Test and Evaluation Resources

Public law requires DOT&E to assess the adequacy of test and evaluation resources and facilities for operational and live fire testing. DOT&E monitors and reviews DOD- and Service-level strategic plans, investment programs, and resource management decisions so that capabilities necessary for realistic operational tests are supported. This report highlights areas of concern in testing current and future systems and discusses significant challenges, DOT&E recommendations, and T&E resource and infrastructure needs to support operational and live fire testing. FY17 focus areas include:

- Increased DOT&E Funding in the DOD Appropriations Act, 2017
- Army Support of OT&E
- Personnel to Support Cyber-related Operational Testing
- Threat Representation for OT&E of Space Systems
- High-Altitude Electromagnetic Pulse Test Capability
- Joint Strike Fighter Advanced Electronic Warfare Test Resources
- Point Mugu Sea Test Range Enhancements to Support OT&E of Air Warfare Programs
- Fifth-Generation Aerial Target
- Electronic Warfare for Land Combat
- Navy Advanced Electronic Warfare Test Resources and Environments
- Equipping a Self-Defense Test Ship for Aegis Combat System, Air and Missile Defense Radar, and Evolved Seasparrow Missile Block 2 Operational Testing
- Multi-Stage Supersonic Targets
- Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare Platforms and Systems
- Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes
- Aircraft Survivability Equipment Test Capability Gaps
- Foreign Materiel Acquisition Support for T&E
- Tactical Engagement Simulation with Real Time Casualty Assessment
- Warrior Injury Assessment Manikin
- Test and Evaluation of Army Software-Defined Tactical Radios
- Range Sustainability

Increased DOT&E Funding in the DOD Appropriations Act, 2017

The FY17 appropriations act added $8 Million to the DOT&E budget for threat systems. The increased funding supported the following test capability enhancements:

- Development and demonstration of a prototype system to support threat electronic warfare (EW)-enabled cyber operations for laboratory and anechoic chamber T&E by collecting classified and open-source data on cyber electronic warfare (C/EW) threats, analyzing DOD and Service requirements for C/EW testing, and acquiring U.S.-targeted systems for lab test articles
- Development of a cyber cloud to address current intelligence analyst pitfalls
- Identification of gaps in the cyber threat library development process such as the lack of a standardized threat library structure across the cyber community and the absence of a centralized storage location for the cyber threat library
- Improved understanding of "wireless" cyber threats to support U.S. weapon systems testing
- Utilization of investments in U.S. weapon systems that blend cyber and EW capabilities comparable to threat T&E assets
- Support for test programs with documented C/EW threat shortfalls such as tactical communications; datalinks; radio communications; networking; data transportation; and command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) sensors and systems
- Initiation of actions to evaluate growing and evolving cyber threat requirements and analyze the convergence of C/EW affecting the baseline required for operational testing
- Continued identification of initiatives to improve:
  - Cyberspace threat representation and prediction
  - Cyber-economic threats to DOD systems
  - Representative threat offensive and defensive cyber operations capabilities
  - Scalable cyberspace threat test environments that can interface with cyber test networks
- Continued efforts to maintain a standard set of threat performance models

This support helped DOT&E carry out its Title 10 responsibilities to assess test adequacy and promote common solutions to Service threat representation needs.

Army Support of OT&E

Beginning with the 2014 Annual Report, DOT&E expressed concern with the continued budget and staffing reductions at the Army Test and Evaluation Command (ATEC) and the office of the Army Test and Evaluation Executive. During the FY17 DOT&E review of the Army's T&E budget and resources, the Army indicated that the office of the Army Test and Evaluation Executive was understaffed to fulfill its mission and there would be further staffing reductions at the Army Evaluation

Center and Operational Test Command through FY19. The Army acknowledged that this may cause the inability to conduct simultaneous operational test events and increased costs to customers. Operational tests planned in 2018 that will overlap include Paladin Integrated Management, Joint Light Tactical Vehicle, and Stryker 30 mm and Stryker Common Remotely Operated Weapon Station – Javelin. Substantial growth in the areas of autonomy, EW, cybersecurity, and big data analysis continue to put new demands on the Army T&E workforce and infrastructure. In addition to staffing reductions, the Army must contend with competition from industry as it struggles to recruit, retain, and grow an analytically and technically competent workforce. The Army currently has four major studies ongoing that are intended to help inform T&E funding and staffing requirements. The Predictive Resource Staffing Model will become operational in December 2017 and is intended to support the planning of workforce requirements. DOT&E is concerned that these budget and staffing reductions may affect test planning, execution, and reporting and may result in delayed acquisition decisions. DOT&E will continue to monitor the Army T&E workforce regarding its capability and capacity to support the evaluations of Army acquisition programs.

Personnel to Support Cyber-related Operational Testing

Well-qualified personnel are essential to planning and executing adequate, threat-representative operational test events involving cybersecurity. The Service Operational Test Agencies (OTAs) and cyber Red Teams do not have enough experienced cybersecurity professionals to accommodate the increasing number and complexity of test events projected in FY18 and beyond.

Two recent changes in DOD cybersecurity test procedures drove the increasing demand for cyber test expertise. In July 2016, DOT&E issued a memorandum describing improvements needed in cybersecurity operational testing to adequately emulate an advanced nation-state threat. To meet the intent of the memorandum, OTAs and Red Teams need additional expertise in the areas of non-Internet Protocol data transmission, industrial control systems, and multi-spectrum cyber threats. Although the OTAs and Red Teams made progress filling these gaps during FY17, most OTAs still do not have the capability to execute adequate operational testing in these areas. In February 2017, USD(AT&L) issued a revision to DOD Instruction 5000.02 that requires operationally realistic cybersecurity testing during a program's developmental testing phases as well as during operational testing. This approach is critical to helping programs find and fix mission-critical cybersecurity vulnerabilities, but it draws upon OTA and Red Team cybersecurity experts to help plan and execute numerous developmental test events as well as operational test events.

In order to acquire and retain experienced cybersecurity test personnel, the Services should develop cyber expertise career options with incentives that are competitive with the private sector and other Federal agencies. The Services should also provide experienced cybersecurity test personnel with interesting, mission-critical work; many cyber experts find mission-critical work as rewarding as pay and benefits increases.

Threat Representation for OT&E of Space Systems

U.S. adversaries are actively pursuing offensive space control capabilities to diminish and overcome U.S. military space superiority, and thus threats to space systems are continually advancing. Although the Services normally test space systems against representative natural hazards and space phenomena, they have not adequately tested them against representative threats emulating a wartime environment. The OT&E of space systems must reflect all threats that U.S. space systems will face, and the Services should provide the additional resources required to ensure these threats are realistically represented and assessed during OT&E.

To achieve operational realism, the Service acquisition officials and OTAs should act in advance of OT&E to develop or procure those space threat resources. If acquisition and employment of actual threats is not practical, would violate U.S. or DOD policy, or would introduce unmitigated and unacceptable operational, security, or safety risks, then the Services should use realistic, accredited threat surrogates to include accredited threat models and simulations in lieu of the actual threat system.

To help ensure adequate testing of threat systems and threat surrogates against satellites for OT&E, the Services should fund pre-launch testing of either first articles or production-representative "test satellite" articles against all validated threats. Representative operational crews should operate satellites being threat tested for OT&E using the control segment and capabilities intended for operational employment. Post-launch, the Services should fund mission-representative articles through the operational life of space systems to support ground testing of those systems against an evolving threat; system of systems assessments; ongoing tactics, techniques, and procedures development; and exercises.

In a memorandum dated March 2016, DOT&E provided guidance to the Service acquisition officials and OTAs to improve their ability to identify and track space threat representation capabilities; identify space threat representation gaps, and request funding to fill those gaps; and to develop modeling and simulation (M&S) capabilities to support the assessment of space threats. DOT&E continues to enforce this guidance, requiring that all space system Test and Evaluation Master Plans (TEMPs) and test plans include the resources for realistic threat representation. The Services should use this guidance, and follow-on efforts such as the studies conducted in 2017 by the Threat Resource Management Center (TRMC) and the Air Force Director of Test and Evaluation, to resource adequate space threat test capabilities for all military space systems.

High-Altitude Electromagnetic Pulse Test Capability

Military Standard 4023 (MIL-STD-4023), "High-Altitude Electromagnetic Pulse (HEMP) Protection for Military Surface Ships," requires full-ship electromagnetic pulse (EMP) testing

to support surface vessel survivability assessments. In addition, because the DDG 51 Flight III destroyer is expected to be capable of operating in an EMP environment, section 407 of the DDG 51 Ship Specification establishes requirements for DDG 51 EMP Protection. Section 407 states that during the guarantee period of the ship, the government will conduct a full-ship EMP test to determine the performance of the ship's electronic systems under simulated EMP conditions.

The Navy does not have a capability to conduct a survivability assessment of a full ship subjected to EMP effects. Current Navy practice is to conduct limited testing on ship systems and sub-systems and then extrapolate these results to the entire ship. This testing method does not provide the data needed to adequately assess full ship EMP survivability at sea in an operational mode. Existing EMP M&S capabilities provide very limited information on ship survivability, with significant uncertainties.

In FY15, the OSD Chemical, Biological, Radiological, and Nuclear Survivability Oversight Group – Nuclear identified a full-ship EMP Threat Level Simulator (TLS) for warships as their most important test capability gap. The Tri-Service Technical Working Group, responsible for the development of MIL-STD-4023, agreed that a full-ship EMP TLS is required for warship EMP threat survivability assurance. The Defense Threat Reduction Agency also determined that testing using a full-ship EMP TLS is the best approach to demonstrate ship threat-level EMP protection and mission assurance in accordance with standing Navy requirements. Currently, surface vessel acquisition programs (e.g., DDG 51) have no plans to conduct a full-ship EMP test because the Navy has no capability to do so. In order to address this testing capability shortfall, in FY16 the Naval Sea Systems Command (NAVSEA) directed the Navy's EMP Program Office to develop a method using a Low-Level Continuous Wave Illuminator to conduct EMP testing on one to-be-determined test ship. Evaluation of this trial will help determine the way forward for development of a full-ship EMP TLS.

In conjunction with NAVSEA, the Defense Threat Reduction Agency estimated the costs to build a full-ship EMP TLS capability to be $49-54 Million. Once operational, the total cost to conduct nine tests is estimated at $17.5-18.6 Million. Full-ship EMP TLS testing at sea will support mission assurance by providing test data for EMP modeling and realistic EMP training scenarios for ship crews. At-sea testing using this capability will demonstrate full-ship EMP survivability and support the U.S. nuclear deterrent posture. DOT&E supports these efforts to address current EMP testing shortfalls as soon as possible.

Joint Strike Fighter Advanced Electronic Warfare Test Resources

In February 2012, DOT&E identified significant shortfalls in EW test resources – in particular surface-to-air threat representation on the open-air ranges, which resulted in nearly $500 Million of funding for the Electronic Warfare Infrastructure Improvement Program (EWIIP). EWIIP was intended to buy both open- and closed-loop threat ground radar emulators for the open-air ranges, provide corresponding upgrades to anechoic chambers and the Joint Strike Fighter (F-35) mission data file reprogramming lab, and provide intelligence products to support the development of the threat emulators.

Significant progress has been made in some instances, but is lacking in others. The open- and closed-loop threat emulators, in addition to the lab upgrades, are key to the development, testing, and timely fielding of numerous U.S. aircraft and airborne EW systems that are critical for prevailing against near-peer adversary threats. These aircraft and EW systems include the F-35, F-22 Increment 3.2 A/B, B-2 Defensive Management System, Long Range Strike Bomber, and the Next Generation Jammer for the EA-18G. The status of various components of the EWIIP effort is displayed in Table 1.

DOT&E championed an effort that resulted in $172 Million of additional funding for the Services for additional range infrastructure for testing, training, and readiness of U.S. aircraft and airborne EW systems. This funding will enable test ranges and M&S (that must be validated with test data) to assess the performance of U.S. systems against near-peer threat air-defense networks of the 2020s. These capabilities include conventional radars with advanced digital signal generation and processing, networked together via advanced track fusion processing systems; multi-static radar networks; passive detection systems; and passive coherent radars. The proposed enhancements are constrained to materiel solutions that can be procured rapidly and off the shelf where possible in order to be available for testing of critical systems such as the Next Generation Jammer.

TABLE 1. RECOMMENDATIONS ON ELECTRONIC WARFARE TEST RESOURCES	
DOT&E Recommendation	**Current Status**
Develop a combination of open- and closed-loop ground radar emulators in the numbers required for operationally realistic open-air range testing of the Joint Strike Fighter (F-35) and other systems beginning in 2018.	EWIIP was scheduled to deliver the first 2 open-loop systems (called Radar Signal Emulators (RSEs)) in 2016, 12 systems in 2017, and the final 2 in early 2018, for a total of 16 RSEs – in time to support F-35 IOT&E and other testing in 2018 and beyond. All 16 are on track to deliver by March 2018. Acceptance and integration testing is underway and on track to support F-35 IOT&E spin-up; this testing will establish procedures for use of RSEs in the F-35 IOT&E and provide validation data for accreditation of the systems for use in OT&E. Two closed-loop systems are in development but are not scheduled to be available until mid-to-late 2019, after completion of the planned F-35 IOT&E. The integration architecture developed for the open-loop RSE systems will provide adequate test capabilities for F-35 Block 3F IOT&E in lieu of closed-loop systems.
Upgrade 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 improved interim signal generation capabilities and initial test support equipment for direct signal injection capability for the F-35. The Navy chamber executed F-35 electronic warfare testing for compliance and simulation validation in September and October 2016. The facility introduced a more substantial upgrade in the summer of 2017 that will allow high-fidelity replication of very high signal density threat environments. • The Air Force chamber has completed one stage of hardware upgrades, improving its ability to replicate high signal density environments, and has identified a path forward covering more extensive upgrades through 2020.
Upgrade the F-35 mission data file reprogramming facility, known as the U.S. Reprogramming Laboratory (USRL), to include realistic threats in realistic numbers.	An F-35 Program Office-sponsored study to determine upgrade requirements for the USRL was completed in December 2014. It confirmed the shortfalls identified by DOT&E in February 2012 and identified many other critical shortfalls preventing effective and efficient mission data file development and reprogramming. Delays since completion of the study have pushed the schedule for upgrades beyond Block 3F IOT&E and fielded operations. Additionally, the program intends to procure fewer signal generators than the study recommended, further jeopardizing the program's ability to generate effective mission data in the future. Hardware and software changes planned for F-35 follow-on modernization will require a significant redesign of the USRL. The point by which the USRL follow-on modernization requirements must be defined to support long lead time equipment purchases is fast approaching. DO&TE is unaware of any formal planning activities that have been conducted for the USRL upgrades required to support follow-on modernization.
Provide Integrated Technical Evaluation and Analysis of Multiple Sources intelligence products needed to guide threat simulations.	Products have been delivered and are being used to support development of the open- and closed-loop threat radar emulators.

Point Mugu Sea Test Range Enhancements to Support OT&E of Air Warfare Programs

In 2015 and 2016, DOT&E and USD(AT&L) allocated $22 Million to fund integration of the Air Warfare Battle Shaping (AWBS) system and the open-loop Radar Signal Emulators (RSEs) at Point Mugu Sea Test Range (STR), California. AWBS is a variant of the Air-to-Air Range Instrumentation system at the Air Force Western Test Range (WTR), Nevada, where it is used for scoring and post-mission reconstruction and analysis of OT&E missions. Use of RSEs at the STR for the F-35 IOT&E will provide operationally realistic scenarios and lessen some of F-35 IOT&E trials at the WTR. Additionally, conducting test trials at the STR could shorten the duration of F-35 IOT&E.

In 2016, Navy and Air Force personnel participated in RSE range integration working groups and, together with DOT&E, observed initial acceptance testing of the first two RSEs. Navy personnel are currently undergoing training for RSE operation, maintenance, and programming. Two RSEs will be temporarily transferred from the Nevada Test and Training Range (NTTR) to the STR during 2017 and early 2018 to complete integration testing at the STR. At the outset of F-35 IOT&E, all 16 RSEs will be stationed at NTTR for F-35 IOT&E trials. Once those scenarios are completed, 12 RSEs will move to the STR for additional F-35 IOT&E trials.

Fifth-Generation Aerial Target

DOT&E has been investigating the means to develop a full scale aerial target to adequately represent the characteristics of fifth-generation threat aircraft. The Fifth-Generation Aerial Target (5GAT) study effort began in 2006 and examined the design and fabrication of a dedicated 5GAT that would be used

in the evaluation of U.S. weapon systems effectiveness. The 5GAT team – comprised of Air Force and Navy experts, retired Skunk Works engineers, and industry experts – completed the preliminary design in 2016. The fully owned Government design includes the aircraft outer mold line, internal structures, loads analysis, propulsion, and subsystems. The 5GAT effort is currently building the first of two demonstration prototypes, including flight propulsion, system integration, and flight simulation/verification activities. The team built one full-scale, flight-representative wing that will be used for structural load tests and a system integration laboratory, as well as a full scale test article for radar cross-section testing. The DOD provided additional funding in FY18-19 to complete the final design, tooling, fabrication, and flight tests (FY19) and to build a second prototype. The prototyping effort will provide cost-informed alternative design and manufacturing approaches for future air vehicle acquisition programs, and verified cost data for all-composite aircraft design/development, alternative tooling approaches, and innovative management applications. The 5GAT effort can also be used to assist with future weapon system design/development, planning and investment, and future analysis of alternative activities. It will also demonstrate reduced signature, basic aerodynamic performance, alternative cost models for aircraft development, and provision for special mission systems.

Electronic Warfare for Land Combat

The Army's Mission Command Network is a key enabler that supports mission execution across the Brigade Combat Team (BCT). Integrated network systems including mobile satellite, digital radio, and mission command applications are distributed throughout a combat formation and its support elements, from the brigade command posts down to the individual dismounted soldier. The Army intends commanders to have rapid access to the information needed to complete their mission and to have the ability to transfer information such as voice, video, text, position location information, and high-resolution photographs throughout the BCT. The expanded use of radio frequency (RF)-based networks expose the BCT to contemporary EW threats, including electronic support (ES) and electronic attack (EA) capabilities. Recent conflicts have demonstrated the paralyzing effects that EW can have on the modern battlefield. As the Army becomes more dependent on RF-based network technologies, it is critical that the developmental and operational test communities continue to identify and assess their vulnerabilities. Decision-makers must understand the inherent vulnerabilities and the ways an enemy may choose to exploit and/or degrade the tactical network.

During operational testing, threat EW is part of a broader combat force that is made available to the opposing force (OPFOR) commander. When possible, the EW systems, tactics, techniques, and procedures employed by the OPFOR during test should represent those of potential adversaries. The Threat Systems Management Office (TSMO) is responsible for developing, operating, and sustaining the Army's suite of threat EW capabilities. There is a gap in the Army's ability to perform ES in higher frequency bands, which TSMO is addressing through the Advanced Networked Electronic Support Threat Sensors project. TSMO has demonstrated a continued commitment to providing realistic threat EW for operational test and mitigating limitations when possible. Because these developing threat test capabilities support increased operational realism in testing, they are critical to support future testing of Warfighter Information Network – Tactical Increment 2, Nett Warrior/Leader Radio, Manpack Radio, Joint Battle Command – Platform, and Assured Positioning Navigation and Timing.

Navy Advanced Electronic Warfare Test Resources and Environments

Improving Capability to Realistically Represent Multiple Anti-Ship Cruise Missile (ASCM) Seekers for Surface Electronic Warfare Improvement Program (SEWIP) Operational Testing

A gap in the ability to realistically represent multiple ASCM seekers during test was initially identified in the DOT&E FY13 Annual Report as "Additional Electronic Warfare Simulator Units for Surface Electronic Warfare Improvement Program (SEWIP) Operational Testing." The Navy subsequently developed a programmable seeker simulator that could represent different ASCM seekers by specifying electronic waveform emission characteristics for one of several possible threats. However, the effective radiated power (ERP) was not among those characteristics, resulting in simulated attacks by ASCM representations displaying disparate levels of ERP that are 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," should 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, to be followed by FOT&E on a Product Line Architecture-compliant DDG 51 with Block 2 integrated with the Aegis Combat System. This integration was not part of the Block 2 IOT&E. Subsequent FOT&E is intended with the DDG 1000 destroyer and CVN 78 aircraft carrier combat systems. The estimated cost to add the ERP improvement is $5 Million.

Improving the Fidelity of ASCM Seeker/Autopilot Simulators for Electronic Warfare Testing

DOT&E initially identified a gap in the fidelity of ASCM seeker/autopilot simulators in the FY13 Annual Report. The gap arose because of continued reliance on manned aircraft for captive-carry of ASCM seeker simulators. Captive-carried simulators can neither demonstrate a kinematic response to EA by SEWIP Block 3 nor demonstrate the effect that such kinematic responses will have on ships' hard-kill systems (e.g. missiles, guns). Manned aircraft fly too high and too slowly for credible ASCM representation and are unable to perform ASCM maneuvers. Credible ASCM representation requires a vehicle that can fly at ASCM speeds and lower altitudes than the current Learjets; 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. Currently, discrete combat system components are tested as a subset of the integrated combat system, leaving integrated combat system capability unknown. SEWIP Block 3 IOT&E is projected for FY21 on a DDG 51-class ship. FOT&E of SEWIP Block 3 integrated with the CVN 78 combat system should occur subsequent to the IOT&E.

Developing Test Surrogates for Hostile Airborne and Surface Radar Systems

In addition to the ASCM surrogates described above, adequate operational testing of active EA systems like SEWIP Block 3 requires development of threat airborne and surface (e.g., coastal defense) radars that active EA systems may be required to thwart. The Navy tests such capababilities at the Shipboard Electronic Systems Evaluation Facility (SESEF). At SESEF, the Navy uses a pulse generator, known as the Combat Electromagnetic Environment Simulator (CEESIM), an amplifier, and an antenna to emulate hostile radars. Such test facilities provide some capability to demonstrate an electornic warfare system's ability to detect and identify threat radars, but the existing capability is not adequate to test EA systems. To test such systems, the threat radar surrogate should better emulate the RF aspects of the threat radar, the signal processing of the radar, and the electrnonic protection aspsects of the radar. On October 20, 2016, DOT&E directed the Navy to develop such threat radar surrogates. Without such test assets, it is unclear how the Navy will credibly test active EA systems like SEWIP Block 3.

Equipping a Self-Defense Test Ship for Aegis Combat System, Air and Missile Defense Radar, and Evolved Seasparrow Missile Block 2 Operational Testing

The close-in ship self-defense battlespace is complex and presents a number of challenges. For example, this environment requires:

- Weapon scheduling with very little time for engagement
- The combat system and its sensors to deal with debris fields generated by successful engagements of individual ASCMs within a multi-ASCM raid
- Rapid multi-salvo kill assessments for multiple targets
- Transitions between Evolved Seasparrow Missile (ESSM) guidance modes
- Conducting ballistic missile defense 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 by the Close-In Weapons System (CIWS)

Multiple hard-kill weapon systems operate close-in, including the Standard Missile 2, the ESSM, and the CIWS. Soft-kill systems such as the 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 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 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 self-defense test ship (SDTS) – ex-USS *Stoddard* – was put into service that same year. A similar incident occurred in November 2013, when two sailors were injured when an aerial target struck USS *Chancellorsville* (CG 62) during a test of its combat system. The *Chancellorsville* incident underscores the inherent dangers of testing with manned ships in the close-in battlespace.

The investigation into the *Chancellorsville* incident caused the Navy to rethink how it will employ subsonic and supersonic aerial targets near manned ships. The Navy has always considered supersonic ASCM targets high risk to safety and will not permit flying them directly at a manned ship. The Navy has invested in a seagoing, 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 the self-defense capabilities of non-Aegis ships can be completely and affordably conducted. The Navy recognizes that the SDTS is 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). However, it has not made a similar investment in an SDTS equipped with an Aegis Combat System, Air and Missile Defense Radar (AMDR), and ESSM Block 2 for adequate operational testing of the DDG 51 Flight III destroyer self-defense capabilities. The current SDTS lacks appropriate sensors and other combat system elements to test these capabilities.

On September 10, 2014, DOT&E submitted a classified memorandum to USD(AT&L) with a review of the Design of Experiments study by the Navy Program Executive Office for Integrated Warfare Systems. The Navy study attempted to provide technical justification to show that an Aegis-equipped SDTS was not required 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 not using an Aegis-equipped SDTS for operational testing.

On December 10, 2014, the Deputy Secretary of Defense (DEPSECDEF) issued a memorandum directing the Director of Cost Assessment and Program Evaluation (CAPE) to identify viable at-sea operational testing options that meet DOT&E adequacy requirements and to recommend a course of action

(with cost estimates, risks, and benefits) to satisfy testing of the AMDR, Aegis Combat System, and ESSM Block 2 in support of the DDG 51 Flight III destroyer program. The CAPE study evaluated four options to deliver an at-sea test platform adequate for self-defense operational testing. Each option required funding beginning in FY18 to support operational testing of these systems in FY22.

On February 10, 2016, the DEPSECDEF directed the Navy to adjust funds within existing resources to procure long lead items to begin procurement of an SDTS equipped with the Aegis Combat System and AMDR. He further directed the Navy to work with DOT&E to develop an integrated test strategy for the DDG 51 Flight III, AMDR, Aegis Modernization, and ESSM Block 2 programs. The DEPSECDEF required the Navy to document that strategy in draft TEMPs for those programs and submit them to DOT&E by July 29, 2016. The Navy has not complied with the direction to provide an integrated test strategy or TEMPs for those programs. Despite initially budgeting for long lead AMDR components, the Navy did not program funding in the Future Years Defense Plan to complete other activities and equipment required to modify the SDTS to support adequate operational testing of the self-defense capabilities of the DDG 51 Flight III, AMDR, and ESSM Block 2 in FY23 as planned. The Navy subsequently removed funding for the long-lead AMDR components.

On November 21, 2016, the DEPSECDEF directed the Navy to fully fund the Aegis SDTS and aerial targets required for testing the DDG 51 Flight III, AMDR, and ESSM Block 2 programs. The Navy initially complied with the direction but subsequently removed all funding for the Aegis SDTS and aerial targets.

On May 4, 2017, the DEPSECDEF directed the Navy to reinstate funding for the Aegis SDTS and associated test firings in compliance with the November 21, 2016, guidance. DOT&E continues to recommend 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 validate ship self-defense performance M&S.

Multi-Stage Supersonic Targets

The Navy initiated a $297 Million program in 2009 to develop and produce 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, CVN 78, DDG 51 Flight III destroyer, LHA(R), AMDR, Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 2 operational test programs. The MSST underwent restructuring and rebaselining from 2013 – 2015 in order to address technical deficiencies as well as cost and schedule breaches, which would have postponed its Initial Operational Capability (IOC) to 2020 and increased the total program cost to $962 Million. Based on the restructured/rebaselined MSST program's high cost and schedule delays, as well as new intelligence reports, the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RDA)) in 2014 directed that alternatives be examined to test against these ASCM threats and subsequently terminated the MSST program. While the details of the final Navy alternative are classified, DOT&E determined that it would be very costly (the Navy estimates $739 Million), very difficult to implement, dependent on the results of highly segmented tests, and would suffer from severe artificialities that would confound interpretation of test results. DOT&E informed the Navy that the proposed alternative was not adequate for operational testing and recommended that the Navy not pursue it. MSST aerial target capabilities are still required to complete end-to-end operational testing of Navy surface ship air-defense systems and to validate M&S capabilities for assessing the probability of raid annihilation for Navy ships.

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

Operational testing of anti-submarine warfare (ASW) and torpedo defense-related systems for all Navy and Navy support ships includes the ability to detect, evade, counter, and/or destroy an incoming threat torpedo. The determination of system or platform performance is dependent on a combination of the characteristics of the incoming torpedo (e.g., dynamics, noise, sensors, logic, etc.). Due to differences in technological approach and development, U.S. torpedoes are not representative of many highly proliferated torpedoes, particularly those employed in anti-surface warfare (ASuW) by other nations. The need for threat-representative torpedo surrogates to support operational testing is detailed in DOT&E memoranda to the ASN(RDA) dated January 9, 2013, and June 18, 2015. Acquisition programs that require threat torpedo surrogates for future operational testing include: *Virginia* and *Columbia* class submarines, *Zumwalt* class destroyer, AN/SQQ-89 surface ship ASW combat system, Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) submarine sonar system, and Navy Torpedo Warning System and Countermeasure Anti-torpedo Torpedo acquisitions systems. Based on the 2014 Naval Undersea Warfare Center (NUWC) Division study, the Navy has taken the following actions to address the gaps in threat representation of torpedo surrogates:

- NUWC Division Keyport commenced a prototype technology development project that is expected to deliver a threat-representative, high speed quiet propulsion system. This effort was funded as an FY16 Resource Enhancement Program project at approximately $1 Million. This project experienced cost and schedule overruns and will complete within the following project, General Threat Torpedo (GTT).
- NUWC Division Keyport is pursuing development of a GTT that will complete development of the high-speed quiet propulsion system prototype and provide threat-representative tactics and countermeasure logic. The GTT project is funded as a Resource Enhancement Program for FY17 with funding of approximately $6.2 Million. DOT&E expects the GTT to fill in many of the gaps in threat representation of torpedo surrogates, however DOT&E remains concerned

that cavitation-generated noise may not be reprentative at ASuW depths. The ability of a successfully developed GTT to adequately support operational testing futher depends on future Navy decisions to procure a sufficient quantity of GTT and achievement of threat representative cavitation noise.

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 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 in May 1992, 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 mock-up of a small diesel-electric submarine, with an approximate program cost of $11 Million. As a moored stationary target, the WSTTT could not 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 mini-submarine (SSM) 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. An engineering assessment of the MASTT reveales the surrogate cannot be used as a set-to-hit target for torpedo testing. After 5 years and an expenditure of approximately $15 Million, the Navy started using the MASTT in limited search training. 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 SSM-sized, moored, set-to-hit target consisting of an open steel framework with a series of corner reflectors to provide appropriate sonar highlights. This surrogate does provide a basic sonar signature. 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 TEMP 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 capable of mobile depth changes and high speeds, autonomous, and certified for representative 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 SSM-sized submarine simulator.

Aircraft Survivability Equipment Test Capability Gaps

Aircraft Survivability Equipment (ASE) is an integral part of military fixed- and rotary-wing platforms. ASE provides aircraft and crew protection and is vital to mission effectiveness in hostile environments. T&E resources, such as foreign threat systems, threat system surrogates, and M&S are needed to effectively evaluate ASE. However, acquiring enough actual threat systems for testing is not always possible. Threat surrogates and M&S require high fidelity information along with intelligence on the actual threats to be able to replicate them accurately. To achieve this, one of DOT&E's objectives is to improve the fidelity and consistency of threat representations and M&S at T&E facilities while reducing overall test costs.

DOT&E has taken the initiative to meet these challenges through various means. DOT&E and the TRMC co-led the Infrared Countermeasure Test Resource Requirements Study (ITRRS), which identified shortfalls in infrared countermeasure (IRCM) testing and developed a prioritized IRCM investment roadmap of projects to mitigate current testing shortfalls. DOT&E, in conjunction with TRMC, is developing a T&E Threat M&S capability/investment roadmap. This comprehensive roadmap will address threat M&S investment needs for both infrared (IR) and RF threats, ensuring adequate evaluation of airborne combat systems. Both roadmaps recommend that programs address EW test capability gaps.

M&S and threat representative systems require accurate data be collected to characterize threats. DOT&E works with both the intelligence and T&E communities to gather threat information and develop test equipment such as the Joint Standard Instrumentation Suite (JSIS) to characterize threat systems that can be used to increase the fidelity of M&S and threat representations. However, the requirements to collect all threat

data have historically been underfunded to a considerable degree, leaving substantial capability gaps in ASE testing.

Throughout the T&E process, M&S representations of threat systems have been used when the actual threat components have limited availability or are not available at all. M&S representations of threat systems also support testing when flight safety precludes live fire testing (i.e., missile launches against manned aircraft). For example, test programs may only conduct 10-20 live missile firing events; whereas, using a threat model or simulation, a test program may extend those results across a broader range of test conditions with different threats, ranges, altitudes, aspect angles, atmospheric conditions, and other variables affecting weapon system performance. Moreover, M&S representations can provide a more complete assessment of a system's operational performance than is possible using open-air facilities alone. However, as models fill a larger role within T&E and new requirements are leveraged on them, significant capability gaps exist in some M&S. Some do not have the appropriate fidelity while other M&S instantiations of the same threat(s) may produce different results.

To help close this gap, DOT&E's T&E Threat Resource Activity (DOT&E/TETRA) provided DOT&E-funded, standardized, and authoritative threat M&S to multiple T&E facilities operated by the Army, Navy, and Air Force. During FY17, DOT&E/TETRA provided over 140 IR threat models to the T&E community. The Services integrated and used this threat M&S to support ASE testing. Furthermore, DOT&E/TETRA developed a T&E Threat M&S Configuration Management System and an M&S Configuration Control Board (CCB) process to implement configuration control and distribution management for threat M&S to ensure model consistency and integrity among various T&E facilities. The management system provides mechanisms to identify and correct anomalies between a threat and its M&S representation. It also assists in controlling model configuration changes, maintains critical documentation such as interface control and validation documents, and provides updated threat models to multiple T&E facilities for developmental and operational T&E requirements. The T&E Threat M&S CCB, comprised of representatives from the T&E and intelligence community, prioritizes existing threat M&S developments and changes to ensure updates are provided efficiently and with minimal effect to T&E user facilities. As of this publication, DOT&E is expanding the CCB role. To successfully bridge this capability gap for RF and IR, additional funding is required to assure consistent and accurate results across the board, and to stay linked with evolving T&E M&S needs that can ultimately reduce T&E costs and time.

A high priority project on the ITRRS list is the ability to measure threat signature data for the development or improvement of the threat models for IR-guided missiles and unguided hostile fire munitions used for the T&E of ASE. These signature models drive a large number of T&E simulation tools. The DOT&E's Center for Countermeasures (the Center) is the executing activity for the JSIS project. JSIS is a Central T&E Investment Program (CTEIP) Resource Enhancement Project designed to mitigate the threat signature data gap, as well as provide ground truth for live fire missile and hostile fire tests for IRCM system testing. At IOC, JSIS will support Advanced Threat Warner (ATW) and the Common Infrared Countermeasures (CIRCM) operational testing. JSIS can be deployed to static live fire venues outside the continental United States, where opportunities exist to measure and collect data for threat assets that are either not available or of insufficient quantities, domestically.

However, the JSIS IOC capability only partially addresses the needs identified by the ITRRS study. For example, it will not provide the capability to measure missile attitude information for the entire missile fly out, nor does the JSIS IOC capability meet all needs related to signature collection fidelity (e.g., frame rates and resolution). Full Operational Capability (FOC) is required to meet all the needs of the Army's CIRCM program, the Navy's ATW program, the Air Force's Large Aircraft Infrared Countermeasure (LAIRCM) program, and the Naval Research Laboratory's Distributed Aperture Infrared Countermeasure (DAIRCM) program. JSIS FOC is needed to collect signature data in support of T&E of advanced IRCM systems, currently in development, that operate in other wavelength bands. However, to do this, JSIS will require additional investment to close this IRCM T&E gap.

Similarly, the ITTRS roadmap has designated projects to address gaps for ground-based missile plume simulators; airborne missile plume simulators; hardware-in-the-loop test facilities; installed system test facilities; surrogate threat missiles; instrumentation suites; open-air test range improvements; and threat system acquisition and storage. Following is a list of these projects:

- Upgrades to both open-air test ranges and indoor test facilities needed to test the latest missile warning systems and IRCM
- Open-air test range improvements that include additional firing points for multi-threat environments and angular separation, upgrades to improve test efficiency, improved instrumentation, and jitter and atmospheric distortion measurement capability
- Upgrades to hardware-in-the-loop and installed system test facilities to better represent the latest threats in an operational simulated environment
- Expansion to heavily-utilized, hardware-in-the-loop, and installed system test facilities to better meet program test schedules
- Increased dynamic range and fidelity for ground-based missile plume simulators to expand their testing envelopes
- Improved surrogate threat missiles to support open-air testing
- Increased cooperation among the military and intelligence agencies to collect more threat systems
- Threat system storage facilities to store actual threats as they become available

The DOT&E threat RF M&S study collected, analyzed, and presented information regarding the design, distribution, integration, and use of RF-related threat M&S across multiple organizations and the Services. The RF study provided a consolidated list of authoritative threat models developed by the Intelligence Production Centers (IPCs). The RF study team surveyed subject matter experts at the IPCs and T&E facilities to

determine common concerns with the implementation of M&S for T&E. The RF study provided the following preliminary top level list of capability gaps to stakeholders for T&E M&S improvements:

- Improve threat M&S management and infrastructure
- Develop new threat models and update threat models for T&E scalability
- Improve multi-spectral signatures and RF data
- Improve threat M&S characterizations for T&E

Foreign Materiel Acquisition Support for T&E

DOT&E is responsible for ensuring U.S. weapons systems are tested in realistic threat environments. Use of actual threat systems and foreign materiel to create realistic threat environments in testing supports DOT&E's ability to determine a system's operational effectiveness in a combat environment. To acquire test capabilities, DOT&E/TETRA develops an annual prioritized list of foreign materiel required by upcoming operational tests. These requirements are submitted to the Defense Intelligence Agency (DIA) Joint Foreign Materiel Program Office and are consolidated with Service requirements to drive Service and Intelligence Community collection opportunities. DOT&E coordinates with the Department of State to identify other opportunities to acquire foreign materiel for use in OT&E.

Foreign materiel requirements span all warfare areas, but DOT&E continues to place a priority on the acquisition of Man-Portable Air Defense Systems (MANPADS) and Anti-Tank Guided Missiles (ATGMs). Foreign MANPADS are needed to address significant threat shortfalls that affect testing for IRCM programs like CIRCM, LAIRCM, and Department of the Navy (DON) LAIRCM. For some programs, a large quantity of MANPADS is required – for development of threat M&S, for use in hardware-in-the-loop laboratories, and for LFT&E, to present realistic threats to IRCM equipment. Using actual missiles and missile seekers aids evaluators in determining the effectiveness of IRCM equipment. Foreign ATGMs are required to support the testing of the Expedited Active Protection System.

Traditional sources have been fully consumed, and there is a critical need to identify and develop new sources and opportunities for acquiring foreign materiel. Foreign materiel acquisitions are usually very lengthy and unpredictable, making it difficult to identify appropriate year funding. Programs have funded as much as $60 Million a year for acquisition opportunities that arise. DOT&E recommends a no-year or non-expiring funding line for foreign materiel acquisitions, funded at a level of $10 Million per year.

Tactical Engagement Simulation with Real Time Casualty Assessment

Realistic operational environments and a well-equipped enemy intent on winning are fundamental to the adequate operational test of land and expeditionary combat systems. Force-on-force battles between tactical units represent the best method of creating a complex and evolving battlefield environment for testing and training. This environment causes commanders and soldiers to make tactical decisions and react to the real-time conditions on the battlefield. Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA) systems integrate live, virtual, and constructive components to enable these simulated force-on-force battles, and provide 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. TES/RTCA systems must replicate the critical attributes of real-world combat environments, such as direct and indirect fires, IEDs and mines, and simulated battle damage and casualties. TES/RTCA systems must record the time-space position information and firing, damage, and casualty data for all players in the test event as an integrated part of the test control and data collection architecture. Post-test playback of these data provide a critical evaluation tool to determine the combat system's capability to support soldiers and marines as they conduct combat missions.

New and upgraded ground combat vehicles are incorporating improved conventional armor, Active Protection Systems, and advanced weapons. These modern developments, as well as upgrades to threat vehicles, should be integrated into the Instrumentable – Multiple Integrated Laser Engagement System (I-MILES) prior to each respective IOT&E. I-MILES is a subsystem of TES/RTCA and is essential to ensuring that engagements have realistic outcomes. I-MILES was designed to replicate the weapons effects against conventional armor, and cannot simulate the dynamic missile defeat technology employed by Active Protection Systems. Updates will also support force-on-force training once these new and upgraded vehicles are fielded.

DOT&E has emphasized the need for sustained investment and regular upgrades in TES/RTCA capabilities since 2002. These capabilities are necessary for testing systems such as Amphibious Combat Vehicle, Bradley and Abrams Upgrades, Armored Multi-purpose Vehicle, AH-64E Block III, Mobile Protected Firepower, Joint Light Tactical Vehicle, and Stryker Upgrades.

Warrior Injury Assessment Manikin

Hybrid III is an anthropomorphic test device (ATD) currently used for LFT&E, but this ATD lacks biofidelity in an underbody blast (UBB) test environment. Therefore, it does not exhibit a human-like response when exposed to UBB loading conditions and lacks capability to fully assess operator survivability to vehicle threats yielding UBB environments. The Warrior Injury Assessment Manikin (WIAMan) Engineering Office (WEO) is developing WIAMan ATD to address this LFT&E capability shortfall. The LFT&E section describes the WIAMan project on page 313.

Test and Evaluation of Army Software-Defined Tactical Radios

Software-Defined Radios have become a cornerstone technology of the Army tactical radio communication systems.

Software-Defined Tactical Radios provide the Army with improved capabilities such as simultaneous voice, data, and video communications; voice and data retransmission; increased throughput; multi-channel operations; and interoperability with fielded radios. Because of the complexity of these tactical radio networks and the added capabilities they provide, improved test instrumentation and data collection methods are needed to support the evaluations of the Army Software-Defined Tactical Radios. Specific evaluation metrics that currently cannot be evaluated include voice quality, call completion rate, and the route each message takes through the network. The Army should investigate methods to collect these metrics and develop a plan to support upcoming IOT&Es. These improvements to instrumentation and data collection methods are necessary to support the test and evaluation of the Leader Radio and Manpack Radio.

Range Sustainability

For the past eight years, DOT&E has reported on land-, air-, sea-space, and frequency spectrum resource problems that limit the DOD's ability to test weapons systems in operationally realistic environments. As previously reported, adequate land-, air-, and sea-space are critical to test weapons and associated systems in operationally realistic conditions. Range sustainability and the preservation of those resources is challenged by factors such as incompatible infrastructure, urban development, natural and cultural resource protection, and frequency spectrum losses. Each of these factors may limit a range's capability to conduct operational test and evaluation.

From a range sustainability perspective, the DOD has had some success in preserving land-, air-, sea-space, and frequency spectrum. Additional work is required, as is a comprehensive plan to address future challenges.

Table 2 illustrates the increase of range sustainability challenges since 2001. While many problems have been mitigated, they have not been eliminated.

Those that are unshaded are being effectively mitigated/managed by the Services/Installations. Those that are shaded presently require additional effort to manage and/or resolve unmitigated challenges. Specific challenges include:

- Renewable Energy and Maritime Sustainability – Energy production infrastructure interference with test capabilities including weapons testing and operational launches, airborne radar, and aircraft systems testing
- Airspace – Insufficient overland range for test flight of hypersonic missiles and growing challenges to offshore airspace from potential energy development
- Cyber Intrusion of Range Instrumentation – Vulnerability of instrumentation and systems under test
- Frequency Spectrum – Inadequate frequency spectrum to accommodate increased data collection and transmission of test data
- Privately Operated Drones – Interference from privately operated aerial drones
- Endangered Species – Test limitations resulting from natural resource protection
- Foreign Investment – Compromise of test data as a result of foreign surveillance
- Cultural Resources – Requirements to conduct surveys

TABLE 2. TEST RANGE SUSTAINABILITY CHALLENGES, 2001-2017

	2001	2003	2005	2007	2009	2011	2013	2015	2017
Endangered Species	•	•	•	•	•	•	•	•	•
Unexploded Ordinance (UXO) and Munitions	•	•	•	•	•	•	•	•	•
Airspace	•	•	•	•	•	•	•	•	•
Maritime Sustainability	•	•	•	•	•	•	•	•	•
Airborne Noise	•	•	•	•	•	•	•	•	•
Frequency Spectrum	•	•	•	•	•	•	•	•	•
Air Quality	•	•	•	•	•	•	•	•	•
Urban Growth	•	•	•	•	•	•	•	•	•
Land Space	•	•	•	•	•	•	•	•	•
Cultural Resources	•	•	•	•	•	•	•	•	•
Adverse Weather Effects on Ranges				•	•	•	•	•	•
Water Rights					•	•	•	•	•
Renewable Energy					•	•	•	•	•
Privately Operated Drones							•	•	•
Foreign Investment							•	•	•
Cyber Intrusion of Range Instrumentation								•	•
Space									•

Unshaded areas are being effectively mitigated/managed by the Services/installations. Shaded areas require additional effort.

Renewable Energy

Siting of energy infrastructure, particularly wind turbines, adjacent to military test installations continues to be a challenge for the DOD. Interference with radar systems adversely affects DOD testing. Where interference has arisen, the effect must be mitigated to allow continued use of test capabilities. The trend toward taller wind turbines with longer blades has exacerbated the negative effects on radar performance. DOT&E continues to work with the DOD Siting Clearinghouse to evaluate projects referred by the Federal Aviation Administration's (FAA) Obstruction Evaluation process and from other sources. Legislation is pending which would strengthen Siting Clearinghouse authorities.

Maritime Sustainability

Outer Continental Shelf leasing for oil and gas exploration and exploitation poses a potential threat to the capability to conduct operational testing. In the Eastern Gulf of Mexico, potential expansion of oil and gas development conflicts with the DOD needs to test advanced weapons systems in an operationally realistic environment. Testing new hypersonic missiles and autonomous systems requires large safety envelopes to minimize risks to populations and infrastructure. These safety requirements likely will drive a change in the DOD test inputs to the current Bureau of Ocean Energy Management (BOEM) program plan because the DOD must now address changes in the threat environment. The DOD works closely with the BOEM to group areas considered for oil and gas development into categories where development can co-exist with DOD requirements and where it cannot.

Airspace

High technology weapons systems designed to counter future threats will require additional air-land space to conduct testing in operationally realistic environments. The DOD needs capabilities to test autonomous systems, hypersonic missiles, theater missile defense, swarm and counter swarm systems, and directed energy systems. These systems greatly stress the land-, air-, and sea-space available for operationally realistic tests. Very simply, test ranges secured in the 1940's were founded on the performance characteristics of weapons systems in that era, and current and proposed weapons systems far exceed those characteristics. The Army intends the Long Range Precision Fires (LRPF) program to extend the range of its tactical missile capabilities beyond 300 km. The LRPF missile must be tested from launch to impact at its maximum range to evaluate effectiveness. The footprint required for testing the maximum range of the LRPF missile exceeds the land area of any single Army test range. LRPF must also be tested in an EW environment to ensure the missile can survive launch, flight, and impact through a contested electromagnetic environment. The Army must develop a solution such that the LRPF can be launched through a threat EW environment at maximum range and impact the ground in a location with threat representative targets. To be able to perform these types of tests, the DOD must work with Federal and state agencies to expand or combine domestic resources or will need to test at overseas ranges where expanded test parameters can be accommodated.

Cyber Intrusion of Range Instrumentation

Recent intrusion to allegedly secure networks raises the issue of whether test range communications networks are as secure as they should be to avoid test data leakage to unauthorized sources. Therefore, vulnerabilities of instrumentation as well as weapons-under-test need to be addressed. Both the 96th Test Wing at Eglin Air Force Base and the White Sands Missile Range conducted tabletop exercises in late 2016 and 2017, and have plans underway to perform more in-depth testing of actual range systems. Other ranges will be conducting similar events going forward.

Frequency Spectrum

The RF spectrum is a vital resource needed to conduct test operations, transmit and receive critical test data, and is necessary to ensure test range safety. Increased weapon system complexity and test data transmission requirements in support of the Joint Strike Fighter, the future Long Range Strike Bomber, and Long Range Stand-Off Weapon, increase the need for RF spectrum to support test operations. Specifically, DOD T&E has a documented need for 865 megahertz (MHz) of RF spectrum required to support test operations by 2025. Meanwhile, national spectrum policy, fueled predominantly by increased demand for commercial cellular and wireless services, is reducing the available amount of RF spectrum to support T&E. For example, the Advanced Wireless Service (AWS-3) auction repurposed the 1755-1780 MHz portion of spectrum that is heavily used to support flight test operations and operational test missions. The main concern is supporting national spectrum policy while ensuring that the DOD has access to the required amount of the RF spectrum to support test operations. DOT&E, in conjunction with TRMC and Service partners, employs strategies to preserve the RF spectrum currently available for DOD use, and supports research initiatives for technologies and equipment that make the most efficient use of available spectrum. DOT&E will continue to monitor frequency spectrum availability related to operational test requirements, review policies and procedures ensuing from the DOD Spectrum Strategy, and engage in other issues that may adversely affect use of spectrum for T&E.

Privately Operated Drones

The widespread operation of recreational drones jeopardizes restricted airspace control. Their use in or near restricted airspace can impede the safe operations of military aircraft and systems, and also poses the threat of surveillance. DOD legal avenues to limit drone access are currently limited, but recent actions by the FAA and Congress to limit drone operations within national security zones are encouraging.

Endangered Species

As discussed in previous reports, DOD ranges contain environmentally sensitive flora and fauna, including those that migrate from disturbed areas external to our ranges. Threatened or endangered species listings have increased from 600 in 1990

to 1,656 in September 2017. The DOD manages and protects more than 400 threatened and endangered species, and more than 550 at risk species on its military installations. Integrated Natural Resources Management Plans (INRMPs) are the key documents that the DOD uses to address how each installation with natural resources will manage those resources – there are 346 INRMPs. To test, the DOD must balance requirements against species preservation, which can be a limiting factor on testing. DOT&E engages Federal, state, local, and private organizations to explore the means to minimize such limitations.

Foreign Investment

Foreign investments in the U.S. may enable foreign intelligence services to conduct surveillance of U.S. weapon systems testing through proximity to test ranges. Such investments may also allow information collection on critical technologies and personally identifiable information of the testers. DOT&E reviews projects submitted to the Committee on Foreign Investment in the United States (CFIUS) for possible security risks associated with foreign surveillance. During the past 12 months, 223 cases, with more than 3,300 supporting documents, were reviewed. Seven cases were assessed to pose a potential threat to test or training ranges and required further investigation and development of mitigation strategies. Submissions are on track to reach 300 cases by the end of calendar year 2017. However, CFIUS only reviews projects submitted by applicants; there is a potential risk that other, unrecorded transactions may create operational security vulnerabilities. DOT&E will continue to exercise vigilance in reviewing all identified cases of foreign investment to ensure that data from weapon system tests are not compromised.

Cultural Resources

Under the National Historic Preservation Act, Federal agencies are required to consult with state and local groups before cultural resources, such as historical or archaeological sites, are damaged. Results of cultural resource surveys are used to inform decision-making by determining how resources may be affected, and what alternatives exist to reduce risk of harm. Many test ranges contain cultural resources, and therefore must conduct surveys to determine where resources exist and to factor potential disturbance into test planning.

The DOD faces competition for many of the natural resources needed to conduct adequate testing. DOT&E will continue to assess the adequacy of resources needed to conduct adequate testing, will alert Department leadership to shortfalls in such resources, and will participate in interagency processes to promote resource adequacy.

Test Infrastructure Efficiency

The recent development and fielding of the Common Range Integrated Instrumentation System (CRIIS) by the TRMC under the Central Test and Evaluation Investment Program (CTEIP) is a major achievement in efficiency within the test and training communities. CRIIS is a family of systems for airborne data collection for all DOD aircraft that replaces the Advanced Range Data System (ARDS). It provides high-speed, real-time, mult-level secure data with position accuracies down to 0.5 meters. A funded software modification to CRIIS datalink capabilities will provide compatibility with Air-to-Air Range Infrastructure (AARI) messages currently in use for F-22 operational testing (OT) and planned for use during F-35 OT. CRIIS also provides an architecture to support live virtual constructive (LVC) testing including the capability to transfer weapon simulation data needed for training missions. The system started fielding this year and will be deployed on approximately 200 aircraft at 8 Major Range and Test Facility Base (MRTFB) locations.

In March 2017, Rockwell Collins, the system's lead developer for CRIIS, was awarded the Navy's Tactical Combat Training System Increment II (TCTS Inc II) contract to develop the next-generation training system. This system will have significant commonality with CRIIS, which will result in a common test and training instrumentation system for MRTFB ranges and Navy training activities. These CRIIS-based solutions will facilitate shared use of one another's assets and range facilities, and will pave the way for a life-cycle strategy that could save the Department millions of dollars in long-term sustainment. In order to save additional DOD operations and sustainment costs and realize the full potential of the CRIIS-based architecture, DOT&E encourages the Air Force to adopt CRIIS interoperable technologies for use by its training community.