

Test and Evaluation Resources

Title 10, U.S. Code requires DOT&E to assess the adequacy of operational and live fire testing conducted for programs under oversight and to include comments and recommendations on resources and facilities available for operational test and evaluation and levels of funding made available for operational test and evaluation activities. DOT&E monitors and reviews DoD and Service-level strategic plans, investment programs, and resource management decisions to ensure capabilities necessary for realistic operational tests are supported. This report addresses the major areas of concern in testing current systems and discusses both resource needs and significant issues for operational and live fire testing. Specific capabilities and test resource areas of concern include:

- General Test Infrastructure
- Next-Generation Electronic Warfare Environment Generator (NEWEG)
- Integrated Technical Evaluation and Analysis of Multiple Sources (ITEAMS)
- Advanced Electronic Warfare (EW) Test Resources
- Cyber Warfare
- Explosive Surrogate for Use in Live Fire Test and Evaluation (LFT&E)
- Tactical Engagement Simulation (TES) and Real Time Casualty Assessment (RTCA)
- Joint Urban Test Capability (JUTC)
- Fifth-Generation Aerial Target
- Automated Test Capabilities for Software-Based Systems
- Steerable Antenna for GQM-163A Supersonic Target Testing
- Additional Electronic Warfare (EW) Simulator Units for Surface EW Improvement Program (SEWIP) Block 2
- Continuing Radio Frequency Spectrum Concerns
- Renewable Energy Infrastructure Impact on Operational Testing

General Test Infrastructure

The DoD budget remains under severe fiscal pressure, and the DoD faces significant budget uncertainty due to legislation limiting Federal spending. In addition to uncertain budgets and funding challenges, the test infrastructure faces technological and policy challenges and risks in maintaining capabilities to test and evaluate the effectiveness, suitability, survivability, and/or lethality of current and future defense systems. The Test Resources Management Center (TRMC) identified a variety of near-term test infrastructure needs in developing the 2012 Strategic Plan for DoD T&E Resources. Some of these needs include:

- Addressing near-term maintenance, sustainment, and modernization needs of T&E facilities across the Services due to obsolescence and equipment deterioration
- Managing the current workforce while shaping future workforce requirements to meet the sophisticated T&E and acquisition challenges brought about by emerging technology
- Developing an investment and operational strategy to produce unmanned and autonomous systems test capability in the air, land, and maritime domains
- Continuing initial efforts to develop a cyberspace test infrastructure capability that provides blue, red, and gray environments with representative threats to offer both defensive and offensive cyber operations

The test infrastructure provides critical support for operational and live fire testing, and DOT&E is working closely with the Deputy Assistant Secretary of Defense, Developmental Test and

Evaluation (DT&E)/Director, TRMC to ensure that the DoD retains sufficient core capabilities to conduct realistic testing. DOT&E has also engaged in the DoD budget process to address problems with electronic warfare threat simulators, the cyber range, and body armor testing.

Savings in Test Infrastructure.

Given the current and projected fiscal environment, DOT&E understands fully the need to seek savings in all areas of the Department's activities and infrastructure, including testing and test infrastructure. The need for cost-effective testing is a key reason DOT&E continues to require that test plans incorporate the use of rigorous statistical methods for determining the scope and breadth of operational testing and for evaluating the data produced by that testing. During the past year, the developmental test office has attempted to identify savings that could be accrued within the Department's test infrastructure, as well as by adopting revised testing practices, and has produced a draft "Comprehensive Review of Test and Evaluation Infrastructure." Although adoption of some of the report's proposals for revised practices would be beneficial, the draft report provided to DOT&E for review has serious shortcomings. Savings taken within any of the Department's activities or infrastructure must be based on actions that are clearly defined and can, therefore, actually be taken; must be capable of assignment to specific elements of the defense budget; and, must be based on credible estimates. Unfortunately, the draft report reviewed by DOT&E satisfies none of these important prerequisites.

Next-Generation Electronic Warfare Environment Generator (NEWEG)

Electronic Warfare (EW) threat simulation capabilities must meet ever-expanding requirements for future strategic, tactical, and support aircraft with electronic combat support systems. These requirements are the result of the increasing sophistication and capabilities of threat radars and the increasing detection and processing capabilities of EW systems, as well as the need for higher-fidelity simulation capability to provide closer correlation between laboratory testing and flight testing. Such a simulation capability would reduce overall test costs and allow greater confidence in laboratory results. To meet these emerging EW requirements, a new generation of EW simulators must make use of state-of-the-art technologies, including modular and scalable architectures, high-speed processing, and integrated radio frequency (RF) subassemblies. The T&E community requires advanced software models to represent platform motion, direction-finding, modulation, and environmental conditions. There is currently no capability to characterize multiple interdependent jammers that simultaneously jam different targets in different bands in different locations in space.

The NEWEG project will use a state-of-the-art, high-fidelity, modular, scalable and reconfigurable EW environment generator and a dynamic multi-beam characterization capability for current and future EW systems testing. It will also establish commonality among DoD stimulators. NEWEG will support both developmental and operational testing and is intended to satisfy shortcomings at Modeling and Simulation and Hardware-in-the-Loop Labs, Installed Systems Integration Facilities, and Open-Air Ranges. The Tri-Service Electronic Warfare Test Capability Study identified these shortcomings in August 2010.

The technical objective of NEWEG is to evolve the state-of-the-art in EW simulation and stimulation technology into much higher-fidelity threat signal simulation. Additional project benefits include establishing commonality between DoD stimulators (leading to improved test repeatability) and continuity between ranges and facilities (resulting in reduced preparation time and cost). NEWEG is intended to:

- Incorporate an open-architecture design facilitating information sharing between EW testers
- Incorporate dynamic jammer recording and analysis
- Include a limited closed-loop threat response capability for Electronic Attack reactivity evaluation
- Allow playback of collected Intelligence/SEI (Specific Emitter Identification) waveforms
- Incorporate an integrated dynamic motion-based RF receive/transmit and analysis subsystem into the Advanced Systems Integration Laboratory (ASIL) at Patuxent River, Maryland

This capability is required for adequate operational testing of F-35 Block 3 in FY17 and beyond. NEWEG development is estimated to cost \$23.9 Million to meet the threshold Key Performance Parameters (KPPs) for the system and \$33.9 Million to achieve the objective KPPs.

Integrated Technical Evaluation and Analysis of Multiple Sources (ITEAMS)

After the fall of the Soviet Union, U.S. testers were able to acquire foreign military weapon systems for testing U.S. weapon systems. The emergence of new potential adversaries in the past two decades has created a threat situation in which foreign assets are not available for exploitation or testing. The Threat Systems Program (TSP) supports U.S. Service members by providing threat intelligence to ensure operational and developmental testing occurs against realistic threat representations. TSP is a partnership of the intelligence, operational testing, and acquisition communities in the DoD. Under a memorandum of agreement between DOT&E and the Defense Intelligence Agency (DIA), the Test and Evaluation Threat Resource Activity (TETRA), within the Missile and Space Intelligence Center, executes the TSP and provides ongoing intelligence analysis and support for DOT&E threat resources while managing and overseeing a DOT&E investment program for the development of threat resources.

TSP pioneered the use of intelligence deep-dives, going beyond the normal intelligence mission to perform intelligence research and analysis necessary to develop threat simulators. These efforts, known as Integrated Technical Evaluation and Analysis of Multiple Sources (ITEAMS), can result in threat representations such as models and simulations or produce blue-print designs for constructing open-air operational test assets, such as hardware solutions representing a threat capability or function.

During FY12, TSP completed ITEAMS projects on land and sea threats. A scientific and technical intelligence staff translated all source technical intelligence on a widely proliferated battle management and command, control, communication, and computer system into a model to support test and evaluation. The model is intended to provide real-time man-in-the-loop operations in an electronic attack environment. Two projects starting in FY12 will address medium-range surface-to-air missile threats from two different adversaries, leveraging previous intelligence collection and analysis on these systems and their predecessors. These efforts are in addition to recently completed ITEAMS of threat Advanced Air Defense Systems. In FY12, DOT&E authorized funding of 10 new ITEAMS to address critical operational test needs for 2014 and beyond.

Advanced EW Test Resources

In February 2012, DOT&E identified shortfalls in EW test resources that prevent development, testing, and timely fielding of U.S. systems capable of operating successfully against threats that currently exist, are proliferating, and are undergoing an accelerating pace of significant upgrades. Subsequently, DOT&E identified the need for approximately \$495 Million in funding from FY13-18 to address these shortfalls and assure the needed test resources would be available in time to support developmental and operational testing of systems including the Joint Strike Fighter. The DOT&E recommendations included accelerating the NEWEG program's production of high fidelity signal generators, upgrading the government anechoic chambers with adequate numbers of signal generators from the NEWEG

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program for realistic threat density, upgrading the Joint Strike Fighter mission data file reprogramming lab to include realistic threats in realistic numbers, providing ITEAMS products needed to guide threat simulations, and developing a combination of open and closed-loop threat simulators in the numbers needed for operationally realistic open-air range testing.

DOT&E participated in a “tiger team” assigned by USD(AT&L) to review the shortfalls identified by DOT&E, which concurred with DOT&E’s conclusions and recommended additional enhancements. The combination of improved government-owned anechoic chambers and new open-air range test assets is needed to evaluate the advanced capabilities under development in the Joint Strike Fighter, F-22 Increment 3.2 A/B, B-2 Defensive Management System, Long-Range Strike Bomber, Next Generation Jammer for the EA-18G, Integrated Defensive Electronic Countermeasures upgrades, as well as several other programs. DOT&E is pursuing, along with the TRMC, the necessary actions to acquire the test assets and integrate them into operational test plans. Absent these test resources, development and adequate, realistic testing of the systems cited above will not be possible.

Cyber Warfare

The capacity to assess realistically advanced cyber warfighting capabilities must be increased to keep pace with heightened demand for those capabilities, advancing technologies, and the growing cyber threat. In February 2011, the Chairman of the Joint Chiefs of Staff issued a memorandum directing that all major exercises include realistic cyber adversary elements as a training objective. To comply with this order, more non-major exercises are needed, and these exercises must include realistic cyber adversaries. The Joint Information Operations Range offers a multi-level security environment to integrate and conduct simultaneous cyber activities.

DOT&E identified a \$90 Million need over the Future Years Defense Program (FYDP) to upgrade range operations and capacity to conduct additional events, handle larger amounts of message traffic, and portray cyber threats and responses with increased fidelity. Additionally, DOT&E estimates \$59 Million over the FYDP is needed to provide additional capabilities for realistic threat development and assessment, as well as additional expertise and training for the Red Teams employing cyber threats during training and test events. Lastly, DOT&E estimates additional funding of \$46 Million across the FYDP will support assessments during all appropriate Combatant Commander and Service exercises.

Explosive Surrogate for Use in Live Fire Test and Evaluation (LFT&E)

Title 10, U.S. Code requires realistic survivability testing of combat and tactical wheeled vehicles against combat-realistic threats. DOT&E oversees survivability testing and has concerns about our ability to test operationally significant scenarios involving underbody blast threats, thereby assuring adequate LFT&E of military vehicles now and in the future. The significant concerns include the need to:

- Develop and rigorously characterize the performance of a surrogate for the Home-Made Explosive (HME) threats now prevalent in Afghanistan because of their ease of fabrication and efficacy, both of which argue for the use of HME by enemies in future conflicts. Currently, LFT&E cannot use HME surrogates because the performance of those surrogates (that is, the blast impulse they deliver to a vehicle) vary greatly from test to test for reasons that are not fully understood. LFT&E requires repeatability from test to test, which can be achieved only when the key factors determining the performance of HME surrogates are known and can be controlled.
- More fully characterize the performance of buried TNT devices, which are the standard threats currently used in LFT&E. The blast impulse delivered by buried TNT to a vehicle is repeatable under the relatively narrow set of conditions now used in LFT&E. However, there is a need to test and compare results obtained under more widely varying conditions.
- Characterize how differences in soil composition affect the blast impulse delivered to vehicles undergoing underbody blast testing. The currently used single standard soil presents multiple limitations to testing for numerous reasons. It does not allow for roadbed compaction, realistic under-wheel threat placements, varying moisture content, or varying soil composition. This constrains the LFT&E community’s ability to evaluate vehicle vulnerability to underbody blast threats for certain critical, operationally significant scenarios. Additionally, the Army may soon be unable to continue procuring soils that meet the current standard.

Proposed funding of \$15 Million for FY13-15 will enable the Army to complete the full scope of effort required to ensure adequate LFT&E of military vehicles against underbody blast threats. Understanding of blast threats will enable improvements to vehicle design and capabilities against underbody blast threats that will save lives in current and future conflicts.

Tactical Engagement Simulation (TES) and Real Time Casualty Assessment (RTCA)

New and upgraded combat systems cannot be adequately evaluated without the exchange of simulated fire between friendly and opposing forces in an operationally realistic environment. These force-on-force battles must contain enough realism to cause Soldiers and their units to make tactical decisions and react to the real-time conditions on the battlefield. Real Time Casualty Assessment (RTCA) is needed to ensure that the simulated engagements have realistic outcomes based on the lethality and survivability characteristics of both the systems under test and the opposing threat systems. Future Tactical Engagement Simulation (TES)/RTCA systems must include critical attributes of real-world combat engagements such as direct and indirect fires, IEDs and mines, realistic battle damage and casualties, a mix of ground and air vehicles, and a competent and capable threat force. TES/RTCA systems must be able to record the time, space, position; and firing, damage, and casualty data for all

players in the test event. Current TES systems cannot support the simulated engagements or the data collection needed for OT&E.

Past efforts by the Army test community to develop a TES/RTCA capability have failed due to affordability issues. Army Operational Test Command has begun a study to review the operational test requirements for RTCA, examine applicable technologies, and recommend a course of action for future developments. The Army has also initiated work on the Army Tactical Engagement Simulation System (A-TESS) program, which seeks to increase interoperability and provide interface standards for future capability growth of its TES systems. The offices responsible for test and training in the Army are committed to working together toward a future system due to their common requirements and limited budgets. DOT&E supports these initiatives and will continue to require an adequate RTCA system to support the OT&E of combat systems such as the Ground Combat Vehicle, Abrams Tank Modernization, Armored Multipurpose Vehicle, Apache Block III, Joint Lightweight Tactical Vehicle, and Stryker upgrades. The estimated cost to develop this capability is \$125 Million.

Joint Urban Test Capability (JUTC)

Operations in urban environments present unique challenges to Service members and their equipment. Degraded mobility, communications, and situational awareness; a large civilian presence; the risk of collateral damage; reduced stand-off distances; and unique threat profiles are some of the obstacles present during urban operations. These challenges justify the requirement that systems be tested in operationally realistic urban environments. The Army-led Urban Environment Test Capability (UETC) study has determined the resources needed to support the T&E of systems operating in urban environments. The UETC summarized this information, along with a study of global urban landscapes, in its final report. The UETC report is the foundation for the Joint Urban Test Capability (JUTC) project being led by the Army and funded through the OSD Central Test and Evaluation Investment Program.

DOT&E is supportive of the JUTC requirement; however, the proposed physical surface urban area of 200 meters by 240 meters will not be large enough to support operational testing of Company size and greater test scenarios. DOT&E recommends that the urban area be expanded to the JUTC objective requirement of 900 meters by 900 meters to support future operational test events. The cost of the current JUTC effort is estimated at \$75-95 Million. DOT&E is coordinating with the TRMC on the feasibility of expanding the JUTC to the larger area.

Fifth-Generation Aerial Target

No U.S. aerial target (including the QF-16 currently in development) can replicate fifth-generation fighter characteristics such as low observability or embedded electronic attack. As a result, operationally realistic testing cannot be accomplished for U.S. air-to-air and surface-to-air weapons systems against fifth-generation fighters. Therefore, DOT&E is executing a target design and cost study based on the recommendation of

the Defense Science Board with a goal of determining if an affordable Fifth-Generation Aerial Target can be developed. The contractor and Institute for Defense Analysis (IDA) provided preliminary cost estimates in FY12. DOT&E will focus on mitigating risk and resolving cost uncertainty as the study continues in FY13. DOT&E is seeking \$60 Million to develop a production-representative prototype(s) to validate cost and performance during flight test in FY15. This capability is required for adequate developmental and operational testing of the Department's ongoing and planned aircraft and missile programs.

Automated Test Capabilities for Software-Based Systems

Current acquisition policy (DoDI 5000.02) requires "manufacturing processes under control" as an entrance criterion for a Milestone C decision for full-rate production. DOT&E now requires an equivalent concept for software acquisitions and software components of a weapon system at IOT&E. Specifically, program managers must demonstrate software system sustainment maturity, including program-conducted T&E in support of routine technology upgrades. A demonstration of sustainment maturity will include a demonstration of applicable test automation and the ability to perform an end-to-end trace of test information from requirements to test scripts and defects.

We anticipate that most programs will take several years to create a software test automation approach that will satisfy the DOT&E requirements. Currently, programs complete test automation and an end-to-end trace of test information on a per program basis at varying levels of adequacy. Very few acquisition programs have mature test automation solutions for regression testing that can be demonstrated at IOT&E, and even fewer programs can create the environments and conditions to validate their regression testing processes. Without substantial help from a central resource, it is likely that most programs will have this deficiency during IOT&E.

The need for software test automation strategies to satisfy DOT&E requirements will create demand for test automation expertise in program offices. Program managers need a resource, such as a center of excellence, to help meet that demand and mitigate problems. A center of excellence will work with vendors and government providers to promote interoperability of Test as a Service (TaaS) and other test automation solutions. This center of excellence is intended to:

- Centralize knowledge of the various automation approaches
- Assist programs in applying software test automation
- Create "in-house" software test automation expertise

A center of excellence may lessen the tendency to use a "stove-piped" approach to testing, may reduce duplicative resources (technological and human), should increase programs' use of existing capabilities, and should improve the consistency and adequacy in the types of testing accomplished. DOT&E estimates the DoD will need \$2 Million over the next two years to establish a software test automation center of excellence that will subsequently be self-supported through fees for test services.

Steerable Antenna for GQM-163A Supersonic Target Testing

A steerable antenna unit is required to provide operationally realistic emissions from the GQM-163A supersonic target that will stay locked on the target ship. This unit is needed to ensure the shipboard EW system has constant track of the incoming target emissions so that Rolling Airframe Missile Block 1 and/or Block 2 missiles can then be launched (and guide on those same emissions) as interceptors. This unit would be similar to the STEERAN unit currently used in the BQM-74E subsonic target. The diameters of the GQM and BQM targets differ greatly, so extensive re-engineering and testing will be needed to adapt the BQM unit to fit the GQM without disturbing the GQM kinematics/maneuverability. This capability is required for adequate operational testing of the CVN-78/Rolling Airframe Missile Block 2 in FY17. Estimated development cost is \$10-20 Million. Estimated unit cost is \$500 thousand.

Additional EW Simulator Units for Surface EW Improvement Program (SEWIP) Block 2 OT

At present, there exists only one each of the Kappa, Uniform, and Gamma EW simulators. These simulators are flown on Lear Jets against shipboard EW systems. SEWIP Block 2 is the latest EW system under development. Two of these simulators are needed (one for each Lear Jet) so that threat-realistic stream raid profiles can be used to adequately test the SEWIP Block 2 in FY14. An estimated development/procurement cost is \$5 Million.

Continuing Radio Frequency Spectrum Concerns

The T&E community competes with commercial and other federal entities for access to the RF spectrum. RF spectrum allocated to commercial uses has increased due to reallocation of the government spectrum and petitioning of the Federal Communications Commission (FCC) for additional frequency assignments. The result is insufficient spectrum to support T&E telemetry operations (primarily in the L and S frequency bands) and FCC restrictions on DoD RF emissions and jamming operations (so as not to interfere with commercial RF use). This problem is exacerbated by the growth in data transmission rates needed as more complex weapon systems are developed (by the U.S., allies, and adversaries) and as the military must demonstrate RF spectrum exploitation to disrupt and deny spectrum access by adversaries. Funding and support from Congress as well as other federal agencies is needed to ensure adequate RF spectrum to support T&E. The objective would be to pursue the following:

- Protect critical T&E RF spectrum bands from reallocation.
- Acquire additional RF spectrum to offset reallocated spectrum. This would include development of a multi-Service implementation plan to ensure acquisition programs and range facilities implement the means to utilize the additional spectrum.
- Develop methods and technologies that more efficiently use the RF spectrum.

TRMC estimates the cost to retain the current capacity of the ranges (i.e., the number of test operations) is on the order of

\$400 Million over five years due to continued growth of data transmission rates, the associated costs of developing the technologies needed to support these data transmission rates, and continuing encroachment on the spectrum needed for testing.

Renewable Energy Infrastructure Impact on Operational Testing

Testing and evaluation of weapons, sensors, command and control networks, and other sensitive technologies often require an electromagnetic environment free of interference. The proliferation of wind and solar renewable energy projects has had an increasing impact on DoD testing and evaluation in an electromagnetic environment. Although most renewable energy projects are compatible with the DoD test capabilities, in some cases, they can interfere with test range instrumentation resources and systems under test. Collocation of wind and solar power renewable energy projects with test resources is requiring careful evaluation and investigation of a variety of potential mitigation strategies, since many of the Nation's most productive wind and solar energy resources exist in close proximity to some of the DoD's most critical test ranges. For example, wind farms located in the Tehachapi Mountains in California currently restrict the ability to test certain airborne radar systems along west-to-east approach vectors to simulated targets. Additionally, proposed new renewable energy developments in the northern Mojave Desert could more severely affect these tests on the east-to-west approach vector. These renewable energy resources may eliminate the ability of the DoD to validate design parameters of radar systems in the southern California/Nevada region test ranges.

There are known sources of interference with test range capabilities from energy infrastructure projects, such as those identified in California and Nevada. Since DoD is only beginning to evaluate such areas of interference because renewable energy development on a large scale did not occur until recently, more data on interference from the various types of renewable energy projects are needed to determine the significance of its effects. Similarly, research is required to develop interference mitigation techniques and technologies.

DoD has observed interference in the following areas: wind turbines on DoD radar systems, central solar power tower impact on radar cross section evaluation, electromagnetic interference from transmission lines, and physical obstruction from transmission lines.

To address these interference problems, DOT&E is working with the DoD Siting Clearinghouse to evaluate proposed renewable energy and infrastructure projects as well as develop expertise in understanding interference issues and establish a strategy for research that will produce mitigation techniques and technologies to resolve interference issues.

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