LIVE FIRE OVERVIEW

The Live Fire Test and Evaluation (LFT&E) Program was enacted into law by Congress beginning in FY86. From its inception, the program has required realistic survivability and lethality testing on platforms and weapons to assure that major systems perform as expected and that combat forces are protected. The number of LFT&E systems on OSD oversight reached 80 programs over the past year, the highest number since the program was enacted. This increase is primarily due to numerous upgrades to existing major systems. Nearly evenly divided between weapons and combat platforms, these programs embrace systems as small as a machine-gun bullet and as large as the National Missile Defense program. It includes fixed and rotary wing aircraft, ships and submarines, and a variety of land combat systems.

The Joint Live Fire (JLF) Program, chartered by the Office of the Secretary of Defense in 1984, is the responsibility of the LFT office. This program is a natural adjunct to the LFT&E program since it tests the vulnerability and lethality of U.S. platforms and weapons that have already been fielded, in contrast to the LFT&E program which evaluates systems still in development. The JLF program has enabled a wide range of testing, including the evaluation of fielded systems to emerging threats and to threats that have been known, but previously unavailable for testing. It has also provided many opportunities to upgrade our vulnerability and lethality models by comparing pre-shot predictions with actual test outcomes and making the needed corrections where possible.

One of the themes that the Secretary of Defense has articulated to the T&E community is the need to combine testing and training where possible. The LFT&E program has taken action on this theme and formulated a Live Fire Testing and Training Initiative with congressional funding beginning in FY97; again in FY98 and FY99. Through a Senior Advisory Group comprised of the Deputy Director, OT&E/LFT and the Commanders of the Service training and simulation commands, this program provides mutual benefits to both the LFT and Training/Readiness communities. These shared benefits are described in more detail later in this section.

Another of the Secretary's themes is to make more effective use of modeling and simulation opportunities. The LFT&E program supports this in several ways. First, requiring pre-shot predictions for each and every LFT&E and JLF test and comparing predictions to test outcomes, continues to provide valuable empirical data to upgrade our vulnerability/lethality models. Secondly, the Target Interaction Lethality/Vulnerability (TILV) program brings together technical experts from the military services and the Defense Special Weapons Agency to examine their plans in the 6.1, 6.2, and 6.3A areas to assure that there is neither unnecessary overlap nor serious gaps in the vulnerability/lethality technology base program. The TILV is co-chaired by ODDR&E and the DDOT&E/LFT. A third effort is to produce computer models with physical underpinnings that not only improve the understanding of current systems, but also more accurately predict test results. Through an agreement between the Director, OT&E and the Assistant Secretary of Energy for Defense Programs, advanced computer codes applied in the Accelerated Strategic Computing Initiative are being used to help make pre-shot predictions for the wide variety of LFT and JLF test opportunities. This effort has proven to be mutually beneficial for both programs and continues to grow in importance.

In July, this office proposed a forum to discuss and consider LFT&E policy. Our premise has been that the requirements for survivable and lethal systems have not diminished, if anything, they are increasing. Greater collaboration between OSD and the Services can clarify LFT&E policy to improve the acquisition process and improve the overall effectiveness of LFT&E programs consistent with statute.

This forum reached agreement on a new DoD 5000.2R revision. This policy has several benefits including the clarification of several terms, as well addressing the live fire testing of commercial off-the-shelf and non-developmental items to be used by our military forces.

LESSONS LEARNED

A central theme in the conduct of any Live Fire program is in documenting "lessons learned." This provides a mechanism by which the acquisition and test communities can incorporate new understanding of system performance under realistic combat conditions.

The Army's M1A2 Tank program provides a good illustration of how LFT&E can contribute to system improvement.

The table below summarizes "lessons learned" from Abrams LFT&E.

Test	Total # of Vulnerability Reduction Recommendations from Abrams LFT&Es	Number of Fixes	Number of TTP* Changes	Number of Recommendations Received but not implemented	Number not Addressed
M1/M1A1 LFT&E	49	20	8	16	5
M1A2 LFT&E	12	9	0	2	1
Others**	10		10		
Total	71	29	18	18	6

* TTP = Tactics, Training, and Procedures

** Other = These are fixes that the U.S. Army Armor Center has incorporated into their doctrine to improve the survivability of Abrams crewman in the battle environment. The fixes relate to how the crew is trained to prepare themselves and the vehicle for battle and were derived from incidents reported during various LFT&E tests.

On average, there has been about one new recommendation for a vulnerability fix per full-up vehicle shot conducted to date. Numerous fixes have been tested and proven effective in significantly reducing vehicle and crew vulnerability. Some significant "lessons learned" fixes have not been tested and will be a primary focus of future tests of the M1A2 Tank 2000. Some of the major "lessons learned" fixes that will soon be tested in the M1A2 include:

- Engine Air Intake.
- Engine PM III-Transmission Shift Select and Fuel Control ("Limp-Home").
- GPS Head Mirror.
- CITV Azimuth Drive.

Some enduring "lessons learned" from this and other programs are:

- There continue to be surprises even on system upgrades when testing at the full-up level.

- It is not too late to make small fixes that have a big impact, even after you have built the entire vehicle.
- LFT&E at the full-up level also has major positive impact on tactics, training, and doctrine.

JOINT LIVE FIRE PROGRAM

The Joint Live Fire (JLF) program was chartered in March 1984 to conduct Live Fire testing of fielded U.S. and foreign air and ground weapons platforms. Programs selected under the original charter and tested include the AV-8B, AH-64, UH-60, F-16, F-15, F/A-18, MIG-23, MI-24 (HIND), T-62, M60A3, T-72, M1, M2/M3, and BMP vehicles. The aircraft systems tested under the JLF program (known as the JLF Air Systems Program) are managed by the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS). Likewise, the JLF Ground Systems Program is managed by the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME).

In the FY99 JLF Air Systems Program, vulnerability tests were conducted on the F-14 Tomcat, F-16 Fighting Falcon, CH-47D Chinook, and AH-1S Cobra. In addition, during FY99, test plans were prepared for testing the vulnerability of the C-130 E/H Hercules wings to hydrodynamic ram effects. Under the JLF Ground Systems Program, tests were conducted to determine the lethality of selected U.S. weapons against a classified foreign armored vehicle identified as Spirit, and another high priority foreign target known as the Scud-B missile and launcher. This work is described in the classified annex to this report. Analysis was performed on tests conducted in prior fiscal years to determine the lethality of the U.S. High-Speed Anti-Radiation Missile (HARM) missile against ground-based elements of foreign surface-to-air missile systems, including SA-6 and SA-8, also discussed in the classified annex.]

F-14 Testing

The JLF Program performed two tests with Stinger missiles fired at static F-14 Tomcat targets. The tests were the first in a broader series of tests to assess the vulnerability of our aircraft to shoulder-fired man-portable air-defense systems (MANPADS). The missiles were shoulder-launched by Marine Corps personnel, flew free flight, guided themselves to their targets, and detonated on impact. Representatives from DOT&E, the Services, and industry witnessed the tests. Analysts, who are developing prediction/assessment modeling and simulation capabilities for MANPADS, are evaluating the damage to the test articles. Initial assessments have revealed unanticipated damage and have raised questions regarding the damage mechanisms and weapon-target interactions associated with this type of threat.

Prior to the F-14 tests, DOT&E and the JLF Program conducted a brief study of methods for testing MANPADS and determined an optimum investment strategy for supporting competing test methods. For the near term, the strategy calls for using free-flight missiles and static targets, as exemplified by the F-14 tests. The F-14 tests demonstrated the feasibility of the test method and provided an excellent return on investment. Valuable information was obtained at relatively low cost. The method is inherently low cost because it does not require development of new launch techniques and can be accomplished with minimum modifications to existing facilities. In the F-14 test, the costs were further reduced by using missiles that were allocated for training soldiers, and by using aircraft targets that had been retired from active use. Additional test methods are being developed to satisfy special requirements. For example, a sled test method to achieve greater control of impact conditions is being developed in conjunction with the JLF F-16 MANPADS tests.

The F-14 tests demonstrated that, by working as a team, we have the ability to pull together several different objectives for the same effort. For example, this test provided realistic training for the Marines, realistic lethality data for the Stinger Program Office, and realistic data for aircraft vulnerability assessment and for future vulnerability reduction efforts. It also provided forensic data that may be useful in future investigations of terrorist use of MANPADS weapons.

F-16 MANPADS Testing

The principal objectives of this ballistic test series are to identify and evaluate the kill mechanisms (e.g., blast, fragments, and missile body kinetic energy) of a MANPADS impacting an F-16 aircraft, and determine how the resulting damage affects the flight performance of the aircraft. Most of the testing in the past has been limited to static tests of warheads alone. These tests are being conducted dynamically (rail-launched or free-flight) against F-16 targets on the ground, and will provide insights into the damage mechanisms resulting from both the warhead and missile body. The F-16 targets are aircraft that had crashed or had been retired to Davis-Monthan AFB, NM. MANPADS missiles for the test series include SA-7A, SA-7B, SA-14, SA-16, SA-18, and STINGER. The 46th Test Wing, Aerospace Survivability Operating Location at Wright-Patterson AFB, OH, is managing the program, with testing performed at a facility operated by the 46th Test Wing's Chicken Little Program at Eglin AFB, FL.

FY99 testing consisted of two rail-launched SA-7 missiles and one free-flight Stinger missile. All three tests were into F-16 wing sections. The rail-launched missiles contained live warheads. The warheads, however, did not detonate due to incorrect intelligence information on firing pin connections. The tests did provide kinetic energy damage mechanism data that will be useful for simulation modeling and comparison with data gathered in future tests. Missile exploitation experts will be suggesting modifications to firing pin connections to prevent warhead detonation failures in future tests. The free-flight Stinger test successfully tracked the target and detonated upon impact with the wing test article. This test is providing data on the synergistic effects of kinetic energy, blast, and fragmentation damage mechanisms. The test also benefited the Stinger Program Office by providing a training exercise for the launch crew.

CH-47D Testing

The JLF program planned a multiphase series of tests to determine the vulnerability of the CH-47D main rotor blades and main rotor drive train. The results of these tests will complement the ongoing LFT&E program for the CH-47 F Improved Cargo Helicopter, since the rotor blades and drive train are common to both variants. Phase 1 of the test series for the main rotor blades includes firing selected threat projectiles at static blades. Phase 2 includes fatigue and residual strength tests of blades that have been ballistically impacted while under simulated flight loads. Phase 3 includes ballistic impacts on rotating blades. During FY99, the main rotor blade Phase 1 detailed test plan and pre-test predictions were prepared and the tests were completed. Phase 2 for the main rotor blades is scheduled for the next fiscal year. Planning for Phase 1 of the main rotor drive series was also initiated in FY99.

AH-1S Testing

The AH-1S testing began four years ago when 12 retired, flyable aircraft were made available to the JLF program. The first series of tests were dedicated to testing the main rotor blades, both statically and dynamically. Modeling and simulation were used extensively to predict rotor blade damage and compared to actual test results. For the first time, the results of the tests showed the differences in rotor blade damage occurring between statically and dynamically-tested rotor blades; i.e., rotor blades fired at while the blades are in motion on a helicopter. Comparisons of test results with analytical predictions

also indicate that improvements in analysis methods are necessary to increase confidence in accurately predicting blade damage.

This year was the fourth year of AH-1S testing and it included firing four types of threats at critical components of the tail rotor drive system for a total of 44 shots. Tests were also conducted on critical components of the fuel system. The tests included four threat types fired at the fuel filter, fuel transfer line, and the fuel supply manifold. There were a total of 26 shots covering a variety of test conditions. In addition to providing valuable vulnerability data, the JLF AH-1 test series has developed test methods using inexpensive test articles that will be applied to current and future acquisition Live Fire Test programs for helicopters. Since test articles for acquisition Live Fire Test programs are generally more expensive to obtain, there is a reluctance to try new test methods on them.

SPIRIT Testing

Test firings were conducted against a threat land combat vehicle code-named SPIRIT. Most of the firings were of older 25mm Armor-Piercing Discarding Sabot kinetic energy (KE) rounds used by the Army's Bradley Fighting Vehicle. The testing confirmed the general lack of effectiveness of the less capable 25mm rounds against the class of systems represented by the SPIRIT. Also, eight shots were fired against the SPIRIT using a foreign designed 40-mm KE round.

SCUD-B Missile and Launcher Testing

Testing was initiated this year on the SCUD-B Missile and Launcher at Eglin AFB, FL. The primary objective is to evaluate the lethality of the SCUD-B system to various inventory munitions. A secondary objective is to collect signature data before, during, and following test events to determine if signature changes might be detected and subsequently correlated to inflicted damage. The goal of this secondary objective is the development of battle damage indicator metrics that might improve battle damage assessment techniques and accuracy.

This marks the first in a series of U.S. Munitions tests that will be fired at an operational SCUD-B missile while mounted on its launcher (in the travel mode) to gather realistic data on actual targets recently been made available for destructive testing. The first series of tests will utilize BLU-97 bomblets delivered to the target area by the Joint Standoff Weapon. The M-74 bomblets, which are delivered to the target area by the Army Tactical Missile System, are next to be tested. Details of these test series are contained in the classified version of this report.

Improved HARM Testing

Analysis of the test results from FY98 continued this year with several data exchanges occurring between the US and Germany to compare analyses results. Sensitivity studies were conducted against validated SA-8 target geometry models to assess analysis sensitivity to ray density and distance. Inputs for the final report are being consolidated for subsequent publication. Battle-damage signature collection, which showed promise in its initial trials during this program, is being incorporated in the SCUD-B JLF program.

LIVE FIRE TESTING AND TRAINING INITIATIVE PROGRAM

One of the goals of the Live Fire Testing and Training (LFT&T) Program is to help implement one of the thrusts articulated by the Secretary of Defense, that of bringing together the testing and

training communities for their mutual benefit. Congress continues to support the Live Fire Testing and Training Program, a national military testing and training initiative administered by DOT&E and the Services' simulation and training agencies. The program is managed by the LFT&T Senior Advisory Group, comprised of the commanders of the four Service training and simulation commands and chaired by the Deputy Director, Operational Test and Evaluation for Live Fire Test. The LFT&T Program fosters the exchange of technology development initiatives and uses between the live fire test and training communities to better serve the ultimate customer—the warfighter. Another goal of the program involves establishing partnerships between DoD and the civilian sector. The LFT&T Program was initially supported by Congress with $3 million in FY97, followed by $4 million in FY98, $5 million in FY99, and $7 million in FY00. This technology development initiative drew heavily upon major U.S. simulation and training centers' expertise.

The Senior Advisory Group meets periodically to review a host of proposals coming in from government and industry and to oversee their progress and products, assuring that these efforts meet the needs of the testing and training communities. Congress has showed growing support for this program every year since its inception, with funding for FY00 at its highest yet. The following projects comprise the FY99 LFT&T Program:

- **Combat Trauma Patient Simulator:** This project addresses one of the highest priorities of the LFT&E Program, that of minimizing combat casualties. It involves joining private sector and military development in ground combat operational assessments and training that simulate emergency medical treatment during combat. The Human Patient Simulator and the Multiple Integrated Laser Engagement System are designed to provide assessment capabilities and training for faster and better treatment to wounded personnel on the battlefield. The project will also enable the evaluation of crew injuries because they effect the performance of weapon systems in battle. Use of the system in normal procedures has "killed" the mannequin, forcing a change in procedures. As a result, this change has, in effect, saved at least one life—the live soldier that would have received treatment prior to change. We could multiply this result numerous times as we promulgate this technology.

- **Synthetic Environment Support for Lethality Live Fire Test and Evaluation of Ground Vehicles:** This project is a first attempt to build a bridge between live and synthetic test environments supporting the U.S. Army's Bradley Fighting Vehicle Program. Developing the capability to conduct weapons firing tests in a synthetic environment enables testers to assess side-by-side comparisons with live fire test results. The simulations will assist in determining the value of synthetic environment testing to LFT&E. Additionally, through this effort, ground crews will be provided the opportunity to refine their gunnery skills.

- **Target Impact Assessment:** LFT&E provides a rich data source of target impact and near-miss signatures from front-line U.S. combat platforms encountering threats. Since most training involves limited actual live firings against realistic threats, there are few opportunities for gunners and their commanders to observe an actual combat hit/kill. This project provides a "proof of concept" to define, document, and demonstrate transforming live fire test photographs and video into high-fidelity training models. It will provide more realistic training and give test evaluators a more tractable method of obtaining improved visual representations of test results. Subsequent integration of these target models into training visual systems will provide enhanced realism/fidelity for combat training scenarios involving detection, acquisition, and engagement of enemy targets.

- **Lethality/Vulnerability Enhancements for Ground Vehicle Direct Fire Simulations:** This project seeks to improve the realism of training simulations through the application of LFT&E data and methodologies. The primary thrust addresses how training simulations use metrics involving probability-of-kill given hit information regarding the mobility of ground vehicles. The project will be executed in three phases: *Phase I* will examine how target-weapon interactions are scored in current training simulations and determine the level of accuracy needed to support training objectives; *Phase II* will analyze how these training models and methods can be improved; and *Phase III* will investigate applying current LFT&E test data and methodologies to enhance the fidelity of training engagement simulations.

- **Effectiveness of Small Arms Fire:** This project provides a reconfigurable engineering tool, the Small Arms Simulator Testbed (SAST), to the small arms testing community which uses modeling and simulation techniques to design, test, evaluate, and modify new weapon concepts. Initiated as a project to support concept development and evaluation of the U.S. Army's Objective Individual Combat Weapon, SAST has evolved into a tool that identifies critical technical/engineering issues through metrics associated with live fire test of future small arms. SAST also shows marked potential as a training aid of existing weapons. The testbed should result in more informed acquisition decisions by providing vital lethality metrics into small arms system design, thereby reducing prototype development cycle time. Efforts have yielded more than $2 million in direct savings to design and evaluation efforts. This project has the potential to greatly enhance the realism of anti-terrorism training simulation in urban settings for current and future weapon systems.

- **Simulation for Producing Realistic Munitions Impact Flash Events:** An extension of the FY97 Target Impact Assessment Project, this project will develop synthetic image generations of visual signatures from flashes produced by kinetic energy (or other) munitions impacting targets. These modeled results will be integrated into training simulator visual systems.

- **Battle Damage Assessment and Repair (BDAR):** A joint U.S. Army and U.S. Air Force effort to develop a portable computer-based BDAR data storage/retrieval and training system supporting assessment and repair of battle-damaged ground vehicles and aircraft. This effort also includes the effects of threat warheads assisting in understanding the lethality of threat projectiles/missiles and recognizing threat "signatures" on damaged units.

- **Augmented Reality-Based Fire Fighting for Total Ship Survivability:** A "proof-of-concept" project supporting Total Ship Survivability Tests using augmented reality technologies to demonstrate the role of shipboard firefighters in fire damage assessment and fire extinguishing employment.

- **Dismounted Infantryman Survivability and Lethality Testbed (DISALT):** The objective of the DISALT system is to provide a multi-user small arms trainer infrastructure, allowing live fire testing and training communities to analyze, and subsequently optimize, the lethality and survivability of a fighting team. Simulated live fire exercises, supporting both live fire testing and training needs, would be developed and conducted on virtual test ranges to examine the complex interrelationships between man and multiple weapon systems. In

addition, performance metrics and methods of analysis would be developed to provide data reduction supporting the LFT and training communities.

- **Enhanced Recovery of Aircrew from Acceleration Induced Loss of Consciousness/Enhanced Acceleration Training:** Acceleration or gravitational induced loss of consciousness (G-LOC) is one, if not the main, physiological threat to aircrew of high performance aircraft. G-LOC has been present since the earliest fighter aircraft were developed (circa 1919). It remains a problem today for successful mission accomplishment. From 1983–1996, the Air Force, the service with the longest history of reporting G-LOC, experienced 24 Class A mishaps and 18 fatalities as a result of G-LOC. Once G-LOC has occurred there are several promising, but as yet untested, approaches to reduce the duration of G-LOC incapacitation. Investigation of these approaches hold the promise of discovering practical, simple, and cost-effective countermeasures capable of greatly reducing the mishap rate due to loss of consciousness in aircraft (during peacetime and combat situations).

- **Live Fire Test and Evaluation Training Opportunities for Battle Damage Assessment (BDA):** The House Armed Services Committee supplement to the 1993 Desert Storm Report concluded, "The most serious failure of U.S. intelligence was in producing accurate battlefield damage assessment." BDA is a critical deficiency on the modern battlefield. Current BDA is based on expert assessment of photographic images. As such, it is slow, subjective, sensitive to the experience of image analysts, and vulnerable to deception. BDA, the last step of a six step targeting cycle, is a key labor-intensive step. It is the step that ties the entire targeting cycle together, assisting in the evaluation of each and every step; i.e., "Did we select the right target?" "Do we need to restrike?" The community recognizes upgraded analyst training as the key to essential improvements in BDA. Live fire test and evaluation offers a unique opportunity to support needed upgrades. Live fire test and evaluation results provide a library of weapons effects data with well-calibrated lethality measures.

- **Non-Ballistic Live Fire Test and Training Opportunities:** Lasers represent critical and unique challenges to both the Live Fire Test community and the training community. Testing the vulnerability of modern weapon systems to laser threats is challenging because of the safety issues and technical difficulties associated with the types of vulnerabilities presented by such threats. From a training standpoint, it is important to prepare troops on how to react to battlefield lasers. Due to safety issues, such training is hard to provide. The development effort will identify crew, sensor, and operations vulnerabilities to laser threats in training system crews to operate in the presence of laser threats. The infrastructure will also provide a platform that permits system proponents to develop and test proposed tactics, techniques, and procedures for weapon systems operating in a laser threat environment.

Live Fire Testing is unique in that, apart from actual combat, it is the only source of realistic combat data, battle damage repair, and user casualty estimates. Efforts continue to make this program an integral part of the LFT&E Program Element.

MODELING AND SIMULATION FOCUS AREAS

The Secretary's theme to make more effective use of modeling and simulation opportunities is the guidance under which the LFT&E office has developed a modeling and simulation advocacy program.

The LFT&E program supports the responsible use of modeling and simulation in several ways, ranging from the immediate application of models to acquisition programs, to mid-term and long-term model development initiatives. Requiring pre-shot predictions for every Live Fire and Joint Live Fire Program is an immediate step that adds discipline to the T&E process. Comparing model predictions to test outcomes continues to provide valuable data to validate or improve our vulnerability/lethality models.

A Target Interaction Lethality/Vulnerability (TILV) program has been established to bring together technical experts from the military services and the Defense Special Weapons Agency, to assure that their research addresses gaps in vulnerability and lethality technology without duplicating efforts. The TILV group is co-chaired by DDR&E and the DDOT&E/LFT and is intended to prioritize mid-term model development investments.

Long-term model improvements are the objective of initiatives established with the Department of Energy National Laboratories to evaluate physics-based computer models. These models have the potential to improve the understanding of system level behavior by more accurately modeling fundamental component and material behavior. Through an agreement between the Director, OT&E and the Assistant Secretary of Energy for Defense Programs, advanced computer codes of the Accelerated Strategic Computing Initiative are being used to help make pre-shot predictions for a wide variety of Live Fire Test and Joint Live Fire test opportunities. This effort has proven to be mutually beneficial for both organizations and continues to grow in importance.

To better understand the role of modeling and simulation in the testing and assessment of major weapon systems under Live Fire conditions, DDOT&E/LF has stressed several critical mission activities. These include a modeling and simulation survey, a strict policy for pretest predictions on Live Fire tests, comprehensive reviews of lethality and vulnerability modeling technology, and specific technical efforts to understand the capabilities of state of the art physics-based models.

DOT&E initiated a Modeling and Simulation Survey in support of major acquisition programs. Twenty-two programs, including air, land, and sea platforms, weapons and Command Control Communication and Intelligence systems, from ACAT I to ACAT IV, were included in the study. The purpose of this study was to profile the investment in modeling and simulation (M&S) software supporting PMs. This survey will be completed in early FY00.

Pre-test predictions are the basic building blocks of M&S facilitated testing. Models are used to investigate the engagement space and choose specific engagement conditions (shot lines) that will be tested and provide a rigorous framework to evaluate our knowledge of the test environment and the behavior of the system under severe/failure conditions.

The TILV Master Plan and Investment Strategy is a comprehensive effort to identify the technology investment areas that provide the largest payoff to the Lethality/Vulnerability (L/V) community. This activity provides a forum for L/V experts from across the Services and other DoD elements to identify and prioritize areas where technology advances are needed. Service updates have been incorporated and a revised plan will be available to support the Technology Area Review and Assessment process.

Survivability of Aircraft Initiative (SSAI) is a collaborative effort between DOT&E/LFT&E, Sandia National Laboratories, and the Air Force Research Laboratory (formerly Wright Labs). The objective of the SSAI is to critically assess our ability to predict the safety of aircraft in fire and blast events under flight conditions. The approach selected involves the use of computational models, well-

controlled experiments, and live fire tests. The complexity of fire scenarios and the requirement to address many operational scenarios requires a tiered modeling approach.

A hypervelocity impact assessment completed this year provides insights into our ability to predict missile intercept lethality. Theater Missile Defense programs rely on two methods of defeating threat missiles: hit-to-kill and fragmenting warheads. In a hit-to-kill system, a kill vehicle is guided to an intercept where all or part of the interceptor impacts the payload section of the threat vehicle. This is sometimes called a body-to-body impact. The kinetic energy of the engagement is the primary source of damage to the threat payload. The Navy Area program uses a fragmenting warhead to provide the capability to defeat targets with blast and fragmentation damage, even when body-to-body impact is not achieved. Missile lethality strategies involve a combination of full-scale sled track testing, sub-scale gas gun testing, detailed physics-based analyses of a limited number of engagements, and fast-running engineering simulations to evaluate the probability of kill across the engagement spectrum. These elements are envisioned as tightly correlated stepping stones in a lethality assessment process. The detailed lethal effects on a threat missile are correlated to terminal flight conditions through modeling and simulation. This study helped the Live Fire office understand the uncertainties and limitations of the underlying physics models.

The ground effects from chemical and biological agents released in a missile intercept are the subject of an ongoing study. There are many sources of uncertainty in the processes associated with intercept damage, agent dispersal and cloud formation, transport of that agent to the ground through complex weather and atmospheric conditions and the subsequent impact on protected assets.

VULNERABILITY ASSESSMENT OF RADIO FREQUENCY

Directed energy threats, including low, medium, and high-energy lasers, high power microwave and radio frequency (RF) devices, and weapons capable of generating a high-power electromagnetic pulse, are emerging around the world. Based on the development of foreign sources recently observed, these threats are expected to be seen in the field of battle against high-technology assets within the next two to three years. DOT&E/LFT&E is concerned by the potential adverse threat posed to current and future U.S. weapons (and supporting defense systems) by these emerging, non-traditional threats. These directed energy threats might be used by an adversary to exploit a specific area of vulnerability, such as communications, information warfare, or other selected areas, to attack U.S. forces more effectively and efficiently, thereby achieving an asymmetric advantage.

The U.S. Congress provided an initial increment of $4.0 million in FY99 to “expand threat vulnerability testing and evaluation to include the threat of RF weapons.” LFT&E initiated an assessment of the requirements for testing the vulnerability of U.S. military systems to these threats. The Deputy Director, OT&E/LFT&E also received a number of residuals (instrumentation and target suites) from the Joint Command and Control Warfare Center used in a previous RF device test program. In addition, LFT&E supported a field test of a RF device against a building containing a set of test objects consisting primarily of computer technologies. A broad agency announcement was prepared and subsequently published in Commerce Business Daily. Twenty-eight responses (a mixture of submittals from both public and private sector vendors) were received in response to the announcement. A technical evaluation committee was convened which subsequently evaluated the submitted proposals. Contract awards are currently being negotiated on a number of these.

The main objective of the vulnerability assessment of the RF program is to conduct vulnerability testing and evaluation of the threat of RF devices on modern and future military systems, support

infrastructure and systems under development using commercial off-the-shelf technology, which could or will have military application. The RF devices are being designed and built based upon the representative threat(s) and characteristic of what a rogue nation or terrorist could fabricate using "open source" information and commonly available hardware components. The devices will be capable of providing wide band and ultra-wide band transient signals. It is expected that a series of devices will be fabricated that will escalate the knowledge of RF device design by using past experience to improve each device. The target systems will be evaluated in regards to their vulnerability, susceptibility, survivability to degradation, disruption, upset, and damage from RF devices. Testing will be conducted in realistic environments where such RF devices would be used. A senior advisory group consisting of DOT&E/LFT&E personnel, RF experts, and senior military advisors will be formed in the near future to review program progress and results.