Live Fire Test and Evaluation (LFT&E)

Summary

- In FY18, DOT&E executed LFT&E oversight for the following:
  - 84 Service acquisition programs
  - Three LFT&E investment programs:
    - Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME)
    - Joint Aircraft Survivability Program (JASP)
    - Joint Live Fire (JLF) Program
  - Three special interest programs:
    - Warrior Injury Assessment Manikin (WIAMan)
    - Combat Damage Assessment
    - Test and Evaluation of Emerging Technologies
- In support of major acquisition decisions, DOT&E published 11 combined OT&E and LFT&E reports and 4 LFT&E reports summarizing the lethality and survivability of the subject systems and offering recommendations intended to further improve lethality and survivability in expected operational scenarios.
- In support of the National Defense Strategy, DOT&E continued efforts to realign the three LFT&E investment programs to focus on the following priorities:
  - Develop a more lethal force by enhancing the capabilities of the joint weaponeering and combat effectiveness tools and by developing critical aircraft survivability enhancement technologies.
  - Strengthen alliances by providing weaponeering tools and training to coalition partners in support of current operations, and by teaming with coalition partners to better characterize and mitigate combat-induced system vulnerabilities.
  - Enable Department reforms by investing in more efficient software development architectures, modeling and simulation (M&S) tools, threat model development, and other innovative T&E methods. These efforts will allow the test community to conduct T&E more efficiently, and more effectively support rapid prototyping and fielding.
- Special interest programs continue to make progress in addressing a test instrumentation shortfall for assessing injuries to ground combat vehicle occupants. These programs also continue to collect combat damage assessment data to ensure operational relevance of LFT&E. Lastly, special interest programs have been established to assess and develop methods to effectively test emerging technologies including non-lethal weapons, directed-energy weapons, and counter-unmanned aerial systems (C-UAS).

LFT&E ACQUISITION PROGRAMS

The primary objective of LFT&E is to evaluate the survivability and lethality of acquisition programs and to identify system design deficiencies to be corrected before fielding or full-rate production. In FY18, DOT&E executed LFT&E oversight for 84 acquisition programs. Of those, 21 operated under the waiver provision of section 2366, title 10, U.S. Code, by executing an approved alternative LFT&E strategy in lieu of full-up system-level testing. In FY18, DOT&E published the following reports reflecting a sample of programs under LFT&E oversight:

- "AC-130J Block 20 Initial Operational Test and Evaluation Report," published in April 2018, reported on the AC-130J survivability against small arms, anti-aircraft artillery, legacy man-portable air-defense systems (MANPADS), and radio frequency (RF)-guided surface-to-air missiles. Additionally, it reported on the AC-130J lethality of the 30 mm gun, 105 mm cannon, and the Griffin missile against their intended targets. LFT&E made seven recommendations intended to further improve the AC-130J survivability and lethality in expected operational scenarios.
- "Patriot Post-Deployment Build-8 (PDB-8) and Missile Segment Enhancement (MSE) Initial Operational Test and Evaluation Report," published in April 2018, reported on the lethality of the Patriot Advanced Capability – 3 (PAC-3) system with both PDB-8 and MSEs. While the PAC-3 system was successfully evaluated against a wide variety of potential threats, the report identified five threats for which the system could not be evaluated and would require future analysis. The report supported the U.S. Army's Full-Rate Production decision for the PAC-3 MSE system in June 2018.
- "Soldier Protective System (SPS) Vital Torso Protection (VTP) Live Fire Report," published in April 2018, reported on the ballistic performance of lighter-weight hard armor inserts to protect soldiers against specified small arms threats. The report recommended the Army establish a credible correlation between threat-induced deformations in the armor inserts and the probability of injury.
- "Integrated Head Protection System (IHPS) Live Fire Report," published in May 2018, reported on the ballistic performance of the SPS helmet subsystem to protect soldiers against specified small arms threats. The report recommended the Army establish a credible correlation between threat-induced deformations in the helmet and the probability of injury.
- "Amphibious Combat Vehicle (ACV) 1.1 Operational Assessment Report," published in June 2018, summarized the force protection performance of two prototype vehicles,

developed by competing contractors, against small arms, heavy machine guns, underbody blast (UBB) mines, and IEDs.
- "M109A7 Family of Vehicles Live Fire Report," published in June 2018, reported on the vehicle's ability to provide force protection and continue with the mission when engaged with threats expected to be encountered in combat.
- "Army Tactical Missile System (ATACMS) Modification (MOD) Combined Live Fire and Operational Test Report," published in September 2018, reported on the lethality, survivability, operational effectiveness, and suitability of the ATACMS MOD. The report was delivered to support the Army's decision to field this upgraded system.

LFT&E INVESTMENT PROGRAMS

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

JTCG/ME is the Department's sole developer of Joint Munition Effectiveness Manuals (JMEMs). JMEM products include tools that enable users across Combatant Commands (CCMDs) to adequately plan combat missions. JMEM tools estimate the effectiveness of a weapon against a specified target and help determine the appropriate type and number of weapons required to achieve the desired lethal effect on that target. As such, JMEMs rely on detailed data describing:
- The physical characteristics and performance of weapons and targets
- Credible mathematical methods that employ these data to generate weapons effectiveness estimates
- User-friendly software that permits mission planners to calculate and visualize weapons effectiveness estimates, and assess mission success risks

JTCG/ME is chartered to authenticate weapons effects data across the Services, develop methods to assess and enable effective weapons employment, and provide reach-back analysis and forward support to prosecute targets. Current JMEM product lines include:
- JMEM Weaponeering Software (JWS)
- Joint Anti-Air Combat Effectiveness (J-ACE) tool
- Digital Precision Strike Suite (DPSS) Collateral Damage Estimation (DCiDE) tool
- Digital Imagery Exploitation Engine (DIEE).

Future product lines include Joint Non-Kinetic Effectiveness (J-NKE) capabilities such as cyber, electromagnetic fires, and directed energy. There are also specialized products driven by the needs of CCMDs, coalition partner interoperability, and lessons learned from current operations. These products include Probability of Kill (Pk) Lookup Tools, Quick Weaponeering Tables, Collateral Damage Estimation (CDE) tables, and scenario-specific CDE analysis packages. Products support mission planners and ongoing operations, and JTCG/ME works with users to establish warfighter requirements for current and future products and training.

JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The purpose of the JASP is to increase military aircraft combat survivability – therefore force lethality – in current and emerging threat environments. JASP funds research and development of emerging aircraft survivability technologies, improves core aircraft survivability assessment tools, and collects and interprets aircraft combat data. JASP focused on projects intended to: 1) develop measures to avoid detection and counter engagement of advanced RF- and infrared (IR)-guided threats, 2) improve aircraft force protection, and 3) improve aircraft survivability to combat-induced fires. In FY18, JASP funded 38 multi-year projects and delivered 23 final reports.

JOINT LIVE FIRE (JLF) PROGRAM

The purpose of the JLF program is to improve force lethality by resolving survivability and lethality challenges of new and fielded weapons systems, and strengthen and leverage alliances by conducting joint survivability and lethality T&E. Lastly, the JLF programs support the Department's business reforms by advancing T&E methods to increase their effectiveness and efficiency to support rapid prototyping and fielding. In FY18, JLF funded 26 projects and delivered 11 reports.

LFT&E INVESTMENT PROGRAM INITIATIVES

In FY18, DOT&E continued to align its investment programs with the three lines of effort identified in the National Defense Strategy. Examples that pertain to this alignment are discussed below.

BUILD A MORE LETHAL FORCE

1. Joint Weaponeering Tools

In FY18, LFT&E investment programs enhanced the capabilities of the JMEM Weaponeering System (JWS). This enabled more effective air-to-surface and surface-to-surface weaponeering across warfare domains. Specifically, JTCG/ME:
- Released a new version of the JWS tool (v2.3) and continued development of the next version (v2.4). Both versions focus on connectivity to other targeting and mission planning capabilities and updated weapon/target data sets for improved estimates and more seamless planning. Specific JWS v2.3 improvements include:
  - Information assurance and cybersecurity
  - Connectivity to permit automatic and optimum transfer of data between planning tools (Modernized Integrated Database, Joint Targeting Toolbox (JTT), and DIEE)

  - Weapons effectiveness estimates and planning optimization for structural and maritime targets by enhancement of the Fast Integrated Structural Tool and Ship Weaponeering Estimation Tool
  - Effectiveness estimates for F-35 gun munitions and C-130 gunship
  - Predicted accuracy of GPS/Inertial Navigation System weapons from satellite time and space calculations (by integrating the Dilution of Precision Tool)
  - Target Location Error estimate from airborne and ground-based sensors
  - Weapons and target vulnerability data with over 65 new target vulnerability data sets across warfare domains
- Provided new accredited Collateral Effects Radii (CER) Reference Tables to mitigate risk to non-combatants during weapons employment decisions. Kinetic strike planners use the JTCG/ME CER tables to minimize civilian casualties.
- Continued the development of two new JMEM tools to enable weaponeering and targeteering with non-kinetic weapons:
  - The Cyber Operation Lethality and Effectiveness (COLE) tool provides cyber effects estimations. Efforts in FY18 focused on standardization of data required to address offensive cyber weapon characterization, target vulnerability, operational environment, and uncertainty metrics. The COLE tool is founded on prior software development work initiated by the Air Force, the Army, the Defense Advanced Research Projects Agency, and data from operational test activities. The first version of the COLE tool is scheduled to be delivered in FY19.
  - The directed-energy weapon effects estimation and standardization tool provides high-energy laser effect estimations. Efforts in FY18 focused on addressing the uniqueness of the high-energy laser kill mechanisms, the uniqueness of the target vulnerability to laser lethal effects, and the atmospherics and other environmental factors that are required to establish a probability of effects calculation. The first version of a directed-energy weaponeering tool and a collateral damage estimation software is scheduled to be delivered in 1QFY19.
- Supported the warfighter with analysis and products for urgent operational needs and future JMEM production:
  - Provided direct forward and reach-back support to Combatant Commanders/Task Forces to enable weapons employment and strike decisions for high-value targets in current operations.
  - Supported current use and future JWS development requirements by hosting and supporting JWS training sessions, Operational Users Working Groups (OUWGs) and user help-desk support. These are critical venues for receiving user feedback and development of future JWS requirements.

2. Joint Anti-Air Combat Effectiveness Tool

In FY18, LFT&E investment programs improved air combat lethality by developing and releasing enhanced versions of the Joint Anti-air Combat Effectiveness (J-ACE) tools. J-ACE provides an assessment of full kill chain capability serving as the primary tool used to underpin air combat tactics, techniques, and procedures (TTP) development. Specifically, JTCG/ME fielded a new version of J-ACE (v5.3) and continued the development of the next J-ACE version (v5.4) with new capabilities, to include:

- Increased aircraft aero performance modeling by integrating the BLUEMAX6 (six degrees of freedom aero performance) model
- Improved real-time user interaction by integrating Hand-On-Throttle-And-Stick controls
- Increased ability to estimate countermeasure effectiveness by leveraging Enhanced Surface-to-Air Missile Simulation (ESAMS)
- Improved Graphical User Interface
- Improved connectivity between J-ACE and debrief/analysis tools at test and training ranges
- Improved target detection capability by leveraging National Air and Space Intelligence Center Radio Frequency models, and an initial Suppression/Destruction of Enemy Air Defense Capabilities.

3. Aircraft Survivability Technology

In FY18, LFT&E investment programs continued the development of aircraft survivability enhancement technologies to defeat near-peer and second-tier adversary threats (i.e., advanced RF and IR threats), and to improve the ability of U.S. aircraft to avoid either threat engagement or to mitigate damage when hit with a rocket-propelled grenade (RPG) or small arms:

- **RF Threats**. JASP funded the development of advanced Digital RF Memory based jamming techniques to provide countermeasure capability against new, more capable threat systems. JASP also co-funded a project with the Georgia Tech Research Institute to assess the sensitivity of countermeasure parameters such as missile break-lock, miss distance, deployment timing, and similar in order to develop the next generation RF towed decoy technology.
- **IR Threats.** JASP sponsored the development of IR countermeasure (IRCM) jam code requirements for Directional Infrared Countermeasure (DIRCM) systems to defeat two new threat systems. JASP also studied the potential advantages of using guided IRCM expendables to counter advanced IR-guided missile seekers. Lastly, JASP optimized algorithms used in existing missile warning sensors (MWS) to enable identification of hostile missile threats with newer classes of IR-guided seekers.
- **RPG Threats.** JASP funded the development and testing of three anti-RPG kill mechanism solutions. Testing

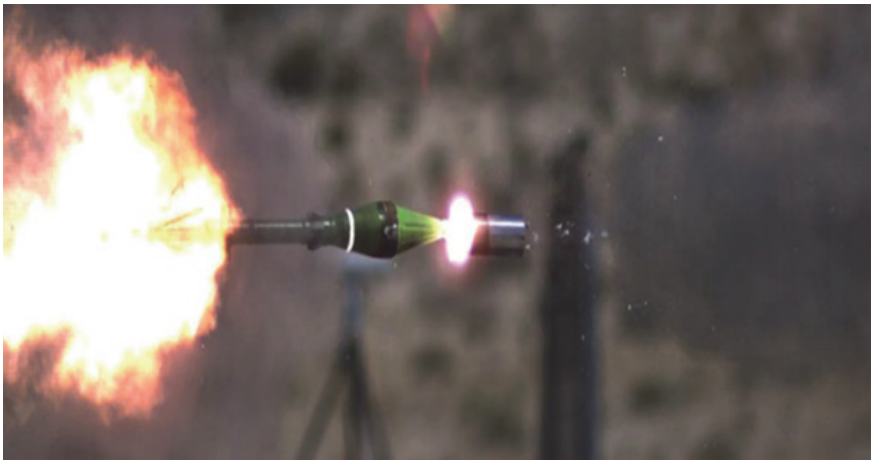

Figure 1. Kinetic Kill Vehicle Impact on RPG PG-7 85 mm (HEAT)

showed two concepts met the performance goals for lethality and collateral damage effects making them viable candidates for future helicopter active protection systems. JASP also continued characterization of debris from Active Protection System (APS) Kill Vehicle (KV) engagements against RPGs as shown in Figure 1.

- **Small Arms.** JASP continued development of aircraft hardening techniques to include transparent and opaque armors. Efforts supported the development of three highly efficient transparent armor designs for small arms projectile protection that reduce weight while improving the thermal durability. Efforts also supported the development of a spaced armor concept capable of stopping small arms armor-piercing (AP) projectiles at substantially less weight than current opaque armors.

In FY18, LFT&E investment programs continued the development and testing of aircraft survivability solutions to maximize residual aircraft flight capability in the event of combat-induced aircraft fires or fuel leaks. Significant FY18 efforts:

- Supported the development of a new intelligent fire suppression system demonstrating a 100 percent success rate in suppressing spray fires using less than 13 grams of agent per fire event.
- Evaluated the V-22's Fuel Management Units and any adverse effects on the fire suppression system due to associated fuel fire in the wing and mid-wing dry bay locations.
- Evaluated the potential fire vulnerabilities associated with auxiliary power unit (APU) accumulators commonly fielded with all versions of H-60 military helicopters.
- Investigated materials to deliver new, lighter weight, more reliable sealing technology for fuel bladders with the goal of reducing weight by 50 percent compared to current self-sealing fuel bladder materials.

STRENGTHEN ALLIANCES AND ATTRACT NEW PARTNERS

In FY18, LFT&E strengthened partnerships by providing weaponeering tools and training to coalition partners in support of current operations, and by teaming with coalition partners to better characterize and mitigate combat-induced system vulnerabilities. Specifically:

- JTCG/ME delivered two JWS version releases and three standalone Pk Lookup tools to key coalition partners in support of current operations under Foreign Military Sales agreements. These deliveries compared current Department efforts with U.S. interests and improved interoperability with allies and partners.
- JTCG/ME leveraged the Test Assistance Group (TAG) to enhance weapons characterization processes. The TAG activities foster an environment of reuse and learning across the coalition, interagency, industry, and DOD partners. For example, JTCG/ME leveraged TAG to partner with Sandia National Laboratories to advance three-dimensional fragmentation modeling and tracking using artificial intelligence techniques, high-speed stereoscopic optical, and x-ray development. These techniques and partnerships have the potential to reduce the number of weapon test articles and labor-intensive activities in future weapon lethality T&E.
- JTCG/ME influenced and supported NATO and international test operation procedures (ITOPs) by archiving, publishing, and sharing weapon characterization standards in updates to the JTCG/ME Weapon Test Procedures Manual.
- The JLF program initiated a project with Canadian counterparts to better characterize realistic torpedo and mine threat effects on Navy platforms. JLF funded the testing of near-field underwater explosion (UNDEX) phenomena while our Canadian counterparts provided the test article (panels extracted from a decommissioned Canadian ship). The collective effort will enhance Canadian and U.S. understanding

of UNDEX bubble phenomena and facilitate the validation of numerical predictions for realistic attacks. The effort will enhance our ability to develop/design more effective underwater weapons.

REFORM THE DEPARTMENT FOR GREATER PERFORMANCE AND AFFORDABILITY

In FY18, LFT&E investment programs enabled Department reforms by funding the development of more efficient software architectures, M&S tools, threat models, and other innovative T&E methods. These investments are intended to enable the test community to conduct T&E more effectively and efficiently, and to support mid-tier acquisition (rapid prototyping and rapid fielding).

1. Software Development Architecture

In FY18, JTCG/ME identified a new software architecture for JMEM tools to provide greater efficiency and optimization of weapons effects across all warfare domains in response to the changing strategic environment, and urban and close-combat operations. For example:

- The next generation JWS tools (v3.x) will use the U.S Air Force's Endgame Framework (EF) as the underlying software architecture to maximize modularity and flexibility of design modification, decrease development time, and reuse of standard capabilities across the community. JTCG/ME finalized the concept plan development and benchmarked the methods available for development within EF.
- The next generation J-ACE (v6.x) will also use EF as the underlying software architecture as well as the Hybrid Integrated Visualization Engine. The new architecture will help address enduring development requirements to include rotary-wing aircraft capability, expanded suppression/destruction of enemy air defense capabilities, and increased electronic warfare and countermeasure capabilities.

2. Modeling and Simulation Tools

JTCG/ME, JASP, and JLF integrated their efforts to rebaseline strategic roadmaps for underlying survivability and lethality M&S tools. These M&S tools are the foundation of JMEM products and LFT&E of acquisition programs. Efforts were focused on the following M&S tools:

- **Computation of Vulnerable Area Tool (COVART).** JASP supported development of an upgrade to COVART to enable six degrees of freedom equations for fragment and projectile penetration calculations. This capability will improve the accuracy of threat residual mass, velocity, and trajectory calculations thereby improving the accuracy and confidence in system Pk analysis. JASP also funded an effort to quantify the sensitivity of system-level Pk values on penetration errors and threat input parameters. In FY18, the model manager modified COVART to enable Monte Carlo processing of penetration errors.
- **Fast Air Target Encounter Penetration (FATEPEN).** JLF and JTCG/ME efforts expanded the capability and accuracy of FATEPEN, a threat penetration model used to predict weapon lethality and platform vulnerability to warhead-generated fragments. JLF collected fragment penetration data for buildings constructed from concrete masonry unit (CMU) blocks commonly observed in ongoing areas of operation. JTCG/ME will utilize these results to develop an accredited CMU target model for FATEPEN, allowing for better lethality predictions of U.S. munitions and better quantification of collateral damage effects. JLF efforts also improved FATEPEN accuracy in modeling lethal effects of irregular fragments ejected by many contemporary munitions.
- **Projectile Penetration (ProjPEN).** JLF sponsored collection of yawed projectile penetration data to support improved accuracy of ProjPEN, a threat penetration model used to predict weapon lethality and platform vulnerability to projectiles. The data will enable improved prediction of the damage caused by AP and armor-piercing incendiary (API) rounds on aircraft as a function of aircraft's velocity.
- **Dynamic System Mechanics Advanced Simulation (DYSMAS).** Hydrocodes have difficulty simulating UNDEX bubble dynamics. JLF funded a test series to quantify energy losses for UNDEX bubbles. The data generated by this task will support the model development task funded separately by the Office of Naval Research. These data will form the cornerstone of model validation for the DYSMAS M&S tool used to assess the vulnerability of submarine hulls and ship structures to large standoff weapons such as mines.
- **Advanced Survivability Assessment Program (ASAP).** Navy equipment "kill" criteria used in ASAP are based on antiquated empirical data. JLF is executing a plan to collect fragility data of shipboard equipment to increase assessment confidence levels. In FY18, JLF identified equipment (or surrogates) to be procured in FY19 and tested in FY20. This effort will improve the validation and pedigree of fragility criteria against modern vital equipment. Ultimately, it will improve the quality of naval ship LFT&E assessments.
- **Integrated Recoverability Model (IRM).** Vulnerability and Recoverability (V&R) M&S rely on estimation of equipment thermal fragility criteria to predict realistic system-of-system performance. One of the most challenging V&R events is a shipboard fire, and prediction efforts have been limited by simple models with significant error ranges. JLF is developing a statistically accurate equipment thermal fragility and failure prediction method. Completion of this program will enhance naval vulnerability data libraries for operationally significant survivability effects and improve critical LFT&E M&S tools.
- **Next Generation Fire Prediction Model.** JASP continued to improve the prediction model of aircraft dry bay fire

ignition due to ballistic threats. JASP, in coordination with Lawrence Livermore National Laboratory, continued with efforts to accurately predict the convergence of energy deposition and hydrodynamic ram (HRAM)/fuel deposition resulting from threat penetration. JASP continued the development of an accurate, fast running engineering model that will form the basis of the Next Generation Fire Prediction Model.

- **Enhanced Surface-to-Air Missile Simulation (ESAMS).** ESAMS is the primary tool used by government and industry to assess the engagement of U.S. aircraft by radar-directed surface-to-air missile systems. JASP continues to develop ESAMS upgrades to accurately model rotorcraft survivability, representative jamming environment, clutter, and existing and emerging RF threats. JASP is also funding an effort to compare ESAMS results with hardware-in-the-loop simulation and flight test data to assess the adequacy of T&E tools and methods used to evaluate performance of new techniques against advanced threat radars.
- **Modeling System for Advanced Investigation of Countermeasures (MOSAIC).** JASP is funding efforts to integrate a capability for guided expendables, as well as a tool to improve effectiveness analysis in MOSAIC.

3. Threat Model Development

To advance LFT&E, it is important to ensure adequate availability of adversary targets/threats and their models since the survivability and lethality evaluation of our systems largely depends on our understanding of adversaries' capabilities and damage effects. In FY18, JLF:

- Sponsored development of a representative TM-62M Russian antitank mine surrogate. The results of this work will allow the LFT&E community to ensure a more operationally representative survivability evaluation of U.S. ground combat vehicles to UBB events.
- Sponsored development of high-fidelity physics-based hydrocode and engineering level models for two widely proliferated (classified) shaped-charged warheads. The modeling methodology established in FY18 will serve as the analytical bridge to develop high-fidelity engineering-level models for similar warheads.
- Funded development of an instrumented inert threat system for use in counter-munition effectiveness evaluations during live fire hard-kill APS testing. Successful conclusion of this work will result in a test surrogate that is more accurate, cheaper, and provides better data to support APS effectiveness analyses. The U.S. Army Redstone Test Center, using JLF funding, defined a tandem warhead threat that best represents contemporary threats to U.S. forces.
- Validated an OG-7V grenade threat model to better evaluate fragmentation grenade effects on rotary-wing aircraft. A threat model, based on UH-60A partial fuselages test data, is being written for the Threat Pedigree books distributed in the Vulnerability Toolkit. The resulting validated fragmentation grenade threat model will lower the cost of rotary-wing design and vulnerability assessments in the future.

4. Innovative T&E Methods

- **Scalable Test Methods.** JLF funded the Air Force Research Laboratory (AFRL) Munitions Directorate to apply scalable experimentation methods in LFT&E. The intent was to provide data for validating JMEM warfighter tools that predict blast effects from detonations inside buildings in a more efficient manner. As new weapons and target sets materialize, JMEM developers will have a tailorable scale model they can use to validate blast effect models at a fraction of the cost of full-scale testing. Such a test method will provide warfighters more accurate weaponeering tools to predict the desired internal building effects and associated collateral damage.
- **Sensitivity Analyses.** The confidence in the results of some vulnerability and lethality M&S tools is either not known or low. JLF funded a project intended to apply sensitivity analyses to better quantify uncertainty in standard vulnerability metrics for variations in model input parameters. The most sensitive parameters will be identified to enable using higher fidelity vulnerability and lethality M&S tools with greater confidence.
- **New M&S capabilities.** The Navy currently has neither an insulation damage model nor significant data relating fire insulation impairment to blast severity. This results in overly conservative estimates of insulation effectiveness against heat/fire. JLF funded the development of an insulation damage model, suitable for whole-ship vulnerability assessments, to relate fire insulation impairment to blast severity. This will improve LFT&E assessments of future Navy ship acquisition programs for typical air-delivered threat weapons.

Figure 2. Buried Ordnance Test using a simulated asphalt roadbed. Results from such tests are used to choose strike packages that achieve desired effects while minimizing collateral damage.

- **Data Analytics.** The DCiDE and the DIEE v2.1 targeting solution products applied advanced automated tools and analytics enabling their release in FY18. DCiDE expedites and simplifies the Collateral Damage Estimation (CDE) process while DIEE enables seamless planning and linkage to various mission planning systems. Both tools increased efficiency and optimized mission planner workflow. In FY18, the Chairman of the Joint Chiefs of Staff issued guidance for the Services, CCMDs, and Combat Support Agencies to upload and use DIEE v2.1. To further validate these automated tools, JTCG/ME initiated a CDE test program to generate data and enhance/validate current weaponeering/CDE methodologies required by Strike Approval Authorities. JTCG/ME executed four buried ordnance tests to evaluate the effects of burial medium and weapon class on warhead performance, crater ejecta, and collateral damage. The results of one of these tests are shown in Figure 2.

LFT&E SPECIAL INTEREST PROGRAMS

WARRIOR INJURY ASSESSMENT MANIKIN (WIAMAN)

In December 2017, the Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) approved the initiation of the WIAMan acquisition effort as a Limited Production Instrumentation and Testing Program. This decision supported efforts to prepare for engineering and manufacturing development activities. In June 2018, the WIAMan Engineering Office (WEO) demonstrated Technical Readiness Level 6 with the four, first generation (Gen 1) anthropomorphic test devices (ATDs), in a realistic UBB event.

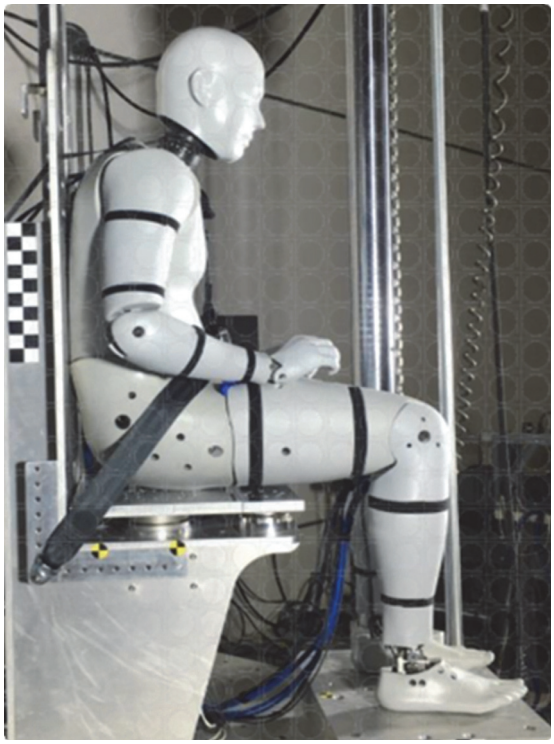

Figure 3. Generation 1 WIAMan ATD

In FY18, the WEO continued the biomechanics research to support development of both human injury probability curves (HIPCs) and injury assessment response curves (IARCs). The biomechanics team has recreated over 370 injuries in the laboratory setting that will be utilized for the development of HIPCs and IARCs. The WEO also completed the final side-by-side male/female test on the Accelerative Loading Fixture. The results of this pilot study will be used to inform a decision about the need to develop unique injury assessment capability for female soldiers. Lastly, the WEO completed a new finite element model (FEM) of the Gen 1 ATD and performed validation studies.

The Army has a requirement for 40 WIAMan ATDs. The current acquisition program is funded through FY19 and will procure up to 10 WIAMan ATDs. The Army has not yet funded WIAMan beyond FY19. The Army plans to use these WIAMan ATDs for AMPV full-up system-level testing in FY20.

COMBAT DAMAGE ASSESSMENT

JASP continued sponsoring aircraft combat damage incident reporting in the DOD through the Joint Combat Assessment Team (JCAT). The JCAT is a team of Army, Navy, and Air Force personnel that deploy to investigate aircraft combat damage in support of combat operations. The team supports assessments remotely from the continental United States and deploys outside of the United States when necessary.

JASP continued working with the U.S. Army Aeromedical Research Laboratory (USAARL) to study and document aviation combat injuries in Operation Iraqi Freedom and Operation Enduring Freedom. The results will be documented in USAARL reports and the Combat Damage Incident Reporting System (CDIRS). JASP, with the support of the Defense Systems Information Analysis Center and the National Ground Intelligence Center (NGIC), continued efforts to transition CDIRS from an Air Force SIPRNET server to NGIC hosting to enable access across the Services. The transition is expected to be complete in early FY19.

The JCAT and JASP Program Office worked in coordination with the Office of the Deputy Assistant Secretary of Defense for Systems Engineering, Office of the Under Secretary of Defense for Personnel and Readiness, and the Joint Staff's Force Structure, Resource, and Assessment Directorate to execute an Aircraft Combat Damage Reporting (ACDR) Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy Change Request (DCR) proposal. The JCAT and JASP are working with the Services to implement the approved DCR recommendations.

TEST AND EVALUATION OF EMERGING TECHNOLOGIES

Joint Non-Lethal Weapons (JNLW) Test and Evaluation Working-Level Integrated Product Team (T&E WIPT)

Non-lethal weapon systems are being developed, tested, and evaluated by each of the Services. In FY18, DOT&E hosted the JNLW T&E WIPT meeting in which each Service briefed its non-lethal weapons portfolio (T&E status, program successes, and failures). The JNLW T&E WIPT will become an annual forum to compare cross-Service experience in order to foster progress in non-lethal weapon systems. DOT&E is currently developing procedures by which programs in this portfolio will be evaluated in the future.

Counter-Unmanned Aerial Systems (C-UAS)

C-UAS systems continue to be developed and evaluated for military operations. In FY18, DOT&E worked with the Services to emphasize the need to test and evaluate C-UAS systems in threat-representative cellular environments. Testing will properly evaluate collateral damage concerns, and develop appropriate sensors to evaluate C-UAS system effectiveness in contested environments.

Directed-Energy Weapon T&E

A variety of directed-energy weapon systems are maturing to the point of military utility. In FY18, DOT&E worked with the Services to identify and develop T&E requirements related to laser weapons. DOT&E is working with the Services to determine how to relate meteorological conditions to laser propagation in T&E activities; develop sensors for dynamic targets; and identify methods to verify, validate, and accredit M&S tools that will be needed during future laser weapon LFT&E.