

## Live Fire Test and Evaluation (LFT&E) Program

DOT&E executed oversight of survivability and lethality test and evaluation for 122 acquisition programs in FY12. Of those 122 programs, 19 operated under the waiver provision of U.S. Code, Title 10, Section 2366, by executing an approved alternate LFT&E strategy in lieu of full-up system-level testing. In addition, Section 2366 also requires DOT&E to report on a program's LFT&E results prior to that program entering into full-rate production.

DOT&E published reports on the following programs during the past year (reports marked with an asterisk were sent to Congress):

### LFT&E Reports

- Enhanced Combat Helmet\*
- Family of Medium Tactical Vehicles (FMTV) A1P2\*
- Stryker Double-V Hull (DVH) Configuration of the Commander's Vehicle (CVV)

### Special Reports Regarding LFT&E

- Active Protection Systems (APS)\*
- Hellfire Romeo Missile
- Mine Resistant Ambush Protected (MRAP) – All-Terrain Vehicle (M-ATV) Underbody Improvement Kit (UIK)
- Stryker Mobile Gun System (MGS) Engineering Change Order (ECO) Block 3
- BAE-Tactical Vehicle System (TVS) Caiman Mine Resistant Ambush Protected (MRAP) Vehicle.

### Combined OT&E/LFT&E Beyond Low-Rate Initial Production Reports

- AH-64D Apache Block III (AB3) Attack Helicopter\*
- Mine Resistant Ambush Protected (MRAP) Family of Vehicles: Dash with Independent Suspension System (ISS), MRAP Recovery Vehicle (MRV), Marine Corps Cougar Ambulance\*

- Spider XM7 Network Command Munition\*
- Stryker Nuclear, Biological, and Chemical Reconnaissance Vehicle (NBCRV)\*
- Terminal High-Altitude Area Defense (THAAD) and AN/TPY-12 Radar\*

### Combined OT&E/LFT&E Assessments

- Family of Medium Tactical Vehicles (FMTV)
- MH-60S Airborne Mine Countermeasures Helicopter and AN/ASQ-20A Mine Detecting Sonar
- Mine Resistant Ambush Protected (MRAP) Family of Vehicles: Navistar Dash Ambulance and MRAP All-Terrain Vehicle (M-ATV) Underbody Improvement Kit (UIK)
- Stryker Double-V Hull (DVH) Configuration of the Engineer Squad Vehicle (ESVV)
- Stryker Double-V Hull (DVH) Configuration of the Scout Vehicle (ICVV)
- Stryker Double-V Hull (DVH) Configuration of the Mortar Carrier Vehicle (MCVV)
- Stryker Double-V Hull (DVH) Configuration of the Medical Evacuation Vehicle (MEVV)

In addition to satisfying acquisition oversight requirements, the LFT&E program funds and executes technical oversight on investment programs that provide joint munitions effectiveness data (Joint Technical Coordinating Group for Munitions Effectiveness). The LFT&E program also develops advanced technologies and analytical methods to increase aircraft survivability (Joint Aircraft Survivability Program), and conducts vulnerability and lethality testing of fielded platforms and weapons systems and improves survivability analysis tools (Joint Live Fire Program). LFT&E investment programs also support quick reaction efforts addressing urgent operational commander's needs.

### JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS EFFECTIVENESS (JTTCG/ME)

The Joint Logistics Commanders chartered the Joint Technical Coordinating Group for Munitions Effectiveness (JTTCG/ME) in 1968 to ensure development of consistent and credible effectiveness estimates for conventional munitions across the DoD. DOT&E oversees the JTTCG/ME and provides funding. The JTTCG/ME produces and distributes these data in Joint Munitions Effectiveness Manuals (JMEMs). The primary application supported is weaponeering, the detailed technical planning of a weapon strike that occurs at multiple levels in the operational chain of command before actual combat. JMEMs provide computerized tools and data for rapid evaluation of alternative weapons and their delivery against specific targets. In many cases, JMEMs generate collateral damage estimates as a part of the decision criteria for strikes approved at the highest levels of the U.S. Government.

In FY12, the JTTCG/ME published two updated JMEMs and a set of Collateral Effects Radii (CER) tables. The JMEM Weaponeering System (JWS) v2.1 software and the JTTCG/ME-generated Chairman of the Joint Chiefs of Staff Instruction 3160.01 CER tables are used for operational weaponeering and collateral damage estimates directly supporting operations in the U.S. Africa Command and U.S. Central Command Areas of Responsibility. To provide continued support to operational commanders, as well as DoD targeting and mission planners, the JTTCG/ME also developed and incorporated geometric models representative of various targets for use in assessing the effectiveness of weapons. JTTCG/ME released the second updated JMEM, JTTCG/ME's air-to-air and surface-to-air planning model, the Joint Anti-Air Combat Effectiveness System (J-ACE) v5.1, in July 2012, which includes the data required to assess the survivability of strike aircraft.

## Operational Weaponneering



JWS is the joint source for air-to-surface and surface-to-surface weaponneering, munitions, and target information. JWS evaluates the effectiveness of a multitude of munition-target combinations for numerous air-to-surface and surface-to-surface munitions against a variety of target types in real-time. JWS v2.1 contains the Fast Integrated Structural Tool (FIST). FIST is the JMEM operational-level tool that allows weaponneers to quickly develop geometric models of soft and hardened targets and use those models to evaluate weapons effects. In particular, the tool can then generate weapon effectiveness and damage assessments for infrastructure targets including buildings, bunkers, and tunnels. JWS v2.1 contains approximately 180 new or updated targets, 15 new and updated munitions, new Explosive Equivalent Weights based on blast testing, and an improved 3-D viewer for displaying target models.

## Operational Mission Planning

JTCG/ME released J-ACE v5.1 to support operational mission planning, particularly at U.S. Strategic Command (USSTRATCOM). J-ACE simulates U.S. and threat air-to-air and surface-to-air engagements, providing flyout models for U.S. and threat air-to-air and surface-to-air missiles, as well as probability of kill estimates. Previous releases generated pre-computed probability of kill tables given an intercept for selected weapon-target pairings and engagement conditions. Because use of these tables proved tedious, J-ACE v5.1 now

provides new Endgame Manager v2.2.0 software and data sets, which allow on-demand calculation of multiple kill levels for specific engagement conditions encountered at intercept. To more effectively support operational mission planning, J-ACE v5.1 also provides a direct interface to force-level simulations. These simulations are used to study tactics, evaluate training, assess the relative performance of missiles, and plan scenarios.

## Collateral Damage Estimation

The JTCG/ME supported development and fielding of the Digital Precision Strike Suite Collateral Damage Estimation tool for operational use. This tool displays accredited Collateral Damage Estimate Level effective radii reference tables. Additionally, JTCG/ME personnel trained nearly 250 users at 10 different commands to support collateral damage estimation decisions.

## Information Operations

In conjunction with the Air Force Targeting Center, the JTCG/ME assessed fielded and emerging applications for conducting information operations as part of early efforts to develop a capability within JMEM to evaluate the effects of such operations. These efforts included the development of an initial set of simple tools for assessing the effects of selected applications when used to conduct Computer Network Attack, Computer Network Defense, Military Information Support Operations, and Electronic Warfare.



## JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

DOT&E sponsors and funds the Joint Aircraft Survivability Program (JASP), which develops techniques and technology to improve the survivability of U.S. military aircraft. The Naval Air Systems Command, Army Aviation and Missile Command, and Air Force Aeronautical Systems Center charter the program. DOT&E establishes objectives and priorities for the JASP and exercises oversight of the program. Working with joint and Service staffs, other government agencies, and industry, the JASP promotes the adoption throughout the Military Services of the most current techniques and technologies for improving aircraft survivability.

The JASP is supporting the Joint Multi-Role (JMR) Technology Capabilities Demonstration (TCD) as a member of the Platform Integrated Product Team. The purpose of the JMR TCD is to demonstrate transformational vertical lift technologies to prepare the DoD to develop the next generation of vertical lift aircraft. JASP was instrumental in establishing assumptions and requirements for the vulnerability analysis used in evaluating the initial three government model prototypes.

The JASP funded 59 development projects (\$10.2 Million) and delivered 41 final reports in FY12. The following examples illustrate current JASP efforts in four focus areas: susceptibility reduction, vulnerability reduction, survivability assessment, and combat damage assessment.

### Susceptibility Reduction

These efforts addressed urgent aircraft survivability needs emerging from Operation Enduring Freedom, as well as improved aircraft survivability against future threats.

### Countermeasure Requirements against New Infrared Seekers.



The JASP, in conjunction with the Naval Research Laboratory (NRL), is performing in-depth analyses of newly obtained threat infrared seekers to develop flare and jammer infrared countermeasures (IRCM). The first objective is to identify

anomalous behavior seen when certain countermeasures are used against one particular threat. The second objective is to evaluate the effectiveness of current countermeasure technologies, tactics, and techniques when employed against these seekers. The third objective is to develop new tactics and techniques to improve countermeasure performance if the current methods are not sufficient in defeating the seekers. Initial results focused on developing new countermeasure solutions for one threat system.

### **Advanced Techniques for Radio Frequency Countermeasures (RFCM).**

In partnership with the U.S. Air Force Special Operations Command, the JASP is developing and testing RFCM technology and techniques to increase aircraft survivability and situational awareness for Army, Navy, and Air Force special operations rotary- and fixed-wing aircraft. This project assesses the ability of onboard systems to receive, process, and display each operating mode of the threat weapon system; develops RFCM techniques; and demonstrates their effectiveness against state-of-the-art threat radar weapons. Validated threat identification and countermeasure techniques for surface-to-air missile and airborne radar systems are being developed for incorporation in the AN/ALQ-211 Suite of Integrated Radio Frequency Countermeasures on the CV-22, MH-47, and MH-60, and in the AN/ALR-69 radar warning receivers on the C-130.



### **Omniscient Electronic Attack.**



In partnership with NRL, the JASP is demonstrating the use of a Digital Radio Frequency Memory jammer that adapts in real-time to the received radar waveform, rather than identifying the threat/radar mode and selecting

electronic attack techniques from a pre-programmed database. The intent is to overcome limitations of pre-programmed response-based electronic attack techniques against advanced, multi-mode, coherent radar threats. If successful, this technique could be implemented on EA-18G Growler aircraft as well as other electronic attack platforms.

### **ShotSense 3-D Aircraft Hostile Fire Indication (HFI) System.**

The JASP and the U.S. Army Communication-Electronics Research Development and Engineering Center supported development of a high performance; low cost, size, weight, and power; uncooled infrared threat detection system for the tracking and



classification of small arms, rocket-propelled grenades (RPGs), missiles, and other hostile fires. The initial focus was on ground testing in natural and urban high-clutter environments. Tests demonstrated the ability to detect and classify threats and cue radars for projectile tracking during a Live Fire Demonstration. The DoD and the United Kingdom Ministry of Defence are considering using the system for HFI/Counter-Rocket, Artillery and Mortar applications at forward operating bases. The DoD is also considering the system for use on the U.S. Special Operations Command Little Bird helicopter to provide that small aircraft with hostile fire and missile warning capabilities.

### **Hostile Fire Indication (HFI) Threat System Geolocation.**

In partnership with the U.S. Army Aviation Applied Technology Directorate, the JASP is developing and testing software algorithms for incorporation in the AN/AVR-2B(V) Laser Warning System enabling the system to perform precise geo-location of hostile fire threats. The algorithms will be applicable to all aircraft using the AN/AVR-2B(V), such as the Apache and Black Hawk helicopters.



### **Vulnerability Reduction**

Several agencies undertook efforts to develop lighter-weight opaque and transparent ballistic protection systems, fuel containment and related fire protection technologies, and tolerant structures and materials, including self-healing composites.

### **Critical Component Protection.**



AH-1Z Flight Control Bell Crank



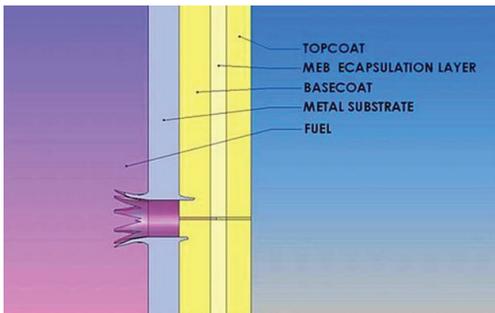
AH-1Z Complex Shape Armor Installation

The U.S. Army Aviation Applied Technology Directorate led a project to manufacture complex, curved ceramic armor for placement at strategic locations on aircraft, improving survivability with minimal weight impact. These installations protect flight-critical aircraft components that when damaged would lead to catastrophic aircraft loss. Due to their complexity, these structurally integrated panels required development

of several cutting-edge material and processing technologies. Two implementations were demonstrated: the OH-58D Kiowa Warrior engine bay door and the AH-1Z Cobra helicopter flight control linkage bell-crank. The exposed bell-crank is a point of vulnerability in the flight control system. The complex (multiple curvatures in multiple directions) panel provides ballistic protection. Both implementations successfully increased protection with little or no weight increase and are being evaluated for transition to the fleet.

## Self-Healing Fuel Cell Membrane.

The Naval Air Warfare Center Weapons Division led development of a new self-sealing coating technology. The coating is designed to mitigate leaks



from composite structures containing fluid (e.g., wet wings or fuel compartments) when subjected to a ballistic impact. The goal is to seal the fuel cell to a damp seal within two minutes at ambient temperature at a reduced weight compared to current self-sealing fuel bladders. The solution must be suitable for retrofit on fielded aircraft or installation on new aircraft and must work equally well with new alternative fuels. Following successful initial testing, the Air Force selected this solution as a component of the vulnerability reduction design for the future KC-46 tanker aircraft.

## Thermal Degradation of Composites.



This project examined the degradation of aircraft structural composite materials due to heat damage caused by short-lived fuel fires. After calibration through mechanical test, evaluations were made of various non-destructive inspection (NDI) methods and

their ability to detect incipient thermal degradation. The results of the testing were transitioned to Fleet Readiness Centers for the generation of inspection and repair procedures. The success of this project also led to a U.S.-Germany bilateral research agreement and a new project to validate fire and heat exposure damage data on representative composites used extensively on the F-35. The new effort will also validate the ability of portable NDI techniques to detect equivalent measures of thermal degradation.

## Survivability Assessment

The projects in this area develop and maintain components of models and simulations that are widely used to support weapon system acquisition (e.g., design studies, specification development, and specification compliance) and test and evaluation (e.g., test design, evaluation, and assessment).

## Suite of Anti-Air Kill Chain – Models and Data (SAK-MD).

The JASP, the JTCG/ME, and USSTRATCOM have been working for several years to improve the methods and data employed by USSTRATCOM to plan global strike missions. Initial efforts developed a new methodology to efficiently and consistently assess probability of kill for a large set of blue aircraft and red threat pairs. More recently, the team has concentrated on adding the effects of radio frequency

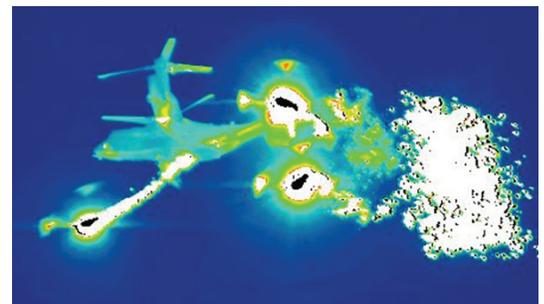
and infrared countermeasures into the methodology and data sets. By coupling widely accepted countermeasure-capable engagement models with fast running operational user-focused models, the team has developed a new benchmark capability for performing aircraft-threat engagement analyses. SAK-MD has been widely distributed as part of the JTCG/ME J-ACE product and, in addition to USSTRATCOM, is used extensively by Air Force, Navy, and Marine Corps aircrews in weapon systems training.

## Crew and Passenger Survivability (CAPS).

The JASP continued to advance the development of analysis, data, test capability, and technology for improving aircraft CAPS. This year concluded the initial effort to develop an analytical framework for CAPS evaluation by demonstrating the inclusion of CAPS in two commonly used vulnerability analysis models. The effort also included drafting a report on the state of crew casualty evaluation methodologies and a roadmap for future methodology development. The project will continue to improve CAPS assessment methodologies, test capabilities, and technologies working in partnership with the National Aeronautics and Space Administration, Federal Aviation Administration, and U.S. Army Tank Automotive Research, Development and Engineering Center.

## Infrared Countermeasure (IRCM) Modeling.

The JASP continued data collection and model development to improve the DoD's IRCM analysis capability against advanced



V-22 Dispensing Flares Clouds

multi-spectral and imaging infrared threats. Current infrared engagement simulations rely on simple flare models that lack the resolution required to address advanced infrared missile seekers. The JASP and Naval Surface Warfare Center – Crane Division are developing physics-based models for pyrotechnic and pyrophoric flares that address combustion, heat and mass transfer, infrared radiation, trajectory, and spatial extent/image presentation; ultimately providing the time evolution of plume or cloud characteristics necessary for analysis of the effectiveness of countermeasures against missiles using advanced infrared seekers. The project is also modernizing the joint modeling and simulation tools, Flare Aerodynamic Modeling Environment, and the Tri-Service Flare Database to improve usability, add 3-D descriptions of air flowing around aircraft, and develop Linux versions of both tools.

## Combat Damage Assessment

JASP continued to support the Joint Combat Assessment Team (JCAT) in FY12. JCAT comprises Army, Air Force, Navy, and Marine Corps personnel deployed in support of combat operations. JCAT continued its operation in Afghanistan

# LFT&E PROGRAM

with full-time deployments in Regional Commands – South, Southwest, and East. Iraq and other areas of the world were supported remotely or by rapid deployment from Afghanistan or stateside.

JCAT inspects damaged and destroyed aircraft, acquires maintenance records, and conducts interviews with aircrew and intelligence personnel to develop an accurate and comprehensive assessment of each aircraft combat damage event. They provide consultation to weapons, tactics, and logistics personnel and comprehensive briefings to commanders in charge of daily air operations. These efforts allow battlefield commanders to adjust operational tactics, techniques, and procedures based on accurate threat and damage assessments. As of November 22, 2012, the JCAT had initiated 221 and completed 179 FY12 aircraft combat damage assessments.

The JCAT improved aircraft combat damage incident reporting in the Services and the DoD. The Combat Damage Incident

Reporting System (CDIRS) hosted by the Survivability/Vulnerability Information Analysis Center (SURVIAC) is the repository for all U.S. aircraft combat damage reports. The JCAT worked closely with SURVIAC to upgrade the CDIRS database, its data reduction capability, and links to the JCAT knowledge centers. JCAT and SURVIAC are also working with OSD and U.S. Central Command (USCENTCOM) on an operational demonstration linking both CDIRS and USCENTCOM databases to more quickly identify, assess, document, and distribute aircraft combat damage incident data to the Services and DoD.

The JCAT trains the U.S. aviation community on potential aircraft threats and combat damage, including representatives from the U.S. Military Services, the Department of State, the Department of Homeland Security, the Federal Aviation Administration, the Department of Energy, the Federal Bureau of Investigation, and the Bureau of Alcohol, Tobacco, Firearms and Explosives.

## JOINT LIVE FIRE (JLF)

The goal of the Joint Live Fire (JLF) program is to test fielded systems, identify vulnerable areas, understand damage mechanisms, and provide the information needed to make design changes; modify tactics, techniques, and procedures; or improve analytical tools. The need for these tests result from systems being exposed to new threats, being used in new, unanticipated ways, or being operated in new combat environments, thereby requiring an updated assessment of their performance.

JLF supplements LFT&E of systems by testing new threats that the requirements community did not anticipate during original development or old threats employed in new ways. The RPG is an example of a threat employed differently than initially intended. Originally developed as an anti-tank or anti-personnel weapon, hostile forces in Afghanistan often use the RPG as an anti-helicopter weapon.

### Aircraft Systems Program

JLF-Air completed nine test series in FY12, with a focus on resolving key modeling and testing deficiencies highlighted in the 2010 Man-Portable Air Defense Systems (MANPADS) Vulnerability Capabilities Roadmap, providing threat characterization data for high-explosive incendiary and armor piercing projectiles, and investigating occupant survivability deficiencies resulting from ballistic events. The JLF program has made significant progress over the last three years in understanding MANPADS threat characteristics and developing a viable test capability for use in LFT&E.

### Large Engine Vulnerability to MANPADS.

This project is assessing the ballistic vulnerability of a large turbofan engine to a MANPADS missile impacting from the rear, and using that information to explore subsequent flying qualities of large aircraft. Live fire testing using realistic engagement conditions were achieved by using shotlines representative of

real-world encounters, operating the engine at typical thrust levels, simulating the proper amount of external airflow across and through the engine, and accurately controlling the MANPADS missile impact location, velocity, and detonation point.

The project provided test results to the National Aeronautics Space Administration enabling it to conduct flight simulations to determine the flying qualities that can be expected during cruise and landing as a result of the damage witnessed in the test. The project will present simulation results, along with test observations, in a final report to be completed in early 2013.

### MANPADS Threat Model Development – Fragment and Debris.

This project concluded testing for the MANPADS Threat Model Development test series. This test series was designed to gather data with sufficient quality to improve the accuracy and credibility of MANPADS threat models used to assess and predict aircraft vulnerability. This test collected warhead fragment and debris for two MANPADS that were flown and detonated in the center of a specially instrumented test arena.

### Supersonic Rocket on a Rope.

This project is developing a capability to support testing of various platforms' vulnerability to MANPADS missiles. Using this technique, the missile is flown along a set of ropes, acting as guide wires, which are cut just before reaching the intended target. Once cut free, the missile is allowed to free-fly into the target achieving a high-level of precision in hitting



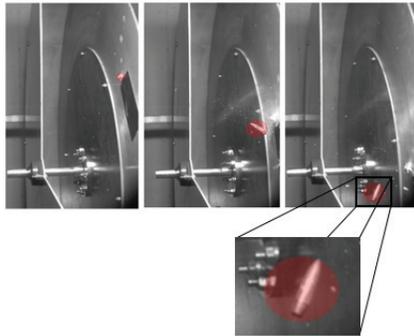
pre-determined impact points. Prior year tests satisfactorily demonstrated high precision hits. This year's tests also included detonating the MANPADS missile warhead using a range-safe fuze. In 2013, the project will be in its final year and is expected to culminate in a demonstration with three shots using actual MANPADS tactical fuzes, rather than range fuzes, for warhead detonation.

### ***Threat Projectile Characterization.***

Several JLF-Air projects focused on collecting threat characterization data for small arms or Anti-Aircraft Artillery (AAA) threats. One such project filled deficiencies in data on the performance of certain fuzes used in 14.5 mm and 23 mm high-explosive incendiary projectiles. A gap in understanding the ballistic performance multiple variations of 7.62 mm and .30-caliber armor piercing/armor piercing incendiary projectiles similarly resulted in a test series to determine the appropriate round for use in experimental ballistic testing.

### ***V<sub>50</sub> Yaw of Projectiles.***

This project is exploring how a projectile, such as those impacting fast moving targets, penetrates typical aircraft materials when impacting the materials at other than normal (i.e., 90 degrees) incidence. Test results will provide immediate feedback



on the accuracy of the analytical vulnerability tools now being commonly used and will be used to update the Computation of Vulnerable Area Tool and the Advanced Joint Effectiveness Model. The test concept was successfully demonstrated in 2012 and 40 test events at varying speeds, effectively creating different yaw angles, are underway.

### ***Rotorcraft Sponson RPG Vulnerability.***

This project evaluated three technologies for suppressing cabin fires resulting from RPG impacts to sponson fuel tanks adjacent to aircraft cabins. Although large main cabin fires occurred in this testing, the testing demonstrated that some of these technologies are effective in either mitigating or eliminating the resulting fire. This testing focused on cabin environment and occupant survivability. Data from cabin thermocouples, pressure transducers, and mannequins were collected to establish occupant effects. These data, along with an evaluation of the fire suppression technologies tested, will be published in FY13.

### ***Crew Compartment Fire Survivability.***

This project characterized the environment of an aircraft main cabin during fires representative of those seen as a result of ballistic events. Baseline testing focused on cabin conditions with no airflow (i.e., all hatches, doors, and windows closed) and the effectiveness of personal fire extinguishers to extinguish those fires. Using a specially modified H-3 helicopter fuselage



developed under this project, data were collected using a comprehensive instrumentation package gathering multiple temperature, oxygen and carbon monoxide levels, and visibility measurements. For each test event, the cause and time to reach an incapacitation threshold were determined.

### **Ground Systems Programs**

#### ***Roadmap to Address Hybrid-III Mannequin Sustainment.***

This project investigated modification and improvement options for the currently utilized Hybrid-III Anthropomorphic Test Device (ATD). The Hybrid-III ATD is the primary instrument for gathering accelerative injury data from live fire underbody blast testing. This project identified several low cost technical upgrades that will help sustain the Hybrid-III ATD through 2018, at which point the live fire community expects to transition to the Warrior Injury Assessment Manikin (WIAMan) ATD, currently under development.



#### ***Test and Analysis to Update Warhead Characterization for MK 82 Bomb.***

This project conducted a series of five MK 82 general purpose bomb tests to characterize fragment size, speed, and direction. Tests were conducted utilizing the JTTCG/ME standard procedures, with fragments collected in recovery bundles and impact speeds measured utilizing electronic triggering panels. The JTTCG/ME Systems Characterization Working Group is reviewing the results, which, when accepted, will be utilized for weapon lethality, collateral damage, and risk assessments. This testing was in direct response to requests from operational Commanders employing the MK 82.

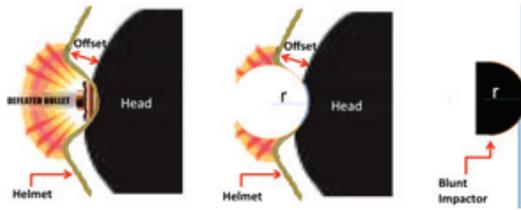
#### ***Testing to Gather Penetration for Low-Collateral Damage Round.***

This project conducted a series of tests with low-collateral damage rounds against plate arrays typical of a light ground mobile target to obtain residual properties of the projectiles (i.e., speed, weight, and orientation after penetration through different materials). Information collected will be utilized to improve the JTTCG/ME predictive Projectile Penetration (ProjPen) model. ProjPen is utilized to predict penetrator performance against ground mobile, rotary- and fixed-wing aircraft, and small watercraft. ProjPen currently lacks predictive capability for this type of round and data did not exist to implement that capability.

#### ***Behind Helmet Blunt Trauma Skull Injury.***

This JLF project is part of a series of experiments to improve the testing and evaluation of military combat helmets. Blunt-ballistic impact tests will be used to develop an injury criterion or risk for behind-helmet blunt trauma, where currently none exist. JLF can

use the injury criterion to assess the severity of loading, as well as the risk

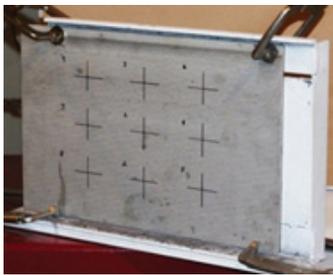


of sustaining injury, with potential to implement this criterion into future testing and evaluation of new protective equipment.

### ***Improvements to Sustained Fire Prediction in Vulnerability/Lethality Analysis Methodologies.***

This project assessed the ability of lethality and vulnerability (L/V) models to predict sustained fire as a kill mechanism for ground mobile targets. Analysis of available test data indicates current L/V fire start methodologies under-predict sustained fire resulting from near-field detonations of blast-frag warheads. This initial assessment of fire start predictive capability will compile available relevant test data and reports, assess the current L/V fire start models in light of their underlying empirical data, and propose a way forward for improving the capability of L/V codes to predict sustained fire as a kill mechanism.

### ***Continued Improvement of Material Characterization for ProjPen Modeling.***



This project is conducting tests to gather data for small caliber armor piercing incendiary projectiles striking stainless steel plates. Testing is focused on penetration velocities and the gathering of residual masses and velocities of penetrating fragments.

This will improve the quality of L/V analyses involving ProjPen. Both the JTCG/ME and JASP utilize ProjPen for the analysis of the damaging effects of small caliber projectiles.

### ***Effects of Buried Homemade Explosive (HME) Performance Variability on Platform and Occupant Survivability.***

This project is quantifying the potential variations in the buried blast performance of materials manufactured to represent a typical Homemade Explosive (HME). Similar to many HMEs, the material is a blend of different materials and is granular in nature. The characteristics being investigated arise from the processes required to manufacture the material. Multiple blends at extreme tolerances of acceptable variances in mixtures are being tested in controlled blast experiments. The results of the tests will be used to establish models for the performance of the material. For effects identified as significant (i.e., greater than standard shot-to-shot variability) the explosive models will be used with a full system model to establish the effect on ballistic effects delivered to a vehicle such as those that may be observed during a live fire test.

### **Sea Systems Program**

The Joint Live Fire Sea Systems Program (JLF-Sea) made significant progress in FY12 towards improving the capability to assess the survivability of submarines and surface ships. These projects benefit ship and submarine acquisition programs as well as the fleet of fielded U.S. Navy vessels.

#### ***Finnish Fast Attack Craft Testing.***

FY12 was the last year of a multiyear, trilateral (United States, Finland, and Germany) cooperative effort to perform damage testing against two aluminum, decommissioned Finnish fast attack craft. The Finnish Navy provided the ships and has conducted testing on their test range in the Baltic Sea and at their test center in Niinisalo, Finland. The objective was to understand the behavior of aluminum structures subjected to various weapon effects. In FY12, shaped charge testing against a section of one of the ships was conducted to study spall and debris from aluminum targets, to perform crew casualty assessments, and to evaluate depth-of-penetration. These tests will fill gaps in our understanding of weapon effects against aluminum ships, and will augment the LFT&E programs for the Littoral Combat Ship and Joint High Speed Vessel.

#### ***Vulnerability of Aluminum Structure to Fire.***

This project conducted tests to determine if fire insulation and its attachment could be defeated by a major fire. A test article representative of a section of a USS *Independence* class Littoral Combat Ship flight deck was built using specified materials and insulation attachment materials and procedures. The article was then exposed to tests similar to those specified by military standard (MIL STD 3020). Results from this project will fill gaps in our understanding of the vulnerabilities of aluminum structures and their insulation systems to weapon-induced fires.



#### ***Crew Casualty Modeling and Simulation Validation Testing.***



The objective of this project, jointly funded by the Office of Naval Research and JLF, is to validate injury response functions developed under an earlier JLF project. Three Hybrid-III ATDs were tested on a floating shock platform to collect data on personnel injuries caused by an underwater explosion. The data and observations from this testing will improve the accuracy of crew casualty predictions made as a part of ship live fire vulnerability assessments.

#### ***Network Fire Model Enhancements.***

This project provided funds to continue development of the NRL network fire model. The model can be used by naval engineers to develop ship designs that limit the spread of fire and smoke. NRL began a two-year effort to improve the model's capability to predict fire characteristics associated with large volume spaces such as hangar and mission bays.

## ***Sea Bottom Underwater Explosion Effects Testing.***

This project, the result of an agreement between the U.S. and German Navies, continues development and validation of simulation tools for assessing ship survivability to various explosive threats. JLF provided funding to conduct underwater explosion testing representing charges located on and near the sea floor to quantify the loading on vessels submerged near the bottom, submerged between the surface and the bottom,

and floating at keel depth. This project provides data to increase the fidelity of models, increase the accuracy of survivability assessments, and to address urgent operational needs.



## **LFT&E SPECIAL INTEREST PROGRAMS**

### **Active Protection Systems (APS)**

In response to FY08 legislation, DOT&E tested and evaluated seven foreign and domestic (two foreign, three domestic, and two combined foreign/domestic) APS with the potential to protect wheeled tactical vehicles from RPGs. DOT&E provided a report to Congress and the Department's acquisition leadership in February 2012. This effort concluded that none of the tested APS are currently mature enough for fielding on any U.S. platform and further development, test, and evaluation are required.

### **Personnel Protection Equipment**

DOT&E continued its oversight of the testing of personnel protection equipment. The Services and Special Operations Command (USSOCOM) continue to implement rigorous, statistically-based testing protocols for hard body armor inserts and military combat helmets approved by DOT&E. The Defense Logistics Agency has utilized the hard armor testing protocol in new contracts for sustainment stocks of hard armor inserts. The Army has incorporated the key concepts of statistical confidence and test design into its requirements for its Soldier Protection System. The Navy and Air Force are also implementing statistical testing concepts for soft armor vests.

DOT&E, in partnership with the Services and USSOCOM, is developing a new soft armor vest testing protocol. That protocol is intended to standardize testing and assure that soft armor vests provided to Service members meet common ballistic protection requirements and provide uniform protection on the battlefield. The implementation of this protocol will further increase government oversight of personal protective equipment by requiring soft armor vests (in addition to hard armor plates and combat helmets) to meet rigorous statistical measures of performance.

The National Academy of Sciences' (NAS) Committee to Review the Testing of Body Armor Materials for Use by the U.S. Army published its final report in May 2012. This report completes the NAS' three-phase review of body armor testing that began in 2009 following the release of a critical 2009 U.S. Government Accountability Office report of testing conducted at the Army's Aberdeen Test Center. The final NAS report reviewed a number of topics, including the use of statistically principled testing, measurement standards, and body armor test methodology. The report concluded that the hard body armor test protocol is statistically principled and provides an acceptable minimum DoD-wide body armor test standard. The report notes

the need for additional work in the areas of both measurement improvement and characterizing variance in the performance of the clay backing material used during testing to further improve test quality. The Army is currently testing a new clay formulation that, if successful, would eliminate the drawbacks of the clay currently used and described in the NAS report. The report also makes several recommendations for research and investigation into the medical effects of blunt force trauma, and for applying the results of this research to improve body armor test procedures. Both DOT&E and the Army are working to use the results of ongoing medical research into blunt trauma to update body armor test methodologies and procedures. DOT&E has asked the NAS to review and comment on the Department's statistically-based combat helmet test protocol, a 15-month study that is expected to be complete by the end of 2013.

### **Stryker Double-V Hull (DVH)**

The Army initiated the Stryker Double-V Hull (DVH) program in response to Operation Enduring Freedom commanders' requests for improved underbody blast threat protection. Under DOT&E oversight, the Army incrementally developed and tested multiple Stryker DVH configurations over a two-year timeframe. The test and evaluation program directly supported critical fielding schedules, and DOT&E reported to the USD(AT&L) and Army leadership on each Stryker DVH configuration's survivability, effectiveness, and suitability prior to its fielding. Test and evaluation confirmed that DVH configurations significantly improve crew protection against IEDs and demonstrated the retention or improvement of required operational characteristics. Relative to flat-bottom Strykers, Stryker DVH remained equally mobile and capable of supporting a unit's ability to accomplish a mission, while providing improved reliability and maintainability. The results of the test and evaluation program also led to design changes that corrected significant shortcomings in DVH suitability and survivability.

### **Underbody Blast Testing**

DOT&E continues to actively pursue efforts to improve LFT&E employing underbody blast threats. In January 2011, the DoD provided funds to the Army to execute a DOT&E-sponsored five-year research and development program. This program will substantially increase the Department's understanding of the cause and nature of injuries incurred in underbody blast combat events and will develop new instrumentation capable of being

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used to accurately assess such injuries in testing. This program, known as WIAMan (Warrior Injury Assessment Manikin), utilizes expertise across multiple commands and disciplines within the Army to generate a medical research plan from which data will, at pre-determined times, be transitioned to the materiel and test and evaluation communities. These data will feed the design of a biofidelic prototype ATD designed to accurately capture occupant loading from the vertical direction, reflecting the primary load axis to which occupants are exposed in an under-vehicle blast event.

Similarly, as a result of DOT&E efforts, the Army will characterize the performance of a surrogate for the Afghanistan IED threat to enable its use in test, the performance of buried TNT blast threats (current test standard), and the effects of soil composition and condition on full-scale buried test threats. This effort will ensure adequate LFT&E in support of OEF as well as of future acquisition programs.

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