Live Fire Test and Evaluation

EXECUTIVE SUMMARY

- In FY20, DOT&E executed LFT&E oversight for 84 Service acquisition programs designed to field DOD technologies, 3 joint programs, and 2 special interest programs.
- In support of fielding DOD technologies, DOT&E published three combined OT&E and LFT&E reports summarizing the survivability and lethality performance of subject systems and offered recommendations to further advance their performance in emerging combat environments.
- In accordance with the National Defense Strategy, DOT&E continued to focus the objectives of the three joint programs to:
  - Deliver and maintain credible joint weaponeering tools capable of providing weapons or mission effect estimates across all warfare domains.
  - Deliver T&E tools and joint aircraft survivability solutions to assess and mitigate U.S. aircraft losses in projected combat missions and areas of operation.
  - Innovate T&E methods to include modeling and simulation (M&S) tools to support efficient prototyping and fielding of DOD technologies.
- DOT&E provided oversight of two special interest projects focused on (1) delivering credible evaluations of combat-induced injuries and (2) collecting adequate combat damage data.

ACQUISITION PROGRAMS

In FY20, DOT&E executed LFT&E oversight for 84 acquisition programs and published 3 combined OT&E and LFT&E reports. These reports provided assessments of the survivability and lethality performance of subject systems and offered recommendations to further advance their performance in emerging combat environments.

- "Abrams M1A2 System Enhancement Package Version 2 (SEPv2) with Trophy Active Protection System Early Fielding Report," published in June 2020, assessed the enhanced survivability of the Abrams M1A2 tank when fitted with Trophy. The report supported the Army's decision for Urgent Material Release of the Enhancement Package to four brigades in Europe and the Pacific.
- "Small Diameter Bomb (SDB) II Early Fielding Report/Phase I Combined Operational Test and Live Fire Test Report," published in July 2020, assessed the SDB's preparedness for fielding on the F-15E aircraft. The report supported the United States Air Force Air Combat Command's authorization for fielding of SDB II on the F-15E.
- "Joint Air to Ground Missile (JAGM) Operational Assessment," published in August 2020, detailed the integration and performance of the JAGM missile on the Army's helicopter platform. JAGM was found to be as lethal as the legacy HELLFIRE missile while also delivering additional operational capability.

JOINT PROGRAM CHARTERS

LFT&E provides oversight of three programs chartered to support LFT&E title 10 requirements and operational needs. A brief description of these programs is below. Given their common objectives, they will be referred to in this report as joint programs.

Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME)

JTCG/ME serves as the DOD's sole developer of joint weaponeering tools known as Joint Munition Effectiveness Manuals (JMEMs). JMEM products include weaponeering tools capable of estimating the appropriate number and types of weapons required by Combatant Commands (CCMDs) to achieve the desired lethal effect on a target while also mitigating risk for collateral damage (reduce civilian casualties). As such, JMEMs rely on:

- Credible and authoritative data to accurately capture the performance of DOD weapons against relevant, adversary targets.
- Accredited physics-based models and analytical methods to estimate DOD weapons effects for a wide range of relevant engagement conditions.
- User-friendly and secure software that permits mission planners to predict and visualize weapons effects, while also estimating the potential for civilian casualties.

DOT&E provides oversight and strategic guidance to JTCG/ME to support the development of credible and operationally

relevant JMEM products as the complexities of the operational environment emerge. The Army's Combat Capability Development Command Data and Analysis Center executes the JTCG/ME mission in accordance with DOT&E guidance, Joint Staff Military Targeting Committee requirements, and Chairman of the Joint Chiefs of Staff Instructions. Current JMEM products include:

1. Digital Imagery Exploitation Engine used to first geographically locate and characterize the target (using National Geospatial-Intelligence Agency tools), then weaponeer the target using JMEM Weaponeering Software, and lastly, estimate collateral damage effects using the Digital Precision Strike Suite Collateral Damage Estimation tool.
2. Joint Anti-Air Combat Effectiveness tool used in combat mission planning, training, and in weapon schools to support the development of air combat tactics, techniques, and procedures.
3. Reach-back analysis packages and reports to directly assist CCMDs and to meet the urgent operational requirements of a dynamic environment (e.g., rapid development of probability of kill data and collateral damage estimates for emerging weapons or targets).

To maintain relevancy in multi-domain combat environments, DOT&E continues to emphasize the need and support for the development of JMEM products capable of estimating lethal effects for cyber, electromagnetic spectrum fires (EMS), and directed energy weapons. Most recent efforts included accreditation of the first Cyber JMEM increment, further advancement of the development of the first Directed Energy Weapons JMEM that included the initiation of a JMEM for High Power Microwaves (HPM), and initiation of the development of the EMS Fires JMEM. Additional resources are required to incorporate the effects of U.S. and adversary countermeasures across JMEM products.

Joint Aircraft Survivability Program (JASP)

JASP serves as the DOD lead in enabling the development of cross-Service aircraft survivability solutions and evaluation methods needed to mitigate operational shortfalls of U.S. aircraft in combat. JASP responds to the existing and emerging multi-domain operating environments and provides solutions to prevent U.S. aircraft losses to either kinetic or non-kinetic engagements. JASP is the only program in the Department positioned to enable the coordination and support for:

- Development of joint M&S tools and capabilities needed to evaluate and advance aircraft survivability as required by title 10, and for use by CCMDs and Service aviation weapons and tactics squadrons, schools, or training ranges for mission planning and combat operations.
- The Joint Combat Assessment Team (JCAT) to collect and analyze U.S. aircraft combat damage and losses. These data and combat reports have been critical in informing title 10 aircraft survivability evaluations and in highlighting the requirements for joint aircraft survivability solutions to provide force protection and remedy operational shortfalls.

JASP is chartered by the aviation components of each Service: the Naval Air Systems Command, the Air Force Life Cycle Management Center, and the Assistant Secretary of the Army for Acquisition, Logistics and Technology. The Services provide the manpower and funds while DOT&E provides stability in funding and strategic guidance for JASP to meet DOD needs.

Joint Live Fire (JLF) Program

JLF program supports LFT&E execution of title 10 responsibilities by addressing a more comprehensive spectrum of survivability and lethality problems as both the complexity of our own technologies and the operational environment advance. The JLF program has been chartered to address two-overarching concerns: (1) survivability/lethality performance shortfalls of deployed DOD systems due to changes in either concepts of operations, systems' mission, rules of engagement, or the emerging threat environment; and (2) survivability/lethality test and evaluation capability shortfalls due to the increased complexity of either DOD systems or adversary threats.

LFT&E JOINT PROGRAM ACCOMPLISHMENTS

BUILD A MORE LETHAL FORCE

In FY20, DOT&E monitored the implementation of updates to current JMEM products designed to estimate lethal and collateral damage effects for kinetic energy weapons. The following updates improved mission planning efficiency, credibility, and analytical support to CCMDs responsible for targeting high-value assets:

- Enhanced Digital Imagery Exploitation Engine to enable greater interoperability of targeting capabilities across the Department.
- New JMEM software design features including effects data libraries to enable more rapid characterization of the adversary target and features that improve connectivity to targeting and mission planning systems.
- Updates to the integrated weapon/target data and damage effects data sets to account for additional weapons in the U.S. inventory for use by the targeting community.
- Updates to Collateral Effects Radii Reference Tables in accordance with Chairman of the Joint Chiefs of Staff Instruction (within the context of Theater Rules of Engagement and the Laws of Armed Conflict) to further mitigate risk to non-combatants during weapons employment.

- Improved collection and analysis of Battle Damage Assessment data post-strike to support validation and confidence of existing weaponeering tools. These efforts leverage digital engineering processes to provide efficiencies and increased data availability to the operational and acquisition communities. Detailed analysis of combat data will optimize munition expenditure rates and will ultimately mitigate stockpile stress.

Although DOT&E continues to enhance the support to JTCG/ME to meet emerging operational needs, additional resources are necessary to update JMEM products to more accurately represent kinetic energy weapon effects in the operational environment. For example, current JMEM tools do not account for emerging capabilities, such as hypersonics as well as the expanding survivability enhancement technologies (e.g., countermeasures, decoys, electromagnetic spectrum management). Current JMEM tools must also include advanced capabilities for maritime targets based on CCMD urgent needs.

In FY20, DOT&E supported the development of four new JMEM tools required to enable multi-domain operations:

- **Cyber Operation Lethality and Effectiveness (COLE) tool.** The COLE tool provides an analytical engine intended to support offensive cyber operations. It provides the means to develop and characterize the target's cyberspace (network and its environment) offering visualization tools to cyber operators previously not available although additional resources are required to automate the development of the network. The COLE tool also enables easy access to a range of weapon and target characterization needed to plan the attack although additional efforts are in place to automate access and ingestion of all available data. Lastly, the COLE tool includes fundamental analytical tools that need to be further advanced to enable effects estimates for a sequence of cyberattacks in the absence of empirical data.
- **Directed Energy Weapons JMEMs.** The Directed Energy Weapons JMEMs will enable targeteers to incorporate High Energy Laser (HEL) and HPM Weapon Systems into the Joint Targeting Cycle:
  - **Joint Laser Weaponeering Software (JLaWS) tool.** The tool is founded on test data collected to verify and validate available M&S tools and to characterize the vulnerability of a subset of operationally relevant targets to high-energy lasers. The tool enables target damage and collateral damage effect estimates unique to directed energy weapons. JTCG/ME is executing a multi-year test and methodology development plan to continue to update this tool with data needed to accurately capture existing and emerging U.S. high-energy laser performance as a function of system power, dwell time, jitter, and other factors needed to validate and operationalize this tool.
  - **High Power Microwave (HPM) Weaponeering tool.** JTCG/ME developed a multiyear test and methodology development plan, which is adequate to underpin data standards and enhance currently available effectiveness and collateral risk estimate methods needed for the development of an HPM weaponeering tool.
- **Electromagnetic Spectrum (EMS) Fires JMEM.** JTCG/ME initiated a new EMS Fires JMEM effort to enable the mission planners and targeteers to: (1) assess the effectiveness of our weapons (specifically the guidance system) in the presence of adversary-induced electromagnetic spectrum effects (e.g., GPS denial); and (2) assess the effectiveness of our own electromagnetic spectrum effects on adversary targets. In FY20, JTCG/ME collected and evaluated operational requirements and started the development of data standards for EMS Fires effects. JTCG/ME also conducted a DOD-wide review of available analytical tools, models, and data sources, to include GPS analytical services that could be used a foundation for the EMS Fires JMEM. These initial tasks intend to leverage and optimize existing Service/Intelligence-based models and data capabilities for efficiency.

In FY20, DOT&E monitored the execution of several efforts that improved air combat lethality and survivability:

- Updates to the Joint Air Combat Effectiveness tools (J-ACE)/Joint Anti-Air Model (JAAM) tool to include implementation of new threat weapons, improved aircraft aero performance and blue air-to-air missile models, and increased validation with test and training range data. J-ACE/JAAM tools estimate air-to-air/surface-to-air combat effectiveness to support air combat tactics, techniques, and procedures development at national test and training ranges. JTCG/ME and JASP continued to develop the next generation J-ACE/JAAM product line founded on a modular architecture and the effects data library with an added capability that also considers rotorcraft platforms with their respective countermeasures.
- Flight testing that demonstrated the effectiveness of a new RF-countermeasure technique to improve the survivability of U.S. aircraft against a class of advanced surveillance radar systems and flight testing that demonstrated the ability of U.S. countermeasures systems to defeat a near-peer electro-optical/infrared (EO/IR)-guided threat system.
- Development of a low size, weight, and power active electronically scanned array to enable effective radio frequency countermeasures (RFCM) capabilities for the DOD vertical lift fleet.
- Collection and analysis of data to identify trends in helicopter combat-related injuries, demonstration of aircraft hardening solutions against high energy laser threats, and development of novel fuel tank solutions to mitigate fire-induced helicopter losses.

In FY20, the Joint Live Fire program addressed several contemporary survivability and force protection problems:

- Development of a new metric to more adequately characterize the behind armor blunt trauma imparted on our joint force by combat-induced, hard armor deformation. This effort will determine if the dynamic deformation rate, not simply

deformation depth, is a potential factor that needs to be considered in future body armor test and evaluation programs.
- Development of a test fixture for use in evaluation of failure criteria of structural components due to internal blast. This test fixture will be used to improve current failure criteria, and the resulting data incorporated into the Advanced Survivability Assessment Program (ASAP) model to be leveraged by naval platform LFT&E programs.
- Development of detailed dataset characterizing titanium fragment penetration, breakup, and flight dynamics through complex target geometries representing steel and aluminum naval ship construction. The experimental data will be compared to M&S predictions to provide improved confidence in the tri-Service/DOD fragment penetration code used in all lethality and survivability evaluations.

STRENGTHEN ALLIANCES AND BUILD NEW PARTNERS

In FY20, DOT&E strengthened alliances by supporting multiple efforts with coalition partners. Specifically:

- Supported the delivery of weaponeering tools/data sets and training to coalition partners in support of current operations under Foreign Military Sales agreements. This included the release of weapon effectiveness tables, Collateral Effects Radii tables, and advanced target development capabilities to key coalition partners to minimize collateral damage/ reduce civilian casualties. These efforts directly supported the Presidential Conventional Arms Control Policy to build partner capacity and prevent civilian casualties.
- Supported information exchange forums via information exchange agreements (IEAs) with several coalition partners. These exchanges facilitate collaboration on methodologies and efforts of mutual interest in the area of weapons effectiveness/ collateral damage estimation.
- Supported standardization of weapon characteristics and interoperability by providing coalition partners with the updated JTCG/ME Weapon Test Procedures Manual, which will augment international test operation procedures.
- Supported the partnership with the Republic of Korea to develop a test capability to induce hydrodynamic ram loads in aircraft structural joints. This collaboration will develop test devices in the U.S. and the Republic of Korea, collect data for model verification, and enable more survivable aircraft structural designs.
- Supported urgent operational needs with rapid development of probability of kill data tables and collateral damage analysis packages for high-priority weapons and targets. These specialized products directly assist CCMDs to meet the operational requirements of a dynamic environment.

REFORM THE DEPARTMENT FOR GREATER PERFORMANCE AND AFFORDABILITY

In FY20, DOT&E managed the oversight of the joint programs to support Department reforms by advancing the state of the art M&S tools and other innovative T&E methods. These efforts continue to introduce efficiencies in LFT&E to support rapid prototyping and rapid fielding while minimizing risk to the warfighter.

New Weaponeering Tool Software Architecture to Enable Targeting Solutions across Warfare Domains

JTCG/ME implemented the use of a new software architecture for JMEM products. The new software will support modular capabilities and improved interface with all new data or methods, which will be stored in various Joint Effects Libraries. These libraries enforce data standardization and enable increased leveraging/sharing of data and models across the Services. This common foundation will increase efficiency and returns on investment for future M&S development. The development of these libraries also increases opportunities to utilize advanced data analytics, such as neural network tools, data compression algorithms (XGBoost), and machine learning. Use of these advanced analytical techniques will improve the quality of existing solutions, decrease computation time of applications, and answer questions previously not possible. Initial implementation efforts included establishing DevSecOps capabilities for Agile software development to reduce product fielding timelines.

Credible Modeling and Simulation (M&S) Tools to Increase Efficiency and Reduce Risk

DOT&E reprioritized the joint programs to focus on increasing the accuracy, credibility, and capability of M&S tools used in title 10 LFT&E evaluations and JMEM products. The efforts focused on baselining M&S tool capabilities and limitations, completing sensitivity studies to identify M&S factors that may drive the output errors, and formulating strategic roadmaps to increase the credibility and/or capability of these tools.

The three major M&S tools used to predict either system survivability or conversely the weapon lethality include the Army-managed Advanced Joint Effectiveness Model (AJEM), the Air Force-managed Computation of Vulnerable Area Tool (COVART), and the Navy-managed Advanced Survivability Assessment Program (ASAP). All three rely on two additional M&S tools: Fast Air Target Encounter Penetration (FATEPEN) model used for estimating penetration of warhead-generated fragments and Projectile Penetration (ProjPEN) used for estimating penetration of small- and medium-caliber projectiles. Two additional M&S tools are used to evaluate the engagement kill chain of adversary surface-to-air and air-to-air weapons against our aircraft: Enhanced Surface-to-Air Missile Simulation (ESAMS) and Brawler.

DOT&E facilitated a tri-Service model review summit to re-baseline the verification, validation, and accreditation (VV&A) process that will be used in re-accrediting these M&S tools. The intent was to characterize the error bounds and understand their root-cause so DOT&E can identify and address shortfalls in upcoming joint program builds. These efforts will ultimately accelerate the overall analysis process and enable the prioritization of test parameters during a T&E program.

- **Advanced Joint Effectiveness Model (AJEM)** estimates the lethality/vulnerability of ground combat vehicles, small boats, and aircraft to kinetic energy weapons. This first FY20 effort focused on increasing the capability of AJEM to model irregular fragments and highly yawed long rods effects as seen in more recent weapon designs. The second effort focused on rebaselining the VV&A processes used in AJEM to increase its credibility while lowering risk in title 10 evaluations. The third effort focused on an adequate transition of AJEM modules (e.g., Operational Requirements-based Casualty Assessment (ORCA) for personnel injury calculation) into previously mentioned Joint Effects Libraries that will serve as the foundation of future weaponeering tools.
- **Computation of Vulnerable Area Tool (COVART)** estimates aircraft vulnerabilities to kinetic energy weapons. This first FY20 effort included a statistical evaluation of the variation in vulnerability analyses due to known errors in the FATEPEN and ProjPen penetration models as well as variability in the threat data and the threat representation. The second effort focused on the integration of key capabilities from the Next Generation Fire Model into COVART to enable credible prediction of threat-induced fires onboard an aircraft. The third effort supported the validation of a rapid structural vulnerability assessment tool for the evaluation of the threat-induced, residual integrity of the systems' structure.
- **Advanced Survivability Assessment Program (ASAP)** predicts the vulnerability of ships to anti-ship weapons. FY20 efforts included verification and validation (V&V) review of ASAP using statistical measures and sensitivity studies. FY20 also included testing needed for validation of improvements to ASAP damage modules currently under development. DOT&E continues to work with the Navy to ensure that V&V of vulnerability assessment tools are adequate and appropriate to their use supporting LFT&E.
- **Fast Air Target Encounter Penetration (FATEPEN)** estimates warhead-generated fragment penetration against an array of operationally representative targets. FY20 efforts initiated the accreditation process to enable lethal effect estimates of highly yawed long rods formed by many contemporary munitions. In parallel, a tri-Service model review committee is completing a full re-accreditation of FATEPEN capabilities.
- **Projectile Penetration (ProjPEN)** estimates projectile penetration against an array of operationally representative targets. FY20 efforts continued to support a parametric study to evaluate the model estimate errors and their root cause. In addition, FY20 efforts included updates to FATEPEN and ProjPEN graphical user interfaces to ensure compliance with current operating systems and to enable data exchanges between FATEPEN and ProjPEN for improved efficiencies.
- **Enhanced Surface-to-Air Missile Simulation (ESAMS)** estimates the probability of engagement of U.S. aircraft by radar-directed, surface-to-air missile systems. FY20 efforts included updates to high-priority missile threat representations that included the latest aerodynamic performance data provided by the Intelligence Community. FY20 efforts also focused on increasing ESAMS capability to assess rotorcraft susceptibility to RF-guided, surface-to-air missile threats. This effort included the development of capabilities to accurately represent the platform's signature with the dynamic blade flash, as well as the effects of low altitude clutter. With ESAMS v5.7 set to be the last version openly distributed throughout the DOD and industry, FY20 efforts also supported the initial development of the Survivability and Lethality Assessments within a Tactical Engagement (SLATE), which shares the same architecture as the JTCG/ME assessment tool, JAAM. The initial version of SLATE, scheduled for release in FY22, will enable the evaluation of the susceptibility of rotorcraft and fixed-wing aircraft to air defense artillery utilizing National Ground Intelligence Center (NGIC) threat representations (Threat Modeling & Analysis Program (TMAP) models), surface-to-air missiles utilizing Missile and Space Intelligence Center and Office of Naval Intelligence TMAP models, and air-to-air missiles utilizing the National Air and Space Intelligence Center TMAP models.
- **Brawler** is an air-to-air engagement analysis tool. FY20 efforts addressed multiple user requested code enhancements including onboard and off-board sensor fusion, increased fidelity of the infrared (IR) environment, increased capability for passing tracks, and increased flexibility in the Brawler generated output files. Brawler supports technology development, analysis of alternatives, and title 10 evaluations.

Innovative T&E Methods

In FY20, DOT&E leveraged the joint programs to research and adapt best practices in industry, academia, and across government laboratories intended to introduce efficiencies in DOT&E processes and increase the credibility of DOT&E evaluations. Examples include:

- **Enhanced Weaponeering and Collateral Damage Effects.** Efforts focused on executing a multiyear test program designed to generate the data needed to enhance and validate current weaponeering and Collateral Damage Effects methodologies as required by Strike Approval Authorities. Testing supported the evaluation of the effects of the ordnance burial medium and the ordnance type on crater ejecta and collateral damage, as well as characterization of building debris to be used by pertinent M&S tools.
- **Data Analytics.** Effort leveraged the expertise at Sandia National Laboratories to capture three-dimensional (3D) tracking warhead fragmentation to enable multi-sensor data fusion for improved warhead characterization and weaponeering solutions. This effort improves the lethality assessment metrics by applying the data to validate relevant M&S tools to establish uncertainty quantification estimates for fragment position, velocity, mass, count, and drag. Application of artificial intelligence techniques, high-speed stereoscopic optical, and x-ray development included in this effort are intended to reduce the number of weapon test articles and labor-intensive activities in future weapon lethality T&E programs.

- **Scalable Test Methods.** Efforts leveraged the expertise at the Air Force Research Laboratory Munitions Directorate to enable the use of scalable experimentation methods in LFT&E. Air Force designed and manufactured a building at 1/9th-scale and executed 42 airblast experiments of operationally relevant weaponeering scenarios. These data will be analyzed to quantify error bounds in JMEM airblast models. As new weapons and target sets materialize, JMEM developers will have a tailorable scale model they can use to validate blast effects models at a fraction of the cost.
- **Advanced Sensors**. Efforts focused on the development of a new sensor that has the ability to accurately measure high frequency and high amplitude motion produced during kinetic energy weapon-induced blast and shock tests. The team executed over 150 laboratory tests to incorporate the sensor suite in 5 Amphibious Combat Vehicle full-up system-level live fire tests. Follow-on analysis of the laboratory and vehicle test data will yield a configurable sensor suite with a supporting user manual and software package.
- **Threat Model Development.** Efforts focused on the development of an all-digital threat model that will allow for more expedient evaluation of IR countermeasure (IRCM) techniques. Similarly, updates to RF-guided threat radar models and the ESAMS signal environment will allow for more expedient development and evaluation of advanced electronic techniques and RFCM. In coordination with the NGIC, efforts also focused on the development of rocket-propelled grenade models and a stand-alone threat electronic warfare system TMAP model for integration into simulation environments. TMAP model will provide a more accurate representation of the electronic environment as it gets incorporated into the DOD/Intelligence Community's M&S framework, Integrated Threat Analysis & Simulation Environment.
- **IRCM Break-lock Test Accuracy.** Effort supported data collection from over 500 IRCM break-lock jam events to compare them with laboratory test data and improve the accuracy of current flight test effectiveness assessment methods.
- **Capability-Based Teaming System Analysis.** Effort leverages the expertise from Massachusetts Institute of Technology and their System Theoretic Process Analysis to support a development of a methodology intended to provide efficient and operationally relevant survivability and lethality evaluation of a system of systems. Capability is being demonstrated on a mission vignette, which includes a lead helicopter and several unmanned aerial vehicles coordinating on identifying and locating a target.
- **Machine Learning to Optimize Armor/Anti-Armor Performance.** Effort is focused on leveraging artificial intelligence and machine learning to optimize armor system designs and the evaluation of their effectiveness against a range of kinetic energy threats. The Army Research Laboratory in coordination with the Aberdeen Test & Evaluation Center is creating a robust scalable armor performance database for use by "to be" developed trained algorithms that can: (1) predict kinetic threat engagement outcomes at a fraction of the cost of a full-scale live-fire test, and (2) optimize armor and anti-armor solutions.
- **Engagement Model of Rotorcraft in an Electromagnetic Spectrum Contested Environment.** Effort is focused on an engagement simulation capability for rotorcraft capable of modeling rotorcraft flight dynamics, maneuvers, and RFCM techniques for the purposes of evaluating rotorcraft survivability. Effort focused on updating threat radars in ESAMS, collecting applicable RCS data for validation, integrating clutter tools, and building a pseudo rotorcraft 6 degrees of freedom flight model with reactive maneuvers. This capability will meet the requirements identified by the Army's Future Attack Reconnaissance Aircraft and Future Long-Range Assault Aircraft, as well as the Marine's Aviation Weapons and Tactics Squadron.
- **Active Protection System (APS) M&S** estimates the survivability of U.S. vehicles equipped with APS systems. FY20 efforts focused on improving the ability to model the APS end-to-end event sequence, focusing on intercept outcomes, residual characterization, and vulnerability of the platform and its crew.
- **Integrated Recoverability Model (IRM) and the Fire and Smoke Simulator (FSSIM)** module predicts the inception of fires, fire spread, and times to extinguish. FY20 efforts yielded incremental improvements model indirect firefighting, HVAC systems effect on smoke spread, fire spread via holing, and flooding effects on fire. Improvements will be incorporated to the models and leveraged by LFT&E programs for secondary effects analyses and recoverability assessments.
- **Total Mine Susceptibility System (TMSS) M&S** predicts the fire points for naval influence mines when interacting with ship underwater signatures. The Navy uses TMSS to predict the operational safe transit depths for U.S. Navy ships. The test data of the 2019, Littoral Combat Ship 11 Advanced Mine Simulator System (AMISS) trial showed poor statistical correlation between the predicted mine fire points from TMSS and the AMISS trial data. In FY20, DOT&E conducted a detailed assessment of the AMISS trial data to determine the root causes of the observed discrepancies. In FY21, DOT&E will engage the mine susceptibility experts from Naval Surface Warfare Center Panama City Division to resolve the identified issues and improve, if needed, the capabilities and accuracy of TMSS.

LFT&E SPECIAL INTEREST PROGRAMS

Warrior Injury Assessment Manikin (WIAMan)

WIAMan is a military-specific anthropomorphic test device (ATD) intended to evaluate injuries to ground combat vehicle occupants due to vertical accelerative loading typically observed in mine engagements. The WIAMan program consists of three main efforts:

- Development of the ATD with an integrated data acquisition system
- Biomechanics research to accurately characterize and predict the injury
- Finite element model of the WIAMan to support future M&S assessments

In FY20, the Army Combat Capabilities Development Command – Data and Analysis Center continued the biomechanics research to support the development of human injury probability curves and injury assessment reference curves. The Army completed the injury curves in 4QFY20. The Army also conducted and analyzed a series of whole body Post-Mortem Human Surrogates and ATD matched-pair experimental tests to support the validation effort of these curves but additional analyses are required to adequately accredit WIAMan for use in LFT&E. The Army intends to complete the VV&A efforts to use the WIAMan in FY21 during Armored Multi-Purpose Vehicle full-up system-level testing.

Combat Damage Assessment

JASP continued to enable adequate aircraft combat damage incident reporting and aviation combat injury analyses through the Joint Combat Analysis Team (JCAT) and the U.S. Army Aeromedical Research Laboratory (USAARL). In FY20, the JCAT completed 20 combat damage assessments supporting operational forces. The USAARL supported the related analysis of aircraft combat injuries and documented all reported AH-64 Apache combat injuries in Operation Iraqi Freedom and Operation Enduring Freedom. To enable combat incident data access across the DOD, Services, and CCMDs, JASP transitioned the Combat Damage Incident Reporting System from an Air Force SIPRNET server to NGIC hosting. In coordination with the Naval Air Systems Command, JASP also enabled automatic collection of time-sensitive threat incident and engagement data to support future aircraft combat incident reporting.