However, extended periods of twilight in both the morning and afternoon allow work to be conducted. On the other hand, the summer days are very long with 21 hours of daylight in late June. Ground elevation at CRTC ranges from 1,175 to 6,200 feet above mean sea level. The terrain is varied and includes areas of forest, plains, muskeg, mountains, tundra, glaciers, rivers, lakes and swamps. CRTC is essentially unaffected by environmental, endangered species, or archeological impediments to test. CRTC has the only DoD high-speed test track. This 3.2 mile oval track has the capability for sustained 82 mph testing with a lateral acceleration pad and test slopes.

Testing in FY2004: Programs included Stryker Cold Weather Fixes Verification, Stryker Mortar Variant, Armored Security Vehicle (ASV), Rapidly Emplaced Bridging

System (REBS), Joint Service General-Purpose Mask (JSGPM), M56 Smoke Generator System, XM8 Rifle, Missile Storage Testing, and NBC Gloves and Boots.

Infrastructure outlook: The projected FY2005 workload at the CRTC will remain stable over the next year. It is anticipated that such programs as the F-22 and F-35 will seek testing at the CRTC in the near future.

5.3.1.7.2 Tropic Regions Test Center (TRTC), Yuma, Arizona; Oahu, Hawaii, Kauai, Hawaii.

Key and unique areas of capability: The Army's Tropic Regions Test Center is headquartered at Yuma Proving Ground with test sites in Panama, Honduras and Hawaii. Each site offers varied climatic, physical and biological settings appropriate for T&E in the tropics. These test sites provide the necessary challenge to systems and material to assure developers and soldiers that equipment will perform reliably in a tropical environment. Testing focuses particularly on soldier systems, communications, sensor adequacy, human factors, and performance.

Testing in FY2004: Current programs include XM8 Rifle, Joint Service Chemical Environment Escape Mask (JSCESM), M56 Smoke Generation System, Joint Services Light Weight Integrated Suit Technology (JSLIST), 90 Day Storage (M393E3/M467E1, XM1028/XM1002), Targeting Test Non-Line-of-Sight Launch Systems ((NLOS-LS), Stryker (NBCRV), Joint Chemical Agent Detector (JCAD), Joint Lightweight Standoff Chemical Agent Detector (JLSCAD) Increment II.

Infrastructure outlook: During October 2004, YPG and SOCOM partnered with the Panamanian National Police (PNP) for dual use of testing/training academy sites in Panama, operated by the PNP. Current facilities include a small arms firing range, a manpack course, a Military Operations in Urban Terrain (MOUT) complex, and small arms storage bunkers. Other partnerships formed include the U.S. Army Medical Research and Materiel Command (telemedicine and T& E requirements) and Special Operations Command (SOCOM) on utilization of Piña (Panama) area (vehicle mobility testing, sensor testing in double and triple canopy, access to UAV staging and support areas, housing and Morale Welfare Recreation (MWR) support for soldiers).

5.3.1.8 Atlantic Undersea Test and Evaluation Center (AUTEC), West Palm Beach, Florida and Andros Island, Bahamas.

Key and unique areas of capability: AUTEC has both deep and shallow water testing environments. It operates a large underwater, instrumented range of 500 contiguous square nautical miles located in a deep-water basin. The range is located in the

Tongue of the Ocean off the coast of Andros Island, Bahamas and is 110 by 20 nautical miles with depths of approximately 1300 to 2000 meters. This basin is bounded on three sides by un-navigable or lightly navigated ocean areas, which makes it an isolated ocean test area. The sheltered location provides undersea acoustic noise levels that are typically below Sea State 1. AUTEC's geographically confined access provides security from commercial or private encroachment. AUTEC supports RDT&E of undersea warfare systems as well as fleet training operations. AUTEC's facilities enable acquisition programs to complete critical performance milestones, conduct radiated noise measurement, and provides U.S. and allied Navy platform measurement systems for basic acoustic, environmental, and oceanographic research and test programs. In addition, AUTEC's high fidelity in-water tracking system enables unique marine mammal monitoring and mitigation tools required to support complex maritime test and training.

AUTEC has a shallow-water test complex (in-air and in-water tracking) range off the Berry Islands with 68 nautical miles of underwater tracking adjacent to an exercise minefield at depths from 25 meters to over 700 meters and includes calibration spheres.

Also located at AUTEC are the NATO Naval Forces Fleet Sensor and Weapons Accuracy and Check Site (FORACS). This range is approximately 7 by 12 nautical miles with multiple-object tracking capability consisting of bottom-mounted transducers, active transponders, and a shore-based passive target signal generator.

AUTEC has portable capabilities including in-water and in-air three-dimensional tracking capability, survey capability, and acoustic measurement capabilities.

Testing in FY2004: Major testing in FY2004 included MK 48 Torpedo Block Upgrade OT&E, Canadian MAD/Royal Navy ASW, AN/WSQ-9, Advanced Sensor Application Program, CCS MK2 (Block 1), BSY-2, CSSQT VLA, Acoustic Rapid Commercial Off The Shelf (COTS) Insertion, SSBN Security Technology Programs, Weapons System Accuracy Trials (WSAT), NATO Forces Sensor Accuracy and Check Site (FORACS), and SSN21 Seawolf OT&E. AUTEC also conducted numerous training programs. These programs include the AIRLANT/SUBLANT/SURFLANT/Submarine Commands Course (SCC) (also known as the Prospective Commanding Officer (PCO)) program, Group Sails, Aviation Readiness Program, Laser/Hellfire Missile Program, and U.S. Air Force 24th Special Tactics Squadron Testing.

Infrastructure outlook: To improve efficiency, upgrade aging capabilities, and increase safety, AUTEC has five investment programs underway.

- Underwater Range Data Communications (URDC) program will provide secure digital communications between the AUTEC range operations center and a submarine operating at speed and depth on the AUTEC range. System

demonstration testing has been completed and final system improvement integration is ongoing.

- Radar System Improvement (RSI) program will replace obsolescent tracking radars and provide aerial surveillance capability for the AUTEC range. Site verification testing of the Multimission Surveillance Radar is underway to validate the interface of radar data into the existing display system.
- Offboard Advanced Systems Stimulus (OASYS) Phase IV of the program will upgrade the mine detection and avoidance systems. Upgrades to the present Mine Warfare capability at the AUTEC Minefield and Shallow Water Range will improve the capability, density, and realism of the minefield.
- Range-Ware Improvement program will replace obsolescent computer hardware and software used for the AUTEC real-time command and control of the range tracking systems as well as collection, processing, and generation of range data products.
- AUTEC Lightening Protection (ALP) program will upgrade or replace the lightning protection systems at the facility to reduce equipment damage and mitigate operational effects caused by lightning damage.

In the future, the following programs are expected to use the T&E capabilities at the AUTEC facility: AN/BLQ-11 Long-term Mine Reconnaissance System (LMRS) program, Surface Ship Combatant 21st Century program, Mine Reconnaissance System, Submarine Torpedo Defense System, and the Surface ASW Combat System Integration program.

5.3.1.9 Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, Maryland; Lakehurst, New Jersey; Key West, Florida.

Key and unique areas of capability: NAWCAD, Patuxent River, serves as a steward of the ranges, test facilities, laboratories, and aircraft necessary to support the Fleet's air vehicle acquisition requirements including the U. S. Navy Test Pilot School. The Lakehurst, New Jersey, site provides support equipment expertise and unique aircraft launch and recovery systems. The Key West, Florida detachment tests developmental antisubmarine warfare hardware in the open ocean. The following describes the MRTFB facilities that reside within NAWCAD:

Atlantic Test Range (ATR) provides a sea level, open-air range with access to 50,000 square miles of air space for conducting flight test operations. The open-air ranges cover regions over Chesapeake Bay and the Atlantic Ocean along the coastline of

Delaware, Maryland, and Virginia. ATR includes a dynamic in-flight radar cross-section measurement facility.

Air Combat Environment T&E Facility (ACETEF) is a fully integrated ground test facility allowing full-spectrum T&E of aircraft and aircraft systems in a secure and controlled engineering environment. The facility uses state-of-the-art simulation and stimulation techniques to provide test scenarios that reproduce actual combat conditions.

Electromagnetic Environmental Effects (E^3) includes the electromagnetic interference and compatibility (EMI/EMC), electromagnetic transients (EMT), lightning, electrostatic discharge (ESD), electromagnetic vulnerability (EMV), electromagnetic pulse (EMP), and TEMPEST/COMSEC test capabilities.

Test Wing Atlantic is composed of the following three MRTFB squadrons: VX-23 Naval Strike aircraft test squadron; HX-21 Naval Rotary Wing Aircraft Test Squadron; and VX-20 Naval Force Aircraft Test Squadron. Facilities also include the automatic carrier landing system facility; and shore-based steam catapults and arresting gear.

The Propulsion Evaluation Facilities include the Propulsion Systems Evaluation Facility (PSEF), the Aircraft T&E Facility (ATEF) and the Outdoor Test Site (OTS) located at NAWC Lakehurst. The PSEF consists of numerous facilities used to test and collect data on propulsion systems, installed and uninstalled, engine components and sub-systems and fuels and lubricants.

Testing in FY2004: Workload at NAWC-AD MRTFB facilities increased from FY2003 to FY2004. Testing during FY2004 included V-22 Osprey, F-35, E-2C, H-1, SH-60R/S, F-18E/F, EA-18G, and EA-6B ICAP.

Infrastructure outlook: The forecast for the next three years indicates relatively stable test workload from Navy users. Recent investments have been made in the NAWCAD MRTFB facilities. Investments included new telemetry, video, flight termination, and Radar Cross Section (RCS) processing systems allowing ATR to keep pace with the test requirements of new air vehicles. The fuel filter and coalescing test capability was increased to meet API 1581 standards and a High Cycle Fatigue test capability was added at PSEF. The CTEIP has resourced state-of-the-art EMI, EMT, ESD, and EMP capabilities at the E3 facilities as well as upgraded IR, radar and Communication, Navigation & Identification (CNI) simulators at ACETEF.

5.3.1.10 Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, California; Point Mugu, California.

Key and unique areas of capability: NAWCWD, China Lake and Point Mugu, serve as a steward of the ranges, test facilities, laboratories, and aircraft necessary to

support the Fleet's weapon and weapon systems acquisition requirements. The following describes the MRTFB facilities that reside within NAWCWD:

Sea Range: The Sea Range located at Point Mugu can support large, complex operations and uses an approved flight corridor between the sea and land air ranges for land-attack cruise missiles. It includes 125,000 square miles of instrumented sea range with 36,000 square miles of controlled overlying airspace, a deepdraft port facility, an airfield, and instrumentation at San Nicolas Island.

Land Range: NAWCWD Land Range located at China Lake includes 1.1 million acres of land space and 17,000 square miles of military restricted airspace. T&E instrumentation capabilities include TSPI; telemetry; communications; data processing and display systems; interoperability between other ranges; special purpose test facilities; and range safety, security, and environmental support.

Electronic Combat Range (ECR): ECR supports free-space testing of airborne electronic combat (EC) systems and tactics against shipboard and land-based air defense systems. ECR test assets accurately represent the performance of a variety of RF guided surface-to-air missile and gun systems such the I-HAWK, Roland II, SA-2, SA-8 ZSU-23, and Gun Dish. In addition ECR simulators provide a capability to evaluate the performance of infrared/ultra-violet missile warning and countermeasures systems against a variety of widely proliferated man-portable air defense missiles (MANPADS) such as the SA-7 and SA-18.

Test Wing Pacific: This facility consists of two T&E squadrons, VX-30 and VX-31. VX-30 owns and operates F/A-18, C-130 and NP-3 aircraft for range, chase, and target support for both land and sea ranges. VX-31 is the Navy's primary test activity for F/A-18 weapons and sensor integration testing and evaluation, utilizing all models of Hornet aircraft to evaluate emerging, state-of-the-art airborne systems and enhancements to fielded systems. The command is also the sole location for USMC AV-8B Harrier T&E of weapons compatibility, weapons and sensor integration and performance, and aircraft engines and airframes. VX-31 also conducts integration testing on the AH-1W Cobra helicopter and provides desert and high-altitude Search and Rescue support for land range and civilian customers.

Targets/Threats: NAWCWD maintains and operates the Navy's aerial and seaborne target. Airborne targets include aircraft and missile (including control systems) and towed targets with passive and active full-spectrum augmentation used to simulate known aerial threats. Seaborne target systems include self-powered, towed, and free-floating targets, configured to represent a wide variety of hostile vessels with both passive and active augmentation.

NAWCWD maintains and operates two supersonic, dual rails, research tracks. One is four miles long, the other 3,000 feet. Capabilities include data collection during programmed events at subsonic or supersonic speeds for captive test items or ballistic tests of weapon systems. Test vehicles of up to 136,000 pounds and speeds of up to 4,500 feet/sec are attainable.

Static RCS. Etcherron Valley RCS Range provides a high-security and RF-interference free environment. Precision RCS measurements in HF, UHF, L, S, C, X, Ku and Ka bands are available. Also available are lookdown and horizontal facilities. Coherent Bi-Static RCS capabilities are also available as well as a wet site to conduct RCS studies in a simulated sea surface environment.

Highpowered Microwave. Naval Air Systems Command (NAVAIR) China Lake has a HPM Tera Hertz Operational Reachback (THOR) device capable of providing source characteristics for susceptibility and vulnerability testing. THOR is an RF generator that can create a custom Ultra Wide Band electromagnetic environment, with an adjustable output pulse.

Ordnance T&E. NAVAIR China Lake provides ordnance T&E in the following areas: propulsion, nondestructive evaluation, warhead, environmental, and safety. Propulsion includes the static firings of solid propulsion systems, aero heat tests of materials, and small RAMJET engine tests. Nondestructive evaluation includes high energy computer automated tomography, leak detection, baroscopic inspection, and convention film x-ray. Warhead testing includes conventional warheads and explosive deices for (Joint Munitions Effectiveness Manual) JMEM effectiveness, fragment impact and sympathetic detonation. Environmental and safety testing includes dynamic vibration and shock, climatic testing, cook-off tests, drop tests, and external fire stack tests.

Testing in FY2004: Major test programs supported during FY2004 included Active Electronically Scanned Array (AESA) Radar, AIM-9X Air-to-Air Missile, AN/AAR-47 (V)2 Missile and Laser Warning System, EA-6B Upgrades (ICAP III and Low Band Transmitter), Evolved Seasparrow Missile, Joint Direct Attack Munition (JDAM), Joint Standoff Weapon (JSOW), Stand-off Land Attack Missile Expanded Range (SLAMER), MH-60 Multi-Mission Helicopter Upgrade, MH-60S Multi-Mission Combat Support Helicopter, Rolling Airframe Missile (RAM) Weapon System, AEGIS 6.1, Standard Missile, Tomahawk, F/A-18 C/D/E/F, AV-8B, AH-1W and IDECM.

Infrastructure outlook: The Navy is completing major investments in ordnance T&E by adding the T-Range heater capability and modernizing warhead and nondestructive evaluation instrumentation. At the ranges, common investments in voice and data communications instrumentation are improving efficiency and interoperability.

Future major investments include replacements of the existing range support aircraft and their associated instrumentation as well as modernization of the existing radar and GPS TSPI systems, transition to a digital video for optical systems, and modernized TENA-based data processing systems. UAV and DE T&E testing will increase over the next 15 years.

5.3.1.11 Pacific NW Range Complex, Pacific Northwest Nanoose and Dabob Ranges

Key and unique areas of capability: Naval Underseas Warfare Center (NUWC), Keyport provides a wide variety of conditions and capabilities that support T&E of undersea weapons and UUVs including both R&D and production acceptance. In December 2004, DOT&E approved the inclusion of Nanoose and Dabob ranges as a part of the MRTFB beginning in FY2006. The following describes the MRTFB capabilities that reside in the Pacific NW Range Complex.

The Dabob bay site is located 15 miles due west of Keyport and is a secure inland range. This provides a safe haven for sensitive testing. The range covers nine square nautical miles (nm) to depths of 100 to 200 meters. TRIDENT Post-Refit Sea Trials are routinely conducted at Dabob.

The Nanoose site, which covers 52 nm, is located approximately 120 miles northwest of Keyport in Canada and includes the Nanoose Range, Jervis Inlet, Area WF and Ranch Point. The Nanoose range supports testing to depths of 1,300 feet. Jervis Inlet supports testing down to 2,400 feet. The WF operational area just north of the Nanoose range supports testing to depths of 250 to 750 feet and is frequently instrumented with portable range tracking hardware. Ranch Point, which has extensive staging and pier facilities, provides operational support for Nanoose, WF, and Jervis Inlet.

Testing in FY2004: DoD testing included R&D; weapon production acceptance; DT and OT of military weapons systems such as the MK 48 ADCAP, MK 54, Torpedo Defense, Rigel, and LMRS; surface ship system tests; and foreign weapon exploitation. NUWC Keyport also conducted non-DoD and commercial testing and provided reactor escorts as well as technical and oceanographic support. In addition, NUWC Keyport supported surface fleet training exercises, air operations with P-3's, and mine warfare exercises. NUWC Keyport workload is broken out as follows: 89 percent DoD testing, 10 percent training, and 1 percent non-DoD.

Infrastructure outlook: The United States Department of State and Canada renewed the Nanoose Range International Agreement on December 17, 1999. The United States and Canada share costs for joint infrastructure, capital investment, and operations

and maintenance. To meet next generation Undersea Warfare (USW) Weapons testing requirements, annual infrastructure investments of $5 million are made to minimize obsolescence and to upgrade the ranges.

5.3.1.12 Pacific Missile Range Facility (PMRF), Kauai, Hawaii.

Key and unique areas of capability: PMRF is a Navy training range capable of supporting surface, subsurface, air, and space operations. One thousand square miles of instrumented underwater range and over 42,000 square miles of controlled airspace make PMRF a leading range for supporting operations from small, single-unit exercises to large, multiple-unit battle group scenarios. When needed, PMRF has cleared over one million square miles of surface and airspace for ballistic missile defense testing. PMRF is linked to other range and data-processing facilities and can transmit real-time test data and video to DoD sites nationwide via microwave, fiber-optic, and satellite networks. While primarily a training range, it is the Navy's primary site for ballistic missile defense testing. In support of the testing, four MRTFB functions are located at PMRF. These areas are imaging radars to include the three Coherent Signal Processor (COSIP) radars and the MK-74, optics to include two Versatile Tracking Mounts (VTM) and two Stabilized High Accuracy Optics Tracking System (SHOTS), Mobile Aerial Target Support System (MATSS), and telemetry.

Testing in FY2004: PMRF is the primary test facility for Aegis Ballistic Missile Defense and and supported multiple tests and training requirements associated with this program during FY2004. PMRF also will support future THAAD element testing for the Ballistic Missile Defense System.

Infrastructure outlook: All PMRF MRTFB assets are relatively new and have had significant recent upgrades. PMRF has a multi-year instrumentation upgrade program that includes installation of three advanced radars (two fixed and one on a mobile sea-going platform), telemetry upgrades, missile assembly building and magazines, SHOTS, Mobile Aerial Target Support System (MATSS) Sea going Mobile Sensor Platform, and MK-74 X-band Radar.

5.3.1.13 Air Force Air Armament Center (AAC)

5.3.1.13.1 46th Test Wing (46thTW), Eglin Air Force Base, Florida.

Key and unique areas of capability: The 46thTW tests and evaluates weapons, navigation/guidance systems, and Command and Control (C2) systems using sea and land ranges as well as ground test facilities. The Eglin Gulf Test Range provides 100,000

square miles of over-water airspace. The land, sea, and air range space (including littoral and riverine environments) provides a capability for large-scale joint test and training events using operationally realistic scenarios. The land range covers 724 square miles and contains 51 test areas, including a depleted uranium test range and a qualified air-to-ground supersonic range. The over-water test areas stretch from the Florida Panhandle south to Key West and encompass the entire eastern Gulf of Mexico. Key attributes of the Gulf Range Complex are 200 x 400 miles of special-use airspace over the Gulf (minimal air and surface traffic), low radio frequency background, as well as littoral areas from deep water to 17 miles of beach with a multitude of bayous, bays, and rivers.

The Armament/C2 Systems Test Environment consists of precision instrumentation for data collection, microwave systems for data transfer, and radio and land communication networks to support tests. It also includes ground-based and airborne systems for testing of developmental multi-spectral systems including electro-optic, infrared, millimeter wave, and RF countermeasures, detectors, and sensors. The C2 Test Operations Center includes laboratory facilities for testing Air Operations Center-level C2 systems and applications as well as mission planning systems in an operationally representative environment. It also includes laboratories, gateways, and open-air facilities for testing multiple tactical datalink networks and systems. C4ISR test capabilities include real-world environment testing, along with anechoic chamber, open-air range, and climatic testing. Software intensive application test facilities include a permanent "hot bench" Joint Tactical Information Distribution System (JTIDS) test bed, with Link-16; an Enhanced JTIDS system exerciser (EJSE); a Single Channel Ground and Airborne Radio System (SINCGARS) radio test facility; and various computer workstations and networking capability for T&E of software applications such as Theater Battle Management Core Systems.

The Santa Rosa Island Tower provides open-air hardware-in-the-loop test capability to bridge the gap between conventional hardware-in-the-loop testing and open-air testing. It also allows evaluation of precision-guided weapons technology in a real world littoral environment.

The unique McKinley Climatic Laboratory (MCL) has a large environmental testing chamber capable of testing all operational aircraft including a C-5 and five additional chambers. Capabilities include rain, snow, icing, dust, sand, salt, fog, humidity, and solar radiation. The Guided Weapons Evaluation Facility (GWEF) provides test support for developing and evaluating the complete spectrum of precision-guided weapons seekers/sensors in simulated "real world" environments. The Joint (RTTC (Army)/Eglin (Air Force)) Preflight Integration of Munitions and Electronic Systems Test Facility

performs installed systems testing of air-to-air and air-to-surface munitions and electronics systems of full-scale aircraft. The facility has the capability to provide electromagnetic countermeasures (ECM) and GPS constellation simulations.

Open-air electromagnetic test capability designated as the Multi-Spectral Test and Training Environment (MSTTE) provides a realistic and flexible open-air multi-spectral environment for testing and training. Various threat systems that operate in different frequency bands and operating modes are represented on the Eglin complex. The MSTTE is capable of evaluating the most complex weapons, C4ISR, and Electronic Combat systems and platforms.

The 46TW is also the home of the Air Force SEEK EAGLE Office, which has the responsibility for making aircraft/store certification recommendations for all Air Force fixed-wing aircraft to their respective System Program Directors. Key assets used in the multi-disciplinary SEEK EAGLE analysis process include: state-of-the-art mass properties measurement facilities; form/fit, loads, flutter, EMI/EMC, vibration/acoustic, stability and control, separation and safe escape analysis tool kits; and a flight test risk and cost reducing high-performance computational modeling and simulation team.

Testing in FY2004: The 46TW performed testing/evaluation for all three Services, DoD contractors and commercial customers.

Infrastructure outlook: The 46TW is continuing to upgrade various test and simulation capabilities. Expanded radar and midwave IR simulators were recently completed upgrades to the GWEF. Upgrades to TSPI systems, telemetry, microwave, communications, arenas, gun test, and photo-optics continue at the Armament Systems Test Equipment (ASTE) Range Systems. Many of these improvements support the testing of longer standoff weapons. Efforts are continuing in the development of an "Operational Ground Test Capability" to test full-up weapons in a ground test facility that will simulate the open- air flight environment. To improve the Preflight Integration of Munitions & Electronic Systems (PRIMES) capability, development of aircraft/munitions interface simulations for F-15 and F-16, and advanced signature generator upgrades were initiated, as well as the completion of the Com/Nav simulator data link.

5.3.1.13.2 46th Test Wing, 46th Test Group (46thTG), Holloman Air Force Base, New Mexico.

Key and unique areas of capability: The 46th Test Group provides a combination of T&E Services and state-of-the-art measurement and support facilities for guidance and navigation testing, sled track testing, radar cross section testing, and flight testing. The Central Inertial Guidance Test Facility (CIGTF, 746 Test Squadron) manages the

Department of Defense (DoD) Center of Expertise for the Space and Missile Systems Center (SMC) Global Positioning System (GPS) Joint Program Office (SMC/GP). CIGTF tests and evaluates Inertial Navigation Systems (INS), GPS, and Embedded GPS/INS (EGI) components and systems in both benign and electronic warfare environments. The Holloman High Speed Test Track (HHSTT, 846 Test Squadron) provides hypersonic-sled test capability and is the DoD's lead track facility and track Center of Expertise for aircraft escape system testing, full-scale lethality testing, kinetic energy weapons testing, electronic countermeasure systems, explosive blast effects, environmental erosion, dispenser testing, and hypersonic environmental testing. The National Radar Cross Section (RCS) Test Facility (NRTF) combines mono-static and bi-static RCS measurements of full-scale flyable targets, glint, imaging, near field and antenna pattern measurements.

Testing in FY2004: CIGTF performed laboratory, field, and flight-testing in two major categories, GPS Vulnerability and GPS Performance. In these categories, CIGTF tested avionics, Information Warfare Battle Lab, Joint Test and Evaluation, Vulnerability/Jamming Programs, and Special Projects. HHSTT demonstrated 9,465 feet-per-second capability, magnetically levitated-sled capability, tested F-22 ejection seats, and tested kinetic energy weapons. The 586 FLTS flight tested EGI navigation systems, electronic warfare, and supported flight weapons testing.

Infrastructure outlook: The NRTF is consolidating with industry and is completing state-of-the-art technology improvements to address advanced stealth techniques. The HHSTT is increasing hypersonic-engine test capability, reduced-atmospheric-pressure testing, and developing magnetic levitation sled test- platforms to improve kinetic performance and data products. The 46th Test Group is developing test capability of UAV and DE weapons. The 586 FLTS is developing low-observable towed targets to enhance stealth testing. CIGTF is developing centrifuge testing enhancements, high-gain antenna tracking, airborne GPS prevention and testing, non-GPS time, space, positioning information references, and an order-of-magnitude improved precision reference system.

5.3.1.14 Arnold Engineering Development Center (AEDC), Arnold Air Force Base, Tennessee; White Oak, Maryland

Key and unique areas of capability: AEDC facilities include 58 aerodynamic (subsonic, supersonic, and hypersonic) and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, ballistic ranges, and other specialized units. Advanced turbine engine and rocket propulsion facilities can simulate

high-altitude operations (up to 100,000 feet altitude) even during testing of large, high-thrust engines. The Aeropropulsion Systems Test Facility can simulate flight conditions and transient conditions of takeoff, climb, multi-speed combat maneuvers, descent, and landing, all using full-scale elements of an aircraft propulsion system or, in some cases, the complete propulsion system. Sea-level engine test cells provide the capability to perform accelerated engine durability testing and testing of engines in hostile environments (e.g., salt-water atmosphere). The AEDC wind tunnel complex includes a hypersonic wind tunnel at White Oak, Maryland. AEDC is modifying capabilities to provide improved testing of aerodynamic and propulsion systems up to Mach 8.

Testing in FY2004: AEDC aeropropulsion testing in FY2004 included development work for the F135 engine powering the Joint Strike Fighter and Component Improvement Program efforts for the F119 (F-22), F100 and F110 engines for the F-15 and F-16. Aerodynamic wind tunnel testing in FY2004 included continued work for the JSF, and significant wind tunnel aerodynamic and material evaluation work for the NASA Shuttle Return to Flight (RTF). AEDC performed space simulation testing in support of the NASA Shuttle RTF effort, advanced material development for atmospheric reentry of strategic systems, and continued qualification testing of upper stage rocket motors for the ICBM fleet

Infrastructure outlook: AEDC is performing testing using its upgraded, mostly 40-year-old facilities. In cooperation with NASA, new aeronautical testing capabilities are being defined to meet future national needs.

AEDC's infrastructure has experienced a number of failures in recent years, including a damaged plant heater, transformer, plant motor, and a Propulsion Wind Tunnel (PWT) starting motor, to name a few. To minimize the effect of unforeseen failures like these, AEDC is managing its funds and pursuing infrastructure maintenance and repairs. AEDC has embarked on an upgrade/modernization schedule to include installing data acquisition and processing systems in both 16-foot wind tunnels, designing electric motor upgrades, and planning flow-quality improvements. A multi-year program is in progress to upgrade the engine test facility, enhancing capability and reducing test costs.

5.3.1.15 Air Force Flight Test Center (AFFTC), Edwards Air Force Base, California.

Key and unique areas of capability: AFFTC is the Air Force aircraft and aircraft systems development T&E center for both manned and unmanned vehicles and home to the Air Force Test Pilot School. Key focus areas are air vehicle, propulsion, avionics, electronic warfare, directed energy and logistics test. Engineering, operations, and

logistics expertise and infrastructure to support ground and flight testing of these focus areas are in place supporting engineering, manufacturing, development and sustainment programs to support Air Force airborne weapon systems.

The AFFTC is centrally located within 20,000 square miles of several highly instrumented ranges: Utah Test and Training Range (UTTR), White Sands Missile Range (WSMR), Vandenberg AFB, and the Naval Air Warfare Centers at Pt Mugu and China Lake. This permits unrestricted flight-testing from ground level to space. The AFFTC capabilities address airworthiness, system of systems integration, suitability, and effectiveness.

AFFTC has an array of ground test facilities including the following: 1. Avionics Test and Integration Complex (ATIC) allows for complete testing of a fully integrated avionics suite in a simulated flight environment including electronic threats and software checkout. 2. Digital Integrated Air Defense System (DIADS) is a simulation system incorporating a software representation of the fusion algorithms used by modern enemy air defense systems deployed or projected to be operational in the 21st century. 3. Test and Evaluation Modeling and Simulation (TEMS) facility provides capabilities to conduct constructive and virtual simulations in support of electronic warfare on air vehicle performance and flying qualities. 4. Integration Facility for Avionics Systems Testing (IFAST) provides a secure, safe, and cost-effective environment for operator-in-the-loop and hardware-in-the-loop integration laboratories to evaluate hardware and software interactions with the entire test vehicle's avionics suite. 5. Benefield Anechoic Facility (BAF) supports installed systems testing for avionics test programs requiring a large, shielded chamber with radio frequency (RF) absorption capability that simulates free space. 6. Air Force Electronic Warfare Evaluation Simulator (AFEWES) is a hardware-in-the-loop facility. 7. Weight and Balance Hangar. 8. Ridley Mission Control Center provides high-speed data connections to other test ranges throughout the western United States. 9. Engine test facilities provide one of only three fully automated engine test cells in the country. 10. Aircraft modification and special instrumentation provide complete aircraft modification design, analysis, documentation, fabrication, installation and test capability as well as special instrumentation planning, operations and maintenance to support its flight test activities.

Testing in FY2004: The T&E workload supports all three Services, DoD contractors, European participating countries, foreign military sales, and commercial customers.

Infrastructure outlook: AFFTC is currently managing major T&E improvement and modernization programs focused on modeling and simulation (M&S), data

acquisition, processing and archiving, spectrum management, hypersonics, and air vehicle instrumentation, Joint Tactical Radio System (JTRS) Study, Airborne Icing Tanker, Next Generation Test Instrumentation. These investments will improve integrated test capabilities and open-air testing of advanced weapon and electronic combat systems (i.e., UAV, directed energy, network centric warfare, hypersonics, survivability/ effectiveness). AFFTC continues its modernization of the support fleet with instrumentation upgrades of our F-16 support fleet, development of a multi-role instrumented tanker, and reconstitution of the Icing Tanker. AFFTC is also preparing for flight test of future hypersonic vehicles.

5.3.1.16 Nevada Test and Training Range (NTTR), Nellis Air Force Base, Nevada.

Key and unique areas of capability: NTTR has 12,000 square nautical miles of airspace over 2,919,890 acres of ground space. It supports operational testing for combat aircraft to ensure new and upgraded systems meet operational requirements. Tactics Development and Evaluation tests are conducted to guarantee aircrews are provided sound combat tactics in concert with new or upgraded systems. The Red Flag exercise generates demands on range airspace and infrastructure. Another large force exercise, the Joint Expeditionary Force Experiment (JEFX) tests advanced technology in field conditions. The NTTR provides instrumentation for tracking up to 100 aircraft participating in multiple missions for data collection and mission debriefing. Weapons scoring systems and tracking are available to support weapon system testing.

Testing in FY2004: The NTTR supported operational tests in simulated combat environments for new aircraft such as the F/A-22, as well as upgrades to existing aircraft such as the A-10, F-15C, F-15E, F-16C, and HH-60G aircraft.

Infrastructure outlook: Target and threat system improvements are planned. The largest improvement planned is the Urban Operations Complex (UOC) on Range 62, programmed at $40 Million for high-fidelity targets and $4 Million for instrumentation over six years. The Dynamic Targeting System (DTS), currently in development and partially funded with Target Management Initiative funding, will provide Time Sensitive Targets by using remote control Sport Utility Vehicles (SUVs). Estimated time for completion for the DTS is June 2005. The Unmanned Threat Emitters (UMTEs) are also scheduled for depot level upgrades to improve fidelity. The 98 RANW has also requested funding for the Fiber Optic Enhanced Range Conductivity (FOERC) to improve long-haul communications with other western ranges. FOERC is a cost shared, long-term, commercial lease of fiber optic transmission capability with other DoD ranges.

5.3.1.17 Utah Test and Training Range (UTTR), Hill Air Force Base, Utah.

Key and unique areas of capability: The UTTR is the primary operational test and training range for DoD's precision guided, air-to-ground, weapons and munitions. It contains 12,574 square nautical miles) of airspace. The UTTR encompasses over 2,675 square miles (1.8 million acres) of DoD and Bureau of Land Management (BLM) land located in northwestern Utah and eastern Nevada. The UTTR supports operational T&E of cruise missiles, unmanned air vehicles, munitions, and advanced weapons systems. Rocket motors for ICBMs and tactical weapons are tested on static firing facilities. Numerous areas are used for precision monitored explosive propagation tests and munitions shelf-life tests. Tests of up to 500,000 pounds of conventional explosive can be conducted.

Testing in FY2004: UTTR test activities included air munitions sustainment and flight testing (Cluster Bomb Unit (CBU) munitions, fuses, mechanical fins, air retarding system, flares, and chaff).

Infrastructure outlook: UTTR continues to support Operational T&E (OT&E) for legacy programs and is developing plans to support new weapon systems moving into production.

5.3.1.18 Western Launch and Test Range (WLTR), 30th Space Wing (30SW), Vandenberg Air Force Base (VAFB), California

Key and unique areas of capability: The WLTR, operated by the 30 SW, conducts west coast spacelift, missile and aeronautical T&E activities for DoD, civilian and commercial customers. The WLTR extends west from the coast of California and provides continuous and complementary instrumentation coverage over a broad portion of the Pacific Ocean. In addition to range assets, WLTR’s launch infrastructure includes various space launch complexes, off-line booster processing facilities, spacecraft processing clean rooms, booster and spacecraft control centers, and storage for liquid and solid rocket propellant and motors.

WLTR’s operational spacelift missions provide capability to launch spacecraft systems at highly inclined (including retro) into polar orbits due to VAFB’s geographic location. It supports small though heavy-lift launch vehicles (e.g., Atlas V) and numerous spacecraft programs. The spacelift mission also supports midrange launches originating in Hawaii, on-orbit and orbital insertion for the Eastern Launch and Test Range (ELTR) launches, on-orbit and contingency landing for the Space Shuttle. A collateral sensor in Hawaii also provides space surveillance and supports for U.S. Space Command Space

Surveillance Network. The West Coast Offshore Operating Area managed by the WLTR, is an approximately 200 by 1300-mile "over-water" flight area along the West Coast spanning the Mexican to Canadian borders. This test corridor provides a large stable air mass for aeronautical tests requiring minimum turbulence, supersonic speeds, low visibility and very low altitude.

Testing in FY2004: WLTR executed ten space and missile launches in FY2004.

Infrastructure outlook: Infrastructure focus is limited to range assets, not launch pads or spacecraft processing facilities. Although upgrades have occurred, some range systems are becoming obsolete and require modernization, recapitalization, or sustainment. The LTRs lack complete inter-range standardization and user interoperability necessary to recognize potential Reliability, Maintainability, Availability (RMA) and life cycle cost efficiencies. Modernization, recapitalization and sustainment projects are addressing these issues in a prioritized manner. Current modernization projects will upgrade core planning and scheduling, weather information, communications, range safety, telemetry and archiving systems. Modernized versions of these systems will populate a new Western Range Operations Control Center. GPS metric tracking capability is also being implemented as a source for tracking vehicles so equipped.

5.3.1.19 Eastern Launch and Test Range (ELTR), 45th Space Wing, Patrick Air Force Base (PAFB)/Cape Canaveral Air Force Station (CCAFS), Florida

Key and unique areas of capability: The ELTR, operated by the 45th Space Wing, conducts East Coast spacelift and missile T&E activities for DoD, civilian and commercial customers. The ELTR extends east from the coast of Florida and provides continuous and complementary instrumentation coverage over a broad portion of the Atlantic Ocean. Launch infrastructure mirror those of the WLTR. ELTR range assets are dispersed throughout CCAFS and other geographically separated locations to include PAFB, Jonathan Dickinson Missile Tracking Annex, Antigua Island, Ascension Island, and Argentia, Newfoundland.

ELTR's operational spacelift missions provide capability to launch spacecraft systems at low to medium (occasionally high) inclination, into low, highly elliptical, medium, or geosynchronous orbits, and interplanetary space missions. Like the WLTR, it supports small though heavy-lift launch vehicles and numerous spacecraft programs including the Navstar Global Positioning System. ELTR collateral assets also provide space surveillance and supports for U.S. Space Command Space Surveillance Network. ELTR's T&E missions, primarily in support relationships with other MRTFBs and

agencies, conduct developmental and operational T&E for launch vehicles (SLBM) and their payloads (sub-orbital reentry vehicles).

Testing in FY2004: Over 19,700 operations supported processing and checkout of launch vehicles and spacecraft; 337 were major operations requiring support from numerous range systems and 478 supported integration and testing of range modernization activities described below. ELTR executed 13 space and missile launches in FY20004.

Infrastructure outlook: The infrastructure focus of the ELTR is similar to that of the WLTR. A dedicated Space and Missile Center (SMC) System Program Office (SPO) manages a combined Eastern and Western LTR range modernization effort as an Integrated Priority List of recapitalization and sustainment projects continues to grow. Recent modernized systems at the ELTR include Centralized Telemetry Processing, Satellite Communications, and Range Safety. Modernization products nearing operational capability include a Planning and Scheduling system; Fiber Optics Network Transport system for voice, data, and video; and a Post Detect Telemetry system, which will reduce bandwidth and cost on satellite and microwave links. Longer-term important range modernization initiatives include meteorological, vehicle command and control, and telemetry systems. GPS metric tracking capability is also being implemented as a source for tracking vehicles so equipped. Additional recapitalization and sustainment projects will upgrade radar, telemetry, optics, command generation sites. A Radar Open Systems Architecture (ROSA) upgrade for a modernized precision radar at Antigua is making significant progress and will be applied to other Eastern and Western LTR radars.

5.3.1.20 Joint Interoperability Test Command (JITC), Fort Huachuca, Arizona; Indian Head, Maryland

Key and unique areas of capability: JITC plans, conducts, evaluates, reports, and certifies the results of interoperability and other tests of information, communications, and intelligence hardware and software systems or elements. It is the sole joint interoperability certifier for DoD. JITC offers complete systems testing with its array of hardware, software, and staffing and technological flexibility. It operates a number of local/distributed test beds with an extensive network of military, commercial, and allied test facilities, interconnected by high-data-rate land circuits as well as radio and satellite links. JITC is also the Operational Test Agency (OTA) for DISA, and select programs for other agencies, such as, Defense Logistics Agency. JITC personnel provide real-time, on-site resolution of interoperability issues in CINC exercises and contingencies. Located at Fort Huachuca, Arizona, JITC is in a comparatively quiet and unrestricted electromagnetic environment. This location allows testing that cannot be performed elsewhere.

JITC also provides and maintains the Joint Distributed Engineering Plant (JDEP) infrastructure. JDEP is a DoD wide capability for Service and Joint resources engineering and integration to provide battlefield representative environments in support of developer, tester, and warfighter requirements.

JITC's Joint Test Facility (JTF) operates a 16-acre test site with five test nodes. It tests every kind of transmission system including tactical line-of-sight, combat net radios; high-frequency microwave and tropospheric scatter systems; fiber optic cable; commercial telephone lines; and satellite links. It uses traffic and message loading devices to simulate high-volume conditions.

Testing in FY2004: During FY2004, JITC conducted over 648 interoperability tests, certifications, and developmental and operational tests and evaluations or assessments. JITC personnel conducted 149 standards conformance tests/certifications as an important first step to achieving interoperability. JITC supports small standards conformance communications tests to major interoperability exercises and real world contingencies. FY2004 testing included Global Command and Control System-Joint (GCCS-J).

Infrastructure outlook: New DoD initiatives, emphasizing testing for interoperability and information assurance, will increase workload as JITC's capabilities and facilities become more critical to achieving the department's objectives. DoD acquisition programs have not fully used the capabilities of JITC, as the Services tend to conduct interoperability testing at their own sites using their own methodologies.

5.3.2 DoD non-MRTFB test ranges and facilities

The individual Services nominate T&E facilities and capabilities for inclusion into the MRTFB, and the TRMC approves such nominations. However, the MRTFB facilities do not contain all of the DoD T&E capabilities that support the warfighter. Non-MRTFB activities also manage and operate other T&E facilities that are often used for operational and developmental testing. Table 5.1 provides the names and locations of many of the activities and ranges that have been supporting T&E events since FY2001. Additional information on some of these facilities is provided in Appendix B. The facilities listed in Table 5.1 are cross referenced with key technology areas that are identified in the Defense Technology Area Plan (DTAP), a plan created under the DUSD (S&T) for the purpose of identifying the vision, strategy, plan, and objectives of the DoD S&T. The 12 key technology areas listed in the DTAP are as follows: Air Platforms; Battlespace Environments; Biomedical Technology; CB Defense Technology: Ground and Sea Vehicles; Human Systems; Materials/Processes; Information Systems Technology;

Nuclear Technology; Sensors, Electronics, and Electronic Warfare; Space Platforms; and Weapons technology. Alignment of S&T technologies with T&E Investments will be an important step in achieving the overall goals and objectives of the T&E community.

Table 5.1
Non-MRTFB DoD Test and Evaluation Activities

Non-MRTFB DoD Test and Evaluation Activities	Test Capabilities and Infrastructure Supporting Specific Weapons Systems and Technology Areas
Air Force	
Buckley AFB, CO	Space Platforms
Ellsworth AFB, SD	Air Platforms
Air Force Space Command, Los Angeles AFB, CA	Sensors/Electronics/EW, Space Platforms, Weapons Systems
Hanscom AFB, MA	Battlespace Environments, Information Systems Technology, Sensors/Electronics/EW
Kirtland AFB, NM	Air platforms, Battlespace Environments, Biomedical, Chemical Biological Defense, Human Systems, Information Systems Technology, Materials and Processes, Nuclear Technology, Sensors/Electronics/EW, Space Platforms, Weapons Technology
Lackland AFB, TX	Information Systems Technology
Tinker AFB, OK	Air platforms, Biomedical, Human Systems, Materials and Processes, Sensors/Electronics/EW
Warner Robbins AFB, GA	Air platforms, Sensors/Electronics/EW, Weapons Technology
Wright-Patterson AFB, OH	Air platforms, Battlespace Environments, Biomedical, Chemical Biological Defense, Ground Vehicles, Human Systems,

	Information Systems Technology, Materials and Processes, Sea Vehicles, Nuclear Technology, Sensors/Electronics/EW, Space Platforms, Weapons Technology
Army	
Aviation Technical Test Center, FT Rucker, AL	Air platforms, Human Systems, Materials and Processes, Weapons Technology
Redstone Technical Test Center, Redstone Arsenal, AL	Weapons Technology, Air Platforms, Human Systems
Fort A P Hill, VA	Ground Vehicles, Human Systems
Fort Bliss, TX	Information Systems Technology, Sensors/Electronics/EW, Weapons Technology
Fort Bragg, NC	Air platforms, Ground Vehicles, Human Systems, Materials and Processes, Information Systems Technology
Fort Hood, TX	Air platforms, Battlespace Environments, Chemical Biological Defense, Ground Vehicles, Human Systems, Information Systems Technology, Sea Vehicles, Weapons Technology
Fort Knox, KY	Ground Vehicles
Fort Leonard Wood, MI	Ground Vehicles, Human Systems, Weapons Technology
Fort Sill, OK	Ground Vehicles, Information Systems Technology, Weapons Technology
Hawthorne Army Depot, NV	Chemical Biological Defense, Weapons Technology
NTC, Fort Irwin CA	Battlespace Environments, Human Systems, Ground Vehicles
Adelphi Laboratory Center, MD	Ground Vehicles, Information Systems Technology, Weapons Technology
Fort Belvoir, VA	Sensors/Electronics/EW
Fort Eustis, VA	Air platforms

Fort Monmouth, NJ	Air platforms, Ground Vehicles, Information Systems Technology, Sensors/Electronics/EW
Picatinny Arsenal, NJ	Materials and Processes, Sensors/Electronics/EW, Weapons Technology
Rock Island Arsenal, IL	Materials and Processes, Weapons Technology
Navy	
NAS Fallon, NV COMNAVAIRSYSCOM	Air Platforms
Keyport, WA	Chemical Biological Defense, Human Systems, Material and Processes
MCMWTC, Bridgeport, CA	Human Systems, Ground Vehicles
NAS Key West, FL	Air platforms, Battlespace Environments, Ground Vehicles, Human Systems, Information Systems Technology, Material and Processes, Nuclear Technology, Sea Vehicles, Weapons Systems
NAVSURFWARCENDIV, Dahlgren, VA	Biomedical, Chemical Biological Defense, Human Systems, Information Systems Technology, Materials and Processes, Nuclear Technology, Sea Vehicles, Weapons Technology
VACAPES, VA	Air Platforms, Battlespace Environments, Chemical Biological Defense, Ground Vehicles, Human Systems, Information Systems Technology, Nuclear Technology, Sea Vehicles, Sensors/Electronics/EW, Space Platforms, Weapons Technology
NAVSURFWARCENDIV, Panama City, FL detachment	Biomedical, Human Systems, Information Systems Technology, Material and

	Processes, Sea Vehicles, Weapons Technology
AEGIS_TECHREP, Moorestown, NJ	Sea Vehicles, Information Systems Technology, Weapons Technology
COMNAVUNSEAWARCEN, Newport, RI	Human Systems, Information Systems Technology, Materials and Processes, Sea Vehicles, Sensors/Electronics/EW, Weapons Technology
Naval Ammunition Depot, Colts Neck, NJ	Weapons Technology
NAVSURFWARCENDIV, Indian Head, MD	Materials and Processes, Weapons Technology
NAVAIRWARCENACDIV, Lakehurst, NJ	Air platforms, Sensors/Electronics/EW,
NAVHLTHRSCHCEN, San Diego, CA Brooks City-Base, TX	Biomedical, Chemical Biological Defense, Human Systems, Materials and Processes
NAVORDTESTU, Cape Canaveral, FL	Nuclear Technology
NAVSURFWARCEN, CARDEROCKDIV, Bethesda, MD	Materials and Processes, Sea Vehicles
NAVSURFWARCEN_CARDEROCKDIV_ BETHESDA_MD at Bayview, ID	Sea Vehicles
NAVSURFWARCEN_CARDEROCKDIV_ BETHESDA_MD at Dania, FL	Sea Vehicles
NAVSURFWARCENDIV, Corona, CA	Air platforms, Ground Vehicles, Information Systems Technology, Materials and Processes, Sea Vehicles, Weapons Technology
NAVSURFWARCENDIV, Crane, IN	Chemical Biological Defense, Materials and Processes, Weapons Technology
NAVSURFWARCENDIV_CRANE_IN at Fallbrook, CA	Weapons Technology
NAVSURFWARCENDIV_INDIAN_HEAD _MD, Seal Beach, CA	Weapons Technology
NAVSURFWARCENSHIPSYSENGSTA, Philadelphia, PA	Information Systems Technology, Materials and Processes, Sea Vehicles
NAVUNSEAWARCENDIV_KEYPORT_ WA at Waianae, HI	Chemical Biological Defense, Materials and Processes, Sea Vehicles,

	Sensors/Electronics/EW, Weapons Technology
NAVUNSEAWARCENDIV_KEYPORT_WA, San Diego, CA	Chemical Biological Defense, Human Systems, Materials and Processes, Sea Vehicles, Sensors/Electronics/EW, Weapons Technology
NCTSI, San Diego, CA	Information Systems Technology
NSWC CARDEROCK DIV DET, Memphis TN	Sea Vehicles
SPAWARSYSCEN, San Diego, CA	Battlespace Environments, Information Systems Technology, Sea Vehicles, Chemical Biological Defense, Biomedical, Ground Vehicles, Human Systems, Materials and Processes, Sensors/Electronics/EW, Space Platforms
SPAWARSYSCEN, Norfolk, VA	Battlespace Environments, Information Systems Technology, Sensors/Electronics/EW, Space Platforms
SPAWARSYSCEN, Charleston, SC	Chemical Biological Defense, Information Systems Technology, Sensors/Electronics/EW
SURFCOMBATSYSCEN, Wallops Island, VA	Information Systems Technology, Sensors/Electronics/EW, Weapons Systems
USN Bremerton, WA	Sea Vehicles
USN Norfolk/Portsmouth, VA	Chemical Biological Defense, Information Systems Technology, Sensors/Electronics/EW
USN Pensacola FL	Chemical Biological Defense, Information Systems Technology, Sensors/Electronics/EW
NAVSURFWARCENDIV, Port Hueneme, CA	Weapons Technology, Sensors/Electronics/EW, Sea Vehicles
VA Beach, VA	Human Systems, Information Systems Technology, Sea Vehicles, Weapons

	Systems
Missile Defense Agency	
Joint National Integration Center (JNIC) Missile Defense Agency, Colorado Springs, CO	Space Platforms, Weapons Systems
Kodiak Launch Complex (KLC), AK	
Marines	
CG_MAGTF_TRNGCOM, 29 Palms, CA	Marine Corps Live Fire Combined Arms Training
CG_MCB_CAMPEN, Camp Pendleton, CA	Chemical Biological Defense, Information Systems Technology
MCAS, Beaufort_SC	Marine Corps Air Squadrons and Expeditionary Force
MCAS Yuma, AZ	Marine Corps Air-to-ground Aviation Training

5.3.3 Other Test Facilities

The Department of Defense relies primarily on its organic ranges and facilities to meet its T&E requirements, but capabilities that exist within other U.S. government agencies, commercial industry, and foreign countries can be used. The Department has long-standing agreements with NASA, DOE, and DOT to use their wind tunnels, nuclear effects, and automotive test facilities among other capabilities. Through the Program Executive Officer (PEO) community, the Department is constantly taking advantage of commercial T&E capabilities to provide data for acquisition program decision-making. Additionally, there is a plethora of multi-national programs and agreements concerning the coordination and adoption of international test standards and procedures, data and technology exchange, and mutual cooperation that the Department fully endorses and

actively supports. Provided below is a sampling of these capabilities that will be further evaluated in future strategic plans.

5.3.3.1 Other US Government Test Facilities

5.3.3.1.1 NASA

Following World War II, Congress established the aeronautical test infrastructure at NASA and AEDC.[2] These facilities were built to complement one another with the intention that the NASA facilities would be used primarily for research and the AEDC facilities primarily for developmental testing. This model changed over the years, and DoD dependence on the NASA facilities for development has grown. Within NASA, the primary wind tunnel facilities are located at Langley, Ames, and Glenn Research Centers. Today these centers are involved in all aspects of aerodynamic and thermodynamic testing with varying capabilities distributed among them. The facilities at Langley Research Center have broad testing capabilities covering subsonic to hypersonic speeds with a major focus on research rather than developmental testing. Glen Research Center also has broad speed range capabilities, however, their focus is primarily on aeropropulsion research testing. Lastly, the Ames Research Center has three large facilities for subsonic, transonic, and supersonic testing, all of which are used primarily for developmental testing.

Historically, DoD has relied upon NASA to fund the institutional costs of these test facilities and defense programs paid only direct costs for use of a facility. However, in 1997, NASA moved to a full cost recovery policy which significantly increased DoD's cost to test at NASA facilities. The higher cost of NASA test facilities has caused defense programs to increasingly rely on sub-scale testing, use overseas test assets, or reduce testing, all actions that increase risk to DoD.

In the spring of 2003, NASA announced that, unless sufficient workload materialized to allow the facility to operate on a self-sustaining basis, the National Full-Scale Aerodynamic Complex (NFAC) located at Ames Research Center would be closed after September 2004 because it was no longer needed in NASA. The NFAC is a unique full-scale test facility and critically important to DoD's advanced rotor and rotorcraft testing. Without NASA funding, DoD decided in the FY2005 budget review, to allocate the necessary funding to maintain the NFAC and provide the necessary investment for

[2] Public Law 81-415: Unitary Wind Tunnel Plan Act of 1949 (50 U.S.C. 511-515) and the Air Engineering Development Center Act of 1949 (50 U.S.C. 521-524)

NFAC to continue to support rotorcraft test needs. The Air Force has the lead for implementing the action and included the NFAC in the FY2006 Defense budget.

In a memorandum dated February 4, 2005 from the Aeronautics Research Mission Directorate, NASA Headquarters to the research centers at Dryden, Glenn, Langley and Ames, NASA announced the formation of the Aeronautics Research Mission Directorate's (ARMD) Corporate Management of Facilities, a management approach to streamline the management and funding of the major aerodynamic, aerothermodynamic, and aeropropulsion ground test facilities[3]. The approached centered on NASA's FY2007 programming guidance which established five categories of facilities:

Category I. Facilities with substantial ARMD program usage forecasted

Category II. Facilities that NASA (other than ARMD), DoD, and industry require now or may require in the future to carry out research and to develop vehicles

Category III. Facilities that are currently not required but are viewed as part of a robust ground test capability

Category IV. Facilities that are not utilized and/or not viewed as components of future ground test capability

Category V. Facilities that are not utilized and/or not viewed as components of a future ground test capability.

On February 10, 2005, NASA informed DoD that because NASA's fiscal year 2006 budget was consistent with the President's goals of implementing the Vision for Space Exploration and reducing the national deficit, and the ARMD's move to the corporate management of test facilities, a large number of aeronautical test facilities used by DoD could be significantly impacted by reduced budgets[4].

Congress, through conference report House Report 108-767 accompanying the FY2005 NDAA, directed the USD (AT&L) "to identify and analyze aeronautics facilities currently managed by NASA that are considered by the Department to be critical to the accomplishment of defense missions and to the maintenance of U.S. leadership in aeronautics." DoD is conducting an 8-month study, led by TRMC to provide the information and analysis necessary to delineate the NASA capabilities critical to DoD. The results of the study will provide DoD officials with the requisite information to determine which NASA aeronautical test capabilities are critical to the defense mission.

[3] NASA Aeronautics Research Mission Directorate letter to Dryden Flight Research Center, Glenn Research Center, Langley Research Center, and Ames Research, February 4, 2005.

[4] NASA Aeronautics Research Mission Directorate letter to Mr. John Manclark, HQ USAF/T&E, February 10, 2005.

5.3.3.1.2 Department of Energy

The Department of Energy (DOE) T&E capabilities are largely related to their Nuclear Weapons program responsibilities. Overall it manages through its Washington DC headquarters 13 field and operations offices, 20 laboratories, 14 facilities, and 5 special purpose offices. Many of these world-class labs and facilities provide direct, indirect or tangential support to defense RDT&E needs. Following are key DOE assets whose capabilities are highlighted for their potential contribution to national defense in the areas of nuclear weapons, conventional and non-conventional warfare and defense related energy resource needs.

5.3.3.1.2.1 The Nevada Test Site (NTS)

NTS is located in a remote area 65 miles north of Las Vegas and is adjacent to the Nellis Air Force range complex. It is a massive outdoor laboratory and experimental center that is approximately 1,375 square miles in area making it one of the largest restricted access areas in the United States. Further, it is the United States' only remaining capability to support nuclear testing and major experiments involving Special Nuclear Materials (SNM) or related hazardous materials. It often has been used to support experimentation, testing and training for DoD systems. The site has been withdrawn from the public domain and authorized to support a variety of functions including, conventional weapons testing, gunnery range, hazardous chemical spill testing, emergency response training, and waste management and environmental technology study support. Its boundary and security areas are guarded, and the area is isolated from population centers.

5.3.3.1.2.2 The Idaho National Engineering Laboratory (INEL)

INEL is located in a sparsely populated sector of southeastern Idaho. The eastern boundary of INEL is 23 miles west of Idaho Falls. The site covers 571,000 acres (893 square miles). INEL was established as the National Reactor Testing Station. It contains the largest concentration of nuclear reactors in the world. Presently, only the Advanced Test Reactor (ATR) and the Advanced Test Reactor Critical Facility Reactor (ATRC) are operating. Although INEL is mainly focused on applied engineering, it supports naval reactor RDT&E programs and also performs work in the areas of non-proliferation and other national security activities. INEL conducts a variety of advanced scientific research and development projects in support of other government agencies, such as the Federal Aviation Administration and the U.S. Air Force. Specific research and development areas

include lasers, organic and inorganic chemistry, biotechnology, genetics, geosciences, material science, physics, and environmental science.

5.3.3.1.2.3 Argonne National Laboratory (ANL)

ANL, located near Chicago IL, is operated by the University of Chicago for the DOE Office of Science. Argonne research falls into five broad categories:

1. Basic science: Includes experimental and theoretical work in materials science, physics, chemistry, biology, high-energy physics, and math and computer science, including high-performance computing.
2. Scientific facilities: Includes the design, construction, and operation of sophisticated research facilities too expensive for a single organization to maintain.
3. Energy resources: Includes the development of advanced batteries and fuel cells, as well as advanced electric power generation and storage systems.
4. Environmental management: Includes researching alternative energy; environmental risk and economic impact assessments; hazardous waste.
5. National Security: Includes the development of instruments and technologies to detect chemical, biological and radioactive threats and identify their sources. Also includes detecting and deterring weapons proliferation or attacks.

Two key laboratories located at ANL having significant defense related RDT&E capabilities are:

1. New Brunswick Laboratory (NBL). NBL develops and maintains state-of-the-art measurement technology with priority given to methods needed for certification of reference materials. Research conducted includes the chemical and instrumental measurement of elemental and isotopic compositions of a broad spectrum of material types. This includes the assay of uranium- and plutonium-containing materials.
2. Ricketts Regional Biocontainment Laboratory (RRBL). RRBL is currently under construction. It is one of nine regional biocontainment laboratories being funded by the National Institute of Allergy and Infectious Diseases, an agency of the National Institutes of Health. Their purpose is to study organisms important to national biodefense efforts as well as those causing emerging infectious diseases. RRBL will become a Regional Center of Excellence for Biodefense and Emerging Infectious Disease Research.

5.3.3.1.2.4 Oak Ridge Operations (ORO)

ORO is responsible for major programs in science, environmental management, assets utilization, and uranium programs. These programs are carried out at facilities located in Oak Ridge, Tennessee; Paducah, Kentucky; Portsmouth, Ohio; and Newport News, Virginia. ORO provides support to national security activities managed by the National Nuclear Security Administration. The majority of its programs are performed at facilities located on the 33,750-acre Oak Ridge Reservation in East Tennessee. The Oak Ridge facilities include the Oak Ridge National Laboratory (ORNL); the Y-12 National Security Complex; and the East Tennessee Technology Park. Science Programs with the most DoD potential are performed at ORNL and Thomas Jefferson National Accelerator Facility (Jefferson Lab). At ORNL, researchers focus on basic and applied research. Jefferson Lab accelerates electrons for use as a probe to study the structure of matter. Oak Ridge's National Security mission is performed at the National Nuclear Security Administration's Y-12 National Security Complex. This includes manufacturing, reworking and dismantling nuclear weapon components, serving as the secure storehouse of special nuclear materials, reducing the global threat from terrorism and weapons of mass destruction, and providing the Navy with nuclear propulsion systems.

5.3.3.2 US Commercial Test facilities

A significant number of US commercial test facilities support developmental testing of DoD acquisition programs. These capabilities will be evaluated in future strategic plans.

5.3.3.3 International Test Facilities

Allied and friendly countries outside the United States having significant military capabilities and a defense industrial base generally maintain a highly capable and sometimes unique supporting T&E infrastructure. It may be appropriate to consider supplementing U.S. T&E capabilities through use of these foreign assets. Overseas however, ownership and control of T&E infrastructure differs markedly from the U.S model. This complicates ensuring the security of classified, sensitive and proprietary data that may be collected through use of a foreign T&E facility. For example, in the United Kingdom, government owned T&E facilities are largely contractor operated. In Japan T&E is mainly conducted within the industrial base that then holds a proprietary interest in the collected data. Israel uses both industry and government owned facilities but often the personnel associated with the Defense ministry are also are employees of Israeli defense industries. Countries in Europe have also partnered to build world-class quasi private/government facilities that compete for international T&E business. Following are

some of the overseas T&E facilities that could be used to augment U.S. defense needs on a case-by-case basis.

5.3.3.3.1 European Transonic Wind tunnel GmbH

The European Transonic Wind tunnel GmbH is a company founded by four European national aerospace research establishments from the UK, Germany, France and the Netherlands. The objective of the company is to operate, maintain and further develop a world-class high Reynolds number transonic wind tunnel facility. It provides high quality wind tunnel test data at actual cruising flight Reynolds numbers of modern transport aircraft and is open to clients from all over the world.

5.3.3.3.2 SCIROCCO Plasma Wind Tunnel

The SCIROCCO Plasma Wind Tunnel, erected at CIRA, the Italian Aerospace Research Center in Capua, Italy, has been jointly funded by ESA and the Italian Ministry for University and Research. This test facility is reputed to be the largest of its kind in the world featuring a large electrical segmented 70 megawatt arc heater and a nozzle with a 2 meter diameter exit to allow full-scale models of space-vehicle thermal protection systems to be tested for up to 30 minutes (a period corresponding to the duration of re-entry). The SCIROCCO Plasma Wind Tunnel is to be used to study earth atmosphere re-entry and space-vehicle trajectory. Designed for testing high temperature materials and structures, this wind tunnel can also be used in other fields of aerospace technology development, such as advanced space propulsion and combustion systems.

5.3.3.3.3 Australian Jervis Bay Telemetry Data Acquisition Facility

The Australian Jervis Bay Telemetry Data Acquisition Facility is located near the Eastern Australian coastline and serves as a ground-based telemetry receiving, processing, and display system for testing Royal Australian Navy (RAN) and Royal Australian Air Force (RAAF) missiles which use standard US Military telemeters.[5] Its capabilities include; a Telemetry Data Acquisition Facility whose primary functions include reception, recording, and reduction of Pulse Amplitude Modulated (PAM), Pulse Code Modulation (PCM) and Frequency Division Multiplexing (FM/FM and FM/PM) Telemetry data radiated from telemetry exercise heads used on surface-to-air and air-to-air missiles. Additional requirements relating to system flexibility were also included in the overall facility design. This could allow expansion capabilities with minimal rework, as well as providing capability for operating with other telemetry data sources that utilize PAM or PCM Frequency Division Multiplexing.

5.3.3.3.4 Woomera Prohibited Area

The Woomera Prohibited Area (WPA) which has been set aside by the Australian government for military and civil applications in the state of South Australia is the largest land-based Range in the western world.[5] This electromagnetically quiet range occupying about 127,000 km2 of plateaus, salt lakes and low vegetation enjoys basically unencumbered airspace and dependable and benign atmospheric conditions. Further, the warm, dry climate allows for near year-round operations. The Woomera Instrumented Range (WIR) can be configured to support space, aircraft, air and ground weapons T&E programs. WIR capabilities include, range control, timing, communications, telemetry, tracking facilities, along with surveyed instrumentation emplacements, launch sites, rocket preparation and recovery facilities. Range capabilities include the ability to skin track non-cooperative aerospace vehicles to 300 km. For precision trajectory measurement, a wide variety of optical and video tracking assets can be optimally placed to meet requirements for miss-distance determination, weapons impact scoring, and measurement of space vehicle, aircraft and missile/store behavior. With adequate notice, optical coverage can be extended to meet wider customer needs. Optical assets can also be used to support stack fragmentation, explosives testing and parachute testing. Meteorological sounding services are available to meet program needs. Both fixed and deployable telemetry and Tele-command assets can be re-configured to meet a variety of customer needs. Tele-command systems used to support both space launch and missile/rocket termination can also be arranged with adequate notification.

6.0 TEST INFRASTRUCTURE MODERNIZATION

6.1 OVERVIEW

This chapter provides the analysis required in considering test infrastructure modernization investments and divestitures. The analysis takes into account the national level guidance from Chapter Three, is consistent with the vision, goals and objectives from Chapter Three, uses T&E capability drivers from Chapter Four, and compares needs against the existing T&E capabilities from Chapter Five to determine test capability needs that should be developed. A test capability "need" is a T&E capability that is projected to be required in the future. In addition to the guidance and drivers from the preceding chapters, the analysis uses information from the "*Reliance Area Capabilities Summaries*" (RACS) provided from the Services through the T&E Reliance process. This approach captures the test capability needs to be pursued in response to high level national and DoD strategies and goals, acquisition programs, emerging technologies, Service and Defense Agency planning, as well as from the point of view of the T&E field personnel.

The RACS provide the major source of detailed information, and therefore, this chapter is organized to correspond with the ten Reliance Panels. The RACS-like sections include Air Combat, Sea Combat, Land Combat, Electronic Combat, Space Combat, Armaments and Munitions, C4ISR, Targets, Common Range Instrumentation, and Test Environments. Each section contains an overview and a capability analysis.

The capability analysis identifies test capability needs, provides a trace matrix, roadmaps, test capability gaps, and provides issues and recommendations. A trace matrix provides a link to a program, guidance, or concept drivers that will require such a test capability to be available at some future time that is not currently available and provides a rough estimate of its criticality.

The test capability needs shown in the trace matrix with the corresponding solutions in the roadmaps are categorized into 22 test capability categories. Each trace matrix is broken out into near term (FY2008-FY2012), mid-term (FY2013-FY2017) and far-term (FY2018-FY2022). Roadmaps provide a timeline for solutions to test capability needs and usually cover the development, procurement and sustainment periods to support a need test date for a future program or project. This organization provides a convenient way to group test capability needs by category for future identification. The 22 test capability categories are as follows:

1. General Test Instrumentation
2. Computer Replacement Upgrades
3. Storage Upgrades
4. Radar
5. Global Positioning System (GPS)
6. Telemetry
7. Communications
8. Sensors
9. Modeling and Simulation (M&S)
10. Transducers
11. Calibration
12. Environmental Test Capabilities
13. Shock & Vibration
14. Integrated Distributed Test Capability
15. Multiple Test Capability
16. Aerothermodynamics Test Capabilities
17. Air Breathing Engine Test Capabilities
18. Non-Air Breathing Engine Test Capabilities
19. Nuclear Weapons Effects Test Capabilities
20. Sled Tracks
21. Chemical-Biological
22. Test Support Vehicles

The selection of test capability categories in each section of this chapter is not exact or necessarily consistent since some may cut across multiple categories and judgments must be made on which are most applicable. Some test capability categories may not be used at all for its respective area. However, these test capability categories are a way of grouping needs for future identification.

A numbering scheme is followed that tracks a test capability need to a respective solution in a roadmap. For example the first test capability need noted in the trace matrix under the sensor category for the Air Combat Section would receive the number 2.8.1 (2-Air Combat, 8-Sensors, 1-first need) and for the Space Combat Section would receive a 6.8.1 (6-Space Combat, 8-Sensors, 1-first need). That same number is used in the roadmaps to find the solution for that need. In some instances with multiple solutions, a fourth digit is added (i.e. 2.8.1.2) to track multiple solutions in a Roadmap to the need in the trace matrix. In some cases where multiple solutions exist for a test capability need,

the solution in the roadmap is noted in general terms to reflect that multiple solutions are being pursued. The roadmaps reflect current solutions being developed as well as plans to provide solutions. The roadmaps are to assist with the planning of future T&E capability investments.

A "test capability gap" or "gap" is defined as a test capability need that does not have a roadmap to provide that capability or the capability is provided too late to support a project or program. Each gap will have a discussion of the risk to the intended program or project that the needed test capability is to support. The way ahead is to mitigate gaps in a timely manner with guidance from risk assessments.

The Issues and Recommendations section provides an area where a relevant item may be addressed that is not a typical test capability need, yet it should be addressed.

Significant effort has been ongoing to mitigate the effects of encroachment upon test and training ranges. This includes eleven encroachment limitation components: Endangered Species and Critical Habitat, Cultural Resources, Unexploded Ordnance and Munitions, Frequency Spectrum, Maritime Sustainability, Air Quality, Air and Land Space Restrictions, Clean Water, Wetlands, Noise, and Urban Growth. A part of this effort, an outreach program, is to help educate range managers, their staffs and surrounding communities of DoD initiatives to be good stewards of the lands in their care while attaining and maintaining force readiness. DoD Directive 3500.15, of January 10, 2003: Sustainment of Ranges and Operating Areas (OPAREAS), establishes policy and assigns responsibilities under Title 10, U.S. Code, for the sustainment of test and training ranges and OPAREAS. Encroachment is an area that cuts across many combat areas in the following chapters. Although this is a common concern in many areas, the issues and needs associated with encroachment are repeated in several combat areas where appropriate to that area.

Although this chapter will show where investments should be made, it will focus only on the major T&E capability needs. This was a collaborative effort with our Strategic Planning Working Group, which includes the major T&E stakeholders. A future implementation effort will identify those T&E capability needs and gaps that are deemed critical for future budgets and POM development. This document does not attempt to address or contain all T&E investments and will focus only a subset of T&E capability needs.

6.2 AIR COMBAT

6.2.1 Overview

Air Combat is a broad warfare area that encompasses the planning, provisioning, executing, and reporting of T&E of fixed- and rotary-wing manned and unmanned aircraft throughout the system life cycle. It includes related mission and support systems, and aircraft integration with armaments and munitions, other external stores, sensors and avionics, C4ISR systems (including offboard systems), and other aircraft subsystems, spiral upgrades, and modifications.

The distinctive transformational capabilities derived from the Services' CONOPS which describe air combat missions and functional capabilities are:

- Information Superiority: information-gathering/management functions (such as aerial reconnaissance and air battle management) from various aerial platforms
- Air Superiority: the negation and penetration of enemy air defenses to clear the path for follow-on joint forces. This involves air-to-air and air-to-ground weapons delivery as well as other supporting systems.
- Precision Engagement: the capability to attack and destroy a target with incredible accuracy and minimal ordnance. This area involves air-to-ground weapons delivery, munitions integration and employment and sensor integration.
- Global Attack: long-range attack
- Rapid Global Mobility: the ability to deploy personnel and materiel rapidly.
- Agile Combat Support: strictly speaking, this function does not directly encompass any air combat mission as described previously. Rather, it involves the readiness, training, equipping, and sustainment of air combat forces.

It also warrants mentioning that almost all of these air combat mission areas and functional capabilities also involve "non-aircraft" systems and capabilities such as networked C4ISR for targeting, battle management, damage assessment, and mobility flow.

Today most of the weapons systems to be tested are "legacy" airframes, such as USAF F-15, F-16, F-117, A-10, USN P-3, F-14, and F/A-18, USMC AV-8B, F/A-18, and US Army AH-64, UH-60. Many of these may still require T&E of upgrades in the timeframe of this plan.

Of particular interest to this plan, the air combat missions will migrate in the timeframe of interest to systems being developed (or in some cases just beginning testing or operational fielding) today, such as: USAF F/A-22, F-35, Advanced Mobility Concept Transport Aircraft (AMC-X), Advanced Mobility Tanker (KC-X), USN and USMC F/A-18E/F SuperHornet, and US Army AH-64 Longbow, to name just a few.

In many instances the Air Combat missions and functions discussed here overlap significantly with other combat areas or test infrastructure areas, such as electronic warfare, common range instrumentation, armaments, or targets. Where possible, Air Combat needs have been identified in those other warfare areas, but may also be mentioned here. In particular, significant overlap occurs with the Armaments & Munitions and Electronic Combat Reliance areas.

Air Combat test capability area includes:

- T&E of all types of aircraft and all related mission and support systems including:
  - Total aircraft weapon systems (to include operational tests and evaluations as well as susceptibility and survivability tests).
  - Air vehicles: fixed wing, rotary wing (helicopters), and hybrid (such as tilt-rotor); manned and unmanned
  - Aircraft stores compatibility.
  - Aerial delivery (including transport and tanker aircraft, and transport aerial delivery systems such as parachute airdrop mechanisms)
  - Subsystems or functions (e.g., avionics, engines, flight controls, subsystems integration, etc.).
  - Software changes/updates.
- T&E Support Aircraft, which includes those test support aircraft used primarily for:
  - Data gathering.
  - Range safety.
  - Test control/monitoring.
  - Presentation of specialized test conditions (e.g. threat emitters, icing sprayers, etc.).
  - Large generic test beds.
  - Target Surrogates/generic adversaries and chase/test observation.
  - Specialized adversary support.

- Specialized T&E training (including specially-modified and unique aircraft not available in operational fleets, such as the "VISTA" Variable Inflight Stability Training/Test Aircraft).

6.2.2 Air Combat Test Capability Analysis

The analysis of Air Combat testing capabilities began with a review of the TRMC interim staff's 2003 Strategic Plan and the 2004 Air Combat Reliance Area Capability Summary (RACS) in order to capture a generic flavor for test capability priorities as forecast last year. The individual Service transformation plans as well as various test center and combatant command roadmaps available as of December 2004 were also reviewed to see what the Services projected for their future warfighting capabilities. These were compared to future projections of test capability priorities outlined in briefings and informal discussions with Service flight testing offices.

Finally, specific test base/range upgrade and modernization project data was reviewed in the three Services' inputs to the TRMC March 29, 2004 call for data. This was supplemented by POM-build and various "quad chart"-type documents obtained either through the Services, OSD libraries, or from knowledgeable personnel from the Air Combat Reliance Panel.

The summary list of relevant data sources follows:

- USAF Transformation Flight Plan
- US Army Transformation Roadmap
- Naval Transformation Roadmap
- AF/TE Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources, March 29, 2004" (dated Jul 21 2004)
- DACS-TE Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated 4 Aug 2004)
- DEPSECNAV/RDT&E Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated Jan 25, 2005)
- DOT&E Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated Aug 31 2004)
- HQ AFMC/DO Briefing, " Transforming T&E In the 21st Century", 16 Nov 04
- HQ AFMC/DOF Briefing, "T&E Flight Plan", 3 Dec 04
- US Army ATTC Inputs to Feb 05 Air Combat modernization draft
- AF/TER Orientation Briefing, March 05
- AFFTC Roadmap website

- Air Combat Command unclassified advanced planning roadmap, from HQ ACC/DR website, Dec 04
- NASA Future Aeronautical Research vision from HQ NASA website
- Air Combat Reliance Area Capability Summary, 31 March 2004

Although inputs varied understandably amongst the various Services and data sources, some common drivers emerged for the Air Combat area:

- As more data on emerging threats become available and the cost of weapons systems increases, Modeling and Simulation (M&S) and stimulation capabilities are evolving and becoming more critical to supplement actual "open air" testing. Dedicated test articles/systems under test are decreasing due to cost, limited production runs, or real-world operational needs. Emerging technologies in the areas of "stealth" (low-observable materials and signatures, passive sensors, multi-spectral camouflage and deception) are also driving the limits of M&S.
- As future air weapons systems become increasingly more complex (such as F/A-22 and JSF), system-of-systems test capabilities are also evolving and becoming more critical. Separated facilities are becoming more interlinked as distributed testing of multiple systems in real and virtual environments gains rigor.
- Network Centric Warfare test capabilities. These require extensive communications in a joint environment. For the T&E community, the challenge is developing a robust capability to test a wide variety of networked systems simultaneously, capturing and analyzing an enormous amount of data.
- Advanced artificial intelligence (AI) capabilities. As AI increases and systems without operators become more reliable, we will see a proliferation of in armed combat as well as C4ISR roles. Likewise, an increasing opportunity for "untended" automated range telemetry and tracking systems.
- Hypersonic air vehicles test capabilities. Tracking and telemetry instrumentation improvements are required, as are increased footprints for testing and improved command and control response mechanisms, materials, and structures.

Significant changes have also occurred in recent years in warfighting strategy, aerial employment tactics, and procurement and sustainment strategies that also present unique

challenges (and opportunities) for Air Combat T&E but which are non-technological in nature. Some examples would include:

- Increasing proliferation and availability of foreign-made, highly capable combat aircraft, air-to-air missiles, surface-to-air missiles, and countermeasures.
- Increasing employment of aging, older airborne platforms in new ways not originally envisioned in their design, but which require testing and evaluation of new tactics or upgraded subsystems (for example, B-52s used in Operation Enduring Freedom for battlefield close air support).
- Increasing emphasis on military operations in urban environments will require testing of air combat systems against simulated hidden targets that require high-fidelity realism.
- Increasing use of unmanned air vehicles (UAVs) in various roles, and increase in autonomous UAV flight operations as technology and concepts of operations mature.
- Decreasing frequency spectrum for military use.

6.2.2.1 Test Capability Needs

The programs and concepts presented in Chapter Four for the Air Combat area and input from the various data sources provide the basis for the Air Combat test capability needs.

The main Air Combat test capability needs can be summarized as follows (the numerical indices are for reference only, not necessarily an order of priority):

1. Increased interoperability and connectivity of T&E resources.
    - Testing locations may become increasingly dispersed as bases downsize or as facilities close. Increasingly complex systems-of-systems being tested will also require distributed testing, tying in multiple assets (live, virtual, constructive) at different places.
    - In some instances, large test areas may be needed (see discussion that follows) but unavailable, and will have to be simulated with distributed testing.
    - Improved distributed engineering analysis framework (tools, methods, processes, and distribution network).
2. Larger test areas and encroachment mitigation:

- New or upgraded weapons or aircraft (e.g., hypersonic vehicles, longer-range weapons, etc.) are driving associated increases in weapons-effect footprints, trajectories, and flight paths.
- In other instances, large test areas may be needed simply to simulate the battlespace environment the SUT will be operated in and to allow fully realistic "free play" between the SUT and threats/targets (for example, 200-mile air-to-air intercepts and beyond-visual-range weapons engagements with multiple moving targets).
- This need for more real estate is becoming more critical as sensor fusion, enhanced man-machine interfaces, and other enablers are driving engagement scenarios far beyond the traditional visual range of today's aircrews and current sensors.
- Heightened sensitivities over public safety and environmental issues have also become increasing concerns as population densities encroach upon test base and test range boundaries.

3. Upgraded test facilities to measure situational awareness.
    - Upgrade M&S models and fidelity
    - Network manned simulators real-time with flight test activities and other distributed virtual environments
    - Upgrade & network HITL, SIL, and MF facilities
    - Gather real-time flight test data, correlate with simulations, incorporate closed-loop feedback
4. Improved T&E capabilities to test integrated avionics, such as:
    - Upgraded simulators
    - Upgraded networks and support systems
    - Robust software testing tools
5. Greater sophistication, more interconnections, and improved validations for Modeling and Simulation (M&S).
6. High fidelity, realistic/authentic threats and targets (aerial, surface, and multi-spectral).
7. Ability to gather, store or telemeter significant amounts of inflight data "on or off-range" with minimal range support or minimal test article modification (or none at all).
8. Reliable, upgraded, and available fleet of Test and Evaluation Support Aircraft (TESA). Many of the aircraft in the current TESA fleet are older airframes and are in need of replacement, maintenance overhaul, or systems modernization.

9. A Low-Speed Aerial Artificial Icing Spray System for inflight icing tests of helicopters and other low-speed aircraft.
10. Upgraded infrastructure:
    - Replace aging facilities, hardware, and base support
    - Hire, train, maintain a skilled Air Combat T&E workforce

Table 6.2.1 outlines the traceability and prioritization of these needs. The only need mentioned above that is not specifically traced or prioritized calls for upgraded test infrastructure and skilled manpower. This is a need voiced by many across the T&E community and is not specific to Air Combat. It is also broad in scope and context and therefore was not included in the table, but deserves mention here for emphasis. Concerns relating to overall range modernization and manpower were voiced from several different venues across the Services and from various flight test inputs.

Table 6.2.1 Air Combat Test Capability Traceability and Prioritization

Item #	Test Capability Needs	Test Resource Category	Programs/Concepts Supported	Relative Priority
2.1	General Test Instrumentation			
Near Term				
2.1.1	Upgrade facilities to measure situational awareness (i.e., cockpit simulators, avionics labs, MITL sim facilities, etc)	M&S, MF, ISTF	Reliance Panel Input Airworthiness, avionics integration Joint test and training Tactics development Legacy fighter/attack/bomber ac F/A-22, F-35, EA-18G, AIM-9X, JHMCS UCAV/J-UCAS/UAVs	Low
2.6	Telemetry			
Near Term				
2.6.1	On-board Telemetry w/minimal off-board support	OAR	Airworthiness, Avionics Integration Testing flexibility/efficient use of assets Combined DT&E, OT&E, or training and experimentation events Decrease ground-based range infrastructure Subsystems upgrades to legacy fighter/bomber/attack ac	Medium
Mid Term				
2.6.2	On-board embedded telemetry	OAR	Airworthiness, Avionics Integration, Supportability,	Medium

	without off-board range support, i.e.: onboard "rangeless instrumentation"		Environment, Stores Integration Embedded instrumentation Testing flexibility/efficient use of assets Combined DT&E, OT&E, or training and experimentation events	
2.9	Modeling & Simulation			
Near-Term				
2.9.1	Greater sophistication and interconnectivity of M&S tools	DMS, IL, ISTF	Reliance Panel input Airworthiness, Avionics Integration, Supportability, Environment, Stores Integration Testing flexibility/efficiency Survivability	Medium (High in Far Term)
2.9.2	Improved M&S fidelity and validations	DMS	Reliance Panel input Airworthiness, Avionics Integration, Supportability, Environment, Stores Integration Testing flexibility/efficiency Survivability Classified programs Joint test and training Multiple legacy & future ac programs	Medium (High in Far Term)
2.14	Integrated Distributed Test Capability			
Mid-Term				
2.14.1	Increased interoperability and connectivity of T&E resources	OAR, HITL, SIL, MF, DMS, DMS	Reliance Panel Input Airworthiness, Avionics Integration, Stores Integration	High

			Testing flexibility/efficiency Survivability Classified programs Joint test and training Multiple legacy & future ac programs	
2.15	Multiple Test Capability			
Near/Mid Term				
2.15.1	Improved ability to test integrated avionics systems	DMS, SIL, HITL, ISTF	Reliance Panel input Avionics Integration, Supportability, Stores Integration System upgrades to legacy fighter/bomber/attack/UAV/UCAV ac F/A-22, F-35, EF-18G, F/A-18E/F, M2C2A, MMA, V-22, C-130 AMP, C-5 RERP, JHMCS, MP-RTIP, AHA, B-1, B-2, B-52, Predator, Global Hawk, UCAV	High
Mid/Far Term				
2.15.2	Make larger test areas available/mitigate encroachment	OAR	Airworthiness, Avionics Integration, Supportability, Environment, Stores Integration Large-scale force-on-force joint test and training/experimentation Public safety Hypersonic vehicles Long-range precision-guided munitions Long-range A/A missiles	High

			F/A-22, JSF, Future Bomber, Long Range Strike, cruise missiles, UAVs/UCAVs, YAL-1 (ABL)	
2.21	Test Support Vehicle Assets			
Near Term				
2.21.1	Establish airworthiness maintenance plan for current TESA airframes in use	OAR	Airworthiness, Avionics Integration, Environment, Stores Integration photo chase, safety chase range safety, area clearance surveillance range security classified test programs range systems calibration various ac test programs	Medium
Mid Term				
2.21.2	Low-Speed Aerial Artificial Icing Spray System	OAR	ATTC Input Airworthiness, Environment ATRMP Armed Reconnaissance Helicopter (ARH),, Light Utility Helicopter (LUH), UC-35 UAVs/UCAVs Vertical Heavy Lift Aircraft (VHLA), VXX	Medium
2.21.3	Have high-fidelity, realistic/authentic threats and targets	OAR	Targets discussed in Section 6.9 Supports Avionics Integration, Stores	See 6.9

	(aerial, surface, multi-spectral)		Integration	
Far Term				
2.21.4	Have a family of common airframes (Fixed-wing, Rotary-wing, Lighter-Than-Air) tailorable to various range support missions, for use at all testing locations where needed.	OAR	Extended Range Support for testing in offshore operating areas away from land ranges MDA and Space Test launches Long-range aerial weapons and cruise missile flight test support Drone/aerial target launches range safety, area clearance surveillance range security classified test programs flight termination system monitor/control replace DC-130, NP-3, E-7A, others Supports various Airworthiness, Avionics Integration, Supportability, Environment, Stores Integration testing	Low/ Medium

6.2.2.2 Roadmaps

Table 6.2.2 outlines notional roadmaps in most of the capability areas previously described. In most instances, a Service-specific project is identified which may meet the need. Only those projects applicable to the timeframe in question, with a significant cost (in the neighborhood of $10M or more) are shown for this sampling. The exception would be a unique project not programmed or planned anywhere else or already met by an existing capability (such as the ATTC proposal for a low-speed aerial icing spray aircraft, estimated at about $8.5M). However, the inclusion of these projects in this table should not be inferred as being the only test capability modernization projects endorsed or examined in this analysis.

Table 6.2.2 Air Combat Test Capability Roadmaps

Development Procurement Sustainment

Item # Test Capability	Program/Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
2.1	General Test Instrumentation															
2.1.1 (Related efforts in 2.14 and 2.15)	ATTC/YPG Systems Test & Integration Lab (STIL)															
2.6	Telemetry															
2.6.1	Phase 1 Sample Projects in work: FMRI, MAnTSS, DAIS upgrades, ARDS, DDAS, other pods, etc															
2.6.2	Phase 2: - Standard common system															
2.9	Modeling & Simulation															
2.9.1 (Phase 1) and 2.9.2	NAWCAD Common Interoperable Tools for M&S															

(Phase 2)																
2.14	Integrated Distributed Test Capability															
2.14.1	AFFTC TM Systems Integration & Support															
2.15	Multiple Test Capability															
2.15.2.1	Phase 1: Identify critical encroachment areas															
2.15.2.2	Phase 2: options for acquisition of buffer areas and mitigating T&E capabilities															
2.21	Test Support Vehicles/Assets															
2.21.1	NAWCAD P-3 Replacement Instrumentation															
2.21.2	Low-Speed Aerial Icing															
2.21.3	Targets discussed in Section 6.9															
2.21.4.1	Phase1: AFFTC Extended Range Support (ERS) Platform															
2.21.4.2	Phase 2: Family of common range support airframes															

6.2.2.3 Test Capability Gaps

In almost every area outlined in Table 6.2.2, Service-unique projects are either planned or underway to address those needs to some degree. Likewise, in every case, likely some opportunity exists for interservice collaboration that has not been fully explored. Sufficient time was not available to quantify to what degree each need could be met across each Service by applying the few projects mentioned. In other words, there is no attempt at this time to quantify which needs are "fully met, mostly met, partially met, or barely met" by exactly which projects.

Gaps are identified where the data we examined either pointed to a need without any potential solution, a solution that did not meet the required timeframe, or the data were just insufficient to determine if a viable solution was available. This complexity was further compounded by the large amount of overlap between the various areas and disciplines as mentioned earlier.

We made a cursory risk assessment for each gap. Risk was qualified high, medium, or low in a broad, subjective evaluation according to the following criteria:

1. High Risk:
    - potential for serious effect on flight test program (greater than 25percent increase in cost or schedule/sortie count/test points re-flown)
    - safety of flight issues indicating serious potential hazards (loss of life or property) to flight test mission, base/range populace, or public at large off-range
    - high dollar cost (25percent or more of the overall test program or acquisition program); no solution identified within limits of current resources, or entirely new technology required for mitigation
2. Medium Risk:
    - possible degradation to flight test program (10-to-25percent increase in cost or schedule/sortie count/test points re-flown)
    - safety of flight issues indicating some potential hazards primarily to flight test mission or base/range populace (some loss of life or property possible; potential injury or damage to property; lesser so for public at large off-range)
    - significant dollar cost (10-to-25percent of the overall test program or acquisition program); solutions exist, but some new technology required or existing technology needs adaptation or procurement
3. Low Risk:
    - little effect on flight test program (10percent or less increase in cost or schedule/sortie count/test points re-flown)
    - safety of flight issues indicating possible hazards to flight test mission, base/range populace, manageable with reasonable processes or existing resources

- solutions exist at low or no-dollar cost; use current technology or resources for mitigation

In order of priority, the Air Combat Test Capability gaps thus identified are as follows:
Priority 1: Capability 2.15.2: Larger Test Areas/Mitigate Encroachment: although the roadmap proposes a two-phase study to address this need and various projects are underway that may affect this capability at various locations, there are currently no plans for a comprehensive, MRTFB-wide study to examine this issue. This is also being identified as a gap since there has been no comprehensive study planned or done that has examined the impact to any major test programs, although most test centers have stated this as a need. Furthermore, although many of the other projects examined in our analysis, or discussed in this section, indicate that technologies may be available to mitigate this gap, no study has been planned or conducted to map specific technologies to specific shortfalls justifying the need for larger test areas, nor has any such comprehensive, department-wide study identified specific encroachment issues with corresponding mitigating technologies, policies, or other solutions.

Risk Assessment:

- In the case of most "classical" air vehicle flight test (performance and flying qualities, subsystems integration and specification compliance, basic stores carriage and separation), the risk is assessed as "low to medium" depending upon the SUT. In general, the basic "wringing out" of the aircraft can be accomplished on the ranges as they are currently laid out.
- In the following cases, with more recent advances in technology as alluded to earlier, the risk to aerial flight test programs is assessed as "high":
  - Longer range, longer-endurance UAVs, especially when global ranges necessitate autonomous operations within common-use airspace shared with commercial traffic
  - Hypersonic vehicles operating at extremely high speeds for very long distances
  - Operational tests and evaluations involving large scale force-vs-force missions in large battlespaces (for example, a large scale "Red Flag" style air war scenario to test F-35 systems in a networked air order of battle with supporting aircraft and opposing adversaries)
  - Employment of long-range armaments, munitions, and directed energy weapons whose range may exceed current range space.

Priority 2: Capability 2.15.1: Improved Avionics Test Capabilities: The long pole in many aircraft flight test programs has often been avionics subsystems and software. Moreover, current transformation plans point toward future systems operating within net-centric environments, battlespaces involving concurrent information warfare operations, and more CONOPS using cooperative engagement—all translating to a critical dependence upon aircraft avionics and electronics. Furthermore, as threat systems improve and proliferate, defensive avionics will be critical for self-protection, and the testing of offensive and defensive avionics systems integration on single platforms as well as within networked air battle forces will be key.

Risk Assessment:

- For the near-term, most avionics flight testing will involve regular avionics upgrades to legacy aircraft, integration of new "add-on" subsystems (such as the pods, weapons, sensors), or the preliminary wring-out of newer advanced systems. In this context, the risk is assessed as "low".
- For the mid to far-terms, as legacy platforms give way to transformational, net-centric systems, artificial intelligence-based systems become more prevalent, and manned systems are increasingly supplanted by unmanned systems, the performance of avionics becomes more critical. Even the avionics packages aboard a single platform are being increasingly tasked to perform multiple functions (such as the AESA radars in F-15s permitting simultaneous A/A and A/G attack functions). As stated, many of the planned and currently envisioned test facility modernization projects touch upon these aspects, but are still focused heavily upon upgrades to existing facilities. The risk is assessed as "Medium".
    - Need more large-scale integration between not just facilities at the same test center, or between adjacent bases/ranges, but also between different facilities at widely-dispersed locations and commands (i.e., training ranges and simulators, labs, Combined Air Operations Centers {CAOCs}, contractor simulators and labs)
    - Need to better mix DT&E and OT&E assets where possible, and integrate Live, Virtual, Constructive test, training, and R&D assets into a seamless operating environment where all communities share common data formats and networks
    - Incorporate simulated threats, targets, and supporting forces with actual flight test assets in flight, or vice-versa, to properly stress and assess avionics performance.

6.2.2.4 Issues and Recommendations

Unmanned Aerial Vehicle (UAV) Flight Testing

Issue: Various UAV and UAV-related programs occurring simultaneously across the Services and different agencies have a high potential for driving common or similar test capability needs.

Background: Various discussions have occurred in the department concerning roles and responsibilities with regard to UAVs. A Joint Overarching IPT (OIPT) has been formed to identify and resolve materiel issues and seek common solutions for all Services. A Joint UAV Center of Excellence (COE) has also been established to examine and improve UAV interoperability and use, and will be "an operationally focused organization concentrating on UAV systems technology, joint concepts, training, tactics, and procedural solutions to the warfighters' needs" (DoD News Release No. 693-05, Jul 08, 2005). UAV testing carries many implications for the T&E community:

- Sharing of airspace with commercial air traffic as well as manned test aircraft
- Flight Termination Systems and frequency management/telemetry processing
- TRMC should be involved in Service discussions of UAV requirements and resources. Existing T&E capabilities may need unique upgrades, or brand-new capabilities may need to be established for Service UAV programs or for the new UAV Joint COE.

Recommendation: The Joint UAV OIPT and COE should work with all UAV stakeholders (to include NASA, DHS, and other non-DoD government entities) and TRMC to define and prioritize unique test capability requirements for UAV-type systems.

Overlap Between Air Combat And Space Combat T&E

Issue: As the distinction between "air" and "space" operations diminishes with the progression of technology and new concepts of operations, so too is the need to better integrate the air and space T&E areas. Currently there is very little such integration between the various Services and testing stakeholders in the department.

Background: The 1960s and 70s saw a blending of air and space test with the flight testing of near-space manned vehicles such as the X-15, X-23, X-24

- There has been a recent resurgence of this type of RDT&E within the DoD and NASA as hypersonic weapons are being discussed, along with other aerospace "crossover" vehicles such as X-34, X-40A and X-37. A good example of cross-disciplinary testing was in the 2000-2001 testing of the X-40A, which involved the airdrop and automated return-to-land testing of a winged space vehicle prototype. Although conducted at Edwards AFB under the auspices of a traditional flight test, it involved space test

experts from the Space and Missile Systems Center (SMC) working in concert with NASA and the Air Force Flight Test Center (AFFTC).

- Future systems such as the Common Aerospace Vehicle for the Long Range Global Strike initiative are yet to be designed but could embody aeronautical components, such as a reusable winged booster.
- Space and aeronautical flight-testing needs should be integrated and viewed as a continuum between different commands, ranges, and Services. However, space operations and space testing tend to focus more so on orbital assets and the corresponding launch base and ground support infrastructure.
- Limited steps in this direction have been taken. The AFFTC formed a hypersonics directorate to work cooperatively with NASA Dryden Flight Research Center and other entities on the testing of transatmospheric systems.
- Likewise, Air Force Space Command established the 1st Air and Space Test Squadron (1ASTS) at Vandenberg AFB in 2003 to plan and conduct testing of developmental space systems, including transatmospheric type weapons systems, but AFSPC overall still focuses primarily on its core missions of on-orbit and launch-related operations. T&E efforts within the aeronautical realm as they relate to space-related efforts have often been overlooked.

Recommendation:

- Establish a joint Air and Space Flight Test working group between the Services and other DoD or non-DoD entities (i.e., NASA, DARPA, NOAA, NSSO) to explore areas of common interest and common need with respect to test assets, resources and test capabilities.
- Dedicate institutional T&E or training funding to the Aerospace Vehicles Test Course, a joint venture begun in 2000 between SMC, NASA-Dryden, and AFFTC to teach the fundamentals of flight test to space test personnel. This training has been dependent upon fallout money from various sources late each fiscal year but has lacked any high-level T&E sponsorship.
- Allocate resources (manpower, workspace, institutional funding for travel, overhead, and administrative support for the establishment of air & space liaison functions within the Service test centers without being dependent upon exclusive space or air combat test programs.

Range Support Aircraft:

Issue: The Air Force, Navy, Army, and Missile Defense Agency have similar needs for an extended range support platform to provide range area clearance, range observation, telemetry relay, and other range functions not supportable with ground facilities.

Background: These are needed for both space as well as aeronautical flight testing. This need is currently being filled in part by P-3 Orions within the Navy and, until recently, also in part by the EC-18A Advanced Range and Instrumentation aircraft for the Air Force (which has recently been retired). The Air Force also has an E-7A aircraft for range surveillance on the Gulf Test Range. At other times various TESA are utilized for various range support functions, either taken "out of hide" by the test center, provided by the test customer/program office, borrowed from an operational command, or contracted to a vendor. Missile Defense Agency is also pursuing several modified aircraft designs for various range support functions.

Recommendation: Conduct a cross-Service needs-and-solutions study to determine the feasibility and affordability of pursuing a joint, common, flexible airframe (off the shelf, modified, or new design) or more likely a family of several common designs—that can be tailored for various test range needs. The study should identify the more prevalent types of missions/taskings, the primary capability drivers (such as speed, crewing requirements, payload, range/endurance, loiter time, etc) and the airframe designs available for these types of missions (for example, a high-altitude long-endurance UAV or airship for telemetry relay, range safety clearance and C2; or a high-speed, maneuverable jet for photo/safety chase). If possible, the organization performing the study should also consider whether NASA, DHS, or other federal non-DoD entities could be invited and should participate, and can benefit from (or contribute to) the potential for affordability.

6.3 ELECTRONIC COMBAT

6.3.1 Overview

Electronic Combat (EC) also known as Electronic Warfare (EW) is the subset of military Information Operations (IO) involving the use of electromagnetic and DE to control the electromagnetic spectrum or to attack the enemy across the broad range of radio frequency and optical bands. Electronic Combat capabilities are subdivided into three major categories; electronic attack (EA), electronic protection (EP), and electronic combat support (ES). Electronic Attack (EA) is the use of electromagnetic, directed energy or anti-radiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability. Electronic Combat Support (ES) includes actions to search for, intercept, identify, and locate sources of intentional and unintentional radiated electromagnetic

energy. ES data can be used to produce signals intelligence (SIGINT) for the purpose of immediate threat recognition, targeting, planning and conduct of future operations. Electronic Protection (EP) involves passive and active means taken to protect personnel, facilities, and equipment. EP capability is typically designed to neutralize, degrade, or destroy the effectiveness of enemy weapon systems at the point of the attack. Tools to accomplish these tasks include radio frequency (RF) and Infrared/Ultra-Violet (IR/UV) sensors, RF/IR jammers and expendable countermeasures, DE weapons using high energy laser or high power microwave, and anti-radiation missiles (ARMS).

Joint Vision 2020 emphasizes the need for 'full *spectrum dominance*' to ensure dominant maneuver, precision engagement, and full dimensional protection. Electronic Combat technology provides the capability to electronically "map" the battlespace for strategic and tactical commanders, which provides "*the ability to locate, discern, and track objectives or targets; to employ the best systems available (kinetic or non-kinetic) to achieve the desired lethal or non-lethal effects…*" (Joint Vision 2020). In the future, the Joint Force will operate in an environment that is increasingly complex, uncertain, and dynamic. Employment of asymmetric strategies by potential adversaries and the proliferation of advance weapons and information technologies will create additional challenges on all EC elements of the force.

The following test capabilities support Electronic Combat System development

- Static/Dynamic Signature Measurement Facilities
- System Integration Laboratories
- Hardware-In-The- Loop (HITL)
- Installed System Test Facilities (ISTF)
- Open Air Ranges (OAR)
- Modeling and Simulation
- Threat Representations (Foreign Material Components, Simulators, Surrogates and Models)

6.3.2 Electronic Combat Test Capability Analysis

The data sources that were used in the analysis of Electronic Combat capabilities include:

- Electronic Combat Reliance Area Capability Summary, FY2006 and Beyond
- Tri-Service IR/UV Test Capabilities Study, January 2004
- Tri-Service Directed Energy Test Capabilities Study, Dec 2004
- Threat Systems Management Office, FY2006 POM Information Briefing
- Conventional Engagement Capability Roadmap, Version 0, March 2005

- Navy, Threat Systems FY2005 Mid-Year Review, April 2005
- Army Test and Evaluation Management Agency T&E Investments Memorandum, May 2005
- Air Force FY2006 PB T&E Investments Planning Summary, May 2005

Electronic Combat test capabilities are not keeping pace with rapidly evolving U.S. weapon system technologies and threat capabilities. Open-air range (OAR) and ISTF upgrades are needed to provide the coherent signal environments and threat densities necessary for realistic testing of EC systems that use multi-spectral discrimination or support sensor track fusion. Improved OAR and ISTF capabilities are needed to evaluate our ability to exploit information vulnerability of adversaries and to protect information in friendly decision support systems. This Net-Centric EC environment must account for the possibilities of network intrusion, deception, disruption and various level of fidelity degradation. Increasing use of improvised explosive devices (IEDs), remotely controlled mines, and rocket-propelled grenades (RPGs), as seen in Operation IRAQI FREEDOM, are driving development of countermeasures and protective systems against these weapons.

Commercial frequency deconflicition considerations will demand innovative approaches to jamming C2 and GPS dependent systems under operational conditions. Signature measurement capabilities must be improved to measure ever decreasing Radar Cross Section (RCS) of low observable targets and address DE weapons needs. HITLs must be equipped with current/emerging air and ground foreign material threat hardware components integrated with validated threat models and simulations. Seamless integration/correlation of HITL and OAR data streams is needed to evaluate RF countermeasures performance against modern seeker-aided ground guidance (SAGG) surface-to-air threats. Improved OAR test capabilities are needed to evaluate the end-to-end performance of next generation IR/UV missile warning and directed infrared countermeasures systems. Multi-band missile plume simulators are needed that emulate the attributes of a threat missile engagement from launch through impact. Validated EC-capable models of threat early warning and fire control radars are needed to evaluate the effectiveness of advanced RF jamming systems. Likewise, threat missile models with EC-capable seeker processing logic are needed to test the effectiveness of active and passive defensive countermeasure techniques. Additionally, threat missile plume signature and aero flyout models are needed to support testing of advanced RF/IR self-protection warning and countermeasures systems. (For additional discussion of threat representation T&E requirements see C6.9 “Targets and Threats”)

6.3.2.1 Test Capability Needs

Electronic Combat test capability needs are summarized in Table 6.3.1.

Table 6.3.1 Electronic Combat Test Capability Traceability and Prioritization

Item #	Test Capability Needs	Test Resource Category	Programs/Concepts Supported	Relative Priority
3.8	Sensors			
Near Term				
3.8.1	Improved low observable (LO) radar cross section measurements	MF	Ch4, Sections 4.4.1, 4.4.2, 4.4.6 Classified tri-Service requirements	High
3.8.2	High Energy Laser Target Measurement (reflected energy, irradiance, fluence surface temperature)	MF, OAR	Ch4 Section 4.4.2 Tri-Service Directed Energy test requirements	High
3.9	Modeling & Simulation			
Near Term				
3.9.1	Validated EC capable, threat surveillance and fire control radar models	SIL, HITL, ISTF	Ch4 Sections 4.4.1, 4.4.2, 4.4.4, and 4.4.6 Survivability testing of manned/unmanned aircraft and standoff aerial weapons. FCS, FA/35, JUCAS	High

3.9.2	Validated EC capable, threat missile models	SIL, HITL, ISTF	Ch4 Sections 4.4.1, 4.4.2, 4.4.5, and 4.4.6 Survivability testing of air platforms, land attack weapons. Evaluate performance of advanced self-protection countermeasures. IDECMs, FCS, F-35, JUCAS	High
3.9.3	Virtual EC operating environment with validated threat /friendly electronic order of battle & signal density. Synthetic battlespace should support seamless interaction with Live, Virtual & Constructive entities.	SIL, HITL, ISTF, OAR	Ch4 Sections 4.4.1, 4.4.2, 4.4.3, 4.4.4, and 4.4.7 Future Tri-Service network-centric IO/EC testing. FCS, ACS, Compass Call, F-35, EF-18G BAMS, E-10A	High
3.15	Multiple Test Capability			
Near Term				
3.15.1	High fidelity Hardware-in-the-Loop simulations of semi-active RF and IR guided surface-to-air missile threats.	HITL	Ch4 Sections 4.4.1, 4.4.2, and 4.4.6 Testing of advanced defensive countermeasures F-35 IRCM and RFCM, TADIRCM, J-UCAS, IDECM	High
3.15.2	Multi-spectral EC mission environment. Robust RF/UV/IR scenes with precise band-to-band temporal and spatial synchronous correlation	OAR, ISTF	Ch4 Sections 4.4.1, 4.4.2, 4.4.3, & 4.4.7 Testing of integrated EC suites and multi-spectral sensor track fusion FCS, ACS, F-35, E-10A	High

3.15.3	Validated multi-spectral band air/ground missile plume simulators the accurately represent both temporal and spatial attributes of a dynamic threat missile fly-out	OAR	Ch4, Sections 4.4.1 and 4.4.2 Testing of IR/UV Missile Warning and Integrated RF/IR Defensive Countermeasures Systems LAIRCM NexGen, TADIRCM, F/A-22 Spiral Upgrades, F-35, SIIRCM-CMWS Spiral Upgrades	High

3.15.4	Advanced RF surface-to-air missile threat. Simulators and/or instrumented actual foreign hardware configured for open/closed-loop testing of EC systems	OAR	Ch4 Sections 4.4.1 and 4.4.2 Aircraft – standoff weapon survivability testing, testing of advanced RF countermeasures IDECM P3I, F/A-22 Spiral upgrades, F-35, JASSM P3I	High
3.15.5	Phase coherent RF simulators. (Red Blue, Grey electronic order of battle)	OAR, ISTF	Ch4 Sections 4.4.1., 4.4.2 and 4.4.7 Testing of state of the art precision location and identification systems ACS, ALR-69 (PLAID), F-35 RFCM, EF-18G	High
3.15.6	Seamless integration - correlation of RF threat systems performance data between OAR, ISTF, HITL	OAR, ISTF, HITL	Ch4 Sections 4.4.1 and 4.4.2 Testing defensive countermeasures against SAAG capable surface to air missile RF threats	High
3.15.7	Millimeter Wave Test Capability. High fidelity representations of semi-active and active threat missiles using very high frequency (MMW) RF guidance.	OAR, ISTF, HITL	Ch4 Section 4.4.2 Testing of advanced ECM against a new class of threats	High
3.15.8	Validated representations of HPM threat. (sources)	OAR	Ch4 Section 4.4.2 Live Fire survivability testing against advanced Directed Energy (HPM) threats	High

6.3.2.2 Roadmaps

Table 6.3.2 highlights key Electronic Combat development and sustainment activity. Although the roadmap does not provide a complete picture of all Service and CTEIP funded programs, it does provide a representative view of projected improvements to current T&E capabilities.

Table 6.3.2 Electronic Combat Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
3.8	Sensors															
3.8.1	National Radar Cross Section Test Facility Upgrades (Air Force)															
3.8.2	HEL Target Measurement (CTEIP)															
3.9	Modeling and Simulation															
3.9.1	Air Warfare Mission Simulator (Air Force)															
3.9.2	Digital Integrated Air Defense System Upgrade (Air Force)															
3.9.3	Threat- Integrated Electronic Warfare Environment (Army)															
3.15	Multiple Test Capability															
3.15.1	Air Force Electronic Warfare Evaluation															

3.15.6	Simulator Upgrades (Air Force)															
3.15.2 3.15.5 3.15.6 3.15.7	Installed Test Integration Program (Air Force)															
3.15.5 3.15.6	Advanced Air Warfare Test and Evaluation Capability (Air Force)															
3.15.4	Advanced Threat Simulator-Next Generation I-32 (Navy)															
3.15.4	Long Range Threat Simulator (Navy)															
3.15.1 3.15.3	IR/RF Response (Navy)															
3.15.3	Reactive Plume Simulator (Navy)															
3.15.1	Advanced Imaging Infrared Seeker(Navy)															
3.15.3	IR Airborne Intercept End-Game Evaluation System (Navy)															
3.15.7.	Millimeter Wave Seeker (Navy)															
3.15.2	Advanced Electronic Order of Battle (Army)															
3.15.8	HPM Sources (CTEIP)															

6.3.2.3 Test Capability Gaps

6.3.2.3.1 IR/UV End-to-End Testing

Current test capabilities do not support realistic OAR testing of state of the art missile attack warning systems that account for both temporal and spatial attributes of a threat missile in flight. Multi-spectral band missile plume simulators are needed for both OAR and ISTF applications that can accurately represent dynamic threat missile flyouts including the flight path divergence that occurs when the incoming missile is defeated. Although Service and CTEIP projects are developing ground and airborne simulators that should significantly improve installed system testing of missile warning and directed IR countermeasures systems. None of the current concepts have yet demonstrated they can support end-to-end installed system performance evaluation under operationally representative conditions, including free-play defensive maneuvering.

Risk Assessment: Current/projected open-air missile plume simulator shortfalls reduce confidence that IR/UV missile warning system capabilities demonstrated during test are truly representative of installed system performance in actual warfighter use.

6.3.2.4 Issues and Recommendations

None

6.4 LAND COMBAT

6.4.1 Overview

Land Combat addresses the systems and vehicles that fight on the ground. For purposes of this plan, Chemical and Biological systems are considered part of land combat. Traditionally, land combat includes direct fire and indirect fire weapons systems, command and control systems, combat support, and combat service support systems. The fundamental mission of land combat forces is to close with and destroy the enemy. Since September 11, 2001, however, the traditional battlefield located on foreign soil has expanded to include the United States and its territories. Terrorist threat incidents such as car bombings and suicide bombings, though not new tactics, are increasing in frequency.

The ability to move, shoot, and communicate is a decisive factor on the modern battlefield. The direct fire component of land combat weapons uses fire, maneuver, and shock effect, synchronized with combat support (CS) and combat service support (CSS) assets to accomplish its assigned missions. When properly supported, our land combat forces are capable of conducting sustained operations against any threat. Critical operational capabilities of direct fire

weapons systems include survivability, lethality, and mobility. The weapons systems must be survivable against threat kinetic energy projectiles, guided and unguided weapons/missiles/bombs, high precision and conventional artillery delivered munitions, and terrorist bombing attempts. Many of the threat weapons can be defeated with basic armor, but improved missiles, new top-attack weapons, and chemical and biological threats often require solutions that exceed weight limitations of our current vehicle fleet. New sensor technologies, countermeasure suites, and signature management techniques have been shown to greatly enhance survivability against the vast majority of threat weapons systems, but survivability remains an issue of highest concern.

Ground combat support (indirect fire weapons) includes artillery units equipped with either field guns such as howitzers or heavy mortars and ground to ground and ground to air missile systems. In battle, the artillery's role is to provide fire support for the infantry, cavalry, armor, and other units directly engaging the enemy. The rocket, missile, and high explosive projectile are the weapons of indirect-fire systems. Operational requirements for indirect-fire systems include destruction, neutralization, and suppression. Destruction puts a target out of action permanently. Direct hits with high-explosive (HE) or concrete-piercing (CP) shells are required to destroy hard materiel targets. Neutralization knocks a target out of action temporarily. It can be achieved by use of any type of shell-fuze combination suitable for attacking a particular type of target. Suppression of a target simply limits the ability of enemy personnel in the target area to perform their jobs.

Combat service support systems encompass those functions, activities, and tasks necessary to sustain all elements of the operating forces. It includes but is not limited to supply, maintenance, transportation, health services, and other services required by ground combat troops to accomplish their mission. The basic mission of CSS is to sustain the battle. The CSS system's sole purpose is to maintain and support soldiers and their weapons systems. CSS operations must focus on sustaining the force as it executes the commander's intent while conducting deep, close, and rear operations. The measurement of sustainment success is the generation of combat power at the right place and time.

The DoD Chemical and Biological Defense Program (CBDP) is a key part of a comprehensive national strategy to counter the threat of chemical/biological (CB) weapons as outlined in *The National Strategy to Combat Weapons of Mass Destruction*, December 2002. The threat from CB weapons is comprised of a complex variety of chemical weapons—including nerve, blood, blister, and choking agents, toxic industrial chemicals, and novel threat agents and biological weapons—including viruses, bacteria, rickettsia, and toxin agents, and potentially novel or genetically engineered agents, as well as emerging infectious diseases. The threat is complicated by the numerous potential means of delivering these weapons, including bombs; spray devices, missiles, or novel delivery devices. In addition, more than 20 nation-states and

several non-state organizations may have or be pursuing CB weapons capabilities that could pose threats to U.S. forces operating abroad or within the United States. The unique physical, toxicological, destructive, and other properties of each type of CB threat requires that operational and technological responses be tailored to the threat and to the diverse requirements of military operations supporting national security and homeland security missions.

The CBDP has in development or procurement a variety of CB defense systems intended to provide U.S. forces with the best available equipment to survive, fight, and win in CB contaminated environments. Systems include:

- *Joint Effects Model (JEM*)- an advanced hazard prediction and effects capability
- *Joint Protective Aircrew Ensemble (JPACE*) - a CBRN protective clothing ensemble intended for use by all military aviators and aircrew for all fixed and rotary wing requirements.
- *Joint Service General Purpose Mask (JSGPM)* - a lightweight protective mask incorporating state-of-the-art technology to protect ground forces from current and future threats.
- *Joint Service Mask Leakage Tester (JSMLT)*
- *Joint Chemical, Biological and Radiological Agent Water Monitor (JCBRAWM)* - a detection system designed to detect chemical, biological and radiological agents in water.
- *Joint Biological Tactical Detection System (JBTDS)* - a light weight biological detector that will detect, warn and collect a sample.
- *Joint Portable Decontamination System (JPDS)* – a decontamination system for immediate and operational use, but may be used to augment thorough decontamination operations.
- *Joint Service Lightweight Integrated Suit Technology (JSLIST)*
- *Joint Warning and Reporting Network (JWARN)* - a warning technology which will collect, analyze, identify, locate, report, and disseminate CB threat information
- *NBC Reconnaissance Vehicle (NBCRV)* – a Stryker vehicle with NBC detection suite integrated into the platform using standoff and point detection. The system is capable of detection identification, and sampling.
- *Joint Biological Point Detection System (JBPDS)* – an automatic, programmable long line source and point/mobile capability to detect and identify bio-agents. Planned upgrades will include an increased number of agents detected and identified with increased sensitivity, lower false alarm rates; reduced size and weight with increased reliability.

- *Joint Collective Protective Equipment (JCPE)* – use the latest technologies in air purification, environmental controls, and power generation to improve and/or standardize current collective protection.
- *Artemis* – an active laser standoff chemical agent detection system.
- *Joint Service Lightweight Chemical Agent Detector (JSLSCAD)* – a standoff sensor/detector that will provide passive, near-real time, on the move, chemical agent vapor detection for contamination avoidance or reconnaissance operations.
- *Joint Chemical Agent Detector (JCAD)* – an improved, all-agent programmable automatic point detection; portable monitor, miniature detectors for aircraft interiors; interior ship spaces; wheeled and tracked vehicles; and individual soldiers.
- *Joint Operational Effects Federation (JOEF)* – an M&S tool used to determine the effects and assess the impact and risks associated with CBRN hazards on military operations.
- *Joint Service Aircrew Mask (JSAM)* – Improved respiratory protection for aviators.

Non-traditional weapons/operations such as chemical/biological attacks; terrorist activities involving airlines, cars, and similar acts such as September 11, 2001, are pushing the department into new technology areas such as long endurance high altitude platforms for homeland surveillance, airborne chemical and biological detectors, border (land, sea, and air) security sensors, low observables such as unmanned aerial vehicles, and electro-magnetic spectrum protection. As these technologies develop, the T&E community will need to modify their infrastructure to support these war fighting and battlefield systems.

The Army is developing a Future Combat System (FCS) that will support rapid engagement and rapid maneuverability. This system of systems will embrace state-of-the-art technology, which will in turn, require state-of-the-art technology for T&E of these systems. This includes not only those systems and subsystems used in mobile, vehicle-oriented operations, but those that support the dismounted soldier.

6.4.2 Land Combat Test Capability Analysis

Transformation efforts are focused on the mobility and agility of ground forces. The Army reoriented its focus to be lighter and more mobile than its current tank and infantry fighting vehicle based units. The centerpiece of this change is the FCS, which is designed to provide a rapidly deployable, highly mobile, lethal land force with the ability to fight on arrival in theater.

Forces will be networked to a system of sensors so that commanders will be able to react and plan in real-time. FCS units will be self-sustaining for limited periods of time, which will reduce the need for an immediate logistics or supply line. These capabilities are designed with the

objective of providing the combatant commanders multiple options in any situation using a single force.

In the Land Combat area, a coherent, focused, T&E modernization strategy is needed to test the transformed force (e.g., the Army's Future Force). A greater emphasis on "systems of systems" testing is required to address the interoperability of all of the components of the transformed land warfare force. A specific concern to the Land Combat community is testing facilities for urban combat operations. Other test area issues include real-time casualty assessment, unmanned ground vehicles, active protection systems, improved data busses, advanced fire control systems testing, and embedded instrumentation.

To increase the mobility and speed up the response time of U.S. troops, the Army, Navy, and Marine Corps are currently experimenting with a commercially developed High Speed Vessel (HSV). Experimentation to date has shown that HSVs are able to move brigades of troops and their equipment at approximately twice the speed of any other sealift vessel. These ships are small enough to allow use in shallow harbors, which means that troops can disembark from more ports. Beyond troop mobility, these platforms are reconfigurable and can be tailored to a wide variety of missions. This concept is being employed by the Navy for its new ship class, the Littoral Combat Ship. Testing the operational concepts of ground forces to utilize HSV type ships represents a challenge to the T&E community.

Communications improvements have already revolutionized the way our forces fight. The department's FY2006/2007 budget continues to support advance technologies which improve and refine the quality and amount of information available to soldiers, and marines on the battlefield. Network Centric Warfare systems will tie real-time intelligence and sensor information, target identification, mission planning and battle damage assessment capabilities together in one place. As the technology develops and evolves, the ability to transmit this information to all forces within range will be possible. Similarly, the Single Integrated Air Picture (SIAP) will correlate radar information from air, ground and sea platforms to create a single radar picture for all forces, allowing for a more complete and accurate rendering of the environment. The testers challenge is to measure and evaluate the capability improvement or degradation of system of systems type programs, i.e. what is the effect on combat effectiveness resulting from the addition or deletion of any component of the system?

Transition to the Future Force will determine the types of systems that will need to be tested. The FCS will use advanced technologies to reduce weight, and increase survivability and lethality. Among the new technologies that will require an associated new test technology or methodology are:

- Area denial weapons
- Non-lethal systems

- New vehicle armament materials
- Precision 'brilliant' munitions, precision guidance munitions
- Electronic gun systems
- Interoperability, digitization, and system-of-system environments
- Enhanced detection, recognition, and combat ID through sensor fusion
- Ballistic body armor, biotechnology, and electronic warfare self protection
- M&S integration of live, virtual, and simulated environments
- Robotics
- MEMS
- Nano-technologies
- Improved and alternative power sources
- Signature management
- Advanced propulsion systems
- Active Protection Systems
- Directed Energy systems

A significant test category within the Land Combat functional area is that of CB defense program testing. Accurate and safe T&E of CB defensive systems remain a challenge. In total, the test facilities possessed by and accessible to the CB defense programs are currently not adequate in terms of capacity over the next decade, given the expanding requirements to test whole systems. A myriad of R&D, component, and simulant capabilities exist, although no standard simulants are available. The test capabilities at R&D facilities do not provide appreciable additions to the total capacity for full system T&E, in that the capabilities are research-oriented and primarily component or materiel focused. The gravest T&E shortfalls lie in the full systems and platform test chambers and supporting instrumentation and fixtures that can introduce and adequately control live chemical and biological agent challenges and provide a range of environmental and challenge conditions to simulate evolving threats, while performing end-to-end systems operations of CB equipment. Shortfalls in instrumentation and methodology to support multiple and diverse concurrent natural environmental, full systems operational tests also exist. Specifically, tests for full systems decontamination capabilities, moving platform biological and chemical long range detectors, and full scale battlefield hazard mitigation of protective ensembles currently do not exist.

CB T&E capabilities currently are not sufficiently versatile to provide full decision support to the commander to address evolving threats, provide advanced technology test systems and methodologies, provide the intellectual infrastructure necessary to maintain a core of expertise to plan for test capabilities and program tests, or provide fully validated characterization data of the

CB battlespace. For the DoD T&E facilities available to support the CB defense programs, there has been no integrated approach to ensure documentation, validation, and repeatability of test procedures in many cases; no basis or mechanism to standardize procedures among labs; and no advanced planning or investment for evolving threats and testing of diverse battlespace conditions and missions. The result is specific, compartmentalized test capabilities and a lack of versatility. Additionally, correlations of agents and simulants and correlation of systems responses to agents and simulants required to support analyses of simulant performance in terms of live agents have not been established.

In the past, the acquisition programs have sponsored expedited applications of existing test capabilities (either in government or commercial facilities) to meet urgent needs. This has often resulted in inadequate or incomplete data for milestone decisions, unsuccessful operational evaluations, increased operational risks, or only partial ability to analyze data. Data analysis was limited because the focus did not include characterization of the underlying physical mechanisms of the CB defense system performance and operational environment, agent-simulant correlations, or development of the required analytical tools and models to provide complete CB defense system performance information to evaluators or commanders. In terms of intellectual capital/personnel resources required to support the CB defense program, the T&E infrastructure is inadequate. As a result of Congressional action consolidating Chem/Bio programs, the current Operational Test Agency (OTA) infrastructure that supports the CB defense program cannot be funded from Service accounts. This hampers the ability of the OTA's to perform early T&E methodology planning and continuous evaluation. The OTA intellectual infrastructure is critical for advanced planning for test capabilities, for adequate testing in terms of scope, threat and scenario types, and for the validation and standardization of test methods to provide robust, defensible data and agent/stimulant/simulant correlations.

6.4.2.1 Test Capability Needs

The advancements in technology integrated into existing or planned weapons systems are also needed in the instrumentation and modeling and simulation tools required to support T&E of these capabilities. Land Combat T&E capability needs consist of:

1. Improved real-time casualty assessment particularly as it applies to non-line of sight and fast moving airborne systems.
2. Measuring performance particularly of dismounted and airborne warriors in urban terrain.
3. Data buses with high transmission rates (up to 500Mb/sec for video systems).
4. New sensor stimulators especially associated with CB simulants.

5. Improved synthetic environments, including hyper-spectral characterization and replication
6. New measurement capabilities comparable to or greater than the capabilities of systems under development such as robotics, hypersonics, and network performance.
7. Protective ensemble testing methodology for CB
8. Embedded instrumentation in systems such as munitions, robotics, vehicular and networks to measure performance.
9. Joint Developmental Testing (DT), Operational Testing (OT), and training instrumentation, and modeling and simulation environments such as common terrain and weather pictures.

Efforts are continuing to identify T&E infrastructure shortfalls critical to the CB defense program and to address evolving threats. Following is a description of activities and capabilities needed to address the full scope of ongoing and planned CB defense program T&E needs:

Whole System Live Agent Testing

Whole System Live Agent Testing (WSLAT) of biological agent point detection systems with live biological agent aerosols is currently conducted only at the subcomponent level, due to size constraints associated with existing aerosol containment chambers. Moreover, whole system testing is conducted solely with biological agent simulants. While the current approaches have met minimum requirements to test and field detectors, more data from WSLAT is needed for sufficient evaluation of detector systems, particularly standoff ones.

CB Field Tests

More than 30 years have passed since the last outdoor test with a live chemical agent, and much of the infrastructure for field-testing of chemical detectors no longer exists or is seriously outdated. A long-range CB field test development effort is underway at Dugway Proving Ground (DPG), to include a safari capability for testing at other domestic and international locations.

Live Agent Test Chamber

A test chamber and validated methods adequate to perform live CB agent testing of active standoff CB detectors is a critical need of the CB defense program. Work with actual agents is necessary for both development and testing to establish the library of algorithms for the system to detect CB agents and to test the efficiency of detection. An active system test chamber for chemical agents is being designed, but a building to house the facility is not programmed for construction. Additionally, there are technical risks associated with the development of this live agent test capability that need to be addressed in order to prevent potential testing delays of active standoff CB detectors.

Protective Ensembles and Equipment

Test methods are required to address emerging threats, including non-traditional agents (NTAs), toxic industrial materials (TIMs), and dusty agents across all commodity areas. A critical requirement exists for a whole system live agent CB ensemble test supported by modeling to allow integration of toxicological data into valid estimates of casualty predictions. Whole ensemble testing is currently conducted with one simulant that has been determined to be safe for human use. Methodology studies are needed to characterize physical properties affecting protection and to understand the interactions among variables that affect protection in order to link all the tests in an analysis and model to predict hazard levels in order to optimize CB ensemble design and deployment. There is no established, quantifiable correlation between the simulant leakage and that of either chemical or biological agents, nor among protection test data and toxicological hazard data. For both individual and collective protection equipment testing, fixtures used to test swatches of material for leakage against chemical agents are outdated and were not designed to represent field wear conditions. Fixtures are technologically feasible and have been designed that contain new sample cells to more accurately sample the air behind the protective material, provide dynamic subsystem tests, and enable tests to characterize the effects of high winds on system protection. However, funding is required to develop and validate these new fixtures.

Decontamination Testing

The testing of decontaminants and decontamination systems is hampered by the lack of any acceptable simulants for field-testing and training and lack of agent-simulant correlations. Due to the unique qualities of chemicals and biological material, even within the same family, no two chemicals or biological materials will always act the same way when exposed to the same decontaminant or environment. Decontamination is a physical process that will depend upon the exact chemical or biologic present. Testing is currently conducted with small components or panels of hardware in test chambers. While whole systems are tested with simulants, this testing is inadequate, since the correct level and type of contamination cannot be realistically presented. The Multipurpose Chamber at DPG was designed for this type of testing, capable of testing up to helicopter and fighter jet-sized test items. Unfortunately this chamber is completely scheduled with detector testing and unavailable until FY2010 or later, when CB detector test facilities are completed. The decontamination pad used at Dugway Proving Ground was contaminated in the 1980s with C8 Emulsion decontaminant. The area is a Solid Waste Management Unit regulated under Resource Conservation and Recovery Act. This limits the type and quantity of

testing that can be done there. This pad needs to be replaced with an environmentally sound system that will collect all run-offs.

Simulants and Agent Characteristics

Agent/simulant correlations are a cross-commodity testing need in the CB defense program. Also in this category are test chambers and methods for NTAs, aerosol chemical agents, testing with TIMs (chemical and biological), new ground-truth sampling systems, realistic threat chemical and biologic dissemination and characterization, surface sampling methods, and an acceptable contact hazard model based on actual data.

Animal Research Facilities

Animal test research that supports the CB defense program requires work with chemical surety materials and will require an increase in scope to support specific hazard definition and protective ensemble performance. Simulant research cannot accurately predict biomedical outcomes of chemical warfare agents. By federal law chemical surety materials, including dilute agents must be under DoD/Department of the Army control. The animal research test facilities at the Army's Edgewood Chemical and Biological Center (ECBC) must be augmented to meet these requirements.

Updating CB T&E Infrastructure

Test infrastructure for other CB defense program systems in development meet minimal testing requirements, but in most cases are outdated, incapable of a high degree of reproducibility or precision, or otherwise inadequate to meet current schedule or quality requirements for operational evaluations or commanders' guidance. Most testing currently performed is neither as operationally relevant, nor based on actual threat scenarios as the warfighters require. The development of all CB defense program materiel—from detectors, individual protective gear, and decontaminants—require test validation against actual chemical warfare agents (CWAs) in systems validated with animal models. Inhalation exposures are the most likely exposure route for volatile CWAs and a likely route for weaponized agents. Such exposures, to either vapor or aerosol forms of CWA, require specialized equipment found in few areas of the world and require expert personnel to supervise and run the exposure trials. At a minimum, expertise is required in inhalation toxicology, analytical chemistry and respiratory physiology. An inhalation agent testing capability has been firmly established at the Edgewood Chemical and Biological Center in accordance with all DoD safety, surety, security and Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) requirements and in compliance with Good Laboratory Practices (GLP) in the new state of the art Life Sciences Research facility.

The programs and concepts identified in Chapter Four for the Land Combat area and input from various relevant data sources provide the basis for the Land Combat test capability needs traceability shown in table 6.4.1. For purposes of this plan, Land Combat analysis is divided into the following test capability categories:

- General Test Instrumentation
- Radar
- Telemetry
- Communications
- Sensors
- Modeling and Simulation
- Integrated Distributed Test Capability
- Chemical and Biological Defense

Table 6.4.1 Land Combat Test Capability Traceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Relative Priority
4.1	General Test Instrumentation			
Near Term				
4.1.1	Performance measurement of dismounted and airborne soldiers in an urban environment	OAR	ATRMP Chapter Four, 4.4.3 Land Warrior and Future Force Warrior systems Battlefield digitization Clothing and Individual Equipment	High
4.1.2	System of system aviation testing and determination of optimum man/machine interface	HITL	ATRMP Chapter Four, 4.4.1, 4.4.3 All Army aviation systems FCS UAV's	High
4.1.3	Improved test data management enabling rapid conversion and visualization	MF	ATRMP Chapter Four, 4.4.3 All LOS/NLOS systems	
4.1.4	Real Time Casualty	MF	ATRMP	High

	Assessment common for test and training		Chapter Four, 4.4.3 Mobile Instrumentation for Operational testing/training of all Army systems	
4.1.5	Synthetic environment replication for full motion and vibration testing	HITL	ATRMP Chapter Four, 4.4.3 All Army missile systems	High
4.1.6	Synthetic environments	OAR	ATRMP Chapter Four, 4.4.3 All Army aviation and UAV systems	High
4.1.7	Modernization and improvement of Test Facilities	All	ATRMP Chapter Four, 4.4.3, 4.5, 4.6 All Army systems	High
4.1.8	Embedded Instrumentation	All	ATRMP Chapter Four, 4.4.3 As feasible for all systems	High
4.4	Radar			
Near Term				
4.4.1	Modernization and technology improvements of test range instrumentation	OAR	ATRMP Chapter Four, 4.4.3, 4.4.9 All systems (airborne and missile) requiring tracking of multiple objects with increased	High

			sensitivity	
4.4.2	Data management, analysis and display	MF	ATRMP Chapter Four, 4.4.3, 4.4.9 All airborne and missile systems	
4.6	Telemetry			
Near Term				
4.6.1	Accurate TSPI for future systems with kinetic energy velocities, small RCS, and low flat trajectories	MF	ATRMP Chapter Four, 4.4.3, 4.4.9 All hypervelocity systems	High
4.6.2	Range modernization and technology upgrades	MF	ATRMP Chapter Four, 4.4.3, 4.4.9 All systems requiring precision TSPI information	High
4.7	Communications			
Near Term				
4.7.1	Mobile instrumentation for support of distributed testing in remote areas	MF	ATRMP Chapter Four, 4.4.3, 4.4.6, 4.4.7 Patriot THAAD MLRS	High
4.7.2	High speed data collection and dissemination	MF	ATRMP, Chapter Four, 4.4.1	High

			FCS, HMMWV FMTV All Aberdeen Test Center tests	
4.7.3	Network performance and integration of joint systems	MF	ATRMP Chapter Four, 4.4.3, 4.4.6, 4.4.7, 4.5 System of system networks and weapon performance FCS Theater air and missile defense systems	High
4.8	Sensors			
Near Term				
4.8.1	IR sensor stimulation Low cost repeatable environment	ISTF	ATRMP Chapter Four, 4.4.1, 4.4.2, 4.4.3 FCS, Aviation and Future Force systems with IR and FLIR sensors.	High
4.8.2	Multi-spectral missile/munition sensor stimulation and advanced environmental simulation	HTIL	ATRMP Chapter Four, 4.4.2, 4.4.3, 4.4.6 NLOS/LOS Javelin Medium Range Munition Tank Extended Range Munition-KE	High

4.8.3	Dynamic IR scene projection	ISTF	ATRMP Chapter Four, 4.4.1, 4.4.2, 4.4.3 Improved Target Acquisition Systems LOSAT All FLIR systems	High
4.9	M&S			
Near Term				
4.9.1	Integrated test suite for simulation, stimulation, and test monitoring for Field Artillery systems	MS	ATRMP Chapter Four, 4.4.3 FCS	High
4.9.2	Test tools to plan an execute live and simulated environments for Intelligence and Electronic Warfare systems	MS	ATRMP Chapter Four, 4.4.2, 4.4.3 FCS DCGS-A ACS ASAS Prophet T-UAV	High
4.9.3	Synthetic environment for C4I Blue and Red forces	MS	ATRMP Chapter Four, 4.4.3, 4.4.8 FBCB2 ABCS	High

4.9.4	Operational Testing instrumentation suite integrating live, virtual, and constructive simulations into realistic test scenarios	MS	ATRMP Chapter Four, 4.4.3, 4.4.8 FCS All future and Objective Force systems	High
4.9.5	Synthetic environments to stress Systems under Developmental Test	MS	ATRMP Chapter Four, 4.4.3, 4.4.8 All systems undergoing Developmental test	High
4.14	Integrated Distributed Test Capability			
Near Term				
4.14.1	Integrated testing of systems of systems. Virtual and distributed environments for Aircraft electronics	IL	ATRMP Chapter Four, 4.4.1, 4.4.3 All Army aviation system FCS DoD Rotary wing and UAV programs	High
4.14.2	Realistic environment with adequate loading of operational architectures suitable for operational test	IL	ATRMP Chapter Four, 4.4.3, 4.4.8 FCS All Army systems under Operational Test	High

4.14.3	System of System Test of Network Centric programs	IL	ATRMP Chapter Four, 4.4.3, 4.5 FCS	High
4.21	Chemical and Biological Defense			
Near Term				
4.21.1	Chemical and Biological stimulant development and correlation	MF	Chapter Four, 4.4.3 JBPDS JCBARWM JBTDS NBCRV-Stryker	High
4.21.2	Chem/Bio standoff detector test capability	OAR/MF	Chapter Four, 4.4.3 Artemis	High
4.21.3	Chem/Bio point detector test capability	OAR/MF	Chapter Four, 4.4.3 JPBDS JCBARWM JBTDS JCAD JSLSCAD	High
4.21.4	Water Monitoring Test Capability	MF	Chapter Four, 4.4.3 JCAD JSLSCAD	High

4.21.5	Full System Decontamination Test Capability	OAR/HITL	Chapter Four, 4.4.3 JPDS	High
4.21.6	Collective and Individual Protection Test Capability	MF	Chapter Four, 4.4.3 JCPE JSLIST JPACE JSGPM JSAM	High

6.4.2.2 Roadmaps

Table 6.4.2 illustrates Roadmaps that provide a timeline for solutions to test capability needs and cover the development, procurement and sustainment periods for the T&E projects to support future programs or projects. The roadmaps represent major projects programmed to improve Land Combat T&E infrastructure. It is not an all-inclusive listing.

Table 6.4.2 Land Combat Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term						Mid Term					Far Term			
		08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
4.1	General Test Instrumentation															
4.1.1	Joint Warfighter Test and Training Suite															
4.1.2	Reconfigurable Cockpit Simulator															
4.1.3	Quantitative Visualization															
4.1.4	Operational Test Tactical Engagement System															
4.1.4	One TESS															
4.1.5	Large Capacity 6DOF Motion Replication															
4.1.6	Helicopter Icing															

	Spray System															
4.1.7	Test Technology and Sustainment Instrumentation															
4.1.8	Embedded Instrumentation Suites															
4.4	Radar															
4.4.1	Advanced Digital Radar Suite															
4.4.2	RF Imaging System															
4.6	Telemetry															
4.6.1	Hypervelocity Advanced Mobile TSPI System															
4.6.2	Enhanced Range Application Program Integration (ENRAP)															

4.7	Communications															
4.7.1	Digital Network Migration															
4.7.2	Fiber Optic Network II--ATC															
4.7.3	Joint Interoperability Test Analysis Capability															
4.8	Sensors															
4.8.1.	Mobile IR Scene Projector															
4.8.2	Advanced Multi-Spectral Sensor and Sub-system Test capability platform															
4.8.3	Dynamic IR Scene Projector P3I															
4.9	M&S															

4.9.1.	Fire Support Automated Test Suite (EXCIS)															
4.9.2	Intelligence M&S for Evaluation (IMASE)															
4.9.3	Simulation Testing Operations Rehearsal Model (STORM)															
4.9.4	OTC Analytic, Simulation and Instrumentation Suite (OASIS)															
4.9.5	Virtual Proving Ground															
4.14	Integrated Distributed Test Capability															
4.14.1 .	Systems Test and Integration Lab															
4.14.2	Synthetic															

	Environment Integration Test															
4.14.3	ATEC Test Integration Network (ATIN)															
4.14.3	21st Century Network Architecture for Distributed Testing															
4.21	Chemical and Biological Defense															
4.21.1	Simulant Development and Agent Correlation															
4.21.2	Chem/Bio Standoff Chamber Test Capability															
4.21.3	Chem/Bio Point Chamber Test Capability															
4.21.4	Water															

	monitoring Test Capability															
4.21.5	Full System Decontamination Test Capability															
4.21.6	Collective and Individual Test Capability															

6.4.2.3 Test Capability Gaps

The CBDP has received a large infusion of funding to address the known test resource requirements and currently programmed efforts should address nearly all known shortfalls. A live agent test chamber adequate to perform live CB agent testing of active standoff CB detectors remains a significant shortfall. Additionally, program risk remains relatively high as many of the newly funded programs rely on unproven technologies.

6.4.2.4 Issues and Recommendations

Issue: An extremely difficult challenge the Services have is the modernization and sustainment of instrumentation that supports T&E for spiral development and P3I weapons system programs. As software is upgraded on weapons systems, the T&E community must also upgrade the instrumentation and modeling and simulation capabilities to support T&E of these changes. Sustainment of these capabilities can be costly if there is limited use of the instrumentation and M&S facilities. Additionally, minimal workforce with the requisite qualifications must be sustained to ensure the fidelity of T&E capabilities.

Recommendation: Services review policies regarding responsibilities for test asset software development, maintenance, upgrade and compatibility to ensure adequate, timely, and cost effective test resources are available to support spiral development acquisition programs.

Issue: DoD must have the T&E infrastructure to adequately stress systems in a large battlefield environment. Furthermore, modeling and simulation T&E capabilities must be available to augment this battlefield as well as interconnectivity of T&E ranges that support numerous battlefield environments. FCS is the first land combat system required to test in a systems of system battlefield environment. The Army Test and Evaluation Command's (ATEC) Test Integration Network (ATIN) instrumentation program is being developed to support this capability. Continued support of this initiative by the Army and OSD is critical across the POM years to build and sustain this capability. With the slip of FCS fielding to FY2014, the Army must continue to maintain the development of this effort to ensure the capability is developed not only to support FCS systems of system testing, but also to support interim and future weapon systems.

Recommendation: Army reviews its policy and procedures for transitioning test assets developed by acquisition program managers to institutional T&E accounts.

Issue: Although the CBDP has recently received increased emphasis and has been the recipient of a large increase in funding, the resulting improvement in CB test resources will only be achieved with an ambitious and aggressive development program. Technical and schedule risk for that development remains high.

Recommendation: The Army, as the T&E executive agent for CB programs, carefully monitor the development and acquisition plans for programmed CB test resources to ensure effective and timely execution and provide the TRMC updated roadmaps on a periodic basis.

6.5 SEA COMBAT

6.5.1 Overview

Because of the literally global breadth of the Sea Combat mission, the associated T&E capabilities to a degree unlike any other must be able to encompass and support the testing of systems that are employed in major elements of all anticipated warfare environments. Furthermore, such forces must be prepared to deploy and employ their systems from probably the most rugged of all naturally hostile environments; the sea, including the air over it and the area below its surface. Many of these systems must also be capable of employment over land in the air and on or against the ground. Some must even be capable of use in space. The last 20 years has seen the lessening of a credible blue-water threat, but this decline has been offset with the commensurate increase in littoral threats.

6.5.2 Sea Combat Test Capability Analysis

As articulated in Chapter Four, naval force structure is undergoing significant change. This transformation fuses the concepts, capabilities, and core competencies articulated in the Navy's Sea Power 21 vision and the Marine Corps' capstone concept Expeditionary Maneuver Warfare (EMW) into the Naval Operating Concept for Joint Operations (NOC). The NOC provides the foundation by which naval participation in the development of joint concepts can be built upon. This also has increased the level of scrutiny that must be paid to the Marine Corps portion of the T&E equation. The Navy’s transformation strategy hinges upon the development of future joint warfighting concepts that describe how the Navy - Marine Corps team will operate as an integrated sea combat force from now through FY2020 in a joint and multinational environment.

The relevant data sources that were used in the analysis of T&E capabilities needed for Sea Combat are as follows:

- Navy Doctrine Publication 1
- Navy's Service vision Sea Power 21
- Marine Corps' capstone concept Expeditionary Maneuver Warfare
- Naval Operating Concept for Joint Operations (NOC)
- Naval Transformation Roadmap 2004

- November 2003 Future Testing Requirements of the Department of Defense - Report to Congress
- DOT&E 2004 Annual Report
- ACAT I-IV USN & USMC List
- DON - Navy Working Capital Fund (NWCF) FY2005 Budget Estimates

Reliance Area Capabilities Summary on Sea Combat

- Sea Combat capabilities currently either under development or being conceptualized are driving significant planned updates to the supporting T&E infrastructure. These capabilities are analyzed and developed almost entirely through the Navy's various systems commands.
- Naval Air Systems Command (NAVAIR) oversees all programs related to aircraft, avionics, air-launched weapons, electronic warfare systems, cruise missiles, unmanned aerial vehicles, launch and arresting gear, training equipment and facilities, and all other equipment related to Navy and Marine Corps air power. Many but not all of these capabilities are addressed under other areas within this plan such as Air Combat and munitions.
- Naval Sea Systems Command (NAVSEA) is the Navy's central activity for designing, engineering, integrating, building and procuring U.S. Naval ships and shipboard weapons and combat systems. Most of the Sea Combat capabilities addressed in this section falls under NAVSEA's responsibility.
- Space & Naval Warfare Systems Command (SPAWAR) develops and delivers the U.S. Navy and Marine Corps operating forces Command, Control and Communications electronic systems. A primary focus has been on undersea surveillance and space systems programs. SPAWAR is the Navy's Battle Force architect, a new area aimed at designing total systems for the forces instead of individual platforms and weapons. Again, many but not all of these capabilities are addressed elsewhere in this plan.

Within the context of the limited scope of this sea combat section as described in the preceding overview, the key drivers effecting T&E infrastructure are grouped here around major U.S. Navy seaborne platforms or systems programs specifically associated with their outfitting. These programs include but are not limited to the DDX, Littoral Combat Ship, SSN-774, and CVN-21. U.S. Marine Corps amphibious warfare capabilities although an extension of sea combat are for purposes of this plan covered under the "Land Combat" section. T&E capability

categories that will either be acquired or undergo major upgrading in support of planned Sea Combat programs include the following:

- Time-Space-Positioning Information Instrumentation
  - Embedded, Fixed and Mobile
  - Range and Rangeless
  - Air, Land, Sea or space based
- Sensors
  - Acoustics (to include active, passive and ship signature)
  - RF
  - Transducer
  - Optical
- Scoring Systems
- Range safety
- Test article control systems
- Information Display systems
- Threat representations
  - Targets
  - Electronic
- Modeling & Simulation
- Specialized test conditions (environmental; RF, heat/cold…); geographic; sea locale, deep, shallow, surface, littoral
- System of systems test capability
  - Joint
  - Inter Sea Combat
- Test beds
  - Generic - e.g. Self Defense Test Ship
  - Specific – e.g. aircraft launch & recovery systems

6.5.2.1 Test Capability Needs

For Strategic Planning purposes, such capabilities exist, have been planned for, or will be necessary to support the following acquisition program areas:

- All associated weapon and weapons countermeasure systems including associated fire control systems (excluding those that are classified or associated with electronic warfare)
  - Missile systems (excluding associated missile type)
    a) Strategic

    b) Anti air (surface or subsurface launched)
    c) Anti surface (surface or subsurface launched)
  - Gunnery systems (large and small caliber) (excluding associated projectiles)
  - Chemical
  - Electrical
  - Directed Energy (excluding those that are classified)
  - Torpedo systems (excluding associated torpedo type)
  - Surface launched Depth charge systems (excluding nuclear and the associated projectile/charge)
  - Mine launching systems (excluding air dropped)
  - Mine sweeping (excluding aviation systems)
- All associated sensor systems (excluding those that are classified or associated with electronic warfare or intelligence gathering)
  - Radar
  - Sonar
  - Magnetic
  - Visual (Electro-Optical)
  - Marine mammal
- All platform related C3 systems (excluding those that are classified, associated with electronic warfare or intelligence)
  - Battle Group Combat Direction Systems (including the Advanced Combat Direction System)
  - Ship Combat Control Systems
  - Warfare engagement systems (including ship self-defense systems)
  - Combat Systems Engineering and Integration systems
  - Communication systems
    a) Internal communications
    b) Short/medium range (VHF/UHF/underwater/Light associated)
    c) Long range (satellite/ HF/LF)
    d) Antennae design
- Navigation systems
  - GPS
  - Inertial
  - Depth finder
- All warfare specialty craft (manned surface and submersible)
    - Amphibious craft (excluding those covered in land combat)

- Unmanned underwater vehicles
- Submarine rescue systems
- SEAL team delivery

- Small boats (rigid, inflatable, combinations and life rafts)
- All naval surface and subsurface vessels systems and subsystems or functions (e.g., hull, mechanical and electrical)
  - Hull forms
  - Armor protection systems
  - Detection suppression systems (IR, Radar, magnetic, camouflage)
  - Rudders and stabilizers
  - Propellers
  - Propulsion (other than nuclear)
  - Engineering auxiliary equipment (other than nuclear associated)
    (a) Generators
    (b) Power distribution
    (c) Pumps
    (d) Distilling systems
    (e) Environmental protection
  - Ship Controls
  - Damage control
  - Deck systems
    a) Aircraft launch and recovery systems
      i. Large deck systems (CVA, LHA)
      ii. Midsize decks (Amphibious ships)
      iii. Helo capable (Cruiser/Destroyer)
      iv. Auxiliaries (Sealift Command's Naval Fleet Auxiliary Force)
    b) Amphibious well deck systems
    c) Underway replenishment systems
    d) Mooring and boat handling systems
    e) Salvage systems
- Diving and underwater salvage and repair
  - Self contained and tethered gas systems
  - Diving support equipment
  - Underwater salvage and repair systems
- Logistics support, stowage and handling systems
  - Combat stowage (rapid offload, as needed)

- Long term stowage (environmental systems)
- Cargo handling
  a) Port facilitated
  b) Self-supporting off/on-loading
  c) Over the beach
- Software changes/updates

New or upgraded T&E needs associated with the four Sea Power Pillars and MDAP programs found in the Sea Combat section of Chapter Four are reflected in Table 6.5.1. These capabilities do not currently exist but are being planned for in the near, mid and far term.

Table 6.5.1 Sea Combat Test Capability Traceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Priority
Near Term (2007 – 2012)				
5.1.1	Realistic and validated threat representation(s) of conventionally powered submarines	Targets	LCS, SSN-774, DDX	High
5.1.2	High fidelity surface target representations *Also See note at end of table	Targets	LCS, DDX, CVN-21	Medium
5.1.3	Enhanced Underwater Magnetic signature Classification	UWR	All ship classes, Future mine warfare systems	Medium
5.8.1	Enhanced underwater littoral/shallow water range T&E capabilities to support: Active/passive/ship signature acoustics Air, surface & underwater tracking Weapons impact scoring Non-acoustic sensor development	Under Water Range (UWR)	Combat systems associated with LCS, SSN-774, DDX, current combatant upgrades, UUV, Mine Warfare, Special Warfare, Marine mammal	Medium
5.9.2	Affordable and validated tool for testing raid annihilation probabilities	DMS	Ship Self Defense Systems	High
5.14.2	Robust Battle Group level Net-centric test systems that span in real time, air, surface and sub-surface war combat domains	DMS IL HITL ISTF	Combat systems and system of systems associated with all future ship classes and current ship class upgrades	High

5.14.3	Integrated T&E capability to support lethal and non-lethal weapons systems testing for ship self defense	SDTS DMS ISTF	All ship classes	High
5.14.4	Joint Command & Control interface test capability including ability to test FORCEnet integration with GIG-BE especially with regard to Information Assurance and latency	DMS IL HITL ISTF	All Sea Combat associated C2 systems including FORCEnet that interface directly or indirectly with Joint C2 systems/system of systems	High
5.15.1	Systems that will employ high capacity electrical power generating sources	MF HITL ISTF OAR	CVN-21 DDX and future ship classes employing electric drive	High
5.15.2	Advanced Gun System/Long Range Land Attack Projectile test bed	DMS MF IL HITL ISTF OAR	DDX	High
Mid Term				
5.9.1	Validated environmental models that replicate Sea Combat conditions in which the: Detect/Identify/ Track Decide/Task/Relay	DMS	CVN-21, LCS, DDX and future combatant classes	High

	Engage/Attack/Assess sequences can be tested			
5.9.3	Validated capability for replacing live explosive shock testing of vessels	DMS	All future ship classes	High
5.14.1	Extended open sea range space for safe firing and impact of gunnery weapons	Open Sea Range (OSR)	ERGM, Electromagnetic rail gun	Medium
Far Term				
None identified				

For Sea Combat Aerial Targets needs, see Section 6.9

6.5.2.2 Roadmaps

Analysis of Table 6.5.1 coupled with other pertinent documents yields roadmaps by which the Navy plans to meet these Test Capability Needs. These roadmaps are visually depicted in Table 6.5.2.

Table 6.5.2 Sea Combat Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
5.1	General Test Instrumentation															
5.1.1.	Realistic and validated threat representation(s) of conventionally powered submarines AAGSS 555 Dolphin Swedish SSK lease as required															
5.1.2	High fidelity surface multi target scoring & control instrumentation related to 40M Patrol Craft 80M MST Replacement															
5.1.3	Enhanced Underwater Magnetic signature Classification															
5.8	Sensors															
5.8.1	Enhanced underwater littoral/shallow water range T&E capabilities to support:															

	Active/passive acoustics Air, surface & underwater tracking Weapons impact scoring Non-acoustic sensor development														
5.9	Modeling & Simulation														
5.9.1	Validated environmental models that replicate Sea Combat conditions in which the: Detect/Identify/ Track Decide/Task/Relay Engage/Attack/Assess sequences can be tested														
5.9.2	Affordable and validated tools for testing raid annihilation probabilities														
5.9.3	Validated capability for replacing live explosive shock testing of vessels														
5.14	Integrated Distributed test Capability														
5.14.1	Extended open sea range space for safe firing and impact of gunnery weapons RIR-716 (modernization) Advanced Range Data System EnRAP														
5.14.2	Robust Battle Group level Net-centric test systems that span in real time, air, surface and sub-														

	surface war combat domains DDX CVN-21															
5.14.3	Integrated T&E capability to support lethal and non-lethal weapons systems testing for ship self defense															
5.14.4	Joint Command & Control interface test capability including ability to test FORCEnet integration with GIG-BE especially with regard to Information Assurance and latency															
5.15	Multiple Test Capability															
5.15.1	Systems that will employ high capacity electrical power generating sources															
5.15.2	Advanced Gun System Projectile test bed															

6.5.2.3 Test Capability Gaps

There are currently no identifiable Sea Combat capability gaps. However, the issues and recommendations section delves into some noted issues, with respective recommendations which if unresolved could become future gaps.

6.5.2.4 Issues and Recommendations

Issue: Large area littoral/shallow water T&E capabilities

Background: The Navy, although possessing ranges in a variety of shallow littoral regions, does not currently have the capability anticipated as needed to conduct instrumented, distributed littoral/shallow surface and underwater T&E for planned ship classes over large, operationally representative areas.

Recommendation: TRMC initiate action to evaluate whether the Navy's current strategy will effectively resolve the issue in sufficient time to preclude this from becoming a gap by the next plan iteration. The evaluation should be completed prior to the FY10 POM submission but not later than March 07.

Issue: Multiple small craft test capabilities

Background: There is a concern on whether the Navy has a supportable plan for adequately testing ship selfdefense systems against small craft swarm attack tactics. There are three elements to this issue:

1. Characterizing the size and capability of a small craft swarm raid
2. How to adequately conduct range control scoring against the swarm raid
3. Design/availability of target control instrumentation for controlling a small craft swarm raid.

Recommendation: Following the release of a detailed intelligence analysis of what constitutes a threat representative small craft target and associated numbers to simulate "swarm" attacks the TRMC will coordinate action to evaluate the Navy's strategy to control and score small craft swarm raids. The evaluation should include any interim fixes, M&S alternatives and funding estimates in order to mitigate potential gaps. The evaluation should be coordinated with the applicable acquisition programs and delivered prior to the next POM submission.

Issue: Testing shipboard systems that will employ high capacity electrical power generating sources

Background: A number of future sea combat systems such as electro-hydraulic aircraft launch and recovery systems are expected to utilize advanced sea-going high capacity electrical power generating technologies. It is not fully evident from current documentation what T&E

support systems or approaches are needed to aid in fielding such advanced new technology systems. These systems however are all in a pre-MDAP status.

Recommendation: The leadtime before potential new T&E capabilities may be needed provides a sufficient cushion for conducting a more cogent evaluation of the Navy's plans with regard to this issue. The TRMC will initiate action to evaluate and determine whether the Navy's current strategy will effectively resolve the issue in sufficient time to preclude this from becoming a gap by the next plan iteration. The evaluation should be delivered before the FY2010 POM submission but not later than July 07.

6.6 SPACE COMBAT

6.6.1 Overview

Space Combat encompasses the planning, execution and reporting of T&E of spacecraft development, space ground control and user equipment, launch vehicles, ballistic missile defense development and missiles (nuclear/conventional/intercontinental and interregional/offensive and defensive).

- T&E of all Space Combat mission areas is supported by the following capabilities:
    - Eastern and Western Range Spacelift Launch Facilities
        - Launch pads
        - Launch vehicle assembly areas
        - Launch vehicle fueling and storage containers
        - Payload test, assembly and integration areas
        - Range Tracking, Telemetry and Commanding (TT&C), C2
        - Area surveillance and flight safety abilities
        - Data reduction and analysis
    - Ground Testing Capability for spacecraft development which support the
        - Space environment chambers
        - Rocket propulsion cells
        - Limited Hypersonic wind tunnels
        - Reentry simulating arc heaters
    - Portable test support platforms
        - Aircraft that provide portable telemetry, Flight Termination System (FTS) and Range Safety
        - Limited range ships with portable tracking and FTS capability
- T&E of the CS mission area is supported by the following capability
    - Space Test and Training Range

    - Integrated Distributed Test Capability
- T&E of the BMD mission area is supported by the following capabilities
    - Pacific BMDS Testbed
    - Space and Missile Defense C2/Sensor Facilities
        - Integrated as part of the live test and M&S capabilities
        - Transportable test support assets
        - Other deployable assets
        - Aircraft that provide portable telemetry, FTS and Range Safety
        - Limited range ships with portable tracking and FTS capability

6.6.2 Space Combat Test Capability Analysis

The relevant data sources that were used in the analysis of T&E capabilities needed for Space Combat are as follows:

- Air Force Space Command Strategic Master Plan, FY2006 and Beyond
- Advanced Range Technologies Working Group Report, AFSPC & NASA, March 2004
- Space Combat Reliance Area Capability Summary
- The USAF Transformation Flight Plan
- MDA/TE Letter dated 27 May 2004
- Lt. Gen Obering, USAF, Prepared Testimony to Strategic Forces Subcommittee, SASC, 4/7/2005
- High Speed/Hypersonic T&E Infrastructure Roadmap (CTEIP study-draft), March 2005

Based on the data sources reviewed, the future Space Combat development efforts will include the use of high-speed communication links with Transformation Communications, hypersonic glide vehicles (CAV) or ORS vehicles and interceptor missiles flying at long ranges and over the horizon/space multispectral sensitive sensors with long range ability. All of these Space combat developments are tied together in a net-centric design concept that ties sensors, engaging elements, ISR assets and Command authorities to provide battlespace awareness. This will push the need for greater interoperability and data fusion to support time critical targeting. Of course this will influence the T&E capability needs to provide a longer range capability for test, improved T&E communications and a portable test capability to support global testing as just a few of the new T&E capability needs.

In addition, space development program schedules include the Operational Responsive Spacelift (ORS) IOC date of 2018 which launches the Common Aero Vehicle (CAV) and the initial ORS small hybrid concept vehicle with testing to begin in 2010. The ORS medium lift testing will begin in 2015. The ORS will drive quick turnaround times for space lift ranges and mandate a Responsive Launch and Test Range (RLTR) to begin development in 2018 with FOC in 2020.

The BMDS program development efforts occur in two year blocks, during which testing is a vital part of that knowledge-based decision process for fielding a BMDS capability in a given block. It is expected that the first THAAD unit will be deployed in the 2008 timeframe. The Multiple Kill Vehicle (MKV) upgrade to the GMD program will provide increased effectiveness against countermeasures and will start some demonstration testing in the 2008 timeframe. Also the Kinetic Energy Interceptor (KEI) program was recently restructured to focus on a technology demonstration test of the land based concept in the 2011 timeframe. The Pacific Range Support Team (PRST) is a major test program coordination asset utilized to facilitate BMDS testing. The recent program focus to extend BMDS in a global fashion will push for testing beyond the initial testbed developed for the Pacific into possibly the Atlantic Ocean.

Our analysis of the Space Combat warfare area is divided into the following test capability categories:

- General Test Instrumentation
- Radar
- GPS
- Telemetry
- Communications
- Sensors
- M&S
- Integrated Distributed Test Capability
- Multiple Test Capability

6.6.2.1 Test Capability Needs

The programs and concepts presented in Chapter Four for the Space Combat area and input from the various relevant data source provide the basis for the Space Combat test capability needs shown in Table 6.6.1.

Table 6.6.1 Space Combat Test Capability Traceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Relative Priority
6.1	General Test Instrumentation			
Near Term				
6.1.1	Advanced command and control capabilities for spacelift test ranges to perform testing on hypersonic and ORS space vehicles at extensive distances from launch Note: This capability could be developed in parallel with 6.6.1 test capability for portable telemetry capability	OAR	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS Med Lift/MDA Block 12/RLTR Development/Hypersonics	High
Mid Term				
6.1.2	Space based command and control capability	OAR	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS Med Lift/MDA Block 16/RLTR Development/Hypersonics	Medium
6.4	Radar			
Near Term				
6.4.1	Upgrade MMW Radar Transmitter at Reagan Test Site in order to increase	OAR	Ch4, section 4.4.5 MDA Block 8 Testing	High

	detection range and resolution of the radar.			
6.4.2	Transportable instrumentation radar to track large numbers of objects at extended ranges	OAR	Ch4, section 4.4.5 MDA FBX-T and THAAD radar development testing	High
6.5	GPS			
Near Term				
6.5.1	Utilize miniature GPS receivers and translators for space systems and environments	MF	Ch4, section 4.4.5 Air Force Transformation Flight Plan ARTWG Roadmap, March 2004 RLTR Development/ORS Med Lift	Medium
6.6	Telemetry			
Near Term				
6.6.1	Portable telemetry capability that can deploy aboard a global hawk or airship Phase I: Data rates greater than 20Mb/s-50Gb/s at ranges greater than 2K miles Phase II: Data rates greater than 50MB/s-1 GB/s at 2K miles	OAR	Ch4, section 4.4.5 Air Force Transformation Flight Plan ARTWG Roadmap, March 2004 MDA KEI Program, ORS CAV	High
6.6.2	Next Generation Satellite TT&C that modernizes obsolete TT&C equipment	OAR	Ch4, section 4.4.5 SBIRS, AFRL RDT&E Satellites, Milstar, SBR	High
Mid Term				
6.6.3	Space borne telemetry Phase I: Data rates of 50MB/s-1GB/s	OAR	Ch4, section 4.4.5 Air Force Transformation Flight Plan	Medium

	Phase II: GIG and IP6 based telemetry		ARTWG Roadmap, March 2004 ORS Medium Lift, Hypersonics Development	
6.7	Communications			
Near Term				
6.7.1	Necessary C4ISR communication infrastructure to support space testing	OAR	Ch4, section 4.4.5 Air Force Transformation Flight Plan ORS, RLTR, MDA Block 12	Medium
6.8	Sensors			
Near Term				
6.8.1	Portable multispectral capability platform that can be deployed anywhere in the world and track great numbers of objects with increased resolution	OAR	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS Med Lift/MDA Block 14/RLTR Development/Hypersonics	Medium
6.9	M&S			
Near Term				
6.9.1	Space Threat Assessment Testbed (STAT) for modeling and simulation capability	HITL	Ch4, section 4.4.5 NPOESS, MDA Block 12, SBRS AF TIPP Plan for FY2009-11	High
6.9.2	Space vehicle breakup and debris prediction simulation capability that predicts fallout of debris in 5 seconds of initiation	DMS	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS CAV/ORS Medium Lift/MDA Block 12	High
Mid Term				
6.9.3	Reusable hypersonic space access	DMS	Ch4, section 4.4.5	Medium

	M&S that simulates major design stressors for hypersonic space access		High Speed/Hypersonic T&E Infrastructure Roadmap, CTEIP study-draft, March 2005 Hypersonic Space Access S&T programs	
6.9.4	Spaceflight & aircraft airway deconfliction simulation to enhance command and control for ORS	DMS	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS Medium Lift	Medium
6.10	Transducers			
Near Term				
6.10.1	Transducers for in-stream measurements on hypersonic flight vehicles	MF	Ch4 section 4.4.5 ARTWG Roadmap, March 2004 High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap, CTEIP Study-Draft, March 2005 Various hypersonic research programs	High
6.14	Integrated Distributed Test Capability			
Near Term				
6.14.1	Space Test and Training Range (STTR) that integrates several distributed test sites for an ability to evaluate, validate, test and demonstrate future offensive and defensive space and counterspace capabilities in a hostile or stressed space environment.	Hybrid	Ch4, section 4.4.5 Supports several Counterspace Projects and ORS CAV program	High
6.15	Multiple Test Capability			

Near Term				
6.15.1	Responsive Launch and Test Range capability that supports multiple launches within hours	OAR	Ch4, section 4.4.5 AF Transformation Flight Plan	Medium
6.15.2	Extended Hypersonic Flight Corridors that are flexible, accessible and over land, water and littoral areas near the US test ranges.	OAR	Ch4, section 4.4.5 High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap, CTEIP Draft Study, March 2005 Supports several Hypersonic programs	High
Mid Term				
6.15.3	Overseas/foreign test capabilities to support ORS and MDA global testing	OAR	Ch4, section 4.4.5 ARTWG Roadmap, March 2004 ORS Medium Lift, MDA Block 14	Medium

6.6.2.2 Roadmaps

Refer to table 6.6.2 for the Space Combat Test Capability Roadmaps.

Table 6.6.2 Space Combat Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
6.1	General Test Instrumentation															
6.1.1.1	Phase I: Perform a trade study to investigate the viability of autonomous FTS command destruct capability vs portable FTS capability															
6.1.1.2	Phase II: A portable/autonomous FTS command destruct capability															
6.1.2.1	Phase I: A space based FTS command destruct capability															
6.4	Radar															
6.4.1.1	MMW radar transmitter upgrade to Reagan Test Site															
6.4.2.1	Transportable Sea-Stabilized X-Band Radar															

6.5	GPS															
6.5.1.1	Phase I: Tech development of miniature GPS r/t for space vehicles															
6.5.1.2	Phase II: Design Implementation and Integration of miniature GPS r/t's into space vehicles															
6.6	Telemetry															
6.6.1.1	Phase I: Portable telemetry capability with data rates greater than 20Mb/s-50Gb/s at ranges greater than 2K miles															
6.6.1.2	Phase II: Portable telemetry capability with data rates greater than 50 MB/s-1 GB/s at 2K miles															
6.6.2.1	Next Generation Satellite TT&C															
6.6.3.1	Space-based Telemetry & Range Study (STARS)															
6.6.3.2	Develop a space borne telemetry capability Phase I: Data rates of 50MB/s-1Gb/s															
6.6.3.3	Phase II: GIG and IP6 base space borne telemetry															
6.7	Communications															
6.7.1.1	Phase I: Identify the specific C4ISR comms needed to support space test															
6.7.1.2	Phase II: Integration and installation of necessary C4ISR communications at ranges															
6.8	Sensors															
6.8.1.1	Phase I: Trade study and development to determine the specific portable technical															

	multispectral solutions needed															
6.8.1.2	Phase II: Integration and development of portable multispectral global tracking capability on platform															
6.9	M&S															
6.9.1.1	STAT Phase I: Links small HIL space chambers to satellite operations centers/simulations to test spacecraft subsystems under various threat conditions.															
6.9.1.2	STAT Phase II: Links large HIL space chambers to satellite operations centers/simulations to test spacecraft under various threat conditions with new added space effects environments.															
6.9.2.1	A space vehicle breakup and debris prediction simulation capability that can predict debris path within 5 sec of initiation															
6.9.3.1	A reusable hypersonic space access M&S that simulates design stressors for hypersonic space access															
6.9.4.1	A spaceflight and aircraft airway deconfliction simulation to enhance command and control for ORS.															
6.10	Transducers															
6.10.1.1	Develop and fly a series of pop-up probes to measure boundary layer pressure and temperature at hypersonic speeds															

6.10.1.2	Develop advanced non-intrusive transducers to measure in-stream combustion products or velocity														
6.14	Integrated Distributed Test Capability														
6.14.1.1	STTR Phase I: Develop network design connectivity and LVC capability at initial sites with limited DS and CS ability														
6.14.1.2	STTR Phase II: Enhance CS and DS effects and add stressed space environment while expanding network														
6.15	Multiple Test Capability														
6.15.1.1	A Responsive Launch and Test Range to support ORS and future space access hypersonic programs														

6.6.2.3 Test Capability Gaps

Currently two Gaps exist from the capability needs that are not addressed by any roadmap or test capability program. The following discussion addresses each of those gaps and presents a risk assessment. The risk assessment considers the probability of occurrence or likelihood that a test capability will not meet a desired date for an acquisition program and maps that against the consequence for that acquisition program.

Priority 1: Hypersonics Flight Test Corridors (Need no. 6.15.2): Currently no test capability program is looking at the prudent development of hypersonic test corridors over water, land or littoral areas to fulfill the future test needs. At the present time, no known program is actively taking the lead to acquire land access, do environmental impacts, or do the necessary requirements analysis to determine the optimum solution for the future. It is expected that the future Hypersonic S&T efforts will start to require extended test corridors in the FY2015 timeframe. However, that applies to only hypersonic programs related to space access. Hypersonic weapon acquisition programs using space may require access in the FY2010-2012 timeframe. It is quite possible that weapon acquisition and ACTD programs requiring space access may miss critical milestones due to this gap. Given the FY2010-2015 timeframe for the hypersonic programs needing the capability, a risk assessment was generated against a risk analysis template as follows:

Risk Assessment: HIGH

Likelihood: 4 out of possible 5(with 5 as Near Certainty)

Consequence:

Technical: 5 out of possible 5 (with 5 as severe)

Schedule: 5

Cost: 5

Priority 2: Develop overseas/foreign test capabilities to support ORS and MDA global testing (Need no. 6.15.3): The ORS medium lift capability will start to place more demands for a global testbed as well as the deployment of the MDA KEI interceptors and tests by global missile defense allies. It is expected that this should start around the FY2014-2015 timeframe. At the present time, no one group coordinates the test efforts with future global missile defense allies and the ORS medium lift for those test capability needs. It is expected that some overseas or foreign test capabilities will be needed to test the ranges for ORS medium lift and the global missile defense. Given the FY2014-2015 timeframe need for this overseas/foreign test capability a risk assessment was generated as follows against the ORS medium lift and MDA block 14 programs jointly:

Overall Risk Assessment: MEDIUM
Likelihood: 3
Consequence:
Technical: 3
Schedule: 3
Cost: 3

6.6.2.4 Issues and Recommendations

Issue: A need exists to train and employ range safety officers capable at any of the OARs supporting space combat T&E.

Recommendation: Recommend that the MDA and Air Force Space Command investigate the possible training of a cadre of safety officers for existing and future space ranges.

Issue: A need exists to standardize range safety operations procedures and equipment at all OARs supporting space combat T&E.

Recommendation: The TRMC in coordination with MDA and Air Force Space Command, establish a common range safety solution for the OARs and establish a schedule for compliance with the new standard. This should leverage the ongoing efforts of MDAs Range Safety Standardization Program whose committees are working standardization issues with the Air Force Space Command.

Issue: The current Tri-Service T&E Executive Agent (EA) is under-represented from a Space perspective. For example, AFSPC range management is not subject to AF/TE nor AFMC, which are part of the EA. This results in few joint T&E projects for space being approved.

Recommendation: Recommend that the T&E Executive Agent (EA) and Strategic Plan Working Group consider options to include representatives from major space communities and Defense Agencies.

6.7 ARMAMENTS AND MUNITIONS

6.7.1 Overview

The Armaments and Munitions test area is a broad and challenging area that encompasses not just the testing and evaluation of a wide variety of systems and products but also overlaps widely with the planning, production, and manufacturing of the same. It also covers a wide range of technical disciplines such as aerodynamics, M&S, chemistry, energetics, explosives physics, and materials science. Finally, employment of many common armaments across the Services on

different platforms and the conduct of their T&E at different Service test locations also add to the challenge in this area.

The missions using armaments and munitions vary tremendously across the Services and the various platforms that carry weapons. In general, armaments and munitions defend and protect friendly joint forces from hostile threats, or destroy a hostile threat or target selectively as desired by the combatant commander. They are used in air warfare (missiles, gun ammunition, bombs) and in surface warfare, (namely land and sea-based artillery, missiles, gun ammunition, and countermeasures against the same).

The Armaments and Munitions area here will *not* cover the following:

- Intercontinental ballistic missiles—these are covered under space combat
- Shipboard detection, targeting, and associated guidance systems for torpedoes (apart from the torpedo itself as a munitions) and mine warfare systems (other than the mine itself as ordnance) — covered under sea combat
- Nuclear weapons effects – covered under test environments

The development, testing, and fielding of the wide variety of armaments and munitions covers such a broad spectrum of activities across the Services, that it would be unmanageable in this document to describe each and every type of developmental, operational, qualification, lot-sampling, live-fire, and other testing activities. However, in generic terms, armaments and munitions testing includes:

- T&E of all different types of explosive munitions and ammunition, to include:
  - ammunition for sidearms, small arms and other personnel-portable light weapons
  - ammunition for guns mounted in aircraft, land vehicles, and seagoing vessels
  - large caliber ammunition used in land artillery and naval guns
  - bombs dropped from various aircraft
- T&E of precision-guided munitions (PGMs), to include:
  - Targeting, guidance, and control subsystems, particularly seeker performance across the electromagnetic/optical spectrum in various environments
  - Autonomous (“fire and forget”) weapon performance in the targeting, midcourse, and terminal phase (“endgame”)
  - Multi-spectral characterization, modeling, and simulation of various types of air/land/sea/targets: for our purposes here this refers mainly to the use of land targets to support munitions testing. (The development and use of targets that emulate enemy airborne, seagoing, and land threats will be addressed in Section 6.9, Targets)
  - Onboard and offboard sensor integration, data fusion, and kill chain networks

  - Air-launched, surface-launched, sub-surface-launched torpedoes
- Testing of all types of guns, including shipborne naval guns, land artillery (including land-based surface-to-surface missile launchers), and aircraft guns
  - A key emerging technology in this area is the electric-propelling gun (or "railgun"), being considered for naval use as well as other possible applications in aircraft, space platforms, or land vehicles
- T&E of missiles, including:
  - Air-launched air-to-air (A/A) and air-to-surface (A/S) missiles
  - Surface-to-air ("SAMs", S/A) and surface-to-surface (S/S) missiles
  - Propulsion technologies for missiles
- Explosive materials and propellants (energetic) testing for energetics characterization but which may not necessarily be specific to a particular weapons system acquisition program. This could also include explosives detection and countermeasures research and development.
- Lethality testing and evaluation
- Environmental effects (simulation, networked)
- Micro-electronics and opto-electronics
- Human-system interfaces (displays and controls, neural networks, sensor data integration).

The Armaments and Munitions Testing area overlaps widely with the Targets, Test Environments, Air/Land/Sea Combat Reliance Areas, and C4ISR modernization areas. A sampling of current and future armaments and munitions programs includes—but is not limited to:

- Air-to-Air: AIM-9X, AIM-120
- Air-to-Surface: HARM, JASSM, JDAM, JSOW, Longbow Hellfire Modular Missile, Small Diameter Bomb (SDB), SLAM-ER, Harpoon
- Surface-to-Surface: ATACMS, CCAWS, Javelin, Tactical Tomahawk, Harpoon
- Surface-to-Air: Evolved Sea Sparrow Missile (ESSM), Rolling Airframe Missile (RAM), Standard Missile, Stinger, THAAD
- Major Gun/Munitions: DDX Electric Gun, Extended Range Gun Munitions (ERGM), EXCALIBUR, GAU-8, Guided 105mm (AC-130 Gunship), LW-155 Towed Howitzer, 120mm Mortar and derivatives, MFCS, M61-A1, and Stryker
- R&D programs: IED detection, defense, and countermeasures; non-lethal anti-personnel weapons; non-destructive large-area-denial weapons

A short summary list follows of the primary facilities, mainly comprising the various Service testing centers:

- AAC, Eglin AFB, Florida
- AEDC (Arnold Engineering Development Center), Arnold AFB, Tennessee
- AFFTC, Edwards AFB, and Mugu/VAFB offshore testing area, California
- ARDEC (Armaments Research, Development and Engineering Center), Picatinny Arsenal, New Jersey
- ATC (Aberdeen Test Center), Aberdeen, Maryland
- NAWCAD, Patuxent River, Maryland, and associated offshore testing area
- NAWCWD, China Lake and Pt Mugu (Ventura), California (and also including the Mugu/VAFB offshore testing area),
- Nevada Test and Training Range (NTTR)/Nellis AFB, Nevada
- Utah Test and Training Range (UTTR), Utah
- Yuma Proving Ground, Yuma, Arizona
- White Sands Missile Range (WSMR)/Holloman AFB, New Mexico
- NSWC Dahlgren, Virginia

6.7.2 Armaments and Munitions Test Capability Analysis

The analysis of Armaments and Munitions testing capabilities began with a review of the TRMC interim staff's 2004 Strategic Plan and the FY2004 Armaments and Munitions Reliance Area Capability Summary (RACS) in order to capture a generic flavor for test capability priorities as forecast last year. The individual Service transformation plans as well as various test center and combatant command roadmaps available as of December FY2004 were also reviewed to see what the Services projected for their future warfighting capabilities. These were compared to future projections of test capability priorities outlined in briefings and informal discussions with Air Force and Army flight-testing leaders. Informal discussions were also held with Navy contacts but information on testing priorities, roadmaps, needs, and so forth were mostly unavailable.

Finally, specific test base and range upgrade and modernization project data were reviewed in the three Services' inputs to the TRMC March 29, 2004 call for data. This was supplemented by POM-build and various "quad chart"-type documents obtained either through the Services, OSD libraries, or from knowledgeable personnel from the Armaments and Munitions Reliance Panel.

- The summary list of relevant data sources follows:
- USAF Transformation Flight Plan
- US Army Transformation Roadmap

- Naval Transformation Roadmap (2003)
- AF/TE Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources, March 29, 2004" (dated Jul 21 2004)
- DACS-TE Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated 4 Aug 2004)
- DEPSECNAV/RDT&E Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated Jan 25, 2005)
- DOT&E Memorandum, "Strategic Planning for Department of Defense Test and Evaluation Resources" (dated Aug 31 2004)
- HQ AFMC/DO Briefing, " Transforming T&E In the 21st Century", 16 Nov 04
- HQ AFMC/DOF Briefing, "Test & Evaluation Flight Plan", 3 Dec 04
- 46TW Fact Sheets, various (dated all in 2004)
- NAVAIR Atlantic Range Facility Website (http://arf.navair.navy.mil)
- International Test Facilities and Ranges Capability Summary, 2004
- Naval Air Systems Command (NAVAIR) website (http://www.navair.navy.mil)
- NAVAIR NAWD (China Lake) website (http://nawcwpns.navy.mil)
- NAVSEA websites for various NSWC facilities and activities (beginning with www.nswcdc.navy.mil)
- US Army TRMP

Although inputs varied understandably among Services and data sources, some common points emerged. Weapon systems of the future will emphasize such attributes as all weather precision strike, higher velocities, smart materials, advanced sensors, lower signatures, and high maneuverability capabilities. Along with the new and improved weapon systems currently being planned, improvements to the test facilities and the technology required to test those upgraded weapons are necessary. T&E infrastructure lead times must be recognized and addressed as well as weapon system lead times. Emerging technologies that will drive Armaments and Munitions T&E capabilities include the following:

- Low-/Very Low-Observable technologies.
- Propulsion technologies for enhanced performance.
- Hypersonic-velocity weapon capabilities
- Energetic Materials.
- Environmental effects (simulation, networked).
- Micro-electronics and opto-electronics.
- Human-system interfaces (neural networks, data integration).

There have also been significant changes in recent years in warfighting strategy and employment tactics that present unique T&E challenges in the Armaments and Munitions area, but which are non-technological in nature. Some examples would include:

- Increasing use of improvised explosive devices (IEDs), mortars, and rocket-propelled grenades (RPGs) as seen in Operation IRAQI FREEDOM are driving development of countermeasures and protective systems against these weapons.
- The precision strike capabilities as highlighted years ago in Operation DESERT STORM are being pushed to the limits in current combat operations. Incidents of collateral damage or unintentional destruction of the wrong targets in both the Afghan and Iraqi theaters have received dramatic media coverage, and will likely continue pointing to the need for accurate targeting, precision strike, and collateral damage avoidance at all possible cost.
- Other urban warfare or MOOTW (military operations other than war) considerations ("smart bullets", non-lethal anti-personnel/area-denial weapons, peacekeeping/riot control operations, etc)
- Fewer numbers of weapons delivery platforms and the decrease in forward basing of forces will continue driving the development of long-range precision strike capabilities.
- Anti-terrorism and homeland security concerns with improvised explosives are an area where cooperative efforts are being explored between the Departments of Defense and Homeland Security in explosives characterization, personnel/ vehicle armoring/protection, and weapons detection.

6.7.2.1 Test Capability Needs

The programs and concepts presented in Chapter Four for the Armaments and Munitions area and inputs from the various relevant data sources provide the basis for the Armaments and Munitions test capability needs.

In no particular order, the Armaments and Munitions test capability needs are as follows:

1. Accurate data on targets with low radar cross-sections (RCS). Specifically, the ability to track and monitor low-RCS projectiles, missiles, objects in-flight, at ranges greater than 40 km.
2. Improved accuracy in tracking and position information capability, including, for example, improved:
    - position information in XYZ coordinates
    - zero velocity and apogee tracking
    - true (measured) position information from radars
    - slave tracking, and

- ballistics measurement systems

3. Test munitions integration, “blue” C4ISR and targeting interfaces and other electronic functions as an integrated weapons system in a ground-based simulation environment.
4. The capability to conduct simultaneous tests of multiple subsystems (sensors, guidance sections, control units, target acquisition and tracking systems, etc.), tied together Infrared/Millimeter Wave/Laser scene generators, environmental effects, and flight motion with real-time dynamic feedback for closed-loop evaluation as an operational system.
5. Interfacing of weapon system components with applicable models in a distributed environment to stress high-risk parameters.
6. Hardware-In-the-Loop test capabilities to evaluate seeker/sensor navigation and guidance technologies such as Advanced Global Positioning System, Hyper spectral/Advanced Imaging Infrared, Low Observable Target Sensors, and advanced seeker designs incorporating improved Laser Detection and Ranging, Synthetic Aperture Radar, and millimeter wave.
7. A capability to test weapons in a realistic hostile environment in a secure, repeatable and controllable manner to achieve test measures of effectiveness up to and including probability of weapon effectiveness.
8. A telemetry data acquisition package for projectiles to record their motion (both balloting and forward movement) and temperatures during launch both inside and outside of guns.
9. An expendable, on-board telemetry and sensor system to acquire and telemeter internal health function measurements, TSPI, and attitude information of various projectiles along the flight trajectory and at impact or warhead initiation.
10. A real-time, non-field perturbing, portable instrumentation capability for monitoring the induced current flow in multiple electro-explosive devices installed on aircraft, missiles, and other systems under test.
11. A capability to detect and discriminate unexploded ordnance at depths of three feet or greater.
12. A high fidelity, synthetic target generator that accurately portrays threat replicas and maneuvering targets and accurately portrays both multi-axis and stream raid targets in a virtual range.
13. Upgraded communications and data networks at various centers, laboratories, and ranges.
14. Improved imaging capabilities.
15. Larger test range areas to allow full-trajectory testing from launch to impact of newer long-range weapons. Corresponding to this discussion is the need to also mitigate, where possible, the geographical and frequency spectrum encroachment upon test ranges that conduct armaments and munitions testing. This mitigation could be driven by many

factors, but mostly by range safety, the need for full-trajectory testing, or by security concerns.

16. A miniaturized flight termination system (FTS) packaged to easily add to small munitions being tested that required commanded destruction for range safety.
17. The Navy's testing of precision-guided munitions requires sophisticated, well-instrumented at-sea virtual ranges that allow for the impact of munitions on land that can be fired from ships located at long-distances from the range. This need will be addressed under the Sea Combat portion of this chapter.

These needs (except 17, the at-sea virtual range) are summarized in Table 6.7.1.

Table 6.7.1 Armaments and Munitions Test Capability Traceability and Prioritization

Item #	Test Capability Needs	Test Resource Category	Programs/Concepts Supported	Relative Priority
7.1	General Test Instrumentation			
Near-Term				
7.1.1	Improve ballistic measurement systems	DMS, MF, ISTF	Joint test and training Multiple programs	Medium
7.1.2	Expendable, on-board telemetry and sensor system	MF	FCS, Stryker Multiple A/A, A/S, S/S, S/A, gun, and ammo programs	Medium
7.1.3	Telemetry data acquisition package for projectiles capable of recording motions/movements during launch both inside and outside of guns	MF	FCS, Stryker, DDX EG, ERGM, Excalibur, 105mm, L-155, 120mm Testing efficiency & flexibility Joint test and training	Low
7.1.4	Real-time, non-perturbing, portable instrument capability for measuring current flow in electro-explosives	MF	Warhead Testing IED Countermeasures Testing	High
7.1.5	Capability to detect and discriminate unexploded ordnance at depths of ≥ 3 ft	MF, OAR	Range safety Test Support (post-event battle damage assessment and ordnance cleanup) IED detection & countermeasures programs	Low
7.1.6	Advanced Survivability Test Instrumentation		FCS, EFV, Stryker, ATACMS from FY	High

	capability		2007-2011	
Near/Mid-Term				
7.1.7	Miniaturized flight termination system (FTS)	OAR	Range Safety Various small PGMs such as Small Diameter Bomb	Medium
7.7	Communications			
Mid-Term				
7.7.1	Upgrade laboratory and communication networks	All	Live Fire Test (S/A and S/S missiles) Sled and lab warhead test	Medium
7.8	Sensors			
Near-Term				
7.8.1	Full-Spectrum Imaging	MF, OAR	FCS, Precision Guided Mortar Munitions, 120mm M829A3, Wide-Area-Munitions from 2007-2011	Medium
Near/Mid-Term				
7.8.2	High-Speed High-Resolution Imaging	OAR	Arena Frag/Lethality tests of IEDs, warheads, MAAWS/AT4 Bunker Busters & other Munitions	Medium
7.9	M&S			
Near-Term				
7.9.1	Develop Ballistics Analysis Tool	DMS	UXO Mine/Countermine, M933/934 Mortar Cartridge	Low
7.14	Integrated Distributed Test Capability			
Mid-Term				

7.14.1	Ability to interface weapons system components with applicable models in a distributed environment in order to stress high-risk parameters	DMS, SIL, HITL, ISTF, MF, OAR	Multiple programs: majors are FCS, JASSM, JSOW, SDB, DDX EG, Stryker, Harpoon, Tomahawk Various seeker/G&C systems EC and other threat/countermeasures in test environments	High
7.15	Multiple Test Capability			
Near-Term				
7.15.1	High-fidelity target generator that can portray threats, maneuvering targets, multi-axis/stream-raid targets in virtual range	DMS, SIL, HITL, ISTF, MF	AIM-9X, AIM-120, F/A-22, F-35, Standard, THAAD, PAC-3	High
7.15.2	Ability to evaluate advanced seeker/sensor nav & guidance technologies with hardware in the loop capability	HITL, SIL	Various guided munitions; majors are: HARM, SDB, JDAM, JSOW, SLAM-ER, Harpoon, JASSM, Hellfire, PGM-mortar	Medium
7.15.3	Ability to test weapons in a realistic hostile environment in a secure repeatable & controllable manner to test measures of effectiveness	DMS, SIL, HITL, ISTF, MF, OAR	Joint test and training Combined DT/OT AIM-9X, AIM-120, HARM, JASSM, JDAM, JSOW, Hellfire, SDB, SLAM-ER, Harpoon, FCS, ATACMS, CCAWS, Tomahawk, Javelin, ESSM, RAM, Standard, Stinger, THAAD, DDX EG, ERGM, Excalibur, MFCS, Stryker	Medium
	Capability to conduct simultaneous tests of multiple subsystems tied together with	DMS, SIL, HITL, ISTF,	AIM-9X, AIM-120, HARM, JASSM, JDAM, JSOW, Hellfire, SDB, SLAM-	Medium

	IR/MMW/LASER scene generators, environmental effects, and flight motion with RT dynamic feedback for closed-loop evaluation as an operational system	MF, OAR	ER, Harpoon, FCS, ATACMS, CCAWS, Tomahawk, Javelin, ESSM, RAM, Standard, Stinger, THAAD, DDX EG, ERGM, Excalibur, MFCS, Stryker	
7.15.5	Capability to test munitions integration, blue C4ISR and targeting interfaces and other electronic functions as an integrated weapons systems in a ground-based simulation environment	DMS, SIL, HITL, ISTF, MF, OAR	Joint test and training, Combined DT/OT, AIM-9X, AIM-120, HARM, JASSM, JDAM, JSOW, Hellfire, SDB, SLAM-ER, Harpoon, FCS, ATACMS, CCAWS, Tomahawk, Javelin, ESSM, RAM, Standard, Stinger, THAAD, DDX EG, ERGM, Excalibur, MFCS, Stryker, F-35	High
7.15.6	Ability to accurately track objects with low radar cross sections	DMS, MF, OAR	AIM-120, F/A-22, JSF, F/A-18E/F, ESSM, RAM, Patriot/PAC-3, Standard, THAAD Homeland defense, cruise missile defense, SRBM defense Various radar and EC test programs	Medium
7.15.7	Larger-scale test ranges/mitigate encroachment	OAR	Homeland defense, cruise missile defense, SRBM defense Various A/A, A/G, and surface-launched weapons, Hypersonic weapons, Directed energy test	Medium

6.7.2.2 Roadmaps

Table 6.7.2 outlines notional roadmaps in most of the capability areas previously described. In most instances, a Service-specific project is identified which may meet the need. Only those projects applicable to the timeframe in question, with a significant cost (in the neighborhood of $10M or more) are shown for this sampling. The exception would be a unique project not programmed or planned anywhere else or not already met by an existing capability. However, the inclusion of these projects in this table should not be inferred as being the only test capability modernization projects endorsed or examined in this analysis.

Several exceptions must be mentioned. The test capability needs for upgraded ballistics measurement capability (7.1.1) and upgraded laboratory comm./data networks (7.7.1) were intentionally omitted from any roadmaps. The reasons for this were twofold: first, our research identified many “small-ticket” projects, either planned or already underway, that were too numerous to list here and none of which by itself could be considered a candidate solution; and second, because of the overarching and generic nature of these needs which can be applied across not just the many facets of the Armaments and Munitions T&E arena but to other T&E modernization areas as well.

Table 6.7.2 Armaments & Munitions Test Capability Roadmaps

Development Procurement Sustainment

Item # Test Capability	Program/Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
7.1	General Test Instrumentation															
7.1.2.1	Phase 1: Leverage instrument & TM portions of the CTEIP Adv CDS program															
7.1.2.2	Phase 2: Strap-on system incorp autonomous sensor and TM capability															
7.1.3.1	Hardened Subminiature Telemetry and Sensor System (HSTSS)															
7.1.3.2	Embedded T&E Instrumentation															
7.9	Modeling & Simulation															
7.9.1.1	AAC Arms/Muns DM&S															
7.14	Integrated Distributed Test Capability															
7.14.1	AAC Operational Ground Test Facility (OGT)															
7.15	Multiple Test Capability															
7.15.2.1	Advanced HITL/Adv Munitions															

	Test Facility															
7.15.3/7.15.4 /7.15.5	AAC Operational Ground Test Facility (OGT)															
7.15.4.1	Phase1: leverage AAC's OGT program to incorporate targeting functions															
7.15.4.2	Phase 2: Expand the mod-OGT to incorporate C4ISR and EC functions															
7.15.6.1	Phase 1: Determine "target" list (bound the "sizes" of RCSs)															
7.15.6.2	Phase 2: Determine needed radar capabilities; procurement decision															
7.15.7.1	Phase 1: Cross-Reliance working group to study encroachment issues and identify critical areas impacted by range size; include training community															
7.15.7.2	Phase 2: identify candidates for mitigating technologies/processes (ie: "rangeless ranges", etc.)															
7.15.7.3	Phase 3: initiate procurement actions for mitigating technologies and/or real estate, frequency spectrum, special use airspace, etc															

6.7.2.3 Test Capability Gaps

In almost every area outlined in Table 6.7.2, Service-unique projects are either planned or underway to address those needs to some degree. Likewise, in every case there is likely an opportunity for interservice collaboration that has not been fully explored. Sufficient time was not available to quantify fully to what degree each need could be met across each Service by applying the few projects mentioned. In other words, there is no attempt at this time to quantify which needs are "fully met, mostly met, partially met, or barely met" by exactly which projects.

A cursory risk assessment was made for each gap. Risk was qualified "High, Medium, or Low" in a very broad, subjective evaluation according to the following criteria:

1. High Risk:
   - potential for serious effect on a test program (greater than 25 percent increase in cost, schedule, number of test points, sorties, weapons/drops/firings/expenditures)
   - test or weapons employment safety issues indicating serious potential hazards (loss of life or property) to the test mission, base/range populace, or public at large off-range
   - high dollar cost (25 percent or more of the overall test program or acquisition program); no solution identified within limits of current resources, or entirely new technology required for mitigation
2. Medium Risk:
   - possible degradation to test program (10-to-25 percent increase in cost, schedule, test points, etc)
   - safety issues indicating some potential hazards primarily to test mission or base/range populace (some loss of life or property possible; potential injury or damage to property; lesser so for public at large off-range)
   - significant dollar cost (10-to-25percent of the overall test program or acquisition program); solutions exist, but some new technology required or existing technology needs adaptation or procurement
3. Low Risk:
   - little effect on test program (10 percent or less increase in cost, schedule, test points, etc)
   - safety of flight issues indicating possible hazards to test mission, base/range populace, manageable with reasonable processes or existing resources

- solutions exist at low or no-dollar cost; use current technology or resources for mitigation

In order of priority, the Armaments and Munitions Test Capability gaps thus identified are:

Priority 1: Larger Test Areas/Mitigate Encroachment (7.15.7): Although the roadmap proposes a three-phase study to address this need, and there are various projects underway that may affect this capability at various locations, there are currently no plans for a comprehensive, MRTFB-wide study to examine this issue. This is also being identified as a gap since there has been no comprehensive study planned or done that has examined its effect on any major test programs, although most test centers have stated this as a need. Furthermore, although many of the other projects examined in our analysis, or discussed in this and other sections, indicate that technologies may be available to mitigate this gap, no study has been planned or conducted to map specific technologies to specific shortfalls justifying the need for larger test areas.

Risk Assessment:

- In the case of most "classical" vehicle or hardware-oriented test (performance and handling qualities, subsystems integration and specification compliance, etc), the risk is assessed as "low to medium" depending upon the SUT. In general, the basic "wringing out" of new vehicles and traditional types of munitions can be accomplished on the ranges as they are currently laid out.
- In the following cases, with more recent advances in technology as alluded to earlier, the risk to newer weapons test programs is assessed as "high":
- Longer range, precision-strike weapons
  - Hypersonic vehicles or weapons operating at extremely high speeds for very long distances
  - Operational tests and evaluations involving large scale force-vs-force missions in large battlespaces
  - Employment of long-range armaments, munitions, and directed energy weapons whose range may exceed current range space.

Priority 2: Miniaturized FTS: (7.1.7): Operational testing of the Small Diameter Bomb (SDB) and several other small long-range precision munitions was hampered by the inability to destroy the munition on command if necessary for range safety.

Recommendation:

- Conduct a study of current munitions in development or undergoing test and identify those most pressing that require this capability.
- Identify a nominal envelope ("smallest-to-largest size") needed for the miniature FTS
- Initiate acquisition actions to develop required FTS

Risk Assessment:

- This risk is dependent upon the SUTs and the ranges most likely to require this capability. But as precision-strike technologies advance, and munitions become smaller (and thus likely become the preferred weapon and probably carried in greater numbers), and as the need for collateral damage and fratricide avoidance gains more importance, so will the T&E of such systems gain importance.
- Correspondingly, as the flight paths of such weapons increase in distance (and in the case of aircraft drops, increase in altitude and standoff distance), so does the importance of range safety gain visibility.
- The technology is estimated as being close to current state-of-the-art, with the only questions being "how small do we need to make it?" and "how durable does it have to be?" Current systems may be possibly adapted, but there is no established program underway. Therefore, the risk is assessed as "medium" in the near- and mid-term, and unknown in the far-term.

Priority 3: High Fidelity Target Generator (7.15.1)

Risk Assessment:

- For the near-term, most testing requiring the type of threats and targets postulated by the Reliance Panel in this context appear to involve those armaments and munitions used in the air defense environment (surface-to-air and air-to-air missiles). These threats are relatively well known and their proliferation is low. The risk is assessed as "low".
- For the mid to far-terms, the risk is assessed as "Medium".
- Procurement certainty of our future air defense systems is somewhat nebulous (how many F/A-22s for the Air Force? How many forward bases overseas?

- Threat proliferation is unknown. How many new types of threats will PAC-"X" need to defend against? (Patriot was originally designed to defend against aircraft only, PAC-3 incorporates defenses against SRBMs). How many more countries will acquire former-Warsaw pact weapons?
- Mitigating this uncertainty is our dominance in the field of modeling and simulation and high-speed computing, although this edge may also likely diminish in the next decade.

Priority 4: Advanced Survivability Test Instrumentation Capability (7.1.6):

Risk Assessment:

- The risk is assessed as "medium." Potential workarounds and abilities with current means and instrumentation.

Priority 5: Real-Time, Non-Perturbing Portable Instrumentation for Measuring Current Flow in Electro-Explosives (7.1.4):

Risk Assessment:

- This need will require more research and resolution. With the current information available, the risk is assessed as "low."

Priority 6: Full-Spectrum Imaging (7.8.1):

Risk Assessment:

- Current imaging systems exist for different portions of the spectrum. Not the ideal desired solution but some capability exists
- Risk is assessed as "low."

Priority 7: High-Speed High-Resolution Imaging (7.8.2):

Risk Assessment:

- Current high-speed imaging systems exist, as do high-resolution imaging systems. Not seen as a technological leap to do both. Risk is assessed as "low."

6.7.2.4 Issues and Recommendations

Foreign Materiel Exploitation and International Armaments Cooperation:

Issue: Opportunities may exist in the international arena for gaining additional test and training capability with various armaments and munitions

Background: International venues offer possible knowledge advances in the areas of target/threat characterization, materials sciences and foreign sources of specialized materials, and intelligence concerning buried/hardened/hidden ground targets and target deception/camouflage.

Recommendation: Cooperative planning efforts should also be pursued with organizations and agencies dealing in foreign materiel exploitation and international armaments cooperation.

6.8 COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS, INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE (C4ISR)

6.8.1 Overview

C4ISR capabilities must be demonstrated via T&E to be interoperable across all Service and allied or coalition boundaries, end-to-end among all users, and to the technological levels of sophistication necessary to meet mission needs, provide an integrated, interactive picture of the battlespace, and rapidly accommodate integration of emerging technologies and capabilities (e.g., computer processing, precise global positioning, telecommunications). (see "*C4ISR Architecture Working Group Final Report of 14 April 1998")*

At the same time, C4ISR capabilities must be verified to be secure from unauthorized access, countermeasures, and deception techniques. Operations in the war on terrorism have demonstrated the advantage of timely and accurate information, while at the same time reinforcing the need for even greater joint, interoperable C4ISR ("*The National Defense Strategy of the United States of America, dated March 2005")*. Continuing advances in information and communications technologies hold promise for networking highly distributed joint and combined forces.

Network-centric operational capability must be verified via T&E for linking compatible information systems with usable data among the warfighters and weapons. The functions of sensing, decision-making, and acting–which in the past were often built into a single platform – now can work closely even when they are geographically distributed across the battlespace. Beyond battlefield applications, a network-centric force can increase efficiency and effectiveness across defense operations, intelligence functions,

and business processes by giving all users access to the latest, most relevant, most accurate information. Transforming to a network-centric force requires fundamental change in processes, policy and culture and will rely on providing the necessary speed, accuracy, and quality of decision-making critical to future success. A common theme that appears in Service transformation roadmaps points to the future capabilities (Chapter Four) of net-centric warfare, longer range/fast/precise weapons, directed energy or non-kinetic weapons, real time common operating pictures, integration of C4ISR/space/information operations into future force operations, information superiority, networked sensors and integrated battle command and control. This is reflected in the DoD requirements and acquisition processes which have shifted to a capabilities-based management strategy to strengthen combined/joint warfighting capabilities and transform to a more truly Joint Force.

The T&E infrastructure must transform to comply with the requirements of the FY2001 Quadrennial Defense Review (QDR), (*"Quadrennial Defense Review (QDR) Report from 30 September 2001"*) which identified six critical operational goals that the department must have to transform the U.S. global military posture for the 21st century. One of the six critical operational goals in the Joint Warfare Science and Technology Plan (JWSTP) that will focus the transformation was, "Leveraging information technology and innovative concepts to develop an interoperable, joint command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) architecture and capability that includes a tailorable joint operational picture." The QDR further points out that to support joint and combined command and control and to enable a common relevant operational picture of the battlespace, the department will enhance end-to-end interoperable communications for secure planning and operations. These communications will provide shared situational awareness and integration of joint force, maneuver, and intelligence. They must be interoperable across all components and tailorable for coalition operations with other countries. The capability provided by this network and its applications will enable rapid response forces to plan and execute faster than the enemy and to seize tactical opportunities.

The JWSTP Strategic Plan calls for Battlespace Awareness citing the main effects of battlespace awareness on the T&E infrastructure to include interoperability, sensor range, sensor performance, network/asset mobility and flexibility, information timeliness/security and ambiguity. This means that the future test range infrastructure must be globally larger, flexible and more integrated with future C4ISR initiatives. The infrastructure will necessarily use several T&E resources and non-traditional T&E resources simultaneously across great distances to include operational command centers

and training activities. Also the infrastructure must be capable of handling greater and more diverse sources of data in an efficient manner. It is important that as designs evolve for battlespace awareness that the "testing" instrumentation become embedded in the future system designs.

The Testing in a Joint Environment Roadmap ("*Testing in a Joint Environment Roadmap Strategic Planning Guidance, Fiscal years 2006-2011 dated Nov 12, 2004"*) identifies changes needed to ensure that T&E is connected in a joint environment and facilitates the fielding of joint capabilities. A similar initiative is being planned under the direction of the Joint C4ISR Decision Support Center Senior Steering Group ("*Draft Joint C4ISR Decision Support Center Senior Steering Group "Terms of Reference" of Feb 15, 2005"*). The Central Test and Evaluation Investment Program (CTEIP) has funded a project (see "*CTEIP 2003 Annual Report")* called the Joint C4ISR Interoperability T&E Capability (InterTEC) that will provide an integrated solution for testing of the scalable and operational relevant interoperability of C4ISR systems. C4ISR InterTEC will develop and deploy a test capability that enables the testing of networked system-of-systems, including testing of the mission capability and operational interoperability certification testing.

- T&E of C4ISR includes the following:
  - Joint Interoperability Test Command
  - Interoperability Testing
  - Information Assurance Testing
- Various Battle Management and C2 Test Centers
  - Modeling & Simulation (M&S)
  - Hardware in the Loop
  - Systems Integration Labs
  - Limited Distributed Test Capability for Live, Virtual and Constructive Capability
- Communication and Tactical Data Link Test Facilities
  - Limited distributed test capability for tactical data link and communication links
  - Communication link protocol, latency and loading testing facilities
  - Limited stress testing of communication links
  - M&S of communication and tactical data links

6.8.2 C4ISR Test Capability Analysis

The relevant data sources that were used in the analysis of T&E capabilities needed for C4ISR are as follows:

- C4I Reliance Area Capability Summary (RACS), 2004
- Testing in a Joint Environment Roadmap Strategic Planning Guidance, Fiscal years 2006-2011 dated Nov 12, 2004
- Draft Joint C4ISR Decision Support Center Senior Steering Group "Terms of Reference" of Feb 15, 2005
- CTEIP 2003 Annual Report
- C4ISR Architecture Working Group Final Report of 14 April 1998

While the T&E infrastructure has capabilities for supporting components and subsystems of C4ISR networks and systems and C4ISR network interfaces with some individual weapon systems, the capabilities necessary for end-to-end T&E in joint and coalition environments with all support elements (e.g., logistics) and threats must be developed and implemented. The T&E C4ISR test capability must address both C4ISR technology and programmatic drivers, the individual weapons and warfighters that are expected to participate in net-centric operations, space and reconnaissance assets, as well as information assurance for other components of the Global Information Grid. Current T&E and DoD laboratory capabilities and investment planning for the T&E infrastructure address some of these needs piecemeal but are inadequate to address total C4ISR network on an end-to-end basis.

C4ISR Technology Evaluation

The required T&E C4ISR test capability must prepare to evaluate progress and achievement of the department's C4ISR vision of the future; i.e., "To provide dominant battlespace awareness to improve situational awareness, decrease response time, and make the battlespace more transparent to friendly participants." It must verify that our warfighters have access to whatever data they need to have a clear picture of the battlespace, including accurate and timely information about opposing forces, friendly forces, and the environment. Within the weapons and warfighter aids, they will have assess to improved sensor capabilities; near real-time displays of text and graphical images such as maps, charts, and overlays to thousands of users; improved decision support and mission planning capabilities; and adaptable, secure, and survivable communication networks. Some of the most critical/enabling technologies required to be evaluated are described below:

Command and Control (C2) Thrust: Flexible, modular, and interoperable C2 to support force multiplication, rapid power projection, and real-time operations to include:

- Advanced planning aids using adaptive cueing, data compression, advanced data pedigree, testing for consistency and accuracy, data fusion and timeliness measured by the speed, accuracy and effectiveness of decision making.
- Automated mission planning schedules with case based resource allocation and continuous model based assessment.
- Automated decision support tools that reduce decision cycles.
- Next generation intelligent information services to support a globally dispersed, joint and coalition, single-thread collaborative planning tool.
- Faster force level planning and control task execution.
- Automated time critical targeting and strike support.
- Improved IFF.
- Enhanced survivability and assurance of continuity of operations.
- Increased situation awareness.
- Link sensors and shooters more quickly and efficiently than ever before.
- Execute within a joint worldwide C4ISR environment worldwide.
- Enhanced, distributed, and dispersed information management and decision making system capabilities.
- Capabilities to enable integrated services such as voice, fax, data, video, imagery, and cartography.
- Capabilities to extend the global backbone of defense and commercial fiber based networks into the theater and tactical environments worldwide.
- Security mechanisms to guarantee that information coming into the networks is correctly classified, that information is prevented from going to unauthorized outside networks (gateways), and that are designed into networks themselves to assure the required security isolation.

Communications Thrust:

- Advanced tactical data links (e.g., Link-16 JTIDS) and messaging systems.
- Modular, programmable radios that are easily maintained, interoperable, robust and multi-level secure.
- Robust networking systems (e.g., asynchronous transfer mode)
- Seamless information handling capabilities to achieve an integrated network environment of distributed systems using light, deployable communication systems.

- Small ground/air transportable communications equipment suite, configured to provide operators with secure simultaneous multi-band, multi-function radio communications.
- Immunity to hostile action through low probability of intercept, anti-jam, and secure operation.
- Robustness in maintaining connectivity and capacity in the face of battle damage, high traffic demands, and other operational stress.
- Interoperability with systems of other Services and friendly forces.
- Reconfigurable and self-healing networks which are capable of operating in a highly dynamic environment with time variant topologies and capacities (e.g., in a system using multiple transmission bands).
- Robust protocols that allow nodes to operate under severely hostile conditions.
- Artificial intelligence (AI) to help monitor, manage, and restore communications.
- Technologies that facilitate the integration or interoperability of current systems such as the Defense Information Systems Network.
- The concept of "Infosphere," in which deployed forces can tap into information sources and services via a global virtual network. The global virtual net will be derived, in part, from commercial systems; however, its extension to the warfighter will be accomplished by military networks.

Intelligence Thrust:

- Real time information into the cockpit fusing off-board sensor data, minimizing task saturation while maximizing task performance and data accuracy.
- Information processing technologies that improve timeliness, reliability, and accessibility of information to the warfighter.
- High precision image/signal/data processing, and imagery/video recording and multi-media storage techniques. Improvements in cataloging, searching, sorting and indexing of this data.
- Advanced signal exploitation techniques to improve timeliness of intelligence to the warfighter.
- Intelligence data handling research technologies to provide rapid access to current data.
- Sensor research that will exploit sensor inputs and allow software to operate across various computing platforms.

- Enhanced speech-processing capability to automate identification of language, speaker, and keywords; reduce interference; compensate for channel variations based on background audio.
- Improved wide-band recording capability; developing digital storage and retrieval capabilities to handle high volume and high data rates.
- Refined collection capability to defeat enemy spoofing; detect, track, and identify; and precisely locate enemy emitters from a single collection platform.
- Detection/collection technology to extract threat laser system information.
- Correlation/fusion/prediction tools based on advanced computer algorithms.

Surveillance/Reconnaissance Thrust:

- Advanced cooperative/non-cooperative bistatics; space-time processing; sensor/data fusion.
- Advanced array antennas; and over-the-horizon radar.
- Weapon/C4I integration including battle damage assessment (BDA) capabilities built into a weapon, network bandwidths to accommodate multiple sensor feeds.
- Remote input and control of weapons and sensors. Increased UAV performance in the areas of recognition and surveillance, increased data downlink bandwidth, error correction and information assurance.
- Surveillance systems (infrared especially) using advanced algorithms to classify and recognize targets.
- Bistatic sensor technology and concepts to reduce system cost and to improve sensor survivability and covertness.
- Cueing and fusion concepts using off board sensor data to improve sensor efficiency, hostile target identification, and real-time situation awareness.
- Concealed weapon detection and through-the-wall surveillance.
- Advanced sensor fusion techniques in support of penetrating and identification radar technology.

Computers:

- Advances in software engineering that include software for high performance architectures, system definition, software and system quality, and system/software support environments.
- Computer systems technologies that include advanced displays and intelligent interfaces, and distributed computer systems including cluster computing

technologies for survivability and for ability to create massed computing power as needed using personal computers (PCs) vice mainframes.

- Artificial intelligence that provides knowledge-based planning and engineering for reconnaissance, intelligence, planning, operations, battle management, armaments, and logistics.

Several C4ISR program initiatives are under way by each Service and linked to several joint efforts. In the near term (until FY2012) the following C4ISR program efforts are noted:

- Distributed Common Ground System-will process, analyze, fuse and manage ISR data
- Combatant Commanders Integrated Command and Control System
- MAGIS-Marine Air-to-Ground Intelligence System
- Tactical Data Link Enhancements
- Single Integrated Air/Land/Marine/Space Pictures
- Multi-Platform Common Data Link
- Global Combat Support System
- Automated ISR
- Cooperative Engagement Capability
- Theater Battle Management Core Systems (TBMCS).
- Contingency Theater Automated Planning System (CTAPS)
- Combat Intelligence System (CIS)
- Wing Command and Control System (WCCS)
- Command and Control Information Processing System (C2 IPS)
- Battlefield Situational Display (BSD)

In the mid- and far-term (beyond FY2012), the Global Information Grid (GIG) Service- oriented architecture, the Navy's FORCEnet, Army's LandWarNet, Air Force C2 Constellation, and the Marine Corps Integrated Architecture Picture will provide the C4ISR community an enhanced edge and a greater battlespace awareness that facilitates a collaborative environment. Projects that are planned for the mid and far term also include GPS Block III, Space Based Radar, Mobile User Objective System, several Network–Centric Operations and Force Application initiatives. Several ongoing ACTDs also feed the C4ISR needs for the future, but two that apply directly are the Adaptive Joint C4ISR Node ACTD and the Network Centric Collaboration and Targeting ACTD. There

currently is a study called the Transformational Air and Space ISR Project that is chartered to look at transformational ideas for the 2008-2018 timeframe.

Our analysis of the C4ISR area is divided into the following test capability categories:

- Modeling and Simulation
- Integrated Distributed Test Capability

6.8.2.1 Test Capability Needs

For this report the needs for C4ISR were primarily derived from the C4ISR Reliance Capability Panel Summary for the MRTFB.

The C4ISR T&E facilities and ranges vary in capability and in the types of tests (modeling and simulation, hardware-in-the-loop, and real world test) they can perform, but no one range or facility is capable of end-to-end testing of a C4ISR system or network. Full end-to-end-to-end T&E of C4ISR will require a collection or ranges and facilities, as well as modeling and simulation assets to support testing to include technology demonstrations, developmental T&E, operational testing, and continuous evaluation to achieve C4ISR test capabilities, a comprehensive identification of the needs must be fully identified such that a realistic roadmap can be developed. One planning step in this direction is being addressed by a CTEIP project involving Joint C4ISR on test ranges. Another is testing in a Joint Environment, directed by the 2004 Strategic Planning Guidance. Yet another is the Joint C4ISR Decision Support Center Senior Steering Group under the USD (AT&L) that is addressing future C4ISR programmatic needs. Thus, while falling short of the comprehensive identification of needs at this time, some of the more immediate needs will be addressed via the following planned investments.

A near-term need is to test precision-guided weapons with data link capability, such as SDB II, JASSM, JSOW, etc. Ranges will need data link transmission equipment (e.g. JRE – Joint Range Extension for Link-16), data link network/monitoring equipment, and 3rd-party targeting capability.

The following table lists the Reliance C4ISR projects approved for the near term period of FY2008-2012. Because of the emphasis stressed by the Services for improved C4ISR test capability; these projects are considered high priority to accomplish the networking of highly distributed, joint and combined forces.

Table 6.8.1 C4ISR Test CapabilityTraceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Relative Priority
8.9	Modeling and Simulation			
Near Term				
8.9.1	Battlefield simulations for control and loading for C4I components	DMS	See Chapter Four. section 4.4.7 AOC Weapon System Regional Section Air operations Center Modernization Time Critical Targeting Theater Battle Management Core Systems Ground Theater Air Control Air Sovereignty Ops Center Deliberate Crisis Action Planning and Execution Segments Joint Range Extension	High
8.14	Integrated Distributed Test Capability			
Near Term				
8.14.1	Test instrumentation control center for integrated distributed testing of C4ISR sites to include the capability for scenario generation, real-time control and	IL/MF/OAR	See Chapter Four. section 4.4.7 SMART-T Secure Mobile Anti-Jam Reliable Tactical- Terminal JSTARS GSM – Joint Sur. & Target Attack Radar	High

	monitoring of C4ISR test progress		Sys. Ground Station Module ASAS (ATCCS) – All Source Analysis System (Army Tactical C2 System) Command and Control Vehicle CSSCS(ATCCS) - CSS Sys. (Army Tactical C2 Sys FCS	
8.14.2	Integrated distributed test capability for Multi-Service battle management systems	IL/MF	See Chapter Four. section 4.4.7 AOC Weapon System Regional Section Air operations Center Modernization Time Critical Targeting Theater Battle Management Core Systems Ground Theater Air Control Air Sovereignty Ops Center Deliberate Crisis Action Planning and Execution Segments Joint Range Extension	High
8.14.3	Joint information assurance test suite that includes a distributed test capability	HITL/MF/ IL/OAR	See Chapter Four. section 4.4.7 Supports Joint DoD dynamic information assurance testing System-of-system stress testing Interoperable testing for web-based systems, connections to DoD C4I test sites.	High

8.14.4	Data link transmission and monitoring instrumentation for precision guided missile and targeting.	OAR	- SDB II, JASSM, JSOW	High
8.15.5	End-to-end joint systems-of-systems stress loading, integrated timeliness and quality measurement, and information assurance.	ALL	Chapter Four. section 4.4.7 Supports Joint DoD dynamic information assurance testing System-of-system stress testing Interoperable testing for web-based systems, connections to DoD C4I test sites.	High

6.8.2.2 Roadmaps

Refer to table 6.8.2 for the C4ISR Test Capability Roadmaps.

Table 6.8.2 C4ISR Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
8.9	Modeling and Simulations															
8.9.1.1	C4I Digital M&S															
8.14.1	Integrated Distributed Test Capability															
8.14.1.1	Starship III (TCFA)															
8.14.2.1	Command and Control Test Ops Center															
8.14.3.1	Joint Information Assurance Test Suite-Web enabled-Phase I															
8.14.3.1	Phase II:															
8.14.3.1	Phase III:															

6.8.2.3 Test Capability Gaps

Priority 1: End-to-End C4ISR Test Capability (Need no. 8.15.5): There is no apparent comprehensive plan to address a capability for full end-to-end C4ISR test and information assurance across multi-Service and allied systems-of-systems driven by the systems discussed in section 4.4.7, and other future C4ISR technology and programmatic drivers. It is clear that this area will require further review and planning across several ranges, facilities, and modeling and simulation activities to develop the required roadmap for the needed end-to-end C4ISR test capability.

Overall Risk Assessment: high

Likelihood: 5

Consequence:

Technical – 5

Schedule – 5

Cost – Unknown

Priority 2: Data Link Transmission and Monitoring (Need no. 8.14.4): There is no apparent plan to address test capabilities for monitoring the large increase in message volume, rates and number of participating RF transmissions and countermeasures for capturing performance data to evaluate interactions between precision missiles and their data links used for targeting, guidance, corrections, fusing, termination, and other functions. Knowledge of how the operational environment (such as the launch platforms, target conditions, and weather), RF phenomena (such as interference, countermeasures, clutter, and multipath), and operators affect data link and missile performance is critical.

Overall Risk Assessment: MEDIUM-high

Likelihood: 3

Consequence:

Technical – 4

Schedule – 4

Cost – Unknown

6.8.2.4 Issues and Recommendations

Issue: Some amount of C4I test capability in the Navy and Air Force resides outside of the test community.

Background: The Navy in particular does much of its testing using a laboratory singly or in conjunction with its ranges or operational assets. The Air Force similarly uses its laboratory assets a great deal but has commissioned a study to investigate testing needs. The Army is exploring how to address net-centric operation relative to the FCS program.

But at this time, there is no adequate nor any planned capability for the necessary end-to-end T&E in joint and friendly environments.

Recommendation: On-going initiatives by CTEIP, by DOT&E in the area of Testing in a Joint Environment, and by the Joint C4ISR Decision Support Center Senior Steering Group are addressing future C4ISR testing needs. From these results, a comprehensive DoD-wide investment plan and roadmap needs to be accomplished addressing the technology and programmatic thrusts.

6.9 TARGETS AND THREATS

6.9.1 Overview

Title 10 of the US Code requires weapon systems testing to be conducted against operationally representative simulations of real world threats. Real world threats can be represented in a variety of forms, including threat representative targets, threat simulators, actual foreign threat weapon system components, and digital threat models.

The Service's develop and field a variety of air, land, and sea targets, target control systems (TCS), and target augmentation/ auxiliary systems (TA/AS) to meet a portion of the threat representation requirement. These target systems provide realistic threat presentations for live fire developmental and operational testing of air-to-air, land-attack, ship self-defense, and air and missile defense weapons. Realistic targets are also needed for live fire and virtual engagements during weapons platform integration testing, and for combat readiness training. Targets related infrastructure is in place to support weapons T&E at fixed-sites and other land, sea, and air deployed operating locales. This infrastructure includes launchers, target platforms, active/passive countermeasures, on board scoring, tracking and control systems.

The other portion of the threat representation requirement is met through the Service's development and or acquisition of threat simulators, threat models and actual foreign material components for use in a variety of HITL, ISTF, and OAR test applications. Air, land, and sea threats replicate adversary force capabilities and the electromagnetic signal environments needed for realistic test of major weapon systems. Testing of electronic combat systems and subsystems is particularly dependent on the availability of high fidelity threat simulators or actual foreign weapon system components. Threat simulation development is accomplished in close coordination with the defense intelligence community to ensure that the simulations accurately reflect the performance and signature attributes of the real world threats as described by the cognizant defense intelligence agencies.

T&E is supported by the following Targets and Threat Capabilities:

- Full-scale Fixed Wing Aerial Targets
- Subscale Fixed Wing Aerial Targets
- Rotary Wing Aerial Targets
- Towed Aerial Targets
- Ballistic Missile Targets
- Cruise Missile Targets
- Anti-Radiation Missile Targets
- Mobile Ground Targets
- Non-Mobile Ground Targets
- Seaborne Targets
- Target Control Systems
- Target On-Board Scoring Systems
- Target Augmentation Systems
- Threat Models (missile flyout, signature, seeker processing logic, etc)
- Threat Simulators (full system replicas, emitter-only, hybrids)
- Threat Surrogates
- Actual Foreign Weapon System Components

6.9.2 Target and Threats Test Capability Analysis

The data sources that were used in the analysis of targets and threats T&E capabilities include:

- Target Systems Reliance Area Capability Summary, FY2006 and Beyond
- Electronic Combat Reliance Area Capability Summary, FY2006 and Beyond
- Tri-Service IR/UV Test Capabilities Study, January 2004
- Targets Management Office, FY2006 POM Information Briefing
- Threat Systems Management Office, FY2006 POM Information Briefing
- COTF Aerial Targets Briefing, 09 Feb 05
- Conventional Engagement Capability Roadmap, Version 0, March 2005
- Targets Management Initiatives Program Review, April 2005
- Navy, Threat Systems FY2005 Mid-Year Review, April 2005

Advancements in U.S. weapon system technologies and the emergence of more capable threats combine to drive the need for higher fidelity targets and threat surrogates. Matching target and surrogate threat capabilities with the assessed performance of real-world threats is a

continuing challenge because our understanding of threat capabilities changes constantly as new information becomes available to United States and allied intelligence agencies and DoD program managers. A thorough intelligence community assessment of the performance and signature attributes of each threat is performed in order to accurately represent those characteristics to a level that stresses the design performance of US weapon systems in a realistic manner.

Intelligent and adaptive target and threat simulation capabilities are needed to create meaningful test environments that will satisfy the demands of network centric operations and system-of-systems testing. Future testing will require seamless integration of target surrogates, open-air simulators, and actual foreign threat weapon system components into live, virtual, and constructive distributed simulation environments. These environments must support testing for homeland security missions, major contingency operations, insurgency operations, and military operations in urban terrain. Tools must be created that enable a relatively small, live opposing force to provide a realistically challenging adversary. Both threat weapons and tactical employment concepts must be adequately considered. Of particular interest are those threat systems that may challenge US information dominance. Targets and threats must replicate the complex network centric battlefield environment of the future to include all aspects of threat information warfare such as computer network attack, intelligence, surveillance, and reconnaissance, camouflage concealment deception and obscurants/countermeasures. A credible representation of threat C4I capability will also be needed to ensure that time sensitive synergistic effects of employment can be realized.

Continuous improvements in the target recognition/discrimination capabilities of US weapon systems will require corresponding increases in the fidelity of target surrogates and threat simulations. Networking of multi-spectral sensors and multi-mode weapons seekers will require target scene fidelity be addressed across the entire sensor to shooter kill chain. Therefore, a key challenge for the T&E and intelligence teams is to determine the acceptable level of threat to be portrayed and the proper mix of actual, surrogate and simulated threats to stress the entire system under test. Because affordability is always a key factor in the test resource adequacy equation, close coordination between the materiel developers, intelligence agencies, and T&E community will be required to achieve efficiencies whenever possible. Due to the POM structure's long leadtime, the Services have limited ability to budget for target and simulator capabilities driven by emerging threat requirements. However, the CTEIP/REP programs can be used to help offset near-term capability shortfalls in this area.

Our analysis of the Targets and Threats area is divided into the following test capability categories:

- Modeling and Simulation
- Multiple Test Capability

6.9.2.1 Test Capability Needs

Threat representation test capability needs are summarized in Table 6.9.1.

Table 6.9.1 Targets and Threats Test Capability Traceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Relative Priority
9.9	Modeling and Simulation			
Near Term				
9.9.1	Validated multi-spectral signature models of air-to-air and surface-to- air threat missiles. Models should accurately depict spectral and temporal attributes of a real-time missile fly-out for all engagement geometries and target speeds.	HITL, ISTF, OAR	Ch4, Sections 4.4.1 and 4.4.2 Missile Warning and Integrated Defensive Countermeasures Systems. SIIRCM, LAIRCM NexGen, TADIRCM F/A-18 IDECM, CV-22, F/A-22 P3I, F-35	High
9.9.2	Multi-spectral signature models of ground targets. Near and far field measurements, with and without augmentation.	HITL, ISTF	Ch4, Sections 4.4.1, 4.4.3 and 4.4.6 Precision guided land attack weapon and UAV programs. AARGM, SDB-Block II, MQ-9, JUCAS, FCS, F-35	High
9.9.3	Multi-spectral signature models of subscale and full-scale aerial targets. Near and far field measurements, with and without augmentation.	HITL, ISTF	Ch4, Sections 4.4.3, 4.4.4 and 4.4.6 Air-to-air and surface-to-air missile systems AIM-120D, AIM-9X P3I, MEADS, SM-6, F-35	High
9.9.4	Validated aero fly-out models for air-to-air and surface-to-air missile threats.	HITL, ISTF, OAR	Ch4, Sections 4.4.1 and 4.4.2 All Missile Warning and Integrated Defensive Countermeasures Systems	High

			SIIRCM, LAIRCM NexGen, TADIRCM F/A-18 IDECM, CV-22, F/A-22 P3I, F-35	
9.9.5	Validated multi-spectral signature models of mobile/transportable ground threats. Measurements desired in RF, IR, LADAR, Acoustic.	HITL, ISTF, OAR	Ch4, Sections 4.4.1, 4.4.3 and 4.4.6 Land attack weapons and UAV programs. FCS, AARGM, MQ-9, JUCAS, F/A-22, F-35	High
9.15	Multiple Test Capability			
Near Term				
9.15.1	Replacement for the QF-4 Full Scale Aerial Target that credibly represents the performance and signature attributes of $4^{th}/5^{th}$ generation fighter threats.	OAR	Ch4, Sections 4.4.1, 4.4.2, 4.4.3 and 4.4.6 Air-to-air and surface to air missile programs. Aircraft integration testing. AIM-120D, AIM-9X P3I, MEADS, F/A-18, F/A-22, F-35	High
9.15.2	Subscale aerial targets that represent aircraft and subsonic cruise missile threats.	OAR	Ch4, Sections 4.4.1, 4.4.2, 4.4.3 and 4.4.6 Air-to-air and surface to air missile systems, aircraft integration testing. AIM-120D, AIM-9X P3I, MEADS, SM-6, NULKA, F/A-18, F/A-22, F-35	High
9.15.3	Supersonic sea-skimming aerial targets that represent “Threats A/B/C/D”	OAR	Ch4, Section 4.4.1, 4.4.4 Ship self-defense weapons programs CEC, ESSM, RAM SM-6, F-35	High
9.15.4	Multi-spectral mobile ground targets that can be reconfigured to match signature attributes to the needs of netted sensors	OAR	Ch4, Sections 4.4.1, 4.4.3 and 4.4.6 Precision guided land attack weapon and UAV programs. AARGM, SDB-Block II, MQ-9, JUCAS, FCS	High

9.15.5	Common/interoperable Target Control Systems that are suitable for use on all DoD test and training ranges	OAR	Ch4, Sections 4.4.1, 4.4.3, 4.4.4 and 4.4.6 All subscale, full scale, seaborne and mobile land target applications.	High
9.15.6	Threat Systems			
9.15.6.1	Foreign Material Acquisition – IR Guided MANPAD missiles for, live fire testing, and conversion into instrumented open/closed-loop threat simulators	HITL, ISTF OAR	Ch4, Sections 4.4.1 and 4.4.2 IR/UV End-to-End Test Capabilities Study Missile Warning and Integrated Defensive Countermeasures Systems. SIIRCM, LAIRCM NexGen, TADIRCM F/A-18 IDECM, CV-22, F/A-22 P3I, F-35	High
9.15.6.2	Threat representative active and passive RF/IR defensive countermeasures systems suitable for use on subscale aerial targets	OAR	Ch4, Sections 4.4.1, 4.4.3, 4.4.4 and 4.4.6 Air-to-air and surface to air missile systems, aircraft integration testing. AIM-120D, AIM-9X P3I, MEADS, SM-6, NULKA, F/A-18, F/A-22, F-35	High
9.15.6.3	Advanced network communications and GPS jammers suitable for force on force testing at all DoD test and training ranges.	OAR	Ch4, Sections 4.4.1, 4.4.3 and 4.4.6 All NetCentric test environments, GPS aided weapons and platform integration testing. FCS, SDB, JSOW, JTRS, MQ-9, WIN-T, F-35	High
9.15.6.4	Threat representative camouflage, concealment, deception, and obscurant countermeasures systems suitable for use on all DoD test and training ranges	OAR	Ch4, Sections 4.4.1, 4.4.3, 4.4.6 and 4.4.7 Precision guided land attack weapon and ISR programs. AARGM, SDB, JSTARS, MQ-9, JUCAS, FCS, F-35	High

6.9.2.2 Roadmaps

Table 6.9.2 highlights key targets and threats development and sustainment activity. Although the roadmaps do not provide a complete picture of all Service targets and threat systems, they do provide a representative view of projected improvements to current T&E capabilities.

Table 6.9.2 Targets and Threats Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
9.9	Modeling and Simulation															
9.9.1 9.9.4 9.9.5	Threat Model Analysis Program application models. (Army, Navy, Air Force)															
9.9.2 9.9.5	Ground Virtual Targets (Army)															
9.9.3	Aerial Virtual Targets (Army)															
9.9.2	Off Shore Scene Recognition Target Development (Air Force)															
9.9.2 9.9.5	Target Simulation Injection in Distributed Battle Space (Army, Navy, Air Force)															
9.15	Multiple Test Capability															
9.15.1	Full Scale Aerial Targets															
9.15.1.1	QF-4 (Air Force)															

9.15.2	Subscale Aerial Targets															
9.15.2.1	BQM-34S (Navy)															
9.15.2.2	BQM-74F Navy)															
9.15.2.2	Advanced Subscale Target (Navy)															
9.15.2.5	MQM-107 (Army)															
9.15.2.6	Advanced Subscale Target (Army)															
9.15.2.7	BQM-167 (Air Force)															
9.15.3	Supersonic Sea Skimming Targets															
9.15.3.1	GQM-163 Supersonic Sea-Skimming Target (Navy)															
9.15.3.2	Threat D Target (Navy)															
9.15.4	Ground Mobile Targets															
9.15.4.1	Mobile Ground Target Surrogates (Army)															
9.15.5	Target Control Systems															
9.15.5.1	Target Tracking Control Station (Army)															
9.15.5.2	Target Tracking Control Station Upgrade (Army)															
9.15.5.3	System for Navy Target Control (Navy)															
9.15.5.4	SNTC-Frequency Agile System (Navy)															
9.15.5.5	Gulf Range Drone Control System (Air Force)															

9.15.5.6	Advanced Target Control System (Air Force)															
9.15.6	Threat Systems															
9.15.6.1	Advanced Man-Portable Air Defense Systems (Army, Navy, Air Force)															
9.15.6.3	Next Generation Communications Jammer (Army)															
9.15.6.3	Threat Dense Environment Radio Frequency Injection (Army)															
9.15.6.3	Advanced GPS Jammers (Army, Navy, Air Force)															
9.15.6.2 9.15.6.3 9.15.6.4	Threat Validation Programs (Army, Navy, Air Force)															

6.9.2.3 Test Capability Gaps

Full-scale Aerial Targets

A replacement for the QF-4 is an immediate concern due to the declining inventory of airframes that can be economically converted into target drones. Additionally, the Vietnam War era fighter is a poor representation of the fourth and fifth generation fighter threats and advanced electronic combat attack techniques of greatest concern in 2010 and beyond. At present, there is no firm program in place to replace the QF-4, although the USAF intends to initiate an Air Superiority Target Analysis of Alternatives Study beginning in FY2006 to examine options for a full-scale follow-on.

Risk Assessment: The inventory of droneable F-4 airframes may be depleted as early as 2010 which creates high risk for a 12-18 month T&E capability void in the 2012 timeframe unless: (1) development of a replacement full scale aerial target begins before FY2008; (2) and/or the development span for the follow-on target is compressed; (3) and/or other acceptable stop-gap measures are instituted to mitigate projected QF-4 inventory depletion.

Supersonic Sea Skimming and Subsonic Targets

The Navy's current inventory of supersonic ASCM targets is not adequate to support projected weapon system T&E. A combination of GQM-163A, MA-3, and "threat D" targets is required for adequate testing of acquisition programs, including LPD-17, SSDS Mark 2, DDX, CVN-21, F-35, LCS, ESSM, and SM-6. Follow-on operational testing of RAM Block 1, CEC, SPY radars, and DDG-51 also require these targets.

Risk Assessment: The current MA-31 supply is nearly depleted and acquisition of additional targets has not occurred due to recurring foreign materiel contracting delays. In the event the MA-31 deliveries do not materialize (moderate–high risk), the Navy must pursue alternative approaches to satisfy the supersonic high-diver requirement currently being met by that Russian built target. The Navy is responding to Threat "D" capability gap by examining options to develop a Threat "D" representative aerial target to meet the projected 2010 T&E need date. Development of an executable program is underway; however, technical design, cost, and schedule have yet to be determined.

6.9.2.4 Issues and Recommendations

None

6.10 COMMON RANGE INSTRUMENTATION

6.10.1 Overview

Common Range Instrumentation (CRI) pertain to classes of basic test capabilities that are common to the technical sustainability of test facilities, primarily those associated with open-air test ranges, and, thus, are not specific to a particular location or program. These needs address not only the support of advances in weapon system technologies and capabilities, but also the necessity to recapitalize the aging and unsupportable test infrastructure capabilities, and to transition technologies and developments from the T&E/S&T program and CTEIP to test range and facility capabilities. A thrust is to ensure that improvements in technology and capabilities being developed and implemented at one location are shared and can be leveraged at other locations. These classes of capabilities are primarily comprised of the facilities and instrumentation that enable systems-under-test (SUTs) and range control facilities to produce repeatable results among ranges, and to be interoperable among ranges in order to exchange, distribute, process, and analyze test data collected elsewhere. The primary CRI focus areas for T&E ranges are as follows:

- Time-Space Position Information (TSPI)
- On-board instrumentation
- Telemetry
- Range control
- Data processing
- Telecommunications and timing
- Test and evaluation (T&E) support vehicles

TSPI refers to instrumentation used to measure, report, and compute the location and orientation of system(s) or vehicle(s) under test at any required time during a test event. Position and attitude parameters are calculated and ultimately ingested by data analysis algorithms that can reconstruct and replay the entire test mission as needed for analysis. Additionally, TSPI data may be compared among test participants, vehicles, targets, and/or other systems to determine miss-distances, flight characteristics, weapons scoring, dispersion patterns, etc. Typical TSPI instrumentation includes radar, optical (e.g., film cameras), electro-optical (e.g., infrared (IR) trackers), multilateration, and GPS-based systems specialized to obtain required accuracies and data availability (e.g., real-time, post-mission). TSPI is a fundamental feature of T&E at OARs.

On-Board Instrumentation (OBI) capabilities for weapons platforms are separated into two categories: temporary equipment and embedded instrumentation. “Temporary equipment” is installed in systems-under-test (e.g., aircraft, tanks, ships, soldiers) in support of specific test

missions or test events, and includes associated off-board support equipment. "Embedded instrumentation" is an inherent part of the infrastructure of the systems-under-test and may include permanently installed sensors designed for the total life cycle. The OBI is responsible for collecting and storing data, and for formatting selected parameters to be transmitted via telemetry to a Range or Mission Control Center. It is also the function of the OBI to process data on-board the SUT allowing real-time event decisions to be made based on the results gathered from the processed data. OBI can consist of transducers, imaging equipment, GPS receivers, telemetry transceivers, aircraft data bus and embedded instrumentation monitors, data recorders, and various other devices that enable critical test data to be collected, processed, formatted, stored and/or transmitted in a timely manner.

Telemetry provides the means by which selected data and commands may be collected and transmitted from a SUT, and the method by which that data are received, processed, and displayed for use in real-time or post-mission. Engineers and program managers are able to monitor the operation and performance of the SUTs of telemetered data remotely from a Range or Mission Control Center. Pressure measurements, strain gauge information, altimeter readings, temperature, and just about any other test event measurement can be transmitted to help assemble the most accurate assessment of the current status, safety, and performance of the system-under-test. The amount of telemetered data is constrained by the availability of RF spectrum for telemetry purposes.

The Range Control is the center-point of all T&E that is -performed at OAR facilities. It is here that all command and control of SUTs is conducted and managed (i.e., mission control), as well as all test range instrumentation and other physical plant assets. Range control serves as the feedback loop at the OAR and is responsible for obtaining data from the test vehicle, processing and displaying that data, and relaying any updates or changes to the pilots or operators of the SUTs. Inside a Range Control Center, entire suites of equipment are dedicated to accepting, processing, and displaying information related to Range Surveillance, Range Clearance, TSPI, Telemetry, and other monitoring devices dedicated to project-specific needs.

Data Processing consists of multiple computers, front-end machines, and associated software and applications that are able to receive, format, and process incoming data streams in real-time from various range equipment including Radars, GPS systems, electro-optical/infrared (EO/IR) tracking mounts, telemetry transceivers, and other customized range data links. It is here that data from these multiple sources are stripped of their system-specific instrumentation characteristics and fused with one another in an effort to provide the best possible resolution and meaningful display of the test event to the Range Control Center. Along with processing, re-formatting, and re-packaging raw data that are collected during an event (i.e., real-time), the Data

Processing function also encompasses storage, archival, retrieval, and overall management of these data for post-mission use.

The Telecommunications and Timing function provides the means for establishing and maintaining the necessary pipelines for data to be exchanged between the Range Control Center and the following range entities in support of a test event: test range instrumentation, physical plant assets, test personnel, other ranges (test and training), off-site facilities, and distributed simulation centers. Proper network protocols, topologies, encryption techniques, and signaling levels are all a part of the Telecommunications and Timing function at a test Range. This function that ensures a network connection remains efficient and reliable so that essential mission data may be accessed by the Range Control function and distributed to other relevant participants as necessary.

T&E Support Vehicles include T&E range general purpose support mobile systems such as aircraft, vans, and ships which are used primarily for: data gathering, range safety, test control/monitoring, presentation of specialized test conditions (e.g. threat emitters, icing, etc.), large generic test beds, target surrogates/generic adversaries, chase/test observation; specialized adversary support, specialized T&E training (including specially-modified and unique aircraft not available in operational fleets), and range calibrations and checkouts. Specific T&E support vehicles related to air, land, and sea are discussed in chapters 6.2, 6.4, and 6.5 respectively.

6.10.2 Common Range Instrumentation Test Capability Analysis

Relevant data sources used are the following:

- 2004 Common Range Instrumentation Reliance Area Capability Summary (RACS)
- FY2005 Annual CTEIP Report
- September 2004 Test Technology Area Plan (TTAP).
- TENA, The Test and Training Enabling Architecture, Architecture Reference Document, Version 2002, November 4, 2002.
- Range Commanders Council standards documents, all years.

The CRI test capability area addresses the general-purpose capabilities that are basic to the infrastructures of almost all open-air ranges. The growing requirements for increased accuracies and quantities of test data, data stream fusion with faster evaluation turnaround time, and co-use of assets from multiple ranges and facilities for major weapon system programs in DoD are primary drivers for CRI required capabilities. These requirements are common to almost all ranges and facilities even though they may vary by degree (e.g., accuracies, number of data streams). As weapon systems and weapon platforms continue to increase in complexity, functionality, autonomy, performance, interoperability, information communications, and

operation in joint environments, then so must these basic T&E range infrastructure capabilities. Solutions for one range must be reviewed for possible applicability as solutions for other ranges, and may become candidates for shared developments, T&E/S&T efforts, or CTEIP projects.

TSPI instrumentation will require upgrades and new developments in radar-type systems, electro-optical systems, and GPS-based systems, as well as conversion of photo-optical film-based systems to video and digitized formats. Most radars used on ranges today were developed in the 1950s and 1960s, and despite attempts to upgrade them with modern electronics, are not up to the challenges of upcoming weapon systems, but are needed for non-cooperative targets. Radar-type systems (including laser radars), dependent on measuring the time differences between transmitted and reflected or return signals, are becoming increasingly challenged by faster-moving vehicles and objects (including plasma blackouts) with lower radar cross-sections and over-the-horizon ranges. For this reason, radars that operate at higher frequencies, increased slew rates, have the ability to track multiple objects (including weapon separations and for miss-distance), and those that can not be augmented by GPS data, should be pursued. To provide higher accuracies afforded by differential GPS solutions and to conserve RF spectrum for multiple participant tracking, alternatives to GPS-based systems such as Advanced Range Data System needs to be investigated and potentially replaced. A miniaturized onboard reference system is required for supplementing TSPI systems for the increased accuracy required to measure performance of advanced navigation and guidance systems in platforms and munitions, and for gap-filling when other TSPI systems are interrupted by electronic combat, plasma blackouts, or line-of-sight interference. Tracking of the individual soldier's position, field of view, weapons, targets, and obstacles in (for example) an urban terrain as well as the associated environmental conditions are required for testing, training, and experimentation. Scoring impacts and miss-distances of munitions and missile intercepts is required not only for land, but also increasingly for over-water and littoral targets, and from greater distances. Film-based photo-optical systems should be converted to digital video for faster data turn-around, enhanced triggering options, data fusion, and real-time qualitative assessment of the test event. Electro-optical (e.g., IR trackers) instrumentation upgrades will continue to be required to document and analyze critical end-game test events and require upgrades. Finally, GPS-based instrumentation will be increasingly needed to address multiple-participant T&E for systems and personnel, in particular, those that are operating at or near ground level, or beyond line-of-sight.

On-board Instrumentation (OBI) will continue to supplement and complement test range instrumentation by collecting and pre-processing data from system-under-test on-board sensors for storage and/or telemetering. Upgrades are needed to accommodate higher data rates (quantities of data), harsher environmental and structural conditions (e.g., hypersonic vehicles), smaller footprints, more diverse power availability, and the continued reductions in frequency

spectrum in the telemetry domain. These obstacles will require reliable high-density recording capabilities and on-board processing in smaller packaging to reduce the necessary transmission rates. Handling the volume and resolution of data will require higher internal bus rates, improved (including lighter weight) bus communications, and a new concept of operation. Fusing of data from both the temporary and embedded sensors will be required along with the necessary encryption and decryption equipment enhancements.

Test range telemetry capabilities require upgrades to address two opposing drivers: increasing data rates and decreasing availability of RF frequency spectrum. The increase in data rates and the number of streams required is resulting from the increase in complexity and number of new technologies being employed in a single weapon system as well as the number of participant systems and personnel (i.e., players) involved in the system-of-systems relating to net-centric and urban terrain operations. Ground level and near-ground level telemetry links must overcome other RF phenomena such as multipath, clutter, line-of-sight obstacles, interference. Telemetry data security enhancements must also be addressed. Additionally, flexibility to locate telemetry systems where it makes the most sense drives the need to convert from fixed receiving sites to mobile or transportable.

Range control systems require varying types of upgrades to meet the mission control needs of range users and new configurations of range instrumentation for the presentation of data and communications with test mission participants, including advancements to maintain compatibility with related systems such as the FAA and DoD target control systems. Range safety and air traffic management systems require upgrades to meet evolving FAA control upgrades and interface requirements. Additionally, general communications upgrades are also required such as upgrading voice and landline radios to enable full voice encryption. Other improvements are required to reduce maintenance and shorten the time required for calibrations. “Computer Network Operations” is a major new driver for visualization instrumentation that reveals non-kinetic weapon route tracking from ‘trigger pull’ to target; real-time weapon health and route disruptions; and effects assessment.

Data Processing provides a capability in an environment that requires ever increasing and more precise amounts of data. Network-Centric Warfare (NCW) is an additional challenge that focuses on data fusion of a myriad of SUTs, stimulations, simulations and operational C4ISR systems. Data processing must provide more automated, real-time, on-line information so the program manager can make critical design change decisions to his SUT. Specifically, integrated, distributed, computer-based systems are needed to identify, manage, and distribute test support data from mission planning to mission completion including real-time to post-test processing and analysis as well as production of data processing products. The data processing systems are increasingly networked, high performance data base management systems, which include storage

media, display subsystems, and engineering workstations. The Range Computation & Control System (RCCS II/III) currently being used at Patuxent River, and China Lake's North Range is an example of the migration to a more common, interoperable data processing system.

Upgrades in capabilities for Telecommunications and Timing are required to improve the ability of test ranges to coordinate, share, and synchronize support and data among all test and training ranges, facilities, and instrumentation involved in test, training, and/or experimentation. These requirements include development of, and compliance with, common architectures, standards, and protocol requirements. New capabilities must entail concepts that foster open-system architecture, use advanced digital electronics developments, and exploit evolving distributed simulation techniques and commercial-off-the-shelf technologies.

While Sections 6.2, 6.4, and 6.5 discuss investment needs for T&E support vehicles specific to support of those warfare areas, upgraded and new T&E support vehicle needs that are for more general purpose applications are addressed under Common Range Instrumentation. As analysis continues of all test capability area needs, it may be determined that the needs for these specific warfare areas can be satisfied with solutions for these more general purpose needs to improve interoperability and shared usage of designs among test ranges.

6.10.2.1 Test Capability Needs

The typical Common Range Instrumentation needs are driven by:

- Sustainability
  - Encroachment and environmental constraints
  - New weapon system technologies and capabilities
  - Acquisition initiatives
  - Maintain schedules (range availability) and costs
  - Faster data and evaluation turn around
  - Improve efficiencies and processes
  - Recapitalization
- Real Time Handling Increased Data Rates:
  - Digital Video
  - Increase Sensor Data Volume
  - TM data
  - On-board TSPI (e.g. GPS)
  - Faster Avionics Bus
  - Simulation Feed
- Radio Frequency Spectrum:
  - Loss to Commercial Users

    - Increasing Data Bandwidth Requirements for Increasing Data Rates
    - Safety of Flight
    - Test Point Clearance
    - Non-Recoverable SUTs
    - Scenario Control
- Robust & Reliable UAV Command Link
- Efficient, Accurate TSPI and Scoring:
    - Cooperative SUT – "GPS"
    - Non-Cooperative – "Optics" Single, Low Altitude
    - Non-Cooperative – "Optics" Multiple High Altitude
        - Hit-to-kill assessment
        - Warhead's kill assessment
- On-Board Instrumentation
    - Temporary Modification
        - Intrusiveness (size, weight, power requirements, intra-communications).
        - Data Storage Increasing
        - Survivability
    - Unavailability of Embedded Instrumentation for Acquisition Programs
        - Technology and development lead-times
        - Risks
- Data Visualization
    - Computer Network Operations

Table 6.10.1 provides a Traceability Chart for CRI needs FY2008-2022. While CRI is usually categorized according to TSPI, Data Processing Systems, On-Board Instrumentation, Telemetry, Range Control Systems, Telecommunications and Timing, and Support Vehicles, this traceability chart will follow the format of this plan by matching needs with the 22 test capability categories described in the chapter overview (section 6.1) as applicable.

Table 6.10.1 Common Range Instrumentation Test Capability Traceability and Prioritization

Item #	Test Capability Need	Test Resource Category	Programs/Concepts Supported	Relative Priority
10.1	General Test Instrumentation			
Near Term				
10.1.1	Upgrade and replace as necessary test range support vehicles (aircraft, ships, land vehicles, unmanned vehicles, and satellites) used to supplement test range capabilities for assuring safety, security, data collection, test beds, and as surrogates for test participants.	OAR	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment	High
Near, Mid and Far Term				
10.1.2	Recapitalize and upgrade general purpose test range instrumentation to improve performance, increase throughput and reliability, and to be compatible with standards for interoperability and co-use with other test and training ranges.	ALL	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment	High
10.2	Computer Replacement Upgrades			
Near, Mid and Far Term				
10.2.1	Upgrade data processing and software used in range and mission control facilities to handle increased data rates and sources.	ALL	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment	High

10.3	Storage Upgrades			
Near, Mid and Far Term				
10.3.1	Expand data storage capacity of on-board recording devices, while at the same time, reducing size, weight, and power requirements.	OAR	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment TTAP	High
10.4	Radar			
Near, Mid and Far Term				
10.4.1	Upgrade general use instrumentation radar systems for accuracy, target acquisition and tracking, and reliability and supportability.	OAR MF	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment	High
10.5	GPS			
Near, Mid and Far Term				
10.5.1	Improve accuracy of range TSPI systems through use of GPS TSPI enhancements and upgrades	OAR MF	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment CTEIP	Medium
10.6	Telemetry			
Near, Mid and Far Term				
10.6.1	Develop and upgrade telemetry data collection, pre-processing, compression, encryption, transmitters, and antenna systems for systems-under-test to require less RF bandwidth and frequencies while accommodating requirements for higher data rates.	OAR MF	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment CTEIP	High
10.6.2	Upgrade ground-based telemetry receiving and	OAR	Ch 3.2.2	High

	retransmission systems for compatibility with transmissions from the systems-under-test.	MF	Ch 4 sections 4.4.9 Recapitalization and sustainment	
Mid and Far Term				
10 6.3	Develop and acquire ground telemetry tracking systems acquiring and tracking hypersonic low-altitude missiles and aircraft.	OAR MF	Ch 3.2.2 Ch 4 sections 4.4.9	High
Mid Term				
10.6.4	Develop and acquire space-borne telemetry receiving/translator stations for tracking low-altitude, over-the-horizon, and earth-bound systems-under-test. Phase I: Data rates of 50MB/s-1GB/s Phase II: GIG and IP6 based telemetry	OAR	Ch 3.2.2 Ch 4 sections 4.4.9 and for application to multiple ranges	High
10.7	Communications			
Near, Mid and Far Term				
10.7.1	Upgrade and replace voice communications radios used on test ranges for compatibility with latest tactical warfighter system protocols and formats.	OAR	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization and sustainment	Medium
10.8	Sensors			
Near, Mid and Far Term				
10 8.1	Convert film-based optical tracking systems to digital video for faster data turnaround.	OAR MF	Ch 3.2.2 Ch 4 sections 4.4.9	High
10.8.2	Upgrade or replace IR and multispectral tracking systems for improving performance and reliability.	OAR MF	Ch 3.2.2 Goal 1 Ch 4 sections 4.4.9	High

			Recapitalization and sustainment TTAP	
10.9	M&S			
Near, Mid and Far Term				
10.9.1	Improve capabilities for integrating M&S (constructive and virtual) with live test, training, and experimentation events through range control, data processing, mission control data presentations, and projection to the system-under-test.	OAR ISTF HITL IL DMS	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization, interoperability, and sustainment	High
10.9.2	Develop compatibilities with the Test and Training Enabling Architecture (TENA) for sharing and co-use of M&S among test, training, and experimentation events involving multiple ranges and facilities.	OAR ISTF HITL IL DMS	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization, interoperability, and sustainment	High
10.10	Transducers			
Near, Mid and Far Term				
10.10.1	Develop families of transducers, data buses and ports, and data storage devices that can be put “on the shelf” for embedding in the design of weapon systems including systems-under-test that will meet test data needs.	OAR ISTF	Ch 3.2.2 Ch 4 sections 4.4.9 TTAP	High
10.10.2	Develop families of miniaturized transducers, data buses and ports, data preprocessors and storage devices, power sources, encryption, and transmitters	OAR ISTF	Ch 3.2.2 Goal 1 Ch 4 sections 4.4.9 TTAP	High

	that can be installed on a system-under-test on a "non-intrusive" basis.			
10.11	Calibration			
Near Term				
10.11.1	Develop a miniaturized non-intrusive on-board ultra-high accuracy reference system for use in calibration, enhancing accuracy, and performing as gap-filler for TSPI for use in testing of advanced navigation and guidance systems.	OAR ISTF MF	Ch 3.2.2 Ch 4 sections 4.4.9	High
10.14	Integrated Distributed Test Capability			
Near, Mid and Far Term				
10.14.1	Improve and upgrade range control facilities for integrating data and M&S from multiple sources to support combined and joint test, training, and experimentation events.	ALL	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization, interoperability, and sustainment	High
10.14.2	Improve or achieve compatibility with the Test and Training Enabling Architecture (TENA) for distributed operations among ranges and facilities during test, training, and experimentation events.	ALL	Ch 3.2.2 Ch 4 sections 4.4.9 Recapitalization, interoperability, and sustainment	High
10.15	Multiple Test Capability			
Near, Mid and Far Term				
10.15.1	Create a Computer Network Operations visualization	ALL	Ch 3.2.2	High

	tool for end-to-end assessment of non-kinetic weapons.		Ch 4 sections 4.4.9	
10.15.2	Improve and expand the Joint Distributed Engineering Plant (JDEP)	ALL	Ch 3.2.2 Ch 4 sections 4.4.9 Interoperability	High

6.10.2.2 Roadmaps

Most investment needs for the Common Range Instrumentation test capability area facilitate sustaining existing capabilities through continuous improvement and modernization programs at most test ranges, however, schedules and rates for accomplishment will vary considerably. For this reason, roadmaps for development, procurement, and sustainment may show concurrency when viewed across multiple ranges. The roadmaps (Table 6.10.2) with schedules portray only representative investments that are currently programmed; whereas, blank schedules indicate test capability area gaps to address a specific need.

Table 6.10.2 Common Range Instrumentation Test Capability Roadmaps

Development Procurement Sustainment

Item #	Test Capability	Near Term				Mid Term					Far Term					
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
10.1	General Test Instrumentation															
10.1.1.1	Mobile Instrumentation Support Vans – Army OT&E															
10.1.2.1	STARS (Standard Terminal Automation Replacement Systems) Procurement -- Navy															
10.2	Computer Replacement Upgrades															
10.2.1.1	Quick Look Instrumentation Reduction Station – Army OT&E															
10.2.1.2	MFS Simulation Computer System Technology Refresh -- Navy															
10.2.1.3	Common Processing and Display System -- Navy															
10.3	Storage Upgrades															
10.3.1.1	High Speed Data Recording System (HSDRS) – Army OT&E															
10.4	Radar															
10.4.1.1	Advanced Digital Radar -- Army															
10.4.1.2	Hypervelocity Advanced Mobile TSPI System -															

Item #	Test Capability	Near Term					Mid Term				Far Term					
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
	- Army															
10.4.1.3	Tracking Radar Modernization -- Navy															
10.5	GPS															
10.5.1.1	GPS Modernization															
10.5.1.2	EnRAP Procurement -- Navy															
10.5.1.3	GPS TSPI Upgrade – Air Force															
10.6	Telemetry															
10.6.1.1	ARTM Range Telemetry --Navy															
10.6.2.1	High Speed Telemetry Systems – Army OT&E															
10.6.2.2	Telemetry Acquisition Modernization Project -- Navy															
10.6.2.3	TM Antenna System Upgrades -- Navy															
10.6.4.1	(See Space Combat 6.6.3.1 and 6.6.3.2)															
10.7	Communications															
10.7.1.1	Fiber Optic Network II - Army (ATC)															
10.7.1.2	Secure Wide Band Satellite Common Link – Army OT&E															
10.7.1.3	ECR Communication/Fiber Upgrade -- Navy															
10.8	Sensors															
10.8.1.1	Film to Digital Video (FVD) -- Army															
10.8.2.1	IR Tracker Replacement -- Navy															

Item #	Test Capability	Near Term					Mid Term				Far Term					
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
10.11	Calibration															
10.11.1.1	Ultra High Accuracy Reference System (UHARS) – Air Force															
10.14	Integrated Distributed Test Capability															
10.14.1.1	Gulf Range Test and Training Control Center (GRTTCC) – Air Force															
10.14.2.1	Range Timing and Data Infrastructure Reengineering – Navy															
10.14.3.1	Common Post Test and Data Warehousing System – Navy															

6.10.2.3 Test Capability Gaps

Based on reference investment plans available, there are no concerted efforts across the T&E infrastructure to address major needed capabilities for: (1) transition embedded instrumentation technology from the T&E/S&T program, (2) fully becoming TENA compliant, (3) providing a Computer Network Operations visualization capability, nor (4) improving and expanding the Joint Distributed Engineering Plant. In addition, although not a test capability gap in a strict sense, there is no initiative to calibrate missile fly-out models across all test ranges and facilities to provide consistent test results.

Priority 1: Embedded Instrumentation (Need no. 10.10.1 and 10.10.2): There is minimal space available for adding instrumentation to new weapon systems subsequent to their design and development, especially since these systems are continually becoming smaller and more compact. Additional weight and power draw can adversely affect the weapon system's signature and performance. Instrumentation for humans-in-the-loop, such as a dismounted soldier, should not detrimentally affect the soldier's performance or be an operational burden. The T&E/S&T program is exploiting the latest technologies that could be transitioned into small, non-intrusive embedded instrumentation that can be integrated into new weapon systems during design and development, and, in some cases, retrofitted into existing platforms. Embedded instrumentation can provide the required data for T&E, training, and logistics throughout the system lifecycle and provide the ability to collect system performance during combat missions. Therefore, should the technologies for embedded instrumentation being developed under the T&E/S&T program not be aggressively put-on-the-shelf for low-cost incorporation into weapon system design by program offices, some on-board critical data will not be available for testing, training, logistics support, or combat documentation. Since the inclusion of embedded instrumentation is optional (unless required in the JCIDS process) by program offices in their weapon system design and development, they are unlikely to accept the risks and costs associated developing their own embedded instrumentation suite, nor are they likely to meet all T&E needs. T&E investment plans and roadmaps are necessary to reflect the T&E/S&T program technology transition plans to ensure that embedded instrumentation can be fully developed and available to program offices with minimal impact on their schedules and costs, and that meet the instrumentation needs of T&E.

Overall Risk Assessment: Medium-High

Likelihood: 4

Consequence:

Technical – 4

Schedule – 4
Cost – 3

Priority 2: TENA Compliance (Need no. 10.9.2): While compliance with the TENA has been implemented within several test and training facilities and ranges, the full potential for interoperability throughout the entire T&E infrastructure will not be realized until an investment plan among all of the Services and Defense Agencies that perform T&E is developed.
Overall Risk Assessment: Low
Likelihood: 2
Consequence:
Technical – 3
Schedule – 2
Cost – 1

Priority 3: Computer Network Operations Visualization (Need no. 10.15.1): All Services are growing their capabilities to mature the Computer Network Operation elements of attack, defense and exploitation. CNO tools and weapons emanating from these programs are poised to fulfill department policy to mature Information Operations (IO) into a core military capability. Achieving a steady-state IO core capability requires that kinetic and non-kinetic capabilities be fully integrated, tested and certified across a range of operational environments against multiple target sets entails integrating and connecting geographically dispersed CNO test capabilities, supporting activities and associated processes into a multi-level security, virtual range capable of supporting experimentation, RDT&E, training and exercises. The “IO" Range will support the warfare Reliance areas of air, land, sea and space combat, as well as electronic warfare and armaments and munitions. However, there is no joint approach or plan on how this is to be achieved.
Overall Risk Assessment: High
Likelihood: 4
Consequence:
Technical – 4
Schedule – 4
Cost – 3

Priority 4: JDEP Improvement and Expansion (Need no. 10.15.2): JDEP has an evolved significant infrastructure and processes, and is currently supporting nine Integrated Air and

Missile Defense (IAMD) and Command and Control (C2) federations involving approximately 35 facilities in providing battlefield representative environments in support of developer, test, and warfighter requirements. The capabilities of JDEP must be upgraded to support the full range of battlefield environments and joint operational missions for interoperability and systems-of-systems, entailing additional facility interfaces. There is no current program management structure or plan established to address this need. The office of USD (AT&L), led by DT&E, is sponsoring a one-year Decision Support Center study on Joint Distributed Systems Engineering and T&E Strategy to define improvements to support joint systems-of-systems testing in a net centric environment.
Overall Risk Assessment: Medium
Likelihood: 3
Consequence:
Technical – 3
Schedule – 3
Cost – 3

Priority 5: Standardized Threat Missile Fly-Out Models (Need no. 10.9.1): Constantly identified as a deficiency is the lack consistent results from missile fly-out models when using multiple test and training ranges for a single test program. No program has been identified to address this issue across all applicable ranges.
Overall Risk Assessment: Medium
Likelihood: 5
Consequence:
Technical – 2
Schedule – 3
Cost – 2

Priority 6: High Slew-Rate Telemetry Tracking (Need no. 10.6.3): As more weapon systems, munitions, and kinetic-kill weapons start operating at hypersonic velocities, especially at lower altitudes, active tracking systems for receiving telemetry data at different open-air ranges will require enhancements or replacement with capabilities for higher slew rates. Doppler effects may also have to be accommodated within the dynamic range of the electronics as well. No program has been identified to correct this issue.
Overall Risk Assessment: Medium
Likelihood: 5
Consequence:

Technical – 2
Schedule – 3
Cost – 1

Issues and Recommendations:

Issue: The T&E Reliance process for Common Range Instrumentation should be strengthened to better meet the needs of the TRMC strategic planning process.

Background: The T&E Reliance planning in the CRI RACS covers many of the traditional areas of test instrumentation for only a portion of the MRTFB and little, if any, of the remainder of the DoD T&E infrastructure, and then only if they exceed certain cost thresholds. The potential exists for significant needs (or even that the test capability already exists) at these other T&E infrastructure activities, for OT&E, or for classified programs that are not addressed in the RACS documents. Therefore, any common range instrumentation needs beyond what is contained in the RACS or provided by the Services and Defense Agencies in current budgets were not available for this analysis. Furthermore, it was apparent that the RACS is not focused beyond current budget years, nor have they considered providing capabilities to facilitate DoD transformation goals and initiatives such as the development of interoperable or common mobile instrumentation, embedded or non-intrusive instrumentation, and eventual connections with the GIG where feasible, for developers, testers, trainers, experimenters, and logisticians, in response to Strategic Planning Guidance to "ensure that T&E is conducted in a joint environment and facilitates the fielding of joint capabilities." And it was noted from reviewing proposed near-term investments by the Services, that several opportunities were missed to leverage investments for capabilities that had common objectives.

Recommendation: The T&E Reliance Panel for Common Range Instrumentation should be strengthened to better address DoD-wide mid-term and far-term needs and solutions for best accommodating the end-state of this plan to include areas such as: seamless interoperability among ranges; T&E of joint systems, systems-of-systems, families-of-systems, and C4ISR; testing in a joint environment; and emerging technologies.

6.11 TEST ENVIRONMENTS

6.11.1 Overview

The Test Environments' (TE) test capability area addresses T&E measurement facilities that replicate the physical conditions needed for development of current and future military systems for all Services and Defense Agencies. This includes direct simulation of the test environment or replication of the salient physical phenomenon that guides weapon system engineering and development for successful implementation and transition of war fighting technologies to fielded systems. These facilities provide simulated operating environments and instrumentation needed for realistic modeling and testing of concepts, designs, components, subsystems, and sub-scale systems before system integration and open-air, -land, -sea testing.

Test Environments replicate physical environments from sea-level to space; Mach numbers from subsonic to hypersonic speeds at the corresponding temperatures, pressures, and chemistry; climates that range from severe cold to extreme heat; and that present full range of conditions from various types of radiation. They are grouped according to six functional sub-areas:

- Aero-thermodynamic Test Capabilities
- Air Breathing Engine Test Capabilities
- Non-Air Breathing Propulsion Test Capabilities
- Environmental Test Capabilities
- Nuclear Weapons Effects Test Capabilities
- Sled Track Test Capabilities

The functional sub-areas under TE mimic the T&E Executive Agent Reliance panel structure. This section includes the capability areas not covered in the previous sections. Four of the six sub-areas support aviation/flight systems for all three Services and DoD agencies. The other two sub-areas support non-aviation as well as aviation/flight systems with non-air flow test capabilities. These are the Environmental and Nuclear Weapons Effects Test Capabilities. For example, a materials and structures static test capability without airflow is addressed under Environmental Test Capabilities. Unique test environments capability needs for the Army and Navy (and Marine Corps) are also addressed in Sections 6.4 and 6.5, Land Combat and Sea Combat, respectively. The capabilities in these sub-areas aid systems engineering, development, acquisition, in-Service engineering, and continuous evaluation for evolutionary acquisition with assessments of performance, operability, and durability, while minimizing program risks and associated costs. These capabilities provide controlled and instrumented conditions under which subsystems and sub-scale models can be used to provide system design information during the early phases of development before committing to costlier production-representative systems. During the later phases of the development process, these capabilities validate design concepts,

certify performance, troubleshoot, and revalidate fielded systems during aging surveillance programs.

Full-scale and prototype systems are typically tested in open-air, -land or -sea ranges and not in TE type capabilities. However, some full scale/prototype systems can be tested in some aero-thermodynamic test capabilities, sled tracks, and environmental test capabilities.

Test capabilities under the TE functional sub-areas support a diverse group of system development efforts for the Air Force, Army, Navy, Defense Advanced Research Projects Agency (DARPA), National Reconnaissance Office (NRO), Missile Defense Agency (MDA), Defense Threat Reduction Agency (DTRA), and, per interagency agreements, the National Aeronautics and Space Administration (NASA). These test capabilities also support technology developments by the S&T community. U.S. commercial activities rely on some of these test capabilities as well.

These test capabilities have been instrumental in the development of superior weapon systems and have allowed the U.S. to maintain its dominance as a military force. Capability upgrades and new capabilities will be needed to ensure that the U.S. maintains this dominance throughout the 21st century and beyond. However, foreign competition is making significant advances in aerospace, including the commercial aircraft market. This will eventually impact military systems because aerospace competencies are integrally related and commercial systems help sustain the workforce during lulls in military aerospace system developments. In addition, several developing countries are investing in aerospace test infrastructure and will pose serious threats to U.S. dominance in aerospace during the 21st Century (Ref. Aerospace Commission report and Dr. Sega in the NAI program).

6.11.2 Test Environment Capability Analysis

This TE capability analysis includes assessment of the test capability requirements for the next ten years, comparison of requirements to existing test capabilities, and identification of test capability gaps. The analysis addresses the following:

- Near-, mid-, and far-term testing requirements
- Unique test capabilities for each of the six sub-areas under TE
- DoD dependence on NASA test capabilities through interagency alliances

The key data sources used in this analysis appear below.

- High level guidance from Chapter Three
- Near- and mid- term needs from MDAPs, etc. in Chapter Four
- Far-term emerging technologies and research thrust areas from Chapter Four
- Current T&E capabilities from Chapter Five

Other sources of data used in the analysis include:

- RAND 2004 Wind Tunnel and Propulsion Report
- Review of the Air Force Test and Evaluation Infrastructure, USAF Scientific Advisory Board, SAB-TR-97-03, November 1998
- FY2004 Defense Planning Guidance Test and Evaluation Task, December 13, 2002
- Report to Congress on the National Aerospace Initiative, September 2003
- Reliance Area Capabilities Summaries (RACS), January 2004
- High Speed/Hypersonic Infrastructure Roadmap, March 2005

Based on these data sources, the critical drivers for test environments are the legacy systems and transformational capabilities like high speed/hypersonic missiles, aircraft, interceptors, and space access systems.

TE capability needs include recapitalization of the aging infrastructure, and new test capabilities to support future military developments, such as air-breathing hypersonic propulsion systems. DoD reliance on NASA for TE support for certain performance regimes may also have to be addressed in the future if NASA continues to scale back their involvement in aeronautics facilities.

Major capability upgrades are needed for TE measurement facilities throughout DoD. Major investments are currently underway or planned to modernize and upgrade some existing infrastructure, but these efforts need to be more inclusive, complementary, and continue without delays. Many of these investments are already late-to-need, but follow-on development programs can still benefit from these investments. This is especially true for the large transonic and supersonic wind tunnels and large air-breathing propulsion test cells.

Developing a hypersonic air-breathing propulsion capability is a major initiative by DDR&E, the National Aerospace Initiative (NAI), and critical to DoD's transformational initiatives. This capability would support the needs of the three Services, DARPA, MDA, and other government agencies. The primary motivation to invest in high speed, hypersonic, air-breathing propulsion systems is to offer the United States a revolutionary or transformational path to global strike and to maintain aerospace dominance. Hypersonic flight is extremely attractive due to its advantages derived from speed, including rapid access to any location on the face of the earth, reduced time-to-target (especially for time-critical targets), and access-to-space with aircraft-like operations. Space launch costs could be reduced by one third with a hypersonic air-breathing propulsion launch system. An air-breathing hypersonic propulsion system will enhance a variety of other weapons as well, e.g. ground-to-air, ground-to-ground, air-to-ground, air-to-air, ship-to-shore, ship-to-air and ship-to-ship systems.

Foreign countries are steadily investing in hypersonic technology and developmental test infrastructure. Therefore, only by developing these test capabilities can the U.S. evolve to realize

aerospace dominance in the 21st century. Numerous studies sound a consistent alarm that the U.S. needs to invest in hypersonic technology and test infrastructure. The capabilities represented under Test Environments are the enablers needed for the U.S. to develop these future hypersonic systems. Existing U.S. hypersonic test capabilities are inadequate at best and not available for the higher Mach numbers or larger systems. This is the case not only to perform developmental testing, but also in performing S&T scramjet developments.

A stepping-stone approach will ensure that near term needs are met with upgrades to existing capabilities for missile-size hypersonic systems. In addition, an appropriate level of facility technology development is needed to insure optimum infrastructure design, and in the long-term, with new test facilities capable of meeting test needs of the more demanding hypersonic aircraft-like and space launch systems.

This analysis includes a review of the test capability needs under TE that support the systems/program developments discussed in Chapter Four. The needs come from either near term system development programs or mid-to-far term technology programs that are expected to transition into ACTD or acquisition programs. All major capability needs will be included herein – those currently programmed as well as those not currently funded. The analysis is not limited to test capabilities for system development programs, but technology program needs are also included; especially where a major test capability is needed to advance the technology for a critical weapon system or where long lead times are needed to provide the test capability. The needs presented herein are primarily for TE Measurement Facilities per the six functional sub-areas.

6.11.2.1 Test Capability Needs

Test Environment capabilities support a wide-range of systems for all three Services, and other DoD agencies, as well as the National Aerospace Initiative. The following is a brief discussion of specific test capability needs described for each of the six sub areas. Each sub area will be discussed in turn with pertinent information only to that sub-area. The brief discussions will follow the Test Capability Traceability and Prioritization matrix, Table 6.11.1. This matrix only includes the top needs.

6.11.2.1.1 Aero-thermodynamic Test Capabilities Needs

A major issue is the aging aero-thermodynamic infrastructure and our inability to adequately invest to sustain and modernize capability. The current infrastructure is inefficient and has a very high maintenance backlog to make it reliable for customers. The existing capabilities are adequate to meet current customer requirements, but inadequate for future needs. The cost of testing and cycle time is increasing. Aero-thermodynamic test capabilities are atrophying with a continuing decline in capability. Many foreign capabilities are now on par and in some cases surpass U.S. aerospace capabilities, e.g. Reynolds number and Mach number simulation. The

U.S. is losing test workload to foreign test capabilities, thus losing vital technical expertise, and perhaps critical data, to foreign competitors and potential adversaries.

Another major issue identified by a recent study is for a hypersonic test capability. Specifically, the study recommends a significant investment over the next 3 years to modify existing capabilities to support near term needs and a major investment over 5 years in facility technology development approaches for a new hypersonic wind tunnel capability. Wind tunnels provide critical inlet/engine compatibility information, but this capability is limited in size and Mach number range. A facility technology development effort is funded by a congressional add to an Army S&T program called MARIAH (Magnetohydrodynamics Accelerator Research in Advanced Hypersonics), but this effort has a high technical risk, will have a short run time, and will only partially meet all the propulsion test requirements. However, a pilot facility, missile-scale, is proposed to assess its full potential for a full-scale test capability. Alternate and complementary test capability concepts and test methodologies are also proposed to ensure that an adequate air-breathing propulsion capability is available to test the entire spectrum of hypersonic systems. Trade studies will determine the most viable hypersonic test capability concept to address Mach 8-12 testing. In addition to MARIAH, an arc heated test capability is a viable and potentially more economical concept. A trade study is needed to determine the viability of these concepts. Current efforts are not adequately funded to support future hypersonic systems developments in the mid-to-far term. (Ref. High Speed/Hypersonic Infrastructure Roadmap, March 2005).

Table 6.11.1, Item# 11.16, describes the needs related to development and technology programs supported, the type of facility needed, and a priority band. Items # 11.16.1 – 11.16.3 and 11.16.8 in the table are for improvement and modernization of existing test capabilities. Item # 11.16.4 is to increase velocity test capability for KEW with a softer launch. Item # 11.16.5 is for a new wind tunnel test capability to evaluate missiles and aviation systems in flight. Items # 11.16.6, 11.16.7, 11.16.10, and 11.16.11 are to develop a hypersonic test capability. Finally, Item # 11.16.12 in the table is to develop a high Reynolds number production-type test capability.

6.11.2.1.2 Air-Breathing Engine Test Capabilities Needs

A major issue is the aging air-breathing engine test infrastructure and our inability to adequately invest to sustain capability. The current infrastructure is inefficient and has a very high maintenance backlog to make it reliable for customers. The existing capabilities are adequate to meet current customer requirements, but will not be able to meet future needs. The cost of testing is increasing and the test environment simulation quality is atrophying.

A major issue is not being able to adequately test ramjet and mode transitions from turbine to ramjet to scramjet. Also, we do not have a ground test capability able to simulate hypersonic

flight trajectories. The greatest deficiency for hypersonic testing is in the air-breathing propulsion test capability area.

Table 6.11.1, Item# 11.17, describes the needs related to development and technology programs supported, the type of capability needed, and a priority band. Items # 11.17.1 – 11.17.3 in the table is for improvement and modernization of existing test capabilities. Items # 11.17.7 – 11.17.9 are for new component test capability testing. Finally, Items # 11.17.4 – 11.17.6, 11.17.10 – 11.17.13 are to develop a hypersonic test capability.

6.11.2.1.3 Non-Air Breathing Propulsion Test Capabilities Needs

A capability is needed to test liquid propellant engines with run times up to 600 seconds at simulated altitude conditions and a large 6 degrees-of-freedom motion replicator.

Table 6.11.1, Item# 11.18, describes the needs related to development and technology programs supported, the type of capability needed, and a priority band for rocket test capability needs. Items # 11.18.1 and 11.18.2 in the table are for a new long duration (600 seconds) liquid-fueled rocket test capability at altitude conditions and a new vibration test capability, respectively.

6.11.2.1.4 Environmental Test Capabilities Needs

Capability needs were identified by the Army, Navy, and Air Force. Three shortfalls were validated by the TE Reliance panel and are identified as test capability needs.

Table 6.11.1, Item#11.12, describes the needs related to development and technology programs supported, the type of capability needed, and a priority band. Item # 11.12.1, 11.12.2, and 11.12.4 in the table are upgrades to existing facilities to improve instrumentation and equipment. Items # 11.12.3 and 11.12.5 are new environmental test capability needs. Item # 11.12.6 is a new capability to test large structures/materials exposed to hypersonic-type temperature conditions.

6.11.2.1.5 Nuclear Weapons Effects Test Capabilities Needs

A “Defense Science Board (DSB) Task Force on “Nuclear Weapon Effects (NWE) Test, Evaluation and Simulation report,” April 2005, assessed DoD capabilities and processes for establishing and enforcing hardness goals. This report also assessed the evolution of DoD and Department of Energy (DoE) modeling, simulation, and above-ground testing capabilities since the cessation of underground testing to understand our ability to qualify hardened systems. The results of this Task Force were developed independent of, but considered highly consistent with, the findings and recommendations of the congressionally mandated Electromagnetic Pulse (EMP) Commission. Some key findings from the report are:

The Report recommends that at least one facility be provided for pulsed neutron environments. Existing facilities are at risk because of escalating costs for safety when using highly enriched uranium (HEU). The task force recommends going with alternate procedures using low enriched uranium (LEU). At least one should be developed for both departments, and in the long run each department should have one.

Currently there are a number of facilities to simulate X-ray environments. The Report states that there is not enough work for all the facilities and that Decade and DTRA West Coast facilities, Double Eagle and Pithon, are largely redundant and should be terminated.

The minimum necessary set of X-ray, EMP, gamma, and neutron effects simulators to meet the needs of both conventional and nuclear forces should be determined. The need for full- scale EMP facilities should be addressed while leading experts are still available.

Concur with canceling the CTEIP upgrade to Decade, and recommend that DTRA consolidate its X-ray facilities at a single location, preferably the West Coast Facility where the last critical mass of expertise exists to support DoD.

The Task Force defers developing a roadmap to be follow-on based on DoD's required response to Congress regarding the recommendations of the EMP Commission. The Task Force urges that its recommendations also be integrated into the response.

Table 6.11.1, Items # 11.19 describes the NWE test capability needs from the DSB Task Force report. However, until a coordinated roadmap between DoD and DoE for divestments, consolidations, and investments in NWE T&E capabilities is developed, these needs cannot be supported and are given a Low relative priority.

6.11.2.1.6 Sled Tracks Test Capabilities Needs

A project to upgrade the supersonic sled track at Holloman AFB, NM is currently underway through a congressional add. No additional test capability needs have been endorsed by the Reliance Panel. Two new test capability needs were included in the High Speed/Hypersonic T&E Infrastructure Roadmap.

Table 6.11.1, Section 11.20, describes the needs related to development and technology programs supported, the type of capability needed, and a priority band. Item # 11.20.1 in the table is for the Maglev High Speed Test Track currently funded through a congressional ad. Items # 11.20.2 and 11.20.3 are for a new hypersonic test capability.

Table 6.11.1 Test Environments Test Capability Traceability and Prioritization

Item #	Test Capability	Test Resource Category	Programs/Concepts Supported	Relative Priority
11.16	Aero-thermodynamic Test Capabilities			
Near Term				
11.16.1	VKF Plan Modernization	MF	Upgrade for Legacy Systems: JSF, F-22, F-18, JDAM, JSOW, JASSM, TMD	High
11.16.2	Tunnel 4T Modernization	MF	Upgrade for Legacy Systems: JSF, F-22, F-18, JDAM, UCAV, AMRAAM, AIM-9X	High
11.16.3	Tunnels ABC Modernization	MF	FALCON/CAV, JDAM, JSOW, JASSM, TMD, Navy Re-entry Vehicle	High
11.16.4	KEW Lethality Test Capability	MF	Miniature Kill Vehicle, GBMD, Aegis BMD, Kinetic Interceptor, Theater High Altitude Area Defense	High
11.16.5	Wind Tunnel Virtual Flight Test Capability	MF	THAAD follow-on, UAVs, UCAVs, Future Missile Systems	Medium
Mid Term				
11.16.6	Ground Test 16S Upgrade to Mach 6	MF	Air Force Transformation Flight Plan, NAI Roadmap (Global Reach A/C, Long Range Hypersonic Missiles, Hypersonic Interceptors, Access-to-space, orbit-on-demand), Falcon/CAV Phase II, High Speed/Hypersonic T&E Infrastructure Roadmap	High

11.16.7	Ground Aero Thermodynamics/Materials	MF	FALCON/CAV, High Speed/Hypersonic T&E Infrastructure Roadmap/NAI	High
11.16.8	Improved Arm/Munitions Wind tunnel Test Capability	MF	Legacy fighter systems: JSF, F-22, F-18, F15, F-16	Medium
11.16.9	Jet Interaction T&E Capability	MF	Kinetic Energy Interceptor	Medium
Far Term				
11.16.10	Missile Scale Clean Air Ground Test Capability (MARIAH)	MF	High Speed/Hypersonic T&E Infrastructure Roadmap	Medium
11.16.11	Large Scale Clean Air Ground Test Capability (MARIAH)	MF	High Speed/Hypersonic T&E Infrastructure Roadmap	Low
11.16.12	High Reynolds Number Test Capability	MF	Legacy Systems: JSF, F-22, F-18, F15, F-16, B-2, C-17, follow-on bombers, tankers, & transports	Low
11.17	Air Breathing Engine Test Capabilities			
Near Term				
11.17.1	Propulsion Consolidation & Streamlining	MF	Legacy aircraft engines: F100, F117, F119, F135 (JSF), PW4000 (New Tanker)	High
11.17.2	AEDC Real-Time Display & Analysis System	MF	Legacy aircraft engines: F100, F117, F119, F135 (JSF), PW4000 (New Tanker)	High
11.17.3	ASTF Plant Right Sizing	MF	Legacy aircraft engines: F100, F117, F119, F135 (JSF), PW4000 (New Tanker)	High
11.17.4	Small High Speed Turbine Engine	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap, Cruise Missile	High
11.17.5	Large High Speed Turbine Engine	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap, High Speed Aircraft	High

11.17.6	Ground Test Variable Mach 4-8 Aero-Propulsion Testing (ramjet/scramjet)	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap,	High
11.17.7	Turbine Engine Combustor Test Capability	MF	Legacy aircraft engines: F100, F117, F119, F135 (JSF), PW4000 (New Tanker)	High
11.17.8	Turbine Engine Augmentor Test Capability	MF	Legacy fighter aircraft engines: F100, F119, F135, High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	High
11.17.9	Turbine Engine Core Test Capability	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
Mid Term				
11.17.10	Small Ram-/Scram-jet Engine Mach 8-12	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
11.17.11	Large Ram-/Scram-jet/Mode Transition Capability at Mach 4-8	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
Far Term				
11.17.12	Large High Speed Aircraft Scramjet Capability at Mach 4-8	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
11.17.13	Large Space Access Propulsion and Aerodynamic Capability at Mach 8-15	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Low
11.18	Non Air-breathing Propulsion Test Capabilities			
Near Term				
11.18.1	J-4 Long Duration Altitude Test Capability	MF	NAI, EELV (Delta IV)	Medium
11.18.2	Large Capacity 6 DOF Motion	MF	FCS, HMMWV, MLRS, PATRIOT PAC-3	Medium

	Replicator			
11.12	Environmental Test Capabilities			
Near Term				
11.12.1	Climatic Lab Inst/Equipment Upgrade	MF	Upgrade instrumentation and equipment for icing tests	High
11.12.2	Warhead/Explosives Upgrade	MF	Instrumentation and equipment replacement	Medium
11.12.3	MTD Ozone Depleting Chemical Replacement Program	MF	Modernize & replace refrigeration system and other equipment	Medium
11.12.4	Non-Destructive Evaluation Upgrades	MF	Legacy systems: Tomahawk, Harpoon, Sea Sparrow, Hellfire, HARM	Medium
11.12.5	E3 Life Cycle Sustainment	MF	Equipment modernization and upgrade to support legacy aircraft systems testing	Medium
Mid Term				
11.12.6	Large-scale no-flow Materials and Structures	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
Far Term				
11.19	Nuclear Weapons Effects Test Capabilities			
Near Term				
11.19.1	Gamma Effects Simulator	MF	DSB Task Force on “Nuclear Weapon Effects (NWE) Test, Evaluation and Simulation” report,” April 2005	Low
11.19.2	Full-Scale Fast Rise EMP Pulser	MF	DSB Task Force on “Nuclear Weapon Effects (NWE) Test, Evaluation and Simulation” report,” April 2005	Low
Mid Term				

11.19.3	LEU Pulsed Fast Neutron Effects Simulator	MF	DSB Task Force on "Nuclear Weapon Effects (NWE) Test, Evaluation and Simulation" report," April 2005	Low
Far Term				
11.20	Sled Tracks			
Near Term				
11.20.1	Maglev High Speed Test Track	MF	MDA lethality	Medium
11.20.2	Higher speed sleds for Kinetic Energy Weapons & Penetrators	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium
Mid Term				
11.20.3	Higher speed sleds for Kinetic Energy Weapons & Penetrators	MF	High Speed/Hypersonic Test and Evaluation Infrastructure Roadmap	Medium

6.11.2.2 Roadmaps

The following is the roadmap for Test Environments. The test capability gaps are needs without definite schedules and are not listed in the roadmap. These are discussed in section 6.11.2.3.

Table 6.11.2 Test Environments Test Capability Roadmaps

Development Procurement Sustainment

Item #/Test Requirement	Program	Near Term					Mid Term					Far Term				
		8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
11.16	Aero-thermodynamic Test Capabilities															
11.16.1	VKF Plant Modernization															
11.16.2	Tunnel 4T Modernization															
11.16.3	Tunnels ABC Modernization															
11.16.4	KEW Lethality Testing															
11.17	Air Breathing Engine Test Capabilities															
11.17.1	Propulsion Consolidation & Streamlining															
11.17.2	AEDC Real-Time Display System															
11.12	Environmental Test Capabilities															
11.12.1	Climatic Lab/Equipment Upgrade															
11.19	Nuclear Weapons Effects Test Capabilities															
11.19.1	(See Issues/Recommendations)															
11.20	Sled Tracks															
11.20.1	Maglev High Speed Track															

6.11.2.3 Test Capability Gaps

The test capability gaps are not addressed by any roadmap or test capability program. These test capability gaps are divided into two categories. These categories are test capabilities for legacy systems, which may have medium or high priority, and a second category for hypersonic test capabilities. There are several gaps within each category with varying priorities. The following is a discussion on each of these gaps and the potential risk to acquisition programs if the test capability is not provided.

Priority 1: Sustainment test capability needs. The Test Environment test capability needs are predominantly in the Aero-thermodynamic and Air Breathing Engine Test Capabilities sub-areas. These test capabilities are by far the most costly and highest in demand during the early phases of system development. Also, most of these test capabilities were build in the early 1950's and require major upgrades to meet the testing demands of current and future systems. The replacement value for these test capabilities is over $6B, so improvement and modernization (I&M) efforts are the less expensive option to provide the test capabilities needed. This is not a gap, as defined earlier in Section 6.1, but a sustainment requirement that needs to be addressed and supported on a continuing basis. Current Service I&M programs are attempting to address these needs, but unfortunately the level of sustainment is only a small fraction of what is required.

Risk Assessment: HIGH (Need No. 11.17.3 and 17.7 – 11.17.9)
Risk Assessment: MEDIUM (Need No. 11.12.2, 11.12.3, 11.12.4, 11.12.5, 11.16.5, 11.16.8, 11.16.9, 11.16.12, 11.18.1, 11.18.2, 11.20.2, and 11.20.3).

Priority 2: Small scramjet engine test capability Mach 4-8 (Clean air may be required) for hypersonic missiles (Need No. 11.17.4 and 11.17.6). Currently there are no test capabilities to test hydrocarbon fueled scramjet engines at Mach 8 for extended periods of time to evaluate engine operability and durability. In addition, there are no test capabilities that can test these engines through the transition region from scramjet to scramjet mode.

Risk Assessment: HIGH

Priority 3: Large high-speed turbine engine up to Mach 4 (Need No. 11.16.6 and 11.17.5). The current test capability is limited to Mach 3.2 for large turbine engines. Future high performance aircraft engines and combined cycle engines will require this test capability.

Risk Assessment: MEDIUM

Priority 4: Large Scramjet engines to Mach 8 (Need No. 11.12.6, 11.16.11, 11.17.11, and 11.17.12). This test capability is to test large aircraft-size and access to space-type systems. Current test capabilities are limited in size and run time. Current computational techniques are not able to adequately model the combustion processes and subscale model combustion cannot be extrapolated to full-scale engine performance, operability, and durability.

Risk Assessment: HIGH

Priority 5: Facility research and definition for test capability needs above Mach 8 (Need No. 11.16.10, 11.17.10 and 11.17.13). There are no test capabilities to test hypersonic engines above Mach 8 with sufficient run times to evaluate performance, operability, and durability. Research is needed to develop and evaluate concepts that will provide this capability.

Risk Assessment: LOW
The risk is LOW because this is a long-range requirement and more research studies are needed before a viable concept is developed.

Issues and Recommendations:

Issue: The "High Speed/Hypersonic Test And Evaluation Infrastructure Roadmap" is well developed and addresses a multitude of test capability needs. However, a plan for executing the roadmap is needed to ensure that appropriate action is taken in developing a hypersonic test capability. This includes refinement and prioritization of efforts.
Recommendation: A project office to prioritize and execute the high speed/hypersonic roadmap.

Issue: Until the recommendations from the DSB Task Force on "Nuclear Weapon Effects (NWE) Test, Evaluation and Simulation" report," April 2005, and the EMP Commission are acted upon, a coordinated roadmap between DoD and DoE for investments and divestments in T&E capabilities and capacities for NWE cannot be developed. Core decision to shape the roadmap will be whether and to what degree DoD weapon systems, including C4ISR systems, will be required to verify nuclear effects hardening during acquisition cycles, and for legacy systems.
Recommendation: TRMC will partner with the TE Reliance Panel and participate in follow-up actions to assist in developing a roadmap for the next edition of the strategic plan.

7.0 FUTURE STRATEGIC PLANNING ACTIVITIES

7.1 CHAPTER OVERVIEW

Congress identified several expectations for the strategic plan in the legislation that established the TRMC and directed the publication of the plan. This strategic plan builds on the efforts of the interim staff and on the information that is documented in the September 26, 2003 Strategic Plan. It represents a significant advance towards our goal of a comprehensive technology and resource assessment that will guide future T&E infrastructure development of the department.

7.2 CONGRESSIONAL DIRECTION

The Title10 USC 196 legislation states that the strategic plan will include the following six elements:

- An assessment of the T&E requirements of the Department for the period covered by the plan, which is addressed in Chapter 6.
- An identification of performance measures associated with the successful achievement of T&E objectives for the period covered by the plan, which is addressed in Chapter 3.
- An assessment of the T&E facilities and resources that will be needed to meet such requirements and satisfy such performance measures, which is addressed in Chapter 6.
- An assessment of the current state of the T&E facilities and resources of the department, which is addressed in Chapter 5.
- An itemization of acquisitions, upgrades, and improvements necessary to ensure that the T&E facilities and resources of the department are adequate to meet such requirements and satisfy such performance measures, which is addressed in Chpater 6.
- An assessment of the budgetary resources necessary to implement such acquisitions, upgrades, and improvements, which is addressed in Chapter 7.

The TRMC plans to improve and expand coverage of the mandated topics in future strategic plans. The following paragraphs outline the intentions of the TRMC.

7.2.1 10-Year Assessment of T&E Requirements for the Department

Title 10, USC 196 requires an assessment of the T&E requirements of the DoD for the next ten years. This strategic plan has made significant progress in this regard. Future T&E infrastructure investments should lead to a comprehensive suite of joint, interoperable capabilities that provide a full spectrum of resources to test current and new technologies including improved sensors, weapons platforms, and C4ISR systems. Furthermore, it has been recognized that there is an increased need to test innovative tactics and aid in the development of new training methods. This plan has identified numerous needs that will have to be addressed in order to achieve a fully capable T&E infrastructure. Future efforts will expand on this theme and examine in a more detailed fashion the specific steps required to achieve this level of functionality.

7.2.2 Identification of Performance Measures Associated with Successful Achievements of T&E Objectives

While this strategic plan includes a series of roadmaps and trace matrices that lay out the investment priorities of T&E community, it is understood that further refinement is necessary and more intimate relationships with the community experts in the technology areas identified need to be formed. Once these relationships have been fostered and a better understanding of planned developments gained, adequate measures of performance can be established and a baseline can be set.

The TRMC will establish a performance measurement process based on the balanced scorecard management system. This process will be used to clarify and translate organizational vision and strategy into action and performance measures. The balanced scorecard management system will be used to help establish organizational performance measures because it views the organization from four perspectives: learning and growth, business process, customer, and financial (depicted in Figure 7.1).

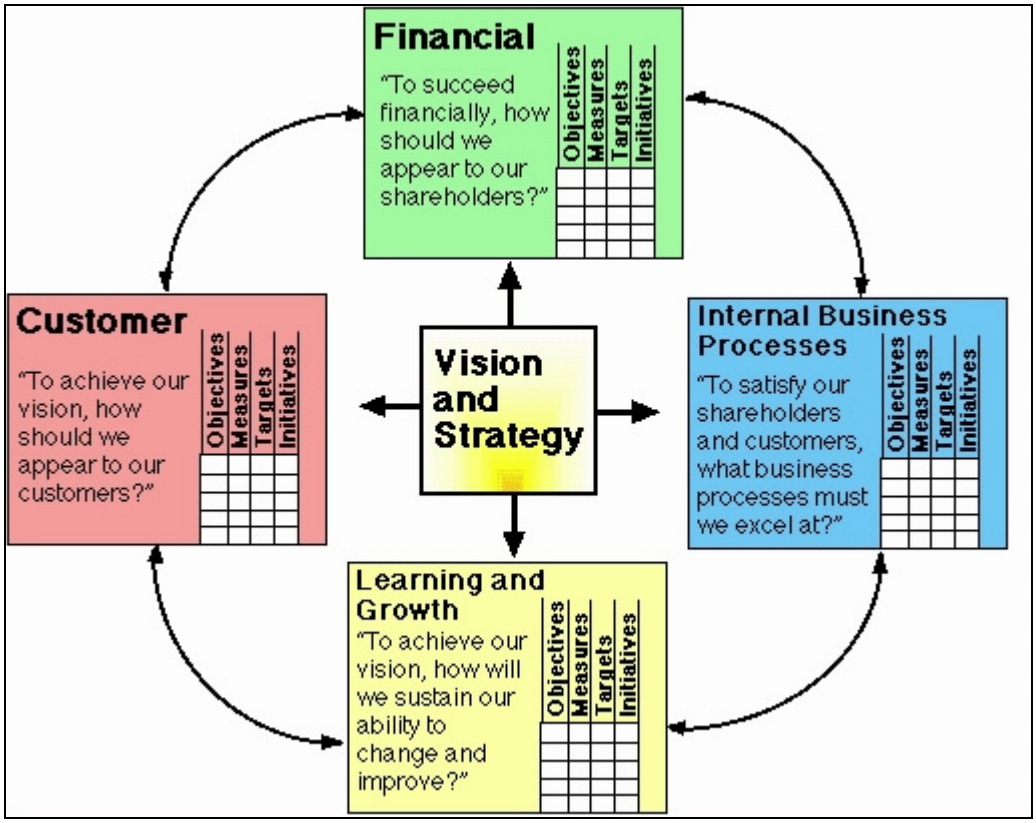

Figure 7.1—Balanced Scorecard (Balanced Scorecard Institute, 2005)

At this time, the necessary information to establish these performance measures has not been collected; however, future versions of this plan will include these measures of performance.

7.2.3 Expanded Assessment of the T&E Facilities and Resources Needed to Meet Requirements.

This subject requires an expanded mapping of the T&E needs that have been addressed in other chapters of this plan as well as those that will be addressed in future plans to performance measures yet to be identified. There is currently an expansive list of investment projects that could improve T&E capabilities, but the ability of these projects to contribute to meeting the vision of a fully capable, responsive, and affordable T&E infrastructure must be measurable and significant. The challenge is to develop a methodology to measure this synergy and accurately compare resources to capabilities in future strategic plans for DoD T&E resources.

7.2.4 Comprehensive Assessment of Current State of the T&E Facilities and Resources of the Department.

Title 10, USC 196 requires an assessment of the current state of T&E facilities and resources. While the descriptions in the earlier sections of this plan provide some insight into the state of these facilities, these discussions could be more comprehensive. Future plans will expand the assessment and include an examination of any impacts that may result from FY2005 Base Realignment and Closure (BRAC) actions. Additionally, coordination with the Quadrennial Defense Review (QDR) will be effected, and any potential issues influencing T&E resources or requirements will be fully vetted.

7.2.4.1 Recapitalization Rate for T&E Facilities

The TRMC will work with the Services and DUSD (I&E) to assess whether accurate data are being provided for the sustainment, restoration, and modernization of T&E facilities and, if necessary, facilitate the reduction in the recapitalization rate for T&E facilities.

7.2.4.2 MRTFB Workforce

Figure 7.2, from the FY2001 DOT&E Annual Report to Congress, shows the trends in the workforce at the MRTFB. The T&E professional workforce is both the greatest asset and the biggest expense for consideration in any strategic planning process. Figure 7.2 shows that, between FY90 and FY2005, the MRTFB workforce has declined by over 25 percent. Future Strategic Plans will address the workforce issue in greater detail and will require close coordination with the National Security Personnel System

(NSPS) and respective Service organizations. Furthermore, any effects resulting from BRAC decisions and the upcoming QDR must also be considered.

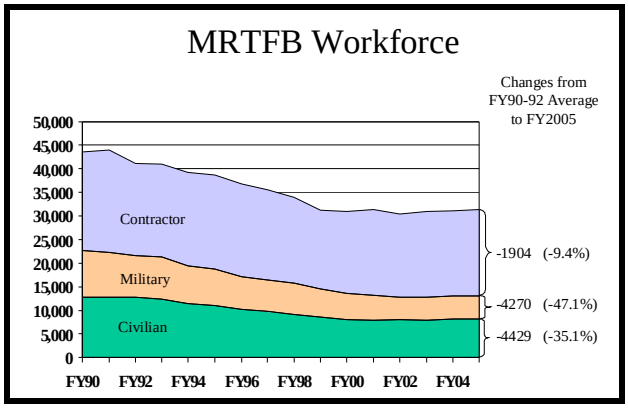

Figure 7.2—MRTFB Workforce

**Source: FY2001 DOT&E Annual Report to Congress

7.2.5 An Itemization of Acquisitions, Upgrades, and Improvements Necessary to Ensure T&E Facilities and Resources are Adequate to Satisfy Performance Measures

As is mentioned in section 7.2.2, adequate performance measures have not yet been fully developed to assess the achievement of T&E objectives. When the measures of performance are established, a list of the acquisitions, upgrades, and improvements needed to achieve success will be made.

7.2.6 Assessment of Budgetary Resources Necessary to Implement Required Acquisitions, Upgrades, and Improvements

The budgetary resources necessary to implement required acquisitions, upgrades, and improvements are currently being identified and will require refinements as solutions to the critical gaps in Chapter Six are determined. Comprehensive assessment methodologies are also being developed. Required budgetary resources will be documented in later versions of this plan.

7.3 POLICY ISSUES

Policy directives have a significant effect on strategic investments. One example that has been discussed in other sections of this plan is the various sources of T&E capabilities that exist outside of the DoD and how the department intends to use them. Another policy issue that must be addressed relates to MRTFB and non-MRTFB

installations and the financing, auditing, and compliance issues associated with the 2003 NDAA. One of the primary issues that needs to be addressed is how willing the DoD is to depend upon non-DoD facilities to provide T&E services. Such issues relate to who is responsible for the T&E of weapons systems and the types of partnerships and arrangements needed to satisfy the DoD needs. The resolution of these and other policy issues, in turn, will directly affect what T&E resources need to be addressed in the strategic plan for DoD in-house T&E capability. These and other policy issues will be addressed in future strategic plans.

7.4 OTHER AREAS TO BE ADDRESSED

Below are five areas identified by the TRMC that represent possible opportunities for improving the management of T&E facilities and resources within the Department of Defense. Further study of these areas will be conducted to identify necessary managerial, administrative, regulatory or legislative improvements.

7.4.1 Composition of the Major Range and Test Facility Base (MRTFB)

The TRMC will examine and modify, as necessary, the policies and regulations regarding the composition of the Major Range and Test Facility Base to best support the objectives of the strategic plan.

7.4.2 Review of Reimbursement Policies for Use of the MRTFB by Federal Departments and Agencies outside DoD

To obtain a clearer picture of the reimbursement procedures being applied within the MRTFB, the TRMC plans to review the use of the MRTFB by federal departments and agencies outside of the Department of Defense. The review objectives will be to identify all federal departments and agencies outside the DoD that use MRTFB facilities, the extent to which each such agencies use MRTFB facilities, whether those federal departments and agencies are charged for the use of those facilities in a uniform manner, the total amount of reimbursement for use the MRTFB from each federal department and agency in the previous fiscal year, and whether all such charges are consistent with the DoD Financial Management Regulation (DoD 7000.14-R) and DoD Directive 3200.11.

Concurrently, the TRMC will request that the DoD components submit reports on DoD use of NASA test facilities in the previous year and the level of reimbursement provided to NASA for use of those facilities. In FY2004, NASA implemented a full-cost recovery policy that departs significantly from previous NASA reimbursement procedures. The objective of the report will be to compare the level of payments that the DoD

components made to NASA for use of its test facilities with those received by the DoD components from NASA for use of the MRTFB. The TRMC will also monitor NASA's response to the congressional appropriations committees' direction that the agency restructure the fees charged for use of its wind tunnels to make them competitive with rates charged overseas. These findings will be documented in a NASA report to the Congress on the agency's plans to restructure its fees.

The results of the foregoing review may require additional guidance in future strategic plans and may initiate changes to DoD Directive 3200.11, DoD 7000.14-R, and any applicable statutory provisions necessary to modify the reimbursement policies for use of the MRTFB by other Federal departments and agencies.

7.4.3 Review of the Manner in which Major Weapons Programs Contribute to Investment in the Test and Evaluation Infrastructure

It is the department's objective that MRTFB indirect costs be funded entirely by the department's institutional accounts. Furthermore, DoD users will be charged no more than the direct costs of their use of the MRTFB. Some questions remain as to whether major weapons programs will continue to pay part of the institutional and overhead costs as part of the cost of testing, particularly with respect to single-use tests at the department's T&E facilities. The contribution that major weapons programs make to the investment in the department's T&E infrastructure is possibly much greater with respect to smaller T&E facilities (including laboratories and research and engineering facilities) outside the MRTFB. The TRMC will study the magnitude of the major weapons programs' expenditures for T&E. The central focus will be to explore the hypothesis that most T&E infrastructure in the Department of Defense is actually funded by T&E investment accounts.

7.4.4 Assessment of Policy Alternatives for the Management of Orphaned Facilities

Within the T&E infrastructure, a number of test assets are critical to the Department of Defense because they provide unique test capabilities even though they are seldom used by the owning Service or agency. Certain assets are considered to be "orphaned" facilities as they lack sufficient support from their parent Service or agency to allow them to be adequately maintained, much less modernized and improved. However, if they were to be closed or eliminated, it would be cost-prohibitive to reconstitute them the next time they are needed. Such assets normally have a very small customer base. The TRMC will assess the magnitude of the problem with "orphaned" T&E facilities within the

department. Based on that assessment, the TRMC will determine whether or not specific policies should be adopted for orphaned facilities.

7.4.5 Establishment of Policies and Procedures Regarding the Use of Foreign Test Facilities

Defense contractors and DoD components have been conducting testing in test facilities outside the United States for many years. In some cases, testing takes place abroad because the foreign facility provides unique capabilities that are not readily available in the U.S. In other cases, the decision to test abroad may be based on a relatively attractive initial cost of testing or due to capacity issues. The TRMC will review DoD policies, procedures, and practices with respect to the establishment and implementation of agreements on cooperative T&E with foreign countries for the purpose of determining if any of those policies, procedures, and practices should be modified.

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APPENDIX

APPENDIX A

MRTFB SITES

A. 1 ABERDEEN TEST CENTER (ATC)

A.1.1 Mission

The primary mission of ATC is to plan and conduct tests supporting RDT&E of military systems and equipment by applying modern test procedures, advanced technologies, and state-of-the-art instrumentation. To accomplish this mission, ATC, operates a diverse infrastructure of automotive test courses, large and small caliber firing ranges, simulators, specialized test facilities, laboratories, technical shops, and instrumentation. ATC's technical staff consists of engineers, scientists, mathematicians, physicists, computer specialists, skilled craftsmen and technicians.

A.1.2 Location

ATC is located at Aberdeen Proving Ground, just east of Aberdeen, Maryland, 40km/25 miles northeast of Baltimore, and is served by two arterial highways, US Route 40 and Interstate 95, with entry and exit points on Maryland Route 22. ATC is also accessible by rail (Conrail and Amtrak) and by sea along the western shore of the Chesapeake Bay. Commercial air terminals are located at the Baltimore Washington International Airport (60km/37 miles), Ronald Reagan Washington National Airport, Washington, DC (111km/69 miles), Washington Dulles International Airport (154km/96 miles) and Philadelphia International Airport (121km/75 miles) from ATC. Phillips Airfield, with runways of 5,000 ft and 8,000 ft in length, is located on the installation.

A.1.3 Features

ATC is situated on approximately 68,000 acres of generally flat land, consisting of a variety of soil types (sand, clay, loam), and varies in elevation from sea level to 60 feet above sea level. Features include woodlands, meadows, marshland, and estuaries of the Chesapeake Bay. ATC's adjacent Churchville Test Area provides terrain typical of the

Appalachian Piedmont (rolling hills). Variations in weather, terrain and vegetation at this single location provide the capability to conduct a major portion of the Army's spectrum of technical testing. An annual average high temperature of 88 degrees F in the summer months and an annual average low temperature of 23 degrees F characterize the temperate climate at ATC in the winter months. The average annual rainfall is 40-45 inches, with an average annual snowfall of 13 inches. Wind velocity typically varies between 4 and 12 miles per hour, and the mean humidity is 70 percent.

A.1.4 Facilities

A.1.4.1 Automotive Test Courses. ATC has a broad assortment of automotive test courses, consisting of paved roads, gravel and dirt secondary roads, level cross-country courses, and hilly cross-country courses. The majority of these courses are located at the Munson, Perryman, and Churchville Test Areas.

A.1.4.1.1 Munson Test Area. The Munson Test Area primarily consists of a continuous two-mile gravel secondary roadway, with access to Belgian Block roadway, standard obstacles and specialized courses. The gravel roadway is surveyed and maintained monthly to ensure a specified severity, and course direction is reversed every four hours. The specialized courses and standard obstacles include:

- Longitudinal slopes (5% to 60% inclines)
- Side slopes (up to 40% incline)
- 2-inch washboard (2-foot centers)
- 6-inch washboard (6-foot centers)
- Wave course (frame twister)
- 1 to 4-inch radial washboard
- 3-inch spaced bump
- Simulated loading ramp
- Imbedded rock course
- Vertical walls (12-inch, 18-inch, 24-inch, 36-in, and 42-inch)
- Bridging device
- Ditch profile
- Turning circle (250-feet diameter)
- Paved road (2,235-feet length)
- Sand course
- Clay soil bin
- Abrasive mud course
- Fording basins
- Amphibian ramp
- Shallow water swimming area

Testing at these courses assesses the ground transport shock and vibration characteristics of military equipment such as communications shelters, ammunition containers and electronics packages. All varieties of carrier and tow vehicles can be made available.

Instrumented tests are conducted using either on-board or telemetered data acquisition when required. Tests are run at prescribed speeds in accordance with MIL-STD-810F.

Munson Test Area

A.1.4.1.2 Mud-Sensitive Test Area. The Perryman Test Area consists of secondary roads, level cross-country courses, a high speed paved road, and a mud bypass course. These courses are used extensively for automotive performance and endurance testing, and are surveyed and maintained monthly to ensure specific profiles. Course directions are reversed every four hours to normalize course conditions and vehicle wear.

The four cross-country courses, designated as No. 1, No. 2, No. 3, and No. 4, increase in severity with the increase in number, varying from relatively mild to extremely rough terrain. Courses No. 2, No. 3, No. 4 are connected, and can be run as a circuit approximately 8 miles long. Cross-country No. 1 course is configured as a winding closed loop, miles long, with substantial roadbed composed of bank gravel and quarry spall.

Secondary Road A is a closed loop course of native soil 2.4 miles long with sharp sweeping turns, typical of unimproved country roads. Secondary Road B is similar, but is long and straight with sharp turnarounds at both ends. The high-speed paved road is a 3.8-mile straightaway with banked turnaround loops at each end. This course is highly utilized for endurance operations and performance tests requiring uninterrupted operation. The Mud Bypass Course is a 0.25-mile bypass off of Course No. 1. It is most useful in periods of dry weather for exposing vehicles to muddy conditions to evaluate seals, brakes, or other mod-sensitive components during endurance operations. The course is prepared by tilling and pumping water onto it from a nearby pond.

Perryman Test Area

A.1.4.1.3 Churchville Test Area and Dynamometer Course. ATC's hilly cross-country courses are located at the Churchville Test Area and are characterized by hilly terrain, typical of the Appalachia Piedmont. Course A, more accurately identified as an area, is the most severe of the hilly cross-country courses. It is heavily wooded and includes rocky terrain, ravines, steep grades up to 30 percent, and side slopes. Course B consists of moderate to rough native soil and stone terrain, with slopes up to 29 percent. Both courses are configured in closed loops over and around the hills. The area is well suited for testing the performance and durability of vehicle power trains, braking systems, and suspensions. Unpaved longitudinal slopes up to 60 percent incline are also available. The ATC dynamometer course is a flat, straight, paved roadway with a total gradient of less than 0.1 percent along its 1-mile length. Turn-arounds are provided at each end. It is used for closely controlled engineering tests such as tractive resistance measurements, acceleration and braking tests, and fuel consumption measurements.

Churchville Test Area

Mobile Dynamometer on Dynamometer Course

A.1.4.2 Specialized Automotive Facilities.

A.1.4.2.1 Roadway Simulator.

The Roadway Simulator facility is the world's largest automotive test simulator designed to perform vehicle dynamics, power train performance, and shock and vibration testing in a laboratory environment. The simulator adaptively constrains a vehicle at its center of gravity and provides vertical, cornering, and tractive forces to the vehicle through the tire/roadway interface using a system of special treadmills. An infinite array of driving profiles can be programmed and executed by the computer-based controller to perform braking, steering, handling, stability, fuel economy, emissions, power train performance, vibration, and ride quality tests. The simulator will support vehicles ranging from 5,000 pound, 2-axle light trucks to 80,000-pound tractor-trailers.

The simulator test capability includes 2-axle light vehicles (up to 120 mph) and trucks with tandem rear axles and a gross vehicle weight up to 30 tons and tractor-trailer combinations with gross vehicle weights as high as 40 tons.

A.1.4.2.2 Accelerated Corrosion Test Facility (ACTF)

The ACTF is the only facility of its kind in the United States. The ACTF enables materiel developers to evaluate the corrosion resistance of their systems. The facility is composed of four co-located entities: salt fog/mist chamber, salt splash trough, grit trough, and high-temperature/high-humidity chamber. Vehicle corrosion testing is combined with durability testing to examine the interaction between corrosion and the physical stresses that act upon a vehicle. Test vehicles are operated over a combination of road courses in accordance with the vehicle's specified mission profile. Each test cycle is performed in one day. Fifteen test cycles replicate one year of field corrosion. Data collected from corrosion testing assists in the prediction of total life cycle costs of vehicle systems.

A.1.4.2.3 Automotive Tilt Table.

The ATC Automotive Tilt Table is a hydraulically actuated platform for tilting test vehicles to determine roll and/or pitch stability. Results can be used to closely approximate roll stability during steady-state cornering. The tilt table platform measures 100 foot long by 14 foot wide, with an expanded width of 25 foot at its midsection, and can be tilted about its longitudinal axis up to an angle of 40°. It can lift loads up to 140 tons over each of five 20-foot sections with uniform loading over the length of the table. A maximum capacity of 700 tons is possible.

A.1.4.2.4 Vibration Laboratory. Accelerated vibration and shock testing of automotive systems, components of systems, and ammunition is conducted at the ATC Vibration Laboratory. Once vibration or shock schedules are determined for test items from ATC's test courses, simulated environments are generated on electrodynamics vibration systems, and testing is conducted at a tremendously accelerated pace. Three separate vibration systems are available, each capable of testing up to 2000 Hz with a force of 40,000 lbs. A centralized instrumentation suite consists of closed circuit video, computer-based data

acquisition, digital waveform generators, and waveform analyzers. Each system has temperature-conditioning capability from -70° to +170°F, and can accommodate up to 1000 lbs of explosives.

A.1.4.2.5 Automotive Impact Facility. The ATC Automotive Impact Facility is used to test the compliance of alternative fueled vehicles (AFVs) and zero emission vehicles (ZEVs) with applicable Federal Motor Vehicle Safety Standards (FMVSS), including crash worthiness standards. The facility is located to minimize dangers associated with impacts on compressed gas fuel tanks. A 4000 lb moving contoured barrier, built in accordance with FMVSS 301 and 303, is propelled towards the stationary test vehicle using a regulated prime mover and wire rope/pulley system, at speeds up to 60 miles per hour along the 800-foot guide rail. The 80 square foot impact area consists of a reinforced-concrete pad with an underground recess to accommodate high-speed photography of the test vehicle undercarriage. The impact pad also features a trough and bilge system to correctly handle any fluid spill that may occur.

A.1.4.3 Transportability Testing Facilities.

A.1.4.3.1 Rail Impact Facility.

The Rail Impact facility is used to determine the effects on equipment that is mounted on rail cars and coupled in trains in preparation for rail shipment. Rail impact testing is conducted in accordance with MIL-STD-810, to ensure compliance with American Association of Railroads (AAR) and Military Traffic Management Command – Transportability Engineering Agency (MTMCTEA) requirements, and sometimes serves as a basis for verification of restraint systems intended for use to transport equipment in US Air Force (USAF) cargo aircraft. Typically measured are impact speed, acceleration, strain and tie-down cable tension. The AAR standard test consists of four impacts at speeds of 4, 6, and 8 miles per hour in the forward direction and 8 miles per hour in the reverse direction. An on-site building is dedicated to railcar loading, blocking, and tie-down. A platform located adjacent to the Rail Impact test site provides easy access for inspections immediately before or after each impact. Test results are usually forwarded to MTMCTEA for consideration in transportability certification.

A.1.4.3.2 Lift and Tie-Down Facility (LTFD).

The strength of lifting, tie-down, and multipurpose provisions applied to military vehicles and equipment are verified through MIL-STD-209 and MIL-STD-913 testing at the LTDF. An electric 55-ton chain hoist, remote controlled 60-ton hydraulic load application system, air bag inflation system and a vast array of specialized test hardware are used at the site. Test personnel administer test loads from within the confines of a ballistic proof test control room equipped with a PC based data acquisition system, and a video system for real time monitoring and recording of test load applications. Customers and technical representatives also witness testing from within this protective enclosure. Test results are usually forwarded to MTMCTEA for consideration in transportability certification. Other tests performed at the LTDF site include center of gravity determination, suspension system, material handling crane and winch testing.

A.1.4.3.3 External Air Transport (EAT) Test Facility.

The ability of equipment to be transported by rotary-winged aircraft (helicopter) is determined at the EAT facility. Testing of military equipment such as communications shelters, equipment trailers and tactical vehicles can include any or all of the following processes required for flight certification: verification of appropriate rigging for flight, strength testing of members in contact with rigging, and dynamic flight testing. Testing is conducted in accordance with MIL-STD-913 and coordinated with the certification authority for EAT, Soldier System Center – Natick (SSC-N). Tests are documented with still and video photography, with instrumentation available as required. All varieties of US Army and Marine qualified lift helicopters/aircrews are available on call. Load weight is limited to the working capacity of the individual aircraft models selected. The Bomb Loading Ramp at Phillips Army Airfield (PAAF) of APG is used as a staging area. Designated APG airspace is used for flight-testing through the full complement of flight maneuvers.

A.1.4.3.4 Internal Air Transport (IAT) Test Facility.

The ability of equipment to be loaded safely in USAF fixed-winged cargo aircraft is determined by testing conducted in cooperative agreement with various regional Air National Guard and regular USAF units. The equipment under test is configured for transportation and measurements are recorded for relevant physical characteristics, such as center of gravity, weight distribution, external dimensions, and tire contact patch pressures. These data are then submitted to the USAF certification authority for IAT, the Air Transportability Test Loading Agency (ATTLA), USAF Aeronautical System Center, for authority to perform a loading test on USAF aircraft. The equipment is then taken to a regional airport or USAF base and driven into the aircraft fuselage using the aircraft loading ramps, or maneuvered onboard with the 463L pallet loader. All testing is performed in accordance with MIL-HDBK-1791 under the active supervision of serving USAF loadmasters, who ensure the maintenance of safety. Specific minimum clearances between loading equipment and aircraft are measured, and the compatibility of the equipment restraint provisions with the aircraft tie-downs is examined. The test process is documented by still and video photography. Results are submitted to ATTLA for consideration for IAT certification.

A.1.4.4 ARMAMENT AND AMMUNITION TESTING FACILITIES

A.1.4.4.1 Main Front Ranges

The Main Front Range area consists of three large caliber firing barricades, designated B1, B2, and B3, and three climatically controlled firing enclosures. Direct- fire accuracy testing of large caliber weapon and ammunition systems are conducted with multiple target capability at ranges up to 4000 meters. Both depleted uranium (DU) and non-DU firing lines are available. Each Large Caliber Firing Barricade features an oversized firing bay with an ATC-designed adjustable trunnion span mount affixed to an inertial mass to accommodate a variety of large caliber weapons. The adjacent area to the right of the span mount is a gravel bed, designed to allow for the positioning of spade outfitted vehicles undergoing firing tests. Extensive concrete pads and walkways line the

facility, providing easy access to test instrumentation, equipment, and vehicle positions. Three cells containing ammunition temperature conditioning units are located to the right of the firing bay. The temperature units are capable of reaching -100 to 200 degrees Fahrenheit with non-ozone depleting refrigerants. Each facility contains a ten-ton overhead crane in the firing bay, an air compressor to operate pneumatic tools, on-site parking, and a barricade control building.

The barricade control building features a customer viewing room, a high-speed photography and ballistic instrumentation suite, a flash x-ray room, rest rooms and storage. Other on-site instrumentation includes an automated video target scoring system, digital Doppler radar systems, and a projectile follower camera system.

The climatic firing chambers can accommodate from 7.62mm up to 176mm weapon systems with range capability out to 22,000 meters. One of the enclosures can contain modern battle tanks, with temperature capability from -65 to +170 degrees F.

A.1.4.4.2 Firing Impulse Simulator (FIS)

The FIS is a hardware-in-the-loop simulator that has the capability to simulate firing impulses of large caliber weapon systems (105mm to 8 inch) at gun elevations positioned from 0 to 85 degrees. The weapon system (e.g., tanks, mobile howitzers) with surrogate gun tubes is positioned on an adjustable platform and the gun tubes are dynamically loaded by a hydraulic ram. The loading is controlled to match actual firing dynamics. The FIS is typically used for testing mechanical and hydraulic components, recoil systems, trunnion and turret ring bearings, gun cradles, and other system components affected by firing impulse. The FIS can be used to conduct life cycle wear, fatigue, and reliability, maintainability, and durability tests of complete systems or cannon. It is also applicable for shock/impact tests of components, isolation mounts, and shock absorption systems (up to a 3 million pound-force).

A.1.4.4.3 Michaelsville Small Arms Ranges. The Michaelsville Range Complex is the Army's center for small arms systems testing. Nine established firing positions include a 100 yard enclosed firing range, a 300 meter covered range open ended to permit target firing to 3000 meters, a state-of-the-art acoustic accuracy dispersion scoring system at multiple ranges to 3000 meters, a dedicated climatic chamber (-70 degrees F to +170 degrees F) with two firing ports, and six general purpose firing ranges. All ranges are high explosive (HE) and laser capable. On-site support includes gunsmith services and nondestructive inspections. This range complex enables ATC to test small arms weapons, ammunition, sight systems, vehicular gun mounts, and ancillary equipment in any environment that the materiel would be expected to encounter during its life cycle.

A.1.4.4.4 Countermine Test and Training Range

This facility is used exclusively for land mine detection tests and training. This facility enables countermine developers to test emerging technologies in a realistic environment. Experimental data gathered during testing provides valuable information and insights to the developers to improve their devices. There is over 1 km of permanent land mine test lanes where systems can be tested against standard mine configurations. Also located on this site is an operations building which houses work areas for hand-held systems, a training area, and communications, weather, and other support systems.

A.1.4.4.5 Developmental Firing Range at Wallops Island

This testing range was created through a partnership between the US Army, Navy, and NASA, and provides a unique long-range indirect fire test capability. The test site offers practically unlimited firing range and the ability to fire items with complex safety areas. The relatively shallow water that extends outwards of 50 nautical miles permit recovery operations of test hardware. Projectile recovery assets include boat and diver support, and unique Navy recovery systems. NASA and Navy test capability combined with ATC technical test services and data collection equate to a unique East Coast capability.

In February 2003, ATC held a groundbreaking ceremony for the Climatic Firing Facility. This facility will enable the test firing of weapon systems, and the operation of other military materiel under the same weather conditions they will experience in the field. It is more cost effective to perform such testing in an artificial environment because it eliminates delays waiting for the proper conditions and permits repeatability. In developmental items, it also allows for on-site vendor modifications to the materiel under study. Construction is expected to take approximately two years. When completed, the Climatic Firing Facility will be comprised of three state-of-the art, controlled environment chambers. One chamber is designed to test all calibers of direct and indirect weapons systems. The other two chambers will be used for testing vehicles and other materiel. Using the facilities' control systems, ATC will be able to remotely monitor the status of systems components, evaluate chamber conditions such as toxic fumes and combustible gasses, and take appropriate actions to protect test personnel and property.

All three chambers will be automated and capable of temperature extremes from -65 degrees F to +165 degrees F, and up to 100 percent humidity.

A.1.4.4.6 Other General Purpose Firing Ranges. ATC has numerous general purpose firing ranges and positions for testing and proofing small arms, armor, mortars, tank weapons, ground-to-ground and air-to-ground missiles, and artillery up to 175mm. Range capability for large caliber weapons exists out to 22 kilometers. Mobile instrumentation such as video scoring, flash x-ray, digital Doppler radar, high-speed photography, fire control instrumentation, and interior ballistic instrumentation, is available to support any of these ranges.

A.1.4.4.7 Climatic Firing Facility. In February 2003, ATC held a groundbreaking ceremony for the Climatic Firing Facility. This facility will enable the test firing of weapon systems, and the operation of other military materiel under the same weather conditions they will experience in the field. It is more cost effective to perform such testing in an artificial environment because it eliminates delays waiting for the proper conditions and permits repeatability. In developmental items, it also allows for on-site vendor modifications to the materiel under study. Construction is expected to take approximately two years. When completed, the Climatic Firing Facility will be comprised of three state-of-the-art, controlled environment chambers. One chamber is designed to test all calibers of direct and indirect weapons systems. The two chambers will be used for testing vehicles and other materiel. Using the facilities' control systems, ATC will be able to remotely monitor the status of systems components, evaluate chamber conditions such as toxic fumes and combustible gasses, and take appropriate actions to protect test personnel and property. All three chambers will be automated and capable of temperature extremes from -65 degrees F to +165 degrees F, and up to 100 percent humidity.

A.1.4.5 Fire Control/Tank Accuracy Ranges and Facilities

A.1.4.5.1 Trench Warfare I (TWI) Evasive Firing Target and Trench Warfare II (TWII) Multiple Target Firing Range

TWI is ATC's outdoor firing range capable of presenting evasive targets to test vehicle fire control systems. The facility was designed to complement ATC's Trench Warfare II range and the Moving Target Simulator, as well as extend hit probability analysis to moving tank moving target engagements. TWII is ATC's tank range for stationary tank stationary target firing conditions, and is primarily used to develop hit probability estimates and fleet zeros for the US Army tank population.

A.1.4.5.2 Moving Target Simulator (MTS)

ATC's MTS is the US Army's indoor simulated firing range, conceived and designed by ATC specifically to develop stationary tank moving target hit probability estimates. The facility is an air-supported hemispherical dome, with a 100-foot radius. Within the facility, a simulated laser target is projected on the inner wall of the enclosure, and presented to the fire control system of the test vehicle positioned near the center of the enclosure. The laser target positioning system is computer controlled, and is capable of ground and aerial evasive second order target paths. The integrated instrumentation suite provides near real-time analysis of total gun pointing error, target inducted error, lay error, tracking rate error, system required lead, and system implementation error.

A.1.4.5.3 H-Field Armament Test Range

The H-Field Armament Test Range is a general purpose facility designed for single target firing occasions out to a range of 3000 meters. For specialized long range firing, a 5000-meter range is available. A constant velocity-moving target is utilized to develop hit probability estimates for both moving vehicle and first order moving target engagements. Additional features of this range include weapon stabilization courses, and a water range for swimming vehicle/land targets. Because of the large open space at this facility, numerous threat vehicles can be positioned at different locations downrange for multiple target acquisition and threat recognition testing.

A.1.4.6 Live Fire and Vulnerability Testing Facilities

A.1.4.6.1 Depleted Uranium (DU) Containment Facility (Superbox)

ATC's Superbox is a state-of-the-art-facility used for the testing of DU materials in a manner compliant with Federal, State, and local regulations to protect the public, workers, and the environment. The Superbox incorporates extensive real-time air monitoring equipment, control instrumentation, and a 99.997

percent efficient air filtration system. Physically, the facility is an 84-foot hemispherical containment vessel constructed of one-inch thick carbon steel, with a 60-foot flight tunnel inlet for firing into the vessel. A 40 foot x 40 foot high fragmentation shield of four inch thick steel is located in the center of the enclosure, and allows the Superbox to withstand the blast effects of a 100 pound TNT-equivalent detonation.

Targets as large as a main battle tank may be tested in the Superbox. The facility is capable of direct fire threat engagement ranges out to 200 meters, dynamic firings of anti-tank guided missiles (ATGM) along a horizontal ballistic sled track, and of static firings inside the dome. The facility is equipped with a remotely operated, multi-stage, fire suppression system for test asset protection and a wash down system. A liquid filtration system, with a holding tank approved for radiological waste, captures and processes the water. Extensive instrumentation at the range allows for measurement of ballistic shock; blast overpressure; toxic fumes; temperature and heat flux; forces and moments on crew; target vehicle parameters (revolutions per minute, oil pressure, etc.), and threat parameters such as velocity, pitch and yaw. Photographic documentation available consists of real-time video, high-speed video, high-speed film, and high-speed digital imaging.

A.1.4.6.2 Vehicle Vulnerability/Lethality Test Range (AA5). The AA5 Range is a secure, environmentally safe, state-of-the-art test range designed primarily for the conduct of live fire vulnerability and lethality tests utilizing domestic and foreign vehicle system targets. AA5 is capable of direct fire threat engagement ranges out to 1000 meters, and of static firings of warheads, mines, artillery, and top attack munitions (from a 70 foot tall warhead tower). Additionally, the range has the capability for dynamically firing Anti-Tank Guided Missiles (ATGM) at attack angles from 0 degrees to 85 degrees above horizontal, with extreme accuracy via horizontal and elevated ballistic sled tracks. Dual target pads allow the simultaneous instrumentation of targets. A remotely operated, multi-stage, fire suppression system is used for test asset protection. Extensive instrumentation at the range allows for measurement of ballistic shock; blast overpressure; toxic fumes; temperature and heat flux; forces and moments on crew; target vehicle parameters (revolutions per minute, oil pressure, etc.); and threat parameters such as velocity, pitch and yaw. Photographic documentation available consists of real-time video, high-speed video, high-speed film, and high-speed digital imaging.

A.1.4.6.3 Underwater Explosions (UNDEX) Test Facility (UTF).

The UTF is a man-made pond that is completely isolated from navigable waters, elliptical in shape, has surface dimensions of 1,070 feet long by 920 feet wide, and a depth of 150 feet. The pond can handle an explosive charge equivalent to 4100 lb. TNT. The slope of the sides of the pond ranges from 2.0:1 to 2.5:1. Stone armors on the perimeter of the pond to prevent the erosion of the surrounding terrain from wave

action created as a result of testing. The pond is environmentally isolated from the nearby navigable water sources. Test items may be delivered to the UTF by ground transportation or by barge to the barge slip via the Chesapeake Bay. The transfer area rail system is then used to transport the test items. Some of the major test programs conducted at the UTF include the UNDEX shock testing of the USS OSPREY, a fully commissioned Coastal Mine Hunter Ship (MHC-51), UNDEX component shock testing for the SEAWOLF and VIRGINIA class submarines using the Navy's largest submarine test vessel (A/B-1), UNDEX shock testing of a Navy 5-inch MK 54 Modular Gun System, operational testing of the Advanced SEAL Delivery System (ASDS), and the Rapid Airborne Mine Clearance System (RAMICS). The facility is capable of testing submarine systems and subsystems, torpedoes, warheads and missiles, mine/countermine measures, amphibious vehicles and landing craft, joint test and training exercises for both the littoral and battlefield environment, remotely operated vehicles, underwater and surface gun firings, acoustic measurements open air blasts and many more R&D programs. Instrumentation includes blast overpressure, shock, internal blast, thermal and toxic gas measurements as well as a multitude of photographic coverage.

A.1.4.6.4 Underwater Explosions (UNDEX) Test Pond

The small UNDEX test pond is a man-made test facility that has a surface diameter of 330 feet, a maximum depth of 55 feet, a flat surface bottom diameter of 70 feet, and side slopes of 2.5:1. The perimeter of the pond is armored with stone to prevent erosion from wave action because the primary type of testing conducted in the pond has involved the detonation of explosive charges either on or under the surface of the water. The surrounding soil is comprised mostly of silt and clay. The maximum recommended charge weight that can be detonated in the UNDEX pond is 300 pounds of TNT. Because the pond is physically and environmentally isolated from the local water sources, it can support a wide range of tests, while inflicting no harm to the environment. The pond can support both floating and submerged test items by using one of the two launch and recovery facilities designed into the pond. A marine rail is an integral part of the UNDEX test pond. It is used for the launch and recovery of submersible test vehicles up to 300 tons. The 214-foot rail can be modified to launch and recover a 500-ton vehicle by adding a third rail. It is comprised of three main sections: 1) Level staging, 2) Transition region, and 3) Inclined section. The total length of the 14:1 incline is 148 feet. The pond also contains a working platform or seawall (wet dock) for launching other types of floating vehicles in and out of the water. The 90 foot wide seawall provides a slip area with an average water depth of 17 feet. The test vehicles weighing up to 100 tons are lifted in and out of the UNDEX pond by using a 250-ton crane.

A.1.4.6.5 Fire Safety Test Enclosure (FSTE). The FSTE, often referred to as ATC's "Firebox," is a state-of-the-art, environmentally sound test enclosure designed for full-

scale fire suppression, live fire, vulnerability, insensitive munitions, blast, and weapons firing tests. The 84-foot diameter dome enclosure is designed to contain a 75-pound TNT-equivalent high explosive event. The internal dome design will completely contain and recover all test fluids and gaseous effluents produced during the various types of testing. The liquid effluents, once recovered, are filtered, separated, and disposed of in accordance with environmental regulations or, in the case of fuels and oils, reused. Gaseous products, CO and particulates are drawn from the enclosure top and scrubbed in a multi-stage 64,000 CFM scrubber system. This facility can house full-size vehicles and other large test items.

A.1.4.6.6 Standardized Unexploded Ordnance (UXO) Demonstration Site. This is the Army's first test range for gathering standardized, comparable data on unexploded ordnance detection technologies. It is designed to accommodate research, development, demonstration, and validation of technologies designed to improved UXO detection and discrimination efficiencies. This UXO site enables standardized technology evaluation of critical parameters such as UXO detection capability, false alarm rates, discrimination, reacquisition, and system efficiency. It utilizes standardized UXO targets, site layout, and procedures approved by the DoD's Environmental Security Technology Certification Program, and the Standardized UXO Technology Demonstration Site Program Committee. The 18-acre site consists of three areas: a calibration lane, a blind test grid, and an open field site. The calibration lane allows demonstrators to test equipment, build a site library, document signal strength and deal with site-specific variables. The blind test grid allows a demonstrator to operate a sensor system without platform, a coordinate system, or operational concerns. The open field site will document the performance of the entire system in actual range operations.

A.1.4.7 Support Equipment Test Facilities

A.1.4.7.1 Generator Test Facility (GTS). This facility is used to conduct performance and reliability, endurance, maintainability (REM) testing in accordance with MIL-STD-705, on a variety of electrical generator sets up to 36 in number from 18 concrete pad locations. Real-time data acquisition and analysis is consolidated in a single, new control building, enabling more efficient operations and reduced staffing. Two mobile data acquisition systems are also available at the site: one in which an automated 200 kW load bank is incorporated, and a second with two 200 kW load banks. Three types of fuel are provided to each test pad through a central, pressurized distribution system: low-sulfur diesel fuel no. 2 (DL2), diesel fuel, referee grade; and jet plane fuel no. 8 (JP8). Alternating current (AC) and direct current (DC) generator sets and power units ranging from less than 3-kW through 200-kW are typically tested, although units as large as 1100-kW have been accommodated. The GTS lies adjacent to an area reserved for audio noise and aural non-detectability testing (see Human Factors and Air Flow Testing Facilities).

A.1.4.7.2 Bridge Crossing Simulator. This facility simulates the crossing loads on a bridge system in a controlled testing environment. The Bridge Crossing Simulator is

designed to apply vehicle rolling loads on a bridge through a system of hydraulic actuators and loading fixtures, instead of using actual vehicles to cross the bridge thousands of times. This system is a tool for conducting durability tests at a huge cost savings; thus enabling the collection of more engineering and statistical data than previously possible on the factors that impact bridge life the most. The design configuration accommodates 14, 26, and 42 meter bridges, and is easily adaptable to any bridge less than 42 meters. This facility supplements the full spectrum of required bridge testing by providing an economic means of establishing and evaluating the durability of portable bridges.

A.1.4.7.3 Bridge Test Sites

A.1.4.7.3.1 Dry Gap Testing

This four-plus acre site is designed for testing dry support bridging systems. Prepared abutments consist of level, longitudinal, side, and reverse slope configurations. The infrastructure supports a wide variety of performance and reliability style testing. The site is collocated with the Perryman Test Area.

A.1.4.7.3.2 Water Obstacle Testing

The Spesutie Island Amphibious Landing Still Water Test Site located in the Chesapeake Bay estuary is used for ribbon bridge testing. These water obstacle-spanning bridge tests include launch/retrieve operations, rafting, and Bollard pull tests. The water velocity at the banks is minimal with tidal range of approximately 1.5 meters. Moving water is available, depending on wind shear and tide movement, along with variable bank slopes for ingress/egress. The site is equipped with power, communications, offices, and storage areas, and is located in the vicinity of the Munson Automotive Test Area for convenient testing of automotive and other performance parameters.

A.1.4.7.4 Material Handling/Construction Equipment Test Site

The MH/CE test site is used to perform customized performance and durability tests of forklifts, cranes, and construction equipment in a rough terrain environment. The site is equipped with several specially designed test courses, and a large complement of test loads, containers, and stands. Extensive instrumentation and real-time data acquisition support are employed to provide a complete record of materiel performance, and a basis for any failure analysis of materials. Tool sets and special handling equipment can also be tested. The facility is close to other widely used test support functions such as maintenance shops, instrumentation, tilt table, environmental chambers, and other test courses. A 50-foot x 60-foot general-purpose shop and office facility is available to support testing.

A.1.4.7.5 Rain/Water Tightness Test Capabilities

A combination of fixed and mobile assets is used to simulate naturally occurring rainfall and perform water tightness tests in accordance with MIL-STD-810. Portable, lightweight arrays containing nozzles specifically designed to produce the spray pattern and droplet size called for in the standard are used to produce simulated rain and the high-pressure spray of water tightness testing. Free falling spray from a suspended spray array is driven by portable wind machines at speeds up to 40 miles per hour to simulate wind-driven rain striking the face of an item under test. Portable pumps are employed to control a variable water pressure to the spray arrays, dependent on the type of test. A series of fixed towers are used to support testing of larger items and in conjunction with wear testing of wet weather garments (see Rain Wear Course). These fixtures are equipped with high-pressure showerheads that project from parapets nine meters above ground level, and are used to produce simulated rainfall of varying intensities.

A.1.4.7.6 Wind Test Capability. Trailer-mounted, engine-driven fans produce simulated steady-state wind conditions of up to 100-mph. These devices are used to support wind-driven rain testing (see Rain/Water tightness Test Capabilities), and impose wind loads on soft shelters (tentage) and other equipment with a wind load test requirement.

A.1.4.8 Soldier Systems Test Facilities

A.1.4.8.1 Footwear Durability Course

The footwear course is an accelerated wear course for testing footwear. It is designed to simulate conditions typically encountered in the field. The 268-meter (1/6 mile) course consists of abrasive surfaces, water and mud troughs and various obstacles. The abrasive surfaces include crushed quartz, chipped and cubed granite, cinders, sand, gravel, slag, and smooth and rough concrete. Additional surfaces such as logs, stones, and metal may be incorporated in adjustable inclined planes for testing footwear traction. A five-step concrete stile with an abrasive surface, an "edge walk," and a stairway with a double jump are used for evaluating the overall durability of footwear. At the end of a test cycle the footwear is examined and all failures are recorded. The attitudes of soldier test participants toward the test items are obtained and tabulated by human factors specialists.

A.1.4.8.2 Shooter Performance Facility

This 600-meter range, also available for soldier systems testing through cooperative agreement with the HRED of ARL, is a computerized state-of-the-art facility that is used for examining soldier marksmanship performance. It consists of multiple stationary targets, controlled from a computer-equipped command and control center. The range permits the engagement of targets at a wide variety of distances, target exposure times, and angles. It features four firing lanes with target exposures from 10 to 550 meters. These firing lanes can be operated simultaneously with the same target scenarios or collectively from a central firing point. Each lane has five targets at 10 and 25 meters for firing personal defense weapons, and three targets each at 50, 75, 100, 150, 200, 250, 300, 400, 500, and 550 meters for rifle firing. Specialized and pneumatically operated target mechanisms are also featured. Programmed arrays of targets can be presented at any distance, time interval, and sequence from the computerized command and control center. System software records and reduces range events, such as targets presented, target time, target hits, shots fired, and time of shot.

A.1.4.8.3 Mobility-Portability Obstacle Course

The effects of soldier load on mobility and individual equipment durability and interconnectivity are determined at this course, available through cooperative agreement with the Human Research and Engineering Directorate (HRED) of the US Army Research Laboratory (ARL). The course consists of hard surfaced and wooded marching areas and obstacles that require the soldier to run, jump, crawl, and climb. Objective course data are augmented with real-time physiological data. The course features interactive system software for information identification, storage, and retrieval; an integrated computerized status display for real-time trail status; and data collection software to compile individual obstacle time, intra-obstacle time, and total elapsed time.

A.1.4.8.4 Rain Wear Course

The Rain Wear course is integrated within the fixed rain facility and is used to test the adequacy of garments as exposed to wet weather. It is configured to simulate natural rainfall and misting that the soldier encounters in the field. The course is divided into dynamic and static sections. Soldiers garbed in the subject garments traverse the obstacles and obstructions of the dynamic section. Stationary items, such as small tents or other weather covers, are placed in the static course section for exposure to controlled free-fall or wind-driven rain simulations for short or extended periods.

A.1.4.8.5 Hand Wear Course

This course is designed to expose gloves, mittens, and other hand wear to accelerated wear conditions typically encountered in routine service usage. It is comprised of a variety of activities intended to stress all aspects of a protective covering of the human hand: the turning windlass, cinder block stack, smooth plank stack, rope climb, gravel shovel, ladder climb, brick stack, punching bag, and chain pull.

A.1.4.8.6 Human Factors Engineering. Human factors and airflow test facilities are used to address the relationship of the human to machines and workspace. An indoor facility with three garage bays, two of sufficient size to accommodate vehicles up to the M1 Abrams, is used for measurement of airflow and ventilation in tactical vehicular and mobile shelter systems. This facility also provides a controlled environment for determination of characteristic workspace measurements, anthropometrics, adequacy of controls and displays, available surface lighting, fields of view and fire of tactical military vehicles, performance effects of protective clothing and gear, and task performance times and peculiarities in variable scenarios. Aural and visual non-detectability (MIL-STD-1474), speech intelligibility, and audio noise tests are conducted at several outdoors facilities; level fields that are clear of reflecting surfaces for a procedure-dependent minimum distance. Human factors specialists and technicians characterize test participants by anthropometrical measurement and demographics, and administer in process and exit interviews of test participants to obtain subjective impressions of equipment under test. Instrumentation unique to the science of human factors is available at this site: devices for measuring workspace and the human body in relation to each other, laminar air flow, differential pressure, luminance at surfaces, wet and dry bulb temperature, wet-bulb globe temperature index, sound pressure levels, etc. Mobile instrumentation vans are available and have been used to replicate all human factors test functions at remote test sites and other locations.

A.1.4.9 Specialized Test Facilities

A.1.4.9.1 Electromagnetic Interference (EMI) Test Facility. This facility includes an electromagnetic shielded enclosure (94 x 60 x 28 feet), which provides a test area for the measurement and generation of emissions up to 40 GHz. Radiated and conducted emissions are measured and recorded by computer controlled automated spectrum surveillance data acquisition and analysis systems. Susceptibility tests are performed using signal sources capable of generating RF fields and voltages. A mobile system is available for electromagnetic emission measurements at field locations. An adjacent instrumentation room is used for EMI measuring and recording instrumentation. Air

intake and exhaust systems with 12,000 cubic feet per minute capacity permits operation of equipment including large engines within the enclosure during EMI tests. All electrical power and communications lines are equipped with 100 decibel in-line filters.

A.1.4.9.2 Climatic Simulation Facilities

A wide variety of simulated environmental tests can be conducted for firing and non-firing systems, to include large and small caliber weapon systems, tactical and combat vehicles, munitions, and individual equipment. All tests are conducted in accordance with MIL-STD-810E. These facilities include the following:

- **Solar Radiation Chambers** One chamber, 12 x 10 x 10 foot with a 12 x 10 foot door. Temperature: ambient to 185 degrees F. Humidity: 3 to 95 percent. Radiation 0 to 1400\Wt/sp-meter, explosive limits of 600 pounds. Two chambers, one 21 x 15 x 10(h) foot with 6 1/2 x 6(w) door, and one 10 1/2 x 10 3/4 x 10(h) foot with a 6 1/2 x 3 foot door. The latter two chambers have the same operational characteristics as the first chamber, except the humidity control is 2 to 50 percent. Total explosive limit between the second two chambers: 3000 lb.

- **Sand and Dust Chamber***:* 4 x 8 x 5 foot with an 8 x 5 foot door. Temperature: ambient to 160°F. Humidity: 3 to 22 percent. Dust rate 0 to 0.3 grams per ft^3. Air velocity: 300 and 1700 cubic feet per minute. Explosive limit: 600 lb.

- **Salt Fog Chamber***:* 10 x 12 x 10(h) foot with a door size of 12(w) x 7 1/3 foot. Temperature: ambient to 145°F. Explosive limit 600 lb.

- **Salt Fog Cabinet***:* 25(w) x 33(h) x 48 in. with a full opening top. Temperature: Ambient to 145 degrees F. Explosive limit: 600 pounds.

- **Wind Driven Rain Machine***:* Rainfall rate of 0 to 12 in./hr. Wind speeds: 0 to 75 mph. Portable. Covers an effective area of approximately 4 x 4 foot.

- **Wind Machine***:* Wind speeds up to 70 miles per hour. Portable. Covers an effective area of approximately 5 x 5 feet.

- **Pressurized Water (water tightness) Facility***:* Covers a vertical plane up to 20(l) x 8(h) foot, and horizontal plane of 8 x 8 foot. Pressure rates up to 70 pounds per square inch. Ambient temperature conditions.

- **Pressurized Immersion**: 3(h) x 1 1/2 (dia), capable of up to 5 pounds per square inch. Used with sodium florescenate for determination of water penetration. Explosive limit: 600 pounds.

- **Temperature Cabinets**: Chamber sizes up to 10(l) x 8(w) x 7 1/2 foot, with a full opening door. Temperature range -100 to 200 degrees F. 34 chambers. Portable.

- **Temperature-Humidity Cabinets**: Chamber sizes up to 10(l) x 8(w) x 7 1/2 foot with a full opening door. Temperature range -100 to 200 degrees F. Humidity 3 to 98 percent. 18 chambers. Portable.

- **Temperature Sources**: Portable units that can supply temperature and temperature - humidity environments to temperature enclosures. Total of five sources. Each has temperature range of -100 to 200 degrees F. Two sources also have a humidity capability of 3 to 98 percent. Can accommodate enclosures up to 21 x 15 x 10 foot.

- **Chambers Used for Automotive and Support Equipment Testing***:* Designed to meet MIL-STD-810. Has a 40 x 75 x 24 foot chamber with a temperature range of -70 to +170°F, plus humidity control (to 98 percent) in an elevated temperature range. Conditioned make-up air supply for sub-zero (to -60°F) engine starts, capacity to 900 cubic feet per minute. It can be divided into two 40 x 37 foot chambers with independent environmental controls. Door size on each end is 16 x 16 foot.

A.1.4.9.3 Outdoor Robotics Test Area. This facility consists of a 14 acre tract of relatively level terrain, surrounded by concrete barricades, and includes a 25 miles per hour sustained speed secondary road course, and a 12 foot elevated platform for targeting exercises and sensor evaluation. Portions of the adjacent Munson Test Course are used for target identification and tracking. Test emphasis is on initial safety evaluation and subsequent repeatable performance measurements.

A.1.4.9.4 Magnetic Latitude Simulator. This simulator consists of large Helmholtz coils with state-of-the-art controllers capable of simulating the earth's magnetic field anywhere on the surface of the earth, or nulling the earth's magnetic field. This facility will accommodate any armored vehicle moving up to 15 miles per hour.

A.1.4.9.5 Phillips Army Airfield (PAAF)

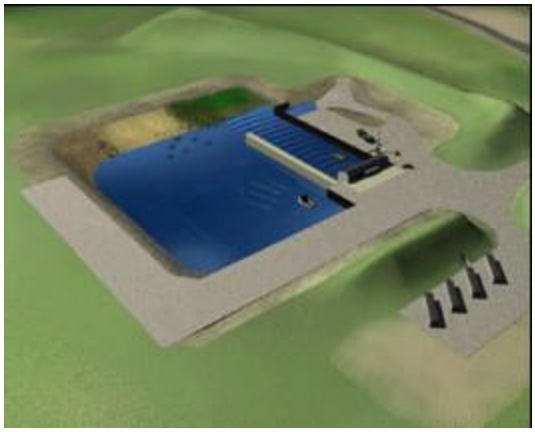
ATC's PAAF provides safe, quality, and professional aviation services and airfield support. Airfield capabilities include an air traffic control tower, runways capable of landing any aircraft, drop zones for personnel, container delivery systems, and standard training bundles and ramp and hard surface areas that can be used for hazardous or heavy cargo handling testing. This

facility can also be used to conduct automotive testing such as steering and handling, brake testing, and mobile field dynamometer testing. Two UH-1H helicopters are available to provide support test missions such as aerial reconnaissance, captive flight sensor or signature testing, aerial photography, and sling-load operations.

A.1.4.9.6 Amphibious Testing

ATC provides the required resources to conduct both high and low speed testing of any amphibious vehicle. Static (leak and bilge pump) tests can be conducted in ATC Fording basins; low speed tests in the ATC Underwater Explosions Test Facility, and high-speed tests in the Bush River and Chesapeake Bay. ATC divers/drivers are trained and experienced to conduct swim testing, and rescue and recovery operations. ATC patrol boats provide safety support and also maintain ATC-controlled water space to ensure there is no interruption during testing. ATC cranes and barges provide lift and recovery capabilities. In addition, ATC is able to perform underwater photographic and videographic documentation of testing which is critical to performing engineering evaluation of any re-design or failure analysis type work.

A.1.4.9.7 Littoral Warfare Environment Facility



The LWE contains 40 million gallons of water and the water surface area is a 300 feet by 400 feet rectangle. The maximum depth of the LWE is 40 feet with a depth of 20 feet in the wave channel. The beach is designed to be reconfigurable based on the requirements of the testing being conducted. The beach measures 350 feet by 150 feet.

The LWE will be equipped with a wave generator capable of producing “sea state three” conditions (per Pierson-Moskowitz sea spectrum). These “sea state three conditions” can be carried the entire length of the LWE to the beach in the wave channel which measures 300 feet by 100 feet. The wave characteristics include wave heights of 3.5 to 5.0 feet and 2.0 to 7.5 second significant period ranges. The LWE has varied configurations to meet a broad range of testing needs.

A.1.4.10 Laboratories

A.1.4.10.1 Materials Laboratories

ATC's Materials Laboratories provide capability in the areas of material evaluation, metrology, and nondestructive testing of systems, structures, and materials. Technical support and specialized equipment is provided in the areas of mechanical testing, material characterization and identification, chemical analysis, metallography, computer modeling and design analysis, stress analysis, visual and microscopic evaluation, nondestructive inspection (NDI), manufacturing processes, welding certification, component testing, failure analysis and verification of material quality.

- The **Metrology Laboratory** is staffed and equipped to provide precision measurement characteristics for both field and laboratory. Field measurements are typically performed to 0.001 inch in the field and 0.00001 inch in the laboratory. Precision measurements to ten micro inches are performed to determine wear and erosion assessments of weapon barrels, evaluation of armor plate, surface roughness of ferrous materials, centerline profile, alignment of optical sights, moments-of-inertia, and centers-of-gravity.

- The **Inspection and Evaluation Facility** (Nondestructive Testing) is staffed and equipped to perform ultrasonic, magnetic-particle, dye-penetrant, eddy current, and magnetic recording borescope inspection. Magnetic particle inspection is used to locate surface and near-surface discontinuities and cracks in ferromagnetic material. Two automated horizontal wet baths 45 ft in length are available for use. Additional capability is provided in the areas of visual weld inspection, precision mechanical measurements, measurements of gun tube erosion/wear, and blacklight/whitelight borescoping of gun tubes.

- The **Industrial X-Ray Facility** can accommodate test items as large as combat vehicles, and penetrate 24-inches of steel with better than 1 percent pentameter sensitivity. Two workrooms are equipped with 1-, 5-, and 20-ton bridge cranes and units less than 4 MeV are portable or mobile for field operations. Explosive items are routinely handled within this facility.

A.1.4.10.2 Chemistry Laboratories

ATC's chemical laboratory assets include the Analytical Chemistry Laboratory, the Petroleum, Oils, and Fuels Laboratory, and facilities and equipment dedicated to material and soft goods testing, toxic fumes and gases testing, and fire extinguishing testing.

- **Analytical Chemistry Laboratory** is used primarily to identify and quantify

trace to bulk quantities of inorganic and organic compounds within various sample matrices and materials identification. Sample types include propellant, waters, industrial hygiene, gases, solids, soils, materials, etc. Instrumentation includes: Gas Chromatograph Mass Spectrometer (GC-MS), Fourier Transform Infrared Spectrometry (FTIR), High Performance Liquid Chromatography (HPLC), Ion Chromatography (IC), Ion Coupled Plasma (ICP) Emission Spectroscopy, Atomic Spectroscopy, and wet chemical procedures with various sampling and data reduction capabilities. An ICP/MS Spectrometer is now available for trace levels (PPT) metal analysis to include depleted uranium in various samples.

- In the **Oils and Fuels Laboratories,** analysis is conducted on fuel, oil, and lubricant (POL) products taken from support equipment and test vehicles before, during, and after development testing for physical properties and contaminants. The physical properties of fuels used by the test vehicles are measured and evaluated to ensure compliance to military specifications. Oils are tested to track wear metals and engine condition. Foreign POL products are analyzed in order to identify their US or NATO counterparts. Instrumentation includes: Spectro M Emission spectrometer, viscometers, wear particle and particle counter analyzers, flash, fire point and distillation apparatuses, cloud and pour point equipment, and sulfur analyzer. JOAP certified the Chemistry Team of ATC as a special laboratory. The Army Petroleum Center certified the Chemistry Team as a Fuel Laboratory.

- The **Environmental Laboratory** utilizes the analytical instrumentation to quantify the various regulated chemicals in water, wastes, etc., from the testing at ATC, to determine the impact of the tested chemicals on the environment. Also the various extractions and digestions of samples are employed before determinations are made by the analytical instrumentation.

- ATC has a unique capability for performing physical testing in a **Materials Laboratory.** The Materials Laboratory tests such items as uniforms, tents, boots, headsets, sleeping bags, gunstocks, etc. The physical testing includes fungus testing, chemical compatibility, immersion, temperature, humidity, salt fog testing, and flammability. Equipment is available for vertical flammability and two types of horizontal flammability testing. Small burn chambers are available to conduct burn rate, burn length, char length, etc., and to conduct burn and flammability tests on medium sized test items which include construction materials.

- Extensive capabilities exist at ATC with **Toxic Fumes and Field Chemical Analysis** to sample and access the gases or fumes produced by weapons, vehicles, ammunition, and other test items. These are tested to determine the potential effects these gases could have on the operators of test items. The instrumentation utilized for these measurements is capable of operation in hostile environments (including live fire situations), and provides for real time analysis of gases and

sample collection for laboratory analysis. Samples include gases, particulates, and halogen-containing pyrolysis products. Unique test instrumentation has been developed for instantaneous determination of concentrations of toxic gases. The gases that are analyzed by dedicated real time IR, chemiluminescent or fluorescent spectrometers are: CO, CO_2, NO, NO_2, methane, SO_2 and Halons. Laboratory samples are collected for HC1, HBr, HF, HCN, metal fumes, particulates, and other chemicals. A laboratory grade Fourier Transform Infrared Spectrometer is now available for field use. This allows for identification and quantification of reactive gases.

A.1.4.10.3 Transducer Calibration Laboratory (TCL). ATC's Transducer Calibration Laboratory provides customers with state-of-the-art transducer calibration support and methodology development for transducer testing. The TCL is ISO/IEC Guide 25 accredited for pressure calibration. The laboratory is equipped with instrumentation that can operate static calibrations up to 145k per square inch, traceable back to the US National Institute of Standards and Technology, dynamic simulations of gas pressure measurements up to 120kpsi and 6msec pulse width, and high (10k per square inch) and low (10 psi) pressure shock tubes for characterizing the dynamic response of pressure transducers and their port geometry.

A.1.4.11 Technical Support Facilities

A.1.4.11.1 Land Vehicle Maintenance Facilities

These facilities provide the capability to inspect, maintain, repair, and rebuild combat and tactical land vehicles at an organizational and direct support level, to include all power trains and electrical systems on domestic and foreign vehicles. Experienced mechanics and integrated electronics mechanics are available to perform major services such as: system refurbishments, troubleshooting, integrated electronics systems, drive trains, computerized 4-wheel alignment, air conditioning service inspections, hydraulics/fuel systems, demilitarization, pay loading, modifications, battle damage assessments and repairs. Over 45,000 square feet of interior bay space is available in the primary land vehicle maintenance facility, which is equipped with a 37.5-ton overhead bridge crane. A closed-loop steam cleaning facility is also available. A complete mobile field service is readily available for use off-site.

A.1.4.11.2 R&D Munitions Fabrication and Processing. These facilities provide capabilities to fabricate experimental and prototype munitions or explosive targets; modify, assemble or disassemble all calibers of standard and foreign ammunition, warheads, pyrotechnics and fuses; perform high-explosive or inert loading capability; complete propellant up- or down-loading with ultra-high-speed deluge systems,

audiovisual recording and computerized propellant weighing capabilities; demonstrate static detonation; provide magnetometer location of impact; enable remote control and robotic range recovery; permit underwater detonation or recovery with scuba divers; and accomplish remote drilling or sawing of ammunition.

A.1.4.11.3 Experimental Fabrication

ATC, provides machining, welding and sheet metal support for fabrication, modification and/or repair of test items and structures during the entire testing phase of military or commercial equipment. The primary fabrication shop has 70,000 square foot of manufacturing area with a 75-ton overhead bridge crane, and also houses a controlled temperature and humidity room for precision parts manufacturing. This shop is also equipped with state-of-the-art computerized numerically controlled equipment to produce high quality, low cost items under short delivery schedules. Mobile welding units are readily available to support testing in progress at remote locations.

A.1.4.11.4 Experimental and Acceptance Weapons Processing Facility

This facility furnishes all weapons processing and painting services required for facilities, equipment, materials and items undergoing testing at ATC. These services include inspection, modification, assembly, maintenance, procurement, and inventory of all acceptance and experimental weapons.

This 123,750-square foot facility houses seven bays with three separate storage buildings, five 10-ton and one 30-ton bridge cranes. Two paint booths, 24 feet X 70 feet each, are capable of spraying chemical agent resistant coating (CARC) and epoxy paints. A sign shop with the latest in graphic design equipment and a fabric shop for fabricating tarps, targets, and specialty canvas items are also available.

A.1.4.12 Technology Centers

A.1.4.12.1 Military Environmental Technology Demonstration Center (METDC). The Military Environmental Technology Demonstration Center provides the Department of Defense, industry, academia, and other government customers a unique resource for environmental technology developments, demonstration, testing, verification, evaluation and transfer. Through technology validation and demonstration, METDC ensures that the innovative technologies are safe, reliable, cost effective, and satisfies the user's need. METDC's core capabilities include technology investigation and validation, advanced technology development, guidance development and program support.

A.1.4.12.2 International Imaging Center (IIC)

The International Imaging Center is comprised of highly talented, creative, and technical personnel who provide documentation services for projects from inception to presentation. ATC uses state-of-the-art imaging systems to provide critical test information. Technical systems available include Ultra-High-Speed Imaging, Flash Radiography, Infrared Thermal Imaging, and High-speed film and electronic imaging. ATC's IIC video production capabilities include non-linear digital editing and BetaSP recording and mastering. Technical Multimedia capabilities include digital test reports, interactive briefings and marketing presentations; touch screen kiosks, distributable multimedia and web site CDs. ATC's photographic dive team is certified to 130 feet and members are trained in performing still photography and video imaging underwater. IIC photographers use gyro stabilizing cameras to record air to air and air to ground scenes. Custom imaging processing and graphics arts services are also available.

A.1.4.12.3 Aberdeen Center for Sensing Technology (ACST). At this technology center, tests are conducted using instrumentation covering the electromagnetic spectrum from the visible through the millimeter wave radar ranges. This instrumentation is used to establish parameters such as emissivities and apparent temperatures that determine probabilities of detection on the battlefield. Facilities include turntables with 70-ton capacities with adjacent tower and mobile cranes. Vehicles and systems can be imaged from multiple elevation angles with 360-degree azimuth coverage. Imaging instrumentation suites are available to cover visible, near infrared and thermal infrared bands. Millimeter wave radar systems are available to provide Inverse Synthetic Aperture Radar (ISAR) and radar cross-section (RCS) data. Holographic radar capabilities have been added recently. Spectral resolution in the visible and thermal infrared is also available. In addition to supporting signature measurements at ATC, all capabilities (except the ISAR and RCS) are fully mobile, and have been utilized at multiple locations across the USA. Trials using human observers are often required to directly determine probabilities of detection. Such trials are also supported by ACST using customized mobile observer booths with high precision aiming mounts that accommodate a wide variety of combat sights. Field-collected imagery can also be presented to observers in perception tests conducted at ATC or at soldier locations. All data collected (imagery, ground truth, observer detect/non-detect data) are available to sponsors in the field, and are delivered post-test in a PC-based database compatible with common office software. These capabilities have been applied in the field and in the laboratory to programs involving targets from the largest combat vehicles down to the individual soldier.

A.1.4.12.4 Center of Excellence for Electric Technologies. The Center of Excellence for Electric Technologies is a range facility dedicated to the Tri-Service R&D testing of Electromagnetic (EM) and Electro-thermal-chemical (ETC) armaments. The facility provides a minimum of 32mJ of pulsed power, an enclosed environmentally conditioned EM gun position, and an open ETC gun position. The range provides direct fire capabilities from 500 to 4,000 meters, indirect fire impact, observation, and recovery fields at 12 and 20 kilometers, and armor penetration testing from 50 to 1,000 meters. All weapon calibers can be accommodated. Weapons can be fired from a rigid accuracy mount or from a tactical vehicle. Complete, real time data acquisition, interconnected via fiber optics, is available at the site.

A.2 DUGWAY PROVING GROUND (DPG)

A.2.1 MISSION

Dugway Proving Ground (DPG) has multiple missions including testing chemical and biological defense systems for the United States and its allies; testing smoke, obscurants, and illumination systems, and environmental characterization and remediation technology; performing chemical and biological survivability testing of defense material; supporting chemical and biological weapons conventions; acting as the Department of Defense Joint Chemical and Biological Defense point of contact in support of warfighting Commanders in Chief; supporting US anti-terrorism initiatives; operating and maintaining an installation to support our test mission; and maintaining and improving the environment and cultural resources at US Army Dugway Proving Ground.

A.2.1.1 Biological Defense Testing. Biological defense testing activities conducted at DPG are part of the DoD's Biological Defense Research Program (BDRP) to establish a solid national defense against biological attack. DPG has the capability to support biological defense tests that require BL 1, 2, and 3 facilities.

DPG uses biological agents and simulants for the following biological defense test purposes:

- **Contamination avoidance** – testing biological agent detection, identification, and early warning equipment
- **Protection** – testing equipment that would sustain life and allow for continued operational capability in biological agent contaminated areas and studying vaccines that can be used to protect individuals who may be exposed to biological agents
- **Decontamination** – testing decontamination methods for equipment and personnel

Contamination avoidance, protection, and decontamination testing involve the following activities:

- Support to customers who are developing new detectors, protective devices, or decontamination systems
- Test methodology activities to evaluate new types of simulants that can be used for testing purposes, to incorporate new scientific and engineering advances into current testing activities, and to develop test methods for new biological defense concerns
- Assessments that facilitate the development of test procedures to mimic battlefield or terrorist activities by identifying biological agent threats up to BL 3 and evaluate parameters
- Operational tests to ensure the performance and reliability of biological defense equipment by testing it under simulated battlefield conditions
- Contamination/decontamination testing on military equipment to determine its ability to withstand repeated biological contamination and decontamination.

Outdoor biological defense testing conducted at DPG is primarily contamination avoidance testing of detectors and decontamination tests. Biological agent early warning systems have also been evaluated. All outdoor tests are conducted with simulants. Aircraft or ground-vehicles disseminate simulants as aerosols for outdoor tests. These outdoor tests allow observation of natural weather conditions on the simulant's droplet size and dispersion/deposition patterns and the effect on equipment operation, decontamination procedures, equipment penetration, and reaerosolization.

Indoor testing with simulants or agents of biological origin includes various detector systems, personal protective equipment, and decontamination systems.

A.2.1.2 Chemical Defense Testing. As the only chemical agent defense proving ground, DPG is the primary location for testing of chemical defense equipment for the DoD chemical defense program. DPG uses chemical agents and simulants for the following chemical defense test purposes:

- **Contamination avoidance** – includes detection, identification, and early warning of chemical agents
- **Protection** – provides life sustainment and continued operational capability for armed forces in chemical agent contaminated areas
- **Decontamination** – includes decontamination methods for equipment and personnel

In addition to these chemical defense tests, DPG also conducts the following types of tests in which chemical agent may be used:

- **Compliance testing** – Chemical agent analysis to support management of chemical agent-related waste and IRP waste
- **Demilitarization testing** – Studying methods to successfully destroy chemical munitions in accordance with US treaty obligations

Outdoor chemical defense testing activities primarily involve large-scale decontamination and contamination avoidance testing. Chemical simulants are necessary for outdoor chemical defense testing because law prohibits the release of chemical agents into the open air for such testing. Chemical agents have not been used for outdoor testing since 1969. Decontamination tests are conducted at decontamination pads and are used to study how a chemical simulant may transfer on to an object and then determine how the object can be most effectively decontaminated. Decontamination tests can also involve testing new decontamination equipment.

Outdoor contamination avoidance tests typically involve testing detectors at test grids using dissemination equipment that disperses chemical simulant vapor or aerosol. Dispersion of chemical simulants for detector tests may involve aerial spray testing, methods, which simulate a munitions delivery system, or various dissemination systems.

Indoor DPG chemical defense testing efforts use both chemical agents and simulants. DPG attempts to use chemical simulants rather than chemical agents for indoor testing activities, but chemical agents must be used when validated simulants are not available for a specific chemical agent. Chemical agents must also be used on developmental contamination avoidance, protection, and decontamination systems to ensure they would function appropriately in an actual chemical agent incident. Indoor testing consists of contamination avoidance, protection, and small-scale decontamination tests that take place in test chambers and laboratories. Large DPG indoor test chamber facilities are typically used for contamination avoidance testing with detectors and protection testing of both PPE and collective equipment systems. However, chemical agent may also be used in test chambers to compare the effectiveness of new decontamination solutions. For certain indoor chamber tests of PPE using chemical simulants, troops may be brought in to wear the PPE as it is being tested.

The majority of DPG laboratory tests involve PPE tests and small-scale decontamination tests. Indoor laboratory tests require very small amounts of chemical agent. Typically, only a few drops of chemical agent are placed on the material or equipment being tested. It is estimated that most laboratory tests involving chemical agents use less than one milliliter of chemical agent and that the largest amount required would be no greater than 40 milliliters. Chemical agent is also used in the laboratory for generating standards to calibrate instruments.

DPG primary indoor facilities for chemical agent and simulant testing include the MTF, CTF, and DTC. See Appendix for pictures.

A.2.2 Location

DPG lies 140 km/87 miles southwest of Salt Lake City in sparsely populated Tooele County, Utah. DPG is accessible by Interstate-80, which runs 60 km/37 miles north of the proving ground. By air, DPG's Michael Army Airfield features a 13,125-foot runway with another 6,000-foot runway suitable for helicopter landing.

DPG includes 1,315 sq miles of exclusive use area contiguous to 900 square miles of the Air Force Utah Test & Training Range (UTTR), with 17,000 square miles of restricted airspace. The surrounding area is largely unpopulated, federally owned lands. DPG’s freedom from population encroachment provides the ideal environment for Chemical and Biological Defense Testing, artillery and mortar testing, and releases of smoke and obscurant materials. The lack of surface water bodies and endangered species allows testing of these chemicals. The vast secure test range, which is electronically and acoustically quiet, as well as free from light pollution at night, is also ideal for special access testing and training programs.

A.2.3 Features. Dugway’s terrain features large expanses of level area, salt flats, sand dunes, juniper wooded mountains, and rolling hills at elevations from 4,215 to 7,068 feet above sea level. DPG averages 55 days a year of precipitation of 0.1 inch or more.

Average annual snowfall is 15.6 inches; average annual precipitation is 7.54 inches. The average high temperature is 65F (18 degrees C) and average low temperature is 38 degrees F (3°C). The average wind velocity is 5 knots and average humidity is 48 percent. Visibility exceeds 10 miles 95 percent of the time; storms are rare and short.

A.2.4 Facilities

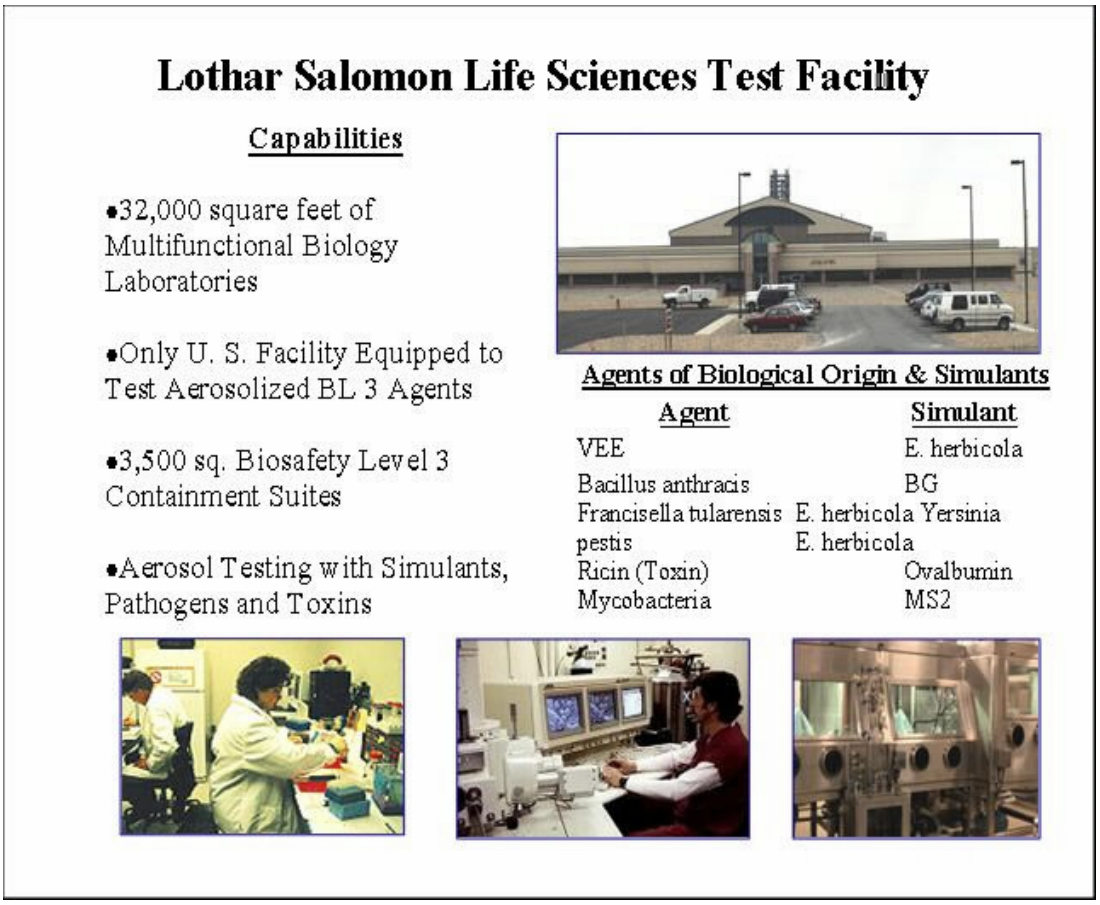
A.2.4.1 Life Science Test Facility (LSTF)

The LSTF is a new laboratory replacing the 1940s vintage Baker Laboratory. The facility has Biosafety Level 2 and 3 (BL-2 and 3) laboratories and chambers, enabling testing and aerosolization of simulated and actual agents of biological origin (ABO). State of the art infrastructure, chambers and technical expertise of the Life Science Division provides a current and versatile facility for test and evaluation of biological detection components and systems. The testing regime includes laboratory testing; simulated environmental aerosol challenges in test chambers and controlled outdoor aerosol challenges. Test items may be challenged with ABO's or simulants, in liquid or aerosol form, in indoor chambers. Tests are conducted only with simulants on the outdoor test grids. ABO's currently under use include: *Yersinia pestis, Francisella tularensis, Coxiella burnetii, Bacillus anthracis,* Venezuelan Equine Encephalitis virus, Botulinum toxin, Staphylococcal Enterotoxin B, and ricin. Laboratory, chamber and field testing combine to provide base line characteristics, operating parameters and detection thresholds for biological sampling and detection devices. The LSTF was designed with two environmentally controlled chambers for challenging test items with aerosolized biological test agents. They are the Aerosol Simulant Exposure Chamber (ASEC) and the Containment Aerosol Chamber (CAC).

The ASEC is a thirteen feet by twelve feet 11.5 feet stainless steel chamber, in which temperature, relative humidity, and simulant concentration are controlled and maintained. Temperatures ranging from 41 degrees F (5 degrees C) to 104 degrees F (42 ^{o}C) and relative humidity ranging from ambient to 100 percent can be maintained. The ASEC has an air mixing and computer controlled dissemination system enabling the repetitive generation of consistent and homogenous simulant aerosol clouds. Battlefield interferents can be introduced into the ASEC to challenge test items, but at this time, there is no system to quantitatively control their dissemination or measure concentration.

The CAC is a 5 feet by 5 feet by 16 feet stainless steal containment chamber in which temperature, relative humidity and ABO concentration can be controlled and maintained. Temperadores ranging from 5 degrees C (41°F) to 40°C (104°F) and relative humidity ranging from 0 percent to 100 percent can be maintained. The CAC is equipped with air mixing and biological agent dissemination capabilities in addition to BL-3 containment. All incoming and exhaust air is HEPA filtered and work is performed utilizing glove ports and uniquely designed standup half-suits. Interferents can be introduced and tested but control of concentration is limited. During most aerosol testing, the CAC is fitted with Test Item Chambers (TIC), smaller plexiglas chambers placed inside the CAC, to

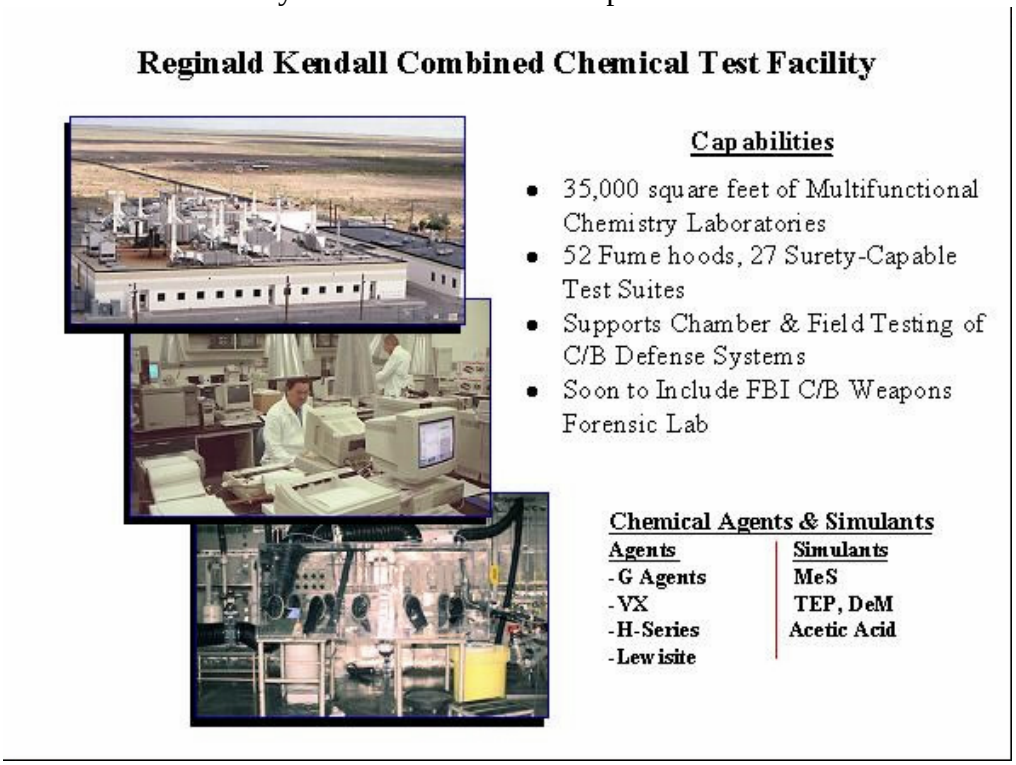
increase versatility and safety. The CAC provides the environmental controls, while the TIC reduces the chamber size. The scaled down size of the TIC requires less ABO material (reducing costs) so higher aerosol concentrations, better control, and increased safety is attained. The TIC is manufactured to suit the particular test item, which allows only the necessary portions of the test item to be directly exposed to the agent.



A.2.4.2 Reginald Kendall Combined Chemical Test Facility (CCTF)

The CCTF is a state-of-the-art 48,000 square feet chemical laboratory facility designed to support testing of chemical warfare defensive equipment. The facility consists of a laboratory building (36,000 square feet and an administrative building (12,000 square feet). The facility also includes a roofed storage pad (1500 square feet) and a building (16,000 square feet) that has been retired as a chemical laboratory and is currently being used to support testing of alternate chemical munitions demilitarization technologies. The facility is equipped with nine testing laboratories, three gas chromatography laboratories, six analysis laboratories, six instrument laboratories, a sampler preparation laboratory, a vault laboratory for agent storage, a waste management room, a solvent dispensary, a glassware cleaning room, and a cylinder storage area. 52 chemical fume hoods, 24 of which are certified for operation with neat chemical agents, support these laboratories.

The CCTF was designed to support work with chemical warfare agents and simulants. The chemical fume hoods and exhaust systems were specifically designed to meet the safety requirements of agent work and to protect the environment. The fume hoods use a state-of-the-art variable air volume control system to provide both maximum operator safety and to conserve energy. The building is maintained under a slight negative pressure to prevent the escape of chemical or agent fumes. All air exhausted from the laboratories is scrubbed through redundant HEPA and activated charcoal filters to remove any escaping fumes. The exhaust system is equipped with redundant fans and motors in case of a mechanical failure. The facility is equipped with an emergency generator to support lighting, heating, air handling equipment, and other critical functions of the building in the event of a power failure. The floors and walls of the laboratory building are coated with a special paint that can be easily decontaminated in the event of an accidental spill. The floor drains of the building drain into a 5,000 gallon spill containment tank to prevent any release of contaminated water resulting from a chemical or agent spill from being released into the environment. The facility is equipped with various security features and intrusion alarm systems to protect the chemical warfare agent. Access to the facility is limited to authorized personnel.



A.2.4.3 Bushnell Materiel Test Facility (BMTF). The BMTF, the world's largest toxic agent test facility, consists of three large chambers to support testing of military equipment/systems against chemical warfare agent challenges. The Multipurpose Chamber is the largest of the three, measuring 50 feet long by 50 feet wide by 30 feet high. It can accommodate most NATO fighter aircraft and helicopters, all military ground vehicle equipment, meeting NATO shipping requirements, protective protection equipment, and large specialized test fixture systems. This stainless steel chamber can be

environmentally controlled over a temperature range of -40°F (-40°C) to +125°F (51°F) with 5 percent to 90 percent relative humidity. In addition, this chamber is certified for gross-level agent contamination testing with concentrations of up to 1000 mg/m^3. The Agent Transfer Chamber (ATC) is 25 feet long by 25 feet wide by 25 feet high. It is equipped with two chemical fume hoods and the agent vault, which provides efficient on-site storage.

This chamber is primarily used for agent transfer, dissemination, and monitoring operations, but can easily support agent testing conducted inside test fixture/glove box systems. The Closed System Chamber (CSC) is 25 feet long by 25 feet wide by 25 feet high. This chamber is used for glove box testing and features a system for providing 1400 cfm of climatically conditioned air to the glove box. The air supply temperature can be controlled from 32 degrees F (0 degrees C) to 125°F (51 degrees C) and relative humidity from five percent to 90 percent. Services common to all three chambers include independent supply fans, compressed dry air, vacuum air, hot and cold service water, 5-90 pounds per square inch steam, access ports for routing data collection and control wiring. A series of negative pressure cascading airlocks ensures personnel movement during agent operations can be safely controlled during chamber entry and exit.

Central to the facility is the Operation Center where all building control and safety air monitoring functions are performed via automated control systems. This area also serves to stage test fixture control and data acquisition equipment for all chamber tests, thus allowing for the control of multiple tests simultaneously. In addition, the Operation Center allows test customers and support personnel to observe testing inside the chambers through the three observation windows.

A.2.4.4 Defensive Test Chamber (DTC). The DTC a remotely located, negative pressure filtered air facility is designed for aerosol and vapor challenge testing using chemical and biological simulants. The interior stainless steel chamber is 30 feet wide by 50 feet long by 20 feet high and can accommodate items as large as the Army's main

battle tank. This chamber is also ideal for staging large specialized test fixtures or support testing of collective protection equipment. All control and operating instruments are contained in separate rooms or modules isolated from the chamber. The chamber can be environmentally controlled over a temperature range of -20 degrees F (-28 degrees C) to 120 degrees F (48 degrees C) with 45 percent to 90 percent relative humidity. A stainless steel wind tunnel was constructed and housed in one side of this chamber. The purpose of the tunnel was to increase wind speed and ensure good mixing of vapor challenge clouds. The wind tunnel has been mapped extensively and it was determined that the effective test area of the tunnel is approximately eight feet high by twelve feet wide by twelve feet long. Airflow velocities within the tunnel can be controlled from 150 feet per minute to 450 feet per minute with a chamber air purge capacity of 5,000 cfm.

A.2.4.5 Technical Information Center. This facility provides a unique collection of more than 60,000 documents that chronicle US and Tripartite C/B programs dating back to early World War II. Thousands of C/B-related foreign intelligence citations are also contained in the collection. Through an automated BRS system, the collection can be searched to provide data/information by key words, authors, titles, dates contract numbers, etc. The entire collection has been transferred to optical disk, which make search and full text retrieval possible at remote computer terminals.

A.2.4.6 Physical Test Facility. The Physical Test Facility is used for conducting vibration tests on military equipment, including explosive ordinance, in accordance with MIL-STD 810F, Method 514.3 and MIL-STD 331. This facility features two complete electrodynamic vibration test systems. Each system is capable of testing in either the vertical or horizontal axis utilizing 60- inch by 60-inch fixture tables for mounting test items. The largest shaker is a 2 -inch peak-to-peak displacement system rated at 36,000-pound force sine and 34,000-pound force random. This system is equipped with a conditioning chamber capable of meeting all temperature and humidity requirements in MIL-STD 810F. The second shaker is a one-inch peak-to-peak displacement system rated at 30,000-pound force sine and 28,000-pound force random. Both shakers are located within a 40 feet by 60 feet test bay equipped with a five ton overhead crane. The Net Explosive Weight (NEW) limit for the bay is 100 pounds. All supporting power amplifiers and controllers are located in an adjacent building separated by a concrete blast wall. Also located within the test bay is a 6,000-pound loose cargo package tester with a six feet by eight feet test bed and a supporting climatic conditioning chamber that meets all MIL-STD 810 temperature conditions. Mobile temperature conditioning chambers are located within close proximity to the test bay to support pre-conditioning of the test items prior to vibration testing. An additional capability is the remotely located drop test facility. It supports drop testing of inert or explosive items up to 40 feet onto a steel or anvil top surface in accordance with, ITOP 4-2-504 and ITOP 4-2-602. This facility has a NEW of up to 3000 pounds and has dedicated pre-conditioning temperature chambers.

A.2.4.7 Climatic Test Facilities. The Climatic Test Facilities consist of a series of portable trailer or skid mounted temperature and specialized conditioning chambers used to support testing in accordance with MIL-STD 810F. There are 37 climatic conditioning

chambers with temperature range controlled from -100 degrees F (-77 degrees C) through 200 degrees F (93 degrees C) and five to 95 percent relative humidity control. Chamber test item compartments range in size from eight feet wide by eight feet high by twelve feet long up to eight feet wide by eight feet high by twenty feet long, with low temperature control achieved by either mechanical refrigeration or CO_2 cooling. Specialized systems include one each altitude, salt fog and fungus chambers. The altitude chamber compartment is four feet by four feet by four feet with a temperature range from -70 degrees F (-56 degrees C) to 200 degrees F (93 degrees C) and altitude range from sea level to 100,000 feet altitude. The salt, fog, and fungus chamber test compartment dimensions are eight feet by eight feet by twelve feet. These chambers meet or exceed all conditioning requirements of MIL-STD 810F for their applicable methods and are certified for testing explosive items. Also available is an assortment of specialized equipment and fixtures for conducting solar, rain, sand, and dust testing in accordance with MIL-STD 810.

A.2.4.8 Nondestructive Test Facility. This facility supports non-destructive inspection and evaluation of both inert and explosive materials and test items. It includes fixed site robotic radiographic inspection (x-ray), both real time and film, as well as real time and film portable x-ray systems. X-ray sources include one each selectable two to six MeV linear accelerator and one each Phillips 420 KeV tube; both 100 percent duty cycle. Additional capabilities include, magnetic particle inspection (krautkrammer Branson USD10), eddy current, Portable Isotopic Neutron Spectroscopy (PINS), liquid penetrant inspection (visible and fluorescent), micro hardness testing (krautkramer Branson-Microdur), and Rockwell hardness testing. Access to Ultrasonic Pulse Echo (UPE) and Acoustic Resonance Spectroscopy (ARS) systems are also possible.

A.2.4.9 Receipt Inspection Facilities. These facilities support receipt inspection, ordnance uploading and downloading, loose powder operations, and round refurbishment. Weight, dimensional measurements, moment of inertia and center of gravity equipment is available for inspection of all artillery and mortar projectiles.

A.2.4.10 Surface Layer Turbulence and Environment Sciences Test Facility (SL TEST). The SLTEST features a flat, undisturbed, vegetation-free surface with a slope of 1/10000 and an extended upwind fetch, unobstructed by wake-generating obstacles. This surface produces a nearly homogeneous wind field. The SLTEST was designed to conduct atmospheric boundary layer studies with measurement capabilities ranging from the viscous sublayer to the top of the mixed layer.

A.2.5 Ranges and Outdoor Grids. DPG has extensive instrumented test grids and ranges. Data acquisition systems, a radar wind profiler, Doppler acoustic sounders, and a network of remote automated weather stations are linked, primarily by fiber optics, to ADF and mission control center. Data is available to both Dugway analysts and test customers in a graphical user interface environment that displays both tabular data and custom-made graphs.

A.2.5.1 Tower Grid. This grid is laid out with concentric sampling radials, enabling sampling in this array at distances of up to one kilometer. The grid may be instrumented with equipment for chemical, biological, and particle sampling in a variety of formats and is equipped with lighting for night testing. Tower grid was designed and has been utilized to test biological detection components and systems. This versatile array will accommodate a variety of testing scenarios. In addition, a small asphalt landing strip was constructed next to tower grid to support unmanned aircraft sampling and detection of biological simulant aerosols.

A.2.5.2 Target S Grid. This grid is a large flat terrain range with an array of roads that are used for testing large biological detection networks. The JBREWS and JBPDS tests were conducted simultaneously in Spring 2000. Both programs required large areas to evaluate their networking capabilities. The test was spread over a seven by seven-kilometer area. This grid has recently been renovated with underground power lines, newly finished roads, optic fiber lines, and communications. Both outdoor test grids can accommodate point, line and aerial dissemination of simulant bioaerosols.

A.2.5.3 White Sage Mortar Range. This range accommodates the Army's present mortar systems, including 4.2 inches, 60 milimeters, 81 milimeters and 120 milimeters; three azimuths of fire facilitate projectile and metal parts recovery; velocity radars, Weibel radar, smear and tracking cameras and survey instrument observation points provide range and deflection functioning data from 500 to 17,500 meters downrange. Horizontal (direct) mortar firing is possible for metal parts recovery, fuze arming, and/or fuze functioning analysis.

A.2.5.4 Mortar Illumination Range The only illumination test range in DoD, this range is instrumented with custom luminance measuring devices; three azimuths of fire facilitate projectile and metal parts recovery; velocity radars, smear and tracking cameras, and survey instrument observation points provide range and deflection functioning data from 500 to 13,500 meters downrange. Horizontal (direct) mortar firing is possible for metal parts recovery, fuze arming, and/or fuze functioning analysis.

A.2.5.5 German Village Artillery Range. This is the primary artillery firing range at DPG and permits full recovery of projectiles. Prepared positions accommodate the entire family of artillery, mortar, tank and smoke obscurant type weapons. Velocity radars, Weibel radar, smear and tracking cameras, M33 radar and survey instrument observation points provide range, deflection and functioning data from 1,000 to 30,000 meters with growth potential to 60,000 meters. Fixed firing positions with off-line firing capabilities, underground electrical distribution, hard wire data acquisition system and on site conditioning chambers provide test support. Horizontal (direct) fire is possible for metal parts recovery, fuze arming, and/or fuze functioning analysis.

A.2.5.6 Romeo Grid. This grid was constructed with a 400-meter long radar retroreflector array for use in testing millimeter wavelength (mmw) obscurants. A scanning radar is

used to create a "map" of attenuation versus time as a mmw obscurant cloud passes in front of it. The Romeo Grid can be instrumented with visible-infrared transmissometers, cloud dimension cameras, target detection and recognition cameras, and other instrumentation to allow the characterization of smokes and obscurants throughout the electromagnetic spectrum from the visible to MMW wavelengths. Continuous disseminators, launched grenades, static fired munitions and pyrotechnic dissemination such as smoke pots can be used at Romeo Grid.

A.2.5.7 M76 Grid. Originally constructed to the XM76 bispectral (visible-infrared) vehicle launched grenade, this grid is used to test continuous disseminators, launched grenades, static fired munitions, and pyrotechnic dissemination such as smokepots. Transmissometer, visible and thermal imagery, particle samplers, vehicle target silhouettes and other instruments are used to characterize visible and infrared obscurants.

A.2.5.8 NASA Grid. This grid is equipped to support a vertical particle-sampling array and is used for obscurant characterization tests requiring intense aerosol sampling.

A.2.5.9 Downwind Grid. This grid allows large-scale smoke and obscurant releases under stable meteorological conditions. Large area screening tests using multiple dissemination systems are conducted here. Instrumented test grids 5 kilometers by 5 kilometers are used in addition to permanent towers for meteorological measurements and instrumentation platforms.

A.2.5.10 Inactive Runway and Decon Pad. This pad is used to test large aircraft decontamination and is the site of operationally oriented tests of aircraft refueling, loading, and rearming procedures in a simulated chemically contaminated environment.

A.2.5.11 Bravo Berm Test Site. This area is a nearly vertical berm used to test chemical detection equipment. Three 50-meter plots of grass, concrete and dirt are sprayed with simulated chemical agents at various concentration densities to provide a vertical line of site for detector testing.

A.2.5.12 Natural Environments Test Range. Over 80 kilometer (50 miles) of rough haul road vehicle test track and a sand and dust test grid. Both sites utilize DPG's natural arid environment to simulate dust conditions as closely as possible to MIL-STD-810E, Method 507.3.

A.2.6 Modeling and Simulation (M&S) with Detector Systems.

DPG is working to develop the definitive M&S capability for chemical and biological point and standoff detector systems. The primary focus of this effort is to use M&S in the WDTC test mission. The goal is to maximize the information content of testing. This information on military utility will have direct application to system evaluation,

operational testing, training, etc. WDTC is committed to providing information that will support the entire acquisition process.

Locating, identifying, tracking and/or predicting CB hazards is a major thrust for the contamination avoidance mission area for chemical and biological defense. Numerous point and standoff detection systems for both chemical and biological agents are in development. These detector systems have established performance requirements (i.e., detection and identification of CB agents locally and at distances of 5km or more) and associated test requirements, test conditions, and evaluation methodologies as specified in Operational Requirements Documents, Test and Evaluation Master Plans, Independent Evaluation Plans, and applicable Test Operating Procedures.

Existing test methodologies are not capable of fully assessing the performance requirements of existing and developmental CB agent detectors. Existing methods test only a very limited subset of the required performance envelope. Field trials using CB agent simulants are of limited value for assessing technical performance of CB detectors because of the inability to track, quantify, and control simulant challenges in a dynamic environment. Chamber methods provide much better control of challenges and allow testing with actual agents. However, the static conditions under which the tests are run make it difficult or impossible to make valid correlations to, or predictions of, operational performance in the field. The field environment is highly dynamic, and characterized by rapid changes in agent challenge, effects of battlefield interferents, and associated meteorological conditions. Dynamic test results are far more realistic and relevant than what is achievable with current static methodologies. More comprehensive test matrices can be completed in a much shorter time. Costly, large-scale tests with “live” CB agents can be reserved for what they are best at, which is looking for unanticipated variables that affect detector performance.

A.2.6.1 CB Dial-a-Sensor (DAS). DAS is an architecture for simulating point and standoff, active and passive, chemical and biological sensor systems. DAS enables users to *dial in* parameters to set performance characteristics for a known or proposed set of detector technologies. These technologies include point ionizing chemical detectors; standoff passive chemical detectors; point particle-counting biological sensors; active imaging sensors and others using extensible markup language (XML) technology. DAS provides the fundamental architecture that allows for integration with other M&S tools. Basic sensor testing involves subjection of a sensor to numerous field trials. In order for a thorough testing of a sensor to occur, however, literally thousands of trials would need to be conducted to ensure all possible test parameters have been varied. Time and budget constraints make this type of testing impossible. DAS fills this testing void by allowing for these thousands of tests to be conducted virtually and at a mere fraction of the time and cost of actual field trials. It is a critical tool in implementing recent National Research Council recommendations for testing CB standoff detectors. CB Analyzer and Stealth used these parameters to monitor the test condition scenarios. This cooperation between DAS and the visualization tools is a vital component to virtual testing because it portrays the sensor *look vector* (*e.g.*, field of view (FOV)) at any point in time.

A.2.6.2 CB Analyzer. CB Analyzer is a software toolkit that allows a user to create threat assessment scenarios for analysis using data from field tests or virtual simulations. The toolkit currently provides support for chemical standoff active (imaging) and passive sensors. These sensors can be attached to the vehicles in the exercise, or placed in stationary locations. The attachment of sensors to vehicles is done via XML files. As the vehicles move over time, the sensor locations are updated appropriately. The parameters for the sensors such as scan pattern, agent detectability, etc. can be customized in an XML file.

A.2.6.3 NCBR Environment Server (NCBR). NCBR is an existing simulation developed by a consortium led by the US Army Edgewood Chemical Biological Command (ECBC) and the Defense Threat Reduction Agency (DTRA) to provide hazard clouds for distributed simulation. The NCBR calculates in real time a high fidelity, three-dimensional hazard environment as a function of hazard delivery system (source term), meteorological conditions and complex three-dimensional terrain. The DTRA SCIPUFF and the Naval Surface Warfare Center (NSWC) VLSTRACK Gaussian puff models provide the means for the NCBR to calculate CBR hazard environments. The NCBR makes the data available to other simulations via full three-dimensional representations of the environments (instantaneous air concentration), two-dimensional grids (dose, deposition, air concentration, and lethal dose (LD) contours), and at a specific point via a subscription process.

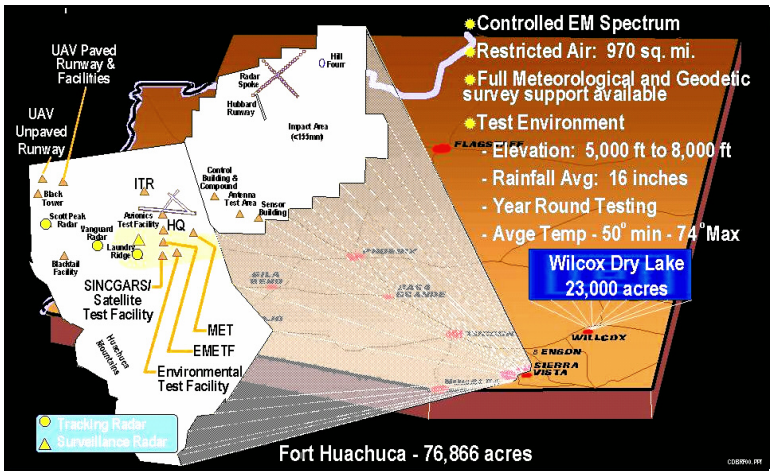
A.2.6.4 MÄK Stealth. MÄK Stealth commercial software provides three-dimensional visualization of the elements of the test. Software engineers use the plug-in capability in MÄK Stealth's architecture to enable visualization of the three-dimensional hazard as recorded by referee systems or from the synthetically generated Gaussian puff hazard calculated by the NCBR Environment Server. The Stealth application displays the hazard cloud on a three-dimensional virtual environment terrain grid. When interfaced with DAS, the Stealth also displays the field of view (FOV) of the detector system. This technology enables the analyst to "fly" through the three-dimensional environment and visualize the detector FOV with respect to the agent hazard during a playback exercise.

A.3 ELECTRONIC PROVING GROUND (EPG)

A.3.1 Mission

The mission of the Electronic Proving Ground (EPG) is to test Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) systems including hardware and all associated software. The mission includes test planning, test conduct, and test reporting. EPG is an Electromagnetic Environmental Effects (E3) tester for C4ISR systems to include EMI/C/V, TEMPEST, and Co-site. The mission includes testing UAV and other reconnaissance, surveillance, and navigation systems. The mission also includes responsibility for the Test fabrication, range assets and facilities, methodologies, test processes, and the development of instrumentation, and other test capabilities. Current program emphasis is on the intensive application of simulation/stimulation and automation technology to test large, complex, computer based distributed C4ISR systems.

A.3.2 Location



EPG is a tenant at Fort Huachuca, in southeastern Arizona, 70 miles southeast of Tucson. It is readily accessible by Interstate 10 and State Route 90, or through commercial airlines, which share the Libby Army Airfield on Fort Huachuca.

A.3.3 Features

EPG is unique within the Department of Defense (DoD) because of its naturally quiet electromagnetic environment, unique specialized facilities, close relationship with the Army Joint Test and Training community, and its ability to use the expansive real estate of southern Arizona. Operations are routinely possible on 70,000 acres at Fort Huachuca, 23,000 acres on Wilcox Dry Lake, and with prior coordination, on approximately 62 million acres of federal and state owned land throughout Arizona.

A.3.3.1 Topography. The area includes mountains, plateaus, and river bottoms. The Huachuca Mountain area slopes east to the San Pedro River. Due to its location on the Northeast side of the Huachuca Mountains, this area is blessed with an almost ideal climate. Set well above and 14 miles distant from the San Pedro River, and at an altitude of 5000 feet above sea level, it enjoys mild winters and pleasant summers. Rainfall is abundant by comparison with other southern Arizona areas. The soil is extremely rocky. However, the surface soil that does exist is fertile and produces an excellent grass crop. The vegetation in the valley and the lower portions of the Huachuca Mountains consist primarily of grass and mesquite. At higher elevation, chaparral and oak timber become common. Above the 6,500-foot level, yellow pine becomes prominent. Typically, 330 clear days per year is average, and in excess of 300 clear days is assured.

A.3.3.2 Climate. The local area is classified as High Desert. High elevation and summer showers provide a mild year-round climate. Annual rainfall is 15 inches with 65 percent occurring in summer, 14 percent in winter with infrequent light snow, and 80 percent of possible sunshine received. January mean temperature is 46.2°F; June mean temperature is 76.7 degrees F. Average wind is 5.6 miles per hour.

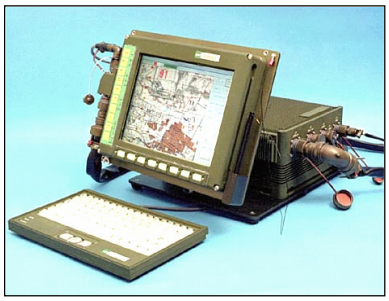
A.3.3.3 Restricted Airspace. 1.1-sq. mi. of restricted airspace is available in the Fort Huachuca vicinity. However, due to the nearest airway being approximately 50 miles to the north, non-hazardous airborne testing is virtually unlimited.

A.3.4 Facilities

EPG facilities are specialized and are primarily designed to support C4ISR Research, RDT&E, with evaluations including human factor, engineering, reliability, maintainability, safety, and soldier-operator-maintainer test considerations.

A.3.4.1 The C4I Test Bed Facility. The C4I Test Bed Facility is an Installed System Test Facility (ISTF) that provides the capability to test new versions of tactical communications equipment and peripheral devices with existing C4I systems in both laboratory and field environments. Training and Test instrumentation vans with a full range of field capabilities are available for normal and quick reaction requirements. The Test Bed includes test trailers, mobile test vans, and a simulated TOC with an inventory of radio and peripheral equipment.

A.3.4.2 Tactical Internet/Force XXI Battle Command Brigade and Below (FBCB2) Test Bed



The FBCB2 Test Bed sponsored by PM Tactical Radio Communications Systems and PM FBCB2, maintains assets to deploy over 100 instrumented nodes throughout Fort Huachuca and the surrounding area. Deployments of equipment are configurable based on customer requirements ranging from representative slices of

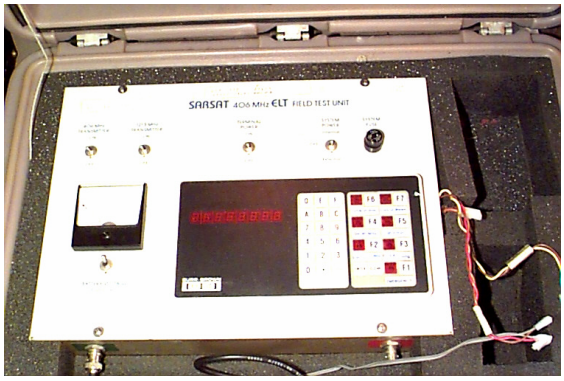
tactical units dispersed over realistic tactical operational distances or clustered together to facilitate integration.

Utilizing the Test Bed assets, the deployments can be established using fixed locations with specially constructed secure mobile containers or using existing buildings capable of representing a Tactical Operations Center (TOC) equivalent of assets. The Test Bed also has configurable vehicles as movers and mobile trailers that can be pre-positioned at field sites and relocated to represent a changing lay down or a movement scenario. The Test Bed can customize deployments and set up realistic Radio Frequency (RF) or Electronic Warfare environments.

A.3.4.3 The Global Positioning System (GPS) Instrumentation Suite (GPSIS). GPSIS provides flexibility in testing receivers and antenna systems by providing operational control of dynamic and repeatable scenarios in a low-cost laboratory environment. The system also provides integrated control for electronic warfare and multi-path signals that are modeled through computer control. The simulated GPS signals can be either injected directly into a GPS receiver under test or can be radiated using the GPSIS Amplifier/Antenna System. This simulation is especially valuable for testing systems in a controlled environment within the environmental test facility. Additionally, EPG incorporates operational test characterization by combining laboratory test instrumentation capabilities with the open-air range resulting in a low-power electronic warfare test range. Because of the clean Electromagnetic Environment and limited commercial air traffic, open air GPS testing of all types are generally allowed.

A.3.4.4 COSPAS-SARSAT Beacon Certification Facility.

COSPAS-SARSAT is one of five certification facilities in the world. Formal Certifications are available for all beacon types and for all protocols (user and location). The EPG facility has GPS Data/Simulation for testing self-locating beacons. The facility can test Antenna characterization and system characterization. EPG has an Open Air Range (OAR) with over 1,000 1st order accuracy survey points and a position



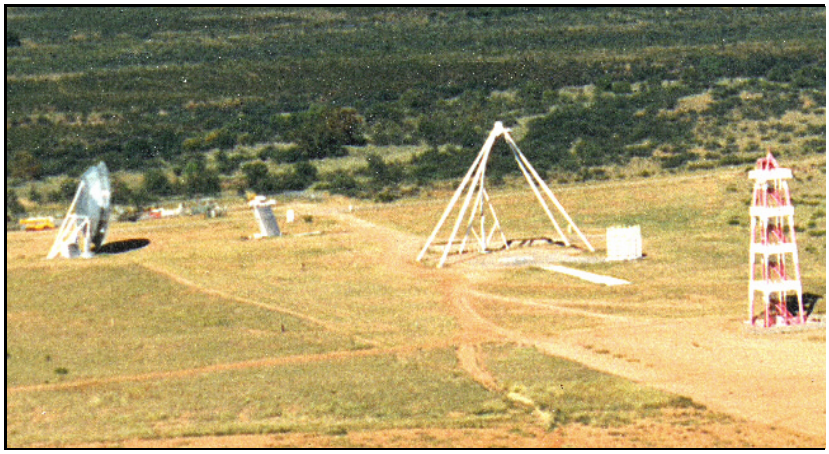
location system with GPS.

A.3.4.5 C4ISR Test Control Complex (TCC)

The TCC control rooms provide facilities/instrumentation for distributed systems testing using the EPG developed – STARSHIP and ORION toolkits. Command and control of range assets during test conduct can be provided in either of two separate control rooms. These functions include distributed systems control and data collection, accurate operation of precision tracking radar, audio/video presentations, data recorders, position location system, surveillance radar, real time data displays, timing, and communications. Data reduction is provided for precision tracking radar and position location system data on a Compaq Alpha and can be provided to the range user in as little as an hour after test completion. The TCC provides communications, reliable real time presentation of instrumentation data and suitable test monitoring capability to the Government's Airspace Safety Officer (ASO) Console and to each of the test user workstations. It can provide control and coordination for multiple test operations, dependent upon the test configuration and scope. The TCC is operational on a daily basis and can be operated as an independent control centers for tests. It is the hub of all testing performed within EPG's Open Air Range (OAR).

A.3.4.6 Antenna Test Facility (ATF)

ATF can measure a vehicle-mounted antenna's radiation pattern over a complete hemisphere with a unique 117-foot arc and 60-ton turntable capable of handling any ground vehicle in the Army inventory. The Arc's sensors cover the spectrum from 20 MHZ to 16 GHz. The turntable is rotated 360 degrees in azimuth to provide an azimuth polar or retangular plot of antenna performance. The Arc is capable of measuring data at elevation angles from –13 to +90 degrees. A 114 foot tall tower is located 500 feet from the arc, with an additional turntable located 500 feet further. These items provide RF signal and test item positioning capabilities for conducting specialized test of direction finding, emitter identification and other RF signal processing systems.

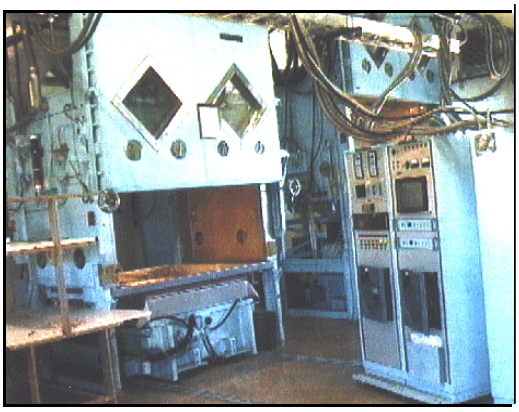


A.3.4.7 Electromagnetic Interference (EMI) and TEMPEST Test Facility

The EMI and TEMPEST Test Facility has test equipment available for EMI, EMC, susceptibility, special investigations, and TEMPEST testing. EMI testing can be performed in accordance with MIL-STD-461A, B, C, D, E; MIL-STD-462D; RTCA/DO-160; ADS-37; and other national and international standards as required. TEMPEST testing is in accordance with NACSIM-5100A, NACSEM-5112, NTISSAM 1-91, 1-92, KAG-30, and other requirements as necessary. EMC testing can be performed in accordance with MIL-STD-464 and other user defined criteria as required. A team of National Association of Radio and Telecommunication Engineers (NARTE) - certified engineers staff the facility. Modeling and simulation, hardware-in-the-loop testing, and/or field-testing are used during system testing. Investigations are conducted to determine problem areas and possible solutions.

A.3.4.8 Environmental Test Facility (ETF).

The ETF can meet all the requirements called out in MIL-STD-810, MIL-STD-781, MIL-S-901, MIL-STD-705, DO-160, and AR 70-38. Test chambers can produce extreme climatic and structural test conditions. In addition to Reliability and Environmental Stress Screening, the ETF can perform natural and induced Environmental Acceptance tests. Conditions are precisely controlled and are 100-percent repeatable. Test chambers at the ETF can produce one or a combination of test conditions at a time for test items up to 11-ft wide by 11-ft high by 33-ft long.



A.3.4.9 Fabrication Facilities

The Fabrication Facilities are a direct result of years of testing support. Through years of experience, the three facilities (Fort Hood, Fort Lewis, and Fort Huachuca) have developed a capability to not only design and fabricate prototypes, but to take concepts through design, fabrication and fielding. The specialty areas are the Tactical Operations Centers (TOCS), related C4I systems, and shelter hardware integration to include Standard Integrated Command Post Systems (SICPS) and Large Scale SICPS. This capability has been extended to the various PM's for the production of "one of a kind" and prototype shelters, as well as providing field maintenance support to various platforms not readily supported by the normal Integrated Logistical Support System (ILS). Through the support provided to PM's, especially PM TOC, EPG has an extensive knowledge of TOC requirements from the Battalion to the CORPS level. EPG has been instrumental in the fabrication of several specialized TOC's, the upgrade of the M577 to the M1068, modifications to the old Command and Control Vehicle (C2V), and specialized fabrication for the STRYKER. We have provided various shelter interconnect systems such as tents with bootwalls that attach to the various vehicles and shelters, providing a large work area in the tactical environment. We have also designed and fabricated two systems that provide an interconnected walkway between the various TOC shelters. These walkways are an integral part of the vehicle and shelter and eliminate the need for additional prime movers to transport walkways and ramps. Unique requirements can be met without hesitation.

A.3.4.10 Electromagnetic Environmental Test Facility (EMETF)

EMETF is the Army's principal facility where equipment, systems, and concepts are tested and evaluated in a simulated electromagnetic (EM) environment, including electronic countermeasures. The facility includes an automated electromagnetic database, deployment, and analysis capability, spectrum signature facility, voice scoring facility, voice interference analysis system, and automatic data collection system.

A.3.4.11 Radar Spoke and Radar Resolution Facility. The Radar and Radar Resolution Facility allows simultaneous measurement of the range and azimuth

resolution of radar systems. Used in conjunction with the Time, Space, and Position Information (TSPI) on the range, very accurate data on the capabilities of radar systems can be determined.

A.3.4.12 Radar Geometric Fidelity Facility. Radar Geometric Fidelity Facility occupies 23,000 acres on the Wilcox Playa and provides a standard for measuring the fidelity of airborne radar mapping systems.

A.3.5 Ranges

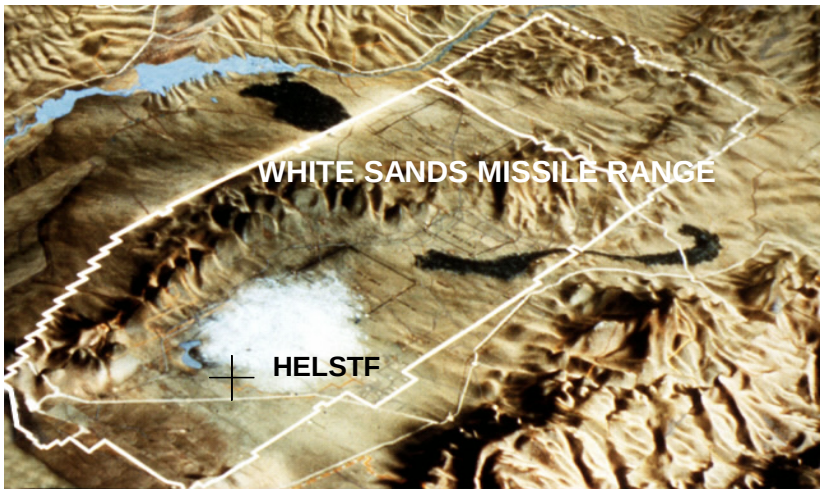
The OAR is available to support testing of C4ISR surveillance devices, navigation, and communication equipment, and other electronic guidance and control systems. The OAR is especially adapted to tests where the devices of the systems being tested are carried in manned or unmanned aircraft. Tests usually require determination of time space and position information (TSPI) and flight characteristics of the aircraft and require facilities for launching and controlling UAVs. In addition to four available runways on Fort Huachuca, the OAR provides several flight areas within the controlled airspace and throughout southern Arizona. Major instrumentation includes precision tracking and surveillance radar systems, telemetry data systems, command/control systems, optical tracking systems, range measurement for up to 60 targets, and air-to-ground and other communication systems. Major complexes throughout southern Arizona are interconnected with a multi-channel microwave radio relay system. Services provided include range-wide communication, precise timing, the TSPI and flight characteristics of manned and unmanned aircraft throughout most of southern Arizona, and in support of national ranges covering an area extending into portions of five states and outer space. The Realistic Battlefield Environment resource is also part of the OAR. Data collected on the OAR are centrally collected at the TCC.

A.4 HIGH ENERGY LASER SYSTEMS TEST FACILITY (HELSTAF)

A.4.1 Mission

The Mission of the HELSTF is to provide directed energy expertise to the warfighter and the Nation by serving as the US Army Space and Missile Defense Command Test and Evaluation facility for current and future directed energy technologies, supporting the integration of directed energy technology into the Army Objective Force and Future Combat System, and by supporting Department of Defense/Department of Energy and other Service high energy laser testing.

A.4.2 Location



HELSTF is located within the boundaries of the White Sands Missile Range, New Mexico. It is approximately 60 miles north of El Paso, Texas, 25 miles west of Alamogordo, New Mexico, and 35 miles east of Las Cruces, New Mexico. HELSTF is situated in the Tularosa Basin, an expanse of the Sonoran desert stretching from Mexico in the south to the Oscura Mountains in the north. To the west, the San Andres Mountains provide a natural beam stop for high-energy laser beams propagated from HELSTF. These mountains range in elevation from 5,000 to 9,000 feet and generally consist of stony sands, clay, and variable bedrock. The Tularosa Basin is generally referred to as a desert; however, this area is more of arid grassland than a true desert. The basin floor has an average elevation of 4,000 ft mean sea level. Soil in the central portion of the Tularosa Basin is primarily composed of white gypsum sand.

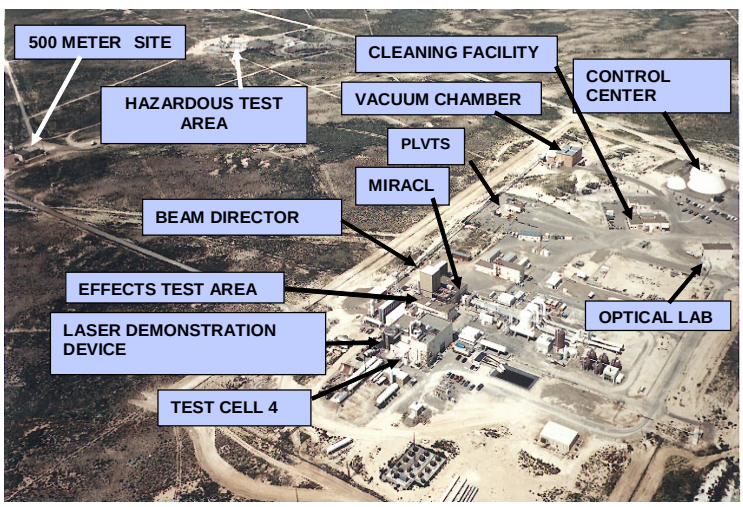
A.4.3 Features

- San Andres Mountains to the west of HELSTF provide a natural beam stop to contain the laser energy within the limits of the White Sands Missile Range.
- Location within the White Sands Missile Range (WSMR)-controlled airspace and far from main commercial air routes minimizes interference with commercial aviation activity.

- A variety of laser devices with power levels ranging from one hundred watts to over a megawatt, and wavelengths of 1.05µm, 2.7µm, 3.8µm, and 10.6µm provides the developer with many options to support experiments.
- Completely instrumented test areas provide the developer with ability to acquire and analyze data concerning laser-target interaction and laser effects.
- A Large Vacuum Chamber provides the ability to simulate high altitude environments for laser effects/countermeasures testing.
- Complete High Energy Laser Meteorological instrumentation provides high-resolution data about atmospheric conditions along the laser beam path.
- A 1.8-meter beam director that is also capable of producing high-resolution IR images of dynamic targets at very long range.

A.4.3.1 Climatic Features. Semi-arid with a visibility greater than 6 miles an average of 343 days per year. HELSTF climatic annual mean values are: temperatures of max-mean-min are 78-62-46°F, relative humidity is 36%, precipitation is 11.9 in; snowfall is 6.5 in, and average wind velocity is 4.7 mph with max gust to 70 mph.

A.4.4 Facilities



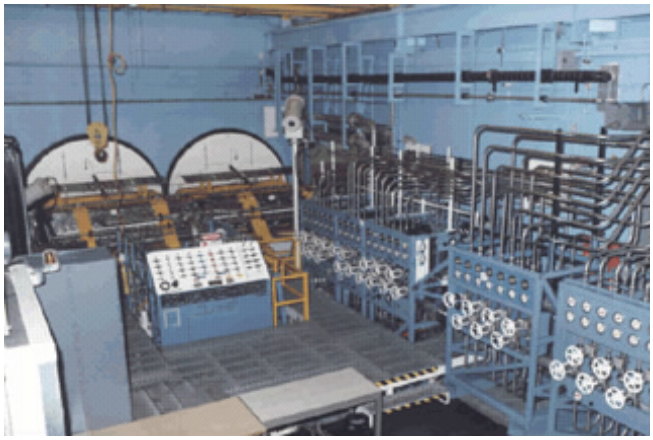
HELSTF is subdivided into a Technical Area (shown below), a Test Support Area, and Downrange Test Areas. Downrange Test Areas include the 500-meter site, the Hazardous Test Area, the Integrated Test Vehicle (ITV), a moving ground target, and the Dynamic Test Area. The 500-meter site and the Hazardous Test Area offer complete instrumentation for recording laser effects. Additional land is available for specialized support of customer projects.

A.4.4.1 Laser Devices. The HELSTF operates and maintains four major laser devices as part of its infrastructure. Each of these devices is discussed below.

A.4.4.1.1 Mid-IR Advanced Chemical Laser (MIRACL).

MIRACL is the first megawatt-class, continuous wave, chemical laser built in the free world. It is a deuterium fluoride (DF) chemical laser with energy spectra distributed among about ten lasing lines between 3.6 and 4.0 microns wavelength. Since it first lased

in 1980, it has accumulated well over 3500 seconds of lasing time. To date, it is the only laser produced in the US, at DF wavelength, which has attained average powers at this high level. MIRACL operation is similar to a rocket engine in which a fuel (ethylene, C2H4) is burned with an oxidizer (nitrogen trifluoride, NF3). Free, excited fluorine atoms are one of the combustion products. Just downstream from the combustor, deuterium and helium are injected into the exhaust. Deuterium reacts with the fluorine to yield excited deuterium fluoride (DF) molecules, while the helium stabilizes the reaction and controls the temperature. The laser's resonator mirrors are mounted outside the excited reaction gas region and optical energy is extracted. The cavity is actively cooled and can be run until the consumable supply is exhausted.



A.4.4.1.2 Laser Demonstration Device (LLD). LDD is a continuous-wave chemical laser designed and constructed by United Technologies Research Center (UTRC) at East Hartford, Connecticut, in 1972, and was used at that facility until 1990. Ownership was transferred to HELSTF in 1991, and the LDD was installed and recharacterized in 1992. LDD was installed to allow experimenters to simulate MIRACL power densities at lower power levels (10-20 kilowatts), reducing the cost per experiment. A user test area is available to LDD where experiments can be performed to the individual customer's specification. Future plans may include integration of LDD into the MIRACL beam train. This will allow the LDD beam to be propagated into any of the HELSTF test areas or to the Sea Lite Beam Director.

A.4.4.1.3 Pulsed Laser Vulnerability Test System (PLVTS)

PLVTS is a suite of lasers and beam directors whose fundamental mission is to support susceptibility and vulnerability testing of components, systems, and materiel of modern US tactical weapon systems. It consists of a device trailer that houses the control room, laser devices, laser beam diagnostics, and a 50-cm static output telescope. There is a 60 cm pointer/tracker beam director that is used for multi-wavelength dynamic target

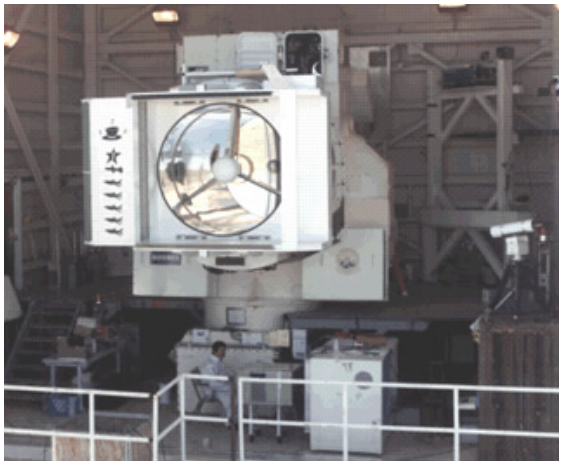
illumination. One of the lasers is a closed-cycle, electric discharge, pulsed CO2 device operating at 10.6 microns that can deliver up to 1200 Joules per pulse at repetition rates of 1 to 30 Hz. This laser is the highest energy pulsed CO2 system in the United States. The confocal unstable resonator accepts an optional grating tuned injection laser for gain switch spike reduction and mode stabilization enhancement.

PLVTS supports a full complement of beam diagnostic instrumentation that measures critical output performance parameters of the lasers, as well as selected parameters at the target plane. An adjustment of the optical train directs the 10-cm square beam into the neighboring test cell for laboratory use.

A.4.4.1.4 Low Power Chemical Laser (LPCL). The Low-Power Chemical laser is a 100-Watt class DF laser that is integrated into the optical train of the MIRACL. This laser is useful for illuminating targets at low power in support of tracking and aim point maintenance experiments.

A.4.4.1.5 Beam Transfer Area (BTA). The Beam Transfer Area (BTA) consists of a set of optics that allow the MIRACL and the Low Power Chemical Laser (LPCL) to be switched among the instrumented test areas, the Sea Lite Beam Director, and the Large Vacuum Chamber. The BTA gives the HELSTF great flexibility in making use of the MIRACL and other laser devices to support fully instrumented experiments.

A.4.4.1.6 Sea-Lite Beam Director (SLBD)



The Sea Lite Beam Director is a high-precision pointer-tracker system that provides the capability to track and irradiate highly maneuverable targets. The SLBD can also serve as a high-resolution infrared imaging system that can record data from missile tests conducted at the White Sands Missile Range. SLBD is a gimbaled, 1.8-meter megawatt class high power laser beam-expanding telescope. It is pointed by conventional azimuth hydraulically driven gimbals to provide wide area coverage with gimbal rates capable of handling the most stressing close-in tactical scenarios. It is the principal device for propagating the MIRACL beam in dynamic tests.

A.4.4.1.7 Effects Test Area (ETA). ETA provides the ability to rapidly process target effects during an experiment using the MIRACL. It is equipped with a high-speed target handling system, and a fast shuttering system to use the MIRACL beam efficiently. The ETA can provide separate data, power and commands for up to 80 target samples. Beam integrator optics maintains MIRACL power very close to a constant value during an

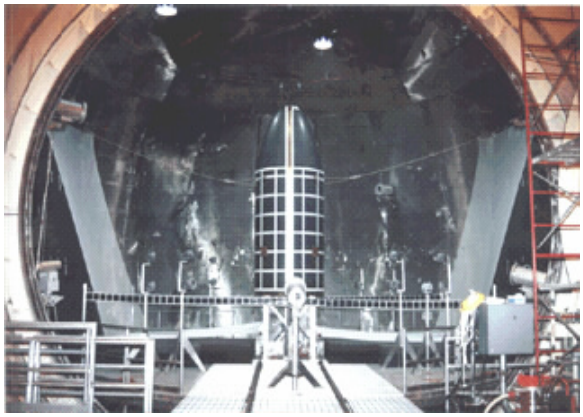
experiment. A gas flow system simulates airflow over a dynamic target. Target instrumentation includes a plume sampling system, high-speed photography, and optical pyrometry.

A.4.4.1.8 Hazardous Test Area (HTA).

The HTA is a remote, instrumented hard target test area capable of handling full-size targets that are explosive or otherwise hazardous. This test area can receive MIRACL power thru the BTA or the Sea-Lite Beam Director (SLBD). The photograph depicts the destruction of a full-size Titan rocket casing by MIRACL in the HTA. This test demonstrates the ability to handle full-size, hazardous targets.

A.4.4.1.9 Large Vacuum Chamber (LVC).

The LVC is a 50-foot diameter vacuum sphere. It is capable of simulating altitudes up to 65,000 feet. The chamber is suited for investigation of laser effects against high altitude targets. A Beam Transfer System, making it possible to fire the MIRACL and other lasers against targets placed in the LVC, connects it to the Beam Transfer Area (BTA). It also has been used for payload checkout and anomaly investigation.



A.5 RONALD REAGAN BALLISTIC MISSILE DEFENSE TEST SITE

A.5.1 Mission

The Ronald Reagan Ballistic Missile Defense Test Site (RTS) is a complex of sophisticated radar, optical and telemetry sensors. A key component of the Pacific Test Bed, RTS has accomplished multiple BMD developmental test intercepts. RTS offers launch capability for strategic interceptors, multistage scientific rockets and all types of theater-range ballistic missiles. As part of the Space Surveillance Network, RTS annually provides data on over 42,000 space objects, including object identification, orbital track information and foreign launches

The Commander, USAKA, is also the US Commander, Pacific, military representative to the Republic of the Marshall Islands. As such, he has specific tasks and duties to further develop the relationship between the United States and the Republic of the Marshall Islands.

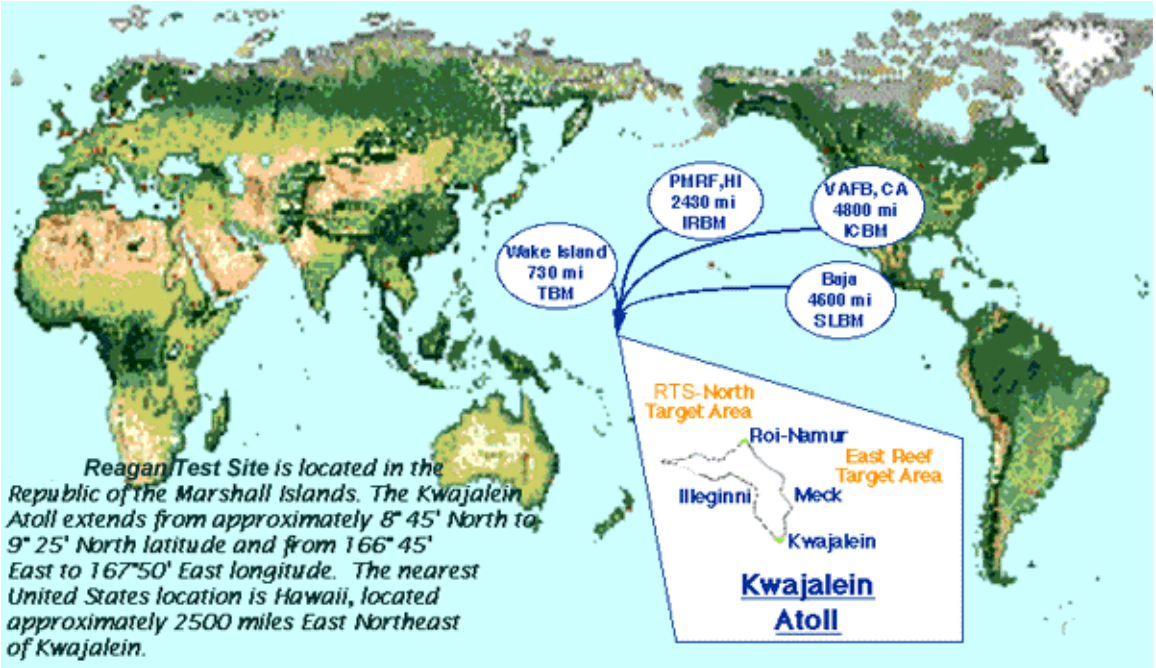
A.5.2 Location

US Army Kwajalein Atoll (USAKA), Reagan Test Site (RTS), is located in the West Central Pacific Ocean (latitude: 8 degrees 43 minutes, north; longitude: 167 degrees 44 minutes, east). It is approximately 2,135 nmi (3,950 km) southwest of Honolulu, Hawaii, and about 4,277 nmi (7,921 km) southwest of San Francisco, California. USAKA is approximately 594 nmi (1,100 km) north of the equator in the latitude of Panama and the southern Philippine Islands, and the same longitude as New Zealand. Commercial air

service is via Air Marshall Islands, Aloha, and Continental Airline's Air Micronesia; US Governmental airfreight and passenger service is via USAF Air Mobility Command (AMC); commercial freight is via ocean-going barge.

A.5.3 Features

Located in the Republic of the Marshall Islands (RMI), Kwajalein is the world's largest



coral atoll surrounding the world's largest lagoon. Eleven of the 100 islands comprising the Atoll are leased by the United States from the RMI government. The Kwajalein Atoll consists of approximately 100 sparsely vegetated coral islands. Surrounded by a broad ocean of more than 750,000 square miles, RTS provides ideal geometries to support all ranges of strategic and theater ballistic missile testing. RTS's vast expanses of water and its remote location provide outstanding security measures for ballistic missile testing. Ocean depths reaching 6,000 feet immediately surrounding Kwajalein Atoll preclude any recovery of sensitive flight hardware. If recovery is an objective, the lagoon's shallow waters (~200 feet maximum depth) permit recovery of flight hardware.

The north-south distance in the Atoll is approximately 50 miles; at the widest point of the instrumented area, the Atoll is approximately 15 miles. The geographic dispersion of the instrumentation sites, especially the optics, provides excellent metric triangulation results.

A.5.3.1 Topography.

The RTS encompasses approximately 750,000 square miles. The total land area is only about 70 square miles. In coordination with the Republic of the Marshall Islands, RTS has control of the RF

spectrum. Environmental impact studies and assessments confirm minimal environmental impact from either current or future range operations.

A.5.3.2 Climate. The climate of the Kwajalein Atoll allows for year-round testing and training activities, with little to no precipitation on over 238 days annually and an average temperature of 87 degrees. The wind velocity typically varies between 9 and 17 mph.

A.5.4 Facilities

A.5.4.1 Wake Island

Wake Island, located 1,100 kilometers north of the Kwajalein Atoll, provides a launch site for intermediate range target missiles. Program requirements, mission planning and implementation, and logistics support are coordinated through RTS.

A.5.4.2 Meck Island

Meck Island is located approximately 17 miles north of Kwajalein Island on the east reef of the atoll and is about 55 acres. There is limited transient housing on the island, as well as logistic facilities such as a mess hall, fire station, power plant, warehouses, helo-pad, pier facilities for both passenger ferry and

cargo barges, maintenance shops, and a dispensary along with the required facility systems such as fresh water, sewage, and electrical power. A 199-passenger ferry from Kwajalein provides transportation to and from the island. Technical facilities include two missile assembly facilities (7,200 sq ft), two missile control buildings (2,300 sq ft and 10,500 sq ft), an active launch cell, two inactive Spartan and two inactive Sprint launch cells, and a launch pad. Two new missile silos to support NMD Ground Based Interceptor (GBI) testing are nearing completion. Assorted support facilities include camera towers, equipment rooms, and holding bays. Meck Island offers launch capability for custom payloads with a minimum of hazard or safety constraints. It also offers an up-to-date technical infrastructure coupled with excellent data collection provided by the RTS instrumentation base. Meck, in conjunction with Vandenberg AFB, allows users to conduct ABM testing. By using Wake Island and other alternative launch sites, Meck allows users to do tactical or theater missile testing.

A.5.5 Range Instrumentation

RTS hosts a suite of instrumentation located on seven islands throughout the atoll. This instrumentation consists of precision metric and signature radars, optical sensors, telemetry receiving stations, impact scoring assets, and the safety and command, control communications (C3) capabilities necessary to support a variety of engagement scenarios.

In February 2003, RTS completed the Kwajalein Modernization and Remoting (KMAR) project, a five-year program to modernize the radars, optics and telemetry sensors on the range. Under the program the Kwajalein Mission Control Center (KMCC) underwent a facelift in the summer of 2000, paving the way for the remoting projects to come. The ARPA Lincoln C-Band Observables Radar (ALCOR) became the first radar remoted to KMCC in October 2000, followed by Millimeter Wave (MMW) in 2001, ARPA Long Range Tracking and Instrumentation Radar (ALTAIR) in June 2002, and Tracking and Discrimination Experiment (TRADEX) in February 2003. The project upgraded optics and moved telemetry assets from outer island to Roi-Namur and Kwajalein, brought four fixed antennas to Roi-Namur, and brought three fixed antennas to Kwajalein's Mount Olympus or what is now known as Telemetry Hill.

Using commercial-off-the-shelf (COTS) technology for an open architecture approach, engineers can now modify the systems more easily thus allowing the necessary flexibility to satisfy customer requirements. With KMAR upgrades, engineers use the same data format for each radar and the same COTS tools to analyze the data, regardless of the source. Display screens offer engineers point-and-click ease as they monitor and track objects

A.5.5.1 Kiernan Reentry Measurement Site (KREMS)

KREMS is a sophisticated radar suite. Coherent signature and metric data are collected across the radar frequency spectrum with high fidelity and accuracy.

A.5.5.1.1 ALTAIR

ALTAIR is the largest of the KREMS radars, simultaneously radiating a peak power of 7 megawatts in VHF and 5 megawatts in UHF from a 150-foot dish. The power and sensitivity of ALTAIR allow it to track an entire target complex at ranges of more than 4,000 km. The massive but agile antenna with its 3-degree beam width supports dual frequency tracking of multiple targets for debris mapping, analysis of break-up events, and performing kill assessment of Theater Missile Defense (TMD) intercepts.

The high power aperture product of ALTAIR allows it to perform its space surveillance mission monitoring near earth as well as deep-space objects and providing coverage for foreign and domestic space launches. ALTAIR supports several operating modes, including tracking and signature collection at VHF and UHF. Target resolution in VHF is 37 meters; in UHF, target resolution is 15 meters. The ALTAIR system provides a large repertoire of narrow- and wide-band waveforms. The high sensitivity and relatively wide beamwidth of the radar make the instrument

ideal for viewing dispersed targets. The same characteristics make the radar ideal for tracking space objects out to and beyond synchronous orbit. ALTAIR can independently track up to 32 targets in both VHF and UHF. Simultaneous track in both frequencies allows real-time ionospheric correction to further refine tracking accuracy. The ALTAIR Recording System (ARS) records phase and amplitude data, both Right Circular and Left Circular on all in-beam, tracked targets, transferring data to high-speed disks at rates up to 56 MBytes/second.

A.5.5.1.2 TRADEX

TRADEX generates 2 megawatts at both L-band and S-band. The radar is noted for its high sensitivity, exceptional waveform flexibility, and extended range recording capability. TRADEX provides long-range target complex evaluation, body motion characterization, and debris mapping, as well as real-time multi-target tracking of up to 63 targets. From this target set, the radar can provide ten target files to KMCC and collect pulse-by-pulse data on up to six targets. TRADEX attributes are ideal for TMD phenomenology assessment. TRADEX supports

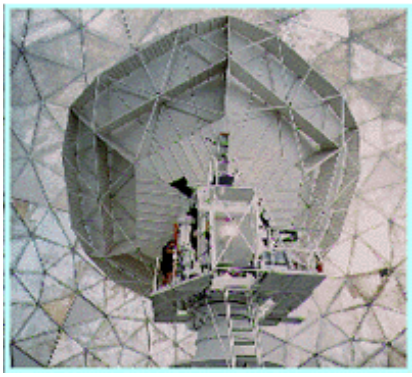
many operating modes, including full range and angle tracking and signature collection at L-band and range-only track with signature collection at S-band. Target resolution at L-band is 15 meters; at S-band, target resolution is nominally 5.5 meters. TRADEX currently transmits Right Circular polarization at L-band and S-band; it records phase and amplitude, both RC and LC, in both bands. The system uses both uniform train and burst sub-pulse spacing to achieve excellent range and velocity resolution. TRADEX uses an Array Processor System to provide coherent integration of RC signal returns. In its extended range mode, the radar can track targets with a single hit SNR of -23 dB. NASA has used TRADEX S-band capabilities and features for detecting and tracking small orbiting debris down to one centimeter in diameter for spacecraft safety analysis.

A.5.5.1.3 ALCOR

ALCOR is a high-power, narrow-beam coherent, chirped monopulse tracking radar. ALCOR supports two operating modes, narrowband (6 MHz bandwidth) and wideband (512 MHz bandwidth). The wideband waveform provides a range resolution of approximately 0.5 meters. A doublet waveform, consisting of two closely spaced wideband pulses, allows measurement of target velocity.

ALCOR is a unique C-band radar with simultaneous dual skin and beacon tracking capability. In the skin track mode, ALCOR utilizes a 500-megahertz bandwidth pulse to achieve 50 centimeter resolution, providing precision metrics, high-quality signature data target motion analysis, event characterization, and target object imaging. ALCOR also has a tracking subsystem that is used to acquire beacon-equipped targets at long ranges. The beacon subsystem has provision for storing four independent sets of beacon parameters, allowing the radar to switch tracks between beacon-bearing vehicles in seconds. Objects under beacon track can be switched directly to skin mode when Signal-to-Noise ratio is adequate. The radar is capable of simultaneous range and angle track on two targets in beacon or skin mode.

ALCOR also serves as primary weather measurement radar for RTSite. Radar Cross Section data recorded following mission activities can be converted to cloud moisture content, thus providing a measure of the weather severity encountered by a reentry vehicle. A weather analysis mode provides Plan Position Indicator and Range-Height Intensity type presentation of radar cross-section returns from moisture concentrations in the atmosphere.



A.5.5.1.4 MMW

The Millimeter Wave Radar (MMW) is a dual frequency (Ka- and W-Band) monopulse tracking radar, characterized by high range and Doppler resolution, high sensitivity, precise pointing and tracking, waveform flexibility, and a high degree of computer control for real-time operation and signal processing. The MMW, at 35 and 95 GHz, is one of the most sophisticated instruments in the world. With a high-precision antenna that provides 70 dB of gain and 2-GHz bandwidth, MMW produces object resolution down to 12.5 cm. MMW utilizes a state-of-the-art dual optical beam waveguide, advanced digital receiver and processing at 2,000 pulses per second to collect precision metrics, body microdynamics, detailed event characterization, and exceptional high-resolution imaging to meet TMD and Space Surveillance requirements. The MMW has a signal bandwidth of 2 GHz yielding a range resolution of 0.014 meters. The Doppler resolution at 35 GHz is 0.214 m/sec. The recording window is 37.5 meters. A larger recording window is available by reducing the pulse bandwidth to 1000 MHz or 500 MHz. For targets that do not require signature waveforms, narrowband pulses of 6 and 12 MHz bandwidth are available.

A.5.5.1.5 MPS-36

There are two MPS-36 C-band general-purpose instrumentation radars located on Kwajalein Island. The systems are fully digitized and have recently been upgraded to full monopulse operation. While ordinarily used for beacon tracking, the radars have the ability to skin track appropriate targets. These instruments provide accurate beacon tracking for both real-

time directing data and post-mission trajectory reconstruction.

A.5.5.2 Optics

Ground based optics at RTS include tracking instruments, ballistic cameras, spectral cameras, and documentary photography systems. Four optics sites around the atoll provide outstanding geometry for the triangulation required for precise trajectory reconstruction, accurate kill assessment, and miss distance estimation to less than 25 cm.

Two Recording Automation Digital Optical Tracker (RADOT) and five Super-RADOT sites at RTS provide a variety of cameras and lenses including video, MWIR, 35 mm and 70 mm motion picture cameras with aperture up to 24 in and focal lengths from 100 to 240 in. Film rates range from 90 to 2,500 frames per second. The extremely agile mounts support mission data collection requirements with slew rates of 60 degrees per second. The high sensitivity and resolution of these optical sensors provide both exo- and endo-atmospheric metric data collection.

A.5.5.3 Scoring. The RTS Missile Impact Scoring System (KMISS) is an array of 10 hydrophones located on the ocean floor in the broad ocean area about 7 nmi east of Gagan Island. The hydrophones lie at depths ranging from 5,000 to 12,000 feet and detect reentry vehicle impacts in all weather conditions. For those objects that impact within the array, the KMISS accuracy is 18 feet (rms) in position and 1 msec in time. RTS provides our nation's only site for conducting ICBM land impacts tests. Illeginni Island is used for land impacts, and post-mission NIMA surveys of the impact area are performed to deliver the impact point. For users requiring recovery of debris for analysis, RTS maintains a submersible vehicle for location of debris within the Kwajalein lagoon and subsequent recovery by a resident dive team.

A.5.5.4 RTS Mission Support. Reliable reception, recording, and processing of telemetered flight data is a critical component of RTS mission support. RTS telemetry sites at Kwajalein, Roi-Namur and Gagan islands include nine autotracking and three fixed antennas configured with multiple receivers and recorders. RTS supports the full IRIG standard frequency range of 1,700–2,400 megahertz for telemetry streams of up to 30 megabits per second, and NRZL and bi-phase capability up to 15 megabits per second. Real-time processing and retransmission of telemetry data are used for RTS Range Safety support functions, in-flight vehicle monitoring, and interceptor targeting. All antennas

have been modernized with a modern antenna control unit to reduce maintenance, to increase automation, and to enable remote operation.

A.5.5.5 RTS Mission Control. KMCC, the RTS Mission Control Center, provides central command, control, communications, and computing essential for directing the real-time data collection efforts of the RTS sensors. A high-bandwidth submarine fiber optic transmission system provides an encrypted connectivity between KMCC and the entire range complex. KMCC processes real-time state vector data from radar tracks using target complex processing algorithms to provide multi-sensor fused cueing data for each sensor. With its exceptional computational capabilities, KMCC is able to distribute real-time data to land, sea, or airborne mobile sensors deployed to support testing at RTS, as well as to CONUS-based test beds and simulation centers via satellite link.

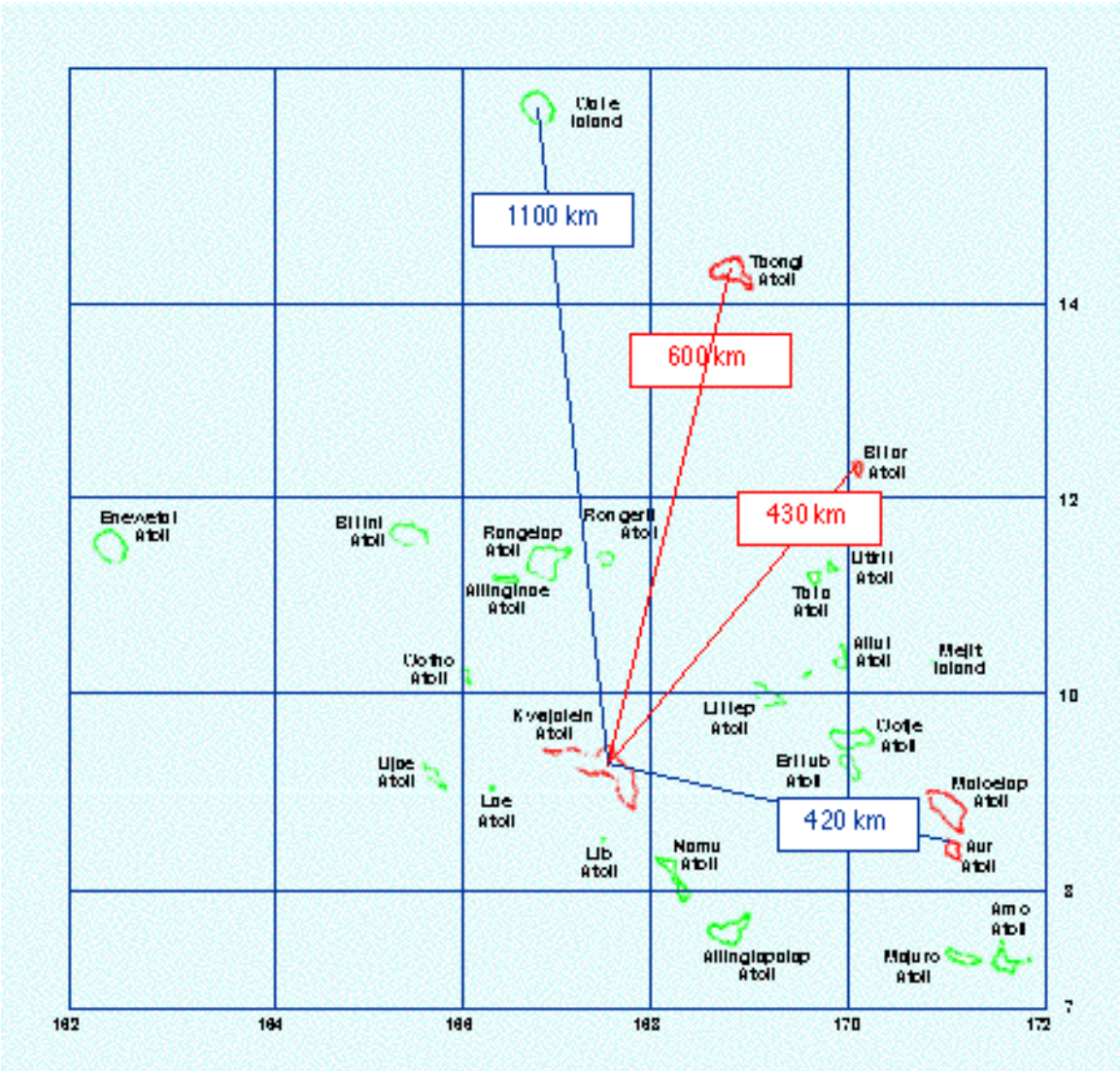
A.5.5.6 Space Operations and Space Object Imaging (SOI)

RTS is part of the Space Surveillance Network (SSN) and provides more than 32,000 observations per year for updating the near-earth and deep-space object catalog. RTS responds to 15 minute on-call tasking for the tracking of approximately 50 commercial and military new foreign launches (NFL) and provides more than 200 radar images of high interest satellites. RTS maintains a range readiness and availability rate at 98 to 99 percent.

A.5.5.7 Launch Facilities

Prior to the United States' withdrawal from the ABM Treaty, RTS possessed the only treaty-approved and operational strategic launch site at Meck Island. RTS provides a full range of instrumentation for collecting intercept data for TMD target ranges of 30–500 km, 1,000 km, and 3,000 km.

The map below illustrates relative locations and ranges of target launch sites at Wake Island and Aur Atoll as well as other sites available for test activities. The Wake Island target launch facilities includes one 50K launcher, a stool launcher for HERA, missile



storage and building facilities. The Wake Island facilities are being upgraded to support multiple simultaneous engagement tests of Theater Ballistic Missile interceptors. The Aur Atoll launch facility is a minimally improved site suitable for tactical launch systems that do not require significant infrastructure. Roi-Namur Island launch facilities include two 20K sounding rocket launchers suitable for sub-scale target and penaid studies. Kwajalein Island has a 5K sounding rocket launcher used primarily for meteorological soundings.

A.5.5.8 Flight Safety – USNS Worthy

RTS maintains a fully redundant flight safety system with remote command destruct transmitters for contingency actions. Planned modernization to the Range Safety Control Center (RSCC) includes a higher level architecture design to support multiple simultaneous engagement (MSE) scenarios.

The Kwajalein Mobile Range Safety System (KMRSS) is a key component of range safety. The KMRSS is hosted on the TAGOS class USNS Worthy. The superstructure of the Worthy was modified to support redundant telemetry antennas. Existing instrumentation compartments provide housing for the telemetry equipment along with the decommutation equipment necessary to provide Flight Safety officers with visual presentation from which to assess missile performance. Each telemetry antenna supports both the S band receiving gear and the

UHF Flight Termination System transmitting antenna. The Worthy also has some capability to support billeting for operations at remote launch sites.

A.6 WHITE SANDS MISSILE RANGE (WSMR)

A.6.1 Mission

The U.S. Army White Sands Missile Range provides test, evaluation, research, assessment, and other technical services to the acquisition programs of the Army, Navy, Air Force, DoD, other government agencies, US companies, and foreign allies.

A.6.2 Location

The WSMR is located in south-central New Mexico. The headquarters area, in the southwest corner of the range, is located 43 miles north of El Paso, Texas, and 25 miles northeast of Las Cruces, New Mexico. The Range is approximately rectangular, about 40 miles east to west and 100 miles south to north, covering approximately 3200 sq miles. Lease/partnering agreements expand the Range to 7100 sq miles when required. Additional WSMR related launch areas are located at McGregor Range in Fort Bliss, TX, and Fort Wingate in northwestern New Mexico. These launch complexes provide support for overland missile flight trajectories of well over 300 kilometers/200 miles.

A.6.3 Features

Most of WSMR is located in the Tularosa Basin, which is bound on four sides by mountains: on the southwest by the Organs, on the northwest by the San Andres, on the north by the Oscuras, and on the east by the Sacramentos. These mountains range in elevation from 5,000 to 12,000 feet and consist of stony sands, clay, and variable bedrock. The Tularosa Basin is generally referred to as a desert, however, this area is more of a semi-arid grassland than a true desert. The basin floor has an average elevation of 4,000 ft msl. Soil in the central portion of the Tularosa Basin is primarily composed of white gypsum sand. WSMR protects the world's largest surface deposit (223 sq miles) of gypsum. An ebony lava flow covering 120 sq miles stretches from the northeast corner of the park.

A.6.3.1 Climatic Features. The semi-arid range offers visibility greater than 6 miles an average of 343 days per year. WSMR climatic annual mean values are: temperatures of max-mean-min are 78-62-46°F, relative humidity is 36%, precipitation is 11.9 in; snowfall is 6.5 in, and average wind velocity is 4.7 mph, with max gusts of over 100 mph being recorded.

A.6.4 Open Air Range

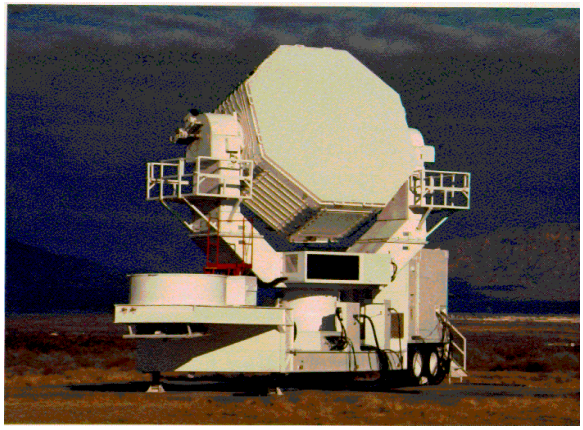
WSMR has full-time control of its air space, which greatly facilitates testing. The all-overland test range also facilitates recovery of test items, an important aspect of postmortem analysis. The range consists of a network of roads (743 mi paved, 1205 unpaved, which is 9.5 percent of all Continental US Army roads), communication facilities, a precisely surveyed coordinate grid system with over 3000 precisely surveyed

instrumentation sites, launch sites, control bunkers, impact areas, extensive instrumentation systems, data processing facilities, and display facilities.

WSMR has facilities to store ordnance and propellants, assemble missile systems, provide target support, and launch missiles and drones. The Range also provides ground and flight safety, impact location, recovery support, and explosive ordnance disposal.

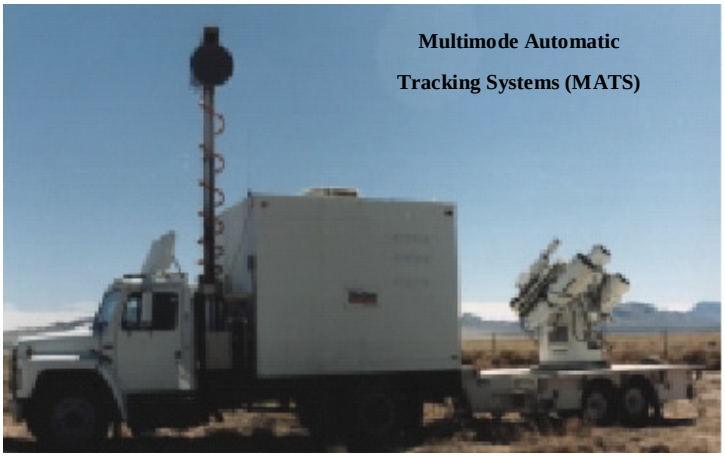
A.6.4.1 Range Instrumentation

Range instrumentation systems include radar, optics, GPS (Global Positioning System), interferometers, telemetry, and meteorological. These systems provide the range's data collection capability. Special instrumentation support is also available.



Radar support includes instrumentation, air surveillance, and an unambiguous Weibel Doppler tracking radars. Picture to the left is a AN/MPS-39 Multiple Object Tracking Radar (MOTR). It is the workhorse instrumentation radar at WSMR. There are two; each provides tracking for up to 40 objects simultaneously over a 60-degree field of view without loss of tracking accuracy. The phased array antenna is located on a standard elevation over azimuth servo-controlled mount so that full hemispheric coverage is possible.

A.6.4.2 Optics Instrumentation



The optics instrumentation system consists of Launch Area Theodolite Systems (LATS), Multimode Automatic Tracking System (MATS) Kiento Tracking Mounts (KTM), Remote Versatile Tracking Mounts (RVTM), Aided Laser Tracking System (ALTS), Distant Object Altitude Measurements System (DOAMS), as well as fixed film and video arrays, and closed circuit television. Data collection cameras can operate at frame rates from 20 to 20,000 frames per second, depending on film size.

A.6.4.3 Telemetry Systems. The telemetry systems are a mixture of fixed and mobile facilities located at optimum sites for mission support. The received telemetry signals are relayed to the Telemetry Data Center (TDC) in the Cox Range Control Center. Special purpose vans are also used for receiving and recording telemetry data in support of range customer requirements. The telemetry systems can receive, record, demultiplex, and format to IRIG 106 Telemetry standards.

A.6.4.4 GPS Systems. GPS is rapidly becoming the system of choice or necessity for many Range users. This list continues to grow and is likely to include use of metric receiver, translator or integrated GPS-inertial platform information as a real-time or post-test measure of vehicle performance. The Range has the capability to process a variety of GPS-based systems including receipt of S-, L-, and C-Band downlink and decommutation of a variety of formatted information including asynchronous, non-IRIG and standard synchronous IRIG formats. The Range also has resources to uplink differential GPS from accurately surveyed reference receivers placed at strategic locations on the Range.

A.6.4.5 Meteorological Systems. The meteorological support consists of state-of-the-art meteorological modeling, instrumentation, and data collection in a data rich range environment. This environment enables tailored weather forecasting and warnings, predictions of impact and points in space, detailed technical reports, and determination of atmospheric effects on materiel. Some specialized products and services available are lightning advisories and watches, surface and upper atmospheric observations, planning and advising for customer's test requirements. Mobile capability includes upper air measuring systems, atmospheric profilers, surface mesonet, wind finding radars, SODAR, fully instrumented towers integrated with a high resolution (1.9 miles) weather model, Thunderstorm Auto-Nowcaster, satellite imagery, and integrated displays.

A.6.4.6 Cox Range Control Center The range instrumentation acquires and tracks objects in flight to provide data for computing position, velocity, acceleration, attitude, events, trajectory, intercept, miss distance, pitch, yaw, roll, and object internal measurements. The timing that is generated and distributed throughout the range correlates data. The new range control center called the Cox Range Control Center (CRCC), receives data from the range instrumentation, and processes and displays the data in real-time for project mission support, flight safety, and range control. The CRCC is a digital facility designed to meet current and future mission requirements and contains the latest in backbone network design and functionality for the range customer. The CRCC contains all functions related to open air range testing to include real time data processing, Air Space Surveillance, Data Control Facility, optics, radar, telemetry, Drone Formation Control System, timing, Video Relay Facility, real time software development, range scheduling, and the Test Support Network Operations Center.

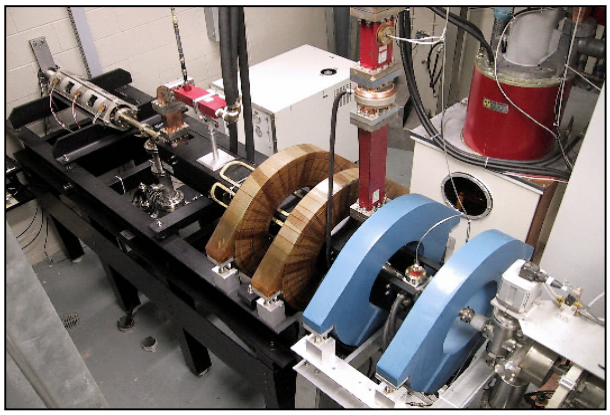
A.6.4.7 The Data Reduction Facility (DRF). DRF provides post-test optical and electronic data conversion and processing. The facility uses film and video measurement equipment, computers, and interactive graphic displays for performing data analysis.

DRF personnel use specialized data processing techniques, software, and analytical expertise to produce a wide variety of high-quality data products. The advanced capabilities of the DRF enable WSMR to provide highly accurate Time Space Position Information attitude, miss distance, event recognition, best estimate of trajectory, and cubic spline trajectory data. State-of-the-art Target Motion Resolution (TMR) techniques process highly accurate range, range rate, and range acceleration data from coherent radars to measure spin, precession, nutation, and events such as stage separations. The DRF can deliver data products in any number of configurations and media types.

A.6.5 Facilities

WSMR operates facilities that provide a full spectrum of battlefield environments for testing such as nuclear, electromagnetic, directed energy, climatic, shock and vibration, upper atmosphere, transportation, static electricity, and electronic or optical countermeasures. Mobile equipment is available to combine multiple climatic, dynamic, and electromagnetic testing of materiel to support remote test sites. Computer-simulated testing of weapon systems can be performed before actual firings are accomplished. Other work conducted at WSMR involves development and acquisition of range instrumentation systems for WSMR as well as other test centers and the other services. The following is a description of some WSMR facilities.

A.6.5.1 Nuclear Effects Test Facility. This facility maintains the capability and has the facilities to produce the full range of tactical, nuclear, endo-atmospheric environments, plus the capability for some exo-atmospheric environments. The Fast Burst Reactor (FBR) provides initial nuclear radiation (INR) neutron environments; the Linear Electron Accelerator (LINAC) shown to the left and the Relativistic Electron Beam Accelerator (REBA) produce INR dose rate environments; and the Gamma Radiation Facility (GRF), and Eldorado generate INR total dose environments. For non-ionizing environments, WSMR operates three electromagnetic pulse (EMP) simulator facilities (two fixed site and one mobile pulse generator).



A.6.5.2 Semiconductor Test Laboratory (STL). STL through a complete array of test equipment, is able to test and evaluate virtually any semiconductor component or piece-part in the military's inventory. The specific purposes of the STL include the verification of complex software survivability models, the determination and documentation of large variations in semiconductor device responses to various nuclear environments, and the tracking and documentation of changes in the manufacturing processes of various semiconductor devices used by the military.

A.6.5.3 Radiation Tolerance Assured Supply and Support Center (RTASSC). RTASSC and the Radiation Tolerance Assured (RTA) Program assist military and space programs in the certification, procurement, testing and storage of hard-to-find Radiation Tolerant (RT) electronic piece-parts. The RTASSC, through its partnerships with electronic device manufactures and others, provides: availability of certified RT devices during design, production, maintenance, and sustainment; options for insertion of newer technologies; and use of Commercial-Off-the-Shelf/Non-Developmental Items for RT designs.

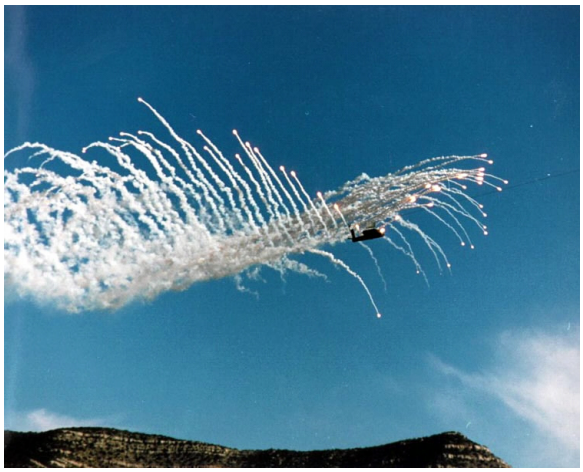
A.6.5.4 Electromagnetic Radiation Effects (EMRE). The EMRF site provides a complete arsenal of electromagnetic effects test facilities including electromagnetic radiation (EMR), electromagnetic interference (EMI) and electrostatic discharge (ESD). EMR testing falls into two categories: Electromagnetic Radiation Operational , which ensures that the test system will operate properly in an EM field; and Electromagnetic Radiation Hazards (EMRH) where the susceptibility of the test system's ordnance is determined. EMR testing uses eight transmitters capable of producing vertically and horizontally polarized EM fields at levels up to 200V/m. EMI is the process of measuring the electromagnetic emissions from a system under test. EMRE uses two facilities for this purpose. The first is a 16'x 20'x 8' anechoic chamber for testing small items. The second is a 50'x 40'x 40' shielded test cell for large items. Electrostatic discharge testing determines the susceptibility of the electronics on a system under test to static electricity. The EMRE site provides two levels of ESD testing. The first is the personnel level (25,000 VDC) testing using a hand-held portable ESD simulator. The second is the helicopter static charge standard (up to 300,000 VDC) generated by a high voltage capacitor bank

A.6.5.5 High-Energy Laser Systems Test Facility (HELSTF). HELSTF was established to conduct Army, Air Force, Navy, and other DoD High-Energy Laser (HEL) test programs and is operated by the Space and Missile Defense Command. HELSTF is the primary DoD facility for conducting HEL tests including damage and vulnerability, component and subsystem, integrated system verification and full-scale lethality demonstrations. Housed in test cell one is the Navy's Mid-Infrared Advanced Chemical Laser (MIRACL), which is the most powerful, continuous-wave laser in DoD. A large vacuum chamber is present to conduct damage and vulnerability effects testing in a space vacuum environment. Also at the site is the transportable Pulsed Laser Vulnerability Test System (PLVTS). This WSMR system is the highest energy pulsed CO_2 laser in the United States. (see additional information in section 5.4)

A.6.5.6 Temperature Test Facilities A number of hot and cold test chambers are available. These chambers include both fixed-site chambers and portable chambers. The fixed-site test facilities include a large chamber measuring 105’ x 40’ x 50’ and a small chamber measuring 35’ x 30’ x 20’. The temperature ranges from -80° F to +180° F in these chambers, with icing or freezing rain provisions as required. The Salt Fog/Humidity Chamber, measuring 20’ x 15’ x 21’, can also support high temperature tests. These chambers are rated for both hazardous and non-hazardous testing. The portable test facilities include two trailer mounted shrouds that measure 25' x 9' x 6' with humidity and temperature shock testing capabilities as required. Two other shrouds with humidity testing capability measure 16' x 9' x 10'. All four shrouds have a temperature capability of -65°F to + 180°F.

A.6.5.7 Dynamic Test Facility. Dynamic Test Facility is approved for hazardous testing and consists of electrodynamics and electro-hydraulics areas. The electrodynamics area includes three bays. One bay has four 18,000 lbf exciters, which can be configured in push-push or push-pull arrangements. Up to eight exciters can be

controlled simultaneously with the Multi-Axis Vibration Control System. A second bay contains the 3-D Exciter System. This system is capable of motion in three axes simultaneously with an output of 1000 lbf or it can be used as an 18,000 lbf single- axis system. The third bay is dedicated to shock testing with 60" x 60" and 12" x 12" machines.



A.6.5.8 Hazardous Test Area (HTA). HTA has facilities for assessing and evaluating warheads and explosive devices, determining the hazards associated with the handling and transportation of explosive materials. Ground safety tests involve a variety of experiments such as Drop Tests (up to 40 ft), including live multi-cargo warheads and rocket motors, detonation propagation tests of small to large explosive items, slow cook-off tests, and fast cook-off tests using JP-4, diesel, or wood. Special tests are also performed, including insensitive munitions tests, bullet impact tests, and warhead arena tests for pattern distribution, density, velocity, blast overpressure, fragment size, and weight.

A.6.5.9 Aerial Cable Range (ACR). ACR is located in the north central area of the range. The three-mile long cable is suspended between two mountain peaks and is the longest unsupported cable span in the world. The cable, which can support up to 20,000 lbs, serves as a path for captive vehicles. These vehicles can be accelerated by gravity or rocket at controlled speeds of up to 150 knots for gravity accelerated items and up to 250 knots for the rocket assisted items. Altitudes can be varied from 100 to 1000 feet above ground level. The ACR is used for the testing of weapon systems and weapon systems components. Typical types of tests include short-range air defense systems, aircraft stores certification, captive flight testing, drop/separation testing, and sensor performance validation.

A.7 YUMA PROVING GROUND (YPG)

A.7.1 Mission

The U.S. Army Yuma Proving Ground is the headquarters of the Yuma Test Center (YTC), Cold Regions Test Center (CRTC) and Tropic Regions Test Center (CRTC). USAYPG is a multi-purpose Proving Ground providing engineering, test and support services to materiel developers to support development of military equipment. Its primary focus is planning, execution, and reporting for development and production testing of artillery, direct fire weapons, automotive and combat systems, aviation and air delivery systems, mines and countermines, UXO systems, and soldier equipment. YPG is the Army's center of excellence for natural environment testing (desert, artic, and tropic) testing of all types of military equipment including Soldier's clothing and personal equipment. Natural environment desert testing is conducted at Yuma Test Center, cold regions testing is conducted at the Cold Regions Test Center, and tropic regions testing is conducted by the Tropic Regions Test Center. YPG is committed to integrating DT and OT testing, and hosts military training units from the Joint services. YPG is home to the Joint Military Free-Fall School and is the Winter training base for the Army's Golden Knights Parachute Team. .

A.7.2 Location

Yuma Proving Ground is located in southwestern Arizona on the Colorado River. It is 23 mi northeast of the city of Yuma, between Interstate Highways I-8 and I-10. It is 180 mi west of Phoenix, AZ, and 180 mi east of San Diego, CA. The Proving Ground is bordered almost entirely by federal and state land, and experiences no encroachment, noise, or safety problems relating to the local area. YTC is located at Yuma Proving Ground, with auxiliary test sites in the surrounding low desert and mountain areas. CRTC is currently headquartered at Fort Wainwright, Alaska, with test facilities located at Fort Greely and the Bolio Lake test sites. TRTC is headquartered at YPG, with test sites in Panama, Hawaii, and Honduras.

A.7.3 Features

A.7.3.1 Topography. The Yuma Proving Ground Yuma Test Center (YTC) is located in the Sonoran Desert, which is a close analog to the deserts of the Middle East. The Yuma Proving Ground Cold Regions Test Center (CRTC) is located in the interior of Alaska and is sited on the edge of the "cold triangle", an area experiencing extended periods of cold and extreme cold temperatures. The Yuma Proving Ground Tropic Regions Test Center (TRTC) tests in different areas in Hawaii, the Republic of Panama, and Honduras, according to the test requirements.

A.7.3.2 Climatic. The climate at YPG provides virtually continuous dry, fair weather with clear air (unlimited ceiling and visibility). There is very little rain, averaging only

3.76 inches (9.5 cm) per year. The climate of CRTC ranges from temperate from May through September to varying degrees of coldness and moisture. The climate of TRTC ranges from near temperate exposure and Soldier system test sites in Hawaii to deep, humid tropic conditions in Panama and Honduras.

A.7.4 Facilities

A.7.4.1 Yuma Test Center. Yuma Test Center is comprised of the KOFA Firing Range, the Cibola Aviation Range, Yuma Proving Ground Garrison, various training areas, and the Materiel Test Area.

A.7.4.1.1 Mission

Testing long range cannon artillery delivered munitions including smart, intelligent, and brilliant munitions, direct fire munitions, mines and countermine systems, tactical vehicles, tanks and tank armaments, aviation systems, aircraft weapons and fire control systems, airborne and ground target acquisition systems (optical, IR, MMW Radar), Unmanned Aerial Vehicles, air delivery systems (parachutes) and air delivery techniques. Desert Natural Environment testing for all types of military equipment including soldier's clothing and personal equipment. Supporting Soldiers and DoD through rapid testing and experimentation for systems used in the Global War on Terrorism.

A.7.4.1.2 Location

YTC is located in southwestern Arizona on the Colorado River. It is 23 mi northeast of the city of Yuma, between Interstate Highways I-8 and I-10. It is 180 mi west of Phoenix, AZ, and 180 mi east of San Diego, CA. The Proving Ground is bordered almost entirely by federal and state land, and experiences no encroachment, noise, or safety problems relating to the local area. Additional test areas in the Imperial Sand Dunes, Senator’s Wash Reservoir, the Mojave Desert, and Oatman Arizona are used for mobility testing.

A.7.4.1.3 Features

A.7.4.1.3.1 Topography. YTC comprises 1,300 sq mi of the Sonoran Desert, which is a close analog to the deserts of the Middle East. The topography includes open, flat desert; rocky hills and mountains, and different types of sand and dust.

A.7.4.1.3.2 Climatic Features. The climate at YTC provides virtually continuous dry, fair weather with clear air (unlimited ceiling and visibility).

A.7.4.1.3.3 Terrain Features. YTC is located at an average ground elevation of 300 ft above mean sea level; its terrain is largely flat areas broken by small desert washes. Thirty percent of the area is bare, steep bedrock mountain blocks with elevations to 2,800

ft. The vegetation is sparse desert shrub with some fairly heavy growth in some wash areas. YTC is essentially unaffected by environmental, endangered species, or archeological impediments to test operations.

A.7.4.1.4 Facilities

A.7.4.1.4.1 Mine Test Facility. YTC mine testing capabilities include projectile-delivered mines, specially prepared impact areas, and the Mines, Countermine, and Demolition Test Complex which includes several facilities: (1) The Open Field Test Facility, which consists of two mine fields, each with four test cells (segregated from each other to enable unprotected personnel to work on one field while live mines are expelled on the other), instrumented with video and acoustic arrays to record mine delivery and function characteristics, a 4-bay ammunition conditioning and handling area with overhead protection, and a centralized facility control building, and (2) the Chambered Cell Test Facility, including 30 concrete-lined mine test chambers with steel inner-structures which allow testers to deposit a test mine, close the chamber, initiate mine functioning through either magnetic or disturbance mechanisms, then evaluate function and lethality. The facility is supported by a 4-bay ammunition conditioning and handling area with overhead protection; and (3) The Smart Weapons Test Range (SWTR) developed to test programmable mine systems.

A.7.4.1.4.2 Artillery Maintenance and Inspection Facility. YTC's Maintenance Facility offers the capabilities to perform all levels of maintenance, from user to depot, on tanks, howitzers (both towed and self propelled), and other fighting vehicles. Collocated with the maintenance facility are capabilities for gun tube inspection and measurement for determining wear, erosion, and internal flaws; non-destructive tests such as radiography, eddy current ultrasonic, magnetic particle, dye penetrant, and fluorescent penetrant inspection for the purpose of flaw detection, determination of physical integrity, and parts positioning; and a fully equipped machine and metal working shop for repair and fabrication. These facilities permit expedited RAM and Integrated Logistics Support (ILS) testing.

A.7.4.1.4.3 Tank-Automotive Test Courses. YTC's extensive Vehicle Testing capabilities include over 200 mi of improved and cross-country durability and mobility courses. Test courses available include paved, improved secondary, and cross country plus four hill courses of varying severity, soft sand, mud, etc. During the past two years, a series of Tire Test Courses, designed specifically to test according to Society of Automotive Engineers (SAE) requirements, have been constructed. These courses are augmented by various MIL-STD performance and handling safety test courses (standard obstacles, 10–40 percent side slopes, 5–60 percent vertical slopes, evasive maneuver and brake test areas), and a 2.5 mi paved Dynamometer Test Course with turn-around loops and a nearly level surface that allows continuous loading of all types of vehicles for evaluation of full-load cooling performance. Additional combat systems test capabilities include a variety of mobility slopes, water fording, and swimming test sites. Other unusual courses available include a Dust Course, the Middle East course, and a Sand Dynamometer course.

A.7.4.1.4.4 Tank-Automotive Maintenance Complex. Vehicle test capabilities are supported by an extensive failure and materials analysis capability, a 90,000-sq-ft maintenance shop with one 40-ton and three 10-ton overhead crane, a 10,000-sq-ft maintenance shop with a 20-ton overhead crane, and a 9,000-sq-ft operations staging area with sensitive items storage, wash rack, 240,000-lb capacity scale, and high-speed refueling facility. A complete welding and machine shop is located near the maintenance shops. A unique tire x-ray capability is also available.

A.7.4.1.4.5 Laguna Army Airfield and Castle Dome Heliport. Laguna Army Airfield (LAAF) provides two runways, one at 5,300 by 150 ft and the other at 6,000 ft by 100 ft, capable of receiving aircraft up to C-5/C-17/C-141, with ramps, hangar, approved aircraft wash facilities, fire and crash rescue, 64,000 gallon fuel storage capacity, hazardous waste disposal, secure indoor and outdoor sensitive item storage, laboratory, and office space dedicated to Cibola Range customers. Another aviation facility, Castle Dome Heliport (CDH), located about nine miles north of LAAF on US Highway 95, is available for special or large helicopter test programs. CDH offers helicopter and Unmanned Aerial Vehicle (UAV) testers a dedicated facility that includes 22,000 sq ft of hangar space and 8,000 sq ft of office space in one building.

A.7.4.1.4.6 Air Delivery Complex. The recently completed Paul R. Reeder Air Cargo Complex became operational in April 1992. This new air cargo test preparation complex enables preparation of loads, maintenance, parachute packing, and air transport rigging. This facility is the best of its type and includes the following facilities: (1) Parachute Pack, Parachute maintenance, and Airdrop Rigging Facility, 43,000 sq ft of interior space including: (a) engineering and operations office space, (b) a 50-ft by 200-ft maintenance bay capable of repair and fabrication of all currently used fabric-type air items with secure and segregated general storage, (c) a 40-ft by 200-ft parachute pack bay with additional segregated storage for general supplies and parachutes, (d) an environmentally controlled drying tower capable of handling the largest parachutes now under development, (e) segregated storage for life support equipment and non-standard test items, a 80-ft by 200-ft airdrop rigging bay with an 80,000-lb bridge crane, a wood shop, honeycomb storage, and general supply, and (f) a 40-ton bridge crane with a 35-ft hook height, (2) Ammunition Handling Facility used to rig explosive and hazardous items encompassing 5,000 sq ft of interior space certified for holding 5,000 lb Net Explosive Weight (NEW) and including: (a) Office space and storage behind a blast wall (b) ammunition receiving and holding room, (c) rigging bay with a 10,000-lb bridge crane, and (d) full Intrusion Detection System (IDS) security, and (3) External Facilities including (a) 48,000 sq ft dedicated aircraft ramp capable of simultaneously parking two C-141 or C-17 aircraft, (b) 100,000-pound capacity truck scale located between the rigging facilities and the aircraft ramp, (c) both secure and open outside storage yards, and (d) a 42,000-pound capacity aircraft loader.

A.7.4.1.4.7 Climatic Firing Chamber. A large, drive-in environmental firing chamber is located on the KOFA Range that will allow full-up firing of large artillery weapons (up to 8-inch) at various elevations (more than 60°) while being subjected to high or low

extreme temperatures and humidity. It can accommodate a helicopter (w/o engine running). Temperature range of the chamber is -60 to 160°F and humidity range is 5 percent to 100 percent in the 60 to 145°F range.

A.7.4.1.4.8 X-ray Facility. The Radiographic Facility has both static (film based) and real-time x-ray evaluation capabilities. A Philips 420KV x-ray Generator and a Varian Linatron 2000A linear accelerator provide the capability to inspect all sizes of ammunition and rocket motors up to Navy 16 inch projectiles. Robotic systems allow remote manipulation of test items and automated movement of projectiles through the facility.

A.7.4.1.4.9 Environmental Test Facilities. Environmental test facilities for ammunition testing include three vibration tables of 30,000 lb force that are unrestricted as to HE quantities. Climatic simulation chambers are available for producing the conditioning extremes of MIL-STD-810 and International Test Operating Procedures (ITOP) requirements. Two environmental test chambers are available for conducting testing of vehicles over a temperature range of -60°F to 160°F. The smaller chamber provides the capability of firing Combat Vehicle mounted weapons up to 40mm. The large chamber provides the capability of firing all calibers of Combat Vehicle Mounted Weapons. A variety of portable chambers, that can be positioned at any site throughout YPG ranges, are available for performing MIL-STD 810 and ITOP requirements for safety certification of ammunition. The Saguaro cactus characterizes the harsh desert environment of YPG. This hardy plant thrives in an area that receives less than three inches of rain per year.

A.7.4.1.4.10 Materials and Chemical Analysis Labs. The Material Analysis Laboratory has extensive capabilities to analyze and identify composition of materials for testing and environmental evaluations. It is equipped to conduct analysis of oils, fuels lubricants, brake fluid, coolant and similar materials to determine metal wear; mineral and other contaminants; compliance with standards, and adequacy for performance testing. Other measurement capabilities include: viscosity, carbon residue, distillations and flash points. This lab provides on site engineering test and analysis of soils, dust, and particulates. Measurements of article sizing, concentrations of dust (air cleaner testing), and toxic fumes analysis (firing and exhaust) can be performed during vehicle and aircraft firing and performance tests. Analytical instrumentation includes: atomic absorption, inductively coupled plasma atomic emission, gas chromatography, x-ray diffraction, x-ray fluorescence, gas chromatograph-mass spectrometry and AOAP emission spectrometer.

A.7.4.1.4.11 Telemetry Facility. Telemetry (TM) services include FM/FM, PCM, Pulse Amplitude Modulation (PAM). MIL-STD-1553 multiplex bus capabilities include monitors and total bus transmission by way of encoders. Nine TM streams can be received simultaneously through three L and S-band autotrack antennas. The Telemetry Center has recording and processing capability and four channels can be simultaneously retransmitted to the Mission Control Center for data merging. Data received may be encrypted.

A.7.4.1.4.12 Video Facility. Video services include transmission and reception of 525- and 875-line video, and application of video cameras for both qualitative imaging and data collection. Encryption of the transmitted video is available. High-speed shuttered video is used when high time resolution is required. YPG has a complete video data reduction facility.

A.7.4.1.4.13 Mobile Dynamometer. YPG has a fleet of three, fully instrumented, mobile dynamometers. YTC's dynamometer fleet provides capabilities to test engine and power train performance under high temperature/high humidity conditions.

A.7.4.1.4.14 Mission Control and Real Time Data Center. The Mission Control Center (MCC) serves as the real-time data collection, processing, and display facility. Range data are received in the MCC, and instrument control, quality assurance, and test command and control are done there. The MCC provides three separate rooms for execution of three tests simultaneously. Each incorporates significant real-time computing capacity, high-resolution graphics displays, video screens and projectors, and complete communications with the range and test participants. The design of this facility allows flexibility in the presentation of data for real-time analysis of test events that permits project engineers and managers to make test program decisions with only minimal or no post test data review being needed.

A.7.4.1.5 Ranges

A.7.4.1.5.1 Cibola Aviation Test Range. Cibola Aviation Complex, supports Army helicopter armaments testing. A precision laser tracking network and telemetry instrumentation system makes Cibola Range a state of the art instrumented air vehicle testing range for helicopters, unmanned aerial vehicles and target drones, and some fixed wing aircraft. Laguna Army Airfield and Castle Dome Heliport provide the ground infrastructure to support air vehicle testing and a unique, austere, dirt airfield adds the capability to simulate combat environments in both the operational and technical testing arenas. These facilities, and proximity to supporting KOFA munitions facilities, enable a materiel

developer to conduct an entire attack helicopter test program at a single test site. The Castle Dome Complex, built before the Vietnam War as a western launch complex for aerial drone vehicles, has been refurbished to support testing for Army and Joint transformation systems. Networked data acquisition systems permit aviation systems level integrated testing and provide nearly instantaneous collection and reduction of TSPI data. A Navigation System Evaluation Range, a 15 km by 60 km instrumented range configured to provide real-time space position and event data of moving aerial and ground platforms, is available for the evaluation of navigation systems. The Rocket Alley Rocket firing range is used for ground testing of air and ground launched rockets. The Cibola Range also hosts the Military Free Fall School's training mission on its drop zones. Joint testing and training missions are supported through purpose-developed training complexes and using the free-fire capabilities of Prospect Square to support live-fire air-to-ground and ground-to-ground missions.

A.7.4.1.5.2 KOFA Artillery Range. With unlimited airspace and ranges out to 75 km, the geography of KOFA Range allows a wide variety of munitions testing. The KOFA Artillery Complex is an integrated test capability for open air testing of U.S. and foreign tank, artillery, mortar, mine, and helicopter munitions and systems. An extensive testing infrastructure has been developed which is capable of meeting all military performance requirements for pre-testing test munitions and their delivery systems. YPG is the primary DOD test site for the electromagnetic gun. The recent transfer of the ammunition production acceptance mission from Jefferson Proving Ground to YPG consolidates most of the Army's munitions and weapons R&D and production testing into a single location. This consolidation establishes a munitions test capability, unique in DOD, that is leveraged by collocation of related test missions including air movement testing, tracked and wheeled vehicle testing, and aviation weapon systems testing. The ammunition inspection facility is capable of receiving, storing and preparing for testing all U.S. and foreign ammunition calibers. Non-destructive test facilities are collocated with the maintenance facility to expedite RAM and ILS testing. Specific test facilities and instrumentation include an environmental ground firing chamber for all sizes of ground vehicles and some helicopters, mobile climatic and dynamic environmental chambers and vibration systems, optical and electronic tracking systems (Radars, camera mounts, and cinetheodolites), more than 400 firing positions, and 13 improved impact fields for evaluation and recovery of bomblets from artillery and rockets. Advanced Artillery Systems testing on KOFA Range takes place from GP4227Z, which hosted the Crusader System and is now home to the developmental artillery systems and munitions supporting the Army Transition. Mortar ammunition development, production, and lot acceptance

testing is also conducted on KOFA Range. The Yuma Meterological Team provides meteorological support.

A.7.4.1.5.3 Direct Fire Ranges. YPG has extensive facilities for testing all types of direct fire weapons. Tank ammunition testing is conducted at KOFA Gun Position (GP) 15 and GP17A. These facilities are fully instrumented to acquire all types of internal and external ballistic data firing from fixed accuracy mounts. A dedicated range for Acceptance Testing of Tank Ammunition (HE and practice rounds) is being constructed as part of the JPG transfer. This Direct Fire Range (DFR) consists of a single gun position with three separate lines of fire, a hardened instrumentation building, a barricaded 3-bay ammunition handling area, communications tower, and access road.

A.7.4.1.5.4 Tank Accuracy Ranges. Combat Vehicle Systems, such as the ABRAMS tank, Bradley Fighting Vehicle, and USMC Light Armored Vehicles (LAV), can be tested at Kofa GP4 (three firing pads, targets to 4 km, firing-on-the-move courses), and at the GP20 Tank Accuracy Range (fully instrumented, direct fire to 6 km, "virtual" scoring targets for obtaining gun "jump," and capable of testing large caliber and small caliber systems simultaneously on adjacent lines of fire). GP20 is licensed by the Nuclear Regulatory Commission (NRC) for testing of Depleted Uranium (DU) munitions. Systems can be tested at the Cibola Direct Fire Range (moving targets with speeds up to 50 mph and gun-to-target distances of 4 km expandable to more than 10 km, with firing-on-the-move courses). There is a small-arms range with an Environmental Chamber capable of accommodating weapons up to 40mm, an adjacent 3 km accuracy range, and graze range (for evaluating the fuse sensitivity of small to medium caliber HE ammunition when impacting various surfaces). Red Bluff Firing Range is a purpose-built direct fire tank ammunition testing range that is fully instrumented using wireless technology and audio-scoring systems for real-time data collection.

A.7.4.1.5.5 Air Delivery Drop Zones. YTC maintains a variety of dedicated DZs, LZs, and EZs located on the Cibola Aviation Range. These include: (a) Eight drop zones (DZs) of which five are fully instrumented, one is a water drop zone and three are acceptable for high altitude drops; (b) one landing zone (LZ); (c) two fully instrumented extraction zones (EZs), and an unprepared runway/landing zone for testing tactical aviation.

A.7.4.1.5.6 Target Recognition Range. The Target Recognition Range, adds the capability to test and validate electro-optic target-acquisition systems, identify-friend-foe systems, and smart sensor systems in a realistic combat environment against a constant (virtually unchanging), baseline terrain.

A.7.4.1.5.7 Natural Environment Test Ranges. YTC's Desert Test capabilities contribute to making YPG the center for environmental testing of Department of Defense ground systems. The desert environment test capabilities include temperature and solar radiation effects, varying degrees of humidity throughout the year, and topographical and climatological conditions duplicating those of the world’s deserts.

A.7.4.2 Cold Regions Test Center. The Cold Regions Test Center is comprised of the headquarters and limited Soldier test sites at Fort Wainwright, AK, and the main test center located at the Bolio Lake test complex and ranges located at the Donnelly Training Area.

A.7.4.2.1 Mission

To plan, conduct, and report the results of cold regions, mountain, and northern environment phases of developmental testing and to provide advice and guidance on testing to materiel developers, materiel producers, sister services, and private industry.

A.7.4.2.2 Location

The Bolio Lake Test Complex is situated near Ft Greely, Alaska. It is situated in the Alaskan interior 100 miles South of Fairbanks, AK, and 80 miles North of the Alaska Range near the junction of the Delta and Tanana Rivers. The Bolio Lake Test Complex is the nucleus of CRTC's test operations. It is designed to provide administrative, shop, and limited billeting space for the test staff and assigned Soldiers or Marines.

A.7.4.2.3 Features

A.7.4.2.3.1 Topography. Cold Regions Test Center has priority of use on 670,000 acres of test ranges and facilities. The location is ideally suited for most testing purposes, with almost all forms of subarctic region environment available within 50 miles of the Bolio Lake Complex.

A.7.4.2.3.2 Climatic Features. The Bolio Lake Test Complex is located at the tip of the "cold triangle, one of the coldest areas on the North American continent. The average winter temperature is lower than 5 degrees F, with typical subarctic periods of several

days to several weeks' duration averaging below 0. Temperatures of -50 degrees F are experienced. Summer temperatures range from the 50s to the high 80s, with a wide range of precipitation.

A.7.4.2.3.3 Terrain Features. High, rugged mountains with glaciers and snow fields are to the South; Muskeg, tundra, and glacial stream beds are in the immediate area of the complex. Marine winter conditions are available 250 miles South of Bolio Lake at Valdez, which approximates the Scandinavian Maritime regions.

A.7.4.2.4 Facilities and Ranges. CRTC facilities and ranges include the High Explosive Range, Maintenance Shops with Heavy Lift Capability, Non-Destructive Test Capabilities, Ammunition Storage and Exposure Test Facilities, Mine/Countermine Test Area, Mobility Courses, Military Operations in Urban Terrain (MOUT) Facility, Numerous Direct and Indirect Firing Ranges, and a Cold Weather Automotive Test Course.

A.7.4.3 Tropic Regions Test Center. The Tropic Regions Test Course is headquartered at YPG and is comprised of exposure, mobility, manpack, and sensor test sites located in Hawaii, the Republic of Panama, and Honduras.

A.7.4.3.1 Mission

The Tropic Regions Test Center mission is to plan, conduct, and report on humid tropic tests of materiel systems to determine the effects of tropic environments on materiel and soldier performance and reliability. TRTC conducts materiel exposure and functional checks in natural tropic, marine, breakwater, coastal, inland-open, and jungle environments. TRTC documents problems related to material system performance and reliability and explains mechanisms of materials corrosion and deterioration.

A.7.4.3.2 Location

The Tropic Regions Test Center is a sub-command of the Yuma Proving Ground and is headquartered with its parent command in southwestern Arizona. TRTC test sites are located in the Republic of Panama, Honduras, Hawaii, and other tropic locations required by test customers. Its natural environment test sites in Hawaii include the marine exposure site at the Pacific Missile Firing Range, courses at Schofield Barracks, and test sites on Kauai. Test sites in Panama include high humidity/salt exposure sites near the Atlantic Coast, deep jungle test sites, and climatological exposure sites. Test sites in Honduras include deep jungle and manpack facilities. Formal coordination with the U.S. Embassy is required for tropic testing at Central America test sites.

A.7.4.3.3 Features

A.7.4.3.3.1 Topography. The topography of TRTC test sites varies widely from deep canopy jungle and swampy areas in Panama and Honduras to tropic and temperate savannahs in Hawaii and Panama. Due to the highly flexible nature of TRTC's operation, any desired topography can be located and made available for testing with prior coordination.

A.7.4.3.3.2 Climatic Features. The climate used in TRTC's testing varies widely with the type of test required. Natural environmental testing is available in all climates from humid tropic conditions to temperate weather. The following are typical figures for test sites in Panama and Honduras: Number of days per year of some precipitation: 275. Annual rainfall: 70 inches on the Pacific side of the Isthmus of Panama, 130 inches on the Caribbean side. Temperature: 70–90°F. Relative humidity: 75 percent (at higher temperatures) to 100 percent (at lower temperatures or within forests). Wind velocity: 4–30 mph.

A.7.4.3.4 Facilities

A.7.4.3.4.1 Mine Test Facilities. TRTC mine and countermine facilities are developed to test Joint Services mine detection equipment in tropic settings in Honduras and Hawaii. These mine facilities are augmented by the expertise, instrumentation, and engineering staff of the YTC Ground Combat Systems Mine and Countermine Division.

A.7.4.3.4.2 Manpack Test Courses. Manpack test courses are located at Schofield Barracks, HA and in Honduras. These courses are designed to test human and equipment interface and capabilities in the tropic environment.

A.7.4.3.4.3 Line of Sight Courses/Sensor Testing. TRTC tests both sensors and the Soldier's ability to operate with equipment in deep jungle environments. The combination of heat, humidity, darkness, and bio-mass interference with sensors, communications, and electronic equipment provide a daunting natural environment in which to test equipment capabilities.

A.7.4.3.4.4 Exposure and Corrosion Testing. Exposure and corrosion testing is currently done at the Ft Sherman test site in partnership with the Technical University of Panama. The Ft Sherman site offers one of the most corrosive salt spray and mist environments in the world.

A.7.4.3.4.5 Laboratory Test Facilities. Laboratory analysis is performed by the support contractor at facilities in the Republic of Panama and through the Technical University of Panama.

A.7.4.3.4.6 Vehicle Mobility Test Areas. TRTC has access through cooperation with the US Department of State and the Panamanian government to test vehicles in Panama. The unique soil and vegetation properties of these areas provide exceptional challenges to mobility and operation.

A.8 EGLIN AIR ARMAMENT CENTER (AAC)

A.8.1 Mission

AAC provides responsive and comprehensive test and evaluation services to support the system and/or component development of air-to-air weapons, guided and unguided air-to-surface weapons, surface-to-surface, and surface-to-air weapons; aircraft guns and ammunition, and aerial targets; electronic warfare (EW) air- and ground-based systems; radar, infrared and electro-optical signature determination; intrusion detection; high-speed simulation; command, control, communications, computers, and intelligence (C4I); and climatic simulation; and navigation/guidance systems.

AAC provides Development Test and Evaluation (DT&E) of non-nuclear air armament for the Air Force to include air/ground launched tactical and air defense missiles, guided weapons, non-nuclear munitions, aircraft guns and ammunition, and aerial targets. It also provides DT&E of electronic warfare (EW) systems and DT&E of C4I systems.

AAC provides support for operational training, Operational Test & Evaluation (OT&E) of armament, EW and C4I systems, and other activities conducted by operational commands. It also provides T&E of aerospace navigation and guidance components, systems, and aided systems, simulation of dynamic flight conditions using a supersonic test track, and radar cross-section measurements of full-scale and subscale targets, and operational support of multi-service, multi-national test aircraft staging out of Holloman AFB, New Mexico.

A.8.2 Location

AAC is located at Eglin AFB, seven miles northeast of Fort Walton Beach, Florida. The Eglin land range covers 724 square miles. The Gulf Test Facility, with 97,963 square miles, covers a large portion of the Gulf of Mexico. Total airspace available for Eglin use is 128,957 square miles. AAC is the parent organization to the 46th Test Wing (TW), which conducts the T&E mission at Eglin AFB. The 46 TW also manages test facilities located at Holloman AFB, New Mexico (supersonic test track, National Radar Cross Section Test Facility (NRTF), and Central Inertial Guidance Test Facility), and Wright Patterson Air Force Base (Aircraft Survivability Facility, Landing Gear Test Facility, Indoor Threat Research Facility, Aircraft Engine Nacelle Facility, Impact Ballistics Lab).

A.8.3 Features

A.8.3.1 Topography Land ranges are cleared and essentially level with some low rolling hills. The surrounding areas are heavily vegetated, with numerous swamps, lakes, and streams. Nineteen miles of Air Force-owned beachfront property provide a unique land-sea interface with contrasting background/clutter environment, which is especially useful for munitions seeker testing. It is the only DoD range with both a water and land range for weapons testing. Both air-to-air and air-to-surface weapon tests exploit this varied

topography, which provides a land clutter background, a land/sea interface, and the water background of the Gulf of Mexico. Elevation is sea level to approximately 100 feet.

A.8.3.2 Climate Varied, moderate, high humidity, and on the average: one day below 32°F and 364 days between 32 and 95°F. Five days below 30 percent relative humidity, 330 days between 30 and 80 percent, and 30 days above 80 percent relative humidity. Zero days when visibility is less than 1 mile all day, 7 days with visibility between 1 and 3 miles, and 358 days with visibility greater than 3 miles during part of the day.

A.8.3.3 Eglin Test Environment The 46th Test Wing responsibilities encompass the management and operation of a broad spectrum of resources to support the T&E mission. Central to these resources is the Eglin test complex, which provides a unique combination of numerous individual test areas, which are part of the Armament Systems Test Environment (ASTE). The test areas are equipped with precision instrumentation for data collection, a microwave system for data transfer, radio and land line communication networks, and a centralized mission control facility which provides flexibility for supporting diverse mission requirements. In addition, the Multispectral Test and Training Environment (MSTTE), a large complex of threat simulators supports the unique electronic warfare system testing requirements.

A.8.3.4 Eglin Adjacent Airspace The airspace around Eglin is military controlled over land (R-2914A/B, R-2915A/B/C, R-2918, R-2919A/B) and water ranges (W-151, W470, W-168, W-155, EWTA-1/-2/-3/-4/-5 and extensions) plus available military operating areas (MOAs) and other available warning areas. Supersonic areas are available over land and over water.

A.8.4 Facilities

A.8.4.1 Armament Systems Test Environment (ASTE) Consists of 724 square miles of varied, multi-environmental land area containing numerous test areas and systems/facilities for testing and evaluation of munitions and weapon systems. The major test areas are Air-to-Ground Ranges, Gunnery and Ballistics Test Facilities, Electro-optical/Millimeter Wave (MMW) Evaluation, Simulated Test Environment for Munitions (STEM) Facility, Static Warhead Test Arenas, Kinetic Energy Munitions Test Facility, and Security Systems Test Facility.

A.8.4.1.1 Facility Description: The mission of ASTE is to provide all the resources needed for conducting open-air test and evaluation of munitions and weapon systems. The ASTE includes 724 square miles of land ranges including B-70, 71, 75, C-72, 52A/C/N; 97,963 square miles of water ranges including the Gulf Test Facility; and all the support infrastructure required to fully support the entire spectrum of armament testing. Nineteen miles of AF-owned beach front property provides a unique land-sea interface with contrasting background/clutter environments, which is especially useful for munitions seeker testing. Military-controlled airspace exists over the entire land and water range complex. In addition, there are adjacent military operating areas (MOA), bringing the total airspace to 133,927 square miles, should a larger area be needed for

specific tests. Numerous simultaneous air-to-air, air-to-ground, and ground missions are controlled from a state-of-the-art Central Control Facility that also houses a real-time and post-mission data reduction facility. The capability to accomplish extensive integration testing, at both the component and systems levels, is available. An AAC Operations Security (OPSEC) program provides tools needed to achieve a secure test environment. Test/programming engineering provides a skilled cadre of personnel that plans, manages, and conducts development, test, and evaluation of weapon and electronic combat systems, and is responsible for data collection, analysis, and technical reports for program documentation. The ASTE provides a vast diversity in capabilities and terrain characteristics ranging from multi-canopied tropical forests to simulated desert areas with large exposed surfaces. Test Area (TA) B-70, established for high altitude and high speed (including supersonic) bombing and rocketry, is approximately 18 miles long, averages 1 1/4 miles wide, and is located approximately 15 miles northwest of Eglin Main. The B-70 complex provides the capability for air-to-ground testing of bombs, napalm, guided munitions, rockets, missiles and submunitions, for laser testing, for static testing of bombs and rockets in cleared arenas, water-filled and mud-filled arenas, and for shallow water mine countermeasure testing. TA B-71 is a submunition and incendiary weapons test area near TA B-70. TA B-71 includes a 2,000' x 4,000' asphalt-covered grid used for submunition testing and a 300' x 1,000' area containing fixed targets used for incendiary weapons testing. TA B-75, a cleared, rectangular area 3 1/2 by 1 1/2 miles located approximately 16 miles northwest of Eglin Main, is primarily used for close air support and high speed (including supersonic) test missions for air-to-ground bombing, rocketry, and napalm delivery against runways/airfields. A 300' x 1,200' runway target is the primary target for air drops and concrete, asphalt, and clay pads are used for static firings and detonations. Also, a tank gun range and target complex superimposed on TA B-75 is used and supported by the Alabama Army National Guard for annual training. TA C-72 is a cleared, major test area approximately 6 miles long extending from the northwest to southeast with varying widths averaging approximately 1 mile. The C-72 complex is primarily used for air-to-ground and ground-to-ground missions involving the development or production testing of conventional munitions. Target arrays include semi-permanent fortified defensive targets, hard structure targets, a 200' x 1,500' runway target, and simulated high value targets such as power lines, bridge pilings, and bunkers. TA C-52A is the southernmost 10 square mile portion of the TA C-52 range complex and is located approximately 18 miles east-northeast of Eglin Main. TA C-52A is primarily used for supporting air and ground testing of EO, IR, laser, and MMW seekers.

A.8.4.1.2 Interconnectivity/Multi-Use of T&E Facility: The ASTE can be linked to Tyndall AFB to provide multiple full-scale and subscale drone targets using the Gulf Range Drone Control System (GRDCS), multilateration TSPI, scalar and vector scoring, additional TM receivers, and two E-9A aircraft for TM and UHF relay and surface clearance for complex Air-to-Air and Air-to-Surface tests. The ASTE also includes special targets ranging from simulated Warsaw Pact A/C shelters and runways to remote controlled tanks and test facilities that are one-of-a-kind in the world, e.g., the shallow water mine countermeasure testing facility and the HELLFIRE Integration Facility and Test Range. A wide range of current threat emitters are available to provide a realistic electromagnetic radiation environment or act as "targets" for armament testing.

A.8.4.2 Multispectral Test and Training Environment (MSTTE). The MSTTE, used in conjunction with the ASTE, provides a real-world multispectral (EO, IR, MMW, RF) test environment for munitions/ weapons systems and command and control (C^2) DT&E and OT&E. The MSTTE also supports electronic warfare test and training as well as live fire tests using actual EO, IR, and RF threat assets. The MSTTE is a highly instrumented test range with multispectral capabilities. The MSTTE contains a wide variety of threats, many of which are fully instrumented ground air defense threats and validated high fidelity simulated threat emitters, and multiple airborne simulated threats seekers and jammers. All are used to realistically represent various threat air defense systems. Threat systems include real-time closed-loop missile/projectile fly-out simulation. The MSTTE complex consists of numerous radars operating in different frequency bands and modes to provide a flexible highly instrumented simulated hostile defense system. The complex can separately or simultaneously support noise and deception jammer evaluations, dynamic chaff and flare reflectivity measurements, radio frequency and optical countermeasures evaluation, dynamic radar cross-section measurements, radar warning receiver evaluations, electromagnetic interference/compatibility, tactics evaluation and electronic countermeasures techniques. The MSTTE open-air test capability can be electronically linked with the simulation facilities for realistic multi-threat testing.

A.8.4.2.1 Facility Description. The mission of the MSTTE is to provide a realistic open-air environment for testing munitions and supporting weapon systems real- and post-time vulnerability and effectiveness testing. The capability to accomplish extensive integration testing, at both the component and system levels, is available. It includes instrumented ground RF threat systems, including real-world systems and validated simulators. It includes surface-to-air missile systems, radar-guided anti-aircraft artillery systems, acquisition/early warning radars, and ground-based jammer systems. Installed instrumentation records operating modes, electronic countermeasure parameters and supports data analysis for tracking accuracy, ECM effectiveness, and dynamic target signature. Military-controlled/used airspace exists over the entire land and water range complex. In addition, there are adjacent DoD controlled/used airspace areas, bringing the total to 133,927 square miles, should larger areas be needed for specific tests.

A.8.4.2.2 Interconnectivity/Multi-Use of T&E Facility. The collection of the MSTTE with the extensive munitions testing capabilities at Eglin allows for testing armament/munitions/EC systems in a realistic RF environment. All types of countermeasures are routinely used, such as electronic countermeasures, chaff, flares, decoys, and obscurants. Instrumentation on MSTTE systems supports precision tracking analysis with TSPI sources, multi-spectral measurement and analysis, and dynamic RCS and target signature measurement.

A.8.4.3 McKinley Climatic Laboratory. A one-of-a-kind national test resource having an almost unlimited capability to simulate the climatic environmental conditions found on the surface of the earth. Its chambers (capable of testing the C-5A aircraft) can produce various combinations of temperature (-65° F to +165°F), humidity (10 percent to 100 percent), rain (up to 15 inches/hour, wind (to 100 knots), snow, icing conditions, salt

spray, sand, dust, and solar radiation. The facility can also provide 1,000 lbs/sec of air makeup for 40 minutes.

A.8.4.3.1 Facility Description: The McKinley Climatic Laboratory Main Chamber (200 x 250 x 70 ft) is the world's largest environmental test chamber. Its mission is to support climatic environmental testing, including high temperature, low temperature, high humidity, snow, rain, sand, dust, salt, fog, icing, altitude, solar radiation, and fog. It can accommodate any aircraft in the DOD inventory and provide a full range of climatic test conditions while permitting jet engine operation. In addition to the main chamber, the McKinley Climatic Laboratory also has an equipment test chamber (30 x 130 x 25 ft), again with full climatic ranges and jet engine operation; an all-weather room (22 x 42 x 14 ft), a sun, wind, rain, and dust chamber (50 x 50 x 30 ft); a salt fog chamber (16 x 54 x 16 ft); and a temperature altitude chamber (13.5 x 9 x 7 ft). The laboratory is responsible for simulation of extreme environmental conditions for full-scale testing of DOD weapons systems. The six chambers in the facility are able to simulate a wide variety of climatic extremes including low temperature, high temperature, rain, snow, icing, fog, solar radiation, wind, humidity, salt fog, sand, dust, and altitude.

A.8.4.4 Santa Rosa Island Open-Air, Hardware-In-The-Loop (OA-HITL) Tower
The OA-HITL Facility provides test support for developing precision guided weapons technology and can evaluate the performance of those systems in real-world environments. The OA-HITL is a 300-foot freestanding tower located on Santa Rosa Island, FL. It overlooks the water ranges in the Gulf of Mexico to the South and the Eglin land ranges to the north. The tower has a high dynamic flight motion simulator located at the top that provides angular motion to seekers and sensors under test.

A.8.4.4.1 Facility Description. The OA-HITL is located at designated test site A-13/B approximately 300 feet from the mean high water mark. The tower provides the capability to look down at land or water backgrounds or at the land/water interface. The control building located at the adjoining Focus test site provides additional space for instrumentation. The tower contains an extensive fiber optic network connecting the functional areas of the tower with both single and multimode fibers. The fibers terminate in a communications room at the tower base and can be patched to form connections between the areas. In addition, fiber optic telemetry packages are available to replicate low bandwidth analog signals between functional areas. Site A-15, approximately 2 miles to the west provides the ability to launch missiles and other ordinance from the surface out over the Gulf. The tower contains several functional areas that are discussed below.

A.8.4.4.1.1 Open Air Platform (OAP). The OAP is located at the 300-foot level and provides a stable platform for observing targets of interest. The platform has 8 mounting stations used to mount the Flight Motion Simulator (FMS) or a Contraves Model 433 Kineto Tracking Mount (KTM). The FMS is capable of providing high dynamic angular motion to a seeker or sensor under test. The KTM provides lower dynamic angular motion to sensors or cameras for collecting performance or truth data. The mounting stations are arranged in pairs to allow simultaneous use of the FMS and KTM. The OAP

is approximately 40 feet in diameter and has a retractable cover to provide temporary protection of equipment from inclement weather.

A.8.4.4.1.2 Fixed Exterior Test Platform (FETP): The FETP is an additional open-air platform located at the 150-foot level. This platform is suitable for temporary placement of small instrumentation that might be used to collect additional information during a test activity.

A.8.4.4.1.3 Moveable Exterior Test Platform (METP): The METP is an 8 foot X 8 foot test platform that moves up and down the western leg of the tower. The METP provides a platform for placement of instrumentation systems that need to be located at an intermediate altitude. This provides alternate elevation viewing angles to targets located near the tower.

A.8.4.4.1.4 Flight Motion Simulator (FMS): The FMS is a modified version of the Carco Model 5-687R-36T. The modifications include performance enhancements over the standard model and considerable environmental hardening which provide all weather capability. The FMS is designed to operate in the temperature extremes expected in the open-air environment. The feedback sensors and hydraulic plumbing are housed inside the gimbal structures to prevent rain or moisture damage. The FMS can also be operated in a mobile configuration at locations other than the tower. This mobile option requires a suitable concrete foundation for mounting, water for cooling and electrical power.

A.8.4.5 Preflight Integration of Munitions and Electronic Systems (PRIMES) The PRIMES Test Facility performs installed systems testing of air-to-air and air-to-surface munitions and electronics systems on full-scale aircraft and land vehicles. PRIMES testing assures that the entire aircraft or system has been tested as an integrated platform before starting the more expensive flight-test program. Through simulation and modeling, vast amounts of performance data can be obtained at a fraction of the time and cost of conventional flight test programs alone.

A.8.4.5.1 Facility Description: The PRIMES facility has an RF Anechoic Chamber providing a controlled, isolated environment that can house a completely suspended and isolated F-15 aircraft. It can be used to simulate a variety of in-flight conditions, including EMI/EMC.

A.8.4.6 Support Capabilities

A.8.4.6.1 Instrumentation. Time-space-position information (TSPI) (optical, radar multilateration, GPS, laser), telemetry (TM), photo, video, frequency control/analysis, flight termination, weather, radar cross section (RCS), engineering sequential blast, structural ballistics, multi-spectral (EO, IR, MMW, RF), impact scoring, real-time data reduction, timing (IRIG). Additional capabilities are available and linked to the Eglin range network from Tyndall AFB, which is located approximately 80 miles east of Eglin. These include aerial target drones through the drone control system (RF multilateration), multilateration TSPI, scalar and vector scoring, and additional TM reception. Two E-9

aircraft operating from Tyndall AFB are used for TM and UHF relay and surface clearance.

A.8.4.6.2 Airborne Targets. All full and subscale drone Air Combat Command units at Tyndall AFB provide targets available at Eglin. Full-scale drone capabilities include: maneuvering targets (to 9g), formations to 200 feet slant range with up to four targets, over-the-horizon low altitude flight, altitude down to 1,000 feet with waivers for lower altitudes possible, ECM and chaff capability, and vector and scalar miss distance equipment. Subscale drone capabilities include maneuvering targets (to 6g), augmentation, formations as above, low altitude flight to 200 feet, ECM and chaff capability, and scalar miss distance equipment.

A.8.4.6.3 Surface Targets. A wide range of land and sea targets are available. Land targets include fixed bunkers and structures; simulated enemy airfields and runways, actual, simulated, and surrogate vehicles (stationary and remote controlled). AAC maintains a fleet of more than 50 threat, mobile, targets with real countermeasures. These combat systems are transportable, along with mobile instrumentation, to support virtually any test location. Deployment locations have included Grayling, MI, (long, cold, snowy, winter) and Yuma, AZ (arid, desert environment). Signatures of threat ground mobile systems are processed and stored in the Target and Background Information Library System (TABILS), the most comprehensive, interactive, source of infrared and millimeter wave target and background data in DOD. Sea targets are usually acquired and configured for specific tests.

A.8.4.6.4 The Test Wing Aircraft Fleet. This facility provides a representative cross section of the operational Air Force inventory (F-15, F-16, A-10). These aircraft have a standard programmable digital instrumentation system and can be modified for unique project requirements.

A.8.4.6.5 Airborne Seeker Evaluation and Test System (ASETS). ASETS is a unique and versatile airborne platform (NC-130A aircraft) with a very large, fully stabilized turret system that is used for development, test, and evaluation of both air-to-air and air-to-surface seekers and sensors. The capabilities of the ASETS include high-resolution infrared imaging, infrared spectrometer, multi-spectral signature measurements, (2 IR bands, visible, millimeter wave (MMW) radar) and multi-seeker carriage. Its size and capacity permit ASETS to provide true side-by-side testing of up to three competing seeker/sensor systems, and at the same time, preserve and protect the proprietary nature of each individual system and its associated data products. ASETS can be used for collecting target and background signature data, comparative seeker evaluations, atmospheric/weather data measurements, and airborne developmental testing of new EO/IR systems and seekers.

A.8.4.6.6 Fielded and Airborne Seeker Test Instrumentation. This instrumentation consists of a number of different airborne pods and ground van-mounted systems that are capable of performing a wide variety of multi-spectral signature measurements, (UV, visible, IR, radar, MMW) and captive carry seeker/sensor evaluation and training. It

supports a wide variety of DT&E and OT&E programs. Generated data is used to provide detailed documentation of test conditions for many different DOD customers who require these data for new weapon system development, model verification, and hardware-in-the-loop simulation testing.

A.8.4.6.7 Gulf Range Drone Control System (GRDCS). GRDCS provides multifunction command, control, and tracking for tests conducted on the Gulf Test Range. The system provides TSPI on GRDCS-equipped drones, shooter aircraft, missiles, and platforms. It provides for selective flight termination of drones and missiles. The GRDCS is a multilateration tracking system but will be converted to GPS to improve absolute accuracy and extended coverage. Platforms are used to track GRDCS targets in an over-the-horizon situation.

A.8.4.6.8 GPS Advanced Range Data System (ARDS). ARDS will provide Time-Space-Position-Information (TSPI) and remote control of up to 25 vehicles. Either internally mounted instrumentation packages or externally mounted pods track aircraft. Support systems include precision multi-spectral TSPI tracking systems operating in the RF, EO, IR, and MMW bands for minimum test item interference. Frequency monitoring stations, telemetry, multi-spectral TSPI, and analysis of systems along with radar cross section measurements are also provided for total multispectral test support.

A.9 ARNOLD ENGINEERING DEVELOPMENT CENTER (AEDC)

A.9.1 Mission

AEDC is a national aerospace ground test facility that conducts tests, engineering analyses, and technical evaluations for research, system development, and operational programs of the Air Force and Department of Defense, other government agencies, and industry. Using ground test facilities, AEDC supports propulsion, aerodynamic, reentry, trans-atmospheric, and space flight systems testing. Testing is performed in an environment that simulates operational conditions. AEDC performs research to develop new technology for advanced test facilities, test techniques, and measurement methodologies associated with ground testing. AEDC is the nation's largest complex of flight simulation and ground test facilities. There are 63 test facilities that include: transonic through hypersonic propulsion capable wind tunnels, rocket and turbine engine test cells, space environmental chambers, reentry simulating arc heaters, extreme velocity ballistic ranges, nuclear weapon effects simulation and other specialized units. Twenty-five of these test facilities are nationally unique and 14 are unmatched in the world. The advanced turbine engine, wind tunnels and rocket propulsion facilities are unique in their ability to continuously simulate high altitude and high-speed flight operations (up to 150,000 feet altitude). The propulsion facilities can also handle extremes of thrust including thrust-vectoring jet engines, and 500,000 pound thrust rocket motors. AEDC is also a DoD Distributed High Performance Computing site and has one of the largest applied computational fluid dynamics departments in the nation. AEDC also operates a hypersonic wind tunnel at White Oak, MD, capable of simulating speeds of up to Mach 16.5.

A.9.2 Location

AEDC is located in the middle of Tennessee, 116 km/72 miles southeast of Nashville and 98km/61 miles northwest of Chattanooga.

A.9.3 Features

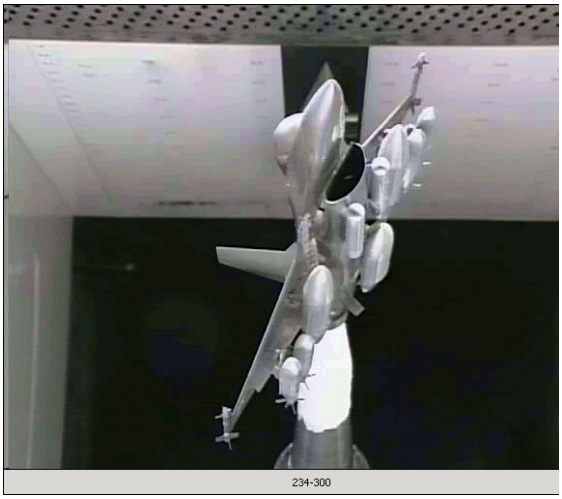
AEDC, a 4,000 acre industrial complex located on 40,000 acres of woodland in middle Tennessee, consolidates the technical expertise and test facilities required to conduct development, certification and qualification testing on aircraft, missile and space systems. Types of tests conducted at AEDC include aerodynamic, aero thermal/material, impact/lethality, integrated test and evaluation, propulsion, radiation effects, sensor/focal plane, spacecraft contamination, thermal/vacuum, and weather/erosion.

A.9.4 Facilities

A.9.4.1 Wind Tunnels

The nine wind tunnels located at the AEDC range in size from test sections of 11 sq ft to 256 sq ft and provide coverage over a Mach number range from 0.04 to 10. They are capable of proving performance, stability and control, store-separation, heat transfer, ablation, and aeroelastic loads data. The 16T and 16S wind tunnels are unique in the United States because they are the only transonic and supersonic wind tunnels where airframe and propulsion integration testing can be done under controlled attitude conditions. Upgrades to facility air processing equipment, control systems, and data acquisition systems are in the final stages in the 16 ft transonic and supersonic facilities. As a result, significant reductions in test cycle time and utilization costs have been achieved making the facility more attractive for air vehicle development programs. The 4 ft and 16 ft transonic tunnels, coupled with the 40-inch and 50-inch supersonic and hypersonic tunnels provide a complete flow simulation capability and have the most advanced captive trajectory systems available. The supersonic/hypersonic facilities offer a wide variety of intrusive and non-intrusive flow diagnostics coupled with high-quality flow-visualization techniques, providing the complete field mapping data necessary for computational fluid dynamics (CFD) code validation.

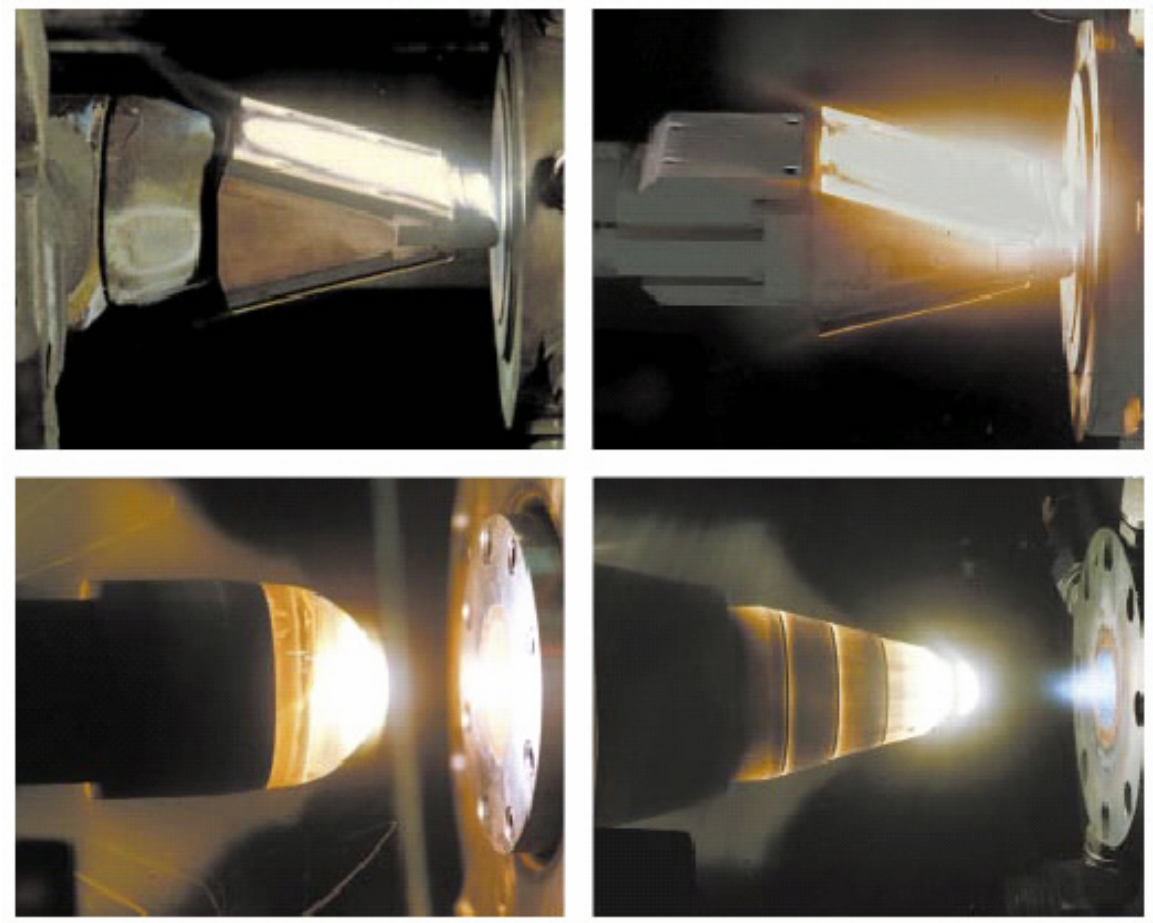
A.9.4.1.1 Hypervelocity Wind Tunnel 9 Facility. This facility is located at White Oak, MD, provides aerodynamic simulation in critical altitude regimes associated with strategic offensive missile systems, advanced defensive interceptor systems, reentry vehicles, and hypersonic vehicle technologies. Tunnel 9 is a blow down type facility with operational Mach numbers of 7, 8, 10, 14, and 16.5. This facility utilizes a storage heater, which provides supply pressures up to 1430 atmospheres and supply temperatures up to 3460 degrees Rankine.



F-16 and F-22 Models in AEDC Wind Tunnels (Movie)

A.9.4.2 Aerodynamic and Propulsion Test Unite (APTU). The Aerodynamic and Propulsion Test Unit (APTU) is a blow down-type facility designed primarily for ramjet and scramjet propulsion system testing. However, the facility's capabilities make possible the conduct of true temperature aerodynamic and high-temperature materials tests. The APTU is operated by using a vitiated air heater (VAH) and is capable of operating at Mach numbers from 2.2 to 4.1 at simulated altitudes ranging from 5,000 to 80,000 ft. Facility upgrades are in progress that are designed to increase the Mach Number and altitude capability to Mach 8 and 120,000 feet. Liquid oxygen is used in the oxygen replenishment system to account for the oxygen consumed by the VAH so that a correct oxygen balance exists in the test medium. The facility is completely computer controlled, and rapid transitions in pressure and temperature can be accomplished at a fixed Mach number. Mach number is varied using interchangeable free-jet nozzles, and the facility utilizes an atmospheric exhaust.

A.9.4.3 Arc Heater Test Units Three test units provide the capability to evaluate the performance of materials/test articles in high-enthalpy flows with or without weather/dust simulation. Tests are routinely performed for a variety of supersonic/hypersonic vehicle applications, including thermo structural design of reentry vehicles and hypersonic interceptors, antenna window survivability and performance, and development of advanced thermal protection materials. Thermal heating/ablation can be simulated at flight altitudes from 20,000 ft to, 160,000 ft with flow enthalpies simulating flight. A 70-MW d-c power supply powers the two segmented arc heaters and one Huels arc heater, providing chamber pressures up to 130 atmospheres. Test articles from one-inch coupons up to full size structural segments of a vehicle (such as antenna windows, nose tips, and seeker components) can be evaluated in flow fields ranging from 1.2-in. to 42-in. in diameter.



Fourteen engine test cells are available for testing aero propulsion engines ranging in size from 50 to 100,000 lbs of thrust, in simulated flight conditions from sea level to 100,000 ft at Mach numbers of 0 to 4.0. Testing can be accomplished in either direct connect or free jet modes. Engine development, performance, operability, inlet/engine integration, environmental effects, corrosion, and inlet icing testing can be accomplished. Two sea level test cells allow testing at both near sea level static and true ram inlet conditions up to 1.2 Mach number for accelerated mission testing. AEDC also operates a component test rig for gas turbine combustor development.

A.9.4.4 Rocket Test Cells. Four test cells are available for testing both small and large rockets under altitude conditions up to 125,000 ft and with thrust levels up to 500,000 lbs.

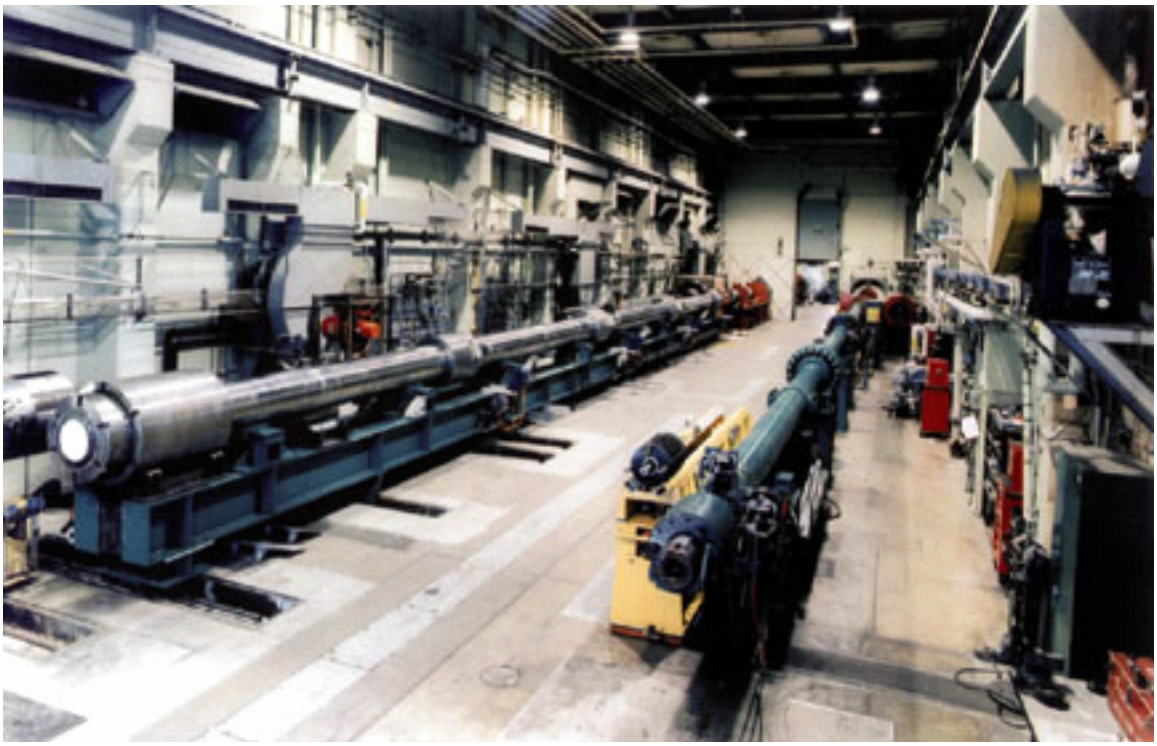
A.9.5 Ranges

A.9.5.1 Space Simulation Facilities Range. Space Simulation Facilities Range is in size and capability from the largest DoD thermal vacuum test chamber, the Mark I, that stands 82 feet tall and 42 feet in diameter, through intermediate-size sensor and ion engine test chambers, to very small research chambers only a few feet in diameter. Space simulation is a broad term for testing and characterizing materials, components, subsystems, up to

full operational satellites in a realistic thermal and vacuum environment representing space. Current test capabilities include thermal and vacuum testing to ensure spacecraft and components function properly in the vacuum of space under extreme temperature ranges. Sensor test capabilities are in place to characterize the performance of sensor hardware and control systems used in airborne sensors, targeting sensors, and observing realistic thermal targets such as reentry vehicles against a space background. These ground capabilities provide both statistical repeatability and edge-of-envelope testing that cannot be economically performed in one of a kind flight tests. Scene generation capabilities include precision black body sources traceable to National Institute of Standards, infrared array sources for extended scenes, and with the completion of 10V Hardware-in-the-Loop for targeting sensor testing in FY06, visible array sources as well. Additional test capabilities include materials characterization for suitability in space, including the Combined Orbital Effects chamber, which is a prototype test facility for understanding the synergistic results of multiple effects, including not just thermal and vacuum effects, but solar radiation, ion plume, and material out gassing as well. Other test capabilities include the ability for test ion thrusters up to 20kw in power. Cryogenic support infrastructure allows continuous low-background (20k or -430F) for infrared sensor testing. State-of-the-art instrumentation, data acquisition, and data processing equipment enhance the extremely versatile and adaptable space simulation test facilities.

A.9.5.2 Radiation Effects Testing The Decade Radiation Test Facility (DRTF) is an advanced generation nuclear test facility designed to test 21st century space and missile systems and their components against nuclear weapons effects. DRTF radiation source capabilities range from 15 Krads Bremsstrahlung dose over an area of 2250 cm2 for a pulse width of up to 45 nsec and an average peak diode voltage of up to 1.8 MV to 400 rads over an area of 3000 cm2 for a pulse width of 30 nsec and an average peak diode voltage of up to 200 kV. The Modular Bremsstrahlung Source (MBS) is a smaller x-ray simulator that operates in a lower energy range. The MBS simulator is used for System Generated Electro-Magnetic Pulse (SGEMP), Internal Electro-Magnetic Pulse (IEMP), and enhancement effects testing.

A.9.4.7 Hypervelocity Ballistic Ranges Three two-stage light-gas gun systems are available at AEDC and are designated Range G, Range S1 and I. Range S3 is a pneumatic launcher used to conduct low speed impact tests. Range G is the largest of the three systems and launches projectiles into a 10-foot-diameter, 929-foot-long instrumented tank. The environment within the tank can be maintained at pressures from 0.2 torr to 1.7 atmospheres. The massive Range G launcher which is the largest routinely operated light-gas gun in the nation, has a “soft launch” (minimized acceleration loading) capability that permits the launching of high-fidelity projectiles at velocities up to 23, 000 ft/sec. Three different size gun barrels are available to be used on the launcher (3.3, 4.0 and 8.0-in. inside diameter barrels). Projectiles can be tested in free flight or on a track system, which is used to precisely guide and recover projectiles intact. Many types of tests have been performed in the ranges, to include: lethality assessments, the effects of plasma physics on seeker accuracy, body/wake signature studies, material evaluation (ablation, weather/erosion, accelerations effect), nosetip transition studies, and determination of aerodynamic characteristics.



A.10 30th SPACE WING (30SW)

A.10.1 Mission

To defend the United States through Launch Range, and Expetionary Operations

A.10.2 Location

Headquartered at Vandenberg Air Force Base (VAFB), the 30th Space Wing (30 SW) conducts and supports west coast space and missile launch operations and manages the Western Range (WR). The north VAFB coastline faces west, supporting ballistic missile launches into broad ocean areas and the Reagan Test Site. South VAFB supports space launches to insert payloads into polar orbit. In conjunction with other ranges, principally the NAWC Weapons Division, Pt Mugu and the Reagan Test Site, the WR provides continuous and complementary instrumentation coverage over a broad portion of the Pacific Ocean. 30 SW instrumentation sites are located along the Pacific coast at Pillar Point AFS (PPAFS), Anderson Peak, VAFB, Santa Ynez Peak, and on the Hawaiian islands. The West Coast Offshore Operating Area (WCOOA), which extends along the Pacific coast from Mexico as far as the Canadian border, provides an aeronautical, and guided missile test corridor.

A.10.3 Facilities/Capabilities

A.10.3.1 Launch. Spacelift facilities consist of space launch complexes with vehicle and payload checkout and processing for Titan, Delta, Atlas, and other government and commercial programs. Ballistic launch and processing facilities exist for Minuteman, Peacekeeper ICBM, and Strategic Missile and Target Launches support test and evaluation programs. Space and ballistic missile launches are possible across a wide range of launch azimuths. This allows direct polar orbit insertion of satellites and ICBM tests without overflight of populated areas.

A.10.3.2 Range. Support includes planning, range safety, scheduling, tracking, data collection, data handling and processing, command and control, communications, and weather. Major instrumentation systems operated include the following:

A.10.3.2.1 Metric Tracking. The 30 SW operates and maintains a network of calibrated precision tracking radars located at PPAFS, VAFB and Kaena Pt. AFS in the Hawaiian Islands. In conjunction with radars located at Pt. Mugu and San Nicolas Island, they are used to obtain trajectory measurements on ballistic missile and spacelift flights at the WR and support aircraft testing in the WCOOA. A variety of processed metric data products are available. The Kaena Point radar is also a contributing sensor for the Space Surveillance Network. Digital and analog GPS metric tracking capability is under development.

A.10.3.2.2 Telemetry. There are two permanent telemetry sites that support WR users, the Vandenberg Telemetry Receiving Site (VTRS) and Pillar Point AFS. These sites

support space, ballistic and aeronautical missions. The mobile telemetry van can be strategically placed to extend coverage where the large aperture fixed antenna line of sight is obstructed. The received telemetry data are both recorded for post-flight processing and also relayed real-time to the telemetry processing facility for display and for range safety use.

A.10.3.2.3 Optical Tracking. Wing large-aperture optical instruments are situated on coastal mountains, one on VAFB, one 150 miles north at Anderson Peak, and one 30 miles southeast at Santa Ynez Peak. Mobile optical tracking mounts are used to provide film and video acquisition capabilities in the vicinity of WR launch sites. These systems provide high quality video and film records of launch operations which satisfy most range users' needs for visual imaging support.

A.10.3.2.4 Command Transmitter (CT). The Wing has five fixed CT sites: three at VAFB, one at PAFS, and a Navy-operated site at Laguna Peak near Pt. Mugu, 100 miles southeast. The Wing also has one mobile system which can be remotely located to support launches from different locations. The CT sites transmit range safety commands to errant missiles or space boosters.

A.10.3.2.5. Midrange Operations Support. The Kaena Point radar on Oahu provides midcourse data on ballistic missile tests and supports on orbit space operations as well a space surveillance mission for NORAD. Additional support is available from the AMOS long-range optical site on Maui, Navy-operated telemetry and radar systems at PMRF, Kauai, and telemetry from the Hawaii Tracking Station on Oahu.

A.10.3.2.6. Reentry Support. The Army-operated instrumentation system complex at Reagan Test Site provides extensive signature data gathering and impact scoring capabilities for reentry vehicles.

A.10.3.2.7 West Coast Offshore Operating Area (WCOOA). The WCOOA is an aeronautical, ballistic missile, and guided missile test area along the west coast. WCOOA is managed by the 30th Space Wing as an adjunct to the WR. Most operations are conducted off the California coast near VAFB, although the extensive test range is approximately 200 miles wide and over 1000 miles long from the Mexican border north to the Canadian Border. WCOOA has features that are singularly unique and offers its users a test arena not duplicated anywhere: Limited Traffic Encroachment, Minimal Sonic Restrictions, Stable Oceanic Air Mass, Extensive Controlled Test Areas, Controlled Test Observability, Unrestricted A/C flight Profiles, Existing Test Range Instrumentation Support, and an Independent Control Center

A.11 45th SPACE WING

A.11.1 Mission

The 45th Space Wing (45 SW) provides assured access to space by conducting launch vehicle and spacecraft processing, as well as launch and range operations to a wide variety of customers. The customers include the US Air Force, Army, Navy, the National Aeronautics and Space Administration (NASA), the National Reconnaissance Office, and private industry.

A.11.2 Location

A.11.2.1 Patrick Air Force Base (PAFB), Florida, USA. Patrick AFB serves as headquarters to the 45 SW and is located on Highway AlA, three miles south of Cocoa Beach, and 69 miles east of Orlando. The base is situated between the Banana River and the Atlantic Ocean. The 1,822-acre area is 4.1 miles from north to south, 1.25 miles from east to west, and nine feet above sea level.

A.11.2.2 Cape Canaveral Air Force Station (CCAFS), Florida, USA. CCAFS, located 21 miles north of PAFB, serves as the processing and launch area for the 45 SW. CCAFS takes in a 25 square mile area of what was previously uninhabited scrubland. Within its boundaries, it has complete assembly and launch facilities for spacelift vehicles, ballistic missiles and space hardware. A 10,000-foot long landing strip (the "skid" strip) permits the airlift of vehicles, space hardware and missiles directly from the manufacturing location to the Cape.

A.11.3 Features

The 45 SW, host organization for PAFB, CCAFS, Jonathon Dickinson Missile Tracking Annex (JDMTA) and island stations of the Eastern Range (ER), is in an ideal location for its role as a space range, and is part of the Major Range and Test Facility Base (MRTFB). The ER consists of a series of stations located at CCAFS and Jonathan Dickinson Missile Tracking Annex (JDMTA) on the Florida mainland, and on the islands of Antigua and Ascension in the Atlantic Ocean, and Argentia in Newfoundland, Canada. The Range covers 15 million square miles and serves as Lead Range for ER launches in a worldwide network, and supports other lead ranges as well as the Air Force Satellite Control Network (AFSCN).

A.11.4 Facilities and Infrastructure

A.11.4.1 CCAFS Facilities They include launch complexes, spacecraft and missile assembly buildings, and all other elements essential to the assembly, pre-launch, launch and post-launch operations of space/ballistic vehicles. The Trident basin and other military port facilities at Port Canaveral support the US Navy Submarine Launch Ballistic Missile program. The Naval Ordnance Test Unit (NOTU), which manages Navy operations on the ER, is located at CCAFS. Some of the ER Range Instrumentation is

located on the Kennedy Space Center (KSC) on Merritt Island so that spatial requirements for the instrumentation can be met.

Cape Canaveral was selected as the launch site for the Nation's exploration of space and ballistic missile tests because it has many advantages over many other locations. The main advantage is the utilization of broad-ocean area flight trajectories that make long-range ballistic missile tests and spacelift missions relatively safer than over landmasses. Situated as it is between the Atlantic Ocean and the Banana River, CCAFS provides both a security and a safety buffer zone around the launch area.

Besides the numerous launch vehicle spacecraft processing facilities at CCAFS, there are commercially operated facilities located off but not to far from CCAFS. There are also similar facilities on NASA's KSC. KSC and the 45 SW are now working jointly in support of many space-related endeavors that include industry, academia and other federal and state agencies. There are over 50 years of experience and at least three generations of people available in the immediate area in support of the Nation's space programs.

A.11.4.2 Precision Tracking Radars. The radars are located at Cape Canaveral, Merritt Island, JDMTA, Patrick AFB and on the islands of Antigua, and Ascension, and a Mobile C-Band Radar is deployed to Argentia for northerly launches. A radar belonging to the US Navy and located on St Croix Island, Virgin Island is also available upon request to support ER operations. The radars are capable of either beacon or echo tracking and provide real time Time-Space-Position (TSP) data to the CCAFS Range Operations Control Center (ROCC) primarily by satellite links.

A.11.4.3 Metric and Imaging Optics Precision Optics for both TSP metric and imaging data are available at CCAFS and Kennedy Space Center (KSC). These systems include precision theodolites and long-range large aperture telescopes.

A.11.4.4 Portable Impact Location Systems (PILS) This is a scoring system that provides impact data for inert and instrumented re-entry bodies. The system is utilizes sonobouys as sensors and is deployed as required by the US Navy. The sensors are configured in a circular array of twelve sonobouys deployed either by P-3C aircraft (PILS-1) or by ship-of-opportunity (PILS-2) in the broad ocean area.

A.11.4.5 Telemetry Instrumentation consists of land-based stations on Merritt Island, JDMTA, Antigua, Ascension Island, and New Boston, New Hampshire (part of the Air Force Satellite Control Network) in support of northerly trajectories. US Navy P-3 aircraft, based upon availability, can provide telemetry aircraft support. Both raw and decommutated near-real-time data is transmitted by satellite to the ROCC at CCAFS for processing, display and recording from down-range stations. JDMTA also has a microwave link redundant capability.

A.11.4.6 Command/Destruct (C/D) The requirement to remotely destroy an errant launch vehicle is met by ultra high frequency uplink signals from transmitters located on

CCAFS, JDMTA, Wallops Island, VA (NASA facility), and Argentia (with equipment deployed in support of northerly launches). The command and control of these transmitters is the responsibility of the Missile Flight Control Officers (MFCOs) located in the ROCC. The MFCOs have complete control of the Range with authority delegated by the Wing commander from a specific time prior to launch until a determination is made by the MFCO there is no danger in allowing the launch vehicle to proceed on a given trajectory.

A.12 46th TEST GROUP

A.12.1 Mission

The Test Group provides a unique combination of test and evaluation services and state-∑of-the-art measurement and support facilities for guidance and navigation testing, sled track testing, radar cross section testing, flight testing, and White Sands Missile Range liaison.

A.12.2 Location

The 46th Test Group is located at Holloman AFB, Alamogordo, New Mexico.

A.12.3 Facilities

The 46th Test Group is a multiple-discipline organization that provides a unique combination of test and evaluation services and state-of-the-art measurement and support facilities for guidance and navigation testing, sled track testing, radar cross section testing, flight testing, and White Sands Missile Range liaison. The 746th Test Squadron's Guidance Facility is the DoD center of expertise for the test and evaluation of Inertial Navigation Systems (INS), Global Positioning System (GPS), and blended GPS/INS components and systems in both benign and electronic warfare environments. The 846th Test Squadron's Holloman High-Speed Test Track is the lead facility for all supersonic tracks and is the track center of expertise for aircraft escape system testing, full-scale lethality testing, electronic countermeasure systems, explosive blast effects, environmental erosion, dispenser testing, and hypersonic environmental testing. The National Radar Cross Section Test Facility (NRTF) is a one-of-a-kind facility combining the best of monostatic and bistatic radar cross-section (RCS) measurements.

A.12.3.1 746th Test Squadron. The 746th Test Squadron (TS), also known as the Central Inertial Guidance Test Facility (CIGTF), is chartered to test and evaluate GPS user equipment (UE) and integrated GPS based guidance and navigation systems. With over 36 years of experience, CIGTF has established itself as a leader in Inertial, GPS, and blended GPS/Inertial component and system testing. In addition, CIGTF's inclusive lab, field, and flight-testing capabilities offer customers a cost-effective means to evaluate their guidance and navigation systems. In support of GPS testing, the 746 TS is the lead test agency and manager for the tri-service GPS Test Center of Expertise (COE) comprised of Army, Navy, and Air Force test agencies chartered to support GPS test and evaluation initiatives. The CIGTF Navigation Test and Evaluation Laboratory (NavTEL) is a state-of-the-art facility used for testing standalone GPS UE and integrated GPS navigation systems. NavTEL enables GPS UE hardware and software to be fully exercised under laboratory conditions by using real-time simulation of GPS satellite signals, and simulated and/or hardware-in-the-loop host vehicle aiding and communication systems. Following functional and performance verification in CIGTF's laboratory and field test environments, flight testing of the item is conducted at White Sands Missile Range (WSMR). CIGTF's fully instrumented aircraft, including the F-16,

AT-38, C-12, and UH-1 are used to provide various low, medium, and high dynamic operating environments for the system under test.

A.12.3.2 846th Test Squadron. The 846th Test Squadron operates the Holloman High Speed Test Track (HHSTT), which simulates selected portions of the flight environment under accurately programmed and instrumented conditions. This capability fills the gap between laboratory investigations and full-scale flight tests. The squadron is DoD's "Center of Expertise" for all ejection seat testing and the lead facility for all supersonic tracks. Its capabilities are world unique in subsonic through hypersonic velocities. Payloads up to full-scale aircraft can be tested at realistic flight velocities. The squadron is fully staffed for test management, test design, engineering, analysis, hardware fabrication, test buildup and support. The 846th Test Squadron has also been designated as the test organization for Missile Defense hypersonic warhead lethality validation and has recently increased its hypersonic capabilities. Warhead lethality testing is accomplished at velocities up to 3-km/sec. The squadron also tests aircraft infrared countermeasures, material response to rain and particle impacts, aerothermal materials/protection systems, and aeropropulsion systems. The 846th Test Squadron is developing a magnetic levitation capability that will significantly reduce vibrations. This will also allow taking larger payloads to higher speeds. The technology required for this magnetic levitation capability has potential commercial application for both land and space transportation.

A.12.3.3 National Radar Cross-Section Test Facility. The RCSNRTF is a one-of-a-kind national asset combining the best of monostatic and bistatic RCS measurements for air vehicles. The NRTF consists of two separate but complementary test sites located on WSMR, Mainsite and the Radar Advanced Measurement System (RAMS). Because of their remote locations, both sites are ideal for testing highly sensitive targets in a very secure environment. Ground access is controlled through multiple guard posts, and civil air traffic access is prohibited over the range. Several special facilities are available on site to store, paint, and prepare customers' targets, as well as fabricate frequency-tuned columns and sub-scale models. With recent advances in VHF/UHF measurement capability, the NRTF introduced the most accurate, flexible, and capable low frequency RCS measurement system available today. A new more sensitive radar was installed at RAMS along with state-of-the-art computer control and data processing system. A technically advanced pylon at RAMS was recently fabricated to accommodate the lower measurement background demanded by customers. To ensure the technological edge protecting today's warfighter, a mobile bistatic coherent measurement system was developed at Mainsite to measure off-directed radar returns from stealth airframes. An upcoming military construction project at RAMS expands the number of target preparation facilities and provides a permanent administrative area and guard station. These initiatives will ensure NRTF remains the premier RCS test facility in the world.

A.12.3.4 586th Flight Test Squadron. The 586th Flight Test Squadron is responsible for all Air Force flight test activity taking place over WSMR. The squadron operates fighter and cargo aircraft in support of avionics, guidance/navigation, and weapon system testing. The 586th fleet of highly modified and unique test support includes the AT-38B

and C-12J aircraft. The C-12J is the only test asset of its kind and provides the ability to conduct Global Positioning System and inertial navigation tests. It also has the capability for electronic-countermeasure testing. The 586th Flight Test Squadron also provides aerial photographic support, flight planning, life support equipment services, aircrew briefings, a government flight representative, and liaison for transient testers.

A.12.3.5 Detachment 1 (DET1), White Sands Missile Range. DET 1 serves as sponsor for all Air Force programs testing at WSMR. DET 1 also provides WSMR scheduling for all Air Force test programs and air operations.

A.13 NEVADA TEST AND TRAINING RANGE (NTTR)

A.13.1 Mission

Provide an operationally oriented, combat-like range facility where large-scale air and ground activities can evaluate integrated air-to-air and air-to-ground Operational Test and Evaluation (OT&E) and training.

A.13.2 Location

NTTR is between Las Vegas and Tonopah in southwestern Nevada.

A.13.3 Features

A.13.3.1 Topography. The range complex covers approximately 2.9 million acres over desert terrain, with north-south mountain ranges separated by valleys and dry lakebeds. Elevations of the area vary from 2,500 ft to 10,000 ft above mean sea level. Dry climate results in excellent flight conditions year-round

A.13.3.2 Airspace. The NTTR is comprised of 12,000 square miles of airspace and is divided into five geographical areas. They consist of the following: R-4806, primarily used for testing and munitions training; R-4807, used for electronic combat and munitions training, R-4808, used by the Department of Energy; R-4809, used primarily as an electronic combat range; and the Desert Military Operating Area, used for air-to-air training.

A.13.3.3 Capabilities. The NTTR provides a realistic integrated threat simulator environment, targets, instrumentation to provide Time-Space-Positioning Information, and two-emergency divert airfields.

A.13.4 Facilities (Anderson)

A.13.4.1 Range Operations Center (ROC). The ROC is an integrated control center responsible for directing and monitoring the activities and safety of project participants and non-participants, controlling range land and airspace use and under the direction of the 98th Range Wing Commander directing Search and Rescue operations. The ROC is

composed of communications, recording equipment, instrumentation, data processing and display equipment that provide observers with a comprehensive picture of the events of a mission.

A.13.4.2 Combined Operations Center (COC). The COC is the focal point for both the Red Force integrated air defense system (IADS) and mixed-force Ground Control Intercept (GCI) activities. Here the Red Forces Battle Commander is fed a variety of data from threat simulators upon which he makes real-time battle decisions. In addition, all Nellis Blue Command and control is conducted in the COC with its extensive radar, data link and communications feeds.

A.13.4.3 Test and Evaluation Mission Instrumentation. Although test missions using the Nellis Air Combat Training System (NACTS) take place on the north and south ranges, the bulk of testing on the Nellis Ranges takes place on Range 63. This is the only range on the NTTR that has been developed and instrumented almost exclusively to support test and evaluation missions. The available equipment is designed and positioned to provide the precise data necessary to allow a thorough analysis of both aircraft and delivered weapons performance. This equipment includes kineto-tracking mounts, remote unmanned high-speed cameras, Television Ordnance Scoring System (TOSS) scoring, and aerial video using helicopters.

A.13.4.3.1 Nellis Air Combat Training System (NACTS). NACTS supports the training of aircrews in air combat maneuvering, weapons employment, and electronic combat during air-to-air, air-to-ground, and ground-to-air combat scenarios. NACTS accommodates 100 simultaneously operating High Activity Aircraft (HAA) equipped with NACTS pods. Through interfaces with FAA and gap filler radars, the NACTS obtains position- only tracking for another 100 Low Activity Aircraft (LAA). Aircraft time-space position information (TSPI) for NACTS-equipped aircraft is provided by differential global positioning (GPS) equipment. NACTS provides full state vector tracking including position, velocity, acceleration, attitude, true air speed, angles of attack and sideslip, and other air mass parameters and will track aircraft from 60,000ft. MSL to 400ft. AGL, with a goal of 100ft AGL. NACTS supports 75 simultaneous threats and threat simulations for HAA. NACTS is also capable of obtaining control, status, and pedestal pointing information for up to 30 threat emitter simulators. Data from Airborne Instrumentation Subsystems, FAA and Gap Filler Radar (GFR) and emitter simulators is processed to provide real time 3-dimensional full-digital graphic and alphanumeric displays depicting aircraft and threat activities. There are 6 Display and Debriefing consoles located in the Red Flag facility and 17 Advanced Display and Debriefing Type A Consoles (ATAUs) at Red Flag, 422 TES, and Weapons School to support user interaction with NACTS for both live missions and debriefs.

A.13.4.3.2 Threat Simulators. The Nellis Range Complex maintains one of the most dense simulator environments available in the United States and allied nations. Simulators include a wide assortment of SAMs with Smokey SAM visual cues and AAAs operated by the 98th Range Wing O&M contractor. All of these assets provide

year-round training to aircrews in Red Flag exercises and USAF Weapons School exercises.

A.13.4.3.3 Communications Jamming/Deception. In addition to the electronic threat simulators, there also exists the capability for intrusion/imitative communications deception and jamming. This capability represents those resources that are deployed to protect homeland target complexes. The resources that provide this capability are operated in accordance with opposing force doctrine.

A.13.4.3.4 Television Ordnance Scoring System (TOSS). The TOSS is a video ordinance scoring system that uses two or more remote-controlled TV cameras to view the target to be scored. Precise bomb release timing is also available on Range 63 if the aircraft utilizes a tone generator. TOSS scores are normally available near real-time when operating on the NTTR, or post-mission via E-mail or Fax.

A.13.5 Ranges

A.13.5.1 North Ranges. Two electronic combat (EC) areas, (Tonopah EC Range and Tolicha Peak EC Range) provide a realistic enemy radar environment for aircrew training. These are manned ranges and contain no live fire targets. The target ranges below are adjacent to the EC ranges and contain some unmanned radar threats.

A.13.5.2 Range 71. Range 71 is located in the northwest corner of R-4807. This tactical range consists of TOSS scorable, simulated missile sites, a convoy, an airfield, an industrial area, a bridge, and a forward edge of the battle area. Live and inert ordnance, except cluster bomb units (CBU), are authorized.

A.13.5.3 Range 74. This is an unmanned Close Air Support range consisting of live and inert targets. The targets consist of an airfield, convoys, oil fields, bunkers, and missile sites. This is the only range in the North that does not have TOSS scoring.

A.13.5.4 Range 75. This unmanned range consists of missile sites convoys, bunkers, and a live CBU grid and is located in the central portion of R-4807. R-75 has live and inert targets and Unmanned Threat Emitters.

A.13.5.5 Range 76. Range 76 is located in the southwestern portion of R-4807 with airfields, missile sites, industrial areas, railroad, railroad tunnel, convoys, and forward-edge-of-the-battle-area arrays. This range now has an urban developed ‘town’ with 20 and 30-foot buildings, courthouse, radio tower, residential area, streets and soccer field. This target will be expanded yearly incorporating other target areas into one large complex. Live and inert ordnance is authorized. One UMTE system is deployed with five emitter units for Ranges 75 and 76.

A.13.5.6 South Ranges. South Ranges provide for air-to-air and air-to-ground munitions delivery, air-to-air combat maneuvering (including air combat maneuvering instrumentation), and realistic ground target simulation.

A.13.5.7 Range 61. Range 61 is located in the northwest corner of R-4806, this range serves well for air-to-air combat and also provides a helicopter interdiction target. Only training and inert weapons are authorized.

A.13.5.8 Range 62. Range 62 is located on the east side of R-4806, the majority of the targets are located in and around Dogbone Lake. The targets include tactical targets consisting of an airfield, supply area, anti-aircraft artillery, convoys, an urban village, which will be expanded yearly, three live Maverick targets and a live CBU grid. Both live and inert weapons are authorized on selected targets. An air-to-air gunnery pattern overlies Range 62. UMTE system emitter units are deployed along the lakebed on this range.

A.13.5.9 Range 63. Range 63 is primarily used for OT&E missions and night conventional weapons training, and as a backup day conventional weapons delivery range. Range 63 will not normally be used for tactics training when ordnance delivery is planned. It can accommodate live or inert ordnance, with TOSS scoring and kineto tracking mounts. The range also has a live and inert CBU grid.

A.13.5.10 Ranges 64 and 64A. Ranges 64 and 64A are located in the western portion of R-4806, range 64a is primarily a flight training area for helicopter close air support operations and a transition area for aircraft into Range 65. No ordnance is authorized in Range 64A and the range must be scheduled separately. Range 64 contains convoys, tank columns, surface-to-air missile (SAM) sites, and supply depots. Both live and inert weapons are authorized on Range 64. Range 64 also offers several Forward Air Controller (FAC) areas and laser designation ground parties. An air-to-air gunnery pattern overlies these ranges. This Range is not TOSS scorable.

A.13.5.11 Range 65. Range 65 is located in the southwest corner of R-4806, Range 65 consists of a manned TOSS scorable conventional range and includes several tactical targets. An air-to-air gunnery pattern overlies Range 65. Only inert weapons are authorized on Range 65.

A.14 UTAH TEST AND TRAINING RANGE (UTTR)

A.14.1 Mission

UTTR provides war fighters with a realistic training environment and conduct operational test and evaluation including tactical development and evaluation supporting large footprint weapon systems to enhance combat readiness, superiority, and sustainability.

A.14.2 Location

UTTR is located in northwestern Utah and eastern Nevada, approximately 113km (70 miles) west of Salt Lake City. The Mission Control Center (MCC), test program planning, and administration is located at Hill Air Force Base (HAFB) as is the Air Operation Control facility.

A.14.3 Features

The UTTR is one range but divided into north and south respectfully. The Army at Dugway Proving Grounds (DPG) is an MRTFB and host service for the south range. The Army and Air Force manage the DoD withdrawn lands that comprise the south range.. The DoD withdrawn lands, that comprise the north range, are managed by the Air Force. The 388th Range Squadron (388 RANS) is responsible for all air-to-ground test activities conducted there. Both DPG and Air Force restricted airspace as well as Military Operating Areas (MOA) airspace situated over Bureau of Land Management (BLM) land is managed exclusively by the Air Force. Hill Air Force Base (HAFB) and the Ogden Air Logistics Center is the host base for the UTTR, 388 FW and 419 FW (USAF Reserves). UTTR airspace overlays extensive BLM, Air Force, and U.S. Army withdrawn lands. The US Army DPG is situated beneath the airspace of the UTTR South Range. HAFB, an Air Force Logistics Center, manages aircraft, munitions, and intercontinental ballistic missiles.

A.14.3.1 Ground. UTTR encompasses over 2,739 square miles (1.8 million acres) of DoD land, of which 1,490 square miles are Air Force owned. The UTTR is primarily surrounded by public domain land and is not likely to be encroached upon in the foreseeable future. High-country deserts, undulating sand dunes, and mountains rising abruptly from the desert floor, and rolling hills building into mountain ranges characterize UTTR terrain. The topography is dominated by large expanses of flat lakebed. The UTTR is surrounded by mountains generally running north and south rising from 8,000 to 12,000 ft and separated by valleys with elevations of approximately 4,500 ft MSL.

A.14.3.2 Airspace. UTTR has the largest overland contiguous special use airspace, measured from the surface or near surface, within the continental U.S. (207 by 92 nautical miles). Of the total 12,574 square nautical miles comprising this area, 6,010 are restricted airspace and 6,564 are MOAs. The airspace is situated over 2,675 square miles of DoD land.

A.14.3.3 Climate. The climate of the UTTR is generally arid with no extended periods of extreme temperature. High temperatures average 98 degrees Fahrenheit during July, the warmest month of the year. The lowest average temperatures occur during January, hovering near 30 degrees Fahrenheit. Visibility and weather are excellent; 96 percent of hourly observations show ceilings of 3,000 feet or higher, and visibility of 3 miles or greater. Storms tend to be short in duration, with visibility exceeding ten miles during more than 95 percent of the year. Flight-testing may normally be carried out 350 days each year.

A.14.4 Facilities

A.14.4.1 Mission Control Center (MCC). MCC is located off-range at HAFB, the MCC processes, records, and displays all range information. State-of-the-art processors provide real-time displays allowing the MCC to monitor and control all test operations conducted on UTTR. Telemetry (TM) data that is encrypted at the source remains encrypted until it reaches the MCC. Time, Space, and Position Information (TSPI) data can be encrypted prior to transmission to the MCC.

A.14.4.2 Air Operations Center (AOC). AOC is located off-range at HAFB, this facility provides air traffic/weapons control through surveillance radar data from the Federal Aviation Administration (FAA) and the UTTR gap filler radars.

A.14.4.3 Training Operations Center (TOC). TOC is located on HAFB, this facility houses the Air Combat Maneuvering Instrumentation System (ACMI) that provides recording and playback of air-to-air training missions performed over the South Range and a smaller arena over the North Range.

A.14.4.4 Avery Technical Center. Avery Technical Center is located immediately east of Michael Army Airfield (MAAF) on DPG, this facility is the main support facility for repair, maintenance, logistics and administrative activities on the south range. Storage facilities are also available on a space available basis.

A.14.4.5 Wig Support Facility. Wig Support Facility is located on the range, this facility is the hub for most of the data and video signals entering and leaving the south range. Video, radar and telemetry data are routed to the appropriate systems and transmitted to the MCC for display and processing based on mission requirements.

A.14.5 Ranges

A.14.5.1 Training. Training opportunities abound at the UTTR. Seven different target complexes provide 330 tactical targets. Two air refueling tracks, supersonic areas, and Smokey Surface-to-Air-Missiles (SAM) are also available. Chaff and flare (self-protection) may be used with pre-authorization.

A.14.5.2 North Range Training Targets.

A.14.5.2.1 Craner's Tactical Target Complex. Craner's Tactical Target complex includes a landing strip with an aircraft, trucks, vans, factory, simulated AAA sites, and a SAM site. Conventional and simulated nuclear deliveries with inert heavy-case bombs and similar inert/training ordnance are authorized.

A.14.5.2.2 Eagle Range. Eagle Range is a manned, scored class A/B/C air-to-ground range consisting of two bomb circles, four strafe targets, and two applied tactics targets.

Conventional and simulated nuclear deliveries with inert heavy-case bombs and similar inert/training ordnance are authorized.

A.14.5.2.3 Helicopter Air-to-Ground Tactical Complex. The Helicopter Air-to-Ground tactical complex, commonly called the HAG, is a high explosive and inert training ordnance drop zone. A "Coffin Area" is at the southern end of the HAG. This area has a graded perimeter, which gives it a coffin-shaped appearance easily distinguishable from the air.

A.14.5.3 South Range Training Targets.

A.14.5.3.1 Baker's Strong Point tactical target complex simulates a fortified desert position. Targets consist of a 100-meter-long revetted area enclosed by a five-meter earthen wall. Within the area are ten revetted artillery positions available for interdiction training. A simulated SAM site, ICBM silo, tower, barracks, refinery, smelting plant, mining operations, fuel tanks, convoy, runway, and aircraft are located north of this target. Bomb deliveries with inert heavy-case bombs and similar inert/training ordnance are authorized.

A.14.5.3.2 Kittycat Live Tactical Target Complex. Kittycat live tactical target complex contains multiple armored targets, Precision Guided Munition (PGM) targets, and munitions storage bunkers. Conventional deliveries of high explosive ordnance with impact fusing are authorized.

A.14.5.3.3 Wildcat Tactical Target Complex. Wildcat tactical target complex has multiple targets located east, north, and northwest of Wildcat Mountain. The complex simulates an airfield with support facilities and area defenses. The Weapons Impact Scoring Set (WISS) provides scoring for bomb deliveries. Conventional and simulated nuclear deliveries with inert heavy-case bombs and similar inert/training ordnance are authorized.

A.14.5.3.4 Test. UTTR was created in 1979 for testing of cruise missiles. The large amount of land and airspace required has made large footprint weapons testing a natural follow-on. The testing of smart munitions, long-range standoff weapons, remote controlled/unmanned air vehicles, boost-glide precision guided munitions, air-to-air missiles, and autonomous loitering anti-radiation missiles have all been accomplished at the UTTR.

A.14.5.3.5 North Range Test Targets

Laser targets, available on both the north and south ranges, are designed to evaluate guidance systems of laser-guided conventional munitions and to enable training in use of laser-guided weapons. Munitions targets are used to test new munitions and conduct shelf life surveillance testing. Each target has been developed for a specific application for use with high explosive or inert munitions. These targets can support a wide range of requirements, including Cluster Bomb Units, runway penetration, and high-volume

propagation. The munitions test targets are generally located in the eastern portion of the north range. Target 24 consists of four graded rectangular pads and one large pad used for munitions propagation testing. Target 22 is a dual-purpose target. It is a 2,500-foot by 3,500-foot rectangle that can accept inert or training munitions and flares. Commonly called, "Big Papa," this propagation test area features a graded, hardened surface built to accommodate a wide variety of conventional munitions propagation tests.

A.14.5.3.6 South Range Test Targets. TS-1 is a target area used primarily as a cruise missile impact area. This target is generally used for cruise missiles equipped with non-tactical instrumentation kits. TS-2 is a 1,500-foot wide by 3,000-foot long hardened surface. This target is normally used for MK-82/84 class weapons. Guided weapons, CBU's and "live" high explosive weapons may be employed against this target. TS-3 is used for collecting ballistic data on all conventional munitions in the Air Force inventory such as laser-guided bombs and guided bomb units. This target consists of two target areas; each made from compacted earth pads measuring 150 feet by 250 feet. Videometric Analysis System (VMAS) and pan and tilt cameras are installed with remote control data connections back to the WIG support facility. A variety of remote control applications can be configured for the target including RF threat emitter control. This area is capable of supporting laser designation from aircraft or the UTTR ground based laser on site.

TS-4 (Sand Island) is a sophisticated, multi-spectral target area. This is a live fire area that can accommodate RF, laser-guided, or infrared seeking weapons with a host of targets. Targets include remote control armored vehicles, air defense radar's, communications transmitters, and others as required by projects. Twenty target pads are available within a four square mile area. Cameras are installed at target pads based on customer requirements. Features of this area also include remote CINE-T scoring, emitter remote control system, VMAS scoring, RF monitoring, and communications and control by fiber optic link. TS-4 is designed to provide a live fire test environment that realistically simulate the offensive or defensive threats an aircraft could experience in the modern battlefield. This target may be used to subject attacking aircraft to a realistic threat environment. Threats are remotely controlled for safety. The primary focus is to test HARMS in a live fire environment. Weapon systems tested could include all those that seek out and destroy threat systems and those that could be attacked by ground threats. A variety of unmanned weapon systems such as cruise missiles, unmanned air vehicles, air-to-ground missiles, and smart munitions can be accommodated.

The "J" target, a part of TS-4, is used for collecting impact data on Joint Stand-Off Weapons (JSOW), Joint Direct Attack Munitions (JDAM), Wind Corrected Munitions Dispenser, Sensor Fuse Weapon, Joint Programmable Fuse, and AGM-88. The area is a compacted pad measuring one mile in length and 60 feet in width. VMAS cameras, remote controlled pan and tilt cameras, and data connections to the center of the pad support the target area. Remote control and data connections are available back to the Wig support facility. A variety of remote control applications can be configured for the target including RF threat emitter control. In addition, heat plate augmented tank bodies

can be fabricated and placed along the edge of the roadway when requested by customers.

TS-5 is a new target complex designed to accommodate large footprint weapons. Our intent is to provide targets that are fixed, high priority, and heavily defended, for defense suppression in an operational test environment. The TS-5 complex offers a 360-degree attack axis and will accommodate weapons that have a maximum energy footprint in excess of 20 nautical miles. Test infrastructure includes targets, VMAS camera stands, Cine-T pads, fiber optic, and power cables. Other capabilities include trajectory and end game scoring data, both for day and night. In addition, a scoreable training target is planned for large footprint weapons.

The PGM area is used to collect ballistic data on various air-to-ground missiles such as AGM-65, AGM-130, and AGM-142. 12 VMAS cameras, remote pan and tilt cameras support the area, and multiple remote data control points in the area. Eight of the VMAS sites are configured to score drops on the static tank array surrounding the target. The remaining two VMAS sites are configured for scoring drops on the wide area targets built from C-containers to represent buildings. The area is capable of supporting a remote controlled moving tank. All remote control and video support cameras are routed back to the Wig support facility. A variety of remote control applications can be configured for the target including RF threat emitter control.

The CALCM target area (located just south of TS-1) is used for cruise missiles carrying live conventional warheads. The CALCM target pad is designed so that a hardened target can be built to the customer's specifications. The CALCM target area is used to collect Time Space Positioning Information and blast pressure data from CALCMs. Four VMAS cameras, one pan and tilt camera, data/remote control circuits, and a full pressure transducer measurement system support the area. All remote control and video support is routed back to the Wig support facility. Pressure wave data is recorded on site. A variety of remote control applications can be configured for the target including RF threat emitter control.

A.14.6 Instrumentation Infrastructure

A.14.6.1 Tracking Radar Systems Tracking radar systems provide TSPI to the UTTR MCC located at HAFB for use in real-time display systems, post-flight analysis, and for use as a pointing source for other range assets. The instrumentation radars provide real-time Cartesian and polar data to the MCC. Systems can acquire and track both skin and beacon targets. The tracking data is also used to point other tracking deices and provides range safety information.

A.14.6.2 High Accuracy Multiple Object Tracing System (HAMOTS). HAMOTS tracks, records, and displays TSPI data of up to 16 high-activity participants. TSPI data are displayed in real-time at the MCC, located at HAFB.

A.14.6.3 Telemetry. Telemetry systems at the UTTR include three fixed telemetry acquisition stations, one mobile single channel acquisition station, and three mobile single channel acquisition trailers. In addition, the UTTR has a ground station located near the flight line for flight line telemetry verification (pre-mission). The fixed telemetry acquisition stations are located at Granite Peak (8' Auto-track Dish), Grassy Mountain West (16' Auto-track Dish), and Wendover Peak (8' Auto-track Dish). The Mobile Telemetry Auto-track Acquisition System (MOTAAS) is a complete, self-powered, stand-alone system that can record pre-decomuttated telemetry streams or transmit acquired telemetry data via fiber optics or installed microwave link. MOTAAS is a fully deployable asset and has supported a number of off-site applications in recent years. All of the acquisition stations can auto-track on both L- and S- bands and omni on P-band and can insert data into the UTTR communications system for transmission back to the MCC.

A.14.6.4 Photo-Optics. UTTR can provide photographic support for TSPI, documentation of specific events or an overall project perspective. UTTR possesses 21 cinetheodolites (CINE-Ts), 3 cinesextants (CINE-Ss), and a very large array of motion and still cameras. Eight of the 21 CINE-Ts are also remotely configured to support test vehicles with large footprints that cannot be tracked safely with human operators. Eight of these remotely controlled CINE-Ts use Forward-Looking Infrared Radar (FLIR) cameras to acquire and track heat-emitting targets.

A.14.6.5 Microwave Communications. All data and video acquired on the UTTR are brought into the MCC through a high-tech fiber-optic and digital microwave communications network, which ties all instrumentation into a central control point. Data can be relayed intra-range and inter-range if required to meet program needs. New digital microwave system installations were completed in August 2002, linking nine key sites on the UTTR. In May 2003, a new high-tech Range Data Transport System (RDTS) fiber-optics network was completed, linking 17 range sites and dramatically increasing video capability via a complex optical multiplexing scheme.

A.14.6.6 Surveillance Radar. The 299th Range Control Squadron (299 RCS) using Federal Aviation Administration – AF owned Air Route Surveillance Radar's located at Cedar Mountain, Trout Creek, and Bovine Mountain to provide gap-filler coverage performs Air Traffic Control and Ground Control Intercept support of UTTR airspace. These radars provide surveillance of the central UTTR and Dugway Proving Ground areas and of the southern, northern, and western approaches to the UTTR. Surveillance and air traffic data from these radars is available for situational awareness to UTTR users, exercise planners, FAA, NAF, AOC, WADS, and MAJCOM facilities as requested.

A.14.6.7 Air Combat Maneuvering Instrumentation (ACMI). ACMI is an instrumentation tracking system for aircraft involved in air-to-air controlled, simulated-weapons training exercises. The system tracks aircraft equipped with a modified P4 HUS Airborne Instrumentation Subsystem (HAIS). The UTTR ACMI System provides real-time monitoring of aircraft position, flight dynamics, weapon status, and firing parameters. Significant performance data is relayed via a communications network from

the MCC to building 3 to be displayed in real-time and recorded for pilot debriefings. Building 3 has two separate debriefing rooms with large screen, high graphics displays. Both debriefing rooms contain complex audio/video equipment to enable pilots to view their Heads Up Display (HUD) tapes. Ultra-high frequency (UHF) radio equipment enables the RTO to communicate essential flight information, mission results, and advisory data to flight leader and aircrews and enables the 299 RCS to communicate Air Traffic Control (ATC) information to aircrews. All flight data and communications are recorded on tape for post-mission replay and debriefing.

A.14.6.8 Test Evaluation Command & Control System (TECCS). TECCS is a display system, which uses available FAA and tracking radar data to monitor range traffic during real-time missions. Additional TSPI sources may be provided by the Advanced Range Data System (ARDS) central processor. TECCS also provides pointing data to target acquisition equipment and is a source of target solutions that may be used in the event the primary TSPI processor fails.

A.14.6.9 ARDS. ARDS is a next generation TSPI system that uses the Global Positioning System (GPS). Each participant must be equipped with either an ARDS pod or plate. Satellite data are collected by the participant and processed along with ground-based reference receiver data that are then transmitted to the MCC. Both raw and processed data are linked to the MCC via the Data Link System, where it is processed further, displayed, and recorded for post-flight processing.

A.14.6.10 Weapon Impact Scoring Set (WISS). WISS provides scoring information for ordnance dropped on numerous complexes throughout the range, including targets located at the Wildcat and Kittycat, Baker Strong Point, Craners, and Eagle target ranges. WISS is designed to provide support in training pilots and aircrews in the delivery of air-to-ground ordnance against fixed or moving targets. WISS is an electro-optical instrumental system designed to accurately measure the impact location of air delivered ordnance with respect to the target center. WISS typically consists of two camera groups that cover the scoring area. Video is sent from the camera groups to a master console located at the Avery Complex on Dugway Proving Ground and is electrical scored in either automatic (<10m accuracy) or manual (<3 accuracy) modes. With the exception of Eagle and Kittycat target areas, all WISS target ranges now have precise infrared scoring cameras for true night scoring capability with or without weapon spotting charges. Night scoring at Eagle and Kittycat can be accomplished with spotting charges only.

A.14.6.11 Video Calibration and Analysis System (VCAS). VCAS is a computer-controlled video measurement system that is used for terminal area scoring. It uses calibrated, Inter-Range Instrumentation Group B synchronized, fixed field of view video cameras to provide three-dimension point in space, attitude, and two dimension data. Various static arena sizes can be supported depending upon the size of the object of interest and the required data accuracy.

A.14.6.12 Threats

A.14.6.12.1 AN/MST-T1A Multiple Threat Emitter Systems (MUTES). MUTES is a computer controlled, multi-emitter system designed to transmit simulated threat signals. MUTES track aircraft using Identification Friend of Foe (IFF), and has a limited TV tracking ability. Using keyboard entry, the operator selects programmed threat scenarios or manually selects individual signals. The computer can store up to 120 different threat signals and can radiate up to five signals at one time. The MUTES does not receive or react to aircraft jamming; scenarios are advanced based on programmed time intervals or aircraft range from the site. Mini-MUTES is a smaller, more mobile version of the MST-T1A MUTES. Each master control group at a radar bomb-scoring site can control up to 10 remotely positioned pedestals. There are six mini-MUTES in three configurations that combine transmitters identical to those used in the larger MUTES, but each pedestal is designed to radiate only a particular threat family of signals or acquisition signals. Acquisition and tracking is accomplished by a built-in IFF system.

A.14.6.12.2 AN/MSR-T4 Threat Reaction and Analysis System. AN/MSR-T4 is a mobile system consisting of a single van capable of receiving electromagnetic transmission for 0.03 Hertz (HZ) to 18.0 Gigahertz (GHZ). The system is deployed with the MST-T1A MUTES and receives electromagnetic emissions from airborne and ground electronic warfare (EW) equipment through a single omni-directional and four directional antennas. The antennas are slaved to the MUTES tracking system and collect data necessary to evaluate airborne and ground EW equipment emissions.

A.14.6.12.3 Remote Smokey Surface to Air Missiles (SAMs). SAMs are installed at Baker's Strong Point, Wildcat, and Craner's target sites. Each site is capable of launching up to 48 Smokey SAMs. All Smokey SAMs can be launched from a single point, currently Clover Control on Hill Air Force Base. Remote control capability allows Clover Control to perform correlated launches based on aircraft location and mission. A mobile Smokey SAM launcher is available for use based on mission requirements.

A.15 AIR FORCE FLIGHT TEST CENTER (AFFTC)

A.15.1 Mission

The Air Force Flight Test Center at Edwards Air Force Base, California, is the Air Force Materiel Command center of excellence for research, development and test and evaluation (RDT&E) of aerospace systems for the United States and its allies. As a Major Range and Test Facility Base (MRTFB), develops, operates and manages the Edwards Flight Test Range (EFTR). It operates the U.S. Air Force Test Pilot School and is home to NASA's Dryden Research Center and to considerable test activity conducted by America's commercial aerospace industry. From the development of the country's first jet aircraft to the Air Force's newest fighter, the F/A-22 Raptor, the test forces at Edwards have played a role in the development of virtually every aircraft to enter the Air Force inventory since the World War II. With the Center's capability of just-in-time

testing, Edwards can provide real time solutions during combat operations. This combat support establishes the Flight Test Center's direct and tangible link to the warfighter.

Guiding this considerable tasking is the Air Force Flight Test Center Headquarters. Led by a two-star general and his command section, Flight Test Center staff agencies include comptroller, contracting, environmental management, history, information technology, inspector general, intelligence, plans, protocol, public affairs, safety, small-business office and the staff judge advocate office.

The two major organizations carrying out the Center's mission are the 412th Test Wing and the 95th Air Base Wing, with their mix of more than 5,500 service members and government employees. The 412th Test Wing manages the Center's flight operations programs and functions. In doing so, it manages all engineering support for manned and unmanned aerospace vehicle test programs. With many different types of planes operated by the 412th aircrews, the Edwards flight line takes on an almost expeditionary aerospace force look. The aircraft flown here include the B-1B, B-2, B-52, C-12, C-17, NKC-135, KC-135, CV-22, F-15, F-16, F/A-22, F-117, T-38 and T-39. Additionally the Global Hawk unmanned aerial vehicle and L-23 glider are tested at Edwards. The Airborne Laser 747 test platform is currently undergoing development and modifications for testing and in 2005 the X-35 Joint Strike Fighter aircraft will be tested here. Additionally, the 412th Test Wing programs, develops, operates and maintains engineering technical services and facilities to support testing, as well as operates and manages logistic support.

A.15.2 Location

AFFTC is located at Edwards AFB, about 161 km/100 miles northeast of Los Angeles, on the western edge of the Mojave Desert.

A.15.3 Features

A.15.3.1. Topography. AFFTC has 65 mi^2 of usable landing area with runway lengths up to 12 km/7.5 mi. Numerous dry lakebeds suitable for emergency landing exist throughout the southwest test range area. Within the restricted airspace lie the highest point and the lowest point in the continental United States.

A.15.3.2 Airspace. R-2508 California Restricted Area (12,000 ft. to unlimited) with military operating area and forward air traffic control assigned airspace, extends approximately 209 km/130 nautical miles north, 48 km/30 nautical miles east, and 64 km/40 nautical miles west of Edwards AFB. Joint management is by AFFTC, Naval Air Warfare Center, and the Army National Training Center. Radar approach control is netted to all mission control centers. Air traffic control exists (surface to unlimited) throughout most of the R-2508 complex. Data links interconnect airspace and technical capability at Naval Weapons Center, Pacific Missile Test Center, and Western Space and Missile Center. The ability to link these centers allows testing in an Air, Land and Sea environment from one location.

A.15.3.3 Capabilities. The Flight Test Center conducts aerodynamic tests, such as performance and flying qualities evaluations, as well as significant avionics systems testing. The capability to test and evaluate subsystems and to perform total weapon system evaluations has also existed since the mid-1950s. Each subsystem is evaluated to determine performance, function with other systems in a mission environment without interference, and effects on the total weapon system. Reliability and maintainability and technical order verification of each subsystem as well as the operational capability of the total weapon system are assessed. The Flight Test Center has the capability to do loads and flutter testing, airdrop/parachute testing, human factors evaluations, and health and environmental engineering test and evaluation. The Electronic Warfare Directorate operates the Avionics Test and Integration Complex (ATIC), which includes simulators, avionics integration test facilities, and an anechoic chamber. The Flight Test Center also conducts research and development necessary for improvement and modernization of ranges, facilities, test techniques and supports the Space Shuttle landings. Development of the capability to test and evaluate the atmospheric flight aspect of future manned vehicles is a continuing effort.

A.15.4 Facilities

A.15.4.1 Ridley Mission Control Complex (RMCC). The Range Division operates the Edwards Flight Test Range and associated facilities at Edwards AFB and is responsible, through the Engineering Directorate, to the 412th Test Wing and to the AFFTC Commander. The Range Division hosts the 412th Test Wing's operations. The RMCC serves as the functional and administrative headquarters for the Range Division. Its primary mission is to serve as the command and control center for all flight test missions at the AFFTC. Aircraft ground tests, flight tests in the local area, or flight tests at distant test ranges can be monitored in any of the RMCC's mission control rooms. The focus of RMCC activities is on real-time collection and display of flight test information, but pretest planning and preparation, and post-mission data processing and analysis are also performed here. The following systems/capabilities are located in the RMCC and are used to support the Range Division mission: Real-Time Telemetry Data Processors, Mission Control Rooms, Communications Switch, Post flight Data Processors, Master Timing Station, Air Traffic Control and Monitoring, Time-Space-Position Information (TSPI) Processing and Analysis, Radar Data Recording and Processing, Global Positioning System (GPS), Video Bomb Scoring System, Video Control Center, Computer Training Facility, Test Evaluation Command & Control System (TECCS), Horn Antennas, Optical Tracker Data Processing, Laser Tracker Data Processing, Telemetry Receivers, Communication, Video, Timing and Infrared Resolution Ranges.

A.15.4.2 Data Acquisition and Reduction Facilities. Instrumentation engineering, range facilities, airborne and ground photography, television and various specialized range instrumentation as well as large-scale digital computers are available.

A.15.4.3 Avionics Test and Integration Complex (ATIC). ATIC possesses three collocated ground test facilities, these are: Test and Evaluation Modeling and Simulation

(TEMS) Facility, Integration Facility for Avionics Systems Testing (IFAST), and Benefield Anechoic Facility (BAF).

A.15.4.4 Test and Evaluation Modeling and Simulation Facility (TEMS). TEMS Facility provides developmental test and evaluation (DT&E) and operational test and evaluation (OT&E) flight test programs with virtual, piloted real-time and constructive, non-real-time simulations. TEMS primarily supports airframe-propulsion-avionics and electronic warfare mission areas by providing full digital simulations to the test and evaluation process. The precise control, flexibility and repeatability of these simulations are paramount in implementing a predict-test-compare and update philosophy leveraging knowledge gained through ground testing before implementing a flight test methodology. TEMS provides a full range of constructive, non-real-time simulations ranging from campaign to mission, engagement, and engineering levels. Based on customer needs, TEMS can model a myriad of simulations focusing on different types of evaluations.

The TEMS can model a multi-day, theater level campaign, simulating a force-on-force, air-land battle. Where mission level metrics are required, TEMS has the ability to model air superiority and survivability to simulate a many-on-many, air-land battle using SUPPRESSOR and the Digital Integrated Air Defense Systems (DIADS). The DIADS at TEMS, will provide a hardware-in-the-loop capability for evaluating operational effectiveness of electronic combat components in a real-time simulated enemy integrated air defense systems (IADS) environment. DIADS is the follow-on core simulation system of the Real-time Electromagnetic Digitally Controlled Analyzer Processor (REDCAP) facility which was previously located in Buffalo, New York. The new DIADS facility at Edwards will incorporate the hardware-in-the-loop subsystems previously located at REDCAP. The hardware-in-the-loop subsystems allow man-in-the-loop operations within the IADS command and control structure.

A.15.4.5 Integration Facility for Avionic Systems Testing. The Integration Facility for Avionic Systems Testing (IFAST), provides a secure, safe, and cost-effective environment for operator-in-the-loop and hardware-in-the-loop integration laboratories to evaluate hardware and software interactions with the entire test vehicle's avionics suite. Orders of magnitude of cost reductions are achieved in comparison to flight test and many ground tests can be accomplished that otherwise would be unsafe or impractical to achieve in flight. The ultimate purpose of the integrated ground and flight test approach supported by the IFAST, is avionics performance risk reduction and cost-effective ground test capabilities, for a systematic approach toward the development of operational flight test programs and advanced avionics hardware.

The IFAST provides unique facility capabilities, the most important of which include: reconfigurable hardware-in-the-loop avionic and radar spread benches; 24 hour test operations year-round with no weather, environmental, facility or operating hour restrictions; existing test bays are cleared for open storage and are designed to accommodate classified testing up to and including Secret and SAR; local area networks; and inter-bay video transmission lines.

A.15.4.6 Benefield Anechoic Facility (BAF). The BAF supports installed systems testing for avionics test programs requiring a large, shielded chamber with radio frequency (RF) absorption capability that simulates free space. The BAF is an ideal ground test facility to investigate and evaluate anomalies associated with Electronic Warfare (EW) systems, avionics, tactical missiles and their host platforms. Tactical-sized, single or multiple, or large vehicles can be operated in a controlled electromagnetic (EM) environment with emitters on and sensors stimulated while RF signals are recorded and analyzed. The largest platforms tested at the BAF have been the B-52 and C-17 aircraft. The BAF supports testing of other types of systems such as spacecraft, tanks, satellites, air defense systems, drones and armored vehicles.

The BAF equipment generates RF signals with a wide variety of characteristics, simulating red/blue/gray (unfriendly/friendly/unknown) surface-based, sea-based, and airborne systems. With the combination of signals and control functions available, a wide variety of test conditions can be emulated. Many conditions that are not available on outdoor ranges can be easily generated from the aspect of signal density, pulse density and number of simultaneous types. Through the use of environmental monitoring systems, an independent agency captures, records, and verifies RF generated signals. These systems have the capabilities for real-time and post-test RF signal parameter measurement, instrument display recording, data analysis and test coordination, as well as providing the data for signal verification. Fiber-optic links interconnect the integration laboratories, the Test and Evaluation Modeling and Simulation Facility, Integration Facility for Avionics System Testing, and the Benefield Anechoic installed systems test facility.

A.15.4.7 Air Force Electronic Warfare Evaluation Simulator (AFEWES). AFEWES provides a hardware-in-the-loop (HITL) simulation capability designed to evaluate electronic combat systems performance against terminal threat systems. AFEWES has 27 closed-loop surface-to-air missile simulations, a Reconfigurable Airborne Interceptor Simulation, and Infrared Laboratory to evaluate infrared countermeasures equipment, and an open-loop Multiple Emitter Generator to evaluate radar warning receivers and/or power managed ECM systems.

The AFEWES is a major HITL electronic combat test facility located at Air Force Plant 4 in Ft. Worth, TX, managed by AFFTC. The mission of the AFEWES is to provide technical evaluations of EC systems (ECM systems, RWRs, decoys, IRCM systems, flares, etc.) and techniques in simulated RF and IR threat environments. All services and allies have used the AFEWES in every phase of the EC system life cycle from concept development through operational changes. The key features of AFEWES combine actual frequency, real-time, and man-in-the-loop testing with the capability to evaluate effectiveness in a dense background environment.

AFEWES simulators are linked to the Lockheed Ft. Worth company-owned Flight Simulator Lab and Tactical Warfare Simulator (TACWARS). Through TACWARS, AFEWES has been linked to the Open Air Flight Test Ranges and has the capability to link to other Government T&E facilities. AFEWES has a large group of surface-to-air

missile, airborne interceptor, IR missile, early warning/acquisition radar, communication/data link, C3, and AAA "closed-loop" simulations available for jammer/receiver evaluations. The AFEWES also has an open-loop simulator, the multiple emitter generator (MEG) that is used to evaluate radar warning receivers and the receiver section of jammers. Measures of performance data for the closed-loop simulators include miss-distance and tracking error data. Measures of performance data for the MEG include such receiver performance data as emitter detection, identification, frequency measurement accuracy, PRI measurement accuracy, receiver response time, and ECM resource allocation.

In addition to the closed-loop and open-loop simulations listed above, AFEWES has such instrumentation assets as: (1) The Test Director System, which includes five Test Management Centers (TMC) and one Test Observation Center (TOC). Each TMC consists of eight digital strip chart recorders, five video monitors, and two video recorders. The TOC consists of a large screen display and four video monitors; (2) The Bus Snapshot Analyzer (BSA) which is used to record EC receiver data during a MEG test. Other AFEWES assets include an RF and IR jammer techniques simulator and an RF clutter generator.

A.15.4.8 Test Stands

A.15.4.8.1 Multi-Axis Thrust Stand (MATS). MATS is located on Lakeshore Drive, just North of the NASA Facilities at Edwards AFB, CA. The MATS is comprised of three vertical poles and a horizontal Tee-frame. The test article is suspended using the Tee-frame and then raised (per customer requests) from ground level to 75 feet to reduce ground effects interference when measuring thrust and control surfaces data. The Tee-frame is raised & lowered by a crane. The vertical poles and the Tee-frame are instrumented with strain gages and three-axis accelerometers to monitor the structural strains and loads for the safety of the stand. There are video cameras on the Tee-frame and mobile cameras on the pad area also. These safety systems are monitored and recorded real time. The MATS facility has a weather station and GPS time, also available for time and weather correlation of thrust and safety data. The data files are provided to the customer in character delimited formats for easy import into the customer’s data reduction applications on a Zip disk, VHS tape (video), CD Rom, or DVD. There is a Data monitor system in a separate facility for additional personnel and to review test data after the test is completed and before test article is removed from stand.

A.15.4.8.2 Rocket Vehicle Integration Test Stand (RVITS). The AFFTC, in conjunction with NASA Dryden and the Air Force Research Laboratory (AFRL), has rehabilitated the historic X-15 Rocket Engine Test Facility (RETF) to become the new Rocket Vehicle Integration Test Stand (RVITS). RVITS supports integrated systems testing of rocket-powered flight vehicles, including hot firings of the propulsion system. This facility supports the basic operational requirements of new or highly modified aerospace vehicles. RVITS may be used to demonstrate flight readiness, troubleshoot

problems, determine airframe/engine integration effects, and verify control system integration with engines. RVITS supports both manned and unmanned vehicle tests. RVITS is a LOX compatible site with a mechanical tie-down structure for confining the vehicle being tested. Trenching directs deluge water toward a containment sump, away from the vehicle. A nearby concrete bunker is available for use as a control room for RVITS test personnel.

A.15.4.8.3 Aircraft Horizontal Thrust Measurement System (AHTMS). AHTMS is located on Pad 18 at Edwards AFB, CA. The AHTMS is comprised of three single axis horizontal platforms capable of measuring in excess of 100,000 pounds of thrust each. Each platform may be used independently or in concert with the others resulting in a total measurement capacity in excess of 300,000 pounds of thrust. The AHTMS is computer controlled from an adjacent underground bunker and will provide the customer with real time aircraft thrust and weather data in both hard copy and data file formats. The data files are provided to the customer in character delimited formats for easy import into the customer's data reduction applications. Communications with the installed test article is provided via VHF/UHF radio and communication with ground personnel is available via a ground intercom system. GPS time tagged video is also available and is provided to the customer in standard VHS format.

A.15.4.9 Hangar Complexes. AFFTC has nineteen aircraft hangar complexes, three with two hangar bays, which include office space for engineering and administrative personnel, shop, and laboratory spaces. Thirteen hangars are located on the Main Base, four at the North Base, and two at the South Base. Hangars for classified programs are also available.

A.15.4.10 Additional Facilities. Additional facilities available at the AFFTC to support flight-testing include a Weight and Balance Facility, a 300'x 200' hangar with four flush mount scales built into the floor. Each scale is calibrated to 280,000 lbs. We can perform weight and balance operations on large and small aircraft. The B-1, B-2, B-52, KC-135, L1011, KC-10, F-15, F-16, T-38, X-38, X-34, SPACE SHUTTLE are just some of the aircraft that we have worked. We also have a Subsonic Airspeed Calibration Facility.

A.15.5 Ranges

A.15.5.1 Take-Off and Landing Facility. This facility incorporates uninterrupted photographic time-space- positioning data on a 300 foot wide by 15,000-foot long main runway, with transition to Rogers Dry Lake.

A.15.5.2 Three Supersonic Corridors. These corridors include the High Altitude Supersonic Test Corridor (30,000 ft to unlimited), the Black Mountain Corridor (500 ft to 30,000 ft with maneuvering area) and the Alpha Corridor Supersonic Lane.

A.15.5.3 Aircraft Spin Areas. Four aircraft spin areas exist with two being instrumented from 10,000 ft mean sea level to unlimited altitude.

A.15.5.4 Precision Impact Range Area (PIRA). The PIRA is located in the southeast portion of the Edwards reservation, covering approximately 75 square miles, and is subdivided into the West Range, the East Range, and the PB-6 Range. Each of the three Ranges can be scheduled individually or in conjunction with one another depending on mission requirements. The PIRA supports the conduct of air-to-ground gunnery, photo and infrared resolution, spin testing, aerial decelerator test, tests requiring precision instrumentation, and precision bombing (PB) tests. Supersonic approaches to the PIRA below 15,000 feet MSL are restricted to the Alpha Corridor (west to east), which may be scheduled in conjunction with PIRA missions. The Alpha Corridor begins at the Southwest corner of the Edwards AFB reservation and extends to the western boundary of the PIRA.

A.15.5.5 Photo and Infrared Resolution Range. Targets include a variety of factual aircraft, land vehicles, tanks, missiles, guns and bunkers.

A.15.5.6 Radar Fidelity and Geometric Range (RADFAG). Various arrays of radar reflectors and a wide assortment of corner reflectors for forward and side-looking radar testing. Subsonic and supersonic runs against these arrays are possible from low to high altitudes.

A.15.5.7 Terrain Following Radar Course. A ground track charted with a Class 1 survey with survey points at every one-foot change in elevation. Over flight data are digitized and provided for post flight analysis.

A.15.5.8 Data Acquisition and Transmission System (DATS). The DATS is a network of microwave and fiber optic transmission systems used for relaying real-time telemetry, video, radar and communications data. The DATS network consists of six segments know as Range DATS (RDATS), China DATS (CDATS), West DATS (WDATS), North DATS (NDATS), Goldstone DATS (GDATS) and East DATS (EDATS). The DATS network is supplemented by the Navy Joint Intra-range Microwave Systems (JIMS), which add additional bandwidth capability between the Air Force and Navy ranges.

A.15.5.8.1 RDATS. RATDS is the local Edwards Air Force Base (EAFB) Range network, which primarily consists of an OC-48 SONET network utilizing the Asynchronous Transfer Mode (ATM) technology. This technology allows for bandwidth efficiency as well as the availability of a guaranteed Quality of Service (QOS). This network connects all EAFB Range assets and buildings as well as the remote DATS locations into one central network with broadcast capabilities.

A.15.5.8.2 CDATS. CDATS connects the Naval Air Weapons Center (NAWC) at China Lake to RDATS at EAFB. This system is digital and is capable of transferring up to three DS-3 channels of data or 135 Mb/s. This system currently utilizes an electrical interface. This system also has three wayside T1s available for traffic assignment.

A.15.5.8.3 WDATS. WDATS connects the Western Range (WR) through Vandenberg Air Force Base to the RDATS at EAFB. This system is digital and is capable of transferring up to three DS-3 channels of data or 135 Mb/s. This system currently utilizes an electrical interface. This system also has three wayside T1s available for traffic assignment. Pt. Mugu NAWC is connected into this system for data transmission to EAFB. The Pt. Mugu bandwidth is limited to one DS-3 or 45 Mb/s. Additional bandwidth is available through the Navy JIMS network.

A.15.5.8.4 NDATS. NDATS connects Nellis AFB to the RDATS network at EAFB. This system is digital and is capable of transferring an OC-3 of data or 155 Mb/s. This system utilizes an optical interface. This system also has three wayside T1s available for traffic assignment.

A.15.5.8.5 GDATS. GDATS is a joint Navy/Air Force system that connects the remote telemetry site at Goldstone to the NAWC and EAFB. The GDATS system is digital and is capable of transferring an OC-3 of data or 155 Mb/s. This system utilizes an optical interface.

A.15.5.8.6 EDATS. EDATS connects EAFB to White Sands Missile Range (WSMR) in New Mexico. This system is digital and is capable of transferring an OC-3 of data or 155 Mb/s. This system utilizes an optical interface.

A.15.5.9 Aircraft Instrumentation. Air vehicle flight test measurement systems are designed, installed, and supported by the Instrumentation Division. Its primary mission is to provide the Truth Data used for Test and Evaluation of aircraft at the AFFTC. The division provides services ranging from measurement consulting to managing instrumentation development projects and provides the evaluators with the independence, knowledge and understanding of the instrumentation providing the data, so an accurate and unbiased Evaluation can be made of the vehicles being tested. Prime capabilities include:

A.15.5.9.1 Aircraft Instrumentation/Measurement Verification. The Instrumentation Division has the people and expertise that provide the flight testers with the measurement system knowledge and data that enables them to perform their Evaluation job. The flight testers must be confident that the data provided is true and accurate. Division personnel manage instrumentation projects and provide the independence, knowledge and understanding of the aircraft instrumentation from the basic design and fabrication through the installation, operation and maintenance.

A.15.5.9.2 Aircraft Instrumentation Modification and Operations. Division instrumentation operations engineering personnel, who are working directly for the customers, provide a direct link for determining and satisfying the customer's requirements. They are part of the customer, so are expected to be part of the solution. The Division provides extensive knowledge on current systems, as well as having the organic capability for advanced planning and development of systems for the future. The knowledge includes design, installation, test and operation of numerous different

instrumentation systems on a wide variety of aircraft. This is a unique capability that is not available in the private sector. AFFTC instrumentation personnel give advice to many companies to the benefit of the DOD. Our operations personnel are empowered to provide whatever support is required to accomplish the missions.

A.15.5.9.3 Special Equipment Acquisition. The instrumentation operations team provides a one-stop shopping location for the customer to satisfy their entire instrumentation system and ancillary support equipment needs. This includes acquisition of all instrumentation system components from multiple vendors and suppliers via existing contracts, drawing from our extensive in-house quick-reaction stock, or borrowing from other government agencies. When the customer provides his own equipment, often through the aircraft contractor, the instrumentation operations team will acquire or develop, using the extensive resources of the Instrumentation Division, supplementary equipment and systems, hardware and software, to provide a completely operational and responsive data acquisition capability.

A.15.5.9.4 Instrumented Test Support Fleet. The instrumentation division supports a wide variety of general test support aircraft that includes both specially instrumented and production F-15, F-16, T-38, C-21, and other aircraft types. Many of these aircraft have been extensively modified with an airborne data system to collect avionic bus or sensor data. Several are configured as generic test beds to support quick reaction instrumentation requirements. The AFFTC also operates several specialized pacer aircraft used to evaluate test aircraft airspeed instruments. Some aircraft are equipped with telemetry re-radiation capability, originally modified in support of B-2 and Cruise Missile programs, to retransmit and/or record airborne telemetry data. The Instrumentation Division provides data system support to the two major refueling aircraft in the Air Force inventory, the KC-135 and the KC-10. The division also provided the data systems for the KC-135R airborne icing tanker (AIT). The AIT was modified to carry two 1000-gallon water tanks, a pump pallet, a 3-bay control console, a highly modified boom for use in conducting in-flight water-spray and icing tests. Water is pumped to a 3 1/2 foot-diameter icing array mounted in place of the fuel nozzle on the modified air-refueling boom. Engine bleed air is used to atomize the water exiting the array nozzles and keep the water from freezing. These modifications made it possible to artificially create icing or rain clouds in a small controlled area behind the tanker for evaluating test aircraft environmental protection systems and other critical areas such as engine inlets and windshield surfaces.

A.15.5.9.5 Measurement Research and Development. The Instrumentation Division supports an extensive research and development capability. Utilizing government labs, university grants, and research funds available we typically spend between 1 and 2 million dollars annually on specific instrumentation R&D. The results of these efforts are used to benefit our customers and improve our test capability at the Air Force Flight Test Center (AFFTC). We have a continuing program for the advanced planning of new requirements, developing test capabilities, acquiring new systems and implementing capabilities to satisfy current and future customers.

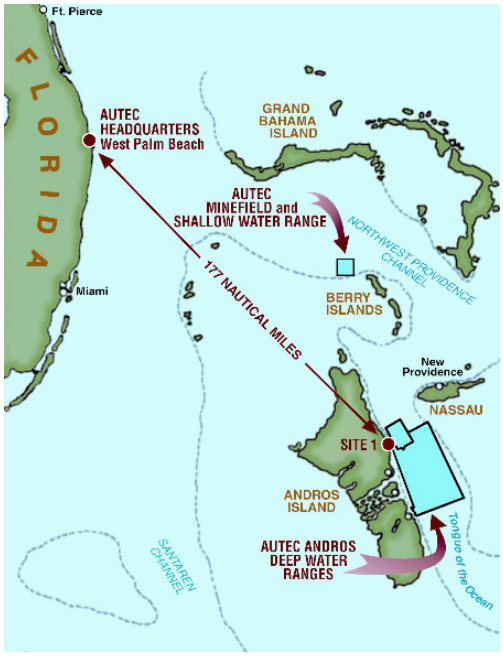
A.16 ATLANTIC UNDERSEA TEST AND EVALUATION CENTER (AUTEC)

A.16.1 Mission

Provide a full spectrum of undersea deep and shallow water test and evaluation facilities supporting underwater acoustic measurements, testing and calibrating sonars. Accurate underwater, surface and in-air tracking data on surface ships, submarines, aircraft and weapons systems is provided in support of the Navy's Anti-Submarine Warfare (ASW) Research, Development, Test and Evaluation programs. AUTEC also provides similar support to the navies of the NATO nations.

A.16.2 Location

AUTEC is headquartered in Newport, Rhode Island. The engineering and administrative offices, located in West Palm Beach, Florida, support range test planning, logistic and administrative services. Range and Test Operations facilities are located on Andros Island, approximately 328 km/177 nautical miles to the southeast, at Andros Island and the Tongue of the Ocean (TOTO) in the Bahamas.



A.16.3 Features

A.16.3 1 Organization. AUTEC is a detachment of the Naval Undersea Warfare Center (NUWC) and a component part of the Naval Undersea Warfare Center Division, Newport (NUWC Division, Newport), Rhode Island. The range OPAREA coordinator/scheduling authority is Commander, Naval Undersea Warfare Center Division, Newport, Rhode Island.

A.16.4 Facilities

A.16.4.1 In-Water Tracking. Provided by a network of bottom-mounted hydrophones connected to shore sites where acoustic signals are processed, recorded, and subsequently displayed in the Command Control Building at Site 1. Tracked objects must be instrumented with acoustic transmitters (e.g., pingers) whose frequency and pulse repetition rates are compatible with the hydrophone tracking system. The in-water system can provide finite geographical position and true motion data in three dimensions,

as well as inter-object relative motion and position data for up to 15 objects simultaneously.

A.16.4.2 On-Range Displays. In-water/in-air tracking displays can be provided to vessels operating in the TOTO using a range provided portable computer with receiver and modem. The portable system can be carried aboard vessels on-range to receive selected tracking data and transmitted via an encrypted RF link from the shore-based track processing and display system.

A.16.4.3 Sonobuoy Tracking System (STS). The STS is a RF interferometer triangulation system, which enables standard configuration sonobouys, deployed by user platforms during ASW exercises, to be tracked on AUTEC's main 3-dimensional tracking range. The STS can track any of the 99 standard sonobuoy frequencies (Channels 1 through 99) but is limited to a maximum of 40 channels at any one time. Channels that are to be tracked must be "assigned" by the STS Controller with the appropriate console commands. The system samples all assigned channels sequentially requiring 0.64 seconds for each channel. Updated sonobuoy positions are thus obtained approximately every half-minute for the maximum of 40 channels and more frequently when fewer buoys are assigned. STS position accuracy for sonobouys is approximately 14m.

Aircraft Sonobuoy Simulation/Stimulation System (AS3) system provides the capability to create a realistic simulated USW threat prosecution and operating environment for ASW aircraft. The AS3 system is comprised of an AN/SRQ-4 Hawklink transceiver coupled to an acoustic simulation system capable of generating actual sonobuoy RF transmissions. The system is currently capable of generating eight channels of simulated sonobuoy RF through a seamless interface with SH-60B and MH-60R aircraft via organic tactical equipment. Expansion of the system to include a P-3C aircraft interface and 32 channels of sonobuoy simulation is being evaluated.

A.16.4.4 In-Air Tracking Systems

A.16.4.4.1 Large Area Tracking Ranges (LATR). A differentially corrected GPS tracking system using standardized instrumentation packages fitted to ships and aircraft. The manufacturer accuracy specification is 8m/25 feet in X and Y, 15m/50 feet in Z. LATR is designed to provide low cost, multiple target, airborne and surface craft tracking capability.

A.16.4.4.2 Multi-Mission Surveillance Radar (MMSR). MMSR is a tracking and surveillance radar is currently being installed. Once installation is completed, the MMSR will be able to detect and track targets from a minimum of 35 ft altitude to a maximum of 10,000 ft; over a dynamic range of 0 to 250 knots. Target Reporting Accuracy will be better than 25 meters.

A.16.4.4.3 Acoustic Measurement System. AUTEC has several systems used for the acquisition of ambient and radiated noise data at sea: Deployable Noise Measurement (DNM) System; Portable Measurement System (PMS); and, Portable Sonobuoy Measurement System (PSMS). The acoustic data is processed in a variety of data

formats, including spectrum level, narrowband, 1/3 octave, octave, LOFAR, and strip chart. In addition, data may be Doppler and/or ambient-corrected.

A.16.4.5 Sensor Accuracy Testing. Sensor accuracy test capability is provided for assessing the azimuth, bearing and/or range accuracy of navigational and target acquisition, localization and tracking sensors installed aboard surface ships, submarines and helicopters. Sensors tested include sonars, surface search radars, gun/missile fire control radars/optics, Electronic Surveillance Measure (ESM) equipments, gyro-compasses/sins, periscopes, etc.

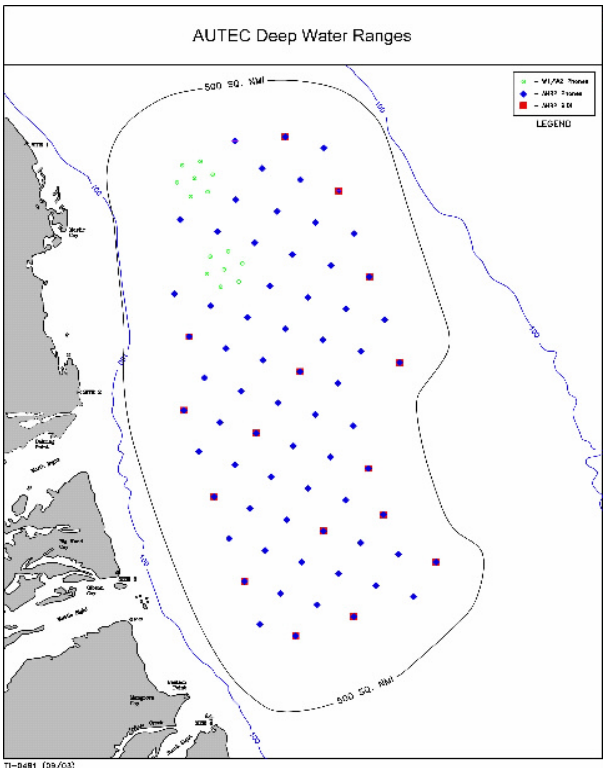
A.16.4.6 Underwater Range Data Communications (URDC). URDC provides secure digital communications between submerged submarines and the AUTEC range operations center through the vessel's acoustic tracking pinger. The Multi-Link Simulation Test and Training Tool (MLST3) provides the capability to evaluate Navy tactical data link performance on ships, submarines and aircraft. The initial capability supports Link 11 and Link 16 with the capability to support future expansion to Link 22 and OTCIXS.

A.16.4.7 Electronic Support Measures (ESM) Threat Simulator System.

This electronic warfare radar signal simulation system provides a dynamic and complex real-time electromagnetic signal environment as part of the AUTEC open air and instrumented underwater test range. Scenario simulation is fully dynamic, including range-based emitter mode transitions. The ESM electronic warfare simulation capability is fully integrated with range tracking and data systems and provides 150 square nmi of coverage over the instrumented range, sufficient to test any system within the coverage of high-accuracy in-air and in-water tracking.

A.16.5 Ranges

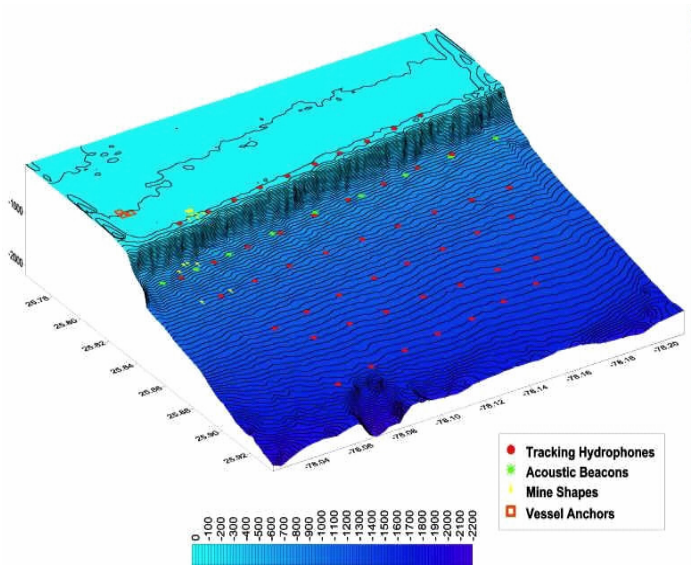
A.16.5.1 Deep Water Range



The Deep Water Range is located in the TOTO. This basin is bounded on three sides by un-navigable or lightly navigated ocean areas, and is a steep-sided, deep-water embayment, approximately 204 km/110 nautical miles long, and 37 km/20 nautical miles wide. It is connected to the Atlantic Ocean by Northeast Providence Channel and Northwest Providence Channel and trends south-southeast (parallel to Andros Island) into the Great Bahama Bank, terminating in a circular cul-de-sac.

The Test Range Complex is adjacent to the East Coast of Andros Island and consists of a sensor accuracy test site and in-water/in-air tracking areas. These tracking areas provide 3-dimensional, real-time position data for aircraft, surface ships, submarines and other instrumentation. Test control support services are located ashore at AUTEC's Andros Island main base (Site 1) and three small down-range sites, extending south along the coast for approximately 35 miles. System accuracy is 3m in the horizontal plane (X/Y) and 1.3m in the vertical plane (Z).

A.16.5.2 AUTEC Minefield and Shallow Water Range (AMSWR).



The AUTEC Minefield and Shallow Water Range (AMSWR) is located on the southern boundary of the Northwest Providence Channel in the Berry Islands and provides 68 square nautical miles of underwater tracking adjacent to a minefield at water depths from 25 meters to over 700 meters, with bottom slope variable between 1.5 and 15 degrees, and in-air tracking coverage is up to a range of 926km/500 nautical miles from 0 to 70,000 feet. Features

include an autonomous underwater acoustic navigation beacons to provide safety and ground truth for submerged operations; a minefield with both tethered and bottomed mine shapes; and, a remote helicopter landing site is located 8 miles from the shallow water range. This range is supported by a Portable Range Operations Center (PROC), capable of providing full Range User and safety support for the fixed shallow water range and can be coupled with the Buoyed Acoustic Range Tracking System (BARTS); a buoy-based telemetry system capable of supporting a range at any user location in depths of up to 600m. In addition, the ranges have received environmental approval from the Chief of Naval Operations (1997) and have mitigation measures in-place that effectively affords protection to the environment. AUTEC also provides portable mitigation measures for off-range testing.

A.16.5.3 Uninstrumented TOTO. Because AUTEC is surrounded by land/shoal and/or water on three sides, the operational area is a quiet acoustic environment with low traffic noise and minimal intrusion for conducting a variety of test programs. For a more thorough description of the TOTO and AMSWR, the Range User is referred to:

- SP-94, Environmental Atlas of the Tongue of the Ocean, Bahamas, prepared by the U.S. Naval Oceanographic Office in 1967 (reprint 1970).
- NUSC Technical Document 666-41A, A Compendium of Environmental Data for AUTEC and the Tongue of the Ocean, prepared by E. M. Podeszwa in May 1991.
- NUWC-NPT Technical Document 11,358, A Compendium of Environmental Data for the Berry Island Shallow Water Range, prepared by Tom Szlyk in March 2002.

A.16.6 Instrumentation Infrastructure

A.16.6.1 Targets. A variety of in-water targets are available which are compatible with surface ship, submarine, and aircraft ASW sensors. AUTEC is a certified Intermediate Maintenance Preparation Activity for the Mk 30 Mobile Target.

A.16.6.2 Main Base. Site 1 is the center for all on-range operations, data collection and post-test data processing. A Command Control Building houses all related equipment, displays, etc. Transient berthing facilities are available to accommodate test program personnel. Facilities are also available for post-run torpedo treatment and subsequent return to CONUS.

A.16.6.3 Data Transmission. The capability exists (and is being expanded) to transmit encrypted classified test data from Andros Island, and display it in real-time at other ranges and facilities in CONUS.

A.16.6.4 Air and Marine Craft. AUTEC has heavy-lift helicopters available to support test operations, including recovery of exercise torpedoes and targets. Fixed-wing air service is provided for personnel and equipment between Andros Island and West Palm Beach, Florida. The heliport at Site 1 can provide support for transient (e.g., Range User) helicopters. A high-speed vessel is used to transfer personnel and equipment to ships and submarines at sea. Marine craft include: Two high sea-state launch and recovery vessels enhanced with a dynamic positioning system; and a third, smaller craft capable of launch and recovery as well as limited oceanographic testing.

A.16.6.5 Environmental Measurement Systems AUTEC has an inventory of various environmental measurement systems that can be utilized for the Environmental Acoustic Monitoring and Characterization of the Ocean Environment. These capabilities are provided for the AUTEC test ranges as well as for remote sites. The following systems are currently available:

A.16.6.5.1 150 Khz Acoustic Doppler Current Profiler (ADCP). ADCP provides 3D water currents in self-contained mode or vessel mounted real-time mode. System can be operated in shallow or deep-water mode to profile accurate current speed and direction in water depths up to 200m. AUTEC can provide various currents versus depth data products.

A.16.6.5.2 Ocean Sensors OS200 portable CTD. The lightweight portable CTD can be hand-deployed to 200m. Directly measure conductivity, temperature, and pressure to provide temperature, salinity, speed of sound, and density versus depth.

A.16.6.5.3 SeaBird SBE25 Sealogger CTD. Research quality CTD profiling system with 600m depth capability. Directly measures and displays in real-time conductivity, temperature, pressure and altitude above bottom to provide temperature, salinity, speed of sound, and density versus depth. Various sensors can be added to meet specific measurement needs.

A.16.6.5.4 Surface Drift Current Meters. Two GPS tracked surface drift current meters are available to provide surface current magnitude and direction up to 10 miles from the support craft.

A.16.6.5.5 Shallow Water Sampler. The Shallow Water Sampler captures water samples at depths to 5m for PH, O2 and sediment studies.

A.16.6.5.6 Marine Mammal Monitoring System. A four-channel system configured to automatically acquire sound data at programmed intervals. System currently utilized to acquire mammal noise from AUTEC bottom-mounted tracking hydrophones.

A.16.6.5.7 Remote Sensing Data Processing Capabilities. AUTEC has the capabilities to process and analyze a wide variety of environmental data, from multi-spectral satellite imagery data to LIDAR hydrographic data, and conduct site classifications and site assessments in both shallow water and terrestrial environments.

A.17 NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION (NAWCAD) PATUXENT RIVER

A.17.1 Mission

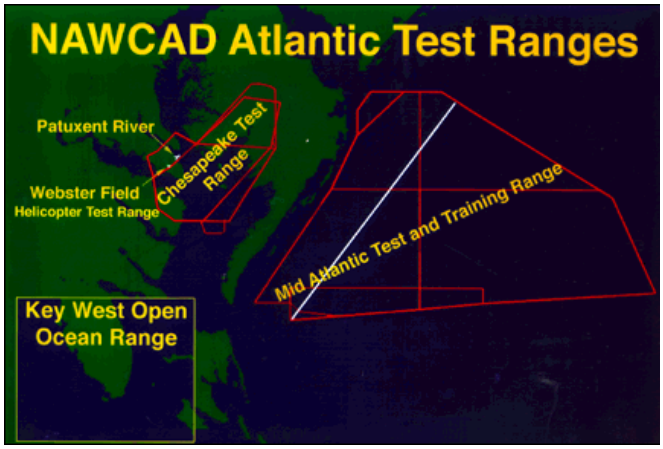
Provide and operate the Navy's principal test, evaluation, engineering, and fleet support activity for Navy aircraft (fixed and rotary wing/manned and unmanned); propulsion, avionics, and aircraft support systems; ship/shore/air operations, and aircraft electronic warfare throughout the life cycle to ensure successful operational performance. Maintain and operate research, development, test and evaluation (RDT&E) facilities/capabilities and perform in-service engineering for aircraft systems. This includes providing a principal site for aircraft RDT&E and providing, as directed, range, technical, engineering and/or base support for DoD users and other Government agencies.

Catapult Launch at Patuxent River

A.17.2 Location

NAWCAD, Patuxent River is located 65 miles south, southeast of Washington, D.C., at the mouth of the Patuxent River on the Chesapeake Bay. NAWCAD Patuxent River is easily accessible from Reagan National Airport, Washington D.C, Washington Dulles International Airport or Baltimore-Washington International Airport in Glen Burnie, Maryland (less than a two-hour drive from any of the three airports).

A.17.3 Features



A.17.3.1 Topography The NAWCAD headquarters, Naval Test Wing Atlantic and its four research, development, test and evaluation squadrons (including Naval Test Pilot School), aircraft ground-based test laboratories, flight systems test laboratories, range control facilities, and flight support facilities are co-located at Naval Air Station, Patuxent River, MD. An approximately 1,800 square mile restricted area complex providing all-weather flight test largely over the Chesapeake Bay and sparsely populated tidal lands of the Delaware/Maryland/Virginia Peninsula from sea level to 85,000 feet. Off shore ranges are located approximately 80 miles due east of the aerodrome within warning areas 108 and 386, accounting for the remainder of the test space of 48,200 square miles.

A.17.3.2 Climatic Features. Mid latitude climate with an average visibility of 7+ miles. NAWCAD Patuxent River climatic annual mean values are: cloud cover 25 percent, temperatures of max-mean-min are 65-58-50(F), relative humidity is 69 percent, precipitation is 41.24 inches, snowfall is 14.8 inches and the prevailing south, southwest wind velocity is 9 mph.

A.17.3.3 Terrain Features. Terrain throughout the Mid-Atlantic coastal plain is generally flat and near sea level elevations. The Patuxent River and Chesapeake Bay border three sides of the airfield affording excellent over water approaches to three major runways and to the landing system test site.

A.17.3.4 Air Space and Ground Facility Features. Aircraft operating capacity, coupled with technical ground and flight test facilities, give NAWCAD the unique capability to conduct complete aircraft system testing at a single site.

A.17.4 Facilities

A.17.4.1 Flight Support Facilities

A.17.4.1.1 Aerodrome. Aerodrome NAWCAD Patuxent River operates from an all-weather aerodrome available 365 days a year. More than 500 paved acres of runways, taxiways, and aprons provide excellent flight facilities. The airfield is surrounded on three sides by water. Over water approaches significantly reduce the air installation impact on the surrounding community.

A.17.4.1.2 Test Aircraft Assets. NAWCAD Patuxent River maintains an average of 120 RDT&E dedicated aircraft, representing 24 different models in 37 configurations. These fighter, attack, trainer, patrol, early warning, electronic warfare, and rotary-wing aircraft serve as flying test beds, chase, target, tanker, and search-and-rescue assets. In addition to these T&E dedicated aircraft, NAWCAD maintains two NP-3D flying laboratories modified to support customers' in-flight evaluation of emerging science and technology efforts. Within a maximum capacity of over 300 aircraft the aerodrome also supports over 40 Fleet aircraft.

A.17.4.1.3 Aircraft Support. NAWCAD Patuxent River maintains an extensive aviation support operation capable of providing squadron-level maintenance and repair to all assigned aircraft including every type/model/series aircraft within the US Naval inventory. An Aircraft Intermediate Maintenance Department provides the next level of support for assigned and transient fleet and research, development, test, and evaluation aircraft. The Supply Department is configured to meet the unusual and varied demands of more than 40 tenants and NAWCAD.

A.17.4.2 Ground Based Test Laboratories

A.17.4.2.1 Electromagnetic Environmental Effects (E3). The E3 facilities at Patuxent River were developed to provide test and evaluation of aircraft, weapon systems, and components. Systems undergo several different E3 tests while test personnel, ground support equipment, and maintenance support remain at the same location. Capabilities include electromagnetic compatibility, electromagnetic interference, electromagnetic vulnerability, TEMPEST, COMSEC certification, precipitation-static, lightning, and low level and direct-drive electromagnetic pulse testing. A radio frequency shielded hangar, anechoic chambers and adjacent facilities permit E3 testing in isolation from external radiation. Specific facilities and capabilities include Intrasystem EMC, 300' x 150' x 65' Shielded Hangar (MIL-STD-464), 100' x 60' x 40' Fully Anechoic Chamber (AATF), 180' x 180' x 60' Fully Anechoic Chamber (ASIL), 675 x 274' Outside Area Test Site (OATS), and Safety of Flight Testing (SOFT).

A.17.4.2.2 Air Combat Environment Test and Evaluation Facility (ACETEF). ACETEF provides a multitude of capabilities used for RDT&E in support of the systems development process. ACETEF is the Navy's Installed Systems Test Facility (ISTF) whose primary purpose is to test aircraft systems in an integrated, secure, multi-spectral warfare environment using state-of-the-art simulation and stimulation technology. Aircraft platforms, typically installed in a shielded hangar or one of two anechoic chambers, are deceived through a combination of simulation by digital computers and stimulation by computer-controlled environment generators providing radio frequency, electro-optical, and laser stimuli that closely duplicate real signals in a combat mission environment. ACETEF is composed of Hi-Fidelity signal generation, man-in-the-loop simulators and stimulators, operational systems, mission level warfare environment, instrumentation systems, Hi-Performance computing resources and integrated configuration and mission control. All of the laboratories, and capabilities listed below are fully integrated, and provide real time, dynamic test environments to the system under test.

A.17.4.2.2.1 High Performance Computing Facility. The High Performance Computing Facility provides high performance processing for computationally intensive installed systems testing. Typical real-time applications include multispectral scene generation and mission environment generation in a warfighting environment.

A.17.4.2.2.2 Manned Flight Simulator. The Manned Flight Simulator is a multiple level of fidelity, man-in-the-loop flight and system simulation facility supporting military and non-military RDT&E, OT&E and Training activities. All capabilities operate either as stand-alone simulations or fully integrated within the ACETEF real time dynamic test environment.

A.17.4.2.2.3 Operations Control Center (OCC). OCC provides the command and control, instrumentation and analysis capabilities for ACETEF laboratory testing. Capabilities include coordination and control of integrated systems testing, red and blue command and control centers, mission level digital environment, virtual and constructive simulations, real time instrumentation and test visualization, and internal/external links supporting network centric warfare.

A.17.4.2.2.4 Electronic Warfare Integrated Systems Test Lab. The Electronic Warfare Integrated Systems Test Lab provides realistic open-loop multispectral environment stimulation to electronic warfare systems during developmental and operational testing. These systems may include radar warning receivers, electronic support measures, defensive electronic countermeasures, communications intercept and communications jammers, missile warning sets, and integrated electronic combat system suites. Capabilities include open-loop multispectral environment stimulation; multiple EW environment stimulators; computer controlled antenna-positioning system; direct injection, closed hats, or free-space radiation of signals; and scripted or real time dynamic stimulation correlated with other ACETEF stimulators.

A.17.4.2.2.5 Communications/Navigation/Identification Lab. This lab provides open and closed-loop simulation of friendly, foreign, and hostile CNI and electronic warfare surveillance systems. The capabilities allow evaluation of CNI systems as installed in aircraft and EW systems as related to threat CNI recognition and exploitations. Capabilities include communications environment simulators, Strategic Data Link Simulator, Tactical Data Link Simulator, GPS and Aux Navigation Simulator, airborne IFF test capabilities, and scripted or real time dynamic stimulation correlated with other ACETEF stimulators.

A.17.4.2.2.6 Red Force Threat Air Defense Lab. This lab provides realistic closed-loop simulations of threat weapons systems to stimulate installed electronic warfare systems and supporting hardware-in-the-loop countermeasures effectiveness. This laboratory provides test assets to verify the functionality of radar warning receivers, defensive electronic countermeasures suites, jammers, jamming decoys, and standoff jamming against man-in-the-loop threat surface-to-air missile and early warning acquisition radar simulators. Capabilities include man-in-the-loop Surface-to-Air Missile Simulators, man-in-the-loop Early Warning Acquisition Radar Simulator, J-Band Advance Technology Simulator, and Red Force Command and Control Stimulator

A.17.4.2.2.7 Offensive Sensors Laboratory (OSL). OSL provides stimulation of aircraft offensive sensors using complex scenarios in which installed sensors are realistically stimulated with actual electro-optical and radar signals. OSL provides open-loop radio frequency and infrared target generation to systems such as aircraft radars, targeting and navigational forward looking infrared, search and track systems, missile

launch detector systems, missile warning systems, missile approach warning systems, and IR missile seekers. Capabilities include Radar Target Simulators for A/A radar tests, infrared sensor stimulation capabilities, scripted or real time dynamic stimulation correlated with other ACETEF stimulators, Warfare Simulation Laboratory, multiple man-in-the-loop virtual stations, mission planning and rehearsal, and real time dynamic simulations integrated with the ACETEF environment.

A.17.4.2.3 Propulsion Systems Test Facilities. The Propulsion Systems Evaluation Facilities include the Propulsion Systems Evaluation Facility (PSEF), the Aircraft Test and Evaluation Facility (ATEF) and the Outdoor Test Site (OTS) located at NAWC Lakehurst. The PSEF consists of numerous facilities used to test and collect data on propulsion components and sub-systems.

A.17.4.2.3.1 Fuels and Lubricants Test Area. This test area consists of 50 test rigs used to evaluate specific performance properties of aircraft fuels and engine/drive train lubricants.

A.17.4.2.3.2 Fuels and Lubricants Laboratory. This laboratory evaluates aircraft fuels and engine/drive train lubricant additives and tests for specification compliance and fleet usage.

A.17.4.2.3.3 Rotor Spin Facility. This facility tests aircraft engine compressor and turbine components under centrifugal loads and supports multi-service requirements. Testing includes Low Cycle Fatigue, Burst and Containment and Life/Design Validation. High Cycle Fatigue testing using Liquid Jet and Eddy Current Excitation and stress measurements using both contact and non-contact systems.

A.17.4.2.3.4 Un-manned Air Vehicle Altitude Test Cell. This facility assesses the operational flight envelope of UAV propulsion systems, evaluates system performance, mission operability, service life and design integrity.

A.17.4.2.3.5 Helicopter Transmission Test Facility. This facility is a unique DoD asset, which provides test and evaluation capability to a multi-service customer base with interests in both the mechanical evaluation of helicopter hardware and the evaluation of diagnostic systems and techniques through the Helicopter Integrated Diagnostics System (HIDS) program.

A.17.4.2.3.6 Accessories Test Area. These test areas are used to test and evaluate auxiliary power units (APU), aircraft starters, starter control valves and prognostics and health management (PHM) technologies. Testing includes life extension evaluations,

performance evaluations and developmental hardware evaluations. This test area also has a High Temperature evaluations of materials coupons using a Laboratory Scale Combustion Rig is also located in this facility.

A.17.4.2.3.7 High Volume Fuel Low Facility. This facility is utilized for evaluation of both aerial and ground refueling components in a safe and cost effective environment

A.17.4.2.3.8 Aircraft Test and Evaluation Facility (ATEF). ATEF permits full systems aircraft ground run-ups in a "Hush House." Special instrumentation and equipment provides instrumentation signals real time during engine operation. Capabilities in addition to High Power Operations include engine/intake/crosswind/ingestion, weight and balance, environmental effects (rain, wind, sun, heat), thrust calibration, residual fuel calibration, X-Ray inspections, Night Vision equipment testing, special instrumentation and equipment permit, fixed-wing aircraft installed systems testing, and uninstalled thrust testing capability has been added to this facility to conduct performance testing and endurance testing at Sea Level Static conditions.

A.17.4.2.3.9 Outdoor Test Site (OTS). These facilities are located on the NAWC Lakehurst site. The site is remote from the main base to minimize the impact of noise, jet blast, etc. The site consists of the following test rigs:

- **Turntable**: This facility allows engine thrust correlation without test cell affects. The stand is also used for noise and IR measurements.
- **Gyro**: This facility subjects the test engine to gyroscopic loading during operations to evaluate the effects of high G maneuvers on engine rotating components.
- **Variable Attitude Test Stand (VATS)**: This stand is used to subject the test engine to pitch and roll extremes during engine operation. The stand will withstand the thrust load from thrust engines and propellers.

A.17.4.3 Flight Systems Test Laboratories.

A.17.4.3.1 Aircraft Instrumentation and Modification Facility. The Test Article Preparation Department's (TAPD) Aircraft Instrumentation and Modification Facility is housed in Hangar 101. This hangar has approximately 55,000 square feet of open deck space where aircraft can be placed for lay-ups of extended or short duration. In addition to the open deck space, Hangar 101 houses approximately 30,000 square feet of office, storeroom, hazardous material, shop, and laboratory spaces. A full service machine shop is conveniently located within easy walking distance across the street from Hangar 101.

Storerooms include supply system specialists, consumable storerooms, and the Special Flight Test Instrumentation Pool. Laboratories include electrical and electronics set-up and checkout laboratories, calibration laboratories for special flight test instrumentation, and strain gage laboratories. Roll-around carts on the open deck space carry specialized test equipment for efficient use on-aircraft. A wide variety of tools and equipment carried within the shops and laboratories enables set-up, maintenance, troubleshooting, and checkout from micro- (individual component) to macro- (end-to-end aircraft checkout) levels. All test equipment is maintained and calibrated with accuracy traceable to NIST. FOD control and positive tool control programs are in place and strictly enforced. The complement of personnel employed within this facility includes experienced electronics, mechanical, computer, and aerospace engineers, computer scientists, engineering and electronics technicians with specialties in instrumentation, calibration, and hazardous materials and trade personnel with specialized expertise in metal work for and mechanical modification of aircraft. This fully equipped and staffed facility enables the Test Article Preparation Department to provide full service cradle-to-grave design, build-up, installation, maintenance, and support of aircraft and other test article instrumentation and prototype modifications.

F-14D Data Collection System Modification in Aircraft Modification Hanger 101

A.17.4.3.2 Aircraft Imaging Facility. The Aircraft Imaging Facility consists of approximately 5600 ft of laboratory, office and storage space for Imaging Branch personnel and imaging equipment. The facility allows for the Imaging Branch to design, develop, test, calibrate and prepare for the installation, operation, maintenance, and servicing of test imaging instrumentation systems utilized in the evaluation and testing of aircraft weapons systems and components in/on aircraft and at other laboratories or test

stands. The facility houses a vast inventory of imaging hardware including airborne cameras, lenses and peripheral equipment. The facility allows for editing, titling and quick look analysis of airborne imaging data.

A.17.4.3.3 Metrology Facility. The Metrology Laboratory is one of the Navy's principal centers of expertise in the application of measurement standards, the calibration of test and monitoring systems, the development of calibration procedures, and in the engineering of both hardware and software for automated-calibration systems. It provides calibration, repair, fabrication, engineering, and acquisition services to the NAWCAD complex and directly to the warfighter. In support of test and evaluation, it evaluates and calibrates airborne instrumentation systems and provides load or strain measurements on aircraft and non-aircraft components.

A.17.4.3.4 Mechanical Solutions Design & Fabrication Facility. The Mechanical Solutions Facility provides the resources to support customers in the mechanical design, fabrication and installation of prototype components and systems relevant to the instrumentation and modification of manned/unmanned aircraft, engines, components and accessories. All airborne installations include the engineering data required to obtain airworthiness certification. This facility also provides mechanical fabrication support to all activities relating to research, development, test and evaluation, limited production and fleet support at the Naval Air Warfare Center, Patuxent River, Maryland. Mechanical engineers, skilled craftsman/tradesmen and support staff are housed in approximately 60,000 square feet of shop facilities. This facility offers, in house, all the processes necessary to complete most mechanical prototyping and fabrication projects. These include design and documentation, computer numerical controlled machining and punching, composite fabrication, welding, chemical coating, painting and other processes common to a modern aerospace fabrication facility

A.17.4.3.5 Real-time Telemetry Processing System (RTPS). This system is comprised of eight telemetry data "streams" each of which is linked to a dedicated Project Engineer Station (PES). Each of the data streams is capable of processing information from up to four PCM and one FM source for a maximum of 2007 Engineering Unit converted data measurements. The PES can be utilized to monitor real-time flights or post-flight data processing.

A.17.4.3.6 Project Engineer Station. Flight test engineers operate the system from any of the eight project engineer stations (PES). Real-time telemeter and calculated results are available in many formats on numerous devices. There are seven SGI workstations, two high-resolution graphics display screens, two limits displays, four ceiling mounted display panels, a printer/plotter and a general purpose printer. Fifty-six strip

chart channels capture data up to 2,000 samples per second. Twenty-four thermal array channels capture data up to 10,000 samples per second. Data may be viewed in real-time in a variety of plot formats at rates up to 500 samples per second. Plot data are also captured and available for replay during the flight. Specialized display formats such as frequency-based plots and three-dimensional aircraft models driven by attitude data are available. Laser printers provide report-quality hard copy.

A.17.4.3.7 Telemetry Ingest and Processing. Sophisticated telemetry decoding equipment provides flexibility in the types and mix of data that may be handled. Each of the eight concurrent test operations is capable of processing four independent 10-megabit pulse code modulation (PCM) sources. Each PCM source may contain two independent sub-frame sets and/or embedded asynchronous wave trains. MIL-STD 1553 avionics bus data handling is built in. Sixty-four channels of analog data at up to 200,000 samples per second and are available to the project engineer station and/or applications programs.

A.17.4.3.8 Real-time Applications. RTPS has powerful, flexible capabilities for performing project-specific computations. Up to 512 measurements can be calculated and made available to the Project Engineer Station. The semi-automated General Applications Program Generator has a large collection of mathematical functions. This tool constructs customized software packages without programming. Functions are added to the library as new techniques and computations are developed. Other application capabilities include a powerful real-time Flutter Analysis Package and sophisticated multisource time-data correlation tools.

A.17.4.3.9 Post Flight Analysis. All telemetered signals are recorded on either an analog or rotary head tape recorder. Also, the engineering units form of the telemetered measurements are recorded on computer-compatible (EU tape) at up to 150,000 samples per second. Another data capture choice is the General Data Collection (GDC) mechanism, which allows saving both calculated and engineering unit measurements. Tapes may be played back to review the flight. All real-time features of the system are available in this mode. EU and GDC tapes are typically processed away from RTPS and used by many post-flight analyses available throughout the Patuxent River Complex.

A.17.4.3.10 Flutter Analysis. The Flutter Software package is a set of FORTRAN programs designed to provide project engineers (PE's) with a variety of time and frequency domain analysis techniques. The Flutter Application can be used for both real-time and post-flight processing utilizing the RTPS project engineer stations. The software that provides this capability resides in the flight support computers at the RTPS facility. Its use requires the standard logon alone tasks. These allow the user to set up specific analysis parameters and to select between the various plots that are available for viewing during flight support both in real-time and in inter-maneuver analysis.

A.17.4.3.11 Remote Site Support. The Telemetry Data Center supports remote-site telemetry operations onboard aircraft carriers and at other air stations and bases. Four Portable Telemetry Processing Systems (PTPS) are available for remote-site support. These systems contain PCM bit synchronizers, PCM decommutators, and Engineering

Units processor, a user-applications processor, a PCM simulator, a DAC card, an IRIG-B time code translator, a 1553 bus monitor and other support processors and hardware. The PTPS is capable of decommutating a 20 Mbps PCM stream, processing the data and routing it to many different display types. The system has 17" color monitors for real-time displays. The system can drive up to eight eight-channel strip chart recorders and log data at the real-time rate to the archiving disk. In a post-flight procedure, the archived data can be converted to an ASCII file and downloaded to either floppy or optical disk. The PTPS can be broken down into several two-person manageable pieces and transported in an average family van.

A.17.4.3.12 Atlantic Test Ranges Data Link. Time-space-position information (TSPI) from theodolite, radar and/or laser tracker is available to RTPS at the Telemetry Data Center. These data, received as a standard PCM source, are recorded along with the telemetered data. RTPS data can be routed to the Range Computation and Control System (RCCS) from any of the streams at the Telemetry Data Center. These data are typically used to drive three-dimensional displays in the RCCS control room. There is also a data link from RTPS to the electronic warfare workstation in the same secure complex.

A.17.4.3.13 Antenna and Avionics Flight Test Facility. This facility provides a comprehensive capability to evaluate aircraft avionics systems, included secure and non-secure communication, IFF, and radar systems. The Antenna Testing Laboratory Automated System (ATLAS) is a key component that provides the unique capability to accurately measure all aircraft antenna patterns in flight. The system's versatility is demonstrated by its capability to fully evaluate a wide range of antennas, including omni, narrow beam, rotating, steerable, and adaptive controlled antennas.

A.17.4.3.14 Catapult and Arresting Gear. NAWCAD Patuxent River operates a ground-based TC-7 steam catapult and two MK-7 arresting gear units to test aircraft carrier suitability under controlled conditions. The arresting gear installation is used in conjunction with both visual landing aids and ACLS.

A.17.4.3.15 Landing Systems Test Facility. The Landing System Test facility (LSTF) is utilized for both Marine Corps and Navy developmental flight test and software support for Shipboard and Shorebased Air Traffic control and Landing Systems including aircraft flight control and cockpit displays. Located next to runway 32, opposite the TC-7 steam catapult and MK-7 arresting gear, it is completely instrumented for real-time reception, time correlation and analysis of aircraft flight test and space position data. The LSTF houses the AN/SPN-41, 42 and AN/SPN-46 shipboard representative radar equipment, an advanced technology Joint Precision Approach and Landing (JPALS) GPS-based developmental system, as well as various instrumentation equipment. The test runway 32 also incorporates the latest Nimitz class flight deck runway lighting system for night carrier landing evaluations.

A.17.4.3.16 Atlantic Test Wing. The Atlantic Test Wing provides trained people, test-ready air vehicles, and access to all the sate-of-the-art facilities necessary for the

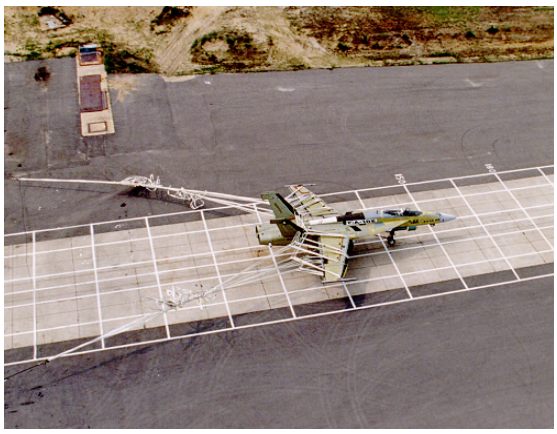
research, development, test, and evaluation of cutting-edge technology to support the warfighting needs of operating forces.

A.17.4.3.17 Test and Evaluation Engineering. The principle function of T&E Engineering Department is to provide life cycle test and evaluation engineering in support of customers, by participation in the full Acquisition Process; from the beginning of the system or Platform Definition, through Engineering Development, Test, Fleet Introduction, and Follow-On Fleet Support. T & E Engineering embodies the concept that T&E is integral to the design and development process and that systems problems and other program test risks should be identified and designed out as early in the acquisition cycle as possible or accounted for early on rather than be found at the end in a pass/fail situation. Toward these T&E engineering supports the customer's efforts in the iterative evolution of configuration changes to constantly improve designs in response to changing mission requirements, threats, design, or performance criteria. Team members are responsible for Air Vehicle and Weapons Systems Flight or Flight Equivalent Testing Processes where Flight Equivalent Testing means System Level Testing conducted in ground facilities in lieu of Flight Test or in direct Pre-Flight Preparation for Flight Testing.

A.17.4.3.18 RDT&E Laboratories. In addition to these various T&E facilities and capabilities NAWCAD has various RDT&E laboratories that provide state-of-the-art expertise in many facets of engineering.

A.17.4.3.18.1 Air Vehicle RDT&E Facilities. Two Hundred thirty-one laboratories associated with Air Vehicle Engineering. These labs consist of: Air Vehicle Systems Engineering, Aeromechanics, Structures, Materials, Vehicle Subsystems, Airworthiness, and Air Vehicle Technology Office.

A.17.4.3.18.2 Air Platform Interface RDT&E Facilities. Twenty-seven laboratories associated with Aircraft Launch and Recovery Equipment (ALRE) and Support Equipment. ALRE labs perform RDT&E of the equipment that launches aircraft from the carrier, that guides the aircraft back to the ship or expeditionary airfield, and that recovers them safely. Support equipment (SE) RDT&E labs are used for development and testing of SE such as: aircraft handling (tow tractors, spotting dollies, weapon loaders), and propulsion support (engine test systems) and avionics support (common automated test equipment). The picture was taken at arrestment testing at NAWCAD Lakehurst.



A.17.4.3.18.3 Aircrew System RDT&E Facilities. Sixteen laboratories associated with processes and facilities necessary to execute the engineering aspects of technology development, systems acquisition and fleet support for the coordinated life cycle management of all aircraft flight crew systems and the human engineering design for all flight crew and maintainer hardware/software interfaces. This includes the application of systems engineering and integration, design analyses, test and evaluation and maintenance engineering. Emphasis is on the design and operational integrity of human-machine systems in the areas of Cockpit/Crew Station Integration, Emergency Egress/Crashworthy Systems, Threat Protection/Mission Enhancement and Human Systems Integration.

A.17.4.3.18.4 Avionics RDT&E Facilities. Sixty-two laboratories associated with test planning, test, resource management of A/C weapons & integrated systems; flight or flight equivalent test; precision approach & landing system certification & verification; mishap investigation.

A.17.4.3.18.5 Mission System RDT&E Facilities. Fourteen laboratories associated with: Avionics Systems Engineering, Information Warfare Systems, Flight Information Systems, EW Systems, Mission & Sensor systems, Component Engineering Software Engineering, and Ship & Shore Based systems.

A.17.4.3.19 Propulsions Systems RDT&E Facilities. Fifty-one laboratories associated with: propulsion system integration, in-service engineering and technology planning, development and transition. These labs support all navy air breathing propulsion & power systems, rapid response to fuel & lubrication issues, and mishap investigation.

A.17.4.3.20 Ship and Shore Electronic Systems RDT&E Facilities. Sixty-one laboratories associated with Ship and Shore Based Electronic Systems. These labs perform engineering tasks and services including: Air Traffic control 9ATC), surface based aircraft Identification Systems (IDS), Shipboard Exterior Communications (EXCOM), Special Communications requirements primarily for the Special Operations and joint Communications), shipboard Data Link Systems, and specialized Information Technology.

A.17.4.3.21 Training Systems RDT&E Facilities. One laboratory associated with Design, Development, Test (V&V), and Deliver Weapon.

A.17.5 Ranges

A.17.5.1 The Atlantic Test Ranges (ATR). The Atlantic Test Range facilities provide aircraft tracking, data acquisitions and relay, range surveillance, targets, and communications/control of multiple aircraft test events in the Chesapeake Bay and Atlantic Warning Areas. An integrated network of cinetheodolites, laser, and radar trackers are lined along the western Chesapeake shore to the computation and control center at ATR. Communications links with NASA Wallops Flight Facility permits

utilization of NASA precision radars in the Atlantic Warning Areas and relay of telemetry to ATR.

Multi-object multilateration tracking and differential GPS receivers provide time, space, and position information for multiple air and surface test vehicles. Special purpose instrumentation includes radar for EW systems simulation and stimulation, video graphic and photographic instrumentation, mobile test instrumentation, and instrumentation for shipboard test of aircraft involving catapults, arresting gear, and automatic carrier landing systems. Air/surface seaborne targets, short-range missile fire areas, direct fire areas, and sonobouy drop areas are integrated with range facilities. Range tracking and target data, telemetry data, EW data, and meteorological data are integrated and correlated in the range computational and control center to provide a final data product. Major testing capabilities include surface targets, aerial targets, subsonic and supersonic airspace and operating areas to support a wide variety of aircraft weapons systems testing. Major test functions include flight quality and performance, weapon separation and delivery system performance, aircraft propulsion system flight tests, aircraft carrier suitability and ship dynamic interface testing. Qualitative and quantitative photogrammetric data analysis is applied, when requested by flight engineering customers, to film and video images captured during flight testing. The three major photogrammetric analysis areas are: store separation, ballistics and ship suitability flight testing. This includes software development for post flight data editing, computation and display.

The Real Time Avionics Flight Test Facility, a component of the Atlantic Test Ranges, is responsible for evaluating in-flight aircraft avionics performance at the component level and evaluation of the aircraft radar return characteristics. This facility stimulates receiving and transmitting avionics equipment on the aircraft, with the equipment on the aircraft, with the equipment in its intended operating environment. The stimulation effects can be observed in real time.

A.18 NAVAL UNDERSEA WARFARE CENTER (NUWC) DIVISION, KEYPORT

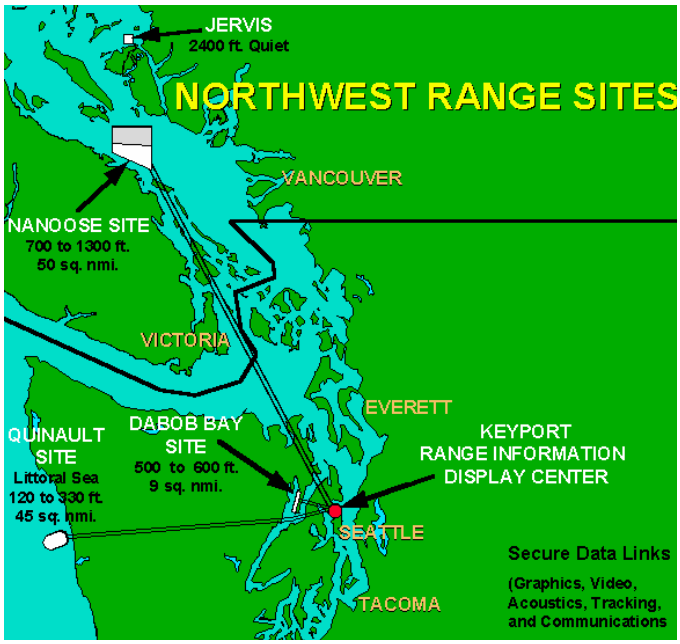
A.18.1 Mission

NUWC Division, Keyport is the site for in-water testing of Undersea Warfare (USW). In addition to offering the most secure and quiet tracking ranges in the world, NUWC Keyport offers a variety of littoral and open-ocean tracking sites with the capability to conduct comprehensive test and evaluation. Sample USW support includes:

- R&D testing of weapons, countermeasures, targets, ship systems and Unmanned Underwater Vehicles (UUVs)
- Test and evaluation of state-of-the-art production weapon systems
- Acoustic, electric and magnetic field measurement of ships, weapons, targets and UUVs
- Mine warfare test and support
- Anti-Submarine Warfare (ASW) systems tests on submarines and surface combatants

A.18.2 Location

The Northwest Range is located in the Pacific Northwest near NUWC Division, Keyport's headquarters at Keyport, Washington. The range's three fixed test sites are situated at locations well suited to their particular missions. The Dabob Bay site is in Hood Canal near Naval Submarine Base, Bangor; the Quinault site is approximately 10 miles off the coast of Washington; and the Nanoose site, a joint U.S./Canadian facility, is in the Strait of Georgia near Vancouver Island in British Columbia, Canada.



A.18.3 Features

The Northwest Range underwater test sites provide approximately 100 square nautical miles of highly accurate underwater tracking in the areas instrumented with underwater tracking arrays. The deployable systems can provide extensive additional tracking areas in a wide variety of testing environments, limited only by the number of sensors deployed.

The range sites share personnel, range craft, support services, and test and evaluation radius of Keyport support facilities. These sites are permanently instrumented and maintained for year round testing and long-term support of extended test, evaluation and training programs.

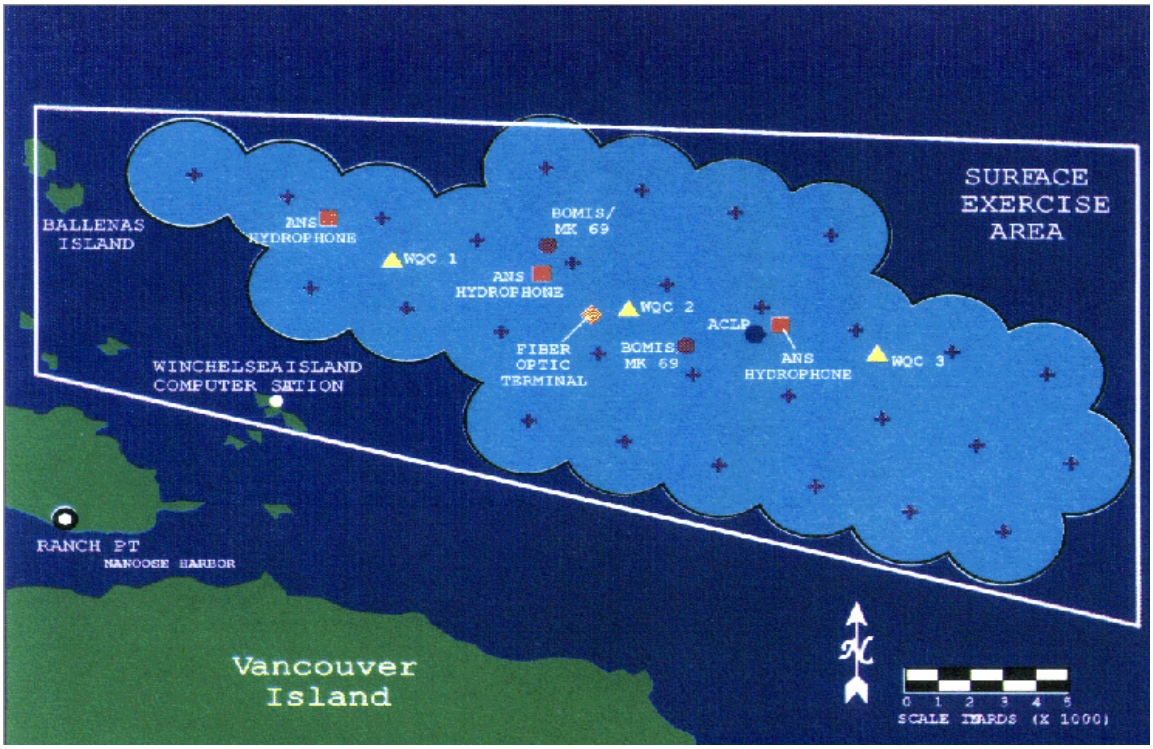
Range Site	Undersea Tracking Coverage (NM^2)	Above-Water Tracking Coverage (NM^2)	Depth (Feet)	Unique Features
Dabob Bay	9	450	120-600	Quiet; Highly Secure
Nanoose	50	450	700-2400	Mid-Depth Littoral
Quinault	45	700	120-330	Shallow Ocean Site

All Northwest Range sites offer a broad spectrum of test support capabilities, including weapon/UUV launch, artificial and real targets, surface weapon retrieval, intact bottom weapon recovery, acoustic measurement and analysis, remote viewing and control, Differential Global Positioning System (DGPS) tracking and positioning, navigation aids, underwater telephone, and secure radio voice and data communications. Other capabilities available at specific range sites include practice mine fields, submarine aid-to-navigation, bottom-mounted instrumentation platforms, magnetic/electric field measurement, and fiber optic terminal for user provided instrumentation.

A.18.4 Sites and Facilities

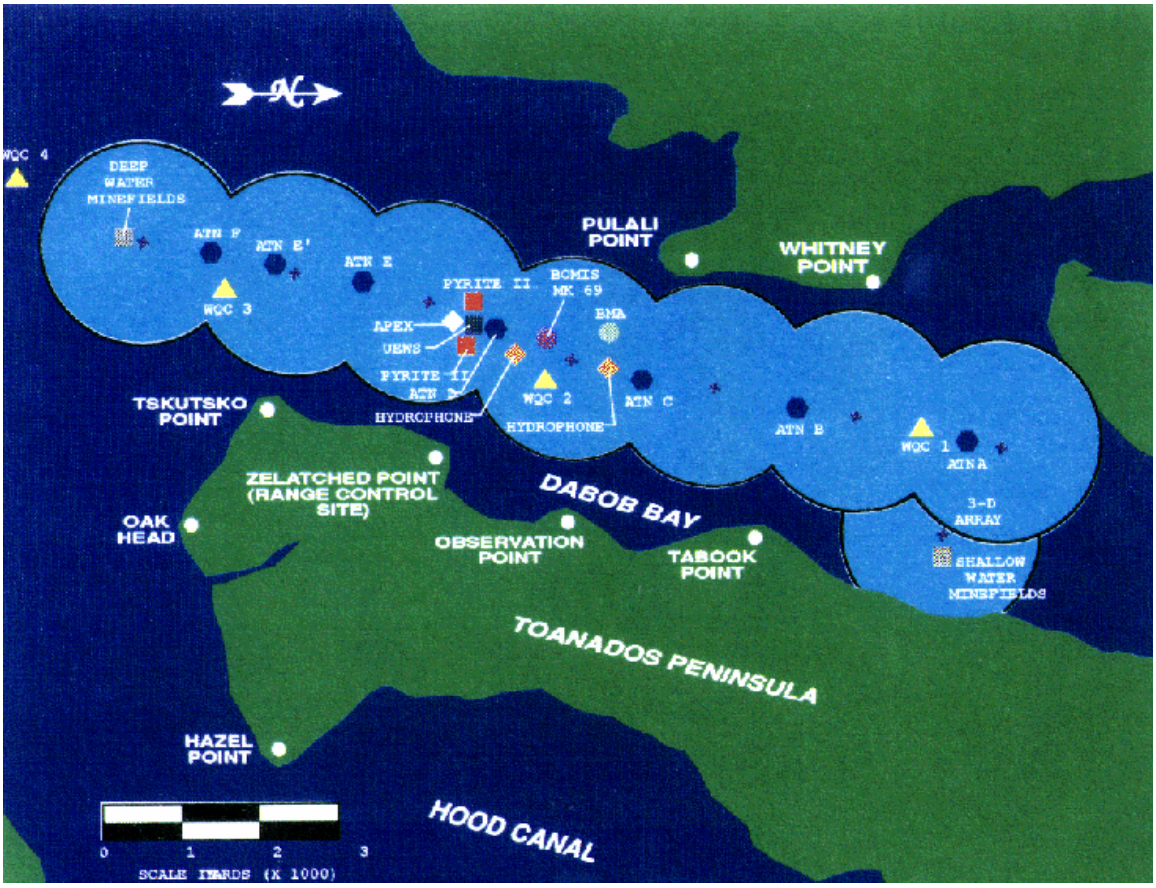
There are three fully instrumented sites on the Northwest Range. They include Nanoose, Dabob, and Quinault. The Jervis and Whiskey Foxtrot sites are only partially instrumented, but provide additional, uniquely featured, operational areas for temporary or future permanent tracking instrumentation. The Jervis site lies approximately 32 miles northeast of the Nanoose site. It features 2400 feet water depth in a 2 mile by 1.5-mile area with environmental conditions similar to Nanoose. Access is by ship or seaplane. The Whiskey Foxtrot site is a shallow (350-600 feet depth) shelf immediately north of the Nanoose site. It provides a unique littoral area convenient to the Nanoose site facilities.

A.18.4.1 Nanoose Site



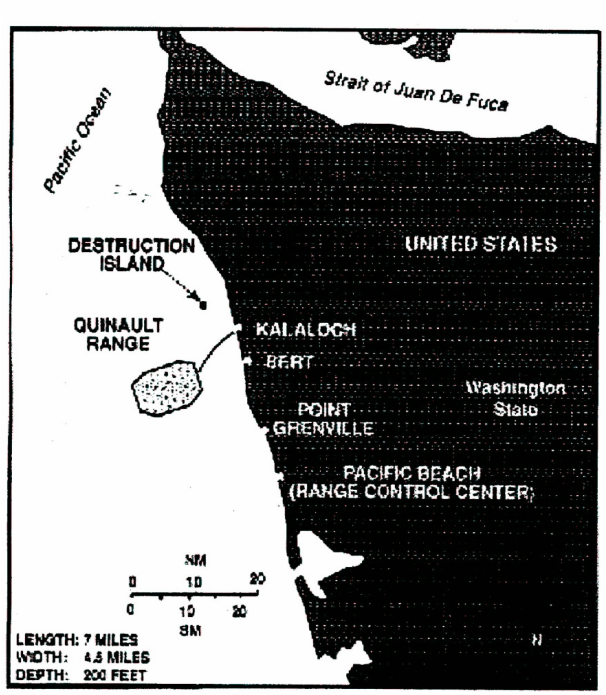
Location	Strait of Georgia, British Columbia, Canada
Distance from Keyport	130 miles north of Keyport, WA
Range Size	50 square miles
Above Water Track	ATR plus up to 8 movers (instrumented)
Bottom Composition	Mud, rock, sand
Sound Velocity Profile	Seasonal, fast surface layer, channeling
Average Daily Air Temperature	30-50° (winter) to 55-75° (summer)
Annual Precipitation	48 inches (some snow)
Wind Speed	5 to 20 knots predominantly from SE
Fog	Anytime, prevalent in fall and winter
Aircraft Support	Helicopter and floatplane
CTD	Yes, integrated with tracking algorithm

A.18.4.2 Dabob



Location	Dabob Bay, Hood Canal, Puget Sound
Distance from Keyport	10 miles west of Keyport, WA
Range Size	9 square miles
Depth	120 to 600 ft.
# Arrays & Separation	7 tracking arrays; 6000 ft. separation
# Simultaneous Tracks	12 vehicles or items
Real Time Telemetry	24 bits/ping
Above Water Track	Up to 8 movers (instrumented)
Visual Track	Theodolite
Bottom Composition	Sand, silt-clay, mud, rock
Sound Velocity Profile	Seasonal, fast surface layer, channeling
Average Daily Air Temperature	30-50° (winter) to 60-80° (summer)
Annual Precipitation	51 inches (some snow)
Wind Speed	5 to 20 knots predominantly from South
Fog	Occasional; prevalent in fall and winter
Aircraft Support	Helicopter
CTD	Yes, integrated with tracking algorithm

A.18.4.3 Quinault



Location	7.5 miles off coast at Kalaloch, WA
Distance from Keyport	95 miles west of Keyport, WA
Range Size	45 square miles (trackable area)
Above Water Track	Up to 8 movers (instrumented)
Bottom Composition	Sand, sediment
Sound Velocity Profile	Seasonal channeling; iso-velocity
Average Daily Air Temperature	40-50° (winter) to 50-60° (summer)
Annual Precipitation	65-75 inches
Wind Speed (knots)	Aug.-April SW 17-20; May-June NW 7-10
Aircraft Support	Helicopter and airplane
CTD	Yes, integrated with tracking algorithm

A.18.5 Infrastructure

A.18.5.1 Tracking Components. The Northwest Rang has an extensive underwater and above water tracking capability allowing range users to observe range exercises in real time and to record the events for post exercise evaluation and exercise scoring. Northwest Range tracking components include:

- Underwater acoustic tracking pingers, installed on each exercise participant, to transmit coded acoustic tracking signals to the receiving hydrophones.
- A group of receiving sensors (either single element or multiple element hydrophone arrays) set on the sea floor of the range.

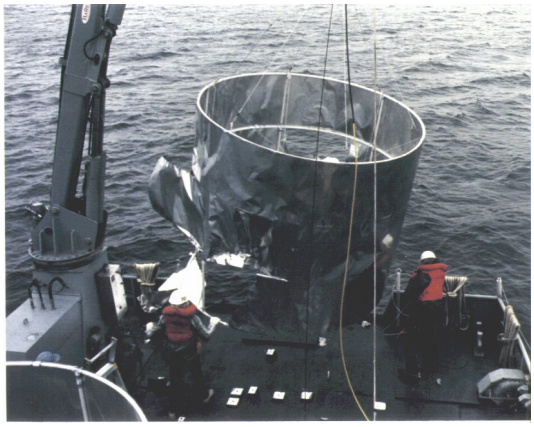
- Undersea cabling to transmit the received tracking signals from the hydrophone arrays to the range site tracking center.
- Tracking center facilities to receive and decode the tracking signals for display processing and recording.
- Support craft (helicopter, fixed wing aircraft, surface vessel, or submarine) to launch one or more vehicles that are to be tracked on the range.
- Radar and DGPS (Differential Global Positioning System) facilities to provide above water tracking of exercise participants.

Supplemental components required to support tracking include:

- Timing and synchronization systems to reference all events to a master clock.
- Water Surface and Underwater Combined, Sonar and Underwater Sound Communications (WQC) underwater telephone for voice communication with submarines operating on range.
- Supplemental safety and navigation systems such as ATN (Aid To Navigation) and UEWS (Underwater Emergency Warning System).
- Communications systems (UHF, VHF, microwave) to link range systems, participants, and customers.
- Environmental data gathering systems (Conductivity, Temperature, & Depth (CTD), weather, sea state) used to improve tracking accuracy and quality.
- Recovery systems to support surface and bottom vehicle recovery.
- Range craft to recover vehicles, deploy targets, collect environmental data, collect acoustic data, survey range component locations, and provide range system maintenance.

A.18.5.2 Fire Control/Launch. NUWC Keyport provides a diverse assortment of fire control equipment, torpedo tubes, and launching devices to support customer testing and development objectives. The fire control and launch systems simulate all aspects of fleet torpedo launches including presetting, launch, and post launch communications between firing craft and torpedo. All lightweight torpedoes are launched from above-water tubes while heavyweight torpedoes are launched from the firing craft's underwater submarine tubes (Figure 5), stern launcher, or side launcher. The Northwest Range also conducts air launches cooperatively with the Whidbey Island Naval Air Station.

A.18.5.3 Targets and Countermeasures. Northwest Range sites offer a full spectrum of artificial/real, active/passive, stationary/mobile targets that are operated and maintained by NUWC Keyport personnel. Targets are typically artificial (e.g., simulate real targets), allowing cost effective, realistic, acoustic response for weapon system test and evaluation. Real targets can be floating or submerged and are usually ex-vessels that can be moored or free floating.



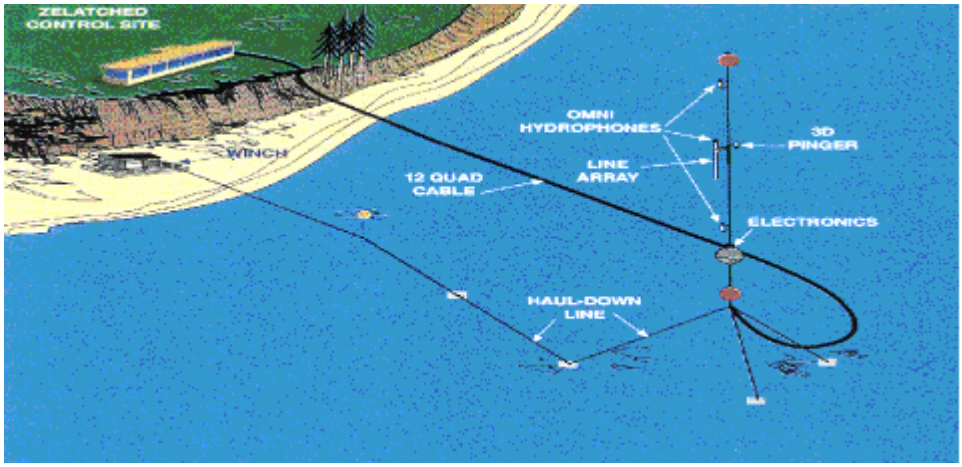
A.18.5.4 Acoustic Measurement. NUWC Keyport provides a full spectrum capability for the measurement and analysis of radiated noise, structure borne noise, self-noise, and ambient noise in support of range operations. They include features for high speed and ultra quiet vehicle measurements. The Northwest Range sites are fully instrumented for acoustic measurement and monitoring with data processing and analysis performed at NUWC Keyport's Underwater Noise Analysis Facility (UNAFAC). NUWC Keyport maintains an acoustic platform for experiments at the Dabob range site. It provides stable mooring for deployment of acoustic measurement systems and test vehicles to 400-foot depths.

The UNAFAC is the Navy's principal facility for the processing and analysis of radiated and structure borne noise from underwater weapons, targets, countermeasures, mines, Unmanned Undersea Vehicles (UUVs), and other special vehicles. Measurements are also conducted for surface ships and submarines. The UNAFAC is a secure computer facility used to process, interactively analyze, and report on all acoustic data acquired at Northwest Range Sites as well as outside sources. The UNAFAC uses state-of-the-art acoustic processing and interactive analysis to provide a real-time capability with secure

links to other Keyport analysis systems. Up to 12 channels of acoustic and vibration data can be analyzed simultaneously. Specialized systems include: color Low Frequency Analysis and Recording (LOFAR), transient capture and analysis, Doppler correction, and high frequency processing. The UNAFAC also has a number of peripheral systems such as tape recorders, strip charts, time-series analyzers, real-time acoustic analyzers, audio monitors, filters and video systems that allow the flexibility to tailor the data processing and analysis to fit the needs of any customer. Analyzed data are available to customers in a variety of formats including graphs, charts, magnetic media (analog and digital), video graphics, and multimedia. Reports are individually configured to specific customer requirements. UNAFAC capabilities are also available for portable noise measurement in the Spectral Analysis System (SAS), providing near-real-time data processing and analysis on site.

The Noise Recording System (NRS-4) is a portable, ship-deployed system used for acquiring radiated noise data from underwater vehicles, surface ships, submarines, and targets. The system acquires underwater acoustic data using omni-directional hydrophones and an optional line array. The NRS-4 is routinely operated to depths of 1,000 feet and may be configured for deployment to 3,000 feet.

A.18.5.5 Bottom Moored Array (BMA). The BMA is a fixed, bottom-deployed system for acquiring and recording underwater-radiated noise at the Dabob Range site. The hydrophone array is identical to the NRS-4, but does not require support craft and can be used in any sea state condition. The array can be vertically positioned to any depth between 100 feet and 425 feet. It is instrumented for 3-D tracking to allow accurate depth positioning. The hydrophone assembly consists of three omni-directional hydrophones in a vertical array, and a 6-foot, segmented, line array. The omni-directional hydrophones are capable of acquiring signals and can be averaged to significantly reduce the effect of multi-path interference. The directive array provides vertical directivity.



A.18.5.6 Range Craft Services. NUWC Keyport operates an active fleet of 12 craft, ranging from the 186-foot Yard Torpedo Test (YTT) craft to a 22-foot Boston Whaler. These include two Yard Torpedo Test (YTT) craft, two Yard Patrol (YP) craft, three

Torpedo Retriever Boats (TRB), one 40-foot range maintenance boat, and two self-propelled barges. Each range site can provide additional craft as required. Range craft duties include target/acoustic system deployment, weapon firing/retrieval, recovery/salvage operations, cable laying/maintenance, diver tending, array planting, and range security. All craft maintenance work, with the exception of YTT overhauls and dry-docking work, is done in house.

A.19 PACIFIC MISSILE RANGE FACILITY

A.19.1 Mission

Provide integrated range service in a modern, multi-threat, multi-dimensional environment that ensures the safe conduct and evaluation of training and T&E missions. Deliver quality products to improve customers' ability to achieve readiness and other national defense objectives.

A.19.2 Location

Located in Hawaii on the western shores of the Island of Kauai, PMRF includes broad ocean areas to the north, south, and west with varying water depths from 20 to 2,500 fathoms.

A.19.3 Features

PMRF's relative isolation, year-round tropical climate, and encroachment-free environment are significant factors in PMRF's excellent record for operation completions. PMRF's proximity to major Department of Defense installations and organizations, and to University of Hawaii ocean research facilities on Oahu, presents cost and operational benefits to the range user. Transportation of project personnel, equipment, and materials is accommodated via commercial or military systems.

A.19.3.1 Topography

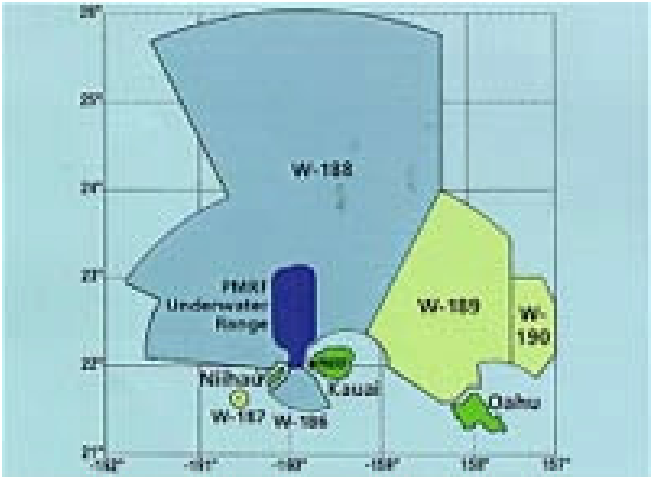
The range is located on a tropical island with Volcanic mountain features surrounded by shallow to deep water ocean and considered largely free of encroachment issues. The Makaha Ridge Site, 8 miles north, at an elevation of 1500 to 1800 ft, features tracking and surveillance radars, primary telemetry receivers and recorders, a Frequency Monitoring Station, and Electronic Warfare and networked communications systems. Kokee Park, 12 miles north and east of Barking Sands at an elevation of 3,400 ft, supports tracking radars, telemetry, UHF/VHF Communications, and Command and Control systems. The Kamokala Caves, two miles east of PMRF, provide secure explosive storage. Niihau, a privately owned island, features a remotely operated APS-134 surveillance radar, an 1100-acre Test Vehicle Recovery Site, the Perch Electronic Warfare site, multiple EW Portable Simulator sites, and a Helicopter Terrain Flight training course

A.19.3.2 Climatic Features

PMRF experiences a year-round tropical climate with an average temperature range from 71.3 (°F) to 79.1 (°F) and an average annual rainfall range from 35 inches at Poipu Beach to 444 inches at the summit of Waialeale (one of the wettest spots in the United States).

A.19.3.3 Ranges

The area surrounding Kauai is divided into warning areas with W-186 and W-188 controlled by PMRF. The Fleet Area Control and Surveillance Facility (FACSFAC) controls W-187, 189, and 190. Space, air, and surface tracking are accomplished from PMRF precision-tracking radar sites at elevations of 75 ft., 1700 ft., and 3800 ft.



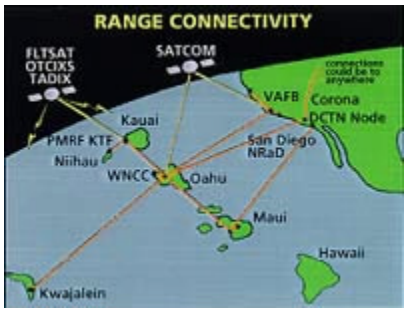
PMRF warning areas

The PMRF Underwater Range consists of a 120 square nm area in the channel between Kauai and Niihau Islands in water depths from 200 to 1,000 fathoms.The adjoining 900-nm area which extends into the open ocean north and west of Kauai, with depths from 1,000 to 2,500 fathoms. Hydrophones connected to the Underwater Data Processing system at Barking Sands yield 10-ft tracking accuracy throughout the Underwater Range. Underwater communications are provided through bottom-mounted transducers.

PMRF facilities on Oahu provide range services to ships and aircraft operating in the areas off Pearl Harbor, as well as ships in port and aircraft on the ramp. Operations support services are also provided in other remote training areas located on neighboring islands in the Hawaiian chain.

Range Interconnectivity

PMRF is linked to other range and data-processing facilities and can transmit real-time test and exercise data and video anywhere in the nation. Interconnectivity is achieved with microwave, fiber-optic, and satellite network communication resources.



A.19.4 Air Space and Sea Facility Features.
Tracking and surveillance radars, data processing, and the communication network are included in the operations area. A target support and red-label area is a mile north of the main gate, with the PMRF ordnance and launching area farther to the north. T&E related facilities include:

- Battle Management Interoperability Center (BMIC)
- Surveillance radar systems for Range Control
- Command, Control & Flight Termination Systems
- Integrated Target Control System (ITCS)
- Multiple Aircraft GPS Integrated Command and Control (MAGICC)
- Cooperative Tracking System (NCTS) GPS Tracking
- Precision tracking radar systems
- PCM, PAM, FM telemetry receivers and recording systems
- Telemetry control-room display systems
- Data Processing (real-time and post-operations)
- ACDS Blk Zero Naval Tactical Data System (NTDS)
- State-of-the-art Communications systems
- Multi-Axis Electronic Warfare systems (fixed & portable)
- Frequency Monitoring sites (Kauai, Oahu)
- Visual Imaging Systems with Video Tele-Conferencing Capability

Recently implemented upgrades having a significant impact on range operations include:

- Mobile Aerial Target Support System
- Shallow Water Range off Barking Sands
- Increased Telemetry and Optical capabilities
- Autonomous Mobile Periscope System (AMPS)
- AQM-37C Air Launch Capabilities
- Additional Ordnance Storage Area
- Missile Assembly Building

A.19.4.1 Flight Support Facilities
Airfield facilities in the main area of Barking Sands are capable of supporting up to and including C5-type cargo aircraft, tactical aircraft, and helicopters.

A.19.4.1.2 Test Aircraft Assets.
Range support aircraft include five UH-3H helicopters which are used for surveillance, personnel transfer, logistics, target launch, and weapon/target recovery; and three C-26 fixed-wing aircraft for range surveillance, electronic warfare, and logistics.

A.19.4.1.3 Range Boats
PMRF has One 120-ft Torpedo Weapon Retriever and two 85-ft Weapon Retriever Boats. Port Allen hosts PMRF's Range Support Boats and Seaborne Powered Target (SEPTAR) Boat operations and maintenance facilities, and provides pier space, protected anchorage, and small-boat launch facilities.

A.19.4.1.4 Range Targets
Aerial Targets (Vandal, BQM-34, BQM-74, AQM-37C, Terrier)
Surface Targets (SEPTARs QST-35, HSMST RIB, ISTT, FAST)
Underwater Targets, Mk 30 and Mk 39 EMATT
Special Targets (STARS, other small rockets)

A.19.4.1.5 Operations Control Center (OCC)

It has 3 Range Operation Control Centers which are located in the Barking Sands operations area. In the Range Operations Control Center, real-time data is presented in analog and digital display devices. Data from range operations are processed and are provided to the range user in the requested medium.

A.19.4.2 External Range Support Agencies
Range support from external agencies, including the following, is coordinated through the PMRF Program Manager.

The Naval Undersea Warfare Center (NUWC) maintains a facility at PMRF and a detachment at Waianae, Oahu, to provide Mk-30 underwater target services and range pinger installation services.

Sandia National Laboratories operates the Kauai Test Facility (KTF) for the Department of Energy and, through inter-Service Support Agreements (ISSA), provides PMRF with rocket launch services for target systems and upper atmosphere measurements. PMRF/KTF is recognized in the INF Treaty as an authorized site from which launches of the STARS missile can be conducted. Environmental documentation is in place for a number of operational launch scenarios.

The Sandia Maui Haleakala Facility can provide telemetry receiving/recording, flight following, command control and flight termination systems for high-altitude/exoatmospheric launches from PMRF, and for high-altitude operations which traverse the Hawaiian Island chain.

The Air Force Maui Optical Station (AMOS), the

Maui Optical Tracking and Identification Facility (MOTIF), and the Ground-based Electro-optical Deep Space Surveillance System (GEODSS) are located at the Maui Space Surveillance Site (MSSS) atop Mount Haleakala. These facilities provide a unique vantage point for observing sub-orbital vehicles. Recent installation of a link to the Maui High Performance Computing Center will allow for state of the art data processing.

The Hawaii Air National Guard provides O&M of the Hawaii Digital Microwave System (HDMS). The Hawaii Tracking Station, located at Kaena Point, Oahu, provides real-time telemetry data to PMRF via the HDMS. The 30th Range Squadron at Kaena Point provides metric and signature tracking data from their FPQ-14 radar via the HDMS.

Wheeler Network Communications Control (WNCC) is a major communications hub for PMRF. Voice and data signals are relayed through the HDMS to the WNCC from Mount Kaala, and are further distributed to other military and commercial communications networks. PMRF has a dedicated data link on the FTS2000 network from Barking Sands to Oahu which provides CONUS interconnectivity to the Naval Warfare Assessment Division (NWAD), Corona, California. This link provides the capability for data reduction at NWAD and for nationwide video teleconferencing.

A.20 CHINA LAKE

A.20.1 Mission

China Lake provides a large, secure, highly instrumented air and ground-range complex for testing live and inert missiles, rockets, guns, lasers, UAV's/UCAV's, aircraft systems, weapon delivery, radar cross section, directed energy (high energy laser and high power microwave), and ordnance (propulsion, warhead, environmental, and insensitive munitions). Capable of day and night operations, the ranges provide an environment for testing conventional weapons and aircraft systems.

A.20.2 Location

The NAWCWD land ranges are located at China Lake, which is situated in the upper Mojave Desert of southern California. The ranges are about 150 miles north of Los Angeles and encompass over 1.1 million acres. It is centrally located within combat radius flight of:

- Point Mugu Sea Range
- Navy's off-coast Fleet Training Range
- Air Force Ranges at Nellis and Tonapah, Nevada
- Edwards AFB
- Navy Strike Warfare Training Center at Fallon, Nevada
- Marine Corps training facility at Twentynine Palms, California
- NTC Fort Irwin

A.20.3 Topography

The land is primarily used for test and evaluation or as a buffer between sensitive or hazardous tests and the surrounding public lands. Most of the heavily instrumented test facilities are concentrated near the vast dry bed of a Pleistocene lake, which covers the southwestern quarter of the China Lake area. The terrain includes dry flat lakebeds, large dry washes, alluvial fans, open desert, and pine covered mountains.

A.20.4 Climate

- Summer: Hot with temperatures ranging up into the low hundreds. However due to the dry desert air of the Land Range, higher temperatures are bearable with cooler, warm nights.
- Winter: Winters are pleasant with lots of sunny days and temperatures ranging from the 30s to high 50s and low 60s. Snow seldom occurs except in the higher mountain sites where it is in abundance.
- Mean annual temperature: 65 degrees Fahrenheit, with average daily minima dropping to 30 F in December and January and average daily maxima reaching just above 100 F in July and August.
- Rainfall: Very light, averaging 4.5 inches (80% falling from November through March).
- Humidity: Average relative humidity is only 33% with 80% or greater readings observed less than 3% of the time.
- Surface Winds: Generally from the southwest at a mean speed from that direction of 9 knots. Overall wind speed (all directions combined) is 6 knots.

A.20.5 Facility Features.

A.20.5.1 Restricted Airspace
Restricted airspace includes:

- R-2508: Surrounding and overlying the China Lake Land Ranges is the R-2508 restricted airspace complex covering 20,000 square miles and restricted from 20,000 feet to infinity. This complex overlies not only the China Lake ranges, but also Edwards AFB and the Army's National Training Center at Fort Irwin.
- R-2505: This airspace is directly over the Land Ranges complex, covers approximately 1,100 square miles, and is restricted from surface to infinity.
- IR-200: An FAA approved low level corridor extending from the Sea Test Range at Point Mugu through the Land Range and on to the Utah Test and Training Range (Fallon, Nevada). It is available for low-level cruise missile flights.
- R-2524: This airspace overlies the Electronic Combat Range complex, and includes 1,200 square miles of restricted airspace from surface to infinity. It is under local control and is scheduled by the Land Range Scheduling Office.

Extended range test operations can simultaneously use both R-2505 and R-2524. Tests exceeding these boundaries but within R-2508 are coordinated with the R-2508 Control Center at Edwards AFB. Tests exceeding the boundaries of R-2508 are scheduled with the FAA.

A.20.5.2 Communications
Range communications provides secure and nonsecure transmission facilities for all video, voice, and data requirements while ensuring communications security. The communications suite is designed around standard telecommunications hardware, allowing for easy compatibility. It also includes fiber-optic distribution facilities, microwave systems, ultra-high frequency (UHF) ground-to-air and VHF ground-to-ground radio systems, digital multiplexing, digital switching, and video codecs.

A.20.6 Ranges

A.20.6.1 Land Ranges. The Land Ranges provide the capability, general management, administration, scheduling, and support required to conduct testing of:

- Air-to-air and air-to-surface weapons systems
- Surface-to-air guided missiles
- Small tactical air-defense systems
- Surface-to-surface systems, including guns and tactical air-defense systems
- Preflight tests of experimental airborne guided missiles and rockets
- Large-scale explosives detonations
- Tests of weapon-delivery

techniques
- Uninhabited Air Vehicles/Unmanned Combat Air Vehicles

The Land Range complex includes 8 unique ranges:
- George, which is a guided missile range,
- Baker & Charlie, which are used for aircraft weapon systems testing,
- Coso, which is used for training and tactics development,
- Superior Valley, which is used for training and special operations,
- Airport Lake, which provides mobile land targets,
- G-6, which provides capability to test point defense systems,
- Redeye, which is a small missile range, and
- Randsburg Fuse range.

A centralized range-control facility provides test operations control, communication, and coordination for collecting real-time data. It can conduct from 1 to 3 test operations simultaneously. It also provides "quick-look" data products based on real-time data. Data can be provided to range users generally within 2 hours of test completion. Real-time data management including quick-look data and data products is available.
- All data entering the Range Control Center is available for real-time display and can be recorded for post-mission use.
- Displays include both analog and computer video.
- Computer video display systems interface in real time with major TSPI sources (GPS, radar, laser, and airspace surveillance systems).
- Real-time telemetry data can be presented either as computer video displays or strip chart oscillographs.
- Scoring data provided by the Metric Video Center are available within 30 seconds after impact
- Quick-look data products are generated from recorded real-time data and are available within 2 hours after the test.

Additional data products are available post-mission.
- GPS data processing
- Post mission telemetry data reduction
- Multi-station/multi-instrument TSPI solutions are generated, as well as merging ground based TSPI data with telemetry data.
- Custom data reduction includes interpolation and extrapolation, filtering and smoothing, various geodetic transformations, and data format conversions.

A.20.6.2 Supersonic Naval Ordnance Research Track (SNORT). SNORT provides testing of weapons and components and parachute systems at operational speeds up to Mach 4 on 4-mile long, dual-rail, precision-aligned track. It combines aspects of laboratory testing with dynamic conditions of free-flight testing. Payloads up to 136,000 pounds can be accommodated. A simulated rain field along a 2,500-foot section can be provided including collecting data on effects of rain erosion on radomes. Optical and electronic instrumentation can be sled-borne or trackside. Types of testing supported include:

- Spacecraft escape systems
- Weapons and weapon release
- Live ordnance
- Components
- Parachute systems
- Ejection seats
- Environmental
- Guidance and fuze functions
- Provides test-item recovery for post-test examination or retest
- Tests run speeds up to Mach 4

A.20.6.3 Electronic Combat Range (ECR). ECR is the Navy's principal range providing decision quality data for the test and evaluation of airborne electronic warfare devices and systems. It is located approximately 30 miles southeast of Ridgecrest in the Randsburg Wash area. ECR's mission is to develop, operate, maintain, and continuously improve an open-air range that provides: electronic warfare assets, engineering, testing (RDT&E / DT&E / OT&E), analysis, and training resources to developers, integrators, testers, and users of systems that counter or penetrate air defenses. ECR operations typically include testing the effectiveness of: electronic counter measures (ECM), radar warning receivers, missile approach warning systems, anti-radiation weapons, towed decoys, expendables (chaff and infrared), UAV / Cruise missiles, and EW training. It is a secure, open-air range for T&E of airborne electronic combat systems with Top secret and special-access level security.

ECR operates numerous actual and simulated threat systems of several classes. ECR has numerous command guided threat Surface to Air Missile (SAM) systems types like the SA-2 FAN SONG and the EURO ROLAND II. ECR has a special facility for the hardware-in-the-loop operation of threat Semi-active Missile seekers in a manner like they are actually in flight called Missile on a Mountain (MoM). ECR is developing the Infrared Countermeasure Assessment System (ICAS) to meet the emerging IR MANPAD threat T&E requirement. ICAS includes platforms for hosting actual MANPAD seekers for countermeasure evaluation, simulators for simulating the UV and IR emissions of the exhaust plumes of these MANPAD missiles when they fly and a ground truth instrumentation system for measuring the physical constants of the test and understanding how the test was executed. ECR has a mountain top facility providing a hardware-in-the-loop Moving Target Simulation called Slate Range Facility, which allows EW developers to test their brass board or prototype systems against the same threats they will later fly against.

A.20.6.4 Etcheron Valley Range (EVR). EVR is an outdoor (65-square-mile) research facility located in a valley on the west side of the Argus Mountain range in the far

northeastern portion of the China Lake Naval Weapons Center. It provides outdoor RDT&E antenna characterization, a GPS antenna test/jamming range, a high-power microwave (HPM)/Transient Electromagnetic test facility, and a radar-cross-section (RCS)/radar signature test facility. The facility provides the instrumentation suite, test coordination, targets, and support functions for a wide range of outdoor range testing. EVR provides the instrumentation suite, test coordination, targets, facilities, and support functions for a wide range of tests involving ground vehicles or full-scale aircraft. The remoteness offers a quiet environment free from electromagnetic interference (EMI). The surrounding mountains and valley floor are primarily volcanic in nature with extremely high iron content. This provides high level of RF shielding for incoming and outgoing signals, and allows radiation at all frequencies at very high power levels.

Precision RCS measurements in HF, UHF, L, S, C, X, Ku and Ka bands are available, as well as coherent bi-static RCS capabilities. A horizontal bounce range provides a turntable capable of rotating objects up to 150 tons. Targets may be rotated 360 degrees to expose all aspects to the radar. At the Look-Down range, the radar looks down on the target from a range of 17,000 feet at an angle of 10 degrees. Two unique features are special-purpose target test beds. The wet site, a 78- by 100-foot pond, creates a simulated sea environment used to investigate background clutter and target-to-surface interactions. The tilt deck is a 80- by 140-foot hydraulically-controlled platform enabling target presentations of 5 to 32 degrees in elevation.

Both facilities have multi-frequency radars that produce a wide range of RF band, pulse-repetition-frequency, and pulse-width combinations. Step-chirp waveforms can be used to provide high range resolution and inverse synthetic aperture radar (ISAR) imaging.

The outdoor High Power Microwave/Transient Electromagnetic test facility supports high power microwave open air testing. EVR has a HPM device (known as THOR) capable of providing a custom ultra wideband electromagnetic environment, with an adjustable output pulse. Also available is a wooden structure containing target electronics for HPM susceptibility and vulnerability testing. Instrumentation is available to characterize the electromagnetic environment created by RF sources.

A.20.6.5 Ordnance T&E. Ordnance T&E facilities provide the nation's most extensive and sophisticated complex of test stands, warhead arenas, ordnance assembly facilities, and instrumented environmental, safety, and nondestructive test facilities. Full spectrum testing includes propulsion, warhead, environmental, nondestructive evaluation, and insensitive munitions/safety.

Propulsion T&E includes the static firings of rocket motors with up to 1 ½ million pounds of thrust, aero heating tests of materials, and small RAMJET engine tests. Nondestructive evaluation includes high energy

computer automated tomography, leak detection, boroscopic inspection, and convention film x-ray. Warhead testing includes conventional warheads and explosive devices for JMEM effectiveness, fragment impact and sympathetic detonation. Environmental and safety testing includes dynamic vibration and shock, climatic testing, cook-off tests, drop tests, and external fire stack tests.

The Aeroheat Test Facility (T-Range) is a high-pressure air blowdown facility extensively used for the testing of materials subjected to aerodynamic heating. It is capable of simulating variable Mach number and altitude flight conditions for materials characterization and testing.

Skytop is the Navy's largest and best-instrumented static-firing rocket motor test installation for the testing of the Trident strategic missile.

A Plume Measurement Capability Facility (PMCF) gathers broadband measurements and provides simultaneous radar cross section, infrared, ultraviolet, and visible characterization of gas turbine engines and liquid- and solid-propellant rocket motor plumes. Real time radiography (RTR) provides the capability to watch, in real-time, the burn characteristics of internal rocket motor ballistics.

A.20.7 Range Targets

A broad selection of Aerial targets is available, including the Nation's largest array of "shootable" RF targets. These include:

A.20.7.1 Mobile Surface Targets

- Includes remote controlled dune buggies and other wheeled and tracked tactical targets.
- Buggies and tanks can be equipped with remotely triggered ordnance-imitation flares, smoke, radar reflectors, headlights, and other devices

A.20.7.2 Aerial Targets Towed targets, subscale subsonic targets, full-scale missile targets, full-scale aircraft targets capable of remote operation by an air or ground-based controller.

- TDU-34B/A and TDU-32 (full-scale towed targets)
- BQM-74E and BQM-34S (subscale subsonic missiles)

A.20.7.3 Fixed Targets

- Cleared (graded) areas of land
- Reinforced concrete walls
- Billboards
- Airborne laser accuracy scoring target (ALAST)
- Bridges, tunnels, surface-to-air missile sites
- Bunkers
- Static vehicles, including tanks, trucks, jeeps, aircraft, etc.

- Surface RF emitter targets include over 50 impactable RF targets as well as airborne drone targets

A.21 POINT MUGU

A.21.1 Mission

To support full-spectrum Research and Development and Test and Evaluation (RDT&E) engineering for weapon systems associated with air warfare, missiles, and missile subsystems; conduct aircraft weapons integration; and airborne electronic warfare systems. Fundamental to this mission is the requirement to conduct testing at the component, sub-system, and system level.

A.21.2 Location

Point Mugu is located in Ventura County, California about 65 miles northwest of Los Angeles on the Oxnard Plain, near the cities of Camarillo and Oxnard. Point Mugu covers a land area of about 4,500 acres, and controls a sea range of 36,000 square miles.

A.21.3 Topography

- Point Mugu topography is composed of a mixture of geographical features typical of a semi-arid Southern California coastal region. It includes coastal wetlands, a mixed farming and urban plain extending back to low hills that eventually merge with mountains to the East. It includes a coastal sea range extending west out past the California Channel Islands. It incorporates as a key asset San Nicolas Island.

A.21.4 Climate

- Summer: The proximity of the cool Pacific Ocean waters results in cool summer days and nights. The climates are Mediterranean with mild temperatures. Sunny weather prevails during the afternoons. Occasionally, temperatures may rise to 90 F in later summer and fall.
- Winter: typical temperatures range from the 40s to 60s with warm days getting up into the 70s and 80s. Freezing temperatures have never been recorded at San Nicolas Island, and occurrences are very rare at Point Mugu. Sunny weather prevails both morning and afternoon during the winter, spring, and fall.
- Mean annual temperature: Average annual temperature at both Point Mugu and San Nicolas Island is 60 F.
- Rainfall: Rainfall is slight and falls principally over November through April, 12.5 inches on average at Point Mugu during the July-June precipitation year and 8 inches at San Nicolas Island.
- Humidity: At Point Mugu, relative humidity typically varies from the 85 % to 95 % range in the early mornings to the low 50 % to high 60 % range for the afternoons, although during offshore flow/Santa Ana episodes, readings are frequently less than 30 % all day, and during strong events less than 10 %. At San Nicolas Island, morning readings are also around 85 %-95 % usually, with afternoon readings averaging from the high 50's to high 60's. However, during strong offshore flow events from the mainland and occurrences of unusually low

subsidence inversion bases, relative humidity at the Island can dip into the 8 %-15 % range.

- Surface Winds: Generally from the west at a mean speed from that direction of 9 knots; at San Nicolas Island, winds are primarily from the northwest at a mean speed from that direction of 12 knots

A.21.5 Facility Features

- San Nicolas Island is approximately 60 miles off the California coast and approximately 30 miles from the nearest other island. It provides a base of operations for events occurring in the outer sea range, and because of its isolation it provides a littoral environment for testing and training events and a potential location for Directed Energy weapons testing.

- Laguna Peak is a 1,500 ft. coastal mainland hill hosting communications, telemetry receiving systems, and instrumentation for extended line-of-sight.
- The Port Hueneme deepwater port (35-foot draft) is adjacent to Sea Range. It supports range surface craft used for target recovery, security support, surface targets as well as the NAVSEA-operated Self Defense Test Ship.
- Two large airfield complexes exist, one at Naval Air Station Point Mugu with an 11,000 ft runway and one on San Nicolas Island with a 10,000 ft runway.
- Metric track, surveillance, telemetry, communications, and command and control sites are located at Point Mugu, Laguna Peak, Santa Cruz Island and Pillar Point.
- An underwater fiber optic communications system known as FOCUS provides a real-time data link between San Nicolas Island and command/control and data processing centers on the mainland.
- All data entering the Range Data System are available for real-time display and recording. Computer displays interface in real-time with radar, GPS, telemetry, surveillance, ACDS/NTDS, and target control systems. Real-time data delivery and display is available at remote customer-specified locations.
- All real-time data sources entering the Range Data System can be recorded for post-mission use. Multi-station, multi-sensor TSPI solutions are available as well as merged TSPI and TM data sources. Products may include tailored processing for unique customer requirements
- Pt. Mugu contains threat simulation and test and evaluation laboratories, and advanced modeling and simulation capabilities.

A.21.6 Sea Range

Sea Range provides a large, instrumented, controlled arena for testing in a maritime environment (Open-ocean, littoral, undersea, and over-water). It is used in support of joint-service programs, Missile Defense Agency events, and Battle Group exercises, in addition to meeting a heavy demand for the T&E needs of Navy acquisition programs.

Test events conducted on the Sea Range include those for air-to-air and air-to-surface weapons systems, surface-to-air guided missiles, surface-to-surface systems (including guns and tactical air-defense systems), Unmanned Air Vehicles/Unmanned Combat Air Vehicles (UAVs/UCAVs), aircraft, and hypersonic systems.

The 36,000 square nautical mile Sea Range is fully instrumented , and can be expanded to 125,000 square miles when required for operations requiring large footprints, such as for hypersonic missile launches and missile defense system tests. Operations are frequently linked with Vandenberg Air Force Base and the Navy's Southern California Offshore Range (SCORE). IR-200, an FAA approved low level corridor extending from the Sea Range through the Land Range at China Lake and on to the Utah Test and Training Range (Fallon, Nevada), is available for low-level cruise missile flights.

San Nicolas Island is the heart of Sea Range instrumentation. Instrumentation includes metric tracking and surveillance radars, Global Positioning System (GPS) receivers, optical systems, telemetry, and communications to support long range and over-the-horizon weapons testing. Ground-based coverage is augmented by airborne instrumentation from NP-3D Orion aircraft.

A.21.7 Range Targets

- Airborne targets include towed targets, subscale subsonic targets, and full-scale missile targets capable of remote operation by an air or ground-based controller and active full-spectrum augmentation to simulate known aerial threats.
- Seaborne target systems include self-powered, towed, and free-floating targets, configured to represent a wide variety of hostile vessels with both passive and active augmentation.
- Aerial targets include TDU-34B/A and TDU-32 (full-scale towed targets), BQM-74E and BQM-34S (subscale subsonic missiles), AQM-37C (subscale supersonic missile), and Vandal and MA-31 (full-scale supersonic missiles).

ADDITIONAL INFORMATION ON SELECTED NON-MRTFB FACILITIES:

A.22 AVIATION TECHNICAL TEST CENTER (ATTC)

A.22.1 Location

The primary mission of the US Army Aviation Technical Test Center (ATTC) is to optimize aviation warfighting capabilities to ensure full spectrum dominance of the battlefield for the soldier. To accomplish this mission, ATTC plans, conducts, analyzes, and reports on the developmental testing and airworthiness qualification of aircraft, aviation systems, and associated equipment throughout the life cycle. Airworthiness qualification testing focuses on assessing the handling qualities of the aerial vehicle and its performance (e.g., flight, hover, autorotation, etc.) and flight in icing conditions. The picture depicts an ATTC Airworthiness and Flight Characteristics Evaluation on the A/MH-6M, Mission Enhancement Little Bird (MELB)

A.22.2 Location. ATTC is located at Cairns Army Airfield, Fort Rucker, Alabama, approximately 142 km/85 miles southeast of Montgomery, AL, 33 km/20 miles west of Dothan, AL, and 150km/90 miles northwest of Panama City, Florida. ATTC can be reached by car via Interstate 10, which runs approximately 60 miles/100km south of Fort Rucker. Cairns Army Airfield, is located one mile south of US Route 84 at the Daleville exit, on Route 85. The Dothan/Houston County airport, located 20 miles/35km east of ATTC, provides commercial air service.

A.22.3 Features. Fort Rucker is situated on 64,500 acres of land 80 statute miles north of the Gulf of Mexico in the mid-lateral Temperate Zone. The terrain within the local flying area slopes from near sea level in the south to elevations exceeding 700 feet in the northeast. ATTC airfield elevation is 340 ft MSL. Rolling hills and cultivated farmland dominate the area. ATTC averages 53 inches of annual rainfall; mean humidity, 70 percent. Average maximum temperature for SE Alabama is 76°F; average minimum temperature, 56°F. Wind velocity typically varies between 4 and 5 mph.

A.22.4 Facilities

A.22.4.1 Cairns Army Airfield

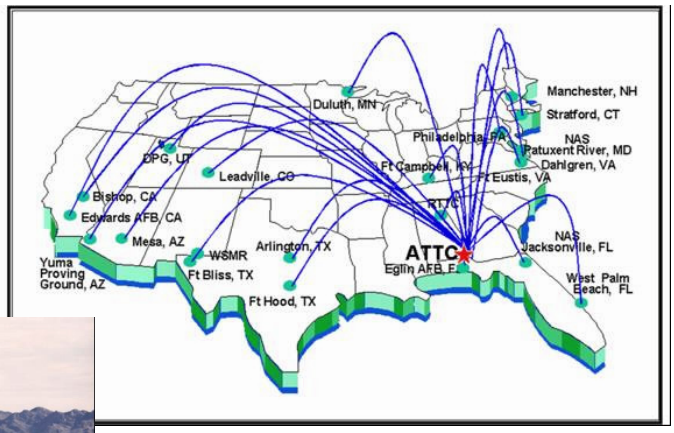
ATTC is currently the work site for approximately 100 government civilians, 25 military, and 200 supporting contractors. Home-based at Cairns Army Air Field (CAAF), the Test Center occupies a total of 206,000 square feet in building space, full access to the two hard-surface runways, and numerous airfields (Figure 3). The two hard surface runways

are oriented North-South and Northeast-Southwest with lengths of 4,500 feet and 5,000 feet. Maintenance facilities include three hangars and 12 support shops, while the engineering, headquarters, and support facilities account for the remainder of the 36 buildings at Cairns. Also located at Cairns field are a tethered hover pad and a calibrated slope landing area.

Fort Rucker's flying area covers approximately 32,000 square miles. ATTC is assigned a primary test area of 2,150 square miles within the southern portion of that airspace, away from the US Army Aviation Center air traffic. An additional 300 square miles are available in the northwest corner of the airspace and is designated as a call-up area to support airworthiness testing.

A.22.4.2 Remote Sites

ATTC conducts tests throughout the continental US. When specific test range capabilities or climatic conditions are required, ATTC test teams conduct tests at various remote geographical sites or at DoD MRTFB's. An example is the rocket fire testing conducted at Yuma Proving Ground, AZ on the OH-58D.



A.22.4.2.1 Icing Facility, Duluth Minnesota

Because of the prevailing weather patterns, temperatures, proximity to a large source of moisture (i.e., Lake Superior), and low density of air traffic, ATTC has historically conducted cold weather and icing tests in the Duluth local flying area. ATTC leases a hangar and ramp space on the airfield from which it bases its icing operations. This facility (Figure 6) provides 20,000 square feet of heated hangar space, 4,500 square feet of office space, and 3,500 square feet of shop and storage space.

A.22.4.3 Specialized Facilities

A.22.4.3.1 Modeling and Simulation

ATTC is developing modeling and simulation tools to enhance its capability to fulfill the Army Aviation flight test mission. The two major initiatives include the Flight Test Simulation Station and the Mobile Infrared Scene Projector, and are discussed in their own sections. Other initiatives that are ongoing at ATTC include the Modeling and Simulation Testbed (M&S Testbed) and the Ground Truth Database. These two initiatives are basic infrastructure used in accomplishing simulation development and verification and validation efforts. The M&S Testbed is the computer systems, networking, and staffing that allows ATTC to conduct distributed simulations in systems of systems testing. The Ground Truth Database is the repository of both flight test and simulation data that has been and is being collected in our testing mission. The repository is accessible with the proper authority through Wide Area Network along with the other test center data under the Development Test Command (DTC). All of the above M&S initiatives are a part of the DTC's Virtual Proving Ground (VPG) concept and will be integrated together with other command wide M&S capabilities.

Mobile Infrared Scene Projector (MIRSP) is tailored to bring a complete infrared (IR) scene projection (IRSP) capability to the field location of the IR sensor being stimulated. The MIRSP is driven by dynamic image sequences that can be generated in real-time from IR stimulation or played back from prerecorded simulation or sensor data. Product improvements continue to be made in the system based on lessons learned and customer inputs.

The Flight Test Simulation Station (FTSS) is a variable fidelity rotorcraft analytical tool structured to support the developmental testing and evaluation process for all modern Army rotorcraft. The FTSS program, as part of the Simulation, Test, and Evaluation Process concept, has the worthy goals of promoting flight test safety while maximizing the employment of the allocated Test and Evaluation (T&E) dollars and enhancing the utilization of flight-test hours. FTSS employs hardware-in-the-loop in conjunction with a synergistic collection of software tools to support aircraft/weapons compatibility and integration issues. These analyses include variable fidelity quasi-steady and time accurate treatments, which encompass many areas of rotorcraft engineering including aeromechanics, vibrations, performance, handling qualities, and flight control system design (Figure 8). FTSS uses the FLIGHTLAB software package to perform the physics based analyses required to simulate the aircraft flight characteristics. Aircraft models currently available in the FTSS model library include the RAH-66 Comanche, UH-60L Blackhawk, AH-64A Apache, and the CH-47D Chinook.

A.22.4.3.2 Human Factors Engineering and System Safety

Human Factors engineers play an integral part in any configuration changes to aircraft at ATTC. Currently, they are active in testing the newest concepts in aviation, the Comanche and Air Warrior programs. Their expertise includes fields of acoustical measurement and analysis; aircraft lighting; cockpit compatibility; crew station design, display and controls; experimental design; pilot performance measurement; system integration and interoperability; and system safety.

A.22.4.3.3 Data Reduction Facility. Real time data processing is provided to test engineers for the purpose of monitoring aircraft performance, handling qualities, and safety considerations. ATTC has recently built a customized, state-of-the-art, mobile vehicle to replace the previous, less capable unit. The self-contained facility provides two engineering stations with strip chart capability, one operator's station, internal and external 100 Mb network connections, internet connectivity, Commercial Off-The-Shelf (COTS) hardware and software, PC based (Windows NT) data reduction system, and real time and post processing of multiple stream data.

A.22.4.3.4 Aircraft Maintenance and Rapid Prototyping. ATTC has a tremendous capability in terms of prototyping, installing non-standard systems, and aircraft modification and fabrication. A number of back-up shops provide ATTC with limited depot level capability to include: instrumentation, machine, engine, welding, hydraulic and turbine, avionics, sheet metal and model making, prop and rotor, paint and fabric, ground support equipment, aircraft survivability equipment, and aviation life support equipment.

ATTC maintains a fleet of approximately 30 test bed aircraft (rotary and fixed wing), representing the Army's fielded aviation systems (AH-64 A/D, UH-60A/L, CH-47D, OH-58D, C-12). Several of these aircraft are specially equipped and instrumented to perform in-flight performance and handling qualities evaluations, while recording and telemetering technical engineering data to ground stations for real time or post flight analysis. The test aircraft becomes a flying laboratory with a flexible "Open Air Range" capability. One of ATTC's unique testing assets worthy of note is the Helicopter Icing Spray System (HISS).

Helicopter Icing Spray System (HISS) is a unique national asset consists of an internally mounted 1800 gallon water tank and external spray boom assembly installed on a modified CH-47D *Chinook* helicopter (Figure 12). When deployed in cold temperatures, the HISS generates an artificial measurable ice cloud 8x34 feet. A C-12 airplane, instrumented to characterize the ice cloud physics, accompanies the CH-47D HISS in conducting natural and artificial icing tests to support military and civilian icing certification.

A.23 NASA WALLOPS FLIGHT FACILITY (WFF) TEST RANGE

A.23.1 Mission

The Wallops Test Range is part of WFF and is managed by the Goddard Space Flight Center Suborbital and Special Orbital Projects Directorate. The range consists of a rocket/missile launch range, an aeronautical research airport, UAV launch and recovery facilities and associated tracking, data acquisition, and control instrumentation systems. The range includes authorized operating space, primarily over the Atlantic Ocean including the Navy's Virginia Capes Operations Area (VACAPES OPAREA) and authorized frequency spectrum. Scientists and engineers from NASA, the Navy and other DoD components have conducted Test and Evaluation (T&E) projects at this range.

A.23.2 Location

WFF is located on Virginia's Eastern Shore 5 miles west of Chincoteague, Virginia, approximately 90 miles north of Norfolk Virginia, and 40 miles southeast of Salisbury, MD. It consists of three separate parcels of real property: the main base, the Mainland, and the Wallops Island Launch Site.

A.23.3 Features

Several Navy organizations are co-located with NASA at Wallops Island to support Navy T&E Programs. The Surface Combat Systems Center (SCSC) is a Program Executive Office, Integrated Warfare Systems Field Activity. They have two unique, multi-functional facilities. The Aegis facility is dedicated to the support of all Aegis cruisers and destroyers. The Ship Self Defense facility supports amphibious ships and aircraft carries. SCSC provides high-fidelity combat systems suites with platform specific voice and data communications, radars and sensors. The Combat System Information Centers are nearly exact shipboard representations and an Operations Control Center is available to provide command and control support for T&E events in the Atlantic and VACAPES OPAREA. The Naval Air Warfare Center, Aircraft Division (NAWCAD) from Patuxent River, Maryland, also maintains facilities and personnel at Wallops. NAWCAD makes regular use of the test range for supersonic and sub-sonic missile and drone targets in support of fleet and land based test events.

A.24 NAVAL SURFACE WAREFARE CENTER

A.24.1 Naval Surface Warfare Center (NSWC) - NSWC provides the technology, capabilities, and specialized research and development facilities to support all aspects of surface warfare. It's 5 T&E related divisions support Surface Warfare requirements. Indian Head, Dahlgren and Port Hueneme, ensure technologically advanced weapon systems and weapon system safety, Carderock concentrates on new ship systems and platform safety and Corona conducts critical analysis of fleet readiness and combat systems performance; Crane, Carderock and Port Hueneme satisfy the life-cycle engineering, logistics and maintenance needs of the fleet.

A.24.1.1 NSWC Indian Head Division - The Indian Head Division is located approximately 20 miles south of Washington, DC on the Potomac River in Charles County, Maryland. Its extensive T&E capabilities are used to ensure material quality and ordnance reliability. Indian Head plans, directs, and conducts nondestructive and destructive life-cycle testing and analysis to evaluate propulsion and other chemically powered systems, inspect raw materials, component parts, and finished products, conduct qualification, pre-production, lot acceptance, and surveillance testing, perform type-life and quality evaluation studies, perform accident investigations and failure analyses, test equipment that requires special handling. T&E capabilities include:

- Physical/chemical analysis of materials, propellant/explosive material characterization and, hazards evaluation of energetic materials (safety testing)
- Nondestructive examination of metals and plastics as well as ferrous and nonferrous metallurgical analysis
- Rocket motor ballistic testing
- Cartridge-actuated devices/explosive devices testing
- Gun ammunition testing
- Systems-level testing
- Field testing of mine clearance and other related systems
- Ground testing of the tomahawk missile and its components; multi-component ballistic testing; high rate/high pressure mechanical properties tensile testing; and 3-d magnetic particle inspections.

A.24.1.2 NSWC Dahlgren Division (NSWCDD) – NSWCDD provides RDT&E, engineering and fleet support activities for surface warfare, surface ship combat systems, ordnance, strategic systems, amphibious warfare, mines and mine countermeasures, and amphibious and special warfare systems. The Division conducts analysis, systems engineering, research, test, evaluation, and integration of important naval and joint warfare systems. Dahlgren is comprised of three major sites: Naval Surface Warfare Center, Dahlgren Laboratory in Dahlgren, VA; the Coastal Systems Station in Panama City, FL; and the Combat Systems Direction Activity at Dam Neck, VA.

A.24.1.2.1 Naval Surface Warfare Center, Dahlgren Laboratory – Areas of T&E encompassed by the lab include:

- Force Level Warfare Systems - Conducts RDT&E associated with systems integration at the battle group, force, and theater level. It includes the development of mission level capabilities, T&E associated with advanced systems and upgrades, and the capability to conduct and analyze battle group hardware-in-the-loop and operational testing through use of the Distributed Engineering Plant and Fleet Exercises.
- Homeland Security and Measured Response Options - Conducts RDT&E and engineering integration of capabilities in support of homeland security requirements. Provides support to the homeland security components of homeland defense and support to civilian authorities to include coastal security, critical infrastructure protection, and counter-drug applications. NSWC's Naval Operations Other Than War Technology Center, The Joint Program Office for Special Technology Countermeasures and Critical Infrastructure Protection, and the DoD Counterdrug Technology Development Program are integral parts of this core equity.
- Force Protection and Chemical/Biological Defense Systems - Conducts RDT&E associated with preventing or mitigating terrorist actions including reducing vulnerability and developing offensive measures to prevent, deter, and respond to terrorism. It functions as the Navy's lead in chemical and biological defense systems.
- Surface Ship Combat Systems - Provides RDT&E, support for Surface Ship Combat Systems from concept through in-service life. Systems and areas covered include;
    - Air and Surface Surveillance and Detection Systems to encompass airborne and surface radar, high vision and Electro-Optics capability, including night vision, laser, low-light-level imaging, infrared, and multi-sensors systems.
    - Combat Control Systems including the various systems and equipments used to display the tactical picture; make or assist making combat decisions, and direct control of the engagement systems.
- Surface Warfare engagement systems concepts, modernizations, and upgrades, and integration into the ship's combat weapons systems. Supports engagement systems including missiles, launching and gun systems, simulators and trainers, exterior communications systems. Provides end-to-end systems engineering of USW command and control across platforms, connectivity for data-sharing at the USW and theater level
    - Navy Strategic Weapon Systems - Provides technology advancement, systems engineering, software development, and operational support for Navy strategic systems and for weapons system test, diagnostic and training equipment.
    - All surface shipboard electronic detection and guidance devices including electronic surveillance measures (ESM), electronic countermeasures (ECM) and electronic attack (EA).

    - Combat Systems Engineering, Integration, T&E & Assessment including the control of interfaces across all ship combat system and warfare elements.
- USW Ranges, Analysis & Assessment - Provides facilities for planning, developing, testing, installing, and operating undersea ranges for US and allied USW training and test and evaluation needs.
- USW Command & Control Systems - Provides facilities for conducting RDT&E, and engineering and operational systems development for USW combat systems on surface ships and submarines to include active and passive detection, classification, tracking and localization capabilities; acoustic communications capabilities; hull-mounted and towed arrays; special acoustic and environmental sensor capabilities, submarine imaging and electronic warfare, submarine space systems that are critical to Navy and national objectives. Key T&E capabilities include
    - Testing capabilities required to support the Navy strategic missile and re-entry systems. Specific areas include fire control, targeting, launcher, and other shipboard subsystems. Supports the testing of the software and hardware needed shipboard and at U.S. Strategic Command for targeting and launching Navy Strategic systems.
    - Testing capabilities to support development of missile propellants and materials technology for SLBMs, and the assessment of the effects of nuclear environments on re-entry body performance. Includes support of the FBM Microelectronics Program. A key element is the development and maintenance of unique design, performance, and test data for re-entry systems.
    - Capability to analyze, test, and evaluate systems which includes support of flight tests through both pre- and post-flight analysis, system accuracy and performance assessment in support of targeting, and management of problems reported by operational forces. Functions are provided for Navy Strategic systems and specifically the SLBM systems.
    - Capabilities to test Non-Nuclear Strategic Weapons Systems deployed on strategic missiles or platforms or used in a strategic role.
- Ordnance - Provides T&E capabilities for a wide variety of expendable ordnance components, devices, including Warheads, Rockets, Ammunition Cartridge Actuated, Pyrotechnic, & Specialty Devices & Other Ordnance Systems, energetic chemicals, propellants, explosives and pyrotechnics. Additionally provides T&E associated with supporting ordnance safety and ordnance environmental capabilities.
- USW Weapon & Vehicle Systems - Provides RDT&E capabilities for all submarine, surface ship, and air-launched torpedo systems and Unmanned Undersea Vehicle (UUV) Systems. Key T&E capabilities include;
    - T&E for integration for new and upgraded torpedo systems
    - Testing of undersea targets, countermeasures, and counter-weapon systems

- Testing torpedo Defensive Systems associated with torpedo detection, classification and localization as well as the various devices and methods employed to defeat them.
- Testing and in-service engineering functions, system analysis and simulation required to define launcher systems and subsystems requirements.
- Facilities testing and operationally supporting USW tactical missile systems to ensure undersea warfare systems readiness. Performs systems engineering, design engineering, software engineering, logistics engineering and T&E for integration of new and existing missile systems on submarines.

A.24.1.3 Coastal Systems Station Panama City, Florida (NSWC PC) - RDT&E responsibilities are focused on Navy and Marine Corps littoral and expeditionary warfare operations. A unique feature is the natural operating environment provided by its access to the Gulf of Mexico and its associated littoral and coastal regions. The Gulf provides a surrogate environment for most of the littoral areas of the world in which the Navy operates in. Its mission is to provide RDT&E and in-service support for amphibious warfare, diving, maritime special operations, mine warfare (mines and mine countermeasures), and other Naval missions that take place in coastal regions. Specific capabilities include:

- Mine Warfare Systems - Provides for the full spectrum of S&T, Research, Development, Test and Evaluation (RDT&E), fleet support and in-service engineering mine and mine countermeasures systems. Advanced sensor and detection technologies are employed to develop versatile and highly effective mines. The mine countermeasures (MCM) efforts exploit new technologies found in existing or emerging mine threats, and design and develop new systems and tactics to counter those threats.

  Amphibious Warfare Systems - Provides for the full spectrum of S&T, RDT&E, fleet support and in-service engineering for Amphibious Warfare Systems found on amphibious units. Specialized capabilities are applied conjunction with test ranges to form a total system capability, technical depth and operational understanding.

  Special Warfare Systems - Provides the RDT&E, Acquisition Support and In-Service Engineering for the systems and equipment required to perform special mobility operations, unconventional warfare, coastal and riverine interdiction, beach and coastal reconnaissance and certain intelligence operations. Supports subsurface and surface mobility vehicles that can be manned, unmanned and remotely operated systems.

  Diving and Life Support Systems - Provides RDT&E, acquisition and in-service engineering support for the Navy's underwater and surface personal life support systems, and tri-service needs for all aspects of diving and personal life support requirements. Supports Naval Special Warfare, Explosive Ordnance Disposal,

U.S. Marine Combat Swimmer, and Salvage Diving for in-theater ship repair. It also supports Life Support systems for manned operations in hazardous environments.

A.24.1.4 Combat Direction Systems Activity (CDSA) Dam Neck - CDSA provides technical support to ships, aircraft, and submarines. The center's mission includes responsibility for planning, developing, testing, and delivering computer programs for shipboard combat direction systems.

A.24.1.5 NSWC Carderock Division - is headquartered in Betheda, MD where its mission encompasses RDT&E, fleet support, and in-service engineering for surface and undersea hull, mechanical, and electrical systems and propulsors. Carderock is responsible for the full spectrum of maritime science and technology, from concept through design and acquisition, to implementation and follow-on engineering. This includes all aspects of testing and improving the performance of ships, submarines, military watercraft, and unmanned vehicles, as well as research for military logistics systems. In addition, the Division is uniquely chartered by Congress to support America's maritime industry. Carderock is composed of 6 departments, five of which are associated with operational and developmental forms of testing. These are:

Ship Signatures – Responsible for developing superior stealth technologies through signature control and silencing to reduce the vulnerability of Navy vessels to mines, torpedoes, and other dangers

Survivability, Structures and Materials - Focuses on overall design and integrity of naval ships as well as weapon systems. This includes performing research, development, testing & evaluation (RDT&E) on marine materials and structures

Ship Systems Integration & Design - focus on integrating multidisciplinary technologies and systems into total ship designs and support analyses for surface ships, submarines, combatant craft, and Marine Corps vehicles.

Hydromechanics - Supports all RDT&E related to ships, submarines, unmanned vehicles and craft by developing technologies for systems which define the external shape of the vehicle, control systems and surfaces, and propulsor interaction with the hull and its environment.

Machinery Research and Engineering - Develops the concepts, technologies, equipment, systems, and procedures enabling Navy ships to operate reliably, affordably, and to meet performance and mission requirements. This RDT&E effort begins at the earliest stages of shipboard equipment and component product development, continues through new ship construction and as In-Service Engineering support to ships and ship systems currently in the fleet. It is also developing technology for future all-electric Navy ships.

Carderock has detachments at other sites across the country. These include:

A.24.1.5.1 Ship Systems Engineering Station (SSES) - Located in Philadelphia, it is the Navy's principal T&E and In-Service engineering agent for all hull, mechanical and electrical ship systems and equipments. SSES has the capability to test and engineer the full range of shipboard systems and equipment from full-scale propulsion systems to digital controls and electric power systems. SSES designs, improves, engineers, supports, tests, and evaluates ship systems, equipment, processes and components. The Station has technical leadership responsibilities in areas, such as:

Machinery research & development

Marine gas turbine systems

Cargo/weapon elevators and vertical package conveyors

Ship survivability and damage control

Shock and vibration

High and low pressure air systems

Undersea vehicle sail, antenna and deployed buoy systems

Submarine life support systems

Air conditioning, refrigeration and ventilation systems

A.24.1.5.2 Acoustic Research Detachment - The Acoustic Research Detachment is located on Lake Pend Oreille in Bayview, ID. It provides a deep, quiet body of water where a free-field ocean-like environment is available without the problems and costs of ocean operations. Unique experimental hardware and floating platforms are located there to support a wide variety of R&D programs ranging from the measurement of flow induced boundary layer fluctuations on sonar domes to the calibrations of full-scale surface ship sonar transducers. A key asset is the Large Scale Vehicle (LSV) which is a structural model of the SSN-21 Class submarine. The facilities also support private industry and research efforts of the United Kingdom.

A.24.1.5.3 Bremerton Detachment - The detachment, located in the Naval Shipyard, Bremerton, WA provides management and logistic support for West Coast full-scale ship and submarine acoustic trials. It is responsible for the operation of :

A.24.1.6 Southeast Alaska Acoustic Measurement Facility Ketchikan, AK - As the Navy's primary acoustic engineering measurement facility in the Pacific, the Southeast Alaska Measurement Facility (SEAFAC) can perform RDT&E evaluations to determine the sources of radiated acoustic noise, to assess vulnerability, and to develop quieting measures. The site is characterized by low ambient noise and minimal noise

interference. SEAFAC supports submarine operations over a full range of speeds and depths required for underway tests during acoustic trials. SEAFAC is also capable of supporting submarine target strength measurements. The facility consists of a site to collect acoustic signatures of submerged submarines underway, and a unique site to measure acoustic signatures of motionless (static) submerged submarines with various onboard machinery secured or under unloaded operation. Acoustic signatures can be collected for a variety of speeds and operating conditions as the submarine transits back and forth between the dual bottom-mounted acoustic arrays. At the static site, suspension barges lower the submarine on cables and position it between measurement arrays to evaluate acoustic signatures of individual machinery components. The Static Site can test vessels of all sizes and types moored or suspended between surface barges. Submarines can be suspended at various depths from the surface barges between two underwater arrays and the ship's propulsion systems secured. Surface ships can be put on shore power with ship power and propulsion systems secured. This allows test personnel to obtain unique measurements on individual pieces of equipment and machinery. The signal processing and in-water hardware are designed to accommodate a variety of sponsors and requirements.

A.24.1.7 Fox Island Laboratory, Fox Island, WA - The lab provides a unique, shallow water, protected, ocean environment facility which operates the M241 Barge, shore facilities, personnel and resources required to support RDT&E of Military and Commercial projects. This includes development and operational evaluation of naval vehicles and equipment, which can counter current and anticipated detection threats. Fox Island Lab also develops and maintains state-of-the-art systems and equipment to support RTD&E of underwater acoustic data acquisition and processing systems; surface and sub-surface navigation and tracking systems hardware and software; acoustic noise characterization and performance of ROV's, UUV's, and specialized underwater tools, sonars, doppler, and mine hunting hardware.

A.24.1.8 South Florida Testing Facility (SFTF) - Located in Fort Lauderdale it is the only ship, submarine, and mine-effectiveness test range with simultaneous air, surface, and subsurface tracking capability. It has the ability to monitor surface ship, submarine, and remote vehicle signatures in the near shore environment. The range encompasses the Navy's only shallow and deep magnetic research and development ranges, including submerged operations. The facility also provides a means to evaluate mine detection, countermeasures and mine response; perform acoustic measurements; and acquire radar cross section and infrared signatures. Surface, air and submerged tracking is also available. There are also deep and shallow water multiplexers allowing for installation of additional sensors on an "as needed" basis.

A.24.1.9 Memphis Detachment - Located at President's Island near Memphis, TN, it is the operating site for a Large Cavitation (LCC). The LCC is one of the world's largest and most technically advanced water tunnel facilities capable of testing all types of ship and submarine propellers and propeller-hull interactions. The LCC was designed as a variable pressure, recirculating, cavitation tunnel with a very low acoustic background level. It provides significant cost savings for testing large-scale

models of advanced ship and submarine system designs and full-scale torpedoes. Commercial uses of this facility include maritime shipping industry applications.

A.24.1.10 Combatant Craft Department (CCD) - Located in Norfolk, VA. CCD performs full life-cycle and spectrum support for all forms of combatant craft, boats, patrol ships, life rafts and their associated hull, mechanical, electrical and electronic systems for the U.S. Navy, Army, Marine Corps, Special Warfare / Special Operations, Air Force, Coast Guard, and other DoD and non-DoD activities including private industry. Services includes RDT&E in the areas of concept feasibility and design, acquisition engineering support, total craft systems engineering and integration, construction and in-service engineering, special projects including hull design, hydrodynamics, stability, arrangements and structures. CCD also manages the Special Trials Facility (STF) located at Patuxent River Naval Air Station. STF supports a wide variety of vehicle research, development, test and evaluation projects including Surface Effects Ship programs.

A.24.1.11 Acoustic Trials Detachment - USNS Hayes, based in Port Canaveral, FL is an ultra-quiet acoustic noise-measuring vessel serving the East coast. Through use of advanced measurement systems including a high capacity data acquisition and processing system and a towed array measurement system, it is capable of measuring radiated noise signatures of the Navy's quietest submarines.

A.24.1.12 Research Vessels: These research vessels are based in Panama City, and consist of three converted Asheville-class patrol gunboats. Two support hydrodynamic and acoustic testing, and one supports electromagnetic signatures testing. *Athena I & II*, have seen extensive service in the development of high speed towed sensors, airborne mine countermeasures, communication systems, and full-scale validations of model predictions for propeller wake surveys and propeller stress studies. The *Lauren* can be configured to evaluate HM&E technologies at a large scale. To enhance *Athena's* capability in taking high-speed acoustic data, she can be fitted with a compound air masker system (CAM), which greatly reduces the ship's radiated noise. She has been modified extensively as a Research Vessel to include: laboratory space with a dedicated power source, deck crane, and A-Frame. A variety of towing winches and handling equipment are also available.

A.24.1.13 NSWC Corona Division – Corona is the Navy's independent analysis and assessment center whose mission is to gauge the warfighting capability of ships and aircraft, form unit to battlegroup level by assessing the suitability of design, the performance of equipment and weapons and the adequacy of training. Corona's 5 departments include; Combat Systems, Force Training, Joint Forces, Measurement Sciences, Product Engineering, and Quality Assessments, all contributing to the support of over 120 Navy, Marine Corps, Army, and Air Force Program Offices, as well as a number of United States and foreign government agencies and industries. Corona has two laboratories that provide measurement and analytical capability for the Armed Services. The Joint Warfare Assessment Laboratory (JWAL) is a secure facility with satellite connectivity that allows the integration and merging of Navy test exercise data needed to assess the performance of Navy ships, aircraft, and combat

systems. The Measure Science and Technology Laboratory (MSTL) is a newly constructed metrology and gage laboratory used to conduct super-precise measurements in support of sophisticated Navy systems. Key capabilities include:

Combat & Weapons Systems Assessment related to Air and Surface Defense Combat System testing.

Missile Systems Assessment of shipboard Anti-Air Warfare, surface strike, and land attack weapons.

Material Readiness Assessment of Combat and C4I Systems including Combat and Weapons Systems Reliability, Maintainability, Availability, and Quality Assessment.

Provides empirical data and analysis in support of upgrades or future systems.

A.24.1.14 NSWC Crane Division - specializes in the acquisition and Fleet support of Electronics, Ordnance and Electronic Warfare products and systems. Its main facility is located in Indiana with a detachment in Fallbrook, California. Crane's mission is to provide engineering and industrial base support of weapon systems, subsystems, equipment, and components with principal emphasis on industrial and product engineering. Key T&E capabilities include:

Developing Automated Test Equipment and Test Program Sets for Airborne Electronic Warfare

Acceptance Testing for chemical and biological warfare detection systems

Testing related to acquisition engineering, design & development, product assessment, M&S related to conventional ammunition systems for ship, air, Marine Corps systems, tactical & strategic missiles, special warfare, air defense, anti-armor, landmine countermeasures

Test support for all high-security locks and keys used for securing arms, ammunition, and explosives

Evaluation of mobile electronic systems associated with Expeditionary Warfare

Test and test program set development related to fleet maintenance and modernization of digital and analog systems such as power and RF devices, computers, displays and peripherals, electronic control systems

Qualification and acceptance testing of microwave vacuum and solid state devices, night vision / electro-optics

Testing power systems such as batteries, fuel cells, chargers and power suppliers

T&E related to pyrotechnics such as signals and markers, smokes and obscurants and IR Countermeasures

T&E related to Army, Air Force, Navy and Marine Radar systems including shipboard training systems, air, surface, weapons, and navigation radars, and Navy antennas

T&E related to small arms such as pistols, rifles, machine guns, crew served weapons, anti-armor weapons and small arms ammunition

Test analysis of space and high reliability electronics and the integration of Commercial Off-the-Shelf products Strategic Systems including Guidance, Missile, Fire Control, Navigation, and GPS, systems

Performance and acceptance testing of Surface Electronic Warfare systems of commercial electronic technology for Ship Systems application found in systems such as the Cooperative Engagement Capability, Aegis, Ship Self Defense Systems, and close quarters combat ranges

Specialized T&E related to Undersea Warfare Systems such as Air-Launched sonobuoys, sonar systems and acoustic sensors, acoustic countermeasures and countermeasure launchers, surface ship ASW systems

A.24.1.15 NSWC Port Hueneme Division - Located on the Pacific coast in Ventura County, CA, Port Hueneme provides a full spectrum of test and evaluation functions, from early test program planning and development, through tests conducted at land-based test sites and onboard ships at sea. Its mission is to provide T&E, In-Service Engineering, and Integrated Logistics Support for surface warfare combat systems and subsystems, unique equipments, and related expendable ordnance of the navy surface fleet. Port Hueneme is also the Navy's only underway replenishment development and test site where conceptual methods for improved replenishment designs are tested Specific types of systems supported include;

- Aegis, STANDARD, NATO Seasparrow, Rolling Airframe, Tomahawk and Harpoon missiles and launchers, associated guidance, search, track, and destroy functions, and missile launch system such as the Vertical Launching System
- Shipboard guns, gun mounts, ammunition handling systems, gun fire control systems as well as radar and communication systems
- Computer software programs associated with offensive and defensive engagements
- Underway replenishment systems engineering.

Specific T&E capabilities include:

A.24.1.15.1 Surface Warfare Engineering Facility (SWEF) - is a land-based test site and laboratory facility that allows test and evaluation of combat and weapon systems designed for use by the fleet. The SWEF ocean front environment makes it possible to simulate shipboard operational problems and evaluate performance without the expense of using ships at sea or the personnel to support these operations.

There are three primary types of systems and equipment installed at the SWEF complex: combat systems, fire control radar systems, and missile launching systems

A.24.1.15.2 Self Defense Test Ship (SDTS) - The former Destroyer, Paul F. Foster (DD 964) is a unique Navy test asset specially refurbished for remote-controlled operation. The ship supports self-defense engineering, test, and evaluation, without the safety constraints and in-port problems associated with manned ships. During typical operations, launched threats attack the SDTS and the combat or weapon system being tested responds to these threats in defense of the ship. The predetermined attack is actually aimed at a decoy barge pulled 150 feet behind the test ship to protect the ship and its assets.

A.24.1.15.3 Underway Replenishment Test Site - Port Hueneme has the only fully equipped and operational UNREP test site. This test site contains modern constant tensioned fueling and cargo systems with Navy standard equipment that represents the latest configurations for both the delivery and receiving parts of the system. As a test site, it is used to fully test new systems, equipment, and configurations under controlled conditions.

Port Hueneme has detachments at San Diego, California; White Sands, New Mexico; Louisville, Kentucky; and Virginia Beach, Virginia.

A.24.1.15.4 San Diego Detachment - The detachment oversees the Integrated Combat System Test Facility (ICSTF) located on SPAWARS Systems Center at Point Loma, CA. The ICSTF certifies the operational programs comprising the combat system for the CV/CVN, LHD, LHA, LSD, DD-963, FFG ship classes. Its mission is to provide engineering and technical support for RDT&E of command and control systems; land-based reliability testing, integration and certification of surface ship combat systems computer program networks both prior to initial operation and for in-service systems; design, development, and lifecycle-maintenance of standardized simulation systems; land-based test facilities and services for the analysis of performance of in-service combat systems, subsystems, and equipments for afloat units; and land-based surface warfare combat systems integration testing. San Diego Detachment laboratory supports Combat System Integration Testing (CSIT), which is a requirement for the delivery of new or modified combat system operational programs to the fleet. CSIT involves developing test beds, consisting of equipment and simulation that functionally replicate the ship combat systems, developing test procedures for operational programs, developing test tools to capture and evaluate Combat System data passed around various subsystems, documenting problems and performing data extraction. San Diego also employs a Navy Distributed Engineering Plant (DEP) test nodewhich is used to support Battle Force Interoperability Testing (BFIT). It can be used to configure existing combat system resources to represent battle groups consisting of CV, DD, FFG, LHA and LHD ship classes. This greatly facilitates the capturing for analysis, test data to identify any interoperability issues. The Det also performs simulation development and maintenance used in supporting

test needs. They also develop and manage T&E plans for all shipboard and shore site installations of the Battle Force Tactical Training (BFTT) family of systems.

A.24.1.15.5 White Sands Detachment - Conducts live-fire testing, and recovery of missile, gun, and rocket systems. It provides an array of test scenarios ranging from restrained rocket motor tests through all-up round engagement of ground, aerial, and theater missile defense targets. It is part of a Tri-Service National Range test facility offering high-speed secure interconnectivity, a variety of network-centric and battle space management scenarios. Recovery of missile and target systems and components permits evaluation of material performance, forensic analyses on failures, and evaluation of warhead fragment performance against real targets. Weapon interfaces with launchers and fire control systems are demonstrated in a live-fire environment providing validation of critical hardware and software. Launch Complex 35W, also known as the Desert Ship, is primarily used for live-fire testing of the STANDARD Missile (SM) and Evolved Seasparrow Missile. The Desert Ship functionally duplicates SM fire control requirements of a surface ship. The facility has tested all versions of SM including Tartar, Terrier, and AEGIS variants of SM-1 and SM-2, Seasparrow, Sealance, Vertical Launch Anti-Submarine Rocket, and 5-inch Guided Projectile. The Desert Ship is migrating to an increasing role in cooperative, integrated synthetic and live-fire testing.

A.24.1.15.6 Louisville Detachment - Supports the Navy's gun systems, including responsibility for the various gun fire control systems, as well as radar and related communication. It provides RDT&E support to emerging naval gun weapon systems, integrated ship defense systems, and equipments.

A.24.1.15.7 Virginia Beach Detachment - Maintains a land-based engineering and test facility complete with 11 air and surface search radar systems that support engineering development, logistics product development, and live radar testing.

A.25. NUWC Division Newport – This Division is located in Newport, RI. Its mission is to provide the technical foundation enabling the conceptualization, research, development, fielding, modernization, and maintenance of systems that ensure the Navy's undersea superiority. This includes responsibility for the full life cycle of submarine and undersea warfare systems. Key T&E support elements located at NUWC Newport include;

A.25.1 Narragansett Bay Shallow Water Test Facility (NBSWTF) - located just off the coast of Newport, RI, it offers a variety of unique shallow water ranges to government and private industry which permit prototype underwater weapons systems to be exposed to real environments with minimum risk of loss. The range is designed to support research and development work in advanced underwater weapons and weapons systems, weapon launchers, exploders, other similar weapon components and equipments, and worldwide offshore/at-sea oceanographics. A key asset associated with this range is the ex USS Salmon anchored 356 feet below the surface. It provides an environmentally safe, and realistic target that is available for a variety of test and evaluation scenarios.

A.25.2 Survivability Test Facility - A specialized laboratory dedicated to survivability and environmental testing of submarine and surface ship systems. It supports measurements of the mechanical parameters of sonar equipment and the properties of materials used in underwater mobile and deployed sonar arrays research and development programs.

A.25.3 Submarine Towed and Deployed Systems RDT&E Complex – Its facilities are located at Newport and at the NUWC compound on Fisher's Island, NY. These facilities are used for engineering development of submarine, surface ship, and other vehicle towed and deployed sensors and handling systems. Specific capabilities include; The Quiet Water Tunnel, Acoustic Wind Tunnel, Anechoic Chamber, Combat Systems Evaluation & Analysis Laboratory, Undersea Warfare Analysis Laboratory, Propulsion Noise Test System, Stereolithography Rapid Prototyping Facility

A.26 Naval Experimental Diving Unit (NEDU) - NEDU is a field activity of Naval Sea Systems Command in support of the Supervisor of Salvage and Diving, is a tenant of the Coastal Systems Station (CSS). It conducts T&E for diving, hyperbaric, and other life-support systems, and conducts research and development in biomedical and environmental physiology for the Navy and other Services. Its customer base also includes other Federal offices, industry and international interests. NEDU T&E related facilities include:

A.26.1 Ocean Simulation Facility (OSF) - The OSF chamber simulates ocean conditions to a maximum pressure equivalent of 2,250 feet seawater and at any salinity level. The chamber complex consists of a 55,000-gallon wet chamber and five interconnected dry living/working chambers. Wet and dry chamber temperatures can be set from 28 to 104 °F. Equipped with the latest data acquisition capability, the OSF can accommodate a wide range of complex experiments including diver biomedical studies and testing of humans as well as small submersible vehicles and other machines in the wet chamber. Saturation dives can be performed for more than 30 days of continuous exposure in the OSF. The dry chambers are also capable of altitude simulation studies to heights of 150,000 feet.

A.26.2 Unmanned Test Facility (UTF) - UTF is equipped with data acquisition instruments, 3 breathing machines that simulate divers' breathing patterns, and mannequins. This facility's hyperbaric chamber complex is available for unmanned testing to 1,640 fsw and over a temperature range from 28 to 110 °F. Research includes freeze studies and work of breathing tests, carbon dioxide absorbent duration and oxygen consumption tests for closed-circuit Underwater Breathing Apparatus (UBAs).

A.26.3 Test Pool - The test pool,15 feet deep, provides temperatures ranging from 34 to 105 °F. Equipped with the latest acquisition instruments, the pool is used in a wide range of studies including physiological testing of divers and evaluating of manned diving equipment and small submersible vehicles.

A.26.4 Environmental Chamber - The environmental chamber is capable of simulating a broad range of temperatures (0 to 130 °F), humidity (5 to 95%), and wind velocity (0 to 20 mph). The chamber is instrumented to conduct physiology studies of divers and to test diving equipment and small submersible vehicles.

A.26.5 Class 100,000 Clean Room - The 100,000 Clean Room performs hydrostatic testing up to 10,000 psi, and oxygen cleaning of piping, valves, regulators, tanks, and filters.

A.27 SPACE & NAVAL WARFARE SYSTEMS COMMAND (SPAWAR) MANAGED T&E FACILITIES. SPAWAR reports to the Chief of Naval Operations. It is responsible for developing and delivering the U.S. Navy and Marine Corps operating forces with Command, Control and Communications electronic systems. A primary focus has been on Undersea Surveillance and Space Systems programs. SPAWAR is the Navy's Battle Force architect, a new area aimed at designing total systems for the forces instead of individual platforms and weapons. Two of SPAWAR's four Systems Centers have to a greater or lesser degree some responsibilities associated with classic T&E functions. Additionally it has one field activity with significant T&E responsibilities. With respect to the centers, their T&E functions are not easily separated from their overall mission objectives as they are embedded to a greater or lesser degree in a continuum-like experimental, developmental, acquisition and sustainment process. The SPAWAR systems centers and field activity with T&E like functionalities are.

A.27.1 Space and Naval Warfare Systems Center, Charleston (SSCC) – Located in Charleston, SC its mission is to provide knowledge superiority to joint warfighters through the development, acquisition, fabrication, integration and testing support of integrated Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems. This responsibility encompasses scalable engineered processes that permit rapid insertion of emerging technology for the fleet and other federal customers. The C4ISR Acquisition Engineering and Integration facility is designed to accommodate any ship set platform. Comprised of 90,000 square feet of synchronous flow production, integration and testing capabilities, the facility contains cable manufacturing work cell, a pre-integration work cell, integration work cells, and a rack refurbishment cell. This facility also offers unique testing capabilities which include two de-ionized fresh water cooling systems, electrical power capabilities and a full spectrum of testing connectivity including high frequency, ultra-high frequency, super high frequency, very high frequency, satellite communications, Secret Internet Protocol Router Network (SIPERNET), Non-Secure Internet Protocol Router Network (NIPERNET), global positioning system (GPS), and more. It is the only DoD activity providing acquisition, engineering, integration, testing, installation, maintenance and lifecycle capabilities for Navy and USMC shore Air Traffic Control (ATC) systems.

A.27.2 Space & Naval Warfare Systems Center San Diego (SSCSD) – Located in San Diego, CA, it is responsible for development of the technology to collect, transmit, process, display and manage information essential to military operations. The Center's focus is on Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR). SSC San Diego leads the RDT&E efforts associated with the Navy's global network. The command conducts research programs in such fields as atmospheric physics, electro-optics, underwater acoustics, engineering psychology, signal propagation and processing, artificial intelligence, material sciences, microelectronics, chemical oceanography, environmental and biological sciences. SSC San Diego leadership areas include;

- Command, control and communication systems
- Command, control and communication systems countermeasures
- Ocean surveillance systems
- Command, control and communication modeling and analysis

- Ocean engineering
- Navigation support
- Marine mammals
- Integration of space communication and surveillance

These leadership areas are supplemented by a set of technology areas in which the Center is significantly involved:

- Ocean and littoral surveillance
- Microelectronics
- Communications and networking
- Topside design/antennas
- Command systems
- Computer technology
- Navigation and aircraft C3
- Intelligence/surveillance/reconnaissance sensors
- Atmospheric effects assessment
- Environmental quality assessment

A.27.3 SPAWAR Space Field Activity (SSFA) - A mission of the SSFA is to develop, acquire, integrate, test, produce, launch and provide operational support to affordable, flexible and seamless space systems that support joint, combined and naval operations; and to be responsible for coordinating all Department of the Navy space research, development, and acquisition programs.