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 DoD provided for in Section 2366, and 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 FY07, DOT&E executed oversight of 108 LFT&E survivability and/or lethality acquisition programs. Of the 108 programs, 18 programs were operating under the waiver provision. LFT&E published the UH-60M, the CH-47F Block II, and the Small Diameter Bomb combined Beyond Low-Rate Initial Production and LFT&E reports. DOT&E also supported quick-reaction efforts in FY07, including congressional inquiries, and managed several survivability and lethality technology investment programs.

In recent years, Congress has expressed an increased focus on, and sensitivity to, personnel injury. Changes to U.S. Code Title 10 contained within the FY05 and FY07 Defense Authorization bills reflect this increased focus. In the former, Congress added language requiring an assessment of warfighter survivability and system suitability against asymmetric threats[1]. The language in the FY07 Defense bill[2] requires DOT&E to provide guidance to and consult with DoD officials regarding the operational test and evaluation or survivability testing of force protection equipment, including non-lethal weapons. Pursuant to the FY07 force protection legislation, DOT&E provided a memorandum to the Service Secretaries, the Joint Staff, the Assistant Secretary of Defense for Networks and Information Integration, and the Directors of Defense Agencies requesting identification of their force protection and non-lethal weapons programs[3]. The tasked agencies have responded and DOT&E is developing guidance for the Services based upon their responses, as well as policy for how DOT&E will interact with these programs.

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 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 support quick-reaction efforts aimed at addressing emerging warfighter needs. Specifically, LFT&E investment programs enabled DOT&E to respond to these warfighter needs in FY07:

- **Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME).** This group publishes weapon effectiveness manuals and produces collateral damage estimation tables 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.
  - In support of the Department's increasing focus on mitigating collateral damage, the JTCG/ME incorporated updated effective miss-distance tables[4] into Chairman of Joint Chiefs of Staff Manual 3160.01b – Collateral Damage Estimation. The JTCG/ME had a significant role in the development of this Collateral Damage Estimation Manual, which has significantly improved the ability of field commanders to make independent targeting decisions without the need to elevate most decisions. This Manual has been instrumental in mission planning in both Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF).
- **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 and Balad and established a senior uniformed presence with Multi-National Corps-Iraq C3 Air at Camp Victory. JCAT uses data gathered from combat, threat exploitation, and Live Fire testing to provide combat commanders information to influence mission planning and tactics.

[1] Public Law 108-375, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Subtitle E, Section 141, Development of Deployable Systems to Include Consideration of Force Protection in Asymmetric Threat Environments.

[2] Public Law 109-364, John Warner National Defense Authorization Act for Fiscal Year 2007, Subtitle D, Section 231(f), Clarification of Duties with Respect to Force Protection Equipment (amending Section 139(d) of Title 10 U.S. Code).

[3] Director, Operational Test and Evaluation Memorandum dated April 9, 2007, Subject: Force Protection Equipment and Non-Lethal Weapons.

[4] Effective miss-distance tables relate collateral damage as a function of distance from a weapon's point of impact, i.e., "How far away from the school should this weapon impact to not cause damage to the school?"

- **Joint Live Fire (JLF).** The Office of the Secretary of Defense 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 FY07, JLF continued its support to, and partnership with, the Joint Improvised Explosive Device Defeat Organization (JIEDDO), and to deployed forces through extensive characterization of improvised explosive munitions. JLF testing incorporates enemy tactics and procedures as reported and continuously updated by the intelligence community. 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.

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

Personnel Armor System for Ground Troops (PASGT) Helmet Survivability. In a memorandum dated July 13, 2007, Deputy Under Secretary of Defense for Logistics and Materiel Readiness, Honorable Jack Bell, requested DOT&E direct a test and assessment of PASGT helmets. This request was in response to a Department of Justice (DOJ) letter that indicated the DOJ was conducting a criminal investigation into a manufacturer of material used in PASGT helmet production. The DOJ letter alleged that the manufacturer was using substandard Kevlar cloth and that therefore, there was a risk that the ballistic protection afforded by the PASGT helmet was below specification. DOT&E coordinated with the Army Test and Evaluation Command (ATEC) and the Army Research Laboratory (ARL) to design and execute a test and analysis program to determine if the helmets in question did or did not meet the ballistic performance specification. Test teams from the Aberdeen Test Center, Maryland, and the Army Research Laboratory's Survivability/Lethality Analysis Directorate (ARL/SLAD) completed a 456-shot test program in less than four days beginning July 17, 2007. The Army Evaluation Center (AEC)/ATEC and ARL/SLAD completed data reduction and performance analysis, providing a report to DOT&E on July 23, 2007. DOT&E reported to the Secretary of Defense on that same day that the helmets tested did meet the ballistic protection requirement.

Personnel Body Armor. In a May 21, 2007, letter to Secretary Gates, recognizing ongoing controversy regarding the capabilities of personnel body armor, Senators John McCain and Carl Levin advised that the DoD "must 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." In a full committee meeting on June 6, 2007, the House Armed Services Committee voiced these same concerns. To alleviate concerns within the DoD, and because of congressional inquiry, the Secretary directed DOT&E to oversee ATEC testing of respondents to a full and open Army solicitation for personnel body armor. The solicitation[5] was open prior to the hearing, but was modified subsequently by Program Executive Office (PEO) - Soldier to ensure that any prospective materiel vendor would not be excluded from submitting proposals. Extensive coordination and planning between DOT&E, ATEC, PEO - Soldier (Army materiel developer), other DoD agencies, and the Government Accountability Office occurred during 3QFY07, resulting in DOT&E approval on September 19, 2007, of Army test plans for the body armor test program. The test program consists of two phases. Phase 1 is ballistic testing in accordance with the Army solicitation that will result in an ATEC evaluation of ballistic performance for each of the solicitation respondents. ATEC anticipates that Phase 1 testing and analysis will continue into 3QFY08. PEO - Soldier will use that evaluation, with other data as required by the solicitation, to complete a source selection process. PEO - Soldier will award contracts to the vendors that pass source selection. ATEC will use material received from those contracts to complete Phase 2 of the test program. Phase 2 consists of additional ballistic testing to increase the confidence in and scope of the Phase 1 ballistic testing, and consists of suitability testing to evaluate parameters such as form, fit, and function. The length and duration of Phase 2 of the test program is dependent upon the number of vendors that pass source selection. The Army solicitation is

QUICK REACTION

[5] Army Research, Development, and Engineering Command Acquisition Center Solicitation W91CRB-07-R-0041, first posted on May 25, 2007.

scheduled to close on February 7, 2008, and ATEC testing will begin thereafter.

As noted in prior DOT&E Annual Reports, between late FY05 and FY07, DOT&E, the Army, and the Marine Corps co-sponsored a series of body armor tests to identify and select the most appropriate testing methodology for soft body armor. Analysis of those data concluded in 1QFY07 and the integrated product team consisting of representatives from DOT&E, the Army, the Air Force, and the Marines Corps agreed to a methodology. That methodology has been codified into a new test operations procedure (TOP), denoted TOP 10-2-208, V50 Ballistic Limit Testing of Fabric Body Armor, Using Clay Backing.

Blunt Impact Testing of Fielded Combat Helmets. As reported last year, on June 20, 2006, the House Armed Services Committee requested the DoD 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. 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. The U.S. Army's Aeromedical Research Laboratory completed testing in September 2006. DOT&E and the USD(AT&L) completed an assessment of the results and provided that assessment to Congress under a letter from Under Secretary Krieg on February 22, 2007. As a result of this effort, the Marine Corps adopted a pad system and has completed retrofitting its helmets with the new system.

Joint Improvised Explosive Device Defeat Organization (JIEDDO). DOT&E continued to support the JIEDDO through participation on the Joint Test Board and its funding of Improvised Explosive Device (IED) and military operations in urban terrain (MOUT) Joint Live Fire 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 Live Fire IED test program supporting JIEDDO is characterizing evolving IED threats and identifying vulnerability mitigation techniques that deployed commanders can employ, and that materiel developers can design into future systems. The JLF MOUT program is characterizing weapons effects and behind wall debris[6] against structures common to the current area of operations. This information assists commanders in deciding weapons employment and helps in developing tactics, techniques, and procedures.

Tactical Ground Vehicle Up-Armoring. DOT&E continues to monitor and support tactical vehicle up-armoring programs within the Army and the Marine Corps. This critical effort addresses urgent armoring needs of deployed forces and new acquisition programs through aggressive testing of potential tactical ground vehicle armor solutions. Materiel developers are focusing their long term armoring efforts on increasing crew and occupant protection. The intent of these programs is to develop an add-on armor package, known as a B-kit that will provide vehicle protection to meet the threat environment into which armed forces are deployed. The High-Mobility Artillery Rocket System – Increased Crew Protection, Long-Term Armoring Strategy (LTAS) – Family of Medium Tactical Vehicles, LTAS - Heavy Expanded Mobility Tactical Truck, and, Logistics Vehicle System Replacement are examples of programs currently undergoing aggressive testing of potential tactical ground vehicle armor solutions. Each of these armor programs is in a different phase of testing and development. As materiel developers integrate armor onto systems, or design them for mounting of add-on armor once deployed, the automotive performance of those systems must be tested and evaluated in an operational environment to ensure that the integrity of the system and its performance are not degraded. As noted in last year's report, test infrastructure limitations at Aberdeen Proving Ground restrict the Army's ability to conduct realistic operational testing of up-armored vehicles. Specifically, the Army and DoD lack a high-speed vehicle test track to demonstrate the safety, compatibility, reliability, durability, and maintainability of up-armored wheeled and tracked vehicles when operated at sustained high speeds. This capability is necessary to assure consistency with current OEF/OIF tactics, techniques, and procedures for programs such as Mine Resistant – Ambush Protected and Joint Lightweight Tactical Vehicle. Since last year, the U.S. Army Corps of Engineers (USACE) completed the design for the first phase of the test track. The Automotive Technology Evaluation Facility (ATEF) has site approval from the Army Garrison at Aberdeen Proving Ground for construction, appropriate wetlands permits from the state and federal governments, an aeronautical services waiver, and an approved safety site plan. DOT&E continues to support the Army's effort to develop this much-needed high-speed test track to compliment the Live Fire and Roadway Simulator test capabilities at Aberdeen Proving Ground.

[6] Behind wall debris is the material that is ejected from the backside of a wall following a ballistic impact to the front of the wall.

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. The joint team completed the first phase of testing in FY06 and published a report documenting the test results in June 2007.

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 response to Joint Staff, mission planners, and weaponeers throughout the combatant commands, the JTCG/ME is actively transitioning to a target-centric weaponeering approach. In support of increasing combined and coalition operations, the JTCG/ME developed and released JMEM Weaponeering System (JWS) DVD v1.2 (1,250 copies to 800 accounts) that provides air-to-surface and surface-to-surface weaponeering tools. This DVD included new/updated warhead data, delivery accuracy updates, approximately 280 new targets/surrogates with associated effectiveness data, and an updated Building Analysis Module (i.e., included Small Diameter Bomb (SDB), Guided Multiple Launch Rocket System (GMLRS), and additional building types and enhanced output to meet Central Command urgent requirements). The JTCG/ME also released the Joint Anti-Air Combat Effectiveness Air Superiority 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 supports the community of fighter pilots concerned with the air superiority mission and Strategic Command global strike mission planning.

JTCG/ME initiated efforts to support Information Operations with JMEM applications for communications electronic attack and computer network operations. These efforts are developing the Computer Network Attack Risk and Effectiveness Analyzer (C-REA), Radar Electronic Attack/Planning Effectiveness Reference (REAPER), and Communications Electronic Attack/ Planning Effectiveness Reference (CREAPER).

In support of current operations, the JTCG/ME updated the Effective Miss Distance tables of the Chairman of the Joint Chiefs of Staff Manual 3160.01b - Collateral Damage Estimation, developed a SDB weaponeering guide, updated J-FIRE (FM 90-20 – Multi-Service Procedures for the Joint Application of Firepower) risk estimates, and provided surrogate target information to coalition weapons for multinational mission planning.

JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The mission of the Joint Aircraft Survivability Program (JASP) is to increase the economy, readiness, and effectiveness of DoD aircraft through the joint coordination and development of survivability (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 (RDT&E) and ensures capabilities are conceived and developed in a joint warfighting context.

The JASP funds projects, complementary to Service survivability programs, to develop and test survivability technologies and assessment methodology. The JASP is sponsored and funded by DOT&E and chartered by the Naval Air Systems Command, Army Aviation and Missile Command, and Air Force Aeronautical Systems Center. DOT&E establishes objectives and priorities for the JASP as well as exercising oversight of the program.

In FY07, 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 54 multi-year survivability projects for $9.5 Million and delivered 35 reports in FY07. The following summaries illustrate current JASP efforts in susceptibility reduction, vulnerability reduction, survivability assessment methodology, and combat damage assessment.

Susceptibility Reduction:
The JASP continues to maintain its position at the forefront of susceptibility (the degree to which a weapon system is open to effective attack due to one or more inherent weaknesses) reduction technology efforts through relevant projects and coordination of technology development. With the ultimate goal

of transitioning to or impacting fielded systems, JASP funded efforts are making an impact now and showing promise for the future.

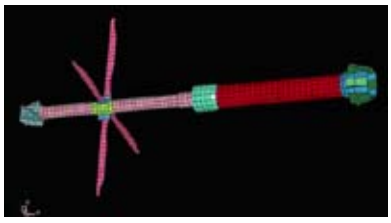
- In partnership with the Army's Aviation Applied Technology Directorate (AATD), a Reactive Infrared Suppressor was successfully flight tested on an AH-64 Apache helicopter. The uniqueness of this infrared suppressor system lies in its capability to provide a significantly reduced infrared signature while minimizing, or eliminating, engine performance penalties. It does this by swiveling the duct for optimization to the current flight and threat condition. The Army's Active/Passive Aircraft Survivability (APAS) program is scheduled to incorporate this technology.

- The JASP continues work at the forefront of advanced infrared missile countermeasure development. Adding to the improved expendable countermeasures project reported last year, efforts to understand the phenomenology of defeating imaging Focal Plane Array (FPA) seekers and technologies to support Directed Energy Infrared Countermeasures (DIRCM) were a focus of the FY07 effort. Significant highlights include a joint Army/Navy project quantifying the laser parameters needed to defeat representative threat seeker FPAs; reducing flight test risks for the Air Force's Affordable Laser IRCM Survivability System (ALISS); and, continued development of high power mid-infrared glass fibers for use in advanced DIRCM systems.

Vulnerability Reduction:

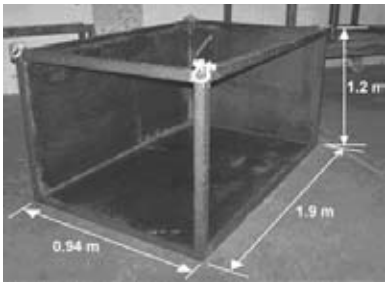
- **Rocket Propelled Grenade (RPG) Characterization and Damage Modeling.** The Army Research Laboratory's Survivability/Lethality Analysis Directorate conducted tests to collect previously unavailable data to support development of finite element (LS-Dyna) RPG threat models for application to high-fidelity dynamic modeling of threat and aircraft structure interaction.

ATEC, together with Boeing, developed a finite element model for RPG-7M damage effects, including blast, fragmentation, copper jet, and rocket body energy. ATEC assessed the accuracy of the model through correlation with an RPG test on an AH-1F Cobra tailboom conducted via the JLF program.



- **Transparent Armor Development.** AATD began work to demonstrate transparent armor concepts for rotorcraft that may yield a 30 percent weight reduction over current systems while lowering manufacturing costs and substantially improving multiple hit performance.

- **Fuel Tank Ullage Vulnerability.** The Air Force's 780th Test Squadron is providing data on the maximum oxygen concentration allowed for safe JP-8 fuel tank inerting under realistic fuel tank conditions for projectile incendiary and tracer ignition sources. A motion simulator at Wright-Patterson AFB reproduces the sloshing environment that exists during flight.



Survivability Assessment:

- The JASP completed a practical demonstration of the Integrated Survivability Assessment (ISA) process in conjunction with the Multi-mission Maritime Aircraft (MMA) program. JASP developed the ISA process at the request of DOT&E for assessment of the relative effectiveness of susceptibility and vulnerability reduction features on overall system survivability. The JASP effort provided infrastructure to pass consistent data to and from the models and databases used in the ISA process. This infrastructure was embodied in a Common Shared Database (CSD). MMA Program analysts can then perform analyses, using a suite of JASP supported models and the CSD, to identify the most effective mix of susceptibility and vulnerability reduction technologies to optimize MMA survivability. These analyses are ongoing and JASP will document the results in an Integrated Survivability Report for the MMA Program.
- The JASP is funding the development of a library of Damage Effects Models that combines threat effects, primarily blast and penetration, with hydro-code structural response models through the LS-DYNA architecture. The project has generated threat models for two high-explosive projectiles (23 mm and 30 mm) and two man-portable air defense systems (MANPADS) (SA-7 and SA-16/18) to date. FY08 plans call for the development of an SA-24 MANPADS model, enhancing a rocket-propelled grenade (RPG-7) model, and developing an air-to-surface missile (S-5) if sufficient data are available. This library of damage effects models supports aircraft designers, improves vulnerability/lethality analyses, and extends the knowledge gained from Live Fire test.

JOINT COMBAT ASSESSMENT TEAM (JCAT)

In FY07, the Joint Combat Assessment Team continued deployment to Operation Iraqi Freedom in support of Combined Forces Aviation. The JCAT continued operations from Al Asad and Balad and established a senior uniformed presence with Multi-National Corp - Iraq C3 AIR at Camp Victory. In 2007, the JCAT will complete 2,154 person-days in Iraq and is likely to assess more than 100 aircraft combat damage incidents. The JCAT accomplishes this by inspecting damaged or destroyed aircraft, acquiring available maintenance documentation, and conducting interviews with aircrew and intelligence personnel. The JCAT provides consultation to weapons, tactics, and logistics personnel and 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.

In 2007, the JCAT and the Survivability/Vulnerability Information Analysis Center (SURVIAC) established the Combat Damage Incident Reporting System (CIDRS) on classified netware. JCAT uses this repository to enter assessment reports and SURVIAC provides access to these assessments to the warfighter and acquisition communities.

A second but equally important mission for JCAT is hands-on combat assessment training of the maintenance personnel that work on battle damaged aircraft. This multiplies the JCAT's effectiveness by enlisting the maintainer's help in documenting battle damage when the team is unable to reach an incident site before mechanics initiate 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 examples of projects funded by JLF or completed in FY07.

Aircraft Systems Program

JLF/AS FY07 projects provided survivability data on currently fielded U.S. aircraft in order to obtain a better understanding of their vulnerability and identified 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.

CH-53E Super Stallion. JLF/AS completed the final year of a multi-year investigation into the vulnerability of the CH-53E platform. In FY07, JLF/AS conducted ballistic tests against the CH-53E tail rotor drive and main flight control systems under flight representative dynamic loads. These efforts contribute to the Navy's efforts to reduce the vulnerability of the fielded CH-53E, as well as improving the survivability of the new CH-53K.

Enhanced Powder Panel Validation. The JASP began investing in powder panel development in the early 2000s with the goal of developing an advanced passive fire extinguishing technology. Enhanced Powder Panels (EPPs) offer significant improvement in passive fire extinguishing and provide a reliable and low-maintenance means of fire mitigation for aircraft dry bays. JLF/AS completed full-scale EPP validation testing in both an AH-1Z fuselage dry bay and a replica A-10 wing leading edge dry bay. Of 16 tests conducted, eight on each article, no sustained fires occurred. Threats ranged from 12.7 mm armor piercing incendiary projectiles to a successful 23 mm high explosive incendiary projectile test. JLF/AS testing was the culmination of developmental ballistic testing for this technology in the protection of aircraft dry bays adjacent to fuel tanks. Both the JASP and JLF/AS organizations are assisting aircraft developers with the integration of this technology.

Rocket-Propelled Grenades (RPGs). The JLF/AS continues to investigate the vulnerability of front-line rotorcraft to this threat with goals of understanding the damage mechanisms of this threat and identifying survivability enhancements to mitigate it. JLF/AS completed a four-phase evaluation program in December 2006. The final phase of the program investigated the damage mechanisms of a free-flight RPG impacting both unprotected and inert fuel cells of AH-1 Cobra aircraft. Materiel developers and survivability engineers have used the results from the four phases of the program to update threat weapons effects and platform vulnerability databases for use in designing future aircraft.

Man-Portable Air Defense System (MANPADS). JLF/AS continued their multi-phase effort to assess large aircraft vulnerability to MANPADS by performing a quick-look assessment of MANPADS damage effects on a large turbofan engine. Test engineers at Wright-Patterson AFB performed live and inert missile tests on a non-operating TF39 engine (common to the C-5 aircraft). Damage proved to correlate well with pretest

predictions generated by General Electric using a missile model supplied by RHAMM Technologies, LLC. This test series marked 1) the first-ever coupling of missile and large turbofan engine models to generate high-fidelity predictions of damage, 2) strong correlation between turbofan engine test results and JASP-funded engine predictions of damage, and 3) validation of the JASP-funded engine-MANPADS modeling procedure.

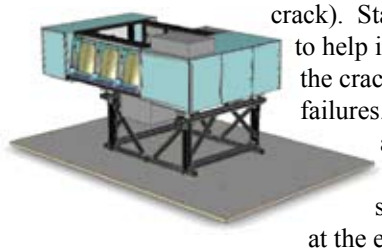
Foreign Unguided Rocket Lethality. This program provided basic warhead characterization data and lethality estimates (versus helicopters) for a single foreign unguided rocket warhead. Survivability engineers and aircraft system trainers are using these data for aircrew training, threat identification, tactics refinement, aircraft vulnerability reduction, and battle damage assessment and repair (BDAR). Survivability engineers will also use these data to better understand the vulnerabilities of deployed aircraft to unguided rockets.

Armor/Anti-Armor Program

U.S. Small Arms Effectiveness Against Threat Body Armors. U.S. troops are currently engaging hostile forces employing body armors (BA) produced by foreign nations. To provide U.S. troops with a situational advantage, the Army Research Laboratory (ARL) conducted test and analysis of U.S. small arms effectiveness against threat BA. ARL selected three potential threat ceramic plates and conducted testing with commonly used U.S. small arms ball and armor piercing (AP) munitions at various velocities to simulate different ranges of engagement. X-rays were taken of the targets before and after each shot to assess damage to the material, and ballistic gelatin blocks were placed behind the targets to assess lethality. ARL used modeling to assess personnel incapacitation. The methodology and modeling used to conduct personnel incapacitation estimation was developed within the small caliber rifle cartridge lethality project that is reported in the Quick Reaction section of this report. This is an excellent example of DOT&E's efforts to standardize test and evaluation methodologies within and across the Services.

Full Vehicle External Blast. JLF conducted a systematic series of experiments to assess the vulnerability of a BM-21 multiple rocket launcher and a URAL-375 cargo truck to external air blast loads. ARL detonated bare explosive spheres at various positions relative to these truck-based targets, and assessed the resulting blast damage. ARL applied instrumentation to the targets to characterize the applied air blast load to the target, and to a limited extent, air blast intrusion into the cab of the truck for assessment of crew casualty. ARL analyzed those data to develop contours of lethal miss distances with respect to mobility, firepower, and catastrophic target kills. The JTCG/ME currently uses simple models and database look-ups to estimate air blast effectiveness of a weapon-target pair, and after coupling with fragment effectiveness, guide the weaponeer in weapon selection and mission planning. 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.

Non–Destructive Evaluation Automated Inspection System (NDE-AIS) Body Armor. Program Executive Office (PEO) - Soldier developed the NDE-AIS to evaluate hard armor inserts and identify armor plates that had cracks, which make them ballistically degraded and unserviceable. Over the course of a year, the NDE-AIS has been constructed and tested to verify its capability and reliability. Starting in early January 2007, the system was field-evaluated to quantify the rate at which the system could evaluate hard armor plates, its reliability of finding cracks, and the effectiveness of evaluating several hard armor plate designs. The first field evaluation was successful and demonstrated that the system could evaluate 260 plates per hour. The system was 97 percent successful at identifying cracked plates. Work continued to reduce the amount of false accepts (plates that were accepted but had a crack). Statistical work also continued to help identify which parameters of the crack were causing more ballistic failures. PEO - Soldier conducted another field evaluation on a control sample of enhanced small arms protective inserts at the end of July 2007. This test was very successful and verified that the system is capable of identifying 99.8 percent of unserviceable plates. The NDE-AIS was also able to identify unserviceable plates that the current evaluation process (torque test) did not detect. The system is able to query data using the Unique Identifying (UID) labels used for materials research analysis as well as logistical concerns.



MOUT Secondary Debris Characterization. ARL conducted testing of direct fire munitions against walls constructed of materials based on information gained from in-theater

reports. These wall types included infill and load bearing walls. The FY07 tests utilized the expanded arena and test fixture that ARL implemented in FY06 and the data collected continues to populate an initial debris characteristics database. The work specifically benefits the DoD joint target community, Central Command, the personnel vulnerability community, operational tests, the Joint Army/Air Force Modular Effectiveness/ Vulnerability Assessment simulation, and the JTCG/ME's ongoing collateral damage estimation efforts. ARL is also using the data collected to increase the fidelity of personnel vulnerability models such as the Operational Requirements-based Casualty Assessment model. The Air Force Research Laboratory (AFRL) conducted testing of bare-charges against triple-brick walls to baseline the wall debris generated during internal and external detonation events. AFRL conducted four tests using Comp-B and a multi-phase blast explosive (MBX) currently being utilized as part of a low-collateral damage warhead. AFRL will combine the data collected with the direct-fire debris data to expand the domain of the debris characteristics database. The tests demonstrated the significant difference in debris characteristics due to the presence of quasi-static gas pressures (internal shots) compared with "free-air" detonations. AFRL will also incorporate this data into their weapon effects computer tools to improve predictive capabilities of structural debris and the collateral hazards for structural and personnel components.

IED Characterization. During FY07, JLF continued its support to JIEDDO and to forward deployed forces through high-resolution characterization of explosive ordnance. JLF extended beyond traditional characterization methodology by altering the threat item in a manner reflective of how the intelligence community has determined the current or future anti-Coalition forces to fight in order to gain a more holistic, comprehensive, and reflective characterization of the modern battlefield. The database of information from threat characterization is a fundamental step in designing countermeasures such as improved armor, effective early detection, and enhanced disarming technologies.

Sea Systems Program

JLF/SS, initiated by DOT&E in 2005, made significant progress toward assessing the survivability of submarines and surface ships, addressing the interests of the Navy, Army, and Marine Corps. 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 Full-Ship Shock Trial (FSST). The FSST involves underwater explosion testing of new acquisition ships. The goal is an integrated testing and simulation process in which the testing is more environmentally friendly and less expensive; and the simulation is capable of predicting mission degradation resulting from expected threat encounters. This JLF/SS task leverages the Navy FSST Alternative Enterprise program, and is coordinated with several major acquisition programs – notably Littoral Combat Ship, LPD 17, LHA 6, DDG 1000, and CVN 78. The non-explosive testing technology (i.e., air guns) development efforts are addressed in a separate task, below.

Test Alternatives to Underwater Explosion (UNDEX). This project is evaluating a less expensive and more environmentally acceptable alternative to UNDEX shock testing. The technical objective is to implement a cost-effective operational ship trial that provides significant data to advance the validity of advanced modeling and simulation used for Navy shock qualification purposes as well as for ship survivability assessments to expected conventional and asymmetric threats. This project leverages a Navy Small Business Innovative Research program to demonstrate the utility of a seismic air-gun array as the non-explosive loading source. The U.S. is collaborating with the UK Ministry of Defence to assess an air-gun array's potential as a surrogate for the traditional full-ship shock trial. In May 2007, test engineers used the circular air-gun array to generate underwater explosion-like loads on a Navy scaled submersible in a quarry. Efforts are quickly ramping up to demonstrate and employ larger arrays against operational Navy warships.