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

DOT&E executed oversight of survivability and lethality test and evaluation for 121 acquisition programs in FY13. Of those 121 programs, 21 operated under the waiver provision of U.S. Code, Title 10, Section 2366, by executing an approved alternative Live Fire Test and Evaluation (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**

- Hellfire Romeo Interim Lethality Assessment
- CH-47F Cargo On-Off Loading System (COOLS) Ballistic Protection System (BPS) Armor Live Fire Test and Evaluation Assessment
- Enhanced Combat Helmet (ECH) Follow-On Live Fire Test and Evaluation Report*
- Live Fire Test and Evaluation Report for the Mk 248 Mod 0 .300 Caliber Cartridge*
- Mine-Resistant Ambush-Protected (MRAP) All-Terrain Vehicle (M-ATV) Underbody Improvement Kit (UIK) Final Live Fire Test and Evaluation Assessment*
- United States Marine Corps Light Armored Vehicle (LAV) with A2 Upgrades Live Fire Test and Evaluation Report*

**DOT&E Reports (with combined OT&E/LFT&E elements)**

- 20 mm Fixed Forward Firing Weapons (FFFW) for the MH-60 Armed Helicopter Weapon System (AHWS) Early Fielding Report*
- Massive Ordnance Penetrator (MOP) Early Fielding Report Phase 2*
- Standard Missile 6 (SM-6) Initial Operational Test and Evaluation Report*
- HC/MC-130J Initial Operational Test and Evaluation Report*
- E-2D Advanced Hawkeye (AHE) Initial Operational Test and Evaluation Report*
- M109 Family of Vehicles Paladin Integrated Management (PIM) Limited User Test Operational Assessment
- CH-47F Cargo On-Off Loading System (COOLS) Operational Assessment (Integrated Test and Live Fire Test)
- KC-46A Operational Assessment #1
- H-1 Upgrades Follow-On Operational Test and Evaluation (FOT&E) Report*
- USNS *Lewis & Clark* (T-AKE) Class of Dry Cargo and Ammunition Ships Follow-On Test and Evaluation Report*

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)
- Funds projects to develop advanced technologies and analytical methods to increase aircraft survivability (Joint Aircraft Survivability Program)
- Conducts vulnerability and lethality testing of fielded platforms and weapons systems and improves survivability analysis tools (Joint Live Fire Program)
- Supports quick reaction efforts addressing urgent operational commander's needs.

## JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS EFFECTIVENESS

The Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) was chartered more than 40 years ago in 1968 to serve as the DoD's focal point for munitions effectiveness information. They produce Joint Munitions Effectiveness Manuals (JMEMs), which provide tri-Service approved effectiveness data for all major non-nuclear U.S. weapons. JTCG/ME authenticates weapons effectiveness data for use in operational weaponeering, strike mission planning, training, systems acquisition, weapon procurement, and combat modeling and simulation. JTCG/ME also develops and standardizes methodologies for evaluating munitions effectiveness and maintains databases for target vulnerability, munitions lethality, and weapon system accuracy.

The Armed Forces of the U.S., NATO, and other allies use JMEMs to plan operational missions, support training and tactics development, and support force-level analyses. The JMEM requirements and development process continues to be driven by operational lessons learned (e.g., Enduring Freedom, Iraqi Freedom, Odyssey Dawn, and ongoing Task Force operations) and the needs of Combatant Commands, Services, the Military Targeting Committee, and Operational Users Working Groups for specific weapon-target pairings and methodologies.

The primary JMEM application is weaponeering, which is the detailed technical planning of a weapon strike that occurs at multiple levels in the operational chain of command before actual combat. JTCG/ME produces, distributes, and regularly updates JMEMs, which provide computerized effectiveness tools and data for rapid weaponeering, i.e., evaluation of alternative weapons and their delivery against specific targets. In many cases, effectiveness and collateral damage estimates generated by these tools are part of the decision criteria for strikes approved at the highest levels of the U.S. Government.

A formal data call is issued annually via J-2 Joint Staff Action Process to the Services and Combatant Commands. DOT&E sponsors the JTCG/ME and provides an annual budget. The

Director, Army Materiel Systems Analysis Activity chairs the JTCG/ME Executive Steering Committee and oversees the Program Office at Aberdeen Proving Ground, Maryland.

### JMEM TARGETING AND WEAPONEERING SOFTWARE

In FY13, the fielded JMEM Weaponeering System (JWS) version 2.1 (v2.1) software and the JTCG/ME-generated Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3160.01 Collateral Effects Radii (CER) tables were used for operational weaponeering and collateral damage estimation calls in direct support of combat operations in the U.S. Africa Command and U.S. Central Command Areas of Responsibility. JWS is a source for air-to-surface and surface-to-surface weaponeering, munitions, and target information; and 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.


JTCG/ME is developing JWS v2.2, which will contain Fast Integrated Structural Tool updates to include an interface to the Digital Precision Strike Suite Collateral Damage Estimation (DCiDE) tool. JWS v2.2 will also contain new/updated targets, new/updated munitions, trajectory simulation updates, browser updates, and an enhanced viewer. In addition, development is ongoing to support the release of the JWS product to coalition partners. This capability represents a significant improvement to coalition warfare.

The Joint Anti-air Combat Effectiveness System (J-ACE) simulates air-to-air and surface-to-air engagements. JTCG/ME released v5.2 in September 2013. Blue, Red, and Gray air-to-air missile models as well as Red and Gray surface-to-air missile fly-out models are included. J-ACE v5.2 provides an updated missile fly-out model, including hundreds of weapon target pairings and an interface to Enhanced Surface-to-Air Missile Simulation for countermeasures.


J-ACE v5.2 also provides the new Endgame Manager (EM) software and data sets. The EM is a new application that adds missile lethality and target vulnerability. EM allows explicit evaluation of weapon miss distance, fuse performance, weapon lethality, and target vulnerability. EM provides the Probability of Kill given an intercept for the entered mission.

To more effectively support operational mission planning, particularly at U.S. Strategic Command, the J-ACE v5.2 also provides a direct interface to force-level simulations. The fidelity is adequate for studying tactics, training evaluation, relative missile performance, and scenario planning.

### OPERATIONAL SUPPORT TO MISSION PLANNING

In support of mission planning for the Combatant Commands and the CJCSI 3160.01, the JTCG/ME supported the release of DCiDE v1.1 for operational use in FY13. This tool displays JTCG/ME accredited Collateral Damage Estimate effective radii reference tables. Additionally, JTCG/ME provided incremental updates in FY13 for CER values for newly fielded/updated systems (e.g., M1130 Projectile, AGM-65-E2/L, and AGM-176-3/2M).

The JTCG/ME continues to have a Senior Weaponeering Instructor stationed at MacDill AFB with U.S. Central Command, CCJ2-JOT, to support the Combatant Commands. The instructor has deployed on numerous occasions in support of current operations, most recently to provide training to weaponeers and targeteers from U.S. Naval Forces Central Command Bahrain, International Security Assistance Force Joint Command in Afghanistan, a Task Force in Afghanistan, and the 609th Air and Space Operations Center at Al Udeid Airbase Qatar. JTCG/ME trained nearly 250 users at 10 different commands to support real-time, operational Collateral Damage Estimation decisions.

### INFORMATION OPERATIONS TOOLS AND CAPABILITIES

In conjunction with the Air Force Targeting Center, the JTCG/ME has established a working group to develop JMEMs for cyberspace operations. This effort led to the development of a first generation of tools, including the Computer Network Attack-Risk and Effectiveness Analyzer, the Weapons Characteristics Manual, Target Vulnerability Assessments, and the Network Risk Assessment Tool. These capabilities are being incorporated as modules within the Joint Capabilities Analysis and Assessment System (JCAAS), formerly known as Information Operations JMEM. JCAAS is intended to be a single point of access for analysts, targeteers, planners, and others to identify and analyze non-kinetic options for military operations.

## JOINT AIRCRAFT SURVIVABILITY PROGRAM

The Joint Aircraft Survivability Program (JASP) develops techniques and technologies to improve the survivability of U.S. military aircraft. Working with joint and Service staffs, other government agencies, and industry, the JASP funds development of new capabilities and works to assure they are pursued jointly by the Services.

DOT&E sponsors and funds JASP. The Naval Air Systems Command, Army Aviation and Missile Command, and Air Force Life Cycle Management Center charter the program. DOT&E establishes objectives and priorities for the JASP and exercises oversight of the program.

JASP is supporting the Joint Multi-Role Technology Capabilities Demonstration program as a member of the Platform Integrated Product Team. The program intends to demonstrate transformational vertical lift capabilities to prepare the DoD for developing the next generation vertical lift fleet. JASP was a driving force in establishing the assumptions and requirements for the Vulnerability Analysis used in evaluating the initial three government model prototypes.

JASP funded 52 multi-year survivability projects for $9.4 Million and delivered 45 final reports in FY13. The following summaries illustrate current JASP efforts in four focus areas: susceptibility reduction, vulnerability reduction, survivability assessment, and combat damage assessment.

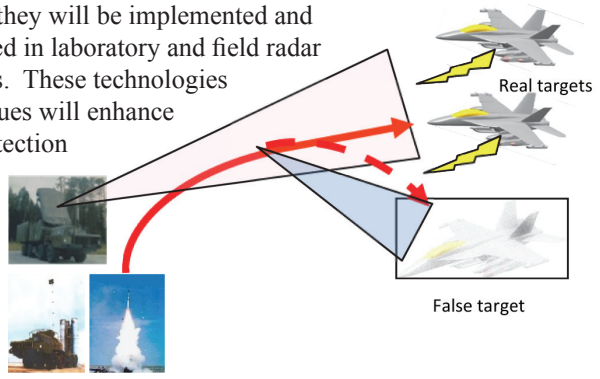
## SUSCEPTIBILITY REDUCTION

These efforts address urgent aircraft survivability needs from current combat operations, as well as provide improved aircraft survivability against future threats.

**Special Threats Investigation and Modeling.** The Naval Research Laboratory is performing an in-depth analysis of newly-obtained threat infrared seekers, which operate in a new portion of the electromagnetic spectrum, to develop flare and jammer countermeasures. The first objective is to develop countermeasure solutions and parametric requirements for flares and jammers to defeat the new missiles. The second objective is to enhance the DoD modeling and simulation tools to support countermeasure analysis in the new band of the electromagnetic spectrum.

**Advanced Pre/Post-Launch Man-portable Air Defense System (MANPADS) Identification.** The U.S. Army Communications-Electronics Research, Development, and Engineering Center/Intelligence and Information Warfare Directorate is developing a methodology for using coded optical waveforms that would allow direct measurement of relative position and reflectivity of optical elements within an optical sight. The system is intended provide the ability to include the unique optical "fingerprint" of the missile seeker. If successful, this technique offers the potential of rapid missile identification, before or after launch, for more effective countermeasures.

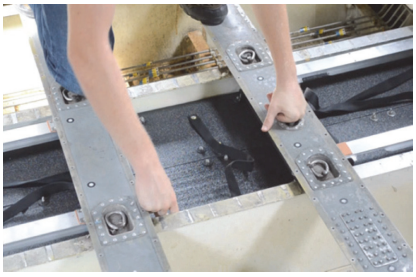
**Multi-Digital Radio Frequency Memory (DRFM) Coherence for Self-Protection and Escort Jamming.** The Naval Research Laboratory is developing algorithms to demonstrate a DRFM jammer pair that operates in concert, but without any link between two independent jammers. Once the algorithms are developed, they will be implemented and demonstrated in laboratory and field radar experiments. These technologies and techniques will enhance the self-protection and support the jamming capability of U.S. military aircraft.



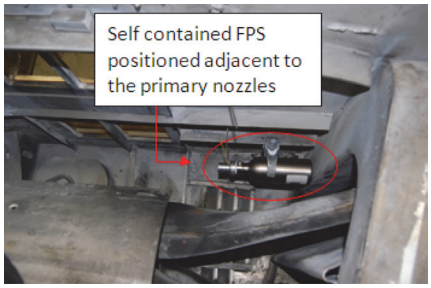

## VULNERABILITY REDUCTION

In FY13, JASP vulnerability reduction projects focused on developing lighter-weight opaque ballistic protection systems, fuel containment and related fire protection technologies, and structures and materials, including composites that are self-healing. Three of the most highly successful projects are highlighted below.

**MH-47 Sub Deck Armor.** The Army Aviation Applied Technology Directorate (AATD), contracting with The Protective Group, completed work on this project during FY13. They developed a non-permanent armor to fit under the floor of the MH-47 helicopter cabin. The goal was to maintain the same minimum level of ballistic protection as the fielded armor, with better durability and less installed weight. Locating the armor under the cabin floor panels greatly reduces the wear and increases its lifespan. The designers also developed an installation and removal system that is lightweight, requires minimal aircraft modification and manpower, and does not interfere with maintenance requirements, mission equipment, or cargo loading systems. The project demonstrated armor panel installation and removal in minutes and achieved a 34 percent reduction in weight over the currently fielded ballistic protection system.

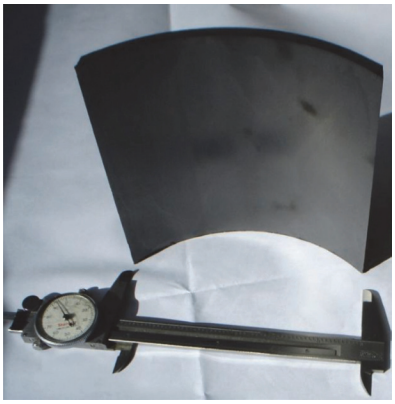


**Self-Contained Fire Protection System (FPS).** The U.S. Air Force 96th Test Group and Engineering and Scientific Innovations, Inc. teamed up to develop self-contained fire protection technology. The system will be lightweight, quick-reacting, and easy to install on aircraft without structural modification to the airframe and without requiring an external power source. The FPS will incorporate



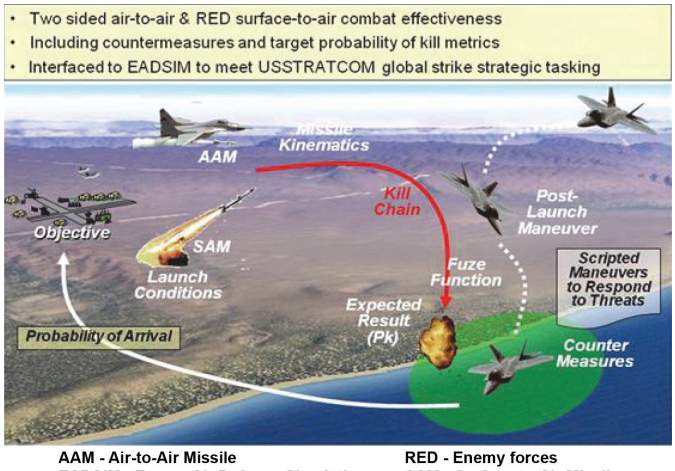
both detection of the fire within 4 microseconds, and suppression within 500 microseconds. In addition, the system will be rechargeable and contained within a single unit.

**Lightweight Conformal Armor.** The United Technologies Research Center (part of the United Technologies Corporation), in coordination with AATD, worked to transition their high impedance ceramic composite backing layer technology from flat armor to conformal (simple curvature) armor. They demonstrated a curved armor technology capable of defeating armor piercing projectiles at a weight savings of 21 percent (over current solutions) and providing suitable protection for objects up to a 7-inch diameter. This solution is most applicable to components such as servos, actuators, and hanger bearings. In addition, the monolithic ceramic-fiber reinforced ceramic matrix composite (CMC) hybrid layering system utilized further enhanced performance and provided additional weight reduction over current solutions. The armor consists of a continuous fiber-reinforced glass-CMC strike face, bonded directly (no adhesive) to a monolithic ceramic, which is in turn directly bonded to a second layer of fiber-reinforced glass-CMC, backed by a final layer of highly cross-linked polyethylene fiber.



## SURVIVABILITY ASSESSMENT

The JASP continues to develop and maintain survivability assessment methodologies from the engineering through the few-on-few engagement levels of analysis. These methodologies are widely used to support system acquisition through design studies; specification development and compliance; and test and evaluation through pre-test predictions, post-test analysis, operational test kill removal, and countermeasure effectiveness assessment.




AAM - Air-to-Air Missile
EADSIM - Enemy Air Defense Simulation
RED - Enemy forces
SAM - Surface-to-Air Missile

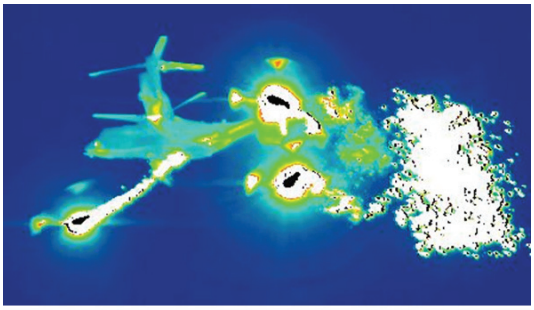
**Suite of Anti-air Kill chain – Models and Data (SAK-MD).** JASP continues to work with the JTCG/ME and the U.S. Strategic Command (USSTRATCOM) to improve the data and methodologies employed by USSTRATCOM to assess options for global strike missions. These assessments are combined with other information at USSTRATCOM into a decision support package that goes to the President to enable strategic power deployment decisions. These tools and data are also used extensively in the Air Force and Navy fighter aircraft community for training and tactics development. The primary FY13 efforts centered on the usability of the SAK-MD software, expanding the EM user base, and subject matter expert reviews of the methodology and data.

**Enhanced Surface-to-Air Missile Simulation (ESAMS) Upgrades.** There were three projects in FY13 to improve the credibility of ESAMS by updating threat system information and conducting verification and validation:

- A multi-year effort by JASP to incorporate the latest surface-to-air missile (SAM) threat system descriptions from the Missile and Space Intelligence Center into ESAMS
- Upgraded modeled threat system radars from analog to digital processing
- Verification and validation of the anti-helicopter mode that was developed for a specific SAM system as a previous JASP effort, which will provide a credible modeling tool for assessing helicopter survivability against radio frequency-guided SAM threat systems.

Radar-guided Surface-to-Air Missile

**Infrared Countermeasure (IRCM) Modeling.** The Naval Surface Warfare Center (NSWC) is developing physics-based models for pyrotechnic and pyrophoric IRCM. These models address combustion, heat, and mass transfer, as well as infrared radiation, trajectory, and spatial extent/image presentation; ultimately providing time-dependent plume or cloud characteristics for use in missile-flare engagement models. Current engagement models, including hardware-in-the-loop simulations, rely on oversimplified inputs that do not have the resolution needed to address the capability of imaging seekers to discern variations within radiation sources.



Infrared Image of V-22 Dispensing Flares

The NSWC is also modernizing the Flare Aerodynamic Modeling Environment (FLAME) and the Tri-Service Flare Database (TFD) software architecture to improve usability, add 3D aircraft flow-fields to FLAME, and develop Linux versions of both tools. The final product will be enhanced versions of both FLAME and TFD that can be run on either Linux or Windows® operating systems. This project will configure FLAME and TFD for distribution through the Survivability/Vulnerability Information Analysis Center (SURVIAC). These projects will enhance the DoD capability to develop countermeasure techniques for advanced infrared-guided missiles.

### COMBAT DAMAGE ASSESSMENT

JASP continued to support the Joint Combat Assessment Team (JCAT) in FY13. JCAT is a team of Air Force, Army, Marine Corps, and Navy personnel deployed in support of combat operations. JCAT continued its operation in Afghanistan 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 the United States.

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 inform battlefield commanders, allowing them to adjust operational tactics, techniques, and procedures (TTPs) based on accurate threat assessments. In FY13, the JCAT had initiated 225 and completed 219 aircraft combat damage assessments.

The JCAT strengthened aircraft combat damage incident reporting in the Services and the DoD. The Combat Damage Incident Reporting System hosted by the SURVIAC is the repository for all U.S. aircraft combat damage reports. JCAT and SURVIAC worked with the Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) and U.S. Central Command on a successful demonstration linking the Combat Damage Incident Reporting System and U.S. Central Command databases to more quickly identify, assess, document, and distribute aircraft combat damage incident data to the Services and DoD. JASP and ODASD(SE) submitted major weapon system combat damage reporting requirement language for the revision of DoD Instruction 5000.02, T&E Enclosure, c.7; and has drafted language for the aircraft combat damage reporting process for inclusion in the Defense Acquisition Guide.

The JCAT trains the U.S. aviation community on potential aircraft threats and combat damage. This training includes but is not limited to: capabilities briefs, intelligence updates, recent "shoot-down" briefs to discuss enemy TTPs, and the combat damage collection and reporting mentioned above. The attendees include aircrews, maintenance personnel, intelligence sections, Service leadership, symposia attendees, and coalition partners. Pre-deployment training was provided to 1,100 aircrew bound for combat duty and another 1,200 survivability community members in professional military education courses and DoD symposia.

## JOINT LIVE FIRE (JLF)

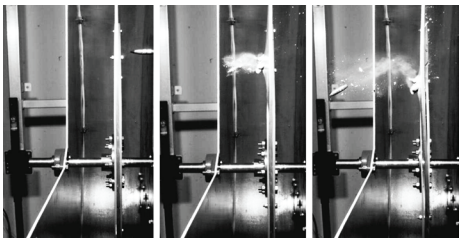
The goal of the Joint Live Fire (JLF) program is to test fielded systems, identify vulnerable areas, understand damage mechanisms, and provide the information needed to make design changes, modify TTPs, or improve analytical tools. The need for these tests results from systems being exposed to new threats; 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 systems against new threats that the requirements community did not anticipate during original development or against old threats employed in new ways. The rocket-propelled grenade (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-aircraft weapon.

### AIRCRAFT SYSTEMS PROGRAM

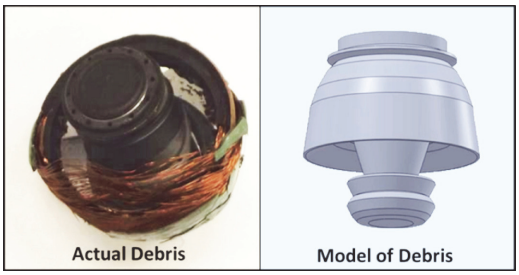
JLF-Air conducted five test series in FY13, with a focus towards collecting blast and penetration data to improve LFT&E assessments through improvements to our vulnerability modeling and simulation capabilities. Data were collected for selected small arms, anti-aircraft artillery, and missile threats.

**V50 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 (COVART) and the Advanced Joint Effectiveness Model (AJEM).



The JLF program executed 76 test events in early FY13. Data were collected for projectile yaw angles of 0, 10, 20, and 30 degrees. Test fixture limitations prevented testing of yaw angles greater than 30 degrees. The Army Research Lab (ARL) is currently analyzing data, and will compare results to pre-test predictions.

**MANPADS Missile Debris Penetration.** This project involves launching MANPADS debris (collected during previous static MANPADS detonations) through a series of aluminum panels, which represent a generic aircraft structure. Collected data will provide model developers insight into the physics of debris threat penetration, and allow an assessment of current penetration methodology.



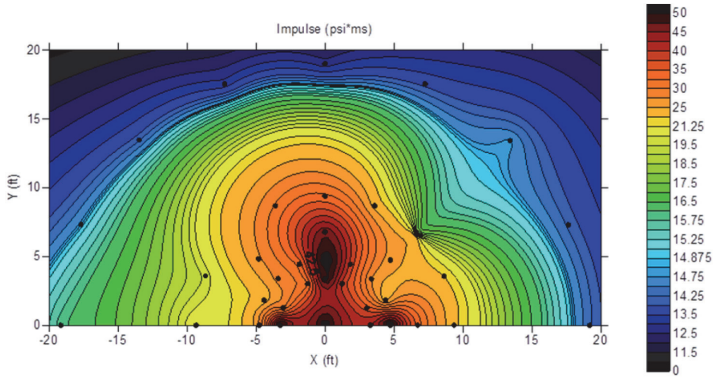

The 30-shot test matrix was completed in September 2013. Testing was executed by Army Research Laboratory (ARL)/ Survivability and Lethality Analysis Division personnel at Aberdeen Proving Ground, Maryland, with Air Force 96th Test Group oversight, and support from Air Force, Army, and Navy model developers.

**Advanced Hit Efficiency and Destruction (AHEAD) Sub-projectile Characterization Testing.** This project is determining the penetration characteristics for a modern anti-aircraft artillery projectile. For the last quarter of a century, rotorcraft vulnerability testing and analyses primarily focused on armor-piercing incendiary (API) and high-explosive incendiary projectiles. However, more advanced threats are being fielded, such as air burst munitions. This project looks at the air bursting AHEAD round and, in particular, the penetration characteristics of its sub-projectiles.

AHEAD sub-projectile

Initial testing started in late FY13 and will continue into FY14. When complete, data from up to 150 shots spread across three obliquity angles and two thicknesses of aluminum will be available for the development of a penetration model to effectively model air burst munitions sub-projectiles, providing an analysis capability presently unavailable for the most commonly used vulnerability codes (AJEM/COVART).

**Non-Spherical Blast Measurement for Missiles.** This project addresses a lack of data needed to understand and characterize non-spherical air-blast pressure distributions produced by missile warheads. Current vulnerability methodologies assume a spherical blast profile, whereas warhead configuration and previous testing indicate blast is non-spherical in nature. Modelers account for this non-spherical nature by increasing the spherical blast pressures by a "fudge" factor, but this may be resulting in over-predicting Probability of Kill due to blast. Vulnerability models are currently incorporating the capability to model non-spherical blast, but data are needed to support those models.




With matching JTCG/ME funding, the first phase of testing completed in late FY13 against a relevant and representative threat air-to-air missile. Testing was at the Air Force Research Laboratory (AFRL) blast pad facility located on Eglin AFB, Florida, where an array of 48 air-blast measurement pressure gages collected the data. Data will be used by COVART, EM, and various JTCG/ME predictive models, which require the free-field characterization of the explosive force. A second phase is planned for FY14, where an additional class of threat weapon utilized by the J-ACE community will be characterized.

**Vulnerability Characteristics of the PT-6A Family of Engines.** This project evaluates the vulnerability of the PT6 turboprop family of engines to ballistic threats and identifies and recommends vulnerability reduction measures. Phase I, conducted in FY13, examined the penetration and damage effects of ball, API, and fragment simulating projectile threats against static engine components to characterize the lower bounds of engine component vulnerability. Test data will be used to validate and expand the previous vulnerability estimates for Probability of Component Damage given a Hit and plan for follow-on testing in FY14 using an operating engine.

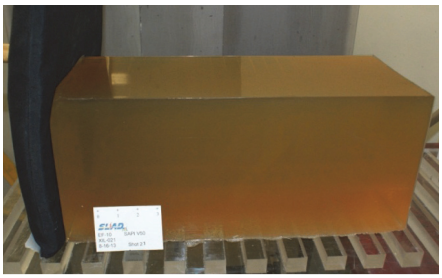
Phase I completed 29 tests (23 planned plus 6 retests) in early FY13 against components from a PT6A-34 engine. Components included gears, bearings, axial rotor, impellor, main shaft/tie bolt, and the fuel control unit. Results varied from no significant effect likely to likely loss of engine power within one minute.

## GROUND SYSTEMS PROGRAMS

**Validation of JTCG/ME Joint Blast Analysis Methodology (JBAM) Tool.** In FY13, ARL conducted testing to support validation efforts for the JTCG/ME JBAM tool. This was a continuation of previous testing efforts conducted over the past few years on both simple plate and full vehicle targets. The FY13 program focused on generating data needed to support the validation efforts for the different plate response algorithms in the JBAM tool. Testers detonated bare explosive spheres at various distances from plates and measured loading on the plates, as well as dynamic and permanent deflections of the

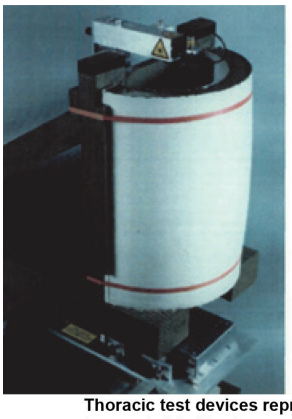
panels. Digital image correlation techniques were used to capture dynamic deflection data. The plate response models in the JBAM tool drive the development of blast lethal volumes that are essential to assess weapons effects on material targets for the JTCG/ME.

**Improved Modeling for Small Arms Protective Inserts (SAPI).** ARL conducted tests of small-caliber rounds against personnel protective equipment Enhanced Small Arms Protective Insert and X-threat Small Arms Protective Insert plates. Data collected from this test program, including V50 (the velocity at which 50 percent of the rounds penetrate the armor plates), residual velocity, and residual mass, will be used to develop better penetration algorithms for vulnerability/ lethality models, and thus to assess personnel survivability.



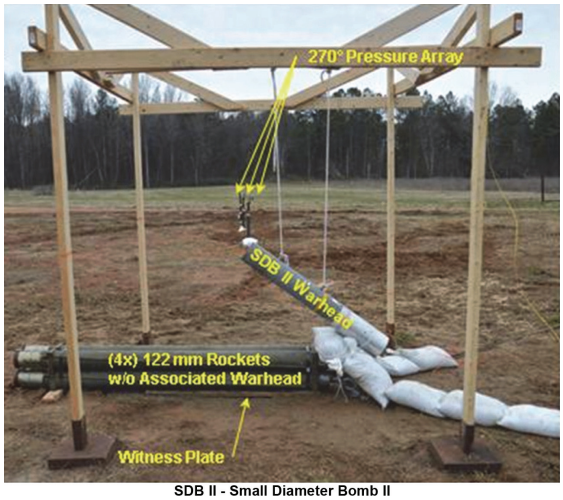
Test setup: Armor Insert with block of ballistic gelatin behind it to capture fragments from any penetrations.

**United Kingdom & Canadian Torso Device Evaluation for Behind Armor Blunt Trauma.** This project quantified and examined the repeatability and reliability of thoracic test devices developed by the United Kingdom and Canada for evaluating behind armor blunt trauma. In order to use the technology offered by these devices for system acquisition, ARL equipped each system with body armor materials and shot at them with ballistic threats. Analysis examined the sensitivity of these devices to evaluate body armor materials from a regime of high and low-velocity impacts. This effort will provide data and in- depth analysis for the body armor community.



Thoracic test devices representing human torso for evaluating blunt trauma behind body armor. (UK version on left, Canadian on right)

**Detonation of Solid Propellant.** This project addresses the inaccuracies in engineering models to predict sympathetic detonation of solid rocket propellant when subjected to non-reactive fragments and shaped charge threats. The Air Force 780th Test Squadron tested the ability of the small diameter bomb warhead to detonate 122 mm rocket motors. The test results were compared with predictions from Sandia National Laboratories' Combined Hydro and Radiation Transport Diffusion Hydrocode by Applied Research Associates. Analysis is ongoing, and is expected to enable further development of concepts and methodologies for enhanced vulnerability, lethality, and survivability in the area of insensitive munitions and non-reactive materials.

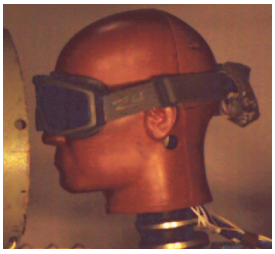



SDB II - Small Diameter Bomb II

**Development of an Engineered Soil Standard for Theater Representation in LFT&E.** The objective of this project is to determine standard parameters for the characterization of engineered soil repeatability, testability, and measurability in LFT&E through a series of sub-scale and full-scale explosive experiments performed by Aberdeen Test Center (ATC) and ARL. Emplacement parameters have been developed for engineered soil to meet roadbed and loose (cross country) emplacement conditions. Fifteen explosive experiments will be conducted at Aberdeen Proving Ground: nine sub-scale at the ARL Vertical Impulse Measurement Facility and six full-scale at ATC's C-field range. The program results will be compared with those of the current DOT&E directive Homemade Explosive Characterization (HME-C) effort, funded by the Army Test and Evaluation Command. ARL has completed nine

sub-scale events. ATC's full-scale testing is underway, utilizing the Army intelligence community's approved HME surrogate developed by the HME-C program. Full-scale explosive experiments will conclude in December 2013.

**Assessment of Ocular Pressure as a Result of Blast for Protected and Unprotected Eyes.** This testing, conducted by ATC, consisted of shock tube testing and free field blast testing using a Facial and Ocular Countermeasure for Safety head form. The primary test objectives were to assess the level of blast protection that goggles and spectacles provide Soldiers during blast events, to quantify pressure levels seen in the ocular region during blast events, and to indicate any design features that could be changed to mitigate effects of blast overpressure and enhance stability of future ocular protection systems. ATC is preparing a final report, which is expected to be published in early 2014.



**Fragment Testing Against Adobe Walls.** NSWC, Dahlgren, Virginia, conducted a series of tests with fragment replicas fired against adobe walls to obtain depth of penetration and/or residual speed and weight. This collected information will be utilized to improve the fragment penetration methodology, Fast Air Target Encounter Penetration. The improved Fast Air Target Encounter Penetration methodology will in turn be utilized to calculate protection provided by adobe walls to support collateral damage and lethality estimates in current theaters.

## SEA SYSTEMS PROGRAM

The Joint Live Fire Sea Systems Program (JLF-Sea) funded projects to improve 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-U.S. Cooperative KATANPÄÄ Shock Trials.** In June 2013, the Finnish Navy and U.S. Navy jointly conducted a series of shock tests against the newly acquired Finnish mine countermeasure vessel KATANPÄÄ. In addition to JLF-Sea, U.S. sponsors of the trial were the Naval Sea Systems Command Chief Technology Office, the Program Executive Office for Littoral Combat Ships, and the Navy International Program Office. Of particular interest to JLF-Sea were Navy efforts to reduce the cost of shock trials. A new instrumentation scheme that used existing network connections to connect each recording station was proposed and demonstrated. The approach significantly reduced ship availability time required to install and remove the instrumentation suite, in addition to substantially reducing the amount of cable required and the number of bulkhead and deck penetrations.

**Bomb Scalability Tests.** This project conducted an experimental evaluation of a foreign asymmetric threat weapon at half-scale. Data collected from the test series are being combined with quarter-scale data collected in an FY12 evaluation for the Office of Naval Intelligence to better understand the characteristics of this threat. Parametric studies are also being conducted to investigate the effects of changing several of the warhead-design variables in order to assess the range of lethal effects.

**U.S. Coast Guard 41-foot Utility Boat Vulnerability Model.** This project developed a target vulnerability model for the U.S. Coast Guard 41-foot utility boat, which is being taken out of service. The Coast Guard has made a number of these boats available to the Navy as targets representing fast-attack craft. JLF-Sea funded NSWC, Dahlgren, to develop a target geometry model for the boat and to develop the failure-analysis logic tree and failure mode effects analysis. Once approved by the JTCG/ME, the model will be made available to acquisition programs with testing requirements against fast-attack craft.

**Sea Bottom Underwater Explosion Effects Testing.** The latest project agreement between the U.S. Navy and German Navy continues development and validation of simulation tools for assessing ship survivability against various explosive threats. In FY12, JLF-Sea provided funding to conduct underwater explosion testing for charges located on the bottom and near the bottom to quantify the loading environment near the bottom, in the middle of the water column, and at keel depth for floating structures. In FY13, the test results were analyzed to better understand the test pond bottom characteristics, explosion bubble migration, and shock loading. This project effectively leverages a joint U.S./German investment of nearly $20 Million and provides data to increase the fidelity of models and the accuracy of survivability assessments, as well as addresses fleet urgent operational needs.

## LFT&E SPECIAL INTEREST PROGRAMS

### PERSONNEL PROTECTION EQUIPMENT

DOT&E continued oversight of personnel protection equipment testing. The Services and U.S. Special Operations Command continue to implement the DoD testing protocols for hard body armor inserts and military combat helmets. The Defense Logistics Agency has utilized the hard armor testing protocol in new contracts for sustainment stocks of hard armor inserts, and included the military combat helmet protocol in its solicitation for the Light Weight Advanced Combat Helmet (ACH). The DoD Inspector General conducted a Technical Assessment of the ACH, with a focus on first article test standards. The DoD Inspector General also initiated a follow-up audit to its 2009 audit of hard body armor testing requirements. The ACH Technical Assessment found that the protocol adopted a statistically principled approach and an improvement with regard to the number of helmets tested, and made recommendations to improve the protocol. DOT&E agreed to implement the recommendations.

The National Academy of Sciences' Committee on Review of Test Protocols Used by the DoD to Test Combat Helmets began its work in January 2013. DOT&E has asked the National Academy of Sciences to review the military helmet test protocols and to evaluate the appropriate use of statistical techniques, the performance metrics, and the adequacy of current test procedures to determine the protection current helmet performance specifications provide. The committee will also comment on considerations for efficient scoping of future helmet characterization efforts. This study is expected to be complete by March 2014.

The Army and U.S. Special Operations Command have developed multi-sized headforms as potential replacements for the single-sized headform currently used for military combat helmet testing. Initial characterization testing should begin in FY14.

### WARRIOR INJURY ASSESSMENT MANIKIN (WIAMan)

DOT&E continued its oversight of the WIAMan project, an Army-led research and development effort to design a biofidelic prototype anthropomorphic test device (ATD) specifically for underbody blast testing. In FY13, the project underwent significant restructuring to address delays in execution and to streamline management and funding lines. The Army Research Laboratory, under the Research, Development, and Engineering Command, is now the home of the newly-formed WIAMan Project Management Office (PMO), which is responsible for execution of all parts of the project, including medical research and ATD development. Currently, the PMO projects that delays from prior fiscal years will push the delivery of the prototype ATD by approximately 12 – 16 months, out to 2018.

While under PMO oversight, execution of the medical research associated with WIAMan has been transitioned from the Army to the Johns Hopkins University Applied Physics Laboratory. Most of the extramural medical researchers have had test plans approved by the PMO and several have initiated body region-specific research activities.

A key programmatic accomplishment in FY13 was the completion of an initial series of experiments, which conducted paired-comparison tests to determine the differences in response between a human and an ATD in an explosively-driven, LFT&E-representative environment. This test series utilized a unique fixture, purpose-built for the WIAMan program, which allows the use of small amounts of explosive to fine-tune loads imparted to occupants seated on a platform on the fixture. This test series demonstrates a stark difference in the kinematic response of a human when compared to that of an ATD in an underbody blast environment, to the point where the loading recorded by the ATDs is likely not representative of actual loads to a person during the course of such an event. These differences highlight the critical need to continue this type of work in order to enhance the DoD's understanding of the human response to the underbody blast environment. Such knowledge will form the basis for significantly improving underbody blast LFT&E capabilities and building better, more protective vehicle platforms for our Soldiers, Sailors, Airmen, and Marines.

### SMALL BOAT SHOOTER'S WORKING GROUP

Small boats represent a growing threat class to ships operating in littoral waters. They have been identified as a required class of targets within a wide variety of tactical missile, rocket, and gun weapon programs under DOT&E oversight, including 25 mm, 30 mm, and 57 mm ammunition; Hellfire, Joint Air-to-Ground, Evolved Sea Sparrow, and Rolling Airframe missiles; and Small Diameter Bomb II; as well as for ships such as the Littoral Combat Ship and the DDG 1000. The target sets, evaluation approaches, and test methodologies for these targets vary widely from program to program.

In an attempt to coordinate across these interests, DOT&E sponsored the second Small Boat Shooter's Working Group on August 29, 2013, hosted at the NSWC, Dahlgren. Fifty-nine weapon system operators, weapons designers, and evaluators met to discuss the nature of the small boat threat, the availability of targets and lethality models representing those threats, and the data collection, test techniques, and instrumentation that have been applied to tests against small boats. Threat experts suggested the inclusion of larger patrol boats such as the CG-41 (being phased out by the Coast Guard), and evaluators encouraged the development of small, easy-to-place "in-situ" camera and overpressure measurement packages on the boats in order to better observe and record the types of damage to target boats during fleet weapons tests.

### COMBAT DATA ANALYSIS

The conflicts in Afghanistan and Iraq have resulted in a large number of rotary-wing aircraft hit by enemy fire resulting in aircraft losses and personnel casualties (fatalities and injuries).

# LFT&E PROGRAM

In 2009, Congress directed the DoD to conduct a study on rotorcraft survivability with the specific intent of identifying key technologies that could help reduce rotary-wing losses and fatalities. However, since non-hostile and non-combat mishaps accounted for more than 80 percent of the losses and 70 percent of the fatalities, conclusions from the 2009 study are more heavily weighted towards preventing mishaps than surviving direct combat engagements. This year, DOT&E analyzed combat damage to the four primary U.S. Army helicopters (AH-64 Apache, H-47 Chinook, H-60 Blackhawk, and OH-58 Kiowa Warrior) to provide insight on the threats (including small arms, MANPADS, and RPGs), aircraft components and systems, and operational conditions that led to the loss or damage of aircraft and personnel casualties. Additionally, combat damage to these four helicopters was compared to live fire testing to determine if any changes need to be made in how live fire test programs are conducted.

Conclusions from this study showed:

- Analyses of combat damage have led to multiple hardware and TTP changes, some of which have already been instituted by the Army, such as the installation of the AN/AAR-57 Common Missile Warning System.
- Results of LFT&E provide good predictors of the types of damage seen in combat.
- The primary causes of threat-induced fatalities and injuries were--
  - The threat directly hitting personnel
  - Catastrophic crashes (i.e., crashes where there are no survivors) caused by the threat hitting a component, which subsequently caused loss of control of the helicopter.

DOT&E made recommendations to the Army to improve design requirements for all helicopters to make them similarly robust to those of the Blackhawk and Apache and to implement existing vulnerability reduction technologies to improve the survivability of all the Army helicopters. DOT&E also made a recommendation to the DoD to institutionalize combat data collection and reporting to avoid losing the capability to collect and analyze this valuable information. DOT&E staff have briefed the results of this study to senior Army leaders, and the Army is using the study to make informative decisions on its future aviation enterprise. A parallel effort for the Navy and Marine Corps helicopters (i.e., H-1, V-22, and H-53) will be conducted next year.