Live Fire Test and Evaluation Program

EXECUTIVE SUMMARY

Title 10, Section 139 requires DOT&E to prepare an annual report summarizing the operational test and evaluation activities (including Live Fire testing activities) of the DoD during the preceding fiscal year. This section of the DOT&E Annual Report to Congress satisfies the requirement for an annual LFT&E report.

In FY08, DOT&E executed oversight of 122 LFT&E survivability and lethality acquisition programs. Of those 122 programs, 18 programs operated under the waiver provision as permitted by Section 2366. LFT&E published the following five reports in FY08: High Mobility Artillery Rocket System Improved Cab Protection LFT&E; H-1 Helicopter Upgrades Beyond Low-Rate Initial Production (BLRIP); Stryker Mobile Gun System BLRIP; T-AKE cargo ship BLRIP; and, the SSGN *Ohio* submarine BLRIP. In addition, LFT&E provided input to individual system assessments contained in this report. DOT&E also supported quick-reaction efforts, including warfighter requests and congressional inquiries, and managed several survivability and lethality technology investment programs.

DOT&E continues to oversee ballistic testing of body armor as reported in last year's annual report. Additionally, DOT&E sponsored limited user evaluations of Army and Marine Corps combat helmet pad suspension systems, and provided Congress a report of the results. In FY08, DOT&E published its policy for force protection, including non-lethal weapons. DOT&E is engaged with the Services to achieve the goals for this effort as established by DOT&E. In the FY09 National Defense Authorization Act, Congress amended Title 10, Section 2366. The new language provides the Secretary of Defense authority to designate programs for oversight pursuant to Section 2366, mirroring authority already granted the DOT&E in Section 139 for operational test and evaluation. In FY09, DOT&E will work with the Services to identify those programs that, due to their direct contribution to warfighter survivability and lethality, warrant DOT&E oversight under this new provision.

In addition to satisfying acquisition program oversight requirements, the LFT&E program funds and exercises technical oversight of investment programs that develop joint munitions effectiveness data; develops advanced technologies and analytical methods to increase aircraft survivability; conducts vulnerability test and evaluation of fielded air, land, and sea platforms; and, conducts munitions lethality testing. LFT&E investment programs also supported quick-reaction efforts in FY08 aimed at addressing warfighter needs.

- **Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME)**. The JTCG/ME publishes weapon effectiveness manuals, collateral damage estimation tables, methodology, and automated tools that enable the warfighter's weaponeering and mission planning processes. 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.
  - The JTCG/ME continues to produce critical Joint Munitions Effectiveness Manual (JMEM) weaponeering and collateral damage estimation products in support of mission planning and execution by all combatant commands and joint and Service staffs in all theaters of current operations including Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF).
  - The JTCG/ME has provided Collateral Effects Radii table updates into the Chairman of the Joint Chiefs of Staff Manual 3160.01b-Collateral Damage and Weaponeering Guides for rapidly fielded systems to include: Excalibur - Unitary (155 mm GPS Guided Projectile), Laser Joint Direct Attack Munition, Focused Lethality Munition, and the Griffin air-to-surface missile.
- **Joint Aircraft Survivability Program (JASP).** The JASP serves as the DoD'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 support of Combined Forces Aviation. JCAT continued operations from bases in Al Asad, Balad, and provided a senior uniformed presence with Multi-National Corps-Iraq C3 Air at Camp Victory in Baghdad. 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).** 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 FY08, JLF continued its support to the Joint Improvised Explosive Device Defeat Organization (JIEDDO) and to the Standardized Military Operations in Urban Terrain (MOUT) Target and Testing Board (SMTTB). In partnership with JIEDDO, JLF continues to extensively characterize improvised explosive

munitions in environments and emplacements that mimic actual combat conditions. Test results provide combat commanders immediate feedback regarding their vulnerabilities and aids in the development of survivability mitigation techniques, both in materiel and in tactics, techniques, and procedures. With the SMTTB, JLF is characterizing weapons effects in MOUT environments, to include behind wall debris following impacts from breaching munitions. Characterizing behind wall debris is critical in fully understanding weapons effects and to better characterize collateral damage.

In addition to these programs, DOT&E also participates in focused initiatives that directly support warfighters or address issues of significant importance to Congress.

QUICK REACTION

DOT&E coordinates and sponsors activities in response to congressional directives and that contribute directly to warfighter survivability in current areas of operation. In FY08, DOT&E participated in or sponsored three such efforts: Personnel Body Armor, Combat Helmets, and JIEDDO.

Personnel Body Armor. As reported last year, DOT&E is overseeing Army body armor testing to "… definitively and officially determine the facts regarding the protective qualities of the body armor we are currently providing our troops and that of any other commercially available comparable and competing system." [1] The test program consists of two phases. Phase 1, completed in June 2008, was ballistic testing in accordance with the Army solicitation. That testing, conducted by the Army's Test and Evaluation Command (ATEC), was adequate to support Program Executive Officer - Soldier's source selection process and ultimately led to contract awards in October 2008. DOT&E provided an interim report documenting the Phase I effort to Congress in October 2008. Pursuant to procurement requirements, ATEC began First Article Testing in November 2008, of all vendors that received contracts via the source selection. ATEC completed First Article Testing in December 2008 and will next execute Phase 2 of the body armor test program. Phase 2 consists of additional ballistic testing to characterize the range of performance of selected solutions in order to determine current performance levels prior to setting future performance requirements. ATEC should complete Phase 2 testing in 4QFY09. Upon completion, DOT&E will provide a final report to Congress that encompasses all phases of the effort.

Limited Field User Evaluations of Army and Marine Corps Combat Helmet Pad Suspension Systems. The DoD conducted limited user evaluations of the pad suspension systems in the Army's Advanced Combat Helmet and the Marines Corps' Lightweight Helmet. Both the Army and Marines conducted their testing and evaluations during 4QFY08, the former at Fort Benning, Georgia, and the latter at the Officer Candidate School at Quantico, Virginia. Although the Services planned and conducted their tests independently, they shared test plans and designed the tests to be nearly identical. Soldiers and Marines wearing typical combat clothing, equipment, and weapons ran through a series of drills including marches, obstacle courses, and equipment compatibility exercises. Following completion of these exercises, the participants completed survey forms that identified their favorability of each pad system tested in terms of form, fit, and function. Each Service completed a comprehensive report. Subsequently, in 1QFY09, DOT&E prepared a summary that was provided to Congress with the Service reports. The evaluations for both Services concluded that the currently fielded pad suspension system is not inferior to any of the other pad systems evaluated. Both Services continue to aggressively pursue a next generation combat helmet and improved helmet suspension systems.

Joint Improvised Explosive Device Defeat Organization (JIEDDO). DOT&E continued to support the JIEDDO through participation on the Joint Test Board, the Joint Requirements and Resources Advisory Board, and the Joint Integrated Product Team. DOT&E also continues to fund IED and MOUT Joint Live Fire test programs, both of which support JIEDDO objectives.

1 May 21, 2007, letter from Senators Levin and McCain to the Secretary of Defense

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

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 accounting for collateral damage, and are critical enablers to the warfighter's weaponeering process.

In FY08, in support of increasing combined and coalition operations, the JTCG/ME developed and released two updated JMEMs. The first was the JMEM Weaponeering System (JWS) DVD v1.2.1 (1,250 copies to 800 accounts) that provides air-to-surface and surface-to-surface weaponeering tools. This DVD included new and updated warhead data, delivery accuracy updates, approximately 375 new targets with associated effectiveness data, and an updated Building Analysis Module. Secondly, the JTCG/ME also released the Joint Anti-Air Combat Effectiveness (J-ACE) CD-ROM v3.2.1 (250 copies to 210 accounts). The update included an interface to F-22 aero performance data, and new threat air-to-air and surface-to-air missile performance models. This JMEM is used by the community of fighter pilots to develop air superiority tactics and by the Strategic Command for global strike mission planning.

In addition to these two JMEM releases in FY08, the JTCG/ME developed and released beta versions of the JWS v2.0 and the J-ACE Air Superiority (AS) v4.0. These upgrades represent major product architecture improvements to efficiently support a target-centric weaponeering paradigm. These products are both scheduled for operational release in early 2009.

The JWS v2.0 is a combined product of the JMEM Air-to-Surface (JMEM/AS) and JMEM Surface-to-Surface (JMEM/SS) communities. It represents a combination of the formerly separate JMEM/AS Weaponeering System (JAWS) and JMEM/SS Weapons Effectiveness (JWES) products. It includes target vulnerability for approximately 200 calculated targets; descriptive information, data, and graphics in the Browse section; computer programs and methods needed to accomplish weaponeering in the Weaponeering section; step-by-step guides to weaponeering in the Training Checklists and Wizards; and Help files. JWS v2.0 provides the capability to evaluate the effectiveness of any number of combinations for various air-to-surface and surface-to-surface weapons against a variety of target types in real-time or in the form of quick, pre-calculated data.

The J-ACE AS v4.0 contains Joint Anti-air Model v3.2.2 which can read Eglin P5-format Time-Space-Position Information (TSPI) data files, new Threat Modeling and Analysis Program (TMAP) models for red and grey air-to-air missiles, Missile and Space Intelligence Center (MSIC) TMAP Surface-to-Air missiles, and logic checks for maximum off-bore sight launch angle limits. Additionally, J-ACE 4.0 contains additional AIM-9M/X and AIM-120C effectiveness data and architectural and graphical user interface improvements.

Also in FY08, the JTCG/ME continued JMEM development efforts to support Information Operations. Specifically these efforts, performed in coordination with the Strategic Command, resulted in the accreditation and/or fielding of the Computer Network Attack Risk and Effectiveness Analyzer and the Effectiveness of psychological operations Influence Calculator. Initiatives related to JMEM development for other non-traditional effects (e.g., non-lethal, High Energy Laser, High Power Microwave) continue.

JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The mission of the JASP is to increase the economy, readiness, and effectiveness of DoD aircraft through coordination and development of susceptibility and vulnerability reduction technology and assessment methodology. The JASP coordinates the inter-Service exchange of information to increase the survivability of aeronautical systems in a combat threat environment. Working with joint and Service staffs, other government agencies, and industry, the JASP identifies new capabilities that require aircraft survivability research, development, test, and evaluation and ensures capabilities are conceived and developed in a joint warfighting context. DOT&E establishes objectives and priorities for the JASP as well as exercising oversight of the program.

In FY08, 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 address critical issues regarding aircraft survivability. Accordingly, JASP funded 61 multi-year survivability projects for $9.6 Million and delivered 38 reports in FY08. The following summaries illustrate current JASP efforts in susceptibility reduction, vulnerability reduction, survivability assessment methodology, and combat damage assessment.

Susceptibility Reduction

The JASP transitions susceptibility (the degree to which an aircraft is open to effective attack) reduction technology and techniques to the warfighter, addresses urgent susceptibility requirements emerging from combat theaters, and reduces aircraft susceptibility against future systems.

Rotorcraft Aircraft Survivability Equipment Effectiveness Against Man Portable Air Defense System (MANPADS)/Optimizing AN/ALQ-144A Effectiveness. This joint Army Research Laboratory and Naval Air Warfare Center study initiated major Army and Navy follow-on efforts that will ultimately improve the employment of Aircraft Survivability Equipment (ASE) on rotorcraft. This study challenged basic beliefs on the effectiveness of current ASE, and the results, validated by flight tests and modeling, have prompted improvement in the overall survivability of rotorcraft.

Rotorcraft Visual Jury Test. In partnership with the Army's Aviation Applied Technology Directorate, the JASP completed testing to quantify the visual effectiveness of optimized single color paint schemes in July 2008. Engineers collected data for four colors against both desert and sky backgrounds. Material developers will use this quantitative data to make paint scheme determinations for rotorcraft operating in desert terrain and sky background conditions.

Imaging Infrared Seeker Countermeasures. Countermeasures development for missiles with infrared seekers remains a key research area for the JASP. In FY08, JASP, along with the Air Force Research Laboratory and the Naval Research Laboratory, initiated a project to investigate and develop countermeasures against a new class of infrared seekers. This project applies established modeling and simulation and hardware-in-the-loop processes to determine the optimum countermeasures against missiles with imaging infrared seekers.

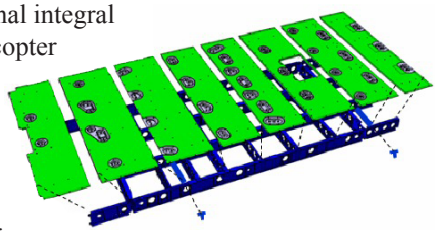
Millimeter Wave (MMW) Electronic Attack Transmitter. In partnership with the Naval Research Laboratory, the JASP is developing countermeasures technology and techniques for MMW radars. While MMW radars are not currently a threat in OIF/OEF, they are of increasing concern. Using previously developed hardware components, this project will demonstrate the feasibility of generating new radar jamming waveforms against these modern radars. The techniques, if successful, will be useful against a wide variety of modern short range, dual frequency surveillance, and targeting radars.

Second Generation Processing for Missile Warning Systems. This JASP project is part of a larger Air Force Research Laboratory project to develop and field an affordable visible missile warning system based on high performance charge-coupled devices or complimentary metal-oxide semiconductor-based detectors. Innovative spatial, spectral, and temporal algorithms extract threats from high clutter environments, but require very high data throughput. The JASP effort combines and optimizes existing algorithm capabilities for integration with a real-time processor coupled to a missile warning system.

Vulnerability Reduction

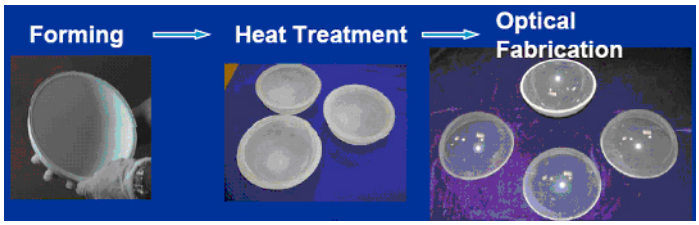
Vulnerability reduction technologies increase an aircraft's capability to withstand the threat environment. In FY08, JASP emphasized work in the areas of developing lighter-weight opaque and transparent ballistic protection systems and fuel containment technologies for fuel system components.

Multi-functional Structures for Ballistic Protection. The Aviation Applied Technology Directorate (AATD) at Fort Eustis, Virginia, together with United Technologies demonstrated an affordable, multi-functional integral armor solution for a helicopter floor that improves ballistic protection and provides significant weight reduction. The prototype floor provides the same ballistic protection and offers a weight savings of 48 percent, compared to current approaches.



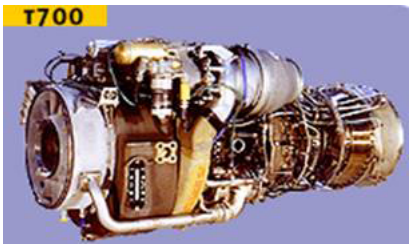
Spaced Armor for Rotorcraft. AATD worked with BAE Systems and Bell Helicopter Textron to design, model, fabricate, and demonstrate two spaced-armor system concepts for rotorcraft that will yield at least a 30 percent weight reduction compared to appliqué steel systems for a given armor-piercing projectile threat.

Development of Transparent Armor Systems. AATD, together with BAE Systems, demonstrated transparent armor concepts for rotorcraft that yielded a 30 percent weight reduction over current systems while lowering manufacturing costs and substantially improving multiple-hit performance. Specifically, various transparent inorganic materials, bonded to a lightweight urethane substrate (Cleargard® variants), were ballistically tested and modeled for optimum ballistic performance.



Flammable Fluid Line Fire Protection. The 780th Test Squadron at Wright-Patterson AFB, Ohio, began development and demonstration of potential low cost, lightweight technologies to reduce the vulnerability of flammable fluid lines to ballistic impacts by increasing fire suppressant concentration and decreasing fluid loss. Under this project, the JASP is comparing technologies such as self-sealing sleeves, spray-on polymers, enhanced powder panels, and rigid foam line wraps against existing self-sealing technologies on standard fuel lines.

Survivable Engine Control Algorithm Development (SECAD) Turboshaft Application. The Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, California, together with General Electric Aircraft Engines, began applying the SECAD methodology to turboshaft engines in cooperation with the T-700 Project Office. Specifically, GE developed damage detection algorithms for integration into the engine controls on the UH-60M helicopter.



Electrical Power Battle Damage. The Naval Air Warfare Center Aircraft Division, Patuxent River, Maryland, began work to improve the electrical power distribution of H-60 helicopters resulting from small arms battle damage to preserve the aircraft's mission capability. The project goal is to characterize electrical system dynamic response to battle damage with and without improved arc fault circuit breakers and confirm the improved system response through live fire testing.

Joint Flare Dispenser Vulnerability Reduction. The NAWCWD, China Lake, California, began to investigate and test novel technologies to mitigate or eliminate the effects of ballistically induced flare initiation in internally installed flare dispensers. The goal is to develop technology that is lightweight, low-cost, capable of installation on future platforms, and retro-fittable to legacy platforms. JASP will assess the ability of the technology to reduce pressure and temperature in the bay behind the flare dispenser on a representative airframe.

Survivability Assessment Methodology
The JASP continued to invest in improving the credibility of significant models and simulations used to design and develop aircraft survivability, and to assess the survivability of U.S. aircraft to realistic threats.

Fire Prediction Model. The Army Research Laboratory recently completed a series of tests to generate data that will validate parts of the Fire Prediction Model and enable development of penetration equations for modern self-sealing fuel tank materials. This test series established penetration data for seven different threats (five fragment masses and two projectiles) fired into fuel tank surrogates and flat plates. The fuel tank tests included shots into the fluid filled region and the space above the fuel, the ullage. Shots into the ullage verified that shots into flat plates resulted in the same project velocity slowdown and were appropriate for penetration calculations. Shots into the fluid region provided information on leakage rates.

Enhanced Surface-to-Air Missile Simulation. The NAWCWD, China Lake, California, teamed with the Air Force Aeronautical Systems Center to validate six threat models in the Enhanced Surface-to-Air Missile Simulation (ESAMS). The six threat systems were chosen based on a combination of frequency of use by the ESAMS users and availability of sufficient data for validation decisions. The study used the latest threat data available from the Missile and Space Intelligence Center. NAWCWD also collaborated with the Air Force Research Laboratory to compile information related to the capability, accuracy, and usability of the Modeling System for Advanced Investigation of Countermeasures (MOSAIC) and document it in an accreditation support package. This is the first step to making MOSAIC available for distribution and user support. MOSAIC will be the first standard code to address infrared threats and countermeasures against them.

Cross-Agency Model Integration. JASP is demonstrating a process for the integration of new Missile and Space Intelligence Center (MSIC) infrared and radio frequency Threat Modeling and Analysis Program (TMAP) threat system models into the corresponding engagement simulations. This project marks the first time TMAP models have been adapted for use in all digital simulations outside of MSIC. Once the integration is complete, testing will commence to verify that the integrated models give the same predictions as the legacy stand-alone models.

JOINT COMBAT ASSESSMENT TEAM (JCAT)

During FY08, JCAT deployed 14 Navy and four Air Force personnel to Iraq to serve with the Multi-National Corps-Iraq in support of OIF. JCAT-Forward locations included Al Asad Air Base in the western Al Anbar Province, Balad Air Base north of Baghdad, and Camp Victory, Bagdad. Due to extensive coalition air and ground engagement with Al-Qaida in Iraq (AQI), a temporary detachment in Mosul, Iraq, was established to complete battle damage assessments and provide training to the maintenance troops. Near real-time JCAT analysis of Mosul Surface-to-Air Fire reports in support of the U.S. aviation assets was credited as a key contributor to the elimination of the Mosul AQI anti-aircraft cell. The JCAT Army component also provided support to the warfighter in Afghanistan, providing training and completing aircraft battle damage assessments. The JCAT support includes inspecting damaged or destroyed aircraft, acquiring available maintenance documentation, and conducting interviews with aircrew and intelligence personnel. JCAT provides consultation to weapons, tactics, and logistics personnel. JCAT also provides comprehensive briefings to commanders in charge of daily air operations. These efforts provide valuable information to commanders allowing them to adjust their tactics, techniques, and procedures based on accurate

threats assessments. These efforts resulted in 2,281 work days of which 1,798 days saw JCAT forward-deployed in Iraq. A total of 51 aircraft evaluations were completed, 49 of which were determined to be actual combat damage.

JCAT provides professional training to the engineers and other support personnel that work aircraft survivability within the United States. Navy JCAT members hosted the 2008 Threat Weapons and Effects Training Seminar at Eglin AFB, Florida. This year's classified symposium was a resounding success as almost 230 people were in attendance. Attendees included industry partners and 12 U.S. government agencies including all four U.S. military Services, the Department of State, the Department of Homeland Security, the Federal Aviation Administration, the Department of Energy, the FBI, and the Alcohol, Tobacco, and Firearms agency. A Man Portable Air Defense System (MANPADS) live fire demonstration shot against a Cobra Aircraft on the Eglin AFB Test Range was one of the many highlights. The Naval Air Systems Command (NAVAIR) sponsored a JCAT Day to provide essential combat-related aircraft survivability data and training to acquisition professional and engineering personnel. JCAT briefed at a total of nine symposia, provided 12 senior executive briefings, and published six articles in widely read professional publications.

The JCAT personnel worked closely with Survivability/Vulnerability Information Analysis Center (SURVIAC) engineers to upgrade the Combat Damage Incident Reporting System database and data reduction capabilities. This SURVIAC database is a repository of all U.S. aircraft battle damage events for use by aircraft survivability engineers and operators alike. Design changes will provide additional in-depth information on OIF hostile fire incidents to engineers working on next-generation aircraft survivability equipment. JCAT is continuously improving the data content and quality of the aircraft battle damage assessment engineering reports. The FY08 report improvements included capturing maintenance repair data (non-mission capable days, cost to repair), local weather observations, and lunar luminescence data.

JOINT LIVE FIRE (JLF)

The Joint Live Fire Program consists of three groups: Aircraft Systems (JLF/AS), Armor/Anti-Armor (JLF/A/AA), and Sea Systems (JLF/SS). Following are examples of projects funded by JLF or completed FY08 JLF programs.

Aircraft Systems Program

Thorough analysis of historical and recent combat events shows that our U.S. military aircraft, both fixed- and rotary-wing, continue to have some degree of vulnerability against various enemy threats. The trend to purchase fewer and more expensive aircraft makes it imperative that we continue to reduce aircraft vulnerability. The goal of JLF/AS is to identify vulnerable areas in current aircraft platforms and understand the mechanism involved in the threat and aircraft reaction, and provide this information to the survivability engineers to improve aircrew and aircraft survivability. This also leads to more effective combat utilization of our assets and aids in mission planning.

AH-64 Fire Extinguishing Technology. JLF/AS completed the final year of this multi-year investigation by assessing the effectiveness of Solid Propellant Gas Generators (SPGGs) in extinguishing aircraft fires, particularly within engine nacelles. These tests use commercially available SPGGs with an active agent embedded within the unit. Data generated from this test indicated the technology was economically feasible to pursue as a possible replacement of current Halon 1301 systems. The Army Apache Equipment program manager is currently evaluating the results of these tests.

Fragment Restraint Solution for HH-60 A/L. The goal of this testing was to find a hardware solution to reduce system-level ballistic vulnerability of the onboard oxygen generating system for the HH-60A and HH 60L Black Hawk MEDEVAC helicopters. The solution was not intended to stop threat projectiles, but to contain any resulting fragments in the aircraft's confined space. The data, report, and recommendations were provided to the Army's HH-60A/L MEDEVAC Program Office. The fragment restraint solution was found to be very effective and kits are currently being procured and sent to MEDEVAC squadrons in theater.

H-60 Main Rotor Mast Ballistic Vulnerability. A review of available documentation showed that the H-60 main rotor shaft and shaft extension have not been tested against small caliber armor-piercing, incendiary projectiles typically found in current combat operations. As an assembly, these critical components retain and drive the main rotor. Test results and other findings will expand the ballistic vulnerability knowledge for helicopter main rotor shafts and extensions. The mast and mast extension demonstrated significant tolerance against the threats tested. Each assembly

tested was subjected to multiple ballistic impacts without evidence of structural failure.

JLF/AS/JASP MANPADS Vulnerability Assessment Capabilities Roadmap. A long-term goal previously expressed by DOT&E/LFT&E was the development of a MANPADS roadmap that encompassed live fire test, evaluation, and modeling. This tool would document current test and evaluation capabilities, delineate known test and evaluation requirements, and define critical test and analysis gaps. It could then be used to guide future live fire projects and funding decisions. Two glaring shortfalls became immediately apparent: a lack of characterization data to validate system-level models; and, an invalidated fly-out/endgame model for the purposes of hit point prediction. JLF/AS will use these findings to drive project selections and funding for the coming fiscal year.

Armor/Anti-Armor Systems Programs

The armor/anti-armor program seeks to fully characterize current threat weapons and munitions, providing critical empirical data to organizations such as the Joint IED Defeat Organization and the Joint Technical Coordinating Group for Munitions Effectiveness. The program also responds to critical warfighter survivability issues such as combat helmet protection and survivability from weapons effects when traveling in tactical vehicles. The armor/anti-armor program has also been instrumental in the understanding of weapons effects in Military Operations in Urban Terrain (MOUT) environments. Below are Armor/Anti-Armor projects conducted during FY08.

IED Characterization for Blast and Fragmentation – Buried Configuration. IEDs used in a sub-surface/shallow-buried configuration are a frequently used threat facing coalition forces in theater. For that reason the development and evaluation of crew survivability models, new armor kits, and other protection systems requires a well characterized threat. The objectives of this test include determining the detailed fragmentation characteristics (mass, velocity, shape factor, and spatial distribution) and peak blast overpressure levels resulting from the function of a single test item as a shallow-buried IED.

Tactical Wheeled Vehicle (TWV) Fuel Fire Testing and Analysis. JLF initiated a set of experiments that will test and evaluate simple low cost fuel tank fire protection concepts against IED threats. The test setup and data collection is being coordinated with a fire prediction model (FPM) developer in order to make enhancements to an existing FPM to address the IED threat. Three low cost concepts are being examined: a 1-inch thick e-glass overwrap; a tank-in-tank design with water in the void between the tanks; and, a tank-in-tank design with a fire extinguishing powder in the void between the tanks. To date, JLF has tested the three concepts against a shaped charge threat and an explosively formed penetrator. JLF will next test the concepts against a fragmenting artillery round. Generic 55 gallon drums are being used in the preliminary tests. JLF will conduct follow-on tests with successful concepts that are more representative of TWV fuel tanks.

Full Vehicle Blast Data. JLF continued external blast damage testing on full vehicles into FY08, continuing work from FY07 on a different class of targets. Testing in FY08 was conducted to assess the vulnerability of a passenger tactical truck, an AH-1 attack helicopter, and a UH-1 utility helicopter to external airblast loads. Testers detonated bare explosive spheres at various positions and made careful assessments of the resulting blast damage. Instrumentation was used to characterize the applied airblast load to the target. Engineers then analyzed data to develop contours of lethal miss distances (the distance from a detonation that a person or equipment must be to survive) with respect to mobility, firepower, and catastrophic target kills. The JTCG/ME currently uses simple models and database look-ups to estimate airblast effectiveness of a weapon-target pair. Results from this program will provide ground truth data for this important class of targets, and serve as a benchmark for the development of methods utilizing three-dimensional contours of kill level for materiel targets.

Advanced Combat Helmet and Pad Suspension Systems Analysis. This study consists of testing the Army Advanced Combat Helmets with the four current pad designs used by Soldiers and five new pad suspension systems to help identify appropriate Quality Assurance procedures as well as develop better protection against blast, blunt, and ballistic threats. This testing will help identify what characteristics of pads will protect the Soldier from several threats and ultimately reduce the amount and severity of Mild Traumatic Brain Injuries (MTBI)

and other head injuries. Several impact surfaces and velocities were used to test the pad and helmet shells at several temperature conditions and three headforms (headforms represent the human head and are used for blunt impact and blast testing). JLF will also conduct shock tube testing to simulate blast events in order to record the dynamic response of the Advance Combat Helmet and performance of the pads.

MOUT Secondary Debris Characterization. In FY08, JLF continued testing direct fire projectiles, both foreign and domestic, against several wall types to collect secondary debris data. A major focus of the 2008 JLF MOUT program concerns the use of high performance concrete as a target material. High performance concrete technologies for building materials (appliqué, structural element, or protection barrier) are propagating worldwide. There is significant interest in the urban operations, warfighter, and intelligence communities on the effects of munitions against this material. The 2008 JLF MOUT testing program has been designed to look at a spectrum of weapons (tank rounds, medium caliber projectiles, rocket-propelled grenades and other emerging threats) to evaluate the response of this material. JLF is comparing effects against this material and effects against conventional strength concrete for some of the weapon/target pairings.

Testing to Collect Data in Support of Expanded Fast Air Target Encounter Penetration (FATEPEN) Accreditation Assessment. JLF has completed testing to potentially expand the accreditation range of the engineering penetration and damage prediction model FATEPEN to larger weight fragments. FATEPEN is utilized by both the JTCG/ME and the Joint Aircraft Survivability Program for the analysis of fragmenting warheads. This testing will provide a greater degree of confidence in assessing fragment lethality and vulnerability/lethality of U.S. and foreign weapon systems.

Dual-Use Manufactured Mannequin with Instrumentation Embedded (DUMMIE). The DUMMIE program is developing the requirements and production feasibility for a LFT&E specific Anthropomorphic Test Device (ATD) that testers can use for both shock/acceleration and fragmentation data collection. Currently two different ATDs are utilized to collect shock/acceleration and fragmentation data. Automotive industry mannequins are currently adapted for shock and acceleration data collection while plywood mannequins are utilized for fragmentation data collection. A dual-use mannequin, specifically designed for LFT&E, would provide greater fidelity data during both shock and fragmentation events and would also be able to discern the primary incapacitation mechanism between shock and fragmentation. Certain asymmetric threats present both incapacitation mechanisms.

Validation of the Current Penetration and Deflation Algorithms for Steel-Belted Radial Tires as Used in Mine Resistant Ambush Protected (MRAP) Vehicles. Through the JLF program, DOT&E sponsored ballistic tests at the Army Research Laboratory on steel-belted radial tires as used on MRAP and other military vehicles to determine the accuracy of the tire penetration and deflation algorithms developed in the mid-1990s for non-steel-belted radial and bias-ply tires. The penetration phase of testing, which included shots on the sidewall and tread sections of MRAP tires, measured residual velocities of fragments and provided data for computation of ballistic limit (V50) estimates. This testing revealed that the current penetration equation requires an update for accurate vulnerability/lethality assessments. Likewise, deflation testing, firing fragments into fully inflated and loaded tires, demonstrated that the previously developed deflation algorithm did not adequately represent the deflation rate for steel-belted tires. JLF will update equations and document recommendations in an official report to aid in increasing future modeling accuracy.

Sea Systems Program

The JLF/SS made significant progress in 2008 toward assessing the survivability of submarines and surface ships. JLF/SS has made particular progress by leveraging major Navy programs. Examples of these and other efforts are discussed below.

Ship Shock Trial Alternatives. This project is helping to develop and validate key components of an alternative to the traditional at-sea Full Ship Shock Trial (FSST). The FSST involves underwater explosion testing against new acquisition ships. The goal of the FSST alternative effort is to provide an integrated testing and simulation capability that is environmentally friendlier without trading-off meaningful assessments of the ship's mission capability/degradation resulting from threat encounters. The task leverages the Navy FSST Alternative program, and is coordinated with several major Navy acquisition

programs (Littoral Combat Ship (both designs), LPD-17, LHA 6, DDG 1000, and CVN 78).

Test Alternatives to Underwater Explosion (UNDEX). This project is evaluating a more environmentally acceptable alternative to underwater explosive ship shock testing. The technical objective is to implement a cost-effective operational ship trial that also provides significant and relevant data to advance the validity of advanced simulations. This project leverages a Navy Small Business Innovative Research program to demonstrate the utility of underwater airguns as the non-explosive loading source. These airguns are currently used by the oil industry. The United States is collaborating with the United Kingdom's Ministry of Defence to assess an airgun array's potential as a surrogate for the traditional FSST. In March 2008, test engineers subjected a decommissioned Royal Navy destroyer in Portsmouth Naval Shipyard to a 16 airgun array prototype. Data from this test series are under study to determine if airgun arrays can generate UNDEX-like environments that realistically stress the mission capabilities of Navy warships.

Well Deck/Vehicle Stowage Fire Protection. This project examined the effectiveness of two types of total flooding high expansion foam systems. JLF tested these foam systems against a mixed solid and liquid fuel fire threat in a well deck area, and against a shielded solid fuel fire. The Naval Research Laboratory conducted this project at the ex-*Shadwell* fire test facility in Mobile, Alabama. One of the high expansion systems tested used fresh air drawn from outside the well deck area to create the foam. The other system used fire combustion gases within the well deck area to create the foam. Both systems proved to be effective in all fire scenarios tested. Engineers used data from these tests to assess system design parameters and to develop techniques and tactical procedures for the use of these systems onboard ships.

N**etwork Fire Model Enhancements.** This project provided funds to the Naval Research Laboratory to support further development of the Fire and Smoke Simulator (FSSIM). This investment improved the model's fidelity for three-dimensional fire and smoke spread in ship-representative structures. The model can support current and future platform designs and aid engineers and architects in providing designs that limit or can manage smoke and fire spread through installed design elements. The FSSIM enhanced model is available to ship designers through the NRL.