# Live Fire Test and Evaluation Program

## EXECUTIVE SUMMARY

U.S. Code Title 10, Section 2366, requires realistic survivability testing of major conventional air, land, and sea platforms and realistic lethality testing of major munitions and missile systems. Title 10, Section 139, states that the Director, Operational Test and Evaluation (DOT&E) shall monitor and review the Live Fire testing activities of the Department of Defense provided for in Section 2366. Section 139 requires the Director to prepare an annual report summarizing the operational test and evaluation activities (including Live Fire testing activities) of the Department of Defense during the preceding fiscal year. This section of the DOT&E Annual Report to Congress satisfies that requirement.

LFT&E survivability assessments emphasize personnel injury with the goal of providing sufficient data and analysis to affect system design and or tactics, techniques, and procedures to prevent or minimize injuries. LFT&E encompasses testing and evaluation throughout the acquisition cycle of a system, typically leveraging contractor, developmental, and operational testing. Early identification of ballistic vulnerability deficiencies allows time to affect design trades and make changes before systems reach their final configuration. If it is impractical and unreasonably expensive to conduct tests against a fully operational system, a waiver provision exists within Section 2366 allowing for DOT&E to approve an alternative approach for completing LFT&E. Strategies for completing LFT&E without full-up system-level testing rely more heavily on early component and subsystem-level testing, as well as significant leveraging with validated and accredited modeling and simulation.

In addition to satisfying acquisition program oversight requirements (Section 2366 of Title 10), the LFT&E program funds and exercises technical oversight of investment programs for developing joint munitions effectiveness data; development of advanced technologies and analytical methods to increase aircraft survivability; vulnerability test and evaluation of fielded air, land, and sea platforms; and munitions lethality testing. Specifically, LFT&E investment programs enabled DOT&E to respond to these warfighter needs in FY06:

- **Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME).** This group publishes weapon effectiveness manuals that enable the warfighter's weaponeering process. The JTCG/ME is also instrumental to the development of improved and validated collateral damage estimation tools urgently requested by mission planners in Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF). DOT&E oversight of the JTCG/ME and its connection to acquisition programs ensures that weapons effectiveness data are available to warfighters when the Services field new weapons.
  - In support of increasing combined and coalition operations in OEF and OIF, the JTCG/ME published a revised Joint Munitions Effectiveness Manual that integrates air-to-surface with surface-to-surface weapons effectiveness data. The manual also incorporates updated and improved weaponeering tools to provide a single product for warfighter use.
- **Joint Aircraft Survivability Program (JASP).** The JASP serves as the Department's focal point for aircraft survivability, establishing survivability as a design discipline, and furthering the advancement of aircraft survivability by investing in development and implementation of new technologies.
  - The Joint Combat Assessment Team (JCAT) of the JASP continued its deployment to OIF in direct support of the 2nd and 3rd Marine Air Wings, expanding its support role to the Army's Aircraft Shoot-Down Assessment Team and to the Combined Explosive Exploitation Cells. JCAT uses data gathered from combat, threat exploitation, and Live Fire testing to provide combat commanders information to influence mission planning and tactics.
- **Joint Live Fire (JLF).** The Office of the Secretary of Defense (OSD) established the JLF program in 1984. JLF is a formal program to test and evaluate fielded U.S. systems against realistic threats. The program places emphasis on addressing urgent needs of deployed forces, testing against emerging threats, and assisting acquisition programs by testing legacy systems and identifying areas for improvement. DOT&E funds, establishes goals and priorities, and oversees the efforts of the JLF program.
  - During FY06, JLF continued its support to the Joint Improvised Explosive Device (IED) Defeat Organization and to deployed forces through extensive characterization of improvised explosive munitions. JLF leveraged intelligence information to conduct testing in a manner representative of threat conditions experienced by deployed coalition forces. Characterization of threat weapons is a fundamental step in designing countermeasures to defeat them.

In addition to the above-mentioned efforts, each of these investment programs has elements that contribute directly to warfighters engaged in OEF and OIF. Examples of such direct support include:

- Updated collateral damage estimation tools with sufficient accuracy to allow local theater commanders to approve strike missions

- In-theater aircraft battle damage assessment training of maintenance personnel
- Characterization of fragmentation and blast effects of emerging threat weapons such as foreign unguided rockets and buried, multiple-IED clusters

The JTCG/ME, JASP, and JLF programs described above are formal programs funded by DOT&E. In addition to these programs and its statutory oversight responsibilities, DOT&E participates in several focused initiatives that directly support warfighters deployed to OEF/OIF. These efforts are described in the Quick Reaction section below.

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In FY06, DOT&E executed oversight of 106 LFT&E survivability and/or lethality acquisition programs. LFT&E published the MH-60R Multi-Mission Helicopter Beyond Low-Rate Initial Production Report. DOT&E also supported quick-reaction efforts in FY06, including Congressional inquiries, and managed several survivability and lethality technology investment programs.

## QUICK REACTION

### Joint Improvised Explosive Device Defeat Organization (JIEDDO)

DOT&E continued to support the JIEDDO through participation on the Joint Test Board. DOT&E continues to fund IED and military operations in urban terrain (MOUT) test programs. The Joint Test Board coordinates and synchronizes IED test and evaluation events across the Services to maximize utility and reduce redundancy. The Joint Test Board maintains a classified web-based database of IED defeat systems that have been tested, are under test, and those to be tested. The database also contains capabilities and limitations reports on platform survivability for systems that are fielded in OEF/OIF. An extensive FY06 task for the Joint Test Board was the production of test protocols for counter-IED testing. These protocols apply to all the Services and private agencies conducting testing and assessment of counter-IED systems and help to ensure the standardization of test processes, enabling accurate comparison of potential solutions.

### Blunt Impact Testing of Fielded Combat Helmets

On June 20, 2006, the House Armed Services Committee requested the Department conduct testing on the currently fielded Marine Lightweight Helmet and the Army's Advanced Combat Helmet. The Committee was concerned about the blunt impact protection afforded Service members by each of the helmets, and specifically the difference in blunt impact protection between the suspension systems within each of the helmets. The Marine Lightweight Helmet utilizes a sling suspension system, whereas the Army helmet uses a pad system, similar to that of commercial bike and sport helmets. The premise of the Committee was that the padded system used by the Army provided enhanced blunt impact protection over that provided by the Marine Lightweight Helmet. USD (AT&L) and DOT&E partnered with the Army and the Marine Corps to plan, fund, and execute a test program to provide the data necessary to address the Committee's concerns. DOT&E chose the Army's Aeromedical Research Laboratory (USAARL) at Fort Rucker, Alabama, to conduct the independent testing based upon their expertise in helmet testing and because they conducted blunt impact testing of the Army Advanced Combat Helmet during its development and acquisition. DOT&E prescribed that the same test standards used for the prior Advanced Combat Helmet testing be duplicated for this effort to allow direct comparison of test data and to ensure that the two helmets could be assessed side-by-side. Fort Rucker, Alabama, initiated testing in mid-August 2006 and completed testing in September. DOT&E and USAARL is scheduled to complete data reduction and analysis in December 2006. DOT&E and USD (AT&L) will assess the data and present a report to the Committee in early 2007.

### Tactical Ground Vehicle Up-Armoring

DOT&E continues to monitor and support the Army's up-armoring efforts. This critical program addresses urgent armoring needs of deployed forces and new acquisition programs through aggressive testing of potential tactical ground vehicle armor solutions. Lessons learned through both ballistic testing of armor solutions and follow-on limited operational testing of up-armored systems has led the Army to develop a Long Term Armoring Strategy (LTAS). The LTAS provides for a building-block approach to meet warfighter needs depending on the threat environment encountered. The strategy is founded on the principal that new production ground vehicles will incorporate sufficient chassis strength to accommodate chassis-mounted and bolt-on armor packages, will include armor in areas not easily accessible once the systems are fielded, and will include mounting brackets to easily accept bolt-on armor packages. This baseline package is termed A-Kit and will be the standard on all future ground tactical vehicles. The bolt-on armor packages are termed B-Kit. B-Kits will be threat-specific armor packages that can be installed in-theater or prior to deployment. DOT&E encourages the Army and the Marine Corps to work together to ensure that acquisition programs for all future ground tactical vehicles adopt the LTAS armoring approach.

As noted in last year's report, test infrastructure limitations at Aberdeen Proving Ground, Maryland, restricts the Army's ability to conduct realistic operational testing of up-armored vehicles. Specifically, the Army lacks a high-speed vehicle test track to demonstrate the safety, compatibility, reliability,

durability, and maintainability of up-armored vehicles when operated at high speeds consistent with current OIF tactics, techniques, and procedures. Since last year, the Army completed 35 percent of the design for the test track, received site approval for construction, appropriate wetlands permits from the state and federal governments, an aeronautical waiver, and has completed the safety site plan. Congress appropriated $8.8 Million in FY07 for the high-speed test track. DOT&E continues to support the Army's effort to develop the much-needed capability of a high-speed test track at Aberdeen Proving Ground.

**Small Caliber Rifle Cartridge Lethality**

DOT&E continued its participation in an ongoing joint investigation of the wounding potential of small caliber, off-the-shelf cartridges. The investigation team is seeking an increase in lethality over the currently fielded M855 cartridge against the lightly clothed enemy that deployed forces are encountering. In parallel with this effort, DOT&E is supporting a Joint Service Wound Ballistics Integrated Product Team to standardize small caliber lethality testing and assessment. The joint team completed the first phase of testing in FY06 and expects to publish their report during FY07.

**Personnel Body Armor**

DOT&E examined the root cause of inconsistencies in personnel body armor effectiveness estimates and found that personnel body armor test facilities use different qualification test procedures. Though this effort was planned for completion in early calendar year 2006, it was extended due to the need to test additional promising test-article mounting techniques that were introduced late in the effort. In addition, several key participants were fully engaged with more pressing issues during this reporting period, thus delaying this effort. During late FY05 and throughout FY06, DOT&E, the Army, and the Marine Corps co-sponsored a series of body armor tests to identify and select the best soft body armor qualification test procedure. The Army and Marine Corps have agreed to incorporate the testing methodology selected by this group in future soft body armor requirements. A final alternate test method underwent testing in 4QFY06. Analysis of the data concluded in November 2006, after which the group selected the best test method. The Army's Aberdeen Test Center is writing the Test Operating Procedure that will become the Department's standard for soft body armor testing. Presently, the Department utilizes a National Institute for Justice (NIJ - part of the Department of Justice) standard for soft body armor testing. The NIJ, as well as other government and private industries, are participating in this effort and have tentatively agreed to use the new standard developed from this effort.

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

The Joint Logistics Commanders chartered the JTCG/ME in 1968 to ensure development of consistent, credible effectiveness estimates for conventional munitions across the DoD. The primary application is weaponeering, the detailed technical planning of a weapon strike that occurs at multiple levels in the operational chain of command before actual combat application. The JTCG/ME produces, distributes, and regularly updates Joint Munitions Effectiveness Manuals (JMEMs). JMEMs provide the warfighter with computerized operational tools and data for rapid evaluation of alternative weapons and their delivery against specific targets. JMEMs help the warfighter effectively accomplish mission objectives, while considering collateral damage, and are critical enablers to the warfighter's weaponeering process.

The JTCG/ME prioritizes its efforts based on annual Joint Staff (J-8) data calls, the Munitions Requirements Process, the Military Targeting Committee, and Operational User's Working Groups. This process ensures focus on the highest priority data for current and future operations.

In FY06, the JTCG/ME addressed collateral damage estimation techniques in response to critical combatant commanders' requirements. They accredited and published a revised methodology in accordance with new Chairman, Joint Chiefs of Staff policy (CJCS memo 3160.01A). They then automated this methodology and fielded it in the Joint Advanced Deep Operations Coordination System used to support current operations.

The JTCG/ME continued to convert JMEMs from a weapon-centric weaponeering tool to one that is target-centric. Joint Staff, mission planners, and weaponeers throughout the combatant commands have identified target-centric JMEMs as a critical priority. In support of increasing combined and coalition operations, the JTCG/ME developed and released JMEM Weaponeering System (JWS) CD-ROM v1.1 (1,250 copies to 850 accounts) that provides air-to-surface and surface-to-surface weaponeering tools. In addition, the JTCG/ME also released the Joint Anti-Air Combat Effectiveness Air Superiority CD-ROM v3.2 (250 copies to 210 accounts). This JMEM supports the community of fighter pilots concerned with the air superiority mission. These releases provided weapons effectiveness data to warfighters for high-priority weapon-target pairings.

The JWS CD-ROM v1.1 release provided the operational community with updated and accredited Collateral Damage Estimate Effective Miss Distance reference tables and methodology. These tables were also automated in the Joint Advanced Deep Operations Coordination System and Fast Assessment Strike Tool-Collateral Damage tools. These accredited tables and operational tools supported the Military Targeting Committee-sponsored Collateral Damage Effects Analysis of Alternatives.

## JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The Joint Aeronautical Commanders Group (JACG) established the JASP by charter in January 2003, integrating the efforts of four separate activities (the JTCG on Aircraft Survivability, the Joint Live Fire Aircraft Systems program, the Joint Combat Assessment Team, and the Joint Accreditation Support Activity). The JASP is sponsored and funded by DOT&E and is chartered by the Naval Air Systems Command, Army Aviation and Missile Command, and Air Force Aeronautical Systems Center. DOT&E establishes program objectives and priorities for the JASP as well as exercising oversight of the program.

The JASP focuses on establishing aircraft survivability as a design discipline and furthering aircraft survivability research, development, test, and evaluation. The JASP:

- Develops vulnerability and susceptibility reduction technologies
- Provides and enhances standard models to assess aircraft survivability
- Supports combat survivability education
- Collects combat damage data for analysis

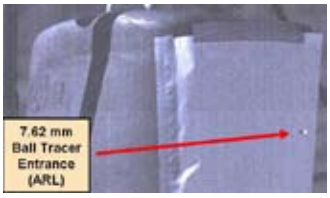
In FY06, the JASP worked with the defense acquisition community, the Department of Homeland Security, the Federal Aviation Administration, the Transportation Security Administration, and the National Aeronautics and Space Administration to identify critical issues regarding aircraft survivability. Accordingly, JASP funded approximately 60 multi-year survivability projects for $9 Million and delivered 49 technical reports in FY06.

**Vulnerability Reduction:**

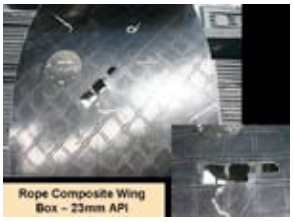
- Man-Portable Air-Defense Systems (MANPADS). This project demonstrated the kinetic energy and detonation effects of a MANPADS impact on a CF6-50 engine. JASP funding enabled the coupling of commercial hydrocode software that replicated the actual damage from the impact to an operating engine model. This JASP approach is an innovative means of predicting MANPADS damage effects for LFT&E and vulnerability reduction design.

  As part of the MANPADS Miss Distance Project, the project team collected video imagery of over 100 MANPADS missiles to triangulate miss distance as a function of missile type and provided those data to JASP and the Army Program Manager for Aircraft Survivability Equipment.

- Ballistic Evaluation of Projectile Tracer Ignition. The Army Research Laboratory completed Live Fire testing to investigate the potential of aircraft fuel cell ullage ignition due to the tracer element on a variety of projectiles. The 18 test events conducted during the evaluation established the potential for fuel cell ullage ignition due to the tracer.

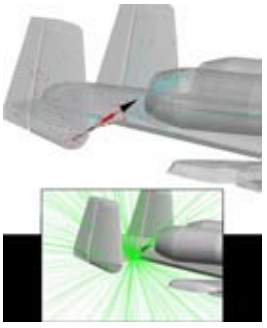



- Ballistic Testing on Unmanned Aerial Vehicle (UAV) Wings. The 46th Test Wing completed the ballistic evaluation of UAV wing panels and spar sections as part of the UAV Hydrodynamic Ram Mitigation project. The testing determined the fuzing and incendiary characteristics of various high explosive incendiary and armor piercing incendiary projectiles on the distinctive, light structure of a typical unmanned system.




**Survivability Assessment:**

- The JASP completed a project to identify and correct errors in the ignition portion of the Fire Prediction Model. This task used an independent subject matter expert review to assess the validity and applicability of the Fire Protection Model algorithms. Engineers gathered test data from ongoing C-5 and F-35 Live Fire testing and several tests specific to this effort. A related JASP effort is underway to collect all existing information on the Fire Protection Model verification, validation, usage history, and accreditations to develop an Accreditation Support Package and long-term Configuration Management Plan for the Fire Protection Model.
- The JASP is co-funding an effort with the Army to obtain experimental data to support the development of an Army structural-response-to-blast model and to validate an Air Force model that predicts blast overpressure loads on various structures. These tools are being developed as modules that software developers can easily integrate into system-level vulnerability/lethality codes. The first phase of this project collected data on helicopter tail booms. The second phase of this project will collect data on typical aircraft structures as found in modern fixed wing aircraft, as well as rotary wing aircraft.



- Responding to a high priority need from the Joint Combat Assessment Team, the JASP developed and fielded an automated Damage Assessment Tool in four months. The personal computer-based tool provides a three dimensional geometric representation of a threat weapon fragmentation pattern on an aircraft. With this tool, the JCAT is able to more quickly determine the threat that engaged an aircraft and assess the resulting effects. There is also considerable interest in using the tool for planning and predicting Live Fire test events. The JASP continues to update the tool's data set and capability to address JCAT requirements.

- The JASP successfully merged two divergent versions of the Enhanced Surface-to-Air Missile Simulation (ESAMS). ESAMS supports system design for survivability and tests for specification compliance, developmental and operational testing, training system simulations, and mission planning systems.

**Susceptibility Reduction:**
The JASP is at the forefront of susceptibility reduction technology efforts through relevant projects and coordination of technology development.

- Reduced Optical Signature Emission Solution (ROSES) addresses an Army requirement for flares that minimize the illumination of aircraft as they dispense. The JASP community developed and tested several advanced infrared decoy flares this year, leading to an Acquisition Decision Memorandum that will immediately help the warfighter.
- This year the Common Service Exciter (CSE) completed development and demonstration of a jammer exciter based on commercial Field Programmable Gate Array technology. This capability promises a significant improvement in instantaneous bandwidth and signal fidelity over current technology. The goal of this joint Air Force/Navy project is to provide U.S. forces with an increased capability to effectively jam advanced radars with parameter agilities. The CSE has proven so effective, the Navy has already transitioned a prototype version into fleet training assets.
- Efforts to advance directed energy infrared countermeasures (DIRCM) technologies continue with completion of several projects this year. One project is addressing the high cost of DIRCM systems by implementing two methods for a low cost laser tracker system. The first method modifies a currently fielded U.S. infrared missile seeker and has the potential to significantly lower the pointer tracker cost. A second method, using fiber bundles, promises even greater cost reductions and improved reliability since there are almost no moving parts. The Navy has already programmed this missile seeker technology to transition into the next generation of DIRCMs.

## JOINT COMBAT ASSESSMENT TEAM (JCAT)

The Joint Combat Assessment Team continued its deployment to OIF in FY06 in direct support of the 2nd and 3rd Marine Aircraft Wings. JCAT continued to expand its reach and presence in theater by assisting the Army's Aircraft Shoot Down Assessment Team (ASDAT) and Combined Explosive Exploitation Cell (CEXC) on 60 Army rotary wing incidents. JCAT accomplished this by inspecting damaged or destroyed aircraft, acquiring available maintenance documentation, and conducting interviews with aircrew and intelligence personnel. JCAT provided consultation to weapons, tactics, and logistics personnel and provided comprehensive briefings to commanders in charge of daily air operations. These efforts provided valuable information to commanders allowing them to adjust their tactics, techniques, and procedures based on accurate threat assessments. All JCAT assessment reports are archived in the Survivability/Vulnerability Information Analysis Center.

In a second effort, JCAT provided combat forensics training to maintenance personnel in theater who directly work on battle-damaged aircraft. This increased the JCAT's effectiveness by allowing the maintainers to provide battle damage data to the JCAT for assessment when the team was unable to reach an incident site before the maintenance crew initiated repairs.

## JOINT LIVE FIRE (JLF)

The Joint Live Fire (JLF) program consists of three groups: Aircraft Systems (JLF/AS), Armor/Anti-Armor (JLF/A/AA), and Sea Systems (JLF/SS). Following are a few examples of projects funded by JLF.

### Aircraft Systems Program

JLF/AS FY06 projects provided survivability data on currently fielded U.S. aircraft in order to obtain a better understanding of their vulnerability and identify ways to reduce that vulnerability. These efforts provided information to aid in combat mission planning, increased aircraft and aircrew combat survival and effectiveness, and provided battle-damage assessment repair training and design recommendations to reduce the ballistic vulnerability of current and future U.S. aircraft.

**OH-58D Kiowa Warrior.** JLF/AS initiated testing on OH-58D Kiowa Warrior components and subsystems to address damage suffered by this class of helicopters in OEF/OIF. The program included gunfire tests versus cockpit components, fuel system components, and main and tail rotor components to obtain a basic understanding of the potential for subsystem degradation/disablement and system kills.

**A-10 Warthog.** The A-10 wing and fuselage dry bay foam, installed to reduce the potential for fire, was changed to increase affordability and maintainability. JLF/AS tested the new dry bay

foam with a combination of airflow and ballistic weapon testing. The A-10 program office consulted on weapons, tactics, and logistics to provide comprehensive, tactical information to optimize the test setup conditions. Test results indicate the new foam does not reduce platform survivability, nor does it increase maintenance procedures.

**CH-53E Super Stallion.** JLF/AS completed the third year of a multi-year investigation into the vulnerability of the CH-53E platform. In FY04, JLF/AS conducted tests against CH-53E rotor and drive subsystems under flight-representative dynamic loads. In FY05, JLF/AS used those tests to perform post damage-operating endurance testing on dynamic components to evaluate the reduction of dynamic flight-load capability. In FY06, JLF/AS conducted testing on the CH-53E fuel systems to evaluate potential fire and explosion vulnerabilities. In addition, this testing demonstrated new fuel system vulnerability reduction technologies. These efforts contribute to the Navy's efforts to reduce the vulnerability of the fielded CH-53E, as well as identifying areas to improve the new CH-53K.

**UH-60 Black Hawk.** JLF/AS completed tests to evaluate UH-60 dry bay foam alternatives and the improved durability gearbox run-dry capability. The program included gunfire tests and controlled damage experiments. The results of these projects are applicable to all tri-Service H-60 aircraft and to future production variants, including the Army's UH-60M model and the Navy's MH-60R and MH-60S.

**Enhanced Powder Panel Validation.** The JASP began investing in powder panel development in the early 2000's with the goal of developing an advanced passive fire extinguishing technology. Enhanced powder panels offer significant improvement in passive fire extinguishing and provide a reliable and low-maintenance means of fire mitigation for aircraft dry bays. Baseline testing of these panels demonstrated their ability to increase powder release, provide better powder dispersion over longer periods, and provide greater design flexibility. JLF/AS completed effectiveness testing and is currently conducting flight certification testing of this technology. Once completed, it can be available to retrofit current aircraft.

**Predator.** Phase I, completed in FY05, investigated component-level vulnerability testing of two different UAV engine types, a gasoline engine and a heavy fuel engine. Phase II, completed in FY06, investigated component-level vulnerability testing of the fuselage and wing fuel tanks of the Predator B. JLF is supporting the UAV Program Office in identifying vulnerability reduction improvements to present and future blocks of the aircraft. Although unmanned, and thereby exempt from Title 10 LFT&E, the survivability of UAVs is increasingly critical to battlefield situational awareness and mission success.

**Rocket-Propelled Grenades (RPGs).** In recent armed conflict, adversaries are using non-traditional weapons, such as anti-tank RPGs, against aircraft. The JLF/AS continues to investigate the vulnerability of front-line rotorcraft to this threat. The goal of this effort is to understand the damage mechanisms of this threat and to identify survivability enhancements. This effort paralleled an effort that characterized the RPG in a fragment arena environment. The survivability community has used the results from the first three phases of the program to update threat databases. The final phase of the program will further investigate the damage mechanisms of a free-flight RPG impacting the fuel cell of an AH-1 Cobra aircraft. This will complete this test program. The results will update threat weapons effects and platform vulnerability databases for use in designing future aircraft.

**MANPADS.** JLF/AS initiated a multi-phase effort to assess large aircraft vulnerability to MANPADS, starting with a quick-look investigation of MANPADS damage effects on aircraft control surfaces. Test engineers performed live missile tests on C-17 and commercial horizontal tails. Based on damage sustained and NASA wind-tunnel tests, NASA developed estimates of the aircraft's ability to fly and land safely.

**AH-64 Engine Nacelle Fire Extinguishing.** JLF/AS initiated a project to evaluate the performance of new, active solid propellant gas generators in extinguishing engine nacelle fires. Testing was performed on an AH-64 Apache helicopter. Engineers will use a stainless steel, surrogate test article of the engine nacelle for repeated fire tests under realistic airflow conditions. Surrogate testing will be followed by testing conducted on the actual production rotorcraft.

**F-35 Aircraft - Armor Piercing Incendiary (API) Functioning.** The initiation of fires caused by armor piercing incendiary (API) projectiles within dry bay areas of aircraft is a vulnerability concern. The functioning characteristics (flash intensity and duration) of API projectiles on the F-35's new advanced composite materials are not known. This effort is designed to

produce a method for consistently and accurately quantifying the characteristics of ballistic impacts against graphite epoxy test panels of similar construction to those being used on the F-35. Testing initiated in FY06 and will conclude in early FY07. Results from this testing will increase the accuracy and reliability of defining the threat-functioning characteristics of concurrent and future composite ballistic testing. Results from this testing will enhance the final vulnerability assessment of the F-35 aircraft as well as other aircraft using advanced composite construction materials.

### Armor/Anti-Armor Program

**Fragment Penetration Testing and Analysis for Masonry.** Little data exist for weapons effects and collateral damage properties (i.e., behind wall debris) against masonry structures. This project collected information on the physical properties of threat projectiles following impacts with masonry walls and wall debris properties (weight, speed, and direction) following threat impact. These data expanded the capabilities of an engineering model (Fast Air Target Encounter Penetration - FATEPEN) used to predict residual impactor properties, target damage, and target debris properties. Analysts can use residual impactor and debris properties to assess damage to personnel and materiel behind walls. This test program is coordinated with a Defense Threat Reduction Agency program that is collecting complementary data and performing the FATEPEN expansion. The work is coordinated with military operations in urban terrain (MOUT) work across the Services. FATEPEN is used in higher-level MOUT analysis codes such as the Integrated Munitions Effects Assessment and the Modular Effectiveness/Vulnerability Assessment models.

**IED Characterization for Blast and Fragmentation.** IED characterization testing continued into FY06, building upon FY05's pioneering work. Testing consisted of three arena tests to collect fragmentation and blast overpressure data. These tests captured ground surface effects of an IED configuration representative of the emplacement conditions observed in OIF. The resultant data supports current and future up-armoring designs, predictive analyses, increased vulnerability/lethality modeling accuracy, and will maximize survivability enhancements to current and future weapon platforms.

**FATEPEN and Project THOR Penetration Algorithm Evaluation Using High Explosive Artillery Fragments.** FATEPEN and THOR are key algorithms used to model the penetration characteristics of artillery fragments. Testing evaluated the accuracy and utility of the FATEPEN and THOR methodologies. The Army Research Laboratory made predictions using the FATEPEN and THOR algorithms and subsequently fired fragments from former Soviet 122 mm and 152 mm and U.S. 155 mm artillery rounds through mild steel target material, collecting residual mass and velocity data. Experimental results will be compared to the model predictions. The Army Research Laboratory will use the analysis to improve artillery fragment lethality predictions against hard and soft targets and aid in determining the vulnerability/lethality of U.S. and foreign weapon systems.

**IED Characterization and Mitigation Techniques against Tactical Wheeled Vehicle Fuel Tanks.** JLF/A/AA initiated an evaluation to determine if effects from an IED can cause a fuel tank explosion or fire in tactical wheeled vehicles. This testing will provide vulnerability reduction recommendations to both warfighters and to the design community to mitigate fuel fires in tactical wheeled vehicles.

**MOUT Secondary Debris Characterization.** Testing of direct fire munitions (tank rounds and shoulder-fired weapons) continued against walls of different materials (concrete, triple brick, and brick/block) to collect secondary debris data. This year's work expands the amount of characterized debris field per shot, includes oblique shots likely to be seen in the urban fight, and continues to populate an initial debris characteristics database. The work specifically benefits the DoD joint target community, the personnel vulnerability community, operational tests, the Joint Army/Air Force's Modular Effectiveness/Vulnerability Assessment simulation, and the JTCG/ME's ongoing collateral damage estimation efforts. The Army Research Laboratory is also using the data collected to increase the fidelity of personnel vulnerability models such as the Operational Requirements-based Casualty Assessment model.

**Middle East Masonry Structures (MEMS) Program.** JLF/A/AA is conducting testing against representative masonry structures typically seen in the Middle East region of the world. Software developers and lethality analysts will use data from this effort to modify existing lethality models to obtain accurate collateral damage estimates for conventional weapons against these types of targets. Initial testing, using western style standard brick walls as a comparative baseline, began in FY06. Future testing will use targets constructed with characteristic Middle-Eastern masonry materials and construction techniques.

**Sensor-Fuzed Weapon (SFW) Cold-Target Effectiveness.** Testing of the SFW evaluated its ability to identify, target, and defeat solar-heated-only "cold targets." SFW is an air-delivered weapon designed to defeat heavy armor targets. SFW is not designed to be effective against a "cold" target, such as a

Homing-All-The-Way-Killer (HAWK) battery or an aircraft sitting on a ramp. However, these types of "cold" targets have become high-priority targets. The JTCG/ME will use the results of this test to update their Joint Munitions Effectiveness Manuals. The program included sensor test and evaluation, as well as vulnerability modeling of HAWK battery components and an F-15. Initial results demonstrated sufficient solar heating to allow the sensor to recognize the target and issue a fire command against HAWK components. The results of signature analysis and testing of the F-15 demonstrated sufficient solar loading that allowed the sensor to recognize the target and issue a fire command.

### Sea Systems Program

JLF/SS, initiated by DOT&E in 2005, has made significant progress toward assessing the survivability of surface ships and submarines. Particular progress has been made in the area of fire fighting and fire mitigation techniques and it is in this area that lessons learned from JLF-Sea are shared most with the other Services. Examples of these and other efforts are discussed below.

**Hydraulic Fluid Hazard Analysis.** This project examined the probability of a hydraulic fluid fire or explosion onboard surface ships and submarines. The Naval Research Laboratory researched hydraulic fluid fires by reviewing results of shock test trials, examining casualty and maintenance reports, and conducting interviews with active duty and retired Navy personnel. A vulnerability analysis considered possible ignition sources and determined that hydraulic fires are a serious concern for submarine and surface ships. The analysis provided engineers with an assessment of the probability of hydraulic fires and their relevant impact to overall vessel survivability.

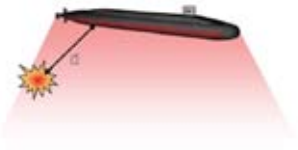
**Shipboard Space Fire Testing.** This project is examining the potential for fire in enclosed shipboard spaces by considering ignition sources and fire sustainability due to materials and equipment stowed within those spaces. The Navy will use data from this effort to improve the design of shipboard spaces. The tests are providing empirical data to improve, verify, and validate fire models.

**Damage Control Readiness Evaluation.** This project initiated the development of metrics for evaluating damage control readiness. Improving initial and refresher damage control training for shipboard crews is also an objective.

**Ship Response to Terrorist Attack.** JLF/SS initiated a two-year project in cooperation with Germany to validate a simulation tool for assessing ship survivability to surface-borne threats. A U.S.-built destroyer, recently decommissioned by the German Navy, was the subject of a series of explosive tests. JLF provided funding to add an additional surface explosion test to the nine-shot matrix, effectively leveraging a joint U.S./German investment of nearly $15 Million. The first three shots were conducted in May 2006, and the remaining five shots were conducted in September and October 2006. Data from these tests will increase the fidelity of models, validate existing models and simulations, increase the accuracy of survivability assessments, and improve design capabilities to mitigate the effects of blast overpressure.

**Survivability of Ships Built to Commercial Standards.** Based on historical evidence, commercial hull structures are more susceptible to underwater shock damage than hull structures built to Navy standards. Although the Navy has conducted limited side-by-side comparison testing between a Navy-designed hull and a commercial hull, little is known about the resistance of commercial hull structures to underwater explosive loadings. This project will use testing and models to assess the survivability of ships built to commercial standards, thereby improving the fidelity of future ship survivability assessments. This will directly benefit ongoing acquisition programs, such as the Joint High-Speed Vessel.

**Submarine Susceptibility to Mines.** This project will improve the current capability to predict threat mine actuation ranges for various mines against submarines. Through testing and susceptibility analysis, improvements will be made to survivability assessment methods. In August 2006, the first successful mine actuation trial was conducted by a submarine to demonstrate the mine actuation system used for evaluating mine susceptibility. This effort will improve future survivability assessments and the test and evaluation program for the *Virginia* and SSGN submarine classes.



**Test Alternatives to Underwater Explosion (UNDEX).** This project is evaluating a less expensive and more environmentally acceptable alternative to UNDEX shock testing. It leverages a Navy Phase II Small Business Incentive Research program that is demonstrating the utility of a seismic air-gun array. The primary objective is to assess the array's potential as a surrogate for the traditional full-ship shock trial. In May 2006, test engineers used the air-gun array to generate shock against a Navy barge in a quarry. Future testing will compare water vehicle response to air-generated shock and explosive shock.