Test and Evaluation Resources

Public law requires DOT&E to assess the adequacy of operational and live fire testing conducted for programs under oversight. This assessment must include comments and recommendations on resources and facilities available for OT&E and LFT&E and on levels of funding made available for these activities. 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. FY16 focus areas include:

- Adjustments to the DOT&E FY16 Budget Request
- Army Support of OT&E
- Cybersecurity Red Team Personnel and Capability Shortfalls
- 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
- Electronic Warfare for Land Combat
- Navy Advanced Electronic Warfare Test Resources and Environments
- Equipping the 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
- Fifth-Generation Aerial Target
- Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare Platforms and Systems
- Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes
- Missile Warning and Infrared Countermeasure Test Capability Gaps
- Threat Modeling and Simulation to Support Aircraft Survivability Equipment Testing
- Foreign Materiel Acquisition Support for T&E
- Tactical Engagement Simulation with Real Time Casualty Assessment
- Warrior Injury Assessment Manikin
- Testing in Urban Environments
- Biological Defense Testing at West Desert Test Center
- Range Sustainability and Radio Frequency Spectrum

Adjustments to the DOT&E FY16 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 FY 2016 budget request included:

- HASC and SASC approval of the President's Budget request in the National Defense Authorization Act for FY16.
- Appropriations increases for:
  - Joint T&E ($10 Million)
  - Threat Resources Analysis ($8 Million)

The Congressional increase for Joint T&E is on track to provide six additional Quick Reaction Tests beyond the six Quick React Tests that were included in the base budget. The increase for Threat Resource Analysis improved threat realism for testing, focusing on the following areas:

- Increased cyber intelligence analyses for characterizing emerging cyberspace threat representations and threat environments
- Analysis for converging electronic warfare (EW) and cyber threats
- Standardized methods for documenting and cataloging cyber threats
- Extended support for development and validation of threat models and simulations to improve their fidelity and availability for T&E

Army Support of OT&E

Beginning with the 2014 Annual Report, DOT&E has expressed concern with the continued budget and staffing reductions at the Army Test & Evaluation Command (ATEC) and the office of the Army Test & Evaluation Executive. During the FY16 DOT&E review of the Army's T&E budget and resources, the Army indicated that there would be further staffing reductions at ATEC's Army Evaluation Center and Operational Test Command through FY19. The Army acknowledged that this may cause increased customer billing rates, the inability to conduct simultaneous operational test events, and longer timelines for the release of test reports. Substantial growth in the areas of autonomy, electronic warfare, cybersecurity, and big data analysis continue to put new demands on the Army T&E workforce and infrastructure. Current funding levels do not support growing T&E analysis capability needs. In addition to staffing reductions, the Army must contend with competition from industry as it struggles to recruit, retain, and grow an analytical and technically competent workforce. DOT&E is concerned that this may impact test planning, execution, and reporting and may result in delayed acquisition decisions. DOT&E will continue to monitor the Army T&E workforce to ensure that it is able to support and not hinder the outcomes of the Army's acquisition programs.

Cybersecurity Red Team Personnel and Capability Shortfalls

DOT&E guidance establishes data and reporting requirements for cybersecurity Red Team involvement in both operational tests of acquisition systems and exercise assessments. The demand on DOD-certified Red Teams, which are the core of the cyber opposing force (OPFOR) teams, has increased significantly in the past 3 years. In the same timeframe, the Cyber Mission Force and private sector have hired away members of Red Teams, resulting in staffing shortfalls at a time when demand is likely to continue to increase. This trend must be reversed if the DOD is to retain the ability to effectively train personnel and assess DOD systems and protective measures against realistic cyber threats. In FY16, the almost non-stop pace of events for all Red Teams challenged their ability to provide complete data sets and complete reports. Without these data and reports, network defenders and trainers will not have the critical inputs they need to develop effective mitigations or perform effective training on new procedures.

DOT&E has already seen instances in which tests were rescheduled or could not be performed as planned due to a lack of available cyber teams authorized to conduct cyber operations on live networks and enclaves. The high operational tempo of the Red Teams has reduced or eliminated opportunities for the teams to train, thereby eroding their ability to ensure their skill level is commensurate with advanced nation state cyber threats. The high operational tempo has also induced a number of experienced Red Team members to seek higher paying, less demanding jobs outside of the Department, further exacerbating the personnel shortfalls.

A number of initiatives would help address the increasing shortfall of qualified cybersecurity Red Team personnel:

- Create pay and other incentives for cybersecurity personnel – such as those afforded to other highly-trained, critical DOD personnel (e.g., pilots) – in order to retain talented Red Team operators
- Expand the number of master-level and journeyman-level Red Team operators, and develop performance-based certification standards to ensure each Red Team is manned with sufficient numbers of qualified operators
- Expand the Persistent Cyber Opposing Force (PCO) to global authorities to provide more long-duration, efficient, flexible, and threat-realistic cyber effects
- Grow Red Team capabilities and infrastructure to better and more efficiently portray advanced cyber threats, and automate the capture of required data
- Develop automated Red Team capabilities that can perform mid-level cyber exploits and identify common cybersecurity vulnerabilities

Threat Representation for OT&E of Space Systems

U.S. adversaries are working to diminish and overcome U.S. military advantage by threatening our space superiority. Although the military Services normally subject space systems to representative natural hazards and space phenomena during the course of integrated testing campaigns, they often inadequately represent a hostile wartime environment during space systems testing. Potential adversaries are relentlessly pursuing offensive space control capabilities. Therefore, the OT&E of space systems must realistically reflect the hostile threats that U.S. space systems will face, and the military Services must provide the additional resources required to conduct such OT&E.

In March 2016, DOT&E provided guidance to military Service acquisition officials and Service operational test agencies (OTAs) to ensure adequate representation of realistic threats in the OT&E of all segments of space systems, including ground control, space-borne, and user equipment. Military Service acquisition officials and OTAs must identify and address the resource and infrastructure limitations that currently constrain our ability to conduct adequate operationally realistic testing of space systems. In addition to the persistent cyber threats which could target all segments of our space systems, our space forces face electronic warfare, kinetic, and directed energy threats. OTAs must insist on current, validated threat assessments for their space systems, and must adequately and realistically represent each of these threats during OT&E.

To ensure operational realism, OTAs must employ actual threat systems when possible in OT&E. If the required threat resources are not available, then the military Service acquisition official and OTA should act in advance of OT&E to develop or procure those 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 OTAs should use realistic, accredited threat surrogates during OT&E in lieu of the actual threat system. If the actual threat system or realistic threat surrogate is not available for OT&E – despite military Service efforts to develop or procure it – then the OTA should employ accredited threat M&S.

To employ actual threat systems and threat surrogates against satellites for OT&E, in cases where risk or policy will limit adequate on-orbit testing, the military Services should fund pre-launch, thermal vacuum chamber (TVAC) testing of either first articles or non-flight, identical "test satellite" articles for cyber, electronic warfare, and directed energy threats. Representative operational crews should operate satellites being threat tested in TVAC for OT&E, using the control segment and capabilities intended for operational employment. If a Service cannot demonstrate realistic threat intensities in a TVAC, the chamber testing should be supplemented by subcomponent testing at realistic threat intensities, with analyses to correlate observed results to system-level effects.

The acquisition and test communities should leverage the space-related expertise and resources of the many U.S. space-related organizations and individuals to mitigate the infrastructure and resource limitations which currently impede DOD's ability to portray realistic space threats in OT&E. For example, test planners should make use of the expertise and resources of organizations such as NASA, the National Reconnaisance Office, the Joint Navigation Warfare Center, the Space Security and Defense Program, the Test Resource Management Center

(TRMC), and adversary tactics organizations such as the 527th Space Aggressor Squadron.

The March 2016 DOT&E guidance recommends the OTAs take immediate steps to improve their ability to adequately represent space threats by: identifying and tracking space threat representation capabilities, including their availability, location, and connectivity; identifying and prioritizing space threat representation gaps, and requesting funding to fill those gaps; documenting space threat operational and system-level concepts of operations (CONOPS) and blue system defensive CONOPS; designating OPFORs for space threat representation in OT&E; and developing M&S capabilities which support the assessment of system- and mission-level impacts of space threats.

TRMC is conducting an assessment to identify the threat environment, current T&E capabilities, and gaps in those T&E capabilities that are needed to support space system T&E requirements. This assessment will provide an estimate of resources required for acquisition programs to sustain operations in a contested space environment. DOT&E requested each Service T&E Executive to brief their plans for threat representation of space systems during the FY16 budget review process. Finally, all space system TEMPs and test plans submitted to DOT&E for approval must include the resources for a thorough representation of potential threats.

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, since the DDG 51 is expected to be capable of operating in an EMP environment, DDG 51 Ship Specification, Section 407 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 currently 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 modeling and simulation 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) has directed the Navy's EMP Program Office to develop a method of 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 the development of a full-ship EMP TLS.

In conjunction with NAVSEA, the Defense Threat Reduction Agency has 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 all 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 threat representation on the open-air ranges. This resulted in nearly $500 Million of funding for the Electronic Warfare Infrastructure Improvement Program (EWIIP). EWIIP intended to buy both open- and closed-loop threat emulators for the open-air ranges, provide upgrades to anechoic chambers and the 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, while progress is lacking in other areas. 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. systems that are critical for operating successfully against near-peer adversary threat systems that exist, are proliferating, or are undergoing an accelerating pace of significant upgrades. The U.S. 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 these EW upgrades is displayed in Table 1.

TABLE 1. RECOMMENDATIONS ON ELECTRONIC WARFARE TEST RESOURCES	
DOT&E Recommendation	**Current Status**
Develop a combination of open- and closed-loop emulators in the numbers required for operationally realistic open-air range testing of the Joint Strike Fighter and other systems beginning in 2018.	Both the open- and closed-loop efforts are underway. The open-loop systems are called Radar Signal Emulators (RSEs). EWIIP was scheduled to deliver the first 2 systems in 2016, 12 systems during 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. Acceptance and integration testing will be conducted during 2016 and 2017; this testing will establish procedures for use of the RSEs in the F-35 IOT&E and provide validation data for the 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. Further, the Navy chamber executed F-35 electronic warfare testing for spec compliance and simulation validation in September and October 2016. The facility will introduce a much 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 significant hardware upgrades, greatly improving its ability to replicate high signal density environments and has identified a path forward covering more extensive upgrades through 2020.
Upgrade the Joint Strike Fighter mission data file reprogramming lab to include realistic threats in realistic numbers.	A Joint Strike Fighter Program Office-sponsored study to determine upgrade requirements was completed in December 2014. It confirmed the shortfalls identified by DOT&E in February 2012, but also identified many other critical shortfalls preventing effective and efficient mission data file development and reprogramming. Unfortunately, inexplicable delays by the program since this study was completed have ensured that upgrades will not be completed in time to affect mission data file production for Block 3F IOT&E and fielded operations. Also, the program plans to procure fewer signal generators than the study recommended, further jeopardizing the program's ability to generate effective mission data in the future.
Provide Integrated Technical Evaluation and Analysis of Multiple Sources intelligence products needed to guide threat simulations.	Products have been completed and delivered, and are being used to support development of the open- and closed-loop threat radar emulators.

Due to delays and inaction by the F-35 Joint Program Office, the situation at the Joint Strike Fighter mission data file reprogramming lab has resulted in the failure to upgrade the lab before IOT&E of Block 3F capability.

DOT&E believes additional funding of $268 Million is needed for additional range infrastructure for testing, training, and readiness of U.S. aircraft and airborne EW systems. This funding would enable the test ranges and the models and simulations (that must be validated with test data) to assess the performance of U.S. systems against the key challenges of 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.

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 the integration of the Air Warfare Battle Shaping (AWBS) system and the open loop 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 essential for scoring as well as post-mission reconstruction and analysis of OT&E missions. The use of the RSEs at the STR for the F-35 IOT&E provides key operationally realistic scenarios and off-loads some of the F-35 IOT&E trials from the WTR, which can only allocate a few range periods per week for the F-35. Conducting test trials at the STR could considerably shorten the duration of F-35 IOT&E.

In 2016, Navy and Air Force personnel participated together in RSE range integration working groups throughout the year and together with DOT&E observed initial acceptance testing of the first two RSEs. Navy personnel are planning to take part in fall 2016 training for operations, maintenance, and programming of

the RSEs. Two RSEs are planned to be temporarily transferred from the Nevada Test and Training Range (NTTR) to the STR during 2017 to complete integration testing at the STR. Eventually, 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.

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. The Army intends commanders, using tactical network systems, to have the ability to transfer information such as voice, video, text, position location information, and high-resolution photographs throughout the BCT, and provide individual commanders access to information needed to complete their mission. The expanded use of radio frequency spectrum to support mission command systems with supporting data networks exposes the BCT to contemporary EW threat vectors available to a broad range of potential enemies. Recent conflicts have demonstrated the mission effects that EW can have on the modern battlefield. As the Army becomes more dependent on these sophisticated network technologies, it is critical that the developmental and operational test communities continue to identify and assess vulnerabilities of these systems. Decision makers must understand the inherent vulnerabilities, as well as the ways in which 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. In early FY17, TSMO will complete the development of three new EW capabilities – to include an upgraded injection jammer, airborne EW payload, and GPS jammer system – demonstrating a continued commitment to providing realistic threat EW for operational test and mitigating limitations when possible. Since they support increased operational realism in testing, these developing threat test capabilities are critical to support future testing of Warfighter Information Network – Tactical Increment 2, Nett Warrior/ Rifleman Radio, Mid-Tier Networking Vehicular Radio, Manpack Radio, Joint Battle Command – Platform, and Assured Positioning Navigation and Timing.

Navy Advanced Electronic Warfare Test Resources and Environments

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

This gap in test capability was initially 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 Anti-Ship Cruise Missile (ASCM) seekers by specifying the 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," 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 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. The estimated cost to add the ERP improvement is $5 Million. The Navy has not planned for or funded this improvement.

Long-Term Improvement in the Fidelity of Anti-Ship Cruise Missile Seeker/Autopilot Simulators for Electronic Warfare Testing

This gap in test capability was initially 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 a kinematic response to electronic attack 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 represent ASCM maneuvers. Credible ASCM representation requires a vehicle that can fly at subsonic 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. An approach to satisfy this requirement is to use a recoverable, unmanned aerial vehicle (UAV) that is equipped with embedded, miniaturized simulators. The UAV should be able to maneuver at ASCM

speeds and altitudes with encrypted telemetry to track seeker/autopilot responses to electronic attack. A human-controlled override capability would be required for safe operation. The remotely controlled Self-Defense Test Ship (SDTS) would tow a ship target for the UAVs to home on. SEWIP Block 3 would be mounted on the SDTS along with hard-kill systems such that the integrated hard-kill and soft-kill (i.e., SEWIP Block 3) combat system capability could be demonstrated. Currently, such testing is at the discrete 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. The cost for the development of these UAVs (with simulators and telemetry) is estimated to be approximately $120 Million for development, testing, and acquisition. The estimated unit cost of each vehicle is not expected to exceed $15 Million. The Navy has not planned for or funded this improvement.

Equipping the 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 battle space 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 weapons 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 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 USS *Stoddard* – was put into service that same year. A similar incident occurred in November 2013, in which 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 USS *Chancellorsville* incident has 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 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 modeling and simulation (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 the 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 a technical justification to show that 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.

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 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 of the DDG 51 Flight III, AMDR, and ESSM Block 2 programs. Each option requires funding beginning in FY18 to ensure support of operational testing of these systems in FY22. A decision on whether to fund the procurement of the needed equipment is pending.

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. The CAPE-estimated cost for development and acquisition of these capabilities over the Future Years Defense Program is approximately $350 Million. Of that, approximately half could 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."

On February 10, 2016, 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. DEPSECDEF required the Navy to document that strategy in a draft TEMP for those programs and submit the TEMP to DOT&E by July 29, 2016. The Navy has complied with the funding direction but has not complied with the DEPSECDEF direction to provide an integrated test strategy for those programs. Despite budgeting for the long lead AMDR components, the Navy has not programmed funding in the Future Years Defense Plan to complete all 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 FY 2023 as planned.

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 Destroyer, CVN 78 Aircraft Carrier, 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 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 hopelessly 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 models and simulation capabilities for assessing the probability of raid annihilation for Navy ships.

Fifth-Generation Aerial Target

DOT&E has been investigating the need for an aerial target to adequately represent the characteristics of Fifth Generation threat aircraft in light of the emergence of threat aircraft like Russia's PAK-FA and China's J-20. 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. Also, the team built one full-scale, flight-representative wing that will be used for structural load tests and a system integration laboratory. The Department provided funding to complete the final design, tooling, fabrication and flight tests. The prototyping effort will provide cost-informed alternative design and manufacturing approaches for future air vehicle acquisition programs. This data can also be used to assist with future weapon system development decisions as well as T&E planning and investment, and will support future T&E analysis of alternative activities. It will also demonstrate reduced signature, basic aerodynamic performance, and provision for special mission systems.

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

Operational testing of anti-submarine warfare (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 of many highly proliferated torpedoes, particularly those employed in anti-surface warfare by other nations. Contractor, developmental, and operational testing that is limited to U.S. exercise torpedoes will not allow the identification of existing limitations of ASW 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 ASN(RDA) identifies specific threat torpedo attributes that the threat torpedo surrogate(s) must be evaluated against. A June 18, 2015, DOT&E memorandum to ASN(RDA) reiterated the need for representative threat torpedo surrogates in operational testing and emphasized understanding threat torpedo behavior, including tactics and countermeasure logic, when evaluating the adequacy of torpedo surrogates. A May 24, 2016, DOT&E memorandum

to the ASN(RDA) further emphasized the importance of resolving the surrogate shortfall in advance of evaluating the Navy Torpedo Warning System and Countermeasure Anti-torpedo Torpedo acquisitions systems. The non-availability of threat-representative torpedo surrogates will prevent adequate development and 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 conducted a study of threat torpedo surrogates in FY14. The $480,000 study was jointly funded by the Navy and DOT&E. The completed study, dated September 4, 2015, confirmed DOT&E concerns that current torpedo surrogates have significant gaps in threat representation for operational testing and provided recommendations for improving current threat torpedo emulation. The Navy has since taken the following actions to address the gaps in threat representation of torpedo surrogates:

- NUWC Division Keyport is currently pursuing a prototype technology development project that will deliver a threat-representative, high speed, quiet propulsion system. The development of a propulsion system prototype is intended to overcome a critical gap identified in the torpedo threat surrogate capability gap analysis, discussed in the preceding paragraph. This effort is funded as an FY16 Resource Enhancement Program project at approximately $1 Million. This project is focused on the propulsion power system but will not address reducing the cavitation noise caused by the surrogate executing operationally realistic threat profiles.
- The Navy proposed development of a General Threat Torpedo (GTT) as a Resource Enhancement Program project for FY17 to provide a torpedo surrogate that better represents threat torpedos in dynamic and acoustic performance, as well as tactical logic. The $6.2 Million project will incorporate the technology developed in the high-speed, quiet propulsion system prototype and is supported by DOT&E. However, the ability of GTT to adequately support operational testing, if developed, will depend on future Navy decisions to procure sufficient quantity of GTT.

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 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 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. 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 has 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 full-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 full-sized submarine simulator. The Navy has not funded the additional efforts.

Missile Warning and Infrared Countermeasure Test Capability Gaps

Aircraft Survivability Equipment (ASE) is an integral part of military fixed and rotary wing platforms to provide aircraft and crew protection, and is vital to mission effectiveness in hostile environments. DOT&E and TRMC co-lead the Infrared Countermeasure Test Resource Requirements Study (ITRRS), which is designed to identify shortfalls in infrared countermeasure (IRCM) testing and develop a prioritized investment roadmap of projects to mitigate current test gaps. However, the resultant roadmap is historically underfunded to a considerable degree. The roadmap has 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.

One of the high priority projects on the ITRRS list is the ability to measure threat signature data for the development or improvement of the threat models for heat seeking missiles and unguided hostile fire munitions used for the T&E of ASE. These models drive a large number of T&E simulation tools listed above. The DOT&E Center for Countermeasures serves as the executing activity for a TRMC Central T&E Investment Program (CTEIP) Resource Enhancement Project – the Joint Standard Instrumentation Suite (JSIS) – in order to mitigate this shortfall as well as provide ground truth for live missile firing and hostile fire tests of IRCM systems. When available, the JSIS initial operational capability (IOC) will support Advanced Threat Warner and Department of the Navy (DON) Large Aircraft Infrared Countermeasure (LAIRCM) operational testing. JSIS IOC capability is scheduled to be delivered in early FY17. 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 team. For example, it will not provide the capability to measure missile attitude information for the entire missile fly out, nor will the JSIS IOC capability meet all needs related to signature collection fidelity (i.e., frame rates and resolution). Full operational capability is required to meet the needs of the Army's Common Infrared Countermeasures (CIRCM) program, Navy's Advanced Threat Warner, Air Force's LAIRCM program, and the Naval Research Laboratory's Distributed Aperture Infrared Countermeasure (DAIRCM) program. JSIS full operational capability is also needed to collect signature data in support of T&E of advanced IRCM systems, currently in development, which operate in other wavelength bands. JSIS requires an additional investment of $43 Million to provide the full operational capability needed for IRCM T&E.

Both open-air test ranges and indoor test facilities require upgrades to test the latest missile warning systems and IRCM. The open-air test range improvements include additional firing points for multi-threat environments and angular separation, upgrades to improve test efficiency, improved instrumentation, and DAIRCM jitter and atmospheric distortion measurement capability. Hardware-in-the-loop and installed system test facilities are in need of upgrades to represent the latest threats in an operational simulated environment. Additionally, these facilities are heavily utilized and in need of expansion to meet program test schedules.

Threat Modeling and Simulation to Support Aircraft Survivability Equipment Testing

Acquiring actual threat systems for widespread testing is not always possible. To address this challenge, DOT&E funded standard, authoritative threat M&S for systems T&E. These may be coupled with U.S.-built threat representations. Although threat M&S capabilities have been used in T&E for many years, they were not always accurate representations, and different M&S instantiations of the same threats often produced different results. DOT&E's objective is to improve the fidelity and consistency of threat M&S at various T&E locations while reducing overall test costs.

Throughout the T&E process, M&S representations of threat systems can be used when actual threat components are not available. Use of these M&S representations may provide a more complete assessment of system operational performance than is possible using open-air facilities alone. M&S representations of threat systems also support testing when flight safety precludes live fire testing, such as missile launches against manned aircraft. For example, test programs may only conduct 10 – 20 live missile firings events; however, using a threat M&S test program may extend those results across a broader range of test conditions (typically 20,000) with different threats, ranges, altitudes, aspect angles, atmospheric conditions, and other environmental variables affecting weapon system performance.

DOT&E developed a T&E Threat M&S Configuration Management System to implement controls and distribution management for threat M&S to ensure integrity for realistic T&E and to ensure M&S consistency of test results among various T&E regimes. This system provides mechanisms to identify and correct anomalies between a threat and its M&S representations. It also assists in controlling model configuration changes, maintains critical documentation such as interface descriptions and validation documents, and provides updated threat M&S to multiple T&E facilities for developmental and operational test needs. The T&E Threat M&S Configuration Control Board (CCB), comprised of representatives from the T&E community and intelligence organizations, 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, anomaly reports, and change requests are managed through an interface on DOD's Secret Internet Protocol Router Network. DOT&E is in the process of expanding the breadth of control by this CCB.

During FY16, the T&E Threat Resource Activity provided standardized authoritative threat M&S to multiple T&E facilities

operated by the Army, Navy, and Air Force. The Services integrated and used this M&S to support ASE testing. DOT&E engaged the United States' closest allied nations to implement the same authoritative threat M&S for allied T&E. This allows the United States and its allies to use each other's ranges and facilities, leveraging this worldwide implementation for T&E.

DOT&E also developed and updated a threat M&S roadmap for ASE T&E to provide a comprehensive plan for future threat M&S. A good example is JSIS, which will capture threat data from live fire test events. The roadmap identifies projects to conduct systematic analyses of JSIS data to feed the development of threat-representative M&S to support U.S. and allied missile warning and infrared countermeasure systems.

DOT&E completed a threat radio-frequency (RF) M&S study which 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 (SMEs) at the IPCs and T&E facilities to determine common issues with the implementation of M&S for T&E. The RF study provided the following list of recommendations to stakeholders for T&E M&S improvements:

1. Assist IPCs with RF threat M&S configuration management (CM) using the existing IR configuration management system
2. Maintain an up-to-date catalog of RF Threat M&S
3. Provide periodic RF threat M&S feedback between IPCs and T&E facilities
4. Sponsor and assist threat RF M&S hardware acceleration programs
5. Develop a roadmap for RF M&S threat representations and technology

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 to adequately evaluate airborne combat systems. The roadmap will also coordinate new development and sustainment programs to address EW test capability shortfalls. These new programs will require additional funding in the next five years.

Foreign Materiel Acquisition Support for T&E

DOT&E is responsible for ensuring U.S. weapons systems are tested in realistic threat environments, using actual threat systems to create these threat environments whenever possible and appropriate. DOT&E develops an annual prioritized list of foreign materiel required by upcoming operational tests. These requirements are submitted to the 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) to address significant threat shortfalls that affect testing for IRCM programs like CIRCM, LAIRCM, and 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. During FY16, ongoing Foreign Materiel Acquisition efforts have continued to lead to new opportunities to acquire assets for IRCM equipment testing.

DOT&E's Test and Evaluation Threat Resource Activity (TETRA) – in collaboration with the Office of the Under Secretary of Defense for Intelligence and Department of State Weapons Removal and Abatement – has made significant progress in raising awareness of the critical shortfalls of MANPADS for T&E. TETRA briefed the National Security Council (NSC) Counter-Terrorism Task Force and the MANPADS Task Force. These efforts led to NSC tasking the organizations responsible for developing sources, which in turn led to the creation of more opportunities for acquisition to meet T&E requirements.

There is an extreme shortfall of foreign materiel for operational testing, particularly MANPADS and anti-tank guided missiles. This shortfall has become critical, as exemplified in the U.S. Special Oeprations Command's 2015 Joint Urgent Operational Needs Statement. 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. DOT&E recommends adding a staff position within the Joint Foreign Materiel Program Office dedicated to developing and executing foreign materiel acquisition opportunities for operational testing. The funding requirement for this staff position is $300,000 per year. DOT&E also 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. Simulated force-on-force battles must contain realism to cause 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 provides a critical evaluation tool to determine the combat system's capability to support soldiers and marines as they conduct combat missions.

In FY15, the Army initiatied the Integrated Test Live, Virtual, and Constructive Environment (ITLE) project to address the known TES/RTCA capability shortfalls and future Army requirements. There was little progress made on the ITLE project in FY16; consequently, funding for the effort has been realigned. DOT&E is concerned that because of delays, ITLE may not be able to accomplish the TES/RTCA upgrades needed to support upcoming operational testing of the Army's major modernization programs.

The Marine Corps' current force-on-force training system, the Instrumented Tactical Engagement Simulation System II (ITESS II), does not support combat vehicle engagements. The Marine Corps Operational Test and Evaluation Activity had planned a substantial upgrade of ITESS II beginning in FY16 to support the upcoming operational testing of combat vehicles, but it was unable to secure the required funding. The estimated cost of the ITESS II upgrade was $9 Million.

DOT&E, beginning with its 2002 annual report, has emphasized the need for continued investment in TES/RTCA capabilities. Further, DOT&E requires these capabilities for testing systems such as Amphibious Combat Vehicle, Bradley and Abrams Upgrades, Armored Multi-purpose Vehicle, AH-64E Block III, Joint Light Tactical Vehicle, and Stryker Upgrades.

Warrior Injury Assessment Manikin

DOT&E has been the advocate for an Army-led project to enhance the Department's ability to assess injuries from under-vehicle IED and mine blasts by creating a military-specific anthropomorphic test device (ATD) and associated injury criteria tailored to the underbody blast environment. The need for this was first documented in 2009 as a result of a SECDEF-directed evaluation of the Department's underbody blast modeling and simulation capabilities, and the need has been validated repeatedly since then. The evaluation concluded that automotive crash test dummies used in LFT&E and the consequent injury criteria – designed and developed for forces and accelerations in the horizontal plane, as seen in automotive frontal impact-induced injuries – were not adequate to assess the effects of the forces and accelerations in the vertical plane typically seen in combat-induced unerbody blast events. To address this limitation in 2010, DOT&E championed initial funding for the Army to lead the effort that became known as the Warrior Injury Assessment Manikin (WIAMan) project. Under this project, the Army initiated critical biomechanical research and the anthropomorphic test devices (ATD) development program to increase DOD's understanding of the cause and nature of injuries incurred in underbody blast combat events.

The science and technology (S&T) and ATD development aspects of the project are being executed by the Army Research Laboratory's WIAMan Engineering Office (WEO). In 2015, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) determined that the WIAMan project is an Acquisiton Category II program of record and, as such, ASA(ALT) has determined that the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) will be responsible for the project's execution post Milestone B. The WEO continues to accomplish its technical goals for S&T and ATD development research, but as a result of the acquisition approach, the WEO is now also supporting PEO STRI, as required by a memorandum of agreement signed by the Army Research, Development, and Engineering Command and PEO STRI. However, no additional personnel or funding has been procured for the WEO to address these additional duties. This has the potential to tax the resources of the WEO and shift the emphasis of the subject matter experts within WEO from S&T to acquisition. The planning and execution of the formal acquisition process is behind schedule, while incurring significant overhead costs.

In FY15, the Assistant Secretary of Defense for Health Affairs committed S&T funding for the program post Milestone B to ensure critical injury biomechanics research is completed. However, the Army had not provided a similar committment to fund this program's acquisition. Consequently, in FY15, DOT&E supported fully funding the acquisition side of the project. As a result, the Army was directed to allocate $16.2 Million over FY17 and FY18 "to continue RDT&E activities and further the acquisition process." However, the critical funding required to continue and complete the execution of this program past FY18 has not yet been resolved.

Some within the Army have questioned whether DOD still needs a combat-specific injury assessment capability. In the view of DOT&E, it is entirely appropriate for DOD, and in particular for the Army, to accord the same high priority to testing and verifying the protection provided to soldiers by their combat vehicles that the commercial automotive industry accords to testing and verifying the protection provided to the U.S. public by their automobiles.

Testing in Urban Environments

Operations in urban environments present unique challenges to the military Services and their equipment. Degraded mobility, maneuver, 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 – and a world population that is becoming increasingly urban – reinforce the requirement that systems be tested in realistic urban environments. DOT&E, beginning with its 2002 annual report,

has been highlighting the need for larger and more complex urban test environments.

With the cancellation of the Army's Joint Urban Test Capability in 2015, the long-standing urban environment operational and developmental test capability shortfall is not being addressed. DOT&E recommends that the Army revisit the urban test capability requirement to capture current and future T&E requirements, and develop a new approach to addressing this shortfall.

Biological Defense Testing at West Desert Test Center

In late FY15, DOD suspended the production of and testing with biological select agents and toxins (BSAT) and derivatives of BSAT materials at the West Desert Test Center (WDTC) on Dugway Proving Ground, Utah. On October 16, 2015, the Secretary of the Army approved the reassignment of the WDTC Life Science Division to the Edgewood Chemical Biological Center (ECBC) in Edgewood, Maryland. On July 1, 2016, ECBC took control of the Life Science Division and changed its name to the WDTC Biological Testing Branch (BTB). In August 2016, the Army completed a review of safety and surety protocols and procedures at WDTC and approved the resumption of field test activities using biological simulants that are safe for open-air use. The Army requested a withdrawal of the Dugway Proving Ground Biosafety Level Three (BSL 3) Centers for Disease Control and Prevention (CDC) permits and plans to apply for a new BSL 3 CDC permit for WDTC BTB facilities. The Army's current projection for achieving WDTC BTB BSL-3 certification is late 2019. WDTC and the BTB have unique biological testing facilities and capabilities that are essential to operationally realistic T&E of biological defense systems. DOT&E continues to monitor the requirement for BSL-3 and work with the Army to develop mitigation plans until the full biological test capability comes back online.

Range Sustainability and Radio Frequency Spectrum

Adequate land-, air-, and sea-space are critical for DOD's capability to test weapon and associated systems in operationally realistic conditions under which performance data can be collected, public safety can be ensured, and physical security and cybersecurity can be protected. Range sustainability is the preservation of, and advocacy for, those spaces. Sustainability is challenged by encroachment factors such as incompatible infrastructure, urban development, natural resource constraints, and frequency spectrum losses. Each of these factors may limit the use of land-, air-, and sea-space for DOT&E to execute its operational test and evaluation mission.

Despite DOT&E's best efforts there are a number of continuing challenges to both preserving current test capabilities and ensuring that there are avenues available to support testing of future weapon systems. Future testing will require expanded footprints, networked sensors, and advanced range capabilities which address complex cybersecurity environments.

Two primary strategies are essential to protect range space and test capabilities. The first is data-driven compatibility analysis – based on weapon system performance requirements – to ensure that evaluations conducted are credible. The second is outreach to other Federal agencies, state and local governments, and non-governmental organizations, to address issues early and to develop solutions that benefit all participants.

A recurrent theme in the evaluations performed for range sustainability is that while most of the challenges have either no compatibility risks or have risks that can be mitigated, there are a few cases that do have adverse impacts on test capabilities. Ongoing vigilance is required to ensure that DOT&E knows about projects that may pose risks to operational testing capabilities, now and in the future, and that DOT&E is in a position to mitigate risks early in the review cycle.

Current major areas of concern are:

- Energy infrastructure projects
- Natural resource protections
- National monuments and marine sanctuaries
- Frequency spectrum reallocation
- Foreign investment
- Privately owned and operated drones

Energy infrastructure projects can adversely affect instrumentation essential for obtaining data on weapon systems being tested, and can create physical obstructions that limit the use of test space. Under the provisions of Public Law 111 383, Section 358, as amended by Public Law 112 81, Section 331, DOD conducts compatibility evaluations of energy infrastructure to ensure that adverse impacts to national security can be identified and mitigated. DOT&E is an active participant in the DOD process to ensure that test capabilities required for realistic testing of current and future weapon systems are available for use. The process enables review and approval or disapproval of projects based upon risk to operational test capabilities. However, the tools available to the Department to require mitigation of problematic aspects of proposed energy infrastructure projects are not currently sufficient to prevent all adverse impacts to test capabilities. The DoD can only directly control development on DOD owned, leased, or withdrawn property. In all other circumstances, the Department must rely on a mix of authorities available to other Federal agencies, or to state and local government intervention. Yet these authorities have proven to be problematic in certain instances. For example:

- DOD relies on the FAA obstruction to flight notification requirements in section 44718 of title 49, U.S. Code (49 USC 44718), to receive notification of energy infrastructure projects. However, the statute gives DOD no authority to evaluate structures not covered by 49 USC 44718, nor does it prescribe any mechanism for DOD to ensure that unacceptable risks do not occur. The FAA does not currently have the authority to withhold approval for projects that do not pose a hazard to flight safety, but are objectionable to DOD. DOT&E has been researching options by which DOD can object to renewable energy and associated infrastructure projects on the basis of adverse impact to national security and will continue to explore and shape policies and procedures that can be

used to ensure that required operational test capabilities are available for use.

- Developers proposing energy infrastructure projects on Federal land must go through the National Environmental Protection Act (NEPA) process. While DOD can be a participating agency on those projects which have the potential to constrain the conduct of operational testing, current rules do not allow the Department to object to projects that would impact its ability to satisfy reasonably foreseeable future testing requirements; the processes are focused on consideration of documented requirements. As mentioned earlier in this report, the Department is confident that the expanded capabilities of new weapon systems will drive operational testing requirements for test spaces with larger footprints than are currently available. DOT&E will work with Federal agencies to ensure that NEPA procedures provide for consideration of reasonable and foreseeable actions to support mid- and long-term weapon systems test requirements.
- For many of the test ranges, particularly those in the Southwest, Federal land is withdrawn for specified periods of time. DOT&E conducts test missions using airspace that is restricted as regulatory, special use airspace through the FAA, and sea-space that is designated as non-regulatory, special use air-space by the FAA. For land withdrawal extensions, test ranges prepare range planning documents to support continued withdrawal. These plans integrate planned test requirements for the individual test range; however they may not adequately consider requirements for integrating requirements with those of other test ranges to allow for combined land and air resources to support future tests of longer range and networked weapon systems. DOT&E will investigate mechanisms to provide for sufficient air- and land-space to support this expanded envelope testing.

The Department requires that its weapon systems be capable of operating in a wide variety of environments, and its ranges are designed to allow testing and training across these environments. However, DOD ranges contain environmentally sensitive flora and fauna, including those that migrate from external disturbed areas. The U. S. Fish and Wildlife Service list of threatened and endangered species and Reports to Congress on the Recovery of Threatened and Endangered Species indicate that the total number of U.S. plant and animal species that are identified as threatened or endangered has more than doubled from 581 in 1990 to 1604 as of September 2016. The growing list of threatened and endangered species, and their proximity to DOD ranges, places significant pressure on the Department to safeguard areas where protected species and habitat exist while testing weapons systems in operationally realistic environments. The DOD challenge is to integrate weapons systems testing needs with environmental restrictions that prevent use of areas designated for operational testing. Accordingly, DOT&E will actively engage other Federal, state, local, and private organizations to reach mutually agreeable arrangements on means to accommodate test disturbances while conserving natural resources.

The declaration of a new or expanded national monument and marine sanctuary has the potential to encroach on existing test ranges, or to preclude expansion of ranges in the future. The challenge is to allow for testing activities, which require vehicle and personnel transit on or above these areas and which may result in damage from test objects, while preserving natural resources. To ensure that use of these areas to satisfy national security requirements, to include test and evaluation, is not precluded, it is essential that the proclamations establishing national monuments and marine sanctuaries include specific language permitting continued DOD use.

Frequency spectrum is required to conduct test operations, and is vital for controlling autonomous vehicles, sending and receiving test data, and ensuring range safety. However, there are continuing pressures to repurpose spectrum currently allocated to DoD to support national broadband expansion. The challenge is how to accommodate approved spectrum repurposing while retaining required spectrum for use by DoD when it is needed. The strategies employed include working to preserve essential frequency spectrum currently available for DoD use and supporting research initiatives for technologies and equipment that makes the most efficient use of available spectrum. DOT&E will continue to monitor frequency spectrum issues related to operational test requirements, review policies and procedures ensuing from DoD's Spectrum Strategy, and engage in other issues that may adversely impact use of spectrum for T&E.

Foreign investment in resources and facilities proximate to test ranges may create undesirable opportunities for intelligence gathering on weapons capabilities. Foreign purchases of U.S. companies that provide test and telemetry equipment used on our ranges and test facilities may likewise create operational security challenges. DOT&E reviews projects referred by the Committee on Foreign Investment in the United States (CFIUS) for possible security risks for foreign data collection. During the past twelve months, 207 cases – with more than 3,500 supporting documents – were reviewed. Sixteen cases were assessed to pose a potential threat to test or training ranges and required further investigation and development of mitigation strategies. However, as currently constituted, CFIUS provides only for the review of projects voluntarily submitted by applicants; there is a potential risk that other, unrecorded transactions may create operational security vulnerabilities. DOT&E will exercise vigilance in this area to ensure that data from weapon system tests are not compromised.

The advent of inexpensive drones, and the institution of public licensure policies, creates potential risks from drones intruding into sensitive DoD airspace, either inadvertently or with malicious intent. This creates safety of flight dangers, and opens potential adversaries to collect information on weapons characteristics. At present, DoD has very few legal avenues to prevent such intrusions, or to act when intrusions are detected. DOT&E will actively work within the Department and with other Federal agencies to ensure that adequate procedures are in place to ensure that drones do not create impediments to effective operational testing.