Resource Challenges for Transforming the T&E Infrastructure

This report concentrates on the transformation of the test and evaluation (T&E) infrastructure which includes people, processes, and facilities. Over the past year some progress was made concerning test resource problems but challenges remain. This report addresses specific initiatives to meet future T&E resource requirements.

The 2001 Quadrennial Defense Review (QDR) states that the transformation of the U.S. military will result from exploiting new operational concepts and capabilities, using existing and emerging technologies, and applying new organizational structures. Transformation of our warfighting systems must be accompanied by transforming the T&E processes and the T&E infrastructure into modern, efficient, joint test capabilities. Transformation of this infrastructure will be a continuing challenge in the years ahead. Sufficient infrastructure funding to enable adequate demonstration and evaluation of weapon system effectiveness, suitability, and survivability before fielding is vital.

The T&E infrastructure must be capable of accommodating a dynamic environment where evolutionary acquisition initially delivers equipment whose design does not satisfy all requirements. Part of the expectation is that the use of these immature systems will define deficiencies and refine requirements for further development. Evolutionary acquisition means that both development and testing will be a continuous process.

New technologies will have significant effects on the evolution of the T&E infrastructure. Examples include embedded instrumentation, nanoelectronics, robotics, directed energy, and hypersonics. New joint warfighting concepts seeking to leverage such technologies will also shape the future infrastructure. New test capabilities and methodologies are needed to adequately evaluate systems-of-systems and families-of-systems. Evaluating larger footprint weapons and sensors will require access to air, land, and sea battle-spaces encompassing both testing and training ranges. Interoperability and commonality between ranges (across Services and between testing and training ranges) are necessary to efficiently use DoD resources and increase the tempo of testing. Currently, modernization plans for test ranges focus on satisfying near-term test requirements and do not adequately map into the future. A long-term, comprehensive, DoD modernization plan that identifies and invests in future needs is essential for transforming T&E capabilities.

PERSONNEL CHALLENGES

Having sufficient personnel with the proper skills to conduct developmental and operational testing is an essential element of adequate T&E resources. Past trends have resulted in the personnel status described below. Future needs demand that these trends be reversed.

Acute Personnel Shortages Exist

During the last ten years, persistent efforts reduced T&E infrastructure expenditures. Eliminating personnel associated with testing was a primary means of reducing expenditures. However, this practice resulted in fewer work shifts available at the remaining test sites, which reduced the tempo of testing. Figure 1 depicts the decline in personnel at the Major Range and Test Facility Base (MRTFB) in terms of work years from 1992 to 2002.

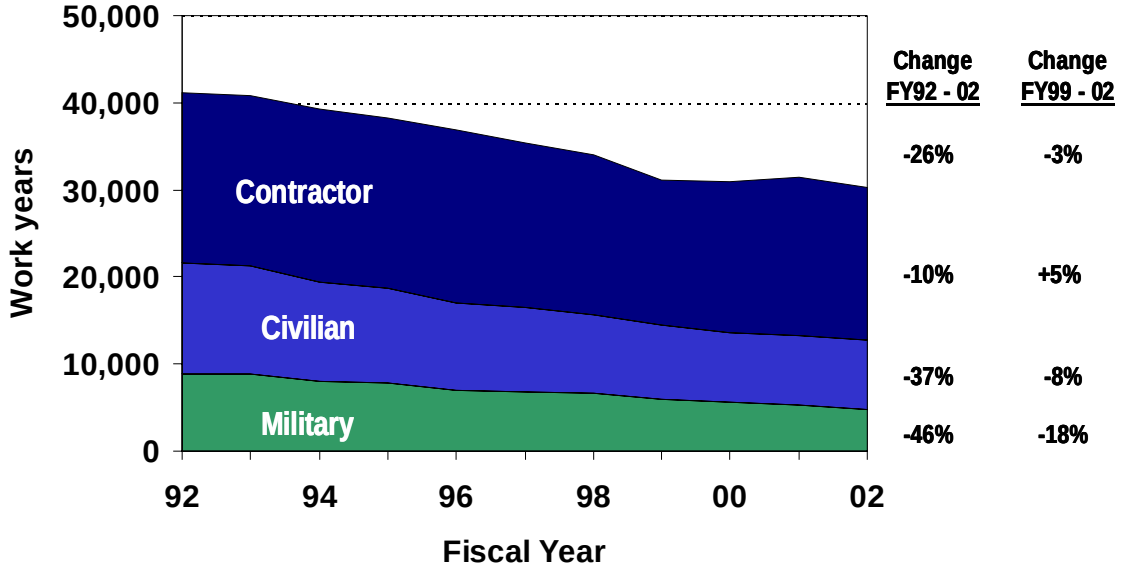

Figure 1. Reductions in MRTFB work years (FY92-FY02)

Having fewer personnel at the test sites not only limits the flexibility of facility managers, but also decreases the capacity of test facilities to meet the needs of test sponsors. Additional test personnel are required to improve test designs and to increase the tempo of testing to support continuous development and the rapid movement and analysis of data. More personnel are also needed to support surge testing. Some of the more pressing personnel needs include:

- *Technologically competent personnel to conduct research and development on future T&E capabilities*—The T&E infrastructure should lead weapon systems acquisition in both sophistication and technology. A capability-based T&E infrastructure is analogous to capability-based acquisition.
- *A force of competent engineers to ensure an adequate reliability component for every test event*—Operational testing often reveals suitability deficiencies in reliability, availability and maintainability. Reliability testing is done to learn where investments could significantly improve reliability.
- *More software professionals capable of evaluating software architectures and designs early in the development process*—The testing infrastructure was designed around hardware, but software is now the critical component of modern weapon systems. Hardware/software integration is increasingly critical to system performance. Test ranges are critically short of software professionals.
- *Military personnel to provide direct user input*—There is an urgent need to bring military personnel, such as the Army's Soldier-Operator-Maintainer-Tester-Evaluators, back into the infrastructure so that systems undergoing developmental test can have the benefit of direct soldier input. There is increased emphasis on providing earlier feedback to the development process, however, user participation is diminished. Military users and operators must be restored to developmental testing in order to enhance the effectiveness of test programs.
- *Additional technical expertise in particular areas*—Shortages exist in flight safety systems, chemical and biological research, and mathematical and statistical analysis experts.

The F-22 program is one example of the effect personnel shortages can have on weapon programs. Slippages in F-22 flight-testing are partly attributable to shortages of key in-house test support personnel. To mitigate this problem, the Air Force has accepted a Lockheed proposal to add additional funding to the F-22 contract so that Lockheed can augment the government-contractor test team with additional contractor technical personnel.

Another example is the B-1B Block E upgrade program, which had difficulty scheduling releases of live weapons at the national ranges- partly because of the shortage of Explosive Ordnance Disposal resources and personnel.

Also, the Navy's VX-9 operational test unit does not have enough flyable F/A-18s to accomplish all the testing that it is tasked to perform. This resulted in deferring Joint Air-to-Surface Standoff Missile (JASSM) carrier operability testing. The Navy reported that F/A-18E/F test aircraft were so over-tasked that they would not be able to test JASSM on the F/A-18E/F until 4QFY03 or later. The Navy attributes the inability to keep the jets flying to shortages in people (ground crews) and parts.

MRTFB Workforce Demographics

Another result of the MRTFB personnel draw down is a dramatic shift in the demographics of civilian government employees in the science and engineering (S&E) workforce. Figure 2 depicts the distribution of civilian government employees at the MRTFB who are in S&E positions as compared to the national S&E workforce. Only 3 percent of the MRTFB civilian S&E workforce is under 30 years of age as compared to 18 percent of the nation's S&E workforce. Over 39 percent of the MRTFB S&E workforce is over 50 years of age and rapidly approaching retirement eligibility. Due to hiring restrictions in recent years there are few junior MRTFB personnel to ensure a strong, technically qualified workforce for future T&E leadership. DoD needs to address the consequences of the aging workforce.

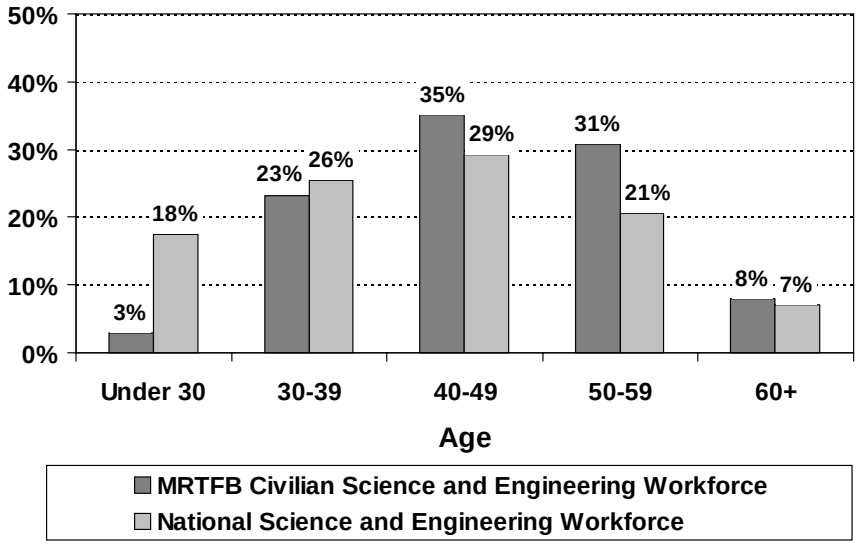

Figure 2. MRTFB civilian science and engineering employee distribution by age

Operational Test Agency (OTA) Personnel

Operational Test Agency (OTA) workload is increasing because:

- The T&E process is more complex as a result of the introduction of advanced technologies.
- System testing occurs in more complex operational environments.
- Evolutionary acquisition emphasizes earlier involvement of operational testers and evaluators in system development and increases the number of test events to be planned, conducted, and evaluated.

Early and continuous involvement by the OTAs is an effective means for obtaining operational insight about a system under development when design flexibility still exists. Early involvement also permits the OTAs to build a knowledge base to enhance the operational test program.

After a steady decline from FY93 to FY00, the OTA workforce rose slightly in FY01 due to an increase in civilian government personnel. Nevertheless, the total OTA workforce in FY02 is smaller than in FY93 despite an increased workload. Although stabilization of the government workforce is a positive sign, there remains a significant imbalance between OTA resources and their respective workloads.

Another concern is the proportionately smaller military presence within the OTA workforce. This represents a potential loss of operational expertise. Concurrently, dependence on contractor support is increasing. Table 1 shows the changes in the OTA workforce composition during the past 12 years.

Table 1. OTA workforce composition

	FY 1990		FY 2002	
	Number	% of Workforce	Number	% of Workforce
Military Personnel	2,112	48	1,305	36
Government-Civilian Personnel	1,236	28	1,150	31
Contractor Personnel	1,048	24	1,222	33
Total	4,396	100	3,677	100

As with the MRTFB S&E workforce, the OTA's are confronted with an aging civilian workforce. The average age of government civilians within the OTA workforce in the GS-7 to GS-15 pay grade range is 51 years. Only 13 percent of the OTA civilians are under 40 years of age. As the workforce ages, government service needs to become more attractive to potential younger recruits entering a highly competitive environment.

Personnel Actions are Required

An increase in T&E personnel is needed to accommodate the transformation of the U.S. military.

Specific personnel actions to address outstanding issues include:

- Recruiting recently educated technical personnel.
- Increasing the number of soldiers, sailors, airmen, and Marines involved in developmental and operational testing.
- Addressing shortfalls in reliability, software, and test engineers; chemical and biological researchers; and statistical analysts.
- Increasing the statistical expertise of the T&E workforce so advanced statistical methods may be more widely applied.
- Increasing OTA staffing (with a focus on operational experience) to more adequately address joint issues, interoperability, early involvement, and testing of non-major systems.

The timeline for reconstituting the testing workforce should address near-, mid-, and long-term remediation. Hiring momentum should address the retirement challenge and guarantee a successful transfer of existing knowledge and experience to the next generation.

MANAGEMENT PROCESSES

Transformation in the acquisition environment will require the Department's T&E infrastructure to change its management processes in order to be more responsive. Such changes should focus on long-range investment planning, funding policy, mitigation of encroachment, and a more useful employment of modeling and simulation.

Funding Policy

One factor that influences the adequacy of testing is the customer charge policies on the different ranges. DoD policy calls for customers to pay for the direct costs associated with testing, while the range or center parent organization pays for sustaining the test facility availability. This uniform charge policy was implemented to promote decisions on where and when to test that reflected program technical requirements.

Preliminary results from a recent DoD-IG study state, "… uniform funding does not occur because the manner, method, and amount of funding received by each range vary significantly, both within and across Services. Some ranges receive higher percentages of institutional funding as well as funding from congressional add-ons, Central Test and Evaluation Investment Program (CTEIP) funds, and funds from other agencies. Some funds for 13 ranges are withheld or the ranges receive funds based on other than a need-based methodology." The preliminary results state "As a result," of this and other factors, "the Office of the Secretary of Defense and the Secretaries of the Military Departments do not have comparable data needed to make informed decisions on the funding levels needed to reduce the backlog of the test assets and infrastructures. In addition, program managers may also be lacking the relevant information necessary to make informed test decisions for their programs."

Figure 3 depicts trends in MRTFB funding sources since FY92. In the period shown, the portion of MRTFB funding borne by test customers increased from 44 percent to over 57 percent. This shift resulted from the failure of institutional funding for the MRTFB to compete successfully with other demands in the Service programming and budgeting processes. This shift in costs to the customers may be a contributing cause to a reduction in developmental testing.

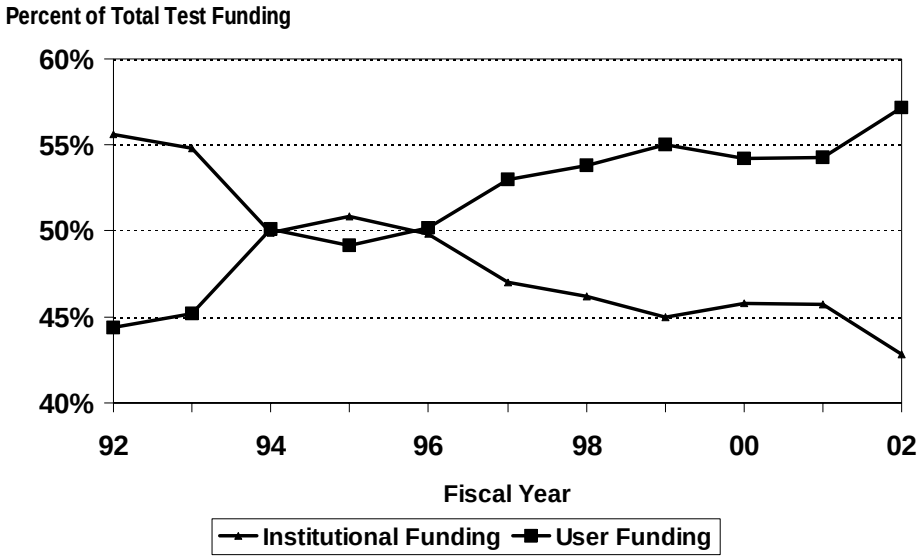

Figure 3. MRTFB funding trends

T&E Infrastructure Modernization
Early in 2002, the Secretary of Defense directed an examination of requirements to modernize the Department's test infrastructure. This report is the foundation for developing a DoD strategic plan for improving the test infrastructure so that it is capable of supporting affordable, adequate testing while leveraging investments in joint training ranges.

Range Encroachment
Encroachment refers to the cumulative result of outside influences that inhibit normal military training and testing. It includes urban sprawl near military areas, loss of frequency spectrum, restrictions on using air, land, and sea space, and endangered species migrating to ranges. A steady increase in such encroachment has serious consequences and threatens the use of testing and training ranges.

Legislative Proposal Addressing Encroachment
To mitigate encroachment, the Department submitted a legislative proposal entitled the Readiness and Range Preservation Initiative (RRPI). DOT&E strongly endorses measures such as the RRPI to sustain access to ranges capable of supporting adequate testing. This legislative package included the following provisions:

- *Endangered Species Act*—Confirms that there is no need to designate critical habitat on military installations for which an Integrated Natural Resources Management Plan (INRMP) is completed.
- *Marine Mammal Protection Act*—Codifies the National Research Council's recommendation that the current definition of "harassment" of marine mammals, which includes "annoyance" or "potential to disturb," be refocused on biologically significant effects.
- *Migratory Bird Treaty Act (MBTA)*—Reverses a March 2002 decision of a U.S. District Court applying the MBTA to training activities at the Farallon de Medinilla range in the Western Pacific. The provision would require the Services to take practical steps to prevent injuries to birds in the course of training.
- *Clean Air Act*—Provides more flexibility by ensuring that emissions from military training and testing are consistent with state implementation plans under the Clean Air Act.
- *Resource Conservation and Recovery Act (RECRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA*)—Confirms that military munitions are subject to the Environmental Protection Agency's Military Munitions Rule while on range and that cleanup of operating ranges is not required so long as the material stays on the range.
- *Cooperative Buffer Zone Acquisition Authority*—Provides DoD with additional authority to work with conservation groups to address urban encroachment of its installations. Purchase of land around existing installations would be managed to protect habitat for sensitive species and to prevent development incompatible with the installation.
- *Conveyance of Surplus Property for Conservation Purposes*—Provides legislative authority to transfer surplus property without charge to state governments, local governments, or private organizations for conservation purposes.

The legislative proposals served to open a needed debate on the effects of encroachment on military readiness. DOT&E will continue to support reasonable measures to address the effects of encroachment on adequate testing of systems prior to fielding. DOT&E is committed to the proposition that adequate testing is an essential element of equipping military units to ensure operational readiness.

Reduction In Available Radio Frequency Spectrum Could Limit Testing
Another constraint on testing is the limitation imposed by the available frequency spectrum. The testing of modern military systems relies heavily on the use of the radio frequency (RF) spectrum. Recent studies show that the DoD transformation initiatives and the next generation of technology being incorporated into weapon designs will require greater spectrum for operation and higher telemetry data rates. The expansion of consumer telecommunication services resulted in pressure from the private sector to reallocate RF spectrum from government to non-government use. This reallocation of available telemetry spectrum, coupled with increased data requirements, threatens the adequacy of

spectrum to support future testing. DOT&E is supporting efforts to defend against spectrum reallocation and to avoid adverse effects on U.S. test ranges and programs that could result from the loss of existing telemetry spectrum.

(CTEIP) initiatives may increase spectrum efficiency. However, the use of higher frequency bands to supplement current capabilities must be explored. An agenda item for the 2006 World Radiocommunication Conference is expansion of the telemetry spectrum by adding frequency allocations in the 3-30 GHz range.

Process Actions are Required

Specific process actions involving T&E resources include the following:

- Developing a comprehensive DoD strategic T&E modernization and investment plan.
- Supporting legislative proposals to mitigate encroachment.
- Decreasing the cost of testing to programs by increasing the institutional funding of the ranges.
- Increasing the amount of testing during development, including reliability testing, software testing, component-level testing, and operational concepts testing.
- Promoting continuous testing of all items in the inventory (but especially for systems that are evolutionary) so that faults are found in testing before they are found in combat.
- Encouraging the use of embedded test instrumentation in conjunction with embedded training.
- Conducting operational tests in the context of joint operations and with joint participation.

FACILITIES

The primary challenge to the T&E infrastructure is ensuring that T&E capabilities keep pace with the transformation of warfighting technologies and operational concepts. The transformation of warfighting capabilities will stress the T&E infrastructure. In some instances, without increased investments in new T&E methods and technologies, a significant risk exists that T&E capabilities may not be adequate to test future systems. The outlines of the transformed force are sufficiently clear to require priority attention to the definition and investment in T&E capabilities necessary to support this force.

Developmental Testing Occurs at the MRTFB

Most developmental testing within the Department is conducted at the MRTFB locations shown in Figure 4. These sites, operated by 30,000 military, civilian government, and contractor personnel, range from wind tunnels and electronics integration test facilities to the Department's largest open-air, land, and sea test ranges. The function of the test infrastructure has remained relatively unchanged since the MRTFB's founding in 1974: "The MRTFB is a national asset that shall be sized, operated, and maintained primarily for DoD T&E support missions."[1]

[1]DoD Directive 3200.11, "Major Range and Test Facility Base (MRTFB)," May 1, 2002.

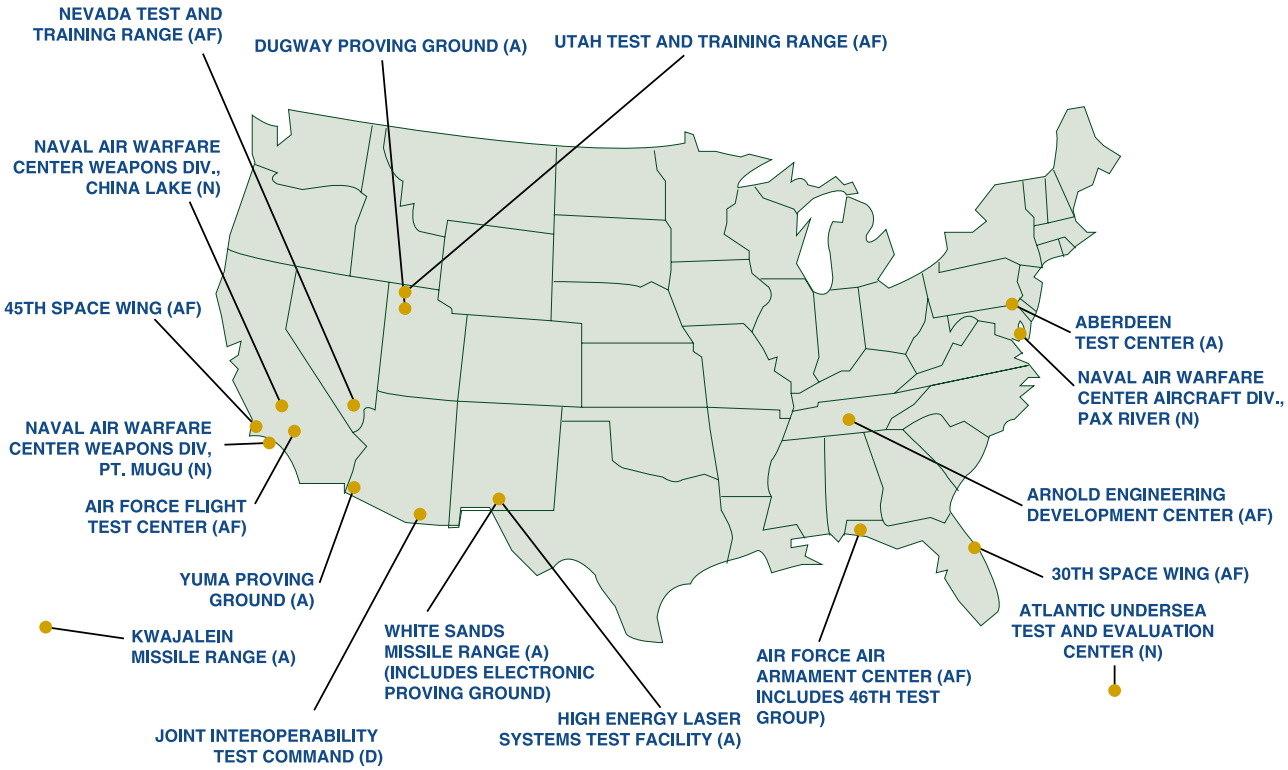

Figure 4. The Major Range and Test Facility Base

T&E Investment Programs are Improving and Extending Current Capabilities
Sustaining current capabilities and improving the test technology are the focus of existing T&E investment programs. The Service and Defense Agency investment and modernization (I&M) programs along with the OSD CTEIP program upgrade existing capabilities, but have inadequate resources to develop the new capabilities required by emerging weapons technologies.

Service and Defense Agency I&M Programs Modernize Existing Capabilities
I&M programs fund the modernization of existing test facilities and the acquisition of new capabilities to meet testing needs. Each Military Service pursues an I&M strategy that often focuses on test assets that are Service-unique with little multi-Service utility. Service I&M funding has been relatively constant in recent years.

In FY02, the Army I&M program completed the major portion of the Ronald Reagan Ballistic Missile Defense Test Site project to provide for remote operation of instrumentation and to modernize radars on different parts of the Kwajalein Atoll. This project will reduce on-island staffing and inter-island transportation and should improve data management and mission response times. Progress on other Army I&M projects included completing the frequency surveillance system and continuing the upgrade of the test support network at White Sands Missile Range. Projects completed at Aberdeen Test Center addressed full spectrum imaging, advanced data acquisition and analysis, and joint fire survivability test instrumentation.

In FY02, the Navy's I&M program completed the hydrophone replacement program at the Atlantic Undersea T&E Center, Bahamas; remote telemetry for the Naval Air Warfare Center Weapons Division; and the multi-spectral avionics testing capability at the Naval Air Warfare Center Aircraft Division. This latter investment provides the capability to test modern

aircraft (e.g., F-22, F-18E/F, and Joint Strike Fighter) across the frequency spectrum¾Radio Frequency (RF), Ultra Violet (UV), Infrared (IR), and Electrical-Optical (EO).

The Air Force's I&M investments completed in FY02 included flight simulation modernization, an interactive T&E network, and C4I modeling and simulation. Future investments will include advanced range telemetry, advanced Global Positioning System (GPS) range sensors, the Air Force Electronic Warfare Evaluation System (AFEWES) upgrade, an air warfare mission simulator development, a weapons integration and compatibility support project, an armaments/munitions digital modeling and simulation capability, a scene characterization and recognition system for advanced munitions, a real-time display and an analysis system for test data, and improved turbine engine structural integrity process.

The Missile Defense Agency (MDA) uses MRTFB facilities and is funding upgrades at the Pacific Missile Range Facility, at the Ronald Reagan Ballistic Missile Defense Test Site, Wake Island, and at the White Sands Missile Range. MDA also is developing a test infrastructure for a wide range of airborne sensor programs, including the High Altitude Observatory Aircraft and the Wide-body Airborne Sensor Platform.

CTEIP Provides Improved Capabilities for All Services
CTEIP is an OSD-managed program established to develop T&E capabilities normally considered beyond a single Service's area of responsibility. Its objectives include applying state-of-the-art technology to correct deficiencies in T&E capabilities and improve the efficiency of the test process; improving interoperability and interconnectivity among test facilities and ranges; developing, validating, and integrating modeling and simulation with open-air testing; and developing mobile test instrumentation as an alternative to fixed facilities.

New test capabilities being developed by CTEIP include:

- *Enhanced Range Applications Program (EnRAP)*—The EnRAP responds to test and training requirements for a spectrum-efficient, flexible data link designed to support a wide variety of applications, including time-space-position information, data transfer, and target control.
- *Third-Generation Range Space Wireless Networks*—This CTEIP project addresses near-term shortfalls in spectrum efficient test capabilities and mitigates spectrum encroachment through development of technologies to operate at higher frequencies that will support more realistic operational testing of future weapons, sensors, and platforms.
- *Foundation Initiative 2010 (FI 2010)*—FI 2010 is developing and validating a common architecture and a core set of tools to permit inter-range communication and networking capabilities that will connect test ranges, test centers, and key high-performance computing capabilities. Millennium Challenge 02 demonstrated the value of FI 2010 to testers, trainers, and experimenters.
- *Theater Air and Missile Defense (TAMD) Interoperability Assessment Capability (TIAC)*—The TIAC project provided the Joint Interoperability Test Command (JITC) with the capability to test TAMD interoperability from multiple interfaces across the Joint Data Network and Joint Planning Network during the Roving Sands exercise in June 2001.
- *Virtual Flight Test (VFT)*—The VFT methodology is expected to bridge the gap between hardware-in-the-loop testing, which is based on static wind tunnel testing, and open-air flight-testing. The airframe, including the autopilot, inertial sensors, and control actuators, can be suspended in the wind tunnel by a device that will allow free rotation of the VFT hardware in response to moments produced by steady and unsteady aerodynamic interaction with the airframe and control devices.

The Test and Evaluation/Science and Technology (T&E/S&T) Program Will Advance New Test Technologies
During FY02, DOT&E launched the Test and Evaluation/Science and Technology (T&E/S&T) program to develop or adapt critical technologies for test applications. Such technologies will transition to test capability investment programs to support DoD transformation initiatives and weapon system acquisition schedules, and will address deficiencies in critical multi-Service T&E infrastructure modernization.

This year, T&E/S&T projects were initiated in three critical areas: high bandwidth communications and spectrum efficiency, multi-spectral systems test, and hypersonic systems test. A backlog of other test technology needs will be addressed as funding becomes available, including miniaturized instrumentation; directed energy, chemical/biological, and information systems testing; and modeling and simulation tools.

T&E Infrastructure is Supporting Joint Experimentation

For over a year, DOT&E worked with U.S. Joint Forces Command (USJFCOM) to provide assistance in the conduct of the Millennium Challenge 2002 (MC02) and to define the role of the T&E ranges in this joint experiment. MC02 was the largest live field experiment ever staged by DoD and was conducted in a distributed fashion on training and test ranges located in the southwestern United States. One of the MC02 goals was to define requirements for future linking of test and training ranges to support testing, training, and experimentation.

The MC02 experiment successfully demonstrated that testing and training ranges throughout the country could be linked for joint training and experimentation. It also included integration of live and simulated actions to facilitate situational awareness at the operational level. T&E range assets and T&E-developed tools such as TENA were indispensable to the success of MC02.

Aging Test Infrastructure Must be Renewed

The T&E infrastructure is in need of recapitalization. This applies to the capital infrastructure (buildings, roads, runways, and major facilities such as wind tunnels) as well as the technical infrastructure (radars, instrumentation, targets, and test equipment used to support testing). The current recapitalization rate is significantly below that of comparable private industrial facilities and does not provide effective T&E capabilities. This results in delays, waivers of test requirements, and test limitations discussed throughout this report. To reestablish an adequate technical test infrastructure, additional resources for test ranges and facilities must be found.

T&E Capabilities Must Change to Keep Pace With Transformation

DoD T&E capabilities must lead, not lag, transformation. Adequate test capabilities must be in place, ready to test transformational systems throughout their development cycles. Additionally, greater flexibility in T&E processes and capabilities must be adopted if they are to adequately support the shorter acquisition cycles planned for developing transformational systems. Evolutionary acquisition will require more frequent—nearly continuous—testing. T&E capabilities must be in place to satisfy an increased tempo of testing.

Operational considerations also influence T&E transformation. For example, it is clear that future operations will be conducted jointly. A joint, seamless command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) network will form the backbone of such operations. Weapon systems will operate over significantly greater ranges with greater precision. The ability to effectively operate in littoral regions and urban areas will be essential and the military reliance on space assets will continue to increase.

Infrastructure Transforming Actions Are Required

DoD T&E infrastructure must provide realistic testing environments, realistic threats, and a well understood "ground truth" that is provided by the proper instrumentation. The testing must be supported by rapid, effective analysis of the test results and must provide prompt feedback to the system developers and warfighters.

Existing T&E capabilities will not be adequate to support the development of the transformed force. It is necessary to implement an investment strategy which fills the "gaps and seams" of the current T&E capability and addresses the following issues:

Joint, Network-Centric Test Environments

DoD test ranges evolved over the years into three sets of Service-centric test capabilities. Now, DoD needs new processes and capabilities that facilitate testing in a joint environment. A network-centric environment is needed that can support joint testing for joint operations by joint forces. A comprehensive "wrap-around" environment should have immediate application to interoperability and system-of-systems testing at every range. Every range could support testing for joint

operations. Specific needs include:

- *Interoperable testing and training ranges*—The barriers between Service-centric test ranges and between test and training ranges must be removed. Millennium Challenge 02 revealed the potential inherent in linking ranges to accomplish joint objectives.
- *Common joint test instrumentation*—Currently a wide variety of different and incompatible T&E range instrumentation impedes the ability to achieve joint, interoperable ranges.
- *Improved systems interoperability testing*—Upgraded distributed test beds, and increased emphasis on testing of system-of-systems C^4ISR capabilities is needed.

Larger Test Areas

Current T&E ranges are inadequate to test the greater reach of the weapon systems under development. DoD must obtain means to test systems with larger operational footprints. In addition to a network of joint, interoperable testing and training ranges, linking live, virtual, and constructive simulations and mobile, common instrumentation will enhance testing larger footprint systems or system-of-systems. The testing community needs to form an alliance with the training community to permit launching from training ranges into the test ranges. The alternative is to extend land ranges into ocean target areas or expand the existing ranges. Similarly, the maneuver areas to test new joint operational concepts will require expanded range space.

Operational Environments

The array of likely operational environments is not adequately replicated in the DoD test infrastructure. The needs include:

- *Adequate unmanned aerial vehicle (UAV) test capabilities*.
- *Improved test facilities for urban warfare*.
- *Improved testing in natural environments*.

New Test Ranges

In some operational areas, new test capabilities or new test ranges are needed. Areas that need to be addressed include:

- *An improved shallow water (littoral) test capability.*
- *Space Range*—There is a recognized need for a T&E capability to adequately test space systems in orbit.
- *Replacement of Atlantic Fleet Weapons Training Facility (AFWTF)*—An adequate replacement for the operational testing capability provided by AFWTF is required.

New Test Range Capabilities

DoD needs to improve existing facilities and ranges in order to provide the capability to test the high-performance systems now being developed. Specific areas include:

- *Testing in wind tunnels.*
- *Missile Defense*—Building the facilities to test elements of the missile defense agency demonstrates an unprecedented need for cross-Service T&E resource integration.

Operations Against a Robust, Adaptive, Asymmetric Threat.

The capabilities to test in a realistic threat environment must also improve. The needs include:

- *Systematic approach to threat analysis and representation throughout the systems development and acquisition process*—"Red Teams" should be established with the dedicated task to probe system weaknesses that are under development and provide feedback to system developers and force developers.
- *More realistic threat representations for all warfare areas*.

New Weapons Technologies
DoD must upgrade current T&E capabilities and provide new capabilities to meet the challenges of testing emerging transformational technologies. The needs include:

- *Capability to test hypersonic systems throughout their flight regimes.*
- *Improved capabilities for testing directed energy weapons.*
- *Test capabilities that address robotics and unmanned vehicles.*

Investment in Advanced Test Technologies and Instrumentation
To meet the challenges of testing the transformed force, we must invest in the test technologies necessary to provide the data to adequately characterize system performance. Test technologies of particular importance include:

- *Test data management, processing, and analysis*—Current systems are inadequate to meet the significant increases in volume, sources, and variety of data that will be generated in future testing.
- *Real Time Casualty Assessment (RTCA) instrumentation*—There is no family of joint, interoperable RTCA instrumentation that can handle the full range of combat interactions, e.g., direct and indirect fires, air-to-ground engagements, and ground-to-air engagements.
- *Embedded instrumentation*—Test (and training) instrumentation should be designed into combat systems from the beginning.
- *Multi-spectral test capabilities.*

Additional and Improved Targets
The current inventory of targets does not adequately replicate emerging threats. Adequate operational testing of new weapon systems requires targets possessing significantly greater threat fidelity. Examples include:

- *Anti-ship cruise missile targets.*
- *Full-scale aerial targets*
- *Subscale aerial targets.*
- *Sea borne targets*—Sea borne targets are needed to represent coastal patrol craft and asymmetric terrorist watercraft.
- *Diesel-electric submarines*—DoD needs realistic diesel-electric submarine targets.

Chemical/Biological Testing
New test chambers are needed as is a review of test methodologies for the chemical/biological testing to ensure we are doing everything necessary to analyze the data we collect. One such review by the National Academy of Sciences is already beginning.

SUMMARY

Thoroughly examining T&E policies, processes, and capabilities must be done in order for DoD to meet the challenges of transforming the U.S. military. The policy must be keep what works, discard what does not, and remain flexible in adapting to new requirements. There must be a corporate approach to policies, processes, and investment priorities in order to accomplish this.

DoD is transforming to meet the dynamic operational requirements of the war on terrorism, as well as future high-technology conflict. This transformation is not only limited to new hardware and technological innovation, but it also involves transforming capabilities through operational innovation. The future T&E infrastructure should comprise a comprehensive suite of joint, interoperable capabilities that provide a spectrum of full and realistic opportunities to test new technologies, improved platforms, and innovative tactics and training methods. We face a strong challenge to recruit and retain personnel, to define and implement innovative T&E processes, to maintain and recapitalize an adequate T&E infrastructure, and to transform the capabilities to meet the demands of the future.