Live Fire Test and Evaluation (LFT&E)

Introduction

- In FY15, DOT&E executed LFT&E oversight for 121 acquisition programs, 3 LFT&E investment programs (Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), Joint Aircraft Survivability Program (JASP), and Joint Live Fire (JLF)), and 3 special interest programs (Warrior Injury Assessment Manikin (WIAMan), Home Made Explosives (HME), and Small Boat Shooters' Working Group).
- In support of a range of acquisition decisions and activities, DOT&E published seven LFT&E reports and six combined OT&E and LFT&E reports. The reports include recommendations to the Services to further improve the survivability and lethality of the subject systems for a range of operationally relevant scenarios in existing and expected combat environments.
- JTCG/ME continued to develop and standardize methodologies for evaluating munitions effectiveness, including target vulnerability characterization, munitions lethality, weapon system accuracy, and specific weapon-target pairings driven primarily by operational lessons learned (Enduring Freedom, Iraqi Freedom, Odyssey Dawn, and Inherent Resolve), Joint Staff Data Call, and the needs of Combatant Commands. The two major JTCG/ME weaponeering products are the Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS) and Joint-Anti-air Combat Effectiveness (J-ACE). JTCG/ME is currently developing a third weaponeering product, a JMEM for cyberspace operations. The JWS and J-ACE enabled:
  - Ongoing Combatant Commands' operational targeting, weaponeering, and collateral damage estimation calls in direct support of operations, mission planning, and training; warfighters were able to put ordnance on target and as such, directly affect combat effectiveness and the war against terrorism.
  - The Air Warfare community, in particular the Navy Strike Fighter Weapons School and the Air Force Weapons School, to develop tactics, techniques, and procedures (TTP) manuals for air superiority applications and to perform post-shot analysis of missile firings following a training mission.
  - The onset of the development of building blocks for a Cyber JMEM (CJMEM).
  - DOD, joint, and Service planners for force-on-force modeling, mission area analysis, requirements studies, and weapon procurement planning.
  - The acquisition community in performance assessment, analysis of alternatives, and survivability enhancement studies.
  - United Kingdom, Canada, Australia, and other coalition partners to plan operational weaponeering and collateral damage estimates, support training and tactics development, and support force-level analyses.
- JASP funded 55 multi-year projects addressing aircraft survivability technologies and aircraft survivability evaluation tools. JASP's primary mission is to increase combat effectiveness of U.S. military aircraft in current and emerging threat environments through joint and Service staff coordination and development of survivability technologies and assessment methodologies. In FY15, JASP made progress in improving:
  - Aircraft ability to counter near-peer and second-tier threats by assessing innovative electro-optical and infrared countermeasures (EO/IRCM) and radio frequency countermeasures (RFCM).
  - Aircraft force protection by (1) addressing the ability to avoid threat detection/engagement, e.g., Hostile Fire (HF) detection, identification, and geolocation technologies to improve aircrew situational awareness, and (2) by implementing aircraft hardening technologies, e.g., armor solutions, self-sealing fuel tanks, and improved crashworthiness technologies including improved helicopter seats.
  - Aircraft survivability to fires, the primary threat-induced aircraft vulnerability.
  - The capabilities of survivability-related models with the inclusion of emerging threats, by automating the analysis and post-processing, and by continuing to validate the new and existing model capabilities.
- JLF supplemented LFT&E of fielded systems, addressed operational commander's needs, and characterized new survivability and lethality effects of fielded systems in response to exposure of U.S. systems to new threats or as a result of systems being used in new, unanticipated ways, or operated in new environments. Specifically, JLF:
  - Assessed the impact of fielded system design changes on survivability (e.g., rotary-wing aircraft with added internal auxiliary fuel tanks)
  - Assessed weapon lethality against new targets (e.g., fast attack craft, a new threat to U.S. ships)
  - Improved accuracy and fidelity of weapon data used as part of mission planning to estimate effectiveness with higher confidence (e.g., improved collateral damage estimates)
  - Advanced live fire test methodologies to keep pace with changing threats
  - Supported the development and improvement of modeling and simulation tools that contribute to survivability and lethality evaluations (e.g., new data to support improvements in predicting weapons effects against aircraft, vehicles, and military structures)

FY15 LFT&E PROGRAM

- LFT&E continued its oversight of three special interest programs:
  - The Warrior Injury Assessment Manikin (WIAMan) project, an Army-led effort, made significant progress in biomechanics testing and anthropomorphic test device (ATD) development to design a biofidelic prototype for assessing injuries to vehicle occupants during the underbody blast (UBB), but the Army has not programmed any funding for this project in FY17 or beyond.
  - The Home Made Explosives Characterization program (HME-C) completed multiple test phases, intended to investigate the repeatability of HME surrogate effects relative to those of TNT and the effects of soil condition and IED emplacement on HME threat performance.
  - The Small Boat Shooters' Working Group continues to synchronize live fire and other operational test approaches against this growing threat class, which operates in littoral waters.

LFT&E OVERSIGHT

The primary objective of LFT&E is to evaluate the survivability and lethality of acquisition programs and to identify deficiencies to be corrected before those platforms or munitions enter full-rate production. In FY15, DOT&E executed LFT&E oversight for 122 acquisition programs. Of those, 21 operated under the waiver provision of U.S. Code, Title 10, Section 2366, by executing an approved alternative LFT&E strategy in lieu of full-up system-level testing. DOT&E published seven LFT&E reports and six combined OT&E and LFT&E reports on the following programs during the past year:[1]

[1] Reports marked with an asterisk were sent to Congress.

LFT&E Reports	Combined OT&E and LFT&E Reports
Interim Report on the LFT&E of the Hellfire Missile Variant	Aegis Ballistic Missile Defense (BMD) 4.0 and Standard Missile-3 Block 1B*
Stryker Reactive Armor Tiles (SRAT) II Live Fire Test & Evaluation*	Lot 4 AH-64E Apache Attack Helicopter with classified annex*
Cartridge 7.62 Ball M80A1 Live Fire Test & Evaluation Report*	Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW)*
MaxxPro Dash with Independent Suspension System (ISS) and Maxx Pro Survivability Upgrade	GBU/53B Small Diameter Bomb, Increment II
Hellfire Final Lethality Report*	Mobile Landing Platform with Core Capability Set (MLP with CCS) and classified annex*
Littoral Combat Ship (LCS) 3 Total Ship Survivability Trial (TSST)	Air Intercept Missile – 9X (AIM-9X) Block II (with appendices)*
Joint Light Tactical Vehicle Live Fire Test & Evaluation Report	

- Four reports supported Full-Rate Production decisions:
  - Aegis Ballistic Missile Defense (BMD) 4.0 and Standard Missile-3 Block 1B reported on the lethality of the Standard Missile-3 Block 1B and included two recommendations to improve future evaluations of BMD lethality.
  - Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW) reported critical weapon lethality data as a function of target types, target areas, target location error, and countermeasures. LFT&E made three recommendations to improve weapon lethality including new targeting procedures and reassessment of the weapon effectiveness requirements to ensure they adequately represented warfighters' mission success needs.
  - Mobile Landing Platform with Core Capability Set (MLP w/CCS) confirmed the survivability shortfalls of this ship (built to commercial standards) including the lack of hull and equipment hardening or personnel protection features necessary to survive enemy weapon effects. LFT&E identified the limitation in data needed to assess the effectiveness of the Embarked Security Teams for close-in self-defense.
  - Air Intercept Missile-9X (AIM-9X) Block II reported on the effectiveness and lethality of the Block II missile. LFT&E assessed that new improvements to the AIM-9X Block II fuze did not degrade the missile's lethality or effectiveness compared to existing AIM-9X Block I missiles.
- Five reports supported a program decision:
  - Cartridge 7.62 Ball M80A1 LFT&E assessed the lethality capability of the new 7.62 mm cartridge, including effective range, as fired from two different weapons and against a range of targets of interest (e.g., soft targets, representative battlefield barriers, and personnel protection equipment). LFT&E identified additional operationally relevant targets that should be assessed for similar munitions in future programs.
  - Joint Light Tactical Vehicle (JLTV) LFT&E provided critical survivability information to the procurement decision makers, with a focus on the ability of each of the three vendor JLTV prototypes to provide protected ground mobility for Soldiers and Marines in a combat environment. LFT&E enabled a performance comparison among the three vendors and against legacy vehicles, and identified recommendations specific for each vendor to help improve crew and vehicle survivability.
  - GBU/53B Small Diameter Bomb, Increment II (SDB II) provided critical program status information to the

acquisition officials on SDB II's lethality and effectiveness when employed in the normal attack mode. LFT&E provided probability of single shot kill information for a range of moving and stationary, operationally representative targets, as a function of weapon accuracy and end-game geometry.
  - Lot 4 AH-64E Apache Attack Helicopter FOT&E with classified annex provided a survivability assessment of the Lot 4 AH-64E. LFT&E evaluated AH-64E survivability against the range of tested threats and recommended improvements and upgrades to several key survivability-related systems.
  - The interim report on the LFT&E of the Hellfire Romeo Missile Variant provided the Program Office with critical weapon lethality assessment when fired from unmanned aerial vehicles against a range of enemy targets of interest. LFT&E made four recommendations to further improve the understanding of the missile's capability against very specific targets of interest or as fired from additional platforms.
- Four reports provided system survivability or lethality evaluations for use by the Service and Program Office:
  - Stryker Reactive Armor Tiles (SRAT) II LFT&E provided critical data on the survivability of Stryker vehicles equipped with SRAT II. LFT&E provided multiple recommendations to the Army to improve survivability of SRAT II-equipped vehicles, as well as lessons learned for future LFT&E efforts involving complex armors.
  - MaxxPro Dash with Independent Suspension System (ISS) and Maxx Pro Survivability Upgrade evaluated the response of the vehicle and subsequent protection of its occupants, Soldiers and Marines, to attacks as those seen in Operation Iraqi Freedom and Operation Enduring Freedom. LFT&E demonstrated that the survivability upgrades provided significant improvement in force protection and set the standards for Mine Resistant Ambush Protected (MRAP)-level underbody blast protection. LFT&E also provided four recommendations to further improve crew protection and fuel fire mitigation.
  - Littoral Combat Ship (LCS) 3 Total Ship Survivability Trial (TSST) confirmed significant vulnerabilities in the Freedom-class. LFT&E provided insight into design changes to reduce ship vulnerability and improve recoverability. LFT&E identified several components and systems that could be redesigned or reconfigured to make the ship more survivable without requiring major structural modifications.
  - The final lethality report on the Hellfire missile provided additional evaluation of weapon lethality against specified maritime targets.
- DOT&E published one classified Special Report, the report on the LCS required by Section 123 of H.R. 3979, National Defense Authorization Act for FY15.

LFT&E INVESTMENT PROGRAMS

JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS EFFECTIVENESS (JTCG/ME)

The Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) continued to update and develop weapons and targets data and methodologies crucial for the development of force employment options for theater commanders and the resulting execution tasking orders for tactical units. The principal products of the JTCG/ME are the Joint Munitions Effectiveness Manuals, or JMEM. The JMEM include detailed data on the physical characteristics and performance of weapons and weapon systems; descriptions of the mathematical methodologies that employ these data to generate effectiveness estimates; software that permit users to calculate effectiveness estimates; and pre-calculated weapon effectiveness estimates. It permits a standardized comparison of weapon effectiveness across all Service communities. All JMEM weapon effectiveness products are integrated into a single program, the JMEM Weaponeering System (JWS), which includes the Joint Anti-Air Combat Effectiveness (J-ACE) product. The JWS is target oriented allowing users to adequately plan the mission by determining the effectiveness of weapon systems against a specified target for a range of weapon delivery modes.

Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS)

JWS is the DOD source for air-to-surface and surface-to-surface weaponeering, munitions, and target information used daily in the U.S. Central Command (USCENTCOM) and U.S. Africa Command (USAFRICOM) Areas of Responsibilities (AORs) in the deliberate planning process directly supporting Joint Publication 3-60 "Joint Targeting."

JWS enables Combatant Commands to efficiently prosecute their target sets. JWS incorporates accredited methodologies, certified munition characteristics, delivery accuracy, target vulnerability data, and numerous user aids to support the operational use of JWS to predict weapons effectiveness for fielded weapons and delivery systems. JWS is the calculation engine used to develop Quick Weaponeering Guides/Probability of Kill Lookup Tables to address time sensitive targets.

In FY15, in support of operational commanders, targeteers, weaponeers, and planners, the JTCG/ME released JWS v2.2 that included Digital Precision Strike Suite (DPSS) Collateral Damage Estimation (DCiDE) Tool Version 1.2.2 and Collateral Damage Estimation (CDE) Tables. JWS v2.2 includes approximately 220

methodology, functionality, weapon/warhead/fuze, and target updates. Development of JWS v2.2 is now complete. As a result, Combatant Commands have access to:

- Additional weapon data updates such as GBU-49; Advanced Precision Kill Weapon System-II; HELLFIRE variants; Joint Air-to-Surface Standoff Missile (JASSM) Delivery Accuracy; and M982 Excalibur trajectory/accuracy.
- Approximately 50 new or updated materiel targets, e.g., new building types such as brick office, pre-cast wall/slab office, earth-timber command post, etc., and new quasi-static blast capability.
- Increased mission planning efficiency through the inclusion of an initial DCiDE connectivity that improves both speed and throughput of data, as shown in Figure 1.

- The JTCG/ME released DCiDE v1.2.2 with enhancements to directly support the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3160.01A – "No-Strike and the Collateral Damage Estimation (CDE) Methodology."
  - The DCiDE tool is critical to the warfighters' ability to meet urgent operational needs for an accredited automated CDE tool that both expedites and simplifies the CDE process. DCiDE is the only automated CDE tool authorized for use in the USCENTCOM and USAFRICOM AORs. The JTCG/ME CDE tables are used in every planned kinetic strike in all AOR's to meet Commanders intent and to minimize civilian casualties. DOT&E has received positive feedback on the use of the Collateral Effect Radii (CER) values as a critical enabler in support of munitions employment against High Value Targets (HVTs).
  - JTCG/ME accredited CER Reference Tables for air-to-surface and surface-to-surface weapons, which are the basic data that supports the CDE methodology. Changes included additions for air burst munitions and nomenclature changes. Additional updates have been provided for newly fielded/updated systems, e.g., GBU-49/BLU-133; AGM-176A; 155 mm M109A, M549A1, and M795 with Guided M1156 Precision Guidance Kit (PGK) Fuze. In support of advanced CDE mitigation techniques, JTCG/ME also developed the Collateral Effects Library Tool.
  - The JTCG/ME trained multiple users at different Commands to support CDE decisions. Specifically the JTCG/ME trained warfighters from the III Corps (G2 and FIRES), 82nd Airborne Division, 3rd Special Forces Group (SFG), 5th SFG, Task Force (TF) 3-10, and CENTCOM Joint Targeting Element (JTE) in support of Operation Inherent Resolve.
- JTCG/ME reviewed and remarked JWS v2.2 to ensure all data were disclosable to facilitate coalition interoperability. Risk Management Framework testing is underway to facilitate release of the product to the field. Based on the current guidance and direction from the Joint Staff, the JWS v2.2 and future versions will be released to several key coalition partners in support of current operations under Foreign Military Sales agreements. This capability is critical to the effectiveness of U.S. targeting and fires personnel working in the combined environment.

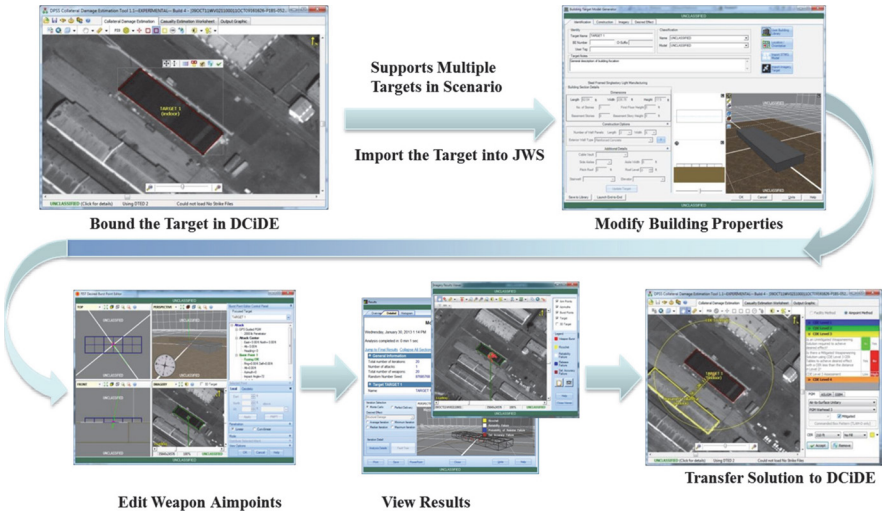

Figure 1. Connectivity between Weaponeering and Collateral Damage Assessment Enables Combatant Commanders to More Rapidly Prosecute Targets

- JWS v2.3 is under development and will include an interface to implement improved aimpoint development, which includes fields for weaponeering, CDE, and precision point mensuration (PPM). This data standard is currently in fielded mission planning systems. JWS v2.3 will also add an updated Gunship Delivery Accuracy Program module, Rotary-Wing Delivery Accuracy Program, and Fast Integrated Structural Tool ground shock kill updates that will improve effectiveness estimates.
- JTCG/ME is initiating efforts to support target production activities by enabling the automated integration of weaponeering, PPM, and CDE. These efforts will improve both timeliness and data throughput associated with these activities. In addition, connectivity to mission planning systems (Joint Targeting Toolbox) and databases (Modernized Integrated Database) is underway to allow data to flow seamlessly within the joint targeting processes.

Joint-Anti-air Combat Effectiveness (J-ACE)

J-ACE is used by U.S. Strategic Command (USSTRATCOM) in the support of route planning for the execution of strike packages. J-ACE simulates air-to-air and surface-to-air engagements. It includes accredited blue/red/gray (friendly/adversary/neutral) air-to-air missile (AAM) models and red/gray surface-to-air missile (SAM) fly-out models to provide probability of kill estimates. J-ACE is the umbrella program that includes both the Joint Anti-air Model (JAAM) and Endgame Manager, which provides a full kill chain end-to-end capability for mission analysis, tactics development, and training.

- J-ACE v5.3, currently under development, will provide extended and updated data sets for blue missile and aircraft target aero-performance, anti-air missile lethality, and red air target vulnerability. In particular, new or updated air-to-air or

surface-to-air government-furnished missile or weapon fly out models will be integrated.

- The JAAM (Figure 2) is integrated into automated systems used directly by the Air Warfare community, in particular the Navy Strike Fighter Weapons School and the Air Force Weapons School, to develop TTP manuals for air superiority applications and to perform post-shot analysis of missile firings following training missions. The JAAM is being updated to include the effect of weapon system reliability on the probability of a successful engagement (i.e., a reliability factor is applied to the weapon system, prior to finishing the tactics development; it is useful to understand outcomes and tactical options when shots fail to achieve the desired effectiveness).

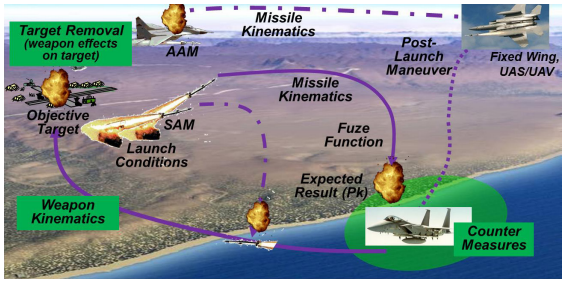

Figure 2. The primary J-ACE interface is through the Joint Anti-Air Model (JAAM). JAAM is a fast running simulation of Air-to-Air Missiles (AAM) and Surface-to-Air Missiles (SAM); and, aircraft aerodynamic performance.

Joint Non-Kinetic Effects – Cyber JMEM

JTCG/ME is continuing the development of non-kinetic tools and capabilities, the Joint Non-Kinetic Effects. Joint Non-Kinetic Effects is intended to be a single source for operational warfighters, analysts, targeteers, and planners to analyze offensive cyber capability effectiveness.

- In conjunction with the Air Force Targeting Center, the JTCG/ME is developing preliminary JMEMs for cyberspace operations. Current efforts are focused on developing the building blocks for a Cyber JMEM (CJMEM) including weapons characteristics, target vulnerability, and effects estimation tools (e.g., Cyber Capabilities Registry (CCR), Cyber Critical Elements/Weaponeering Guide). In FY15, JTCG/ME made progress in developing weapons characterization data and testing standards.

Operational Users Working Group

The Operational Users Working Group (OUWG) is a critical venue for receiving direct user feedback and development of future requirements from the operational community in regards to needed software enhancements and capabilities to support air-to-surface and surface-to-surface target engagements. Examples of user requirements are: the ability to release weaponeering information to coalition partners; connectivity between tools and mission planning systems; current weapon and fuze information; training materials, quick weaponeering guides, and graphical user interface enhancements; and improved blast/fragment methodologies in support of small precision munitions.

JTCG/ME continued to chair OUWGs to establish warfighter requirements for ongoing development of the JWS software and DCiDE tool. Representatives from USCENTCOM, USAFRICOM, USSTRATCOM, U.S. Pacific Command (USPACOM), U.S. Special Operations Command (USSOCOM), the Services, the Defense Intelligence Agency (DIA), the Defense Threat Reduction Agency (DTRA), the Fires Center of Excellence, Service School Houses, the Marine Aviation Weapons/Tactics Squadron, Operations Support Squadrons, Intelligence Squadrons, and numerous other operational units routinely participate.

JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The primary mission of the Joint Aircraft Survivability Program (JASP) is to increase military aircraft combat effectiveness in current and emerging threat environments. This is accomplished through joint and Service staff coordination of research and development of aircraft survivability technologies, assessment methodologies, and combat data collection to support technology development and acquisition planning. In FY15, JASP funded 55 multi-year projects and delivered 33 final reports that focused on two major areas: aircraft survivability technology research and development and aircraft survivability assessment methods. JASP also investigated and catalogued combat damage incidents through the Joint Combat Assessment Team (JCAT).

Aircraft Survivability Technology Research and Development

JASP has focused the research and development on three major aircraft survivability technology areas to: (1) help defeat the near-peer and second-tier adversary threats by developing measures to avoid detection and engagement of advanced radio frequency-guided and infrared-guided threats; (2) improve aircraft force protection; and (3) improve aircraft survivability to combat-induced fires.

Defeat Near-Peer and Second-Tier Adversary Threats.

To advance U.S. air superiority and improve U.S. aircraft survivability against near-peer and second-tier adversaries, JASP focused on addressing feasible technologies and technology improvements that would effectively counter prevalent, current, and emerging threats.

- In FY15, JASP assessed measures to counter adversary radio frequency-guided threats and anti-access/area-denial capabilities. JASP funded the Naval Research Laboratory (NRL) to significantly advance electronic attack capabilities while continuing to support radio frequency-guided threat countermeasure jamming development:
  - Completed the development of algorithms for use on current and future jammers.
  - Demonstrated the potential of improved jammer techniques. The project tested these in the laboratory and will be flight tested in FY16.
- Many aircraft are equipped with active infrared jammers, flare dispensers, and missile approach warning systems to cue countermeasures deployment (Figure 3). These helped

reduce the helicopter loss rates during the invasion in Iraq and the subsequent counter-insurgency campaign. In FY15, JASP assessed measures to counter existing and emerging infrared homing threats and focused on identifying solutions to counter newer seeker technologies:

Figure 3. AH-64 Apache Helicopter Launching Flares in the Dark

- Matured a technology and technique to identify infrared-guided threats before or immediately after launch, thereby improving both the timeliness and effectiveness of countermeasures.
- Analyzed and optimized IRCM flare characteristics that affect the ejection velocity to improve countermeasure effectiveness. Ultraviolet spectral data were gathered on flares in flight test for the first time. The spectrometry data will be placed in the Tri-service Flare Database for the Services to use in expendable countermeasure development and assessment. These data will support the development of new flares and evaluate flare effectiveness against advanced EO/IR guided threats.
- Flight tested seven different IRCM flares to gather trajectory data and high fidelity signature data to improve the fidelity of tri-service IRCM effectiveness modeling and simulation.

Aircraft Force Protection. Aircraft and crew losses due to anti-aircraft artillery and other unguided threats like the rocket-propelled grenades (RPGs) remain a concern. Recent helicopter combat data analysis suggest that about 88 percent of the helicopter hits are due to small arms and automatic weapons resulting in about 28 percent of the aircraft losses and about 10 percent of the loss of life. RPG/rockets account for about 40 percent loss of aircraft and about 53 percent loss of life. To improve the ability of our aircraft to avoid threat detection and engagement and to mitigate damage and prevent destruction when hit, JASP has focused on several schemes to protect U.S. aircraft and crew against these threats: (1) improved situational awareness, and (2) aircraft system hardening solutions.

- **Situational Awareness.** Other than countermeasures, evasive maneuvers can be effective in evading gunfire and other unguided threats, but this is predicated on the crew's knowledge of the attack, and the location of the attack. Acoustic system detection and smart mission management systems that can leverage battlefield intelligence databases are a few promising technologies. JASP has been focusing on the development of an advanced hostile fire detection and shooter geo-location sensor compatible with current threat warning systems. JASP sponsored development of a sensor package that incorporates both mid-wave infrared (MWIR) and acoustic waveforms for detecting hostile fires and determining the location of the shooter. In FY15 (the first year of a three year program), the project developed a combined MWIR and acoustic detection and geo-location approach that enables reliable muzzle flash detection, hostile intent determination (determination that an aircraft is the intended target), and reduced false alarms for a dependable shooter geolocation.
- **Aircraft System Hardening Solutions.** Inevitably, aircraft will be drawn into close combat and will be engaged by anti-aircraft weapons systems, the results of which could be devastating as shown in Figure 4. The majority of JASP vulnerability reduction focus areas have been aimed at schemes that would help the aircraft system absorb the damage, avoid aircraft destruction, and save the crew during an attack or in the event of a crash. These include energy absorbing structure technologies, crash protective seats, innovative armor solutions, and include the assessment of aircraft survivability against unconventional threats, e.g., directed energy lasers.

Figure 4. Coalition Helicopter Crash in Afghanistan

  - Initiated a project to test hydrodynamic compliant structure concepts to determine their application to improving aircraft structure absorbing technologies. This project is scheduled to be completed in FY16.
  - Initiated a project to test an adaptive seat energy absorber with a goal of improving the crash protectiveness of aircraft seats. This project looks at the effect of advanced stroking seat technology and is scheduled to be completed in FY16.
  - Developed a lighter more protective transparent armor that defeats the 7.62x39 ball round (single shot) at reduced weight of 4.8 pounds per square foot (psf) (a 10 percent weight reduction). The project produced armors well within the expected design envelope and exceeded the ballistic goal. The success of this project has led to a second phase examining performance in different environments and to a more demanding threat.
  - Determined High Energy Laser effects against typical aircraft composite materials and determined the significance of vulnerability factors. These results will support Air Force Research Lab and NRL development of material solutions.

Aircraft Survivability to Combat-Induced Fire. Ballistically-induced fires are a primary contributor to aircraft vulnerability. Understanding the causes and likelihood of fire is a necessary part of developing survivable combat aircraft and

assessing their vulnerability to fire. In FY15, JASP focused on developing solutions to maximize residual flight capability in the event of threat-induced onboard fires.

- JASP contributed to development of a self-contained compact, low-weight, low-cost, high-efficiency universal smart nozzle fire suppression delivery system capable of directly discharging multi-phase agents to a fire zone. The system detects and locates a fire within 100 milliseconds of fire initiation (existing systems require 2 seconds to detect and react to a fire). The "smart nozzle" fire suppression system adjusts the orientation and momentum of the discharging fire suppressant jet directly towards the fire region. This directional capability reduces the amount of agent required while maintaining the ability to be used multiple times during the same flight. The current weight of the system is approximately 3.5 pounds with 1.75 ounces of agent. The units would be ideal for larger rotary-wing cabin areas where troops reside.

Aircraft Survivability Evaluation Tools

- JASP continues to provide the DOD with modeling and simulation capabilities to support Analysis of Alternative studies (for development and verification of aircraft requirements), to assess operational and live fire test results, and to plan and rehearse training missions. JASP focused on increasing the capabilities of five survivability-related models with the inclusion of emerging threats, by automating the analysis and post-processing, and by continuing to validate new and existing model capabilities: (1) Enhanced Surface-to-Air Missile Simulation (ESAMS), (2) BRAWLER (air-to-air combat), (3) Modeling System for Advanced Investigation of Counter Measures (MOSAIC), (4) Computation of Vulnerable Area Tool (COVART), and (5) Fire Prediction Model (FPM)/Next Generation Fire Model. In conjunction with the Defense Systems Information and Analysis Center (DSIAC), JASP has established a standard process for the distribution and maintenance of these key survivability models.
- In FY15, DSIAC distributed the latest versions of the survivability models: BRAWLER 8.1, COVART 6.5, ESAMS 5.0, and FPM 4.2.
  - Studies supported by BRAWLER in 2015 include: F-35 Initial Operational Capability Support and Block 4 capability studies, 4th Generation/5th Generation Force Mix Analysis, F-22 Modernization Candidate Selection, and the F-15 /F-16 Modernization and Service Life Extension Program (SLEP) Decisions.
  - COVART was used to support the F-35A, KC-46A, AC-130J, and CH-53K programs, particularly in terms of their design requirements and LFT&E programs.
  - FPM was also used extensively in the KC-46A LFT&E program for shot line selection and pre-test predictions.
  - ESAMS was used on several studies for defining requirements and operational concepts for upgrades to current Air Force platforms (F-22A, F-35, B-2A) and future Air Force concepts (Next Generation Bomber), Hypersonic Air-breathing Weapon Concept (HAWC), and the Advanced Air Refueling Capability Concepts (AARCC).
- In FY15, JASP funded three projects to enhance ESAMS (used for assessing radio frequency-guided SAM engagements, including countermeasure effects where possible) capabilities to respond to the requirements identified by operator and user needs. These enhancements:
  - Incorporated an advanced naval SAM model developed at the Office of Naval Intelligence
  - Updated the legacy model and developed a new model for advanced radio frequency chaff
  - Updated radar and missile guidance models for two SAM systems so they reflect the latest intelligence assessment of the systems capabilities
- JASP also supported the development of high fidelity flare models to design and evaluate flares against current and future EO/IR guided threats. These projects developed the requirements for high fidelity infrared flare models that will work in all the Services' hardware-in-the-loop (HWIL) EO/IR threat simulation facilities. The DSIAC distributed two validated flare models, the pyrotechnic MJU-32 and pyrophoric MJU-49, with the Flare Imagery Analysis Tool v1.0 in September 2015.
- JASP collaborated with Air Force Research Lab (AFRL) and the Large Aircraft Infrared Countermeasures (LAIRCM) Program Office to validate the MOSAIC simulation to augment the flight testing and HWIL modeling supporting IOT&E of the LAIRCM system. This capability will also support other future laser-based directed energy countermeasure programs.
- Within the vulnerability assessment technical area, JASP funded projects addressing the following two major issues:
  - Fire prediction capability by initiating the Next Generation Fire Model plan, which identifies four broad modeling and test areas that need substantial improvement: Penetration (particularly of fluid backed structures), Energy Deposition (from fragment flash and armor piercing incendiary flash), Fuel Deposition (from hydrodynamic ram phenomenology), and Ignition (the interaction between Energy Deposition and Fuel Deposition.
  - Rotorcraft crew casualty assessment by exercising the integrated Crew and Passenger Survivability (CAPS) methodology. The Army performed analyses using their DESCENT model to assess possible crash landing conditions based on data collected from the Navy Safety Center, the Combat Damage Incident Reporting System (CDIRS), and DSIAC relevant to a CAPS assessment for the CH-53E. Additionally, the Naval Air Systems Command will perform manned-simulator tests to assess what kind of system malfunctions may occur due to threat impacts, and whether these malfunctions would be survivable. The project will provide a better understanding of the Integrated CAPS methodology sensitivities to help prioritize future efforts to improve the modeling capability,

technology development, and rotorcraft occupant survivability.

Combat Damage Assessment

- JASP strengthened aircraft combat damage incident reporting in the Services and the DOD by continuing to support the Joint Combat Assessment Team (JCAT). The JCAT is a team of Air Force, Army, and Navy personnel that deploy to investigate aircraft combat damage in support of combat operations. JCAT ended its operation in Afghanistan in October 2014 with the return of deployed assessors to the United States. The team continued to support assessments remotely from the continental United States and is ready to deploy rapidly outside of the U.S. if necessary
- In FY15, the JCAT worked to review and update more than 10 years of combat damage reports in CDIRS.
- The JCAT and Joint Aircraft Survivability Program Office worked in coordination with the Office of the Deputy Assistant Secretary of Defense for Systems Engineering, OSD (Personnel and Readiness), and JS/J8 on an Aircraft Combat Damage Reporting (ACDR) Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy(DOTmLPF-P) Change Request (DCR) proposal that would institutionalize ACDR through changes in joint doctrine, training, IT infrastructure, and policy. DOT&E approved the DCR, which was submitted to JS/J8 in October 2015.
- The JCAT trained the U.S. aviation community on potential aircraft threats and combat damage. This training includes but is not limited to: capabilities briefs, intelligence updates, recent "shoot-down" briefs to discuss enemy TTPs, and the combat damage collection and reporting mentioned above. The attendees include aircrews, maintenance personnel, intelligence sections, Service leadership, symposia attendees, and coalition partners.

THE JOINT LIVE FIRE (JLF) PROGRAM

In FY15, JLF funded 26 projects and delivered 24 reports. Focus areas for JLF included projects that either 1) characterized new survivability issues; 2) characterized new lethality issues; 3) improved accuracy and fidelity of weapon data; 4) improved test methods; or 5) improved modeling and simulation methods.

Characterization of New Survivability Issues

- The U.S. military operates numerous aircraft powered by the PT6A engine. Variants of the PT6A engine are installed on the C-12 aircraft and other comparable platforms that provide intelligence, surveillance, and reconnaissance; medical evacuation; and passenger and light cargo transport for the Army, Navy, Air Force, and Marine Corps in both hostile and non-hostile environments. In FY15, JLF assessed the survivability of these aircraft due to direct ballistic engagements to the aircraft propulsion system.
  - Despite PT6A design features such as multiple casings, vacuum pumps, and a centrifugal impellor that inherently reduce ballistic vulnerability, the PT6A engine components are vulnerable to small arms and fragmenting threats. These threats penetrated the engine's outer case at most engine sections. Although none of the resulting damage suggested a catastrophic failure of the engine, many of the test results would have likely resulted in a major loss of engine power within five minutes or less. The failure modes to the engine include either mechanical damage causing a loss of engine power or mechanical damage and oil starvation.
  - Vulnerability could be reduced further by incorporating redundant supply lines (fuel and oil) with smart valves in the hot section and shaped inlet screens on the oil pumps, and by rerouting critical lines to increase masking (to select threats). Additionally, ballistic shielding could be integrated with the aircraft's cowl structure to protect the engine.
- The CH-53E, CH-47F, and CV-22/MV-22 utilize auxiliary fuel tanks in order to extend their range and to support forward area refueling point (FARP) missions. The FARP mission requires CH-53E and CH-47F helicopters to carry up to three 800-gallon auxiliary fuel tanks placed in the aircraft cabins. The impact of these additional fuel tanks on aircraft survivability had to be assessed to identify and address any new system vulnerabilities:
  - JLF demonstrated an increase in aircraft vulnerability and increased potential for fire from an armor piercing incendiary threat-induced ullage explosion and dry bay fire effects of the non-inerted, non-self-sealing, 800-gallon auxiliary fuel tanks in the rotorcraft cabins.
  - The project recommended design improvements to: 1) incorporate technology (e.g., reticulated foam, ullage inerting system) to mitigate the potential of fuel vapor ignition in the tank; and 2) raise or upgrade the fielded tank's self-sealing performance to meet today's MIL-DTL-27422E self-sealing requirement (leak reduced to a damp seal within 2 minutes) for all surfaces on the tank.
- Survivability of U.S. ships to a recently identified asymmetric threat:
  - In FY15, The Naval Surface Warfare Center, Carderock Division built a full-scale bomb using the results of the previously conducted quarter and half scale tests, along with the results of a parametric study that varied different threat weapon parameters. The full-scale bomb will be stored, along with supporting documentation of weapon design, and safe handling and transport, until a suitable land or at-sea test opportunity becomes available.
  - A full-scale test is needed to show scalability and confirm the previously conducted tests, and to demonstrate the effects of this threat against actual ship structure.
- Previous aircraft LFT&E assessments included limited or no CAPS assessments. JLF conducted emergency egress testing on a CH-47F helicopter to determine the time it takes

occupants to exit the aircraft under a variety of realistic cabin conditions and Soldier combat gear loadouts.
  - Combined with the baseline fire assumptions developed under another JLF project, the results provide an increased understanding of the factors driving casualties during aircraft emergency egress for use in future LFT&E efforts.
  - Supplementing data available from the Federal Aviation Administration for commercial airlines, this project fills a data void for military helicopters with cabin fuel lines and unique Soldier equipment configurations. This data set baselines assumptions for the CH-47 in particular, and medium-sized cargo/troop class aircraft in general for use in CAPS assessments.

Characterization of New Lethality Issues

- Assessment of HELLFIRE missile lethality against fast-attack craft, a new threat to U.S. ships operating in the littoral environment.
  - JLF collected critical blast, fragmentation, and impact damage data to assess the capability of the HELLFIRE against the threat posed by fast-attack craft or other small boats to U.S. ships operating in the littoral environment (Figure 5).
  - The project demonstrated the utility of the unique rocket-on-a-rope testing technique to propel the missile to the target (a decommissioned Coast Guard target craft) in achieving the desired dive angle, impact velocity, and impact hit point.

Weapons Data Accuracy

- JLF obtained new arena test data on the HELLFIRE missile to permit improved collateral damage estimates, risk to personnel estimates, and lethality effectiveness of material targets for the HELLFIRE missile.
  - The HELLFIRE missile is frequently used by the warfighters to pursue high value targets. Given the location of these targets and the need to minimize collateral damage, additional test data increased the required accuracy and fidelity of the missile zonal data file. The added confidence for the HELLFIRE zonal data will allow the operational users to plan their missions and minimize collateral damage with higher confidence. Blast pressure data and shape charge penetration data were collected to more accurately model the blast and penetration capabilities to evaluate the effectiveness against material and personnel targets.

Figure 5. HELLFIRE against Fast-Attack Craft

  - Fragmentation files are a critical input to weapon effectiveness analysis programs that are utilized in JMEMs to provide the operational users with data that can be used for mission planning purposes.
- JLF was resourced to obtain new arena test data on the MK 84 due to concerns about the quality of the existing MK 84 characterization data. JTCG/ME will incorporate the results of this test into JTCG/ME products and tools.
  - Initial examination of the test data indicated a variance from the current characterization data. This variance has a strong potential to influence weapon usage for lethality, collateral damage estimates, and risk assessment.
  - Data will be compared with the output of shock physics predictive tools to improve the warhead detonation model to produce high fidelity results, potentially reduce the number of tests required for characterization, and to provide a better understanding of the fragment cloud.

Improvements of Live Fire Test Methods

- JLF investigated the feasibility of using a novel state-of-the art stereographic video technology to more efficiently and accurately characterize munition lethality.
  - Enables the collection of full hemispherical fragmentation data, individual fragment characterization, and rapid post-test analysis capability. This technology will also provide a vital method for collecting data for future weapon technology, specifically directional/focus munitions.
  - This technology was demonstrated on an MK 84 arena test. Utilizing advanced image processing techniques and a fragment tracking algorithm, tests were able to successfully demonstrate the identification and tracking of 1,016 fragments with stereographic video during the arena test event.
- JLF investigated test instrumentation to more accurately capture and evaluate the blast effects on armored vehicles subjected to live-fire mine and IED tests, and improve the ability to make test-to-test and test-to-simulation comparisons.
  - Legacy gauges used during these tests do not permit collection of the broader range of data needed to support additional analysis capabilities currently utilized.
  - High fidelity computer modeling is more commonly used in vehicle design and test planning, so correlating simulation and test data has become increasingly important.
  - This project identified gauge and mount combinations with capabilities more appropriately matched for the blast environment. In addition to providing data that supports best practices for gauge selection (data that describes instrumentation behavior in different frequency domains and, therefore, in different applications like hull response, local floor response, and seat input and response), the project also developed a test protocol to allow for the evaluation of new accelerometers and/or isolators being considered for use in LFT&E.
- JLF investigated test instrumentation to provide data for real-time crew kill assessments in maritime live fire test

events; more specifically a capability to remotely sense valid fragment strikes to pre-defined anatomical regions strategically located on a ballistic mannequin that provides for a limited case real-time assessment of rapid incapacitation.
  - JLF continued the development and demonstration of the concept of a hit sensor behind a calibrated plywood velocity barrier that successfully detects a valid fragment strike at a given velocity and provides proper positive indication of the hit to a remote station and display.
  - During FY14 and FY15, JLF identified the fragment group of interest, relevant crew work assignments, critical body regions, and developed the physical barrier. Sensor component development and testing of both the barrier and sensor will continue into next year.

Improvements of Live Fire Modeling and Simulation

- Fire is the largest contributor to the vulnerability of fixed-wing aircraft and a JLF project was used to support the fire prediction model capability improvements.
  - Test data determined fire initiation as a function of threat type, velocity, panel thickness, obliquity angle, and fuel temperature. This is part of a collaborative effort to develop the ignition module for the next generation fire prediction model.
- JLF provided a complete and traceable data set to validate blast/fragmentation predictions to support the Endgame Manager model development. When validated, this model can be applied to dynamic aircraft and missile engagements as part of an LFT&E program.
  - A WDU-17/B warhead and a warhead of a foreign surface-to-air missile were successfully tested against a full-up non-operating F-16 aircraft.
  - The JCAT, in conjunction with Air Force engineers, conducted a post-test damage assessment and validated key predictions and assumptions for current vulnerability assessment models (i.e. COVART).
  - This testing proved out a laser metrology data collection method to allow for accurate three-dimensional mapping of damage.
- JLF supported the improvement of the Behind Armor Debris (BAD) algorithm by collecting unprecedented, high-speed images of shape-charge warhead BAD using the pulsed laser illumination system (Figure 6).
  - Three-dimensional analyses of these images produced fragment speeds as a function of the fragment's angle from the residual jet.
  - Using the velocity field based on test data builds confidence in the modeling of the damage that BAD fragments cause to internal vehicle components, including personnel.
- The modeling and simulation challenges of weapons include not only the primary (blast and fragmentation) effects against urban structures, but also the potential for additional damage and casualties created by the failing structures.
  - Analytic tools for predicting weapon effects against structures were originally created to provide a conservative estimate of large (greater than 500 pounds) weapon effects against military structures.
  - Trends in weapon employment to smaller munitions to reduce collateral damage and increased use in urban environments have shown that the tools are inadequate in these regimes.
  - This shortfall resulted in joint Army/Air Force programs to more accurately determine the damaging effects of smaller munitions against urban structures and an international project agreement led by the Army Research Laboratory (ARL) to improve U.S. predictive capabilities in this area.
  - The Air Force Research Lab (AFRL) has managed development of a number of fast running structural response models for smaller weapon effects, but lacks the validation data needed to increase the confidence in the models and allow for their timely transition into the warfighter's weaponeering tool (JWS).
  - JLF project helped fund six live fire experiments against urban wall constructions to measure their response to the detonation and the potential damaging effects of the resulting debris against personnel and equipment. The test data will be used to provide improved estimates of weapons effects.
- JLF continued a joint effort with Germany to develop and validate the Dynamic Systems Mechanical Advanced Simulation (DYSMAS) hydrocode used to model bottom and near-bottom underwater explosions effects.
  - In FY14, several tests were conducted in the Briar Point test pond at the Aberdeen Test Center, Maryland, using a floating shock platform to collect data on platform response from charges located at mid-depth, near-bottom, and on the bottom.
  - The analysis of those test results was completed in FY15, providing additional validation for the use of DYSMAS in vulnerability assessments for the modeling of underwater explosion loading and ship responses in littoral or harbor environments, where bottomed or tethered mines are likely to be encountered.
- JLF supported the development of shaped charge jets effects model.

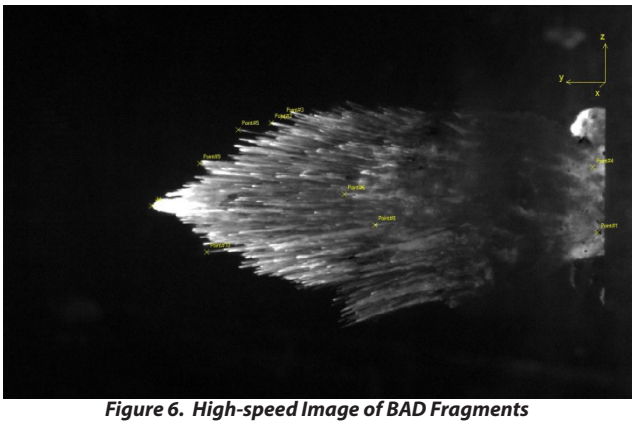

Figure 6. High-speed Image of BAD Fragments

- Initiation of stowed 25 mm ammunition is one of several lethal mechanisms that can impart catastrophic levels of damage to a ground vehicle. Testing on stowed 25 mm training rounds with shaped-charge jets of varying size and velocity collected quasi-static pressure versus time data that will be used to develop a new ammunition compartment vulnerability model.

LFT&E SPECIAL INTEREST PROGRAM

Warrior Injury Assessment Manikin (WIAMan)

- The Army will transition the WIAMan project to a program of record (POR) at Milestone B, projected to occur in FY18. The Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) will be the post-transition program manager. To ensure the injury biomechanics, anthropomorphic test device (ATD) expertise, and live fire testing experience of the WIAMan Engineering Office (WEO) remains a part of the project post-transition, the Army Research, Development, and Engineering Command (RDECOM) and PEO STRI are in the process of staffing a Memorandum of Agreement codifying the roles and responsibilities of their respective offices post-transition.
- In preparation for establishing the POR, the Army initiated an effort to create a Test Capability Requirements Document for the WIAMan system, which documents the key performance parameters and key system attributes the system is required to meet in order to progress through its milestones. This document will be signed by DOT&E, RDECOM, and the Army Test and Evaluation Command, and will include requirements to execute exploratory research on the response of females to underbody blast loading conditions to determine the scope a test program that would be required for the development of a female ATD.
- The WEO continued to demonstrate that the current ATD used in LFT&E, the Hybrid III, lacks biofidelity in the underbody blast (UBB) test environment, meaning it does not respond as a human does when exposed to similar loads. Establishing the human response to the UBB domain is essential in developing a military-specific ATD, and a critical first step is establishing biofidelity response corridors (BRCs) for the human body regions of interest.
  - In FY15, the project delivered 10 of an expected 16 total BRCs, with the remaining BRCs to be delivered by 3QFY16. These BRCs are focused on the human response in the head/neck, lumbar spine, pelvis, and lower leg/foot and ankle body regions. BRCs for the whole body are also under development.
  - In addition, the Army generated initial data on the tolerance of bones to severe loading conditions and developed human injury probability curves for foot and ankle fractures. The investigation of these foot and ankle injuries benefitted from updated analyses of injuries experienced by Soldiers in combat; these analyses revealed greater detail on the exact type and nature of the skeletal fractures suffered.
- In FY15, the WEO awarded a contract to Diversified Technical Systems (DTS) for a technical demonstrator of the ATD, which DTS is expected to deliver at the end of 1QFY16. The WEO and DTS utilized computational modeling to prescribe a range of candidate materials for the ATD and its parts; use of the proper materials is critical for establishing and ensuring the robustness of the ATD in UBB conditions, as well as to ensure the response of the ATD falls within the BRCs. DTS will perform iterative testing that includes matched pair BRC testing in multiple phases to allow opportunities to alter material selection and component geometry to improve biofidelity. The first tests of WIAMan ATD hardware of the cervical spine and pelvis were conducted at Duke University and the University of Virginia, respectively.
- The WEO is developing an optimized ATD finite element model (FEM) as test results become available. This FEM will support analyses to accelerate the re-design of the ATD to achieve strength-of-design, biofidelity, and usability goals. The FEM is also used to produce pre-test predictions to aid in test planning and identifying risks to the robustness of the design and the compliance of the materials. To date, a full three-dimensional description of the ATD has been created, along with models of the test devices in which the ATD will be evaluated.
- The technical achievements made by the WEO and the concerted effort by the Army to create the foundation for a formal acquisition program represent major steps forward for the WIAMan project, and the effort is poised to make addition progress in FY16 and beyond. However, the Army has not programmed funding for the WIAMan project past FY17. The T&E Resources section of this annual report provides additional information regarding the funding history of the WIAMan project.

Home Made Explosives (HMEs)

- DOT&E continues to participate in Army-led efforts to characterize a surrogate for IEDs often encountered in Afghanistan operations, also known as Home-Made Explosives (HME). The ongoing HME characterization (HME-C) effort originated to address concerns regarding the Department's ability to test operationally significant scenarios involving underbody blast threats, and to ensure adequate LFT&E of military vehicles now and in the future. The HME-C program intends to do the following:
  - Establish a threat surrogate for HME, approved by the Army's Office of the Deputy Chief of Staff, Intelligence.
  - Characterize the surrogate threat's effect on ground vehicle targets to determine its suitability for use in Title 10 ground vehicle LFT&E.
  - Ensure the HME surrogate's testability, repeatability, and measurability.
  - Conduct additional characterization of TNT, which is the military bulk explosive currently used in LFT&E. The DOD currently has insufficient data to relate testing under

current conditions to other operationally significant soils, test sites, and threats.
  - Establish a new soil standard for future LFT&E that includes buried underbody blast threats.
  - Investigate and develop new test protocols to ensure adequate and repeatable underbody blast threat testing in the future.
- In FY15, the HME-C program completed multiple test phases, which are intended to investigate the repeatability of HME surrogate effects relative to those of TNT and the effects of soil condition and IED emplacement on HME threat performance. DOT&E is currently working with the Army to analyze the data from the HME-C program to support decisions regarding the use of HME in LFT&E and the implementation of new soil standards (soil type, condition, and preparation) for underbody blast threat testing. The Department expects to make these decisions in FY16.

Small Boat Shooters' Working Group

- Small boats represent a growing threat class to ships operating in littoral waters, and are targeted by a wide variety of weapon systems.
  - In FY15, DOT&E sponsored the fourth annual Small Boat Shooter's Working Group, which examined the general nature of the small boat threat in littoral waters; summarized the threat classes and available targets and models available for ammunition, rocket, and tactical missile weapon systems; and attempted to synchronize various LFT&E and other operational test approaches among the various programs/Services by sharing the breadth of test and evaluation options available to evaluators.
  - The working group assessed the nature of the small boat threat; the availability of targets and lethality models representing those threats; the data collection, test techniques, and instrumentation that have been applied to small boats; and the performance of shipboard and aircraft weapons against small boat threats.
  - The working group identified the need for incorporating a broader variety of surrogate small boat targets into operational testing, and for gathering better live fire data from operational test events (e.g., HELLFIRE Romeo missiles fired against the ex-Coast Guard CG-41 FAC surrogate, and HELLFIRE longbow missiles vertically fired from a ship against High Speed Mobile Surface Targets as part of the Littoral Combat Ship (LCS) program).

RECOMMENDATION

1. The Army should identify and secure the funding outlined in the WIAMan Program Office Estimate so the project can continue uninterrupted. Any disruption in funding is likely to affect significantly the Army's ability to execute the project in its entirety. Any program delays will force the Department to continue using inadequate vehicle underbody blast test instrumentation and injury criteria.