Test and Evaluation Resources

Public law requires DOT&E to assess the adequacy of operational and live fire testing conducted for programs under oversight, and to include comments and recommendations on resources and facilities available for operational testing and evaluation (OT&E) and on levels of funding made available for OT&E activities. DOT&E monitors and reviews DOD and Service-level strategic plans, investment programs, and resource management decisions to ensure capabilities necessary for realistic operational tests are supported. This report highlights general areas of concern in testing current systems and discusses significant issues, DOT&E recommendations, and T&E resource and infrastructure needs to support operational and live fire testing. FY14 focus areas include:

- Adjustments to DOT&E FY15 Budget Request
- Army Support of OT&E
- Operational Test Agency Support for Missile Defense Testing
- Cyber Warfare
- Joint Strike Fighter (JSF) Advanced Electronic Warfare Test Resources
- Electronic Warfare for Land Combat
- Navy Advanced Electronic Warfare Test Resources and Environments
- Equipping Self-Defense Test Ship (SDTS) for Aegis Combat System, Air and Missile Defense Radar (AMDR) and Evolved SeaSparrow Missile (ESSM) Block 2 Operational Testing
- Multi-Stage Supersonic Targets
- Fifth-Generation Aerial Target
- Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare (ASW) Platforms and Systems
- Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes
- Threat Modeling and Simulation (M&S) to Support Aircraft Survivability Equipment (ASE) Testing
- Foreign Materiel Acquisition Support for T&E
- Real-Time Casualty Assessment (RTCA)
- Joint Urban Test Capability (JUTC)
- Hypersonic Weapons Test Infrastructure
- Range Sustainability
- Continuing Radio Frequency Spectrum Concerns

Adjustments to DOT&E FY15 Budget Request

Action by the House Armed Services Committee (HASC), the Senate Armed Services Committee (SASC), the House Appropriations Committee, and the Senate Appropriations Committee on the FY15 budget request included:

- HASC and SASC approval of the President's Budget request in the FY15 National Defense Authorization Act.
- Appropriations increases for –
  - Cyber force training and resiliency ($10.0 Million)
  - U.S. Pacific Command cyber range training ($4.9 Million)
  - Cyber Red Team and training ($3.8 Million)
  - Threat Resources Analysis ($5.0 Million)
  - Joint T&E ($18.0 Million)

Army Support of Operational Test and Evaluation

For the fifth year in a row, the Army is reducing the funding level for the direct support of OT&E of Army programs. In FY10, the Army's budget for "Support of Operational Testing" (PE 0605712A) was ~$78.4 Million, and as of FY15, that budget is ~$49.2 Million (FY10 $45.4 Million), a 42 percent reduction from FY10 funding levels. In FY10, the Army's budget for the "Army Evaluation Center" (PE 0605716A) was ~$63.9 Million, and as of FY15, that budget is ~$55.0 Million (FY10 $50.8 Million), a 21 percent reduction from FY10 funding levels.

These cuts have resulted in staff level reductions in both the Army Operational Test Command (OTC) and the Army Evaluation Center (AEC) of approximately 22 and 25 percent, respectively, from FY10 to FY14. Further cuts in staff of 10 and 6 percent, respectively, are anticipated in FY16. These reduced staff levels are likely to cause delays to developmental and operational testing, the inability to conduct simultaneous operational test events, and longer timelines for the release of test reports. Delays in test execution and test reporting may delay acquisition decisions. The small savings generated by further reducing the staff of OTC and AEC may result in a cost penalty to acquisition programs that is proportional to spend rates multiplied by the duration of delay. Other smaller but still valuable programs may be delayed even longer, as priority will be given to the Major Defense Acquisition Programs.

These reductions to the Army T&E operational accounts are part of broader cuts that the Army has taken across the T&E enterprise, including in the office of the Army T&E Executive. The Army T&E Executive performs various critical roles managing the Army T&E enterprise and ensuring T&E adequacy within the Army and Chemical and Biological Defense Program (CBDP), including the following:

- Establishing, reviewing, and enforcing Army and CBDP T&E policy and procedures.
- Coordinating and facilitating communication with OSD on all T&E matters.
- Providing oversight and policy for the management and operation of the Headquarters, Department of the Army

(HQDA) Major Range and Test Facility Base activities and major investments. A roughly $1 Billion/year-enterprise.
- Managing the staffing and approval process for Army Test and Evaluation Master Plans that require HQDA and OSD approval.
- Supporting the Vice Chief of Staff Army by serving as a member of the Board of Directors Executive Secretariat.
- Administering the Army portion of the Under Secretary of Defense for Acquisition, Technology and Logistics' Central Test and Evaluation Investment Program and Resource Enhancement Program, and provide representation on the OSD Test Investment Coordinating Committee.
- Ensuring that threat-representative targets and threat simulators are validated to support accreditation for test.

In 2008, the Army eliminated the office of the Director, Test and Evaluation Management Agency (TEMA) within the Office of the Chief of Staff of the Army, and moved many of TEMA's responsibilities under the Army T&E Executive. The duties of these two offices are now being performed by a staff of 11 individuals, with an additional 12 individuals dedicated to the CBDP. This is a nearly 50 percent reduction over the past 5 years and staffing levels are now such that the ability of the Office to function effectively is at risk.

In a memorandum dated November 12, 2014, DOT&E recommended the Secretary of the Army reverse these trends. In particular, DOT&E recommends that the Army restore budgets that will maintain FY14 staffing levels at OTC and AEC, as well as assure staffing levels of the Army T&E Executive are consistent with its mission.

Operational Test Agency Support for Missile Defense Testing

The Ballistic Missile Defense System (BMDS) Operational Test Agency (OTA) is customer-funded by the Missile Defense Agency (MDA). The BMDS OTA's mission includes test planning and execution; system evaluation, analysis, and assessment; and system-level Modeling and Simulation (M&S) accreditation across the entire MDA. However, all BMDS OTA funding is channeled through the Test Directorate. Because of this structure, the BMDS OTA budget has suffered percentage cuts proportional to MDA test program budget reductions over the past two years. Further, as Congress has restored funding to the MDA test program, the BMDS OTA funding remained constant. Over the last two years, the BMDS OTA budget has been reduced $3.6 Million per year from its requested $16.1 Million per year, resulting in significant staff reductions. The Test Directorate recently reduced the BMDS OTA's FY15 budget an additional $1.0 Million to a total of $11.5 Million per year, and additional reductions are anticipated throughout the Future Years Defense Program. These cuts are not consistent with the BMDS OTA's mandate and have resulted in the BMDS OTA operating at risk in critical mission areas such as system-level M&S accreditation and Ground-based Midcourse Defense operational test and evaluation. The currently unfunded requirement for these two areas alone require an additional $1.3 Million per year funding for M&S accreditation and an additional $3.8 Million per year funding for Ground-based Midcourse Defense operational test and evaluation. DOT&E strongly recommends that the BMDS OTA funding line be 1) realigned at the agency level within MDA, and 2) restored to a level of funding appropriate to its entire mission.

Cyber Warfare

Experimentation, development, testing, training, and mission rehearsal of offensive and defensive cyber-warfighting capabilities require representative cyber environments. Such environments are created with distributed cyber ranges and labs that provide or host realistic network environments; emulation of adversary targets and offensive/defensive capabilities; and representative warfighter systems, network defenses, and operators. Cyber ranges and environments can be joined with other DOD ranges as critical enablers of operations in the air, land, sea, and space domains.

In FY11 and FY12, DOT&E proposed enhancements to existing facilities to create the DOD Enterprise Cyber Range Environment (DECRE) comprised of the National Cyber Range (NCR), the DOD Cybersecurity Range, the Joint Information Operations Range (JIOR), and the Joint Staff J-6 Command, Control, Communications, and Computers (C4) Assessments Division (C4AD). Approved enhancements include an additional $172 Million and 10 civilian positions for the DECRE, and are intended to provide:
- Consistent portrayal of operationally realistic, threat-representative cyber environments
- Expansion of JIOR operations capacity to plan and rigorously execute approximately 100 distinct events per year
- Upgrades to introduce cloud-based Regional Service Delivery Points
- Incorporation of technologies emerging from the NCR for rapid design, reconfiguration, and sanitization of networks
- Incorporation of various Live, Virtual, and Constructive capabilities
- Range environments where advanced cyber-attacks can be conducted to understand the scope and duration of cyber effects, and where training and tactics, techniques, and procedures development and validation can be performed
- Archival capabilities to record and play back live events, and blend mixes of live and previously-recorded events

The four elements of the DECRE received the first increment of new funding in FY14, and have begun to reverse some of the negative trends that motivated DOT&E to propose these enhancements. With assistance from DOT&E, the C4AD Team developed a high-fidelity environment to examine the effects of cyber-attacks on systems that support Combatant Commands' (CCMD) Common Operating Picture. This environment has performed multiple demonstrations to characterize potential cyber effects in this mission area, and several assessment teams for FY15 CCMD exercises will employ this environment to increase the threat realism of their assessments. C4AD is

growing the operational and network realism of this and several other environments that they host.

Other environments in use or in development include those for missile defense, satellite systems, and remote testing of interoperability and cyber security by acquisition programs via connection to the DECRE. This last environment will permit a program manager to routinely access the archives of information-exchange requirements to confirm interoperability, subject system software to known cyber-attacks, and receive automated reports of the cybersecurity and interoperability status of the system software. C4AD and the T&E community will test this new environment in 2QFY15, and it should be accessible via the DECRE by the end of FY15.

The NCR experienced a substantial increase in customers in FY14, and needs to develop options for expanding significant NCR capabilities and making these accessible to a growing customer base. The Test Resource Management Center (TRMC), which oversees the NCR, has initiated studies to examine new capabilities to further expedite the planning, execution, and sanitization of NCR events.

The JIOR initiated an upgrade of its nearly 100 Service Delivery Points (SDPs) with the new Pico SDP, and plans to migrate to a new capability set that will interoperate fully with the new capability under development by the TRMC's Joint Mission Environment Test Capability (JMETC) Program (i.e., both JIOR and JMETC are migrating to a new set of interoperability standards that define the future DECRE). These migrations will provide efficiencies for the DOD, and will be essential to maximize the utility of the next-generation Regional SDP (RSDP) technology. The TRMC has completed assembly of the third RSDP and is resourced to build and deliver a new RSDP each year across the Future Years Defense Program. RSDPs are effectively cloud-based mini-ranges that can host virtual environments, instrumentation, and traffic generation capabilities, and connect to other nodes or RSDPs via the JIOR or JMETC.

As funding permits, DOT&E will initiate development of several additional environments each year, often driven by the need to characterize cyber effects that are not permissible on operational networks. DOT&E expects that these high-fidelity cyber environments will become essential to cybersecurity and interoperability assessments, OT&E, and also to the training of the DOD Cyber Mission Force being implemented by U.S. Cyber Command.

Although many improvements are in progress, DOT&E expects the demand for high-fidelity cyber environments and range events will continue to outpace the nascent DECRE capabilities. For example, U.S. Cyber Command alone estimates that the Cyber Mission Force will require more than 100 training activities each month, a great deal more than the current capability for 100 events per year across all DOD customers. DOT&E projects that by FY19, 160 range events will be needed annually to support OT&E for oversight programs, and many more by the Services for non-oversight programs. DOT&E also projects that in FY15, approximately 50 range events will be needed for various non-OT&E events that DOT&E will support on behalf of CCMDs and other partner organizations.

The integration of key U.S. and coalition range nodes and laboratories for distributed, secure, operationally realistic, and threat-representative cyber environments will further expand the demand. DOT&E will continue to monitor and report on the evolution of DECRE during FY15. DOT&E recommends that the currently fragmented management and resourcing of DECRE be consolidated under an Executive Agent with the authority to identify requirements, standards, and priorities across DECRE elements.

Joint Strike Fighter (JSF) Advanced Electronic Warfare Test

Since February 2012, when DOT&E identified shortfalls in electronic warfare test resources, progress in procuring these assets has been very slow. These shortfalls prevent development, testing, and timely fielding of U.S. systems capable of operating successfully against threats that currently exist, are proliferating, and are undergoing an accelerating pace of significant upgrades. While FY13-18 funding was identified to address these shortfalls, and this was updated in the FY15-19 budget, the delay in acting to use the funding is jeopardizing the opportunity to make the needed test resources available in time to support developmental and operational testing of systems, including the JSF. Capabilities under development in JSF, F-22 Increment 3.2 A/B, B-2 Defensive Management System, Long-Range Strike Bomber, Next Generation Jammer for the EA-18G, Countermeasures upgrades, as well as several other programs, require the combination of improved government-owned anechoic chambers and new open-air range test assets recommended by DOT&E. DOT&E recommendations and current statuses are shown in the table below.

TABLE 1. RECOMMENDATIONS ON ELECTRONIC WARFARE TEST RESOURCES

DOT&E Recommendation	Current Status
Developing a combination of open- and closed-loop threat radar simulators in the numbers required for operationally realistic open-air range testing of JSF and other systems beginning in 2018.	Risk reduction efforts have begun; however, the opportunity to procure the number and type of systems needed to represent the threat before 2018 is fleeting.
Upgrading the government anechoic chambers with adequate numbers of signal generators for realistic threat density.	Initial studies of materiel solutions to achieve realistic densities have begun • The Navy chamber has procured initial test support equipment for direct injection capability and executed a limited F-35 electronic warfare test in September 2014. • The JSF program has yet to develop plans to integrate chamber testing into the verification test strategy.
Upgrading the JSF mission data file reprogramming lab to include realistic threats in realistic numbers.	An initial study to determine upgrade requirements has begun.
Providing Integrated Evaluation and Analysis of Multiple Sources intelligence products needed to guide threat simulations.	Products have been completed and delivered, additional requests for information have been submitted.

Regarding the shortfall with respect to JSF testing and the time lost so far, the challenges to delivering the desired test environment so as to verify performance in the 2018 Initial Operational Test and Evaluation (IOT&E) can be largely overcome with efficient and aggressive use of the available funds. The risk of not doing so is two-fold: a) the JSF IOT&E of Block 3F capability will not be adequate—performance in the existing threat environment will not be known; b) the development environment sufficient and necessary for Block 4 will be late to meet the need.

Electronic Warfare for Land Combat

Networked mission command systems that support the commander's mission execution across the Brigade Combat Team (BCT) are a cornerstone of the Army's modernization plan. These integrated network capabilities are distributed throughout a combat formation and its support elements, from the brigade command posts down to the individual dismounted Soldier. Commanders using tactical network systems have the unprecedented ability to transfer information such as voice, video, text, position location information, and high-resolution photographs throughout the BCT, and provide individual Soldiers access to information needed to complete their mission. The expanded use of these radio frequency datalink-based systems also exposes the BCT to new electronic warfare threat vectors the enemy may utilize.

While the Army Threat Systems Management Office has continued to improve their threat electronic warfare simulator equipment, it has not kept pace with the advances in the tactical network systems or the known threat capabilities such as advanced jamming and direction-finding techniques. As the Army becomes more dependent on these sophisticated network technologies, it is critical that the developmental/operational test communities continue to identify vulnerabilities of these systems. Decision makers must understand these inherent vulnerabilities, as well as the ways in which an enemy may choose to exploit and/or degrade the network. These critical threat capabilities are needed to support testing of Warfighter Information Network – Tactical Increment 2, Nett Warrior, Mid-Tier Networking Vehicular Radio, Manpack radio, and Joint Battle Command – Platform. DOT&E recommends the Army make additional resources available to improve and expand its ground-based threat electronic warfare capabilities to support operational testing.

Navy Advanced Electronic Warfare Test Resources and Environments

Capability for Realistic Representation of Multiple Anti-Ship Cruise Missile (ASCM) Seekers for Surface Electronic Warfare Improvement Program (SEWIP) Operational Testing

This gap in test capability was identified in DOT&E's FY13 Annual Report as "Additional Electronic Warfare Simulator Units for Surface Electronic Warfare Improvement Program (SEWIP) Operational Testing." The Navy addressed it with development of a programmable seeker simulator that could represent different ASCM seekers by specifying the electronic waveform emission characteristics for one of several possible threats. The effective radiated power (ERP) was not among those characteristics, with the result that simulated attacks by ASCM representations displayed disparate levels of ERP that were unlikely to be encountered during a stream raid attack of two ASCMs (along the same bearing and elevation and within close proximity of one another). The programmable seeker simulator, termed the "Complex Arbitrary Waveform Synthesizer," needs to be modified such that its ERP more realistically represents the second ASCM of a dual ASCM stream raid.

The next SEWIP Block 2 OT&E is projected for FY19. This is to be followed by Follow-On Operational Test and Evaluation (FOT&E) on a Product Line Architecture-compliant DDG 51 with Block 2 actually integrated with the Aegis Combat System. This integration was not part of the Block 2 IOT&E. Subsequent FOT&E would be with the DDG 1000 and CVN-78 combat systems. Estimated cost to add the ERP improvement is $5.0 Million.

Long-Term Improvement in Fidelity of ASCM Seeker/Autopilot Simulators for Electronic Warfare Testing

This gap in test capability was identified in DOT&E's FY13 Annual Report due to the continued reliance on manned aircraft for captive-carry of the ASCM seeker simulators. Such simulators will be unable to demonstrate kinematic response to electronic attack by SEWIP Block 3. The manned aircraft fly too high and too slow for credible ASCM representation and are unable to represent ASCM maneuvers. Credible ASCM representation requires a vehicle that can fly at subsonic ASCM speeds and lower altitudes than the current Lear Jets; can home on a platform representing a SEWIP Block 3-mounted ship, using a threat-representative radar seeker and autopilot; and can respond realistically to Block 3 electronic jamming. Plausible approaches might include:

- Recoverable, unmanned aerial vehicles using embedded, miniaturized simulators that are maneuverable at ASCM speeds and altitudes
- Encrypted telemetry to track seeker/autopilot responses to electronic attack
- Human-controlled override capability
- Use of an unmanned, remotely controllable Self-Defense Test Ship (SDTS) that would tow a ship target for the unmanned aerial vehicles to home on. SEWIP Block 3 would be mounted on the SDTS, as would hard-kill elements (missile and gun systems) such that the integrated hard-kill/soft-kill (Block 3) combat system could demonstrate capability. Currently, such testing is at the combat system element level, leaving integrated combat system capability unknown.

SEWIP Block 3 IOT&E is projected for FY19. FOT&E of Block 3 integrated with the DDG 1000 combat system, as well as FOT&E with the CVN-78 combat system, should occur subsequent to the IOT&E. Estimated costs are $120.0 Million for development, testing, and acquisition. Estimated unit cost is $15.0 Million.

Equipping Self-Defense Test Ship (SDTS) for Aegis Combat System, Air and Missile Defense Radar (AMDR) and Evolved SeaSparrow Missile (ESSM) Block 2 Operational Testing

The close-in ship self-defense battle space is complex and presents a number of challenges for OT&E. For example, this environment requires:

- Weapon scheduling with very little time for engagement
- AMDR and Close-In Weapons System (CIWS) (to deal with debris fields due to previous successful engagements of individual ASCMs within a multi-ASCM raid)
- Rapid multi-salvo kill assessments for multiple targets
- Transitions from ESSM Command Midcourse Guidance mode to Home-All-the-Way guidance mode
- Conducting BMD and area air defense missions (i.e., integrated air and missile defense) while simultaneously conducting ship self-defense
- Contending with stream raids of multiple ASCMs attacking along the same bearing, in which directors illuminate multiple targets (especially true for maneuvering threats)
- Designating targets for destruction very close-in by CIWS

Multiple hard-kill weapons systems operate close-in, including the Standard Missile 2 (SM-2), the ESSM, and the CIWS. Soft-kill systems such as Nulka Mk 53 decoy launching system also operate close-in. The short timelines required to conduct successful ship self-defense place great stress on combat system logic, combat system element synchronization, combat system integration, and end-to-end performance.

Navy range safety restrictions prohibit close-in testing on a manned ship because the targets and debris from successful intercepts will pose an unacceptable risk to the ship and personnel at the ranges where these self-defense engagements take place. These restrictions were imposed following a February 1983 incident on the USS *Antrim* (FFG 20), which was struck with a subsonic BQM-74 aerial target during a test of its self-defense weapon systems, killing a civilian instructor. The first unmanned, remotely controlled SDTS (the ex-*Stoddard*) was put into service that same year. A similar incident occurred in November 2013, where two sailors were injured when the same type of aerial target struck the USS *Chancellorsville* (CG 62) during what was considered to be a low-risk test of its combat system. This latest incident underscores the inherent dangers of testing with manned ships in the close-in battlespace.

While the investigation into the *Chancellorsville* incident has caused the Navy to rethink how they will employ subsonic and supersonic aerial targets near manned ships, the Navy has always considered supersonic ASCM targets a high risk to safety and will not permit flying them directly at a manned ship. The Navy has invested in a current at-sea, unmanned, remotely-controlled test asset (the SDTS) and is using it to overcome these safety restrictions. The Navy is accrediting a high-fidelity M&S capability utilizing data from the SDTS, as well as data from manned ship testing, so that a full assessment of ship self-defense capabilities of non-Aegis ships can be completely and affordably conducted. While the Navy recognizes the capability as integral to the test programs for certain weapons systems (the Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 1) and ship classes (LPD-17, LHA-6, Littoral Combat Ship, LSD 41/49, DDG 1000, and CVN-78), they have not made a similar investment in an SDTS equipped with an Aegis Combat System, AMDR, and ESSM Block 2 for adequate operational testing of the DDG 51 Flight III Destroyer self-defense capabilities. The current SDTS lacks the appropriate sensors and other combat system elements to test these capabilities.

On September 10, 2014, DOT&E issued a classified memorandum to the Under Secretary of Defense for Acquisition, Technology and Logistics with a review of the Design of Experiments study by the Navy Program Executive Office for Integrated Warfare Systems, which attempted to provide a technical justification to show the test program did not require an SDTS to adequately assess the self-defense capability of the DDG 51 Flight III Class Destroyers. DOT&E found that the study presented a number of flawed justifications and failed to make a cogent argument for why an SDTS is not needed for operational testing.

DOT&E recommends equipping an SDTS with capabilities to support Aegis Combat System, AMDR, and ESSM Block 2 OT&E to test ship self-defense systems' performance in the final seconds of the close-in battle and to acquire sufficient data to accredit ship self-defense performance M&S. The estimated cost for development and acquisition of these capabilities over the Future Years Defense Program is approximately $284 Million. Of that, $228 Million would be recouped after the test program completes by installing the hardware in a future DDG 51 Flight III Destroyer hull. The Navy previously agreed with this "re-use" approach in their December 2005 Air Warfare/Ship Self Defense Test and Evaluation Strategy stating that "…upon completion of testing and when compatible with future test events, refurbish and return the test units to operational condition for re-use."

Multi-Stage Supersonic Targets (MSST)

The Navy initiated a $120 Million program in 2010 to develop an adequate multi-stage supersonic target (MSST) required for adequate operational testing of Navy surface ship air defense systems. The MSST is critical to the DDG 1000 Destroyer, CVN-78 Aircraft Carrier, DDG 51 Flight III Destroyer, AMDR, Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 2 operational test programs. The MSST program is currently undergoing a re-structure/baseline to address technical deficiencies as well as cost and schedule breaches that will postpone its initial operational capability (IOC) to late CY19. FY15 decrements to the MSST program will delay MSST IOC until late CY20, further delaying the completion of operational testing for those programs.

Fifth-Generation Aerial Target

Current aerial targets, including the QF-16 (in development) and sub-scale drones, do not adequately represent fifth-generation fighter capabilities, including low observability, low probability

of intercept sensors, and embedded electronic attack. Aerial targets with the capacity to represent these characteristics are required for the operational test adequacy of U.S. air-to-air and surface-to-air weapons systems. With the projected deployment of foreign fifth-generation fighters in the next five years, the feasibility of completing operationally realistic testing will decline significantly without a new full-scale aerial target solution. The risk to the DOD in assessing the mission effectiveness of surface-to-air and air-to-air missile weapon systems will be unacceptable without a representative fifth-generation aerial target. Over the next decade, the production and proliferation of foreign fifth-generation fighter aircraft will enhance their Anti-Access/Area Denial capabilities and, without question, challenge U.S. air superiority in future conflicts. Current weapon system testing is limited to segmented approaches using a combination of captive carry against the F-22 and live-fire against sub-scale and fourth-generation full-scale aerial targets. The capacity to conduct end-to-end testing, from weapon system radar acquisition and tracking, missile launch, and post-launch seeker acquisition to end-game fusing against a fifth-generation fighter threat with electronic attack capabilities does not exist and constitutes a critical shortfall.

DOT&E initiated studies in 2006 on the design and fabrication of a dedicated fifth-generation aerial target to evaluate U.S. weapon systems effectiveness. The study team, comprised of Air Force and Navy experts, retired Skunk Works engineers, and industry, completed a preliminary design review for a government-owned design. DOT&E requested $83 Million in the FY15 program review to complete final design, tooling, and prototyping efforts. U.S. industry and the Canadian Government informally expressed interest in potential public-private partnership opportunities to develop this target system.

Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare (ASW) Platforms and Systems

Operational testing of ASW platforms and related systems includes the ability to detect, evade, counter, and/or destroy an incoming threat torpedo. The determination of system or platform performance is critically dependent on a combination of the characteristics of the incoming torpedo (e.g., dynamics, noise, fusing, sensors, logic, etc.). Due to differences in technological approach and development, U.S. torpedoes are not representative in many of these torpedo characteristics for many highly proliferated torpedoes, particularly those employed in Anti-Surface Warfare by other nations. Operational testing that is limited to U.S. exercise torpedoes will not allow the identification of existing limitations of ASW systems and related systems against threat torpedoes and will result in uninformed decisions in the employment of these same systems in wartime. A January 9, 2013 DOT&E memorandum to the Assistant Secretary of the Navy (Research, Development & Acquisition) identifies specific threat torpedo attributes that the threat torpedo surrogate(s) must be evaluated against. The non-availability of threat-representative torpedo surrogates will prevent adequate operational testing for ASW platforms and related systems, as well as adversely affect tactics development and validation of these tactics within the fleet.

Naval Undersea Warfare Center (NUWC) Division Keyport commenced a study of threat torpedo surrogates in FY14. The $480,000 study is jointly funded by the Navy and DOT&E. The study focuses on the identification of capability gaps between existing torpedo surrogates and threat torpedoes. The study will provide an analysis of alternatives for improvements to current torpedo surrogates and development of new torpedo surrogates that address critical gaps in threat representation.

NUWC Division Keyport is also pursuing a prototype technology development project that will deliver a threat-representative high-speed quiet propulsion system. The development of a propulsion system prototype will leverage the critical gaps identified in the torpedo threat surrogate capability gap analysis, discussed in the preceding paragraph. This effort is funded by DOT&E at approximately $1.0 Million with delivery in 4QFY16. The NUWC Division Keyport study and prototype development could support future development of a threat torpedo surrogate. Procurement of adequate threat torpedo surrogates, however, is dependent on future Navy decisions. DOT&E believes further development and production of threat torpedo surrogates will benefit from an enterprise approach to prevent burdening a single acquisition program.

Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes

The Navy routinely conducts in-water operational testing of lightweight and heavyweight ASW torpedoes against manned U.S. Navy submarines. Although these exercise torpedoes do not contain explosive warheads, peacetime safety rules require that the weapons run above or below the target submarine with a significant depth stratum offset to avoid collision. While this procedure allows the torpedo to detect, verify, and initiate homing on the target, it does not support assessment of the complete homing and intercept sequence. One additional limitation is the fact that U.S. nuclear attack submarines may not appropriately emulate the active target strength (sonar cross-section) of smaller threats of interest, such as diesel-electric submarines. During the Mk 50 lightweight torpedo operational test, the Navy conducted some limited set-to-hit testing against manned submarines, which included impact against the target hull, but that practice has been discontinued.

In preparation for the 2004 Mk 54 lightweight torpedo operational test, DOT&E supported the development and construction of the unmanned Weapon Set-to-Hit Torpedo Threat Target (WSTTT) using Resource Enhancement Project funding. The WSTTT was a full-sized steel mockup of a small diesel-electric submarine, with an approximate program cost of $11 Million. As a moored stationary target, the WSTTT was limited in its ability to emulate an evading threat but its use in the Mk 54 operational test demonstrated the value of such a dedicated resource. Unfortunately, the Navy did not properly

maintain the WSTTT and abandoned it on the bottom of the sea off the California coast in 2006. In subsequent years, the Navy was able to make some limited use of the WSTTT hulk as a bottomed target for torpedo testing.

In a separate effort, the Navy built the Mobile Anti-Submarine Training Target (MASTT), designed to serve as a full-sized threat surrogate for use in training by surface and air ASW forces. The Chief of Naval Operations initiated the program in 2010 with the goal of achieving operational capability by late 2011. After four years and an expenditure of approximately $15 Million, the Navy has yet to use the MASTT in training and seems to be on the brink of abandoning the asset. The Navy resisted design input from the operational test community and made it clear that the MASTT was not intended to support torpedo testing.

In support of a 2010 Urgent Operational Need Statement, the Navy funded the construction of the Steel Diesel-Electric Submarine (SSSK), a full-sized moored set-to-hit target consisting of an open steel framework with a series of corner reflectors to provide appropriate sonar highlights. The Navy used the SSSK as a target for the Mk 54 torpedo in a 2011 Quick Reaction Assessment and 2013 FOT&E. As part of the Test and Evaluation Master Plan approval for the latter, DOT&E sent a memorandum indicating that the Navy must develop an appropriate mobile target to support future Mk 54 testing.

Since early 2013, DOT&E has participated in a Navy working group attempting to define the requirements for a mobile set-to-hit torpedo target. The group has identified a spectrum of options and capabilities, ranging from a torpedo-sized vehicle towing a long acoustic array to a full-sized submarine surrogate. At the very least, the target is expected to be mobile, autonomous, and certified for lightweight torpedo set-to-hit scenarios. More advanced goals might include realistic active and passive sonar signatures to support ASW search and reactive capability to present a more realistically evasive target. Cost estimates range from under $10 Million for a towed target to over $30 Million for a full-sized submarine simulator.

Threat Modeling and Simulation (M&S) to Support Aircraft Survivability Equipment (ASE) Testing

Building actual threat representations for widespread testing is expensive; therefore, DOT&E focused on funding incremental efforts that advance the use of authoritative threat M&S for systems T&E. Although threat M&S capabilities have been used in T&E for many years, these were not always threat-representative, and different M&S instantiations of the same threats produced different results. DOT&E's objective is to improve the consistency of threat M&S at various T&E locations while reducing overall costs.

Throughout the T&E processes, M&S represents threats when actual threat components are not available; provides more complete testing than possible through open-air and hardware-in-the-loop test facilities; and provides testing when operational reasons such as flight safety preclude physical tests, especially with crew. For example, test programs may conduct 10 – 20 live threat missile firings using actual threats. Using threat M&S extends those results across a much larger range, typically 20,000 cases covering different threats, ranges, altitudes, aspect angles, atmospheric conditions, and other environmental variables affecting weapon system performance.

DOT&E implemented controls and distribution management for threat M&S to ensure integrity for realistic T&E and to ensure test results were not affected by using various threat M&S across T&E regimes. The T&E Threat M&S Configuration Management System provides mechanisms to effectively identify and correct anomalies between threats and threat representations, maintain critical documentation such as interface descriptions and validation documents, control model configuration changes, and disperse updated threat M&S to multiple T&E facilities for consistency. The T&E Threat M&S Configuration Control Board, comprised of representatives from intelligence organizations and the T&E community, prioritizes existing threat M&S developments and changes to ensure updates are provided efficiently to T&E user facilities. Requests for T&E threat M&S, report anomalies, or request changes are managed through an interface on DOD's Secret Internet Protocol Router Network.

During FY14, the T&E Threat Resource Activity provided standardized and authoritative threat M&S to multiple T&E facilities operated by the Army, Navy, and Air Force who implemented them into various T&E uses supporting Aircraft Survivability Equipment (ASE) testing. DOT&E also engaged close U.S. allies to implement same threat M&S for allied T&E, leveraging worldwide implementation of standard, authoritative threat M&S capabilities for T&E.

DOT&E also developed a threat M&S roadmap for ASE T&E to provide a comprehensive plan and to prepare future test capabilities using standardized and authoritative threat M&S. For example, Joint Standards Instrumentation Suite captures threat data from live fire test events to support threat M&S development. Starting with a systematic analysis of problems and projects that support effective testing, the roadmap lays out a path for the development of threat-representative test M&S to support U.S. and allied missile warning and infrared countermeasure systems. DOT&E estimates that $10 to 13 Million will be needed between FY16 – 20 to fully implement this roadmap.

Foreign Materiel Acquisition Support for T&E

DOT&E is responsible for ensuring U.S. weapons systems are tested in realistic threat environments. Ideally, operational testing should use actual threat systems to create realistic threat environments. Because limited resources are available to acquire foreign threats, DOT&E annually develops a prioritized list of threat requirements tied to upcoming testing of programs on the OSD T&E Oversight List and submits them to the Defense Intelligence Agency Joint Foreign Materiel Program Office. These requirements are consolidated with Service needs and then processed through various Service and intelligence community collection activities. DOT&E then coordinates

with the Department of State to identify sources and increase opportunities to acquire foreign materiel for use in operational test and evaluation.

Foreign materiel requirements span all warfare areas, but recently DOT&E has placed a priority on the acquisition of Man-Portable Air Defense Systems (MANPADS) to address significant threat shortfalls that affect testing for infrared countermeasures (IRCM) programs like Common IRCM (CIRCM), Large Aircraft IRCM (LAIRCM), and Department of the Navy (DoN) LAIRCM. In many cases, hundreds of MANPADS are required for the development of threat M&S, for use in hardware-in-the-loop laboratories, and for live-fire T&E, all to present realistic threats to IRCM equipment. Using actual missiles with actual missile seekers aids evaluators in determining the effectiveness of IRCM equipment, but is also invaluable in development of effective countermeasures throughout the U.S. weapon system's life.

Due to the inherent challenge of developing reliable sources for foreign materiel, negotiating the acquisition of foreign materiel, and the difficulty of using annual appropriations for foreign materiel acquisitions, DOT&E recommends establishment of dedicated, non-expiring funding authority to support foreign materiel acquisitions.

Real Time Casualty Assessment (RTCA)

Force-on-force battles between tactical units are the best method of achieving a realistic environment in which to conduct operational testing of land and expeditionary warfare systems. Simulated force-on-force battles must contain realism to cause Soldiers in their respective units to make tactical decisions and react to the real-time conditions on the battlefield. Real Time Casualty Assessment (RTCA) systems integrate Live, Virtual, and Constructive components to enable these simulated force-on-force battles. RTCA capability provides a means for simulated engagements to have realistic outcomes based on the lethality and survivability characteristics of both the systems under test and the opposing threat systems. RTCA systems must replicate the critical attributes of real-world combat environments such as direct and indirect fires, Improvised Explosive Devices and mines, realistic battle damage, and casualties. RTCA systems must record the time-space position information and firing, damage, and casualty data for all players in the test event. Post-test playback of these data provides a critical evaluation tool to determine the combat system's capability to support Soldiers/Marines as they conduct combat missions.

DOT&E has requested that Army Test and Evaluation Command (ATEC) use its available RTCA capability to improve operational realism and to provide RTCA data collection and post-event playback in support of the operational testing of land combat systems. During FY14, two separate systems, The ATEC Player and Event Tracking System (TAPETS) and the Homestation Instrumentation Training System (HITS), were used by ATEC to provide RTCA. Both interface with the Instrumentable Multiple Integrated Laser Engagement System (I-MILES) for direct fire engagement simulation.

TAPETS/I-MILES, the legacy RTCA system operated by Army Operational Test Command (OTC), was used successfully during Network Integration Evaluation (NIE) 14.1 and NIE 14.2. The birds-eye-view playback of data collected during NIE 14.1 proved to be instrumental during the evaluation of the AN/PRC-117G radio, and data collected during NIE 14.2 supported the evaluation of the AN/PRC-155 Manpack radio. ATEC should continue to work to optimize the current TAPETS/I-MILES system and look for ways to reduce its operational costs. The Army should update the probability of kill tables that are the foundation of I-MILES engagements, as they have not kept pace with the fielding of new vehicles and onboard communication and networking equipment.

The Army developed HITS to provide tactical engagement simulation for units during force-on-force training; this capability already exists on a number of Army training installations. HITS/I-MILES were used to support the Joint Light Tactical Vehicle Limited User Test at Fort Stewart, Georgia. This is the first attempted use of HITS to support OT&E, and early indications are that HITS has some shortfalls as a test tool. Most significantly, the HITS system is not able to save its database to support post-test analysis and playback, which reduces its effectiveness as an evaluation tool. The Army should make the necessary modifications to the HITS software immediately so that it can continue to be used to support testing.

These proposed near-term improvements to HITS and TAPETS will give ATEC the flexibility to select the most capable and cost-effective RTCA instrumentation available based on where operational test is being conducted. In support of future test requirements, the Army created a new program within the Project Manager Instrumentation, Targets, and Threat Systems called RTCA Integrated Test Live, Virtual, and Constructive Environment (ITLE). ITLE will provide a much-needed stream of funding to address the shortfalls identified in the recent ATEC RTCA study. These shortfalls include improving the ability to seamlessly simulate indirect fire weapons, IEDs/mines, and air-to-ground/ground-to-air combat. DOT&E is encouraged by the increase in resources the Army has dedicated to RTCA development and use. RTCA is essential to realistic force-on-force testing of current and future land and expeditionary warfare systems, and DOT&E requires RTCA for systems such as Family of Light Amphibious Vehicles, Bradley and Abrams Upgrades, Armored Multi-purpose Vehicle, AH-64E Block III, Joint Light Tactical Vehicle, and Stryker upgrades. The estimated cost to make the necessary improve to the ATEC RTCA systems is $40 Million over the next five years. The Army has made a commitment that is commensurate with this need.

Joint Urban Test Capability (JUTC)

Operations in urban environments present unique challenges to Service members and their equipment. Degraded mobility, communications, and situational awareness; a large civilian presence; the risk of collateral damage; reduced stand-off distances; and unique threat profiles are some of the conditions present during urban operations. These challenges underpin

the requirement that systems be tested in operationally realistic urban environments.

The Army is currently developing the Joint Urban Test Capability (JUTC) at White Sands Missile Range with funding provided by the OSD Central Test and Evaluation Investment Program. DOT&E is supportive of the JUTC requirement, but the proposed physical surface urban area of 200 meters by 240 meters is not large enough to support operational testing of mechanized units of company size and greater. The remote location chosen for JUTC will make support of operational testing difficult, which could limit its utilization. DOT&E recommends the urban area be expanded to the JUTC objective requirement of 900 meters by 900 meters originally proposed in the Urban Environment Test Capability study, and that the proposed location be reconsidered to support future operational test events. The cost of the current JUTC effort is estimated at $75-95 Million.

Hypersonic Weapons Test Infrastructure

After 60 years of research, the U.S. is on the verge of developing operational hypersonic weapons. The United States is not alone in its pursuit of these capabilities and, as recently noted by the Acting Assistant Secretary of Defense for Research and Engineering, "We…do not want to be the second country to understand how to control hypersonics." Hypersonic weapons will present a challenge to potential adversaries that have invested in anti-access and area-denial capabilities. Consequently, the U.S. Air Force Chief of Staff has identified hypersonic weapons as one of five "game-changing" technologies in Air Force strategic planning.

The current U.S. hypersonic T&E infrastructure is not adequate to accomplish critical operational or developmental test objectives, reduce risk, and adequately inform acquisition decisions for hypersonic weapon programs. There are gaps in important ground test capabilities for aero-propulsion, aerodynamic, aerothermodynamic, and material evaluation, and in test assets for lethality, sensor integration and guidance, navigation, and control. Current flight test ranges cannot support over-the-horizon testing of long-range hypersonic weapons. Modeling & simulation tools are not mature enough to supplement ground and flight testing.

In the past 20 years, over half of the nation's hypersonic T&E ground facilities built in the 1950s through the 1970s to support U.S. space and missile programs have been closed or demolished. Many of the remaining 19 "critical," one of a kind hypersonic Research, Development, and T&E facilities are in poor or dilapidated condition from fiscal neglect. For example, in one of the most critical hypersonic test facilities, plastic tarps are being used to prevent sensitive equipment from damage by rainwater leaking through the roof. Adequate hypersonic test infrastructure is required to support the development of engineers and technicians skilled in hypersonics. The shrinking and aging workforce is currently insufficient to support future hypersonic testing needs.

Without additional investment in hypersonic T&E infrastructure and personnel, hypersonic weapon acquisition programs will need to rely on expensive and high-risk flight tests, without adequate precursor ground testing. Premature, catastrophic termination of four out of six recent test flights for the X-51, Advanced Hypersonic Weapon and Hypersonic Technology Vehicle 2 underscore that cost and risk. Existing ground-based hypersonic T&E facilities that help prevent future flight test failures are already overtaxed. As hypersonic programs mature, ground test requirements will increase. The Test Resource Management Center (TRMC) estimates the requirement for additional hypersonic T&E resource investments from FY16–20 at $330 Million.

DOT&E recommends funding these investments to address existing hypersonic T&E gaps, and to better maintain current hypersonic T&E infrastructure, without which the U.S. will risk ceding the advantage of hypersonic weapons to potential adversaries.

Range Sustainability

DOT&E must advocate for the testing of new and upgraded military capabilities in the most realistic threat-representative environment possible. Due to safety and security imperatives, these environments are limited to geographic areas set aside for military testing and training. DOD test and training ranges are located in once-remote and relatively-undisturbed areas of the country—the same areas that today are sought after for development of renewable energy and associated electrical power transmission infrastructure. Yet energy encroachment is not the only impact to a robust and sustainable range infrastructure. Other factors continue to challenge DOD's ability to test advanced weapons systems in real-world, open-air environments throughout systems' operational envelopes. These include populations moving into these same areas, incompatibility issues from urban growth, competition for resource use (e.g., water, land, airspace, frequency spectrum), an increasing number of (and associated requirements to protect) listed and candidate-threatened and endangered species, and increased government regulation. Already, test envelopes to evaluate weapons systems are constricted due to increased combat radii for threat engagement. The Major Test and Range Facility Base is also threatened by the impacts of extreme weather and potential water shortages and other effects from a changing climate.

As reflected in past annual reports, DOT&E has engaged on behalf of the DOD test community to ensure required capabilities remain available to test DOD systems' effectiveness, reliability, and lethality. Two current major areas of concern are availability of frequency spectrum (addressed later in this section) and encroachment posed by the development of renewable energy and transmission line projects. This new form of encroachment risks the Department's ability to test systems under realistic conditions using operational resources. While M&S is used increasingly for testing, development of realistic models requires data that can only be obtained from live testing.

DOT&E is a co-chair of the DOD Siting Clearinghouse, along with the Deputy Under Secretary of Defense for Installations and Environment and the Deputy Assistant Secretary of Defense for Readiness (DASD(Readiness)). The number of projects received by the Clearinghouse under the Federal Aviation Agency Obstruction Evaluation Airport Airspace Analysis (FAA/OE-AAA) process increased by 13 percent from FY13 to FY14 (from an average of 173/month to 220/month). Of the total number of projects, 14 currently under review have a significant potential impact on DOD range capabilities in the absence of acceptable mitigations. In addition, there are other renewable energy and electrical power transmission infrastructure project that have potential impact to test capabilities that have been addressed with other Federal Departments and Agencies.

Mitigation measures such as curtailment of wind turbine operations during test periods, identification of alternative siting for renewable energy infrastructure, alternative siting for affected tests, and updates to DOD test hardware and software are considered during review of each proposed projects. In addition, research is being pursued to determine the effect various renewable energy projects may have on DOD's instrumentation capabilities, such as from electromagnetic interference from electrical power transmission infrastructure, and glint and glare from utility-scale solar energy projects. The Department has invested significant time and resources over the past three years to identify the impact of wind turbines on ground-based and airborne radars, and this investment may help mitigate interference of wind turbines with test range infrastructure. Additionally, the advent of electrical power transmission infrastructure near the test and training ranges can be an obstruction to low-level flight tests, and mitigation options such as burial of the power line may be required.

Over the coming year, DOT&E will continue to work with the Clearinghouse, the TRMC, the Deputy Under Secretary of Defense for Installations and Environment, DASD(Readiness), Military Departments, and other Federal Departments and Agencies, such as the FAA and Department of the Interior, to refine processes for resolving compatibility issues between renewable energy projects and DOD test and training requirements.

Continuing Radio Frequency Spectrum Concerns

Test range use of frequency spectrum continues to be challenged by pressures to repurpose spectrum to broadband wireless and other uses such as medical telemetry and wireless microphone use. DOT&E documented the pending loss of 1755 – 1780 MegaHertz (MHz) and compression into 1780 – 1850 MHz in its FY13 Annual Report. Table 2 illustrates the frequency bands used for test and evaluation and identifies resource issues and their potential mitigations. An additional development during 2014 is the DOD's work to implement its Electromagnetic Spectrum Strategy (EMS), as well as understanding of how implementation will affect DOD testing. Adequate frequency spectrum is a critical resource for testing. It is required to both upload and download test data between the article being tested to test instrumentation, and to control resources during test operations.

The spectrum allocated is used full time during the range day (i.e., from 6:00am to 6:00pm), and continued unimpeded use is vital to accommodate the increasing volume of test data (e.g., that of the F-35 JSF). As Table 2 points out, both the range's primary L- and S-bands are now being targeted for repurposing to broadband wireless use. The cost impacts to the Services' T&E infrastructure for transitioning capabilities from the L-band are:

- Army – $27.7 Million is required to retrofit the Aerial Telemetry Systems (AMTs) at White Sands Missile Range that are operating in the 1755 – 1850 MHz band. With the loss of the lower 25 MHz (1755 – 1780 band), the proposed solution is to compress operations of the AMTs into the retained 1780 – 1850 MHz band without having to relocate/transition into another spectrum. $1 Million is required to replace three point-to-point datalinks at Aberdeen Test Center that are operating in the 1755 – 1780 MHz band. New equipment will be installed to operate in the 4 GigaHertz (GHz) (C-band) to accommodate testing of robotics which will be relocating to 4 GHz.
- Navy – $180 Million for transitioning Aeronautical Mobile Telemetry using an approved transition plan.
- Air Force – $100 Million over 5 to 8 years to modify 95 antennas, 628 receivers, and 53 transmitters for compressing aeronautical telemetry into the 1780 – 1850 MHz band.

The test ranges' primary band for telemetry, 1435 – 1525 MHz, has two pressing challenges. The first is from pending Federal Communication Commission rulemaking to allow shared use with wireless microphones used for major concerts and sports events, and the second from proposed World Radiocommunications Conference (WRC) repurposing for worldwide wireless broadband use. The first issue can be mitigated, as has been worked between DOD and industry, through adoption of use agreements (such as not-to-interfere agreements) and use of electronic keys to coordinate use. The second issue, WRC re-purposing the spectrum for worldwide broadband use, is more difficult for the test ranges. Canada has engaged with DOD and the aircraft industry to define protection methodologies, and Mexico has been approached to work mitigation strategies. Due to the location of many of the test ranges in the Southwest continental United States and aircraft manufacturers' testing proximate to the U.S. and Canadian border, repurposing of the 1435 – 1525 MHz spectrum is of major concern.

The second most-used band for test range telemetry is the 2360 – 2390 MHz spectrum. The issue confronting the ranges is the assignment of adjacent spectrum 2345 – 2360 MHz for wireless broadband use. This problem is resolvable if the vendor using the adjacent spectrum implements International Telecommunications Union rules, which prescribe out-of-band emissions protection. DOD is working this issue with both the Federal Communication Commission and the vendor.

Since the DOD EMS was published in 2013, there has been ongoing work to develop implementation action plans. Many of these action plans address issues the test community has already been working, such as securing sufficient frequency to sustain test operations, and developing technologies to use available frequency more efficiently. Apart from these similar approaches, other action plans address operational use of spectrum. The conceived new EMS operational environment will influence DOT&E oversight of test planning, given consolidation and development of operational spectrum tools (spectrum identification, characterization, assignment). When implemented, many of the EMS action plans could "simplify" the operating environment by stipulating clear policy, procedures, and master architectures, and eliminating the myriad of stove-piped systems that have been deployed. Thus, the EMS has the potential to change the operating environment for Spectrum Dependent Systems, and the ways such systems are operated during testing. The TRMC, acting as the proxy for the DOD T&E community, will have varying degrees of participation in 88 of the 349 action plan tasks identified by DOD (primary responsibility for 10, and coordinating responsibility for 78).

Frequency spectrum is a limited resource with many more demands than supply. With allocations, both domestically and internationally, being repurposed for non-defense wireless transmission needs, DOT&E will need to remain actively engaged with DASD(DT&E), TRMC, and the DOD Chief Information Officer to ensure frequency spectrum allocations are sufficient for the conduct of test operations, and also that these operations use frequency efficiently.

TABLE 2. FREQUENCY ALLOCATIONS USED FOR TESTING AND DOD RESOURCE ISSUES AND POTENTIAL MITIGATIONS				
Frequency	**Use**	**Users**	**Resource Issue and Potential Mitigation**	**Notes**
406.1 - 420 MHz	Land mobile radio	Test control and field ops		
1350 - 1390 MHz	Time, Space, Position Information	Critical to almost all open-air tests; range surveillance radar (Air Route Surveillance Radar-4)		
1435 - 1525 MHz	L-Band Telemetry - Primary Telemetry Band	SDB, UH1/AH, T-45, SH-60, VH-S, V-22, F-18, F-18E, F-22, F-35, B-2, F-16, B-1, B-2, B-52, Global Hawk	• Issue: Wireless microphone use. • Potential Mitigation: Alternate user coordination with assigned key codes for spectrum access in allotted time periods. • Issue: WRC assignment to worldwide wireless broadband use. • Potential Mitigation: Ongoing negotiations with Canada and Mexico.	The Light Squared (satellite/terrestrial network proposed and abandoned) proposal targets 1505 - 1525 MHz
1675 - 1710 MHz	Weather, including wind speed measurement	Critical to almost all open-air tests		
1755 to 1780	L-Band Telemetry	F/EA-18G, Aerostar, ASVS, SM-2, RAM, SSRT, Classified UAV (WSMR), ARAV, X-47, the only band for miss-distance indicators used to score missile shots	• Issue: Auction pending • Potential Mitigation: Use relocation to 4400 – 4940 MHz and 5091 – 5150 MHz with Spectrum Relocation Fund reimbursement.	
1780 - 1850 MHz	L-Band Telemetry	F/EA-18G, Aerostar, ASVS, SM-2, RAM, SSRT, Classified UAV (WSMR), ARAV, X-47, the only band for miss-distance indicators used to score missile shots		This spectrum will be auctioned over the next 10 years, and some sharing has been proposed
2200 - 2290 MHz	S-Band Telemetry	AIM-9X, AIM-120, JAASM, JDAM, WCMD, JSOW, SDB, Aerostar, ASVS, WSI, 6DOF, MDA, Patriot, SM-2, ATACMS, F-15, F-16, F-22, F-35, T-38, B-1, B-2, B-52, C-17, Global Hawk, X-51 Waverider		
2360 - 2390 MHz	Upper S-Band Telemetry	F-18E/400, E2-D, P-8A, Exdrone, Silver Fox, THAAD, F-16, F-22, B-1, B-2, B-52, C-17, Global Hawk	• Issue: AT&T wireless communications use of 2345-2360 MHz without Out of Band Emissions protections. • Potential Mitigation: Pending	
2390 - 2395 MHz	Upper S-Band Telemetry	F-18E/400, E2-D, P-8A, Exdrone, Silver Fox, THAAD, F-16, F-22, B-1, B-2, B-52, C-17, Global Hawk		Shared for additional Upper S-Band coverage
2700 - 2900 MHz	Range surveillance radar	Critical to almost all open-air tests		
4400 - 4940 MHz	Range Telemetry	F-15SA, F-15 (pending), fixed point-to-point microwave, tactical radio, UAV, threat simulators	• Issue: Pending Federal Communications Commission(FCC) Rulemaking. • Potential Mitigation: FCC has allowed band use	Band is just now coming into use
5091 - 5150 MHz (Region 2: 5091 - 6700 MHz)	Range Telemetry	F-15SA	• Issue: Pending FCC Rulemaking. • Potential Mitigation: FCC has allowed band use	Shared with Federal Aviation Administration. Band is just now coming into use; DoD has requested that the band be extended to 5250 MHz when 1755 - 1850 MHz is auctioned.