TELEMETRY IN THEATER MISSILE DEFENSE DEVELOPMENT

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ABSTRACT

Since the Gulf War, there has been significant interest in Theater Missile Defense (TMD) resulting in funding growth from tens of millions of dollars at the time of the Gulf War to $1.7 Billion in 1994. The Ballistic Missile Defense Organization (BMDO) has developed a Theater Missile Defense test and evaluation program that will assess technological feasibility and the degree to which system functionality and performance meet technical and operational requirements. The complexity of the TMD program necessitates a comprehensive test program which includes flight testing, ground testing, and modeling and simulation. This article will provide and overview the requirements and capabilities needed to satisfy these requirements. The data processing, and telemetry communities will play a major role in providing the expertise to support the development of the nation's future Theater Missile Defense capabilities.

KEY WORDS

Theater Missile Defense, test and evaluation, system performance, live flight testing, ground testing, modeling and simulation, Air Defense, CINCs experiments, optical measurement, X-band measurement, phenomenology data collection, THAAD interceptor, radar, BMC3, System Integration Test, ERINT missile, Sealite Beam Director, High Energy Laser, National Test Facility, Airborne Surveillance Testbed, HALO, Rapid Optical Beam Sensing system, Cobra Eye, Cobra Judy, Aria, P3, GPS, WSMR, TSPI, Kwajalein, distributed interactive simulation.

INTRODUCTION

Since the Gulf War there has been significant interest in Theater Missile Defense (TMD). This interest has resulted in major budget increases. TMD funding has grown from tens of millions of dollars at the time of the gulf war to $1.7 billion in 1994. The TMD program consists of four core programs - TMD BMC3, Patriot PAC3, Theater High Altitude Air Defense (THAAD) System, and Navy Area Defense System. Three

other programs - Corps Sam, Boost Phase intercept (BPI), and Navy Theater Defense - are being considered to become acquisition programs at the end of the decade.

THEATER MISSILE DEFENSE TEST AND EVALUATION PROGRAM

The TMD test and evaluation program will assess technological feasibility and the degree to which system functionality and performance meet technical and operational requirements. The program is structured to assess technology, reduce acquisition risk, verify attainment of technical performance, ensure that systems are operationally effective and suitable, and provide timely information to support decision making. The complexity of the TMD acquisition/ development program necessitates a comprehensive test program, using all available test and evaluation techniques and methodologies to ensure that system performance and capabilities are fully tested and risk is minimized. Achieving system confidence through flight testing alone is impractical for TMD, given the system complexity, broad operational performance regimes, and high levels of effectiveness required. The Test and Evaluation program therefore emphasizes the use of models, simulations and various degrees of ground testing (as shown in Figure 1) prior to conduct of flight tests. This approach is necessary to conduct the number of trials needed to build confidence in performance

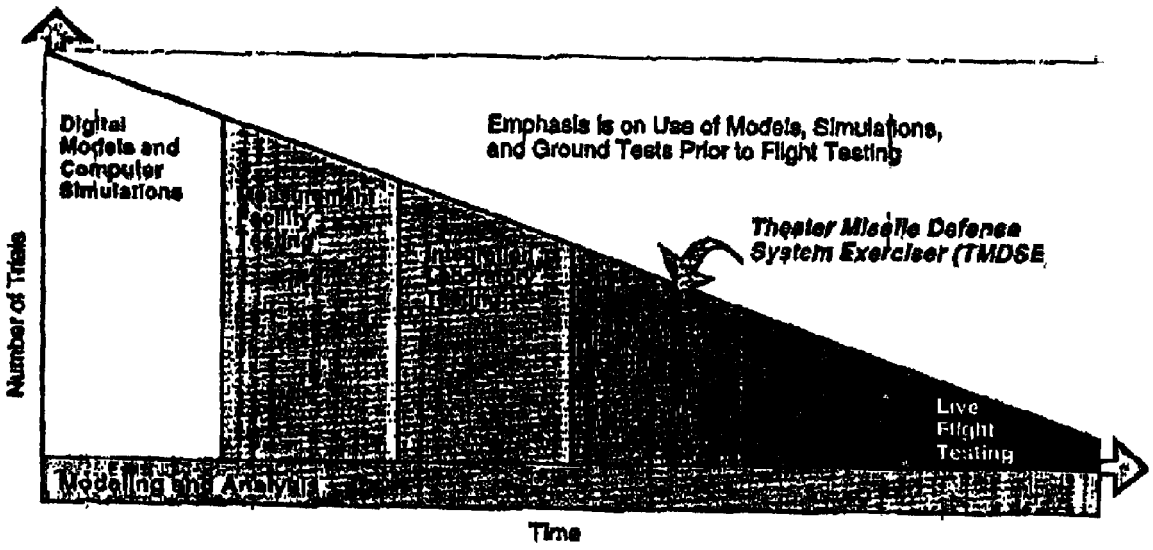

FIGURE 1. TEST AND EVALUATION TEST PROCESS AND METHODOLOGY

and explore a full range of operational scenarios and conditions while keeping the test program manageable and affordable. The combination of modeling and simulation, ground testing, and live flight testing provide a high-leverage, low risk approach to test and evaluation for the TMD program. Developing and testing these systems will require new or improved digital models and simulations, signature information on

theater ballistic missiles, ground test facilities, signal and data processing and data fusion, accurate time, space and position information capabilities over extended ranges, measurement capabilities for hit-to-kill lethality, and passive and active data collection capabilities. This article will provide and overview the requirements and capabilities needed to satisfy these requirements. The data processing, and telemetry communities will play a major role in providing the expertise to support the development of the nation's future Theater Missile Defense capabilities.

TMD system performance will be verified through the process shown in Figure 2. Improved digital models and simulations will be required for these systems. The Extended Air Defense Simulation (EADSIM) and the Extended Air Defense Testbed (EADTB) will be used to TMD system analysis. War games at the National Test Facility will help to refine user TMD operational concepts. The Surveillance Testbed provides a detailed engineering model to address sensor-to-sensor handover, sensor fusion and discrimination algorithm testing. Digital models for the detect, track, and engage functions will be used by each of the core programs to refine their program design. Phenomenology data on threats and countermeasures must be collected by static characterization in measurement facilities of optical and radar signatures. These static measurements will be complemented with dynamic measurements during flights. Once designs are converted into hardware and software, they will be tested on contractor and government ground test facilities. Examples of these would include the

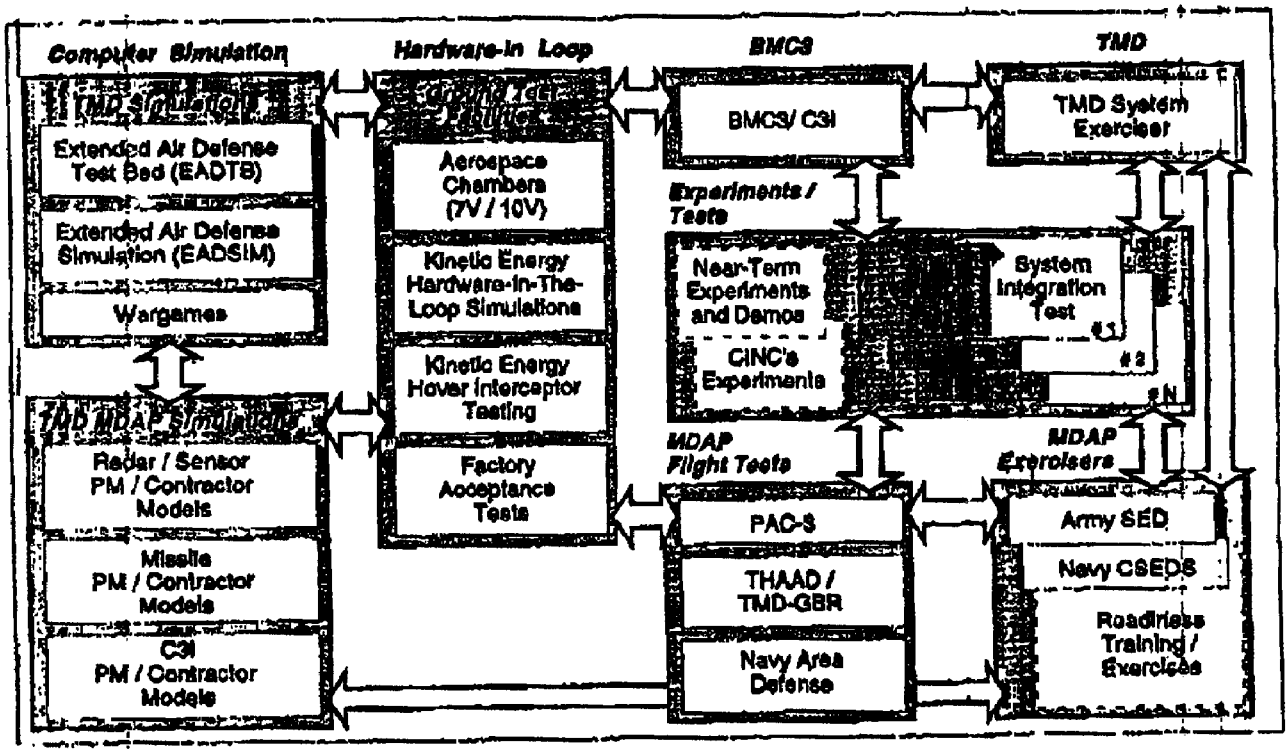

FIGURE 2. TMD SYSTEM PERFORMANCE VERIFICATION PROCESS

Software Integration Laboratory (SIL) at Lockheed Space and Missile Center in Sunnyvale, California and the Kinetic Energy Hardware in the Loop Simulation (KHILS) at Eglin AFB, Florida. The SIL provides a hardware-in-the-loop capability to integrate the THAAD interceptor, radar, and BMC3. KHILS complements the SIL with risk reduction testing such as the ShaRP. Technology programs are also looking at future kill vehicles which would integrate multiband passive and active laser radar systems to improve discrimination and end game performance. These will require capabilities such as array signal processing, improved data processing, and data fusion.

The Patriot Multimode Missile and the ERINT missile completed a series of flight tests at White Sands Missile Range during 1993-1994 (Figure 3). In addition to the metrics provided by the usual assortment of range sensors, these tests provided the opportunity to collect data on the Storm target in the infrared portion of the spectrum to support TMD system development. The Sealite Beam Director (SLBD) at the High Energy Laser Test Facility (HELSTF) in the southern part of the range provided a 1.5 meter aperture sensor to collect resolved signature data for use in interceptor end game algorithm development. The telescope at the Experimental Test Station at the north end of the range was also used for data collection. In addition to providing valuable data, these tests also identified a number of lessons learned. Reliably acquiring and maintaining track with these sensors was a problem. The solution will probably require improvements in the autotrack capability at the sensors as well as an improvement in the update rate in the PAS handover of the use of optical sensor rather than radar for handover. Other sensors were used for data collection on these tests. These included the Airborne Surveillance Testbed (AST) and the HALO/IRIS aircraft for optical measurements and the Cobra Judy ship for X-band radar measurements. A transportable ground based sensor, the Rapid Optical Beam Sensing (ROBS) system was used for the first time in a checkout mode on the last ERINT test against an airbreathing target. To improve the quality and reliability of data, other sensors are being considered at WSMR. These include a 3.5 meter telescope at Apache Point and 1.0 meter Air Force GEODS telescopes. Appropriate infrared cameras, video trackers, optical modifications, and computer hardware and software would be made to provide required phenomenology data to support TMD systems' development. The GEODS would be mounted on a trailer with environmental shelters so these sensors could be positioned at various locations such as Apache Point, Salinas Peak or the Lincoln National Forest to provide an east-west viewing line.

The sensors mentioned above will be used to support the extensive schedule to TMD tests to be conducted at WSMR in the 1990s. In the fall of 1994, the Theater High Altitude Air Defense (THAAD) system will begin a multiyear flight test series at WSMR (Figure 3). In 1995, the Navy will conduct a series of Block IVa(-) tests at

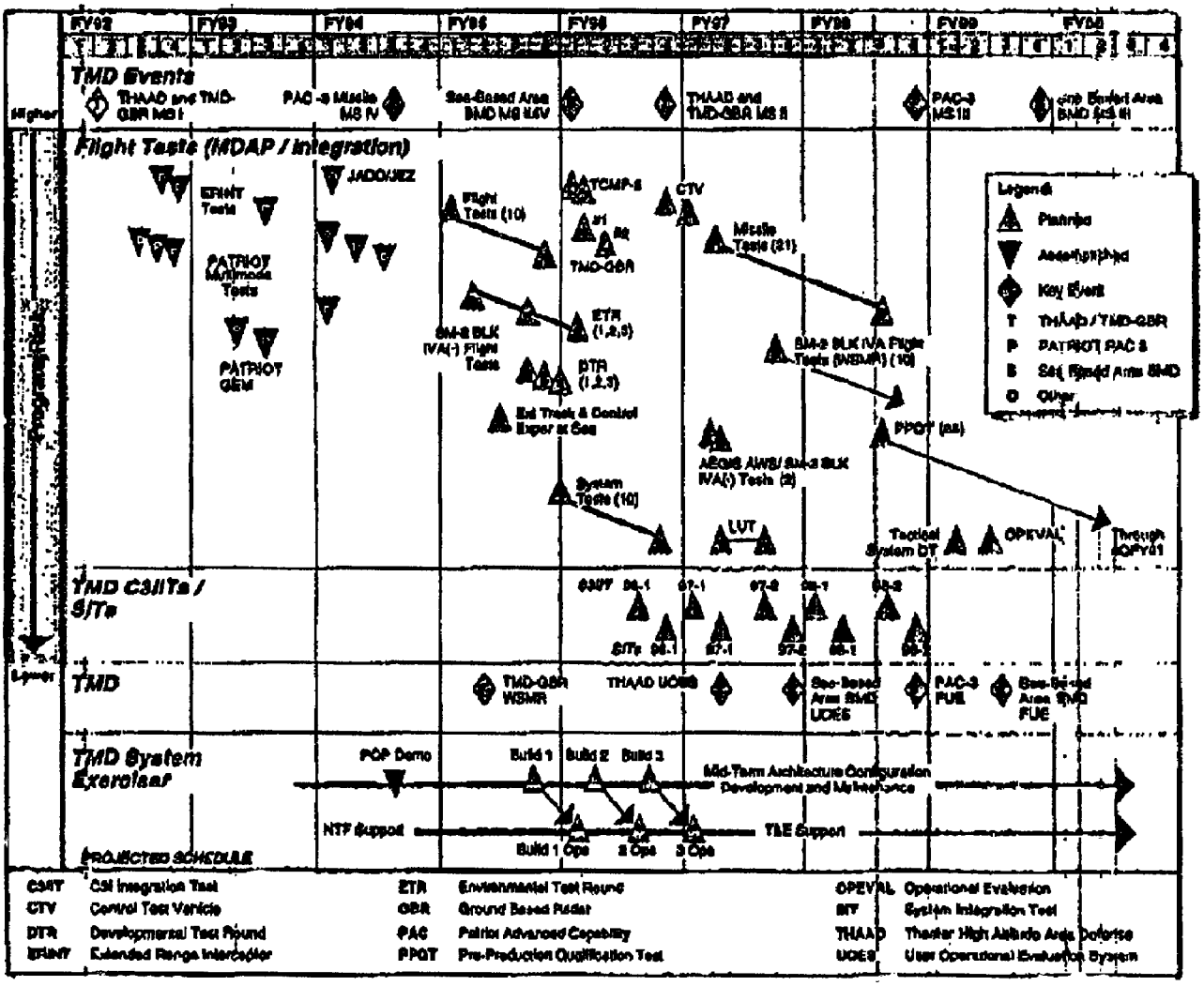

FIGURE 3. TMD RISK REDUCTION THROUGH EARLY COMPREHENSIVE TESTING

WSMR. These will be followed by a series of Block IVA and Patriot tests beginning in 1997. The Navy Extended Tracking and Control Experiment at sea in 1995 will involve a Sirypi 9 target launch from Barking Sands, Pacific Missile Range Facility (PMRF) on Kaui with launch detection by DSP and cueing provided to an Aegis System. The above sensors will complement existing range sensors to provide the phenomenology data to support these TMD systems' development. Accurate miss distance information is required for both fragmentation and hit-to-kill warheads. This miss distance information will be provided by existing optical and radar systems. For hit-to-kill warheads a Photonics Hit Indicator is being developed to provide accurate data where the interceptor hits the target. The Global Positioning System (GPS) is also being considered to provide accurate time, space, and position information (TSPI). The advantages of receivers versus transponders will be evaluated. For long range flights GPS is also being considered for use in providing position information for range safety.

The TMD requires a variety of ranges and range support capabilities to safely and adequately test the kinds of weapons technologies, targets, and systems which are being developed to provide missile defense. A number of mobile assets to include AST, HALO/IRIS, Cobra Eye, Cobra Judy, Aria and P3 aircraft, and ROBS will be used as required to support phenomenology data collection and testing at the various test ranges. Launch trajectories, endo and exo-atmospheric performance envelopes, footprints and debris considerations stress traditional test range capabilities. The challenge of accommodating long-range, high-altitude testing with threat-representative target engagements is being addressed. The performance envelopes of the systems being developed for TMD may not be fully tested within the constraints of White Sands Missile Range. Testing of the TMD systems will require target launches from distances of 1100 kilometers in the rear term. The test may be conducted at a number of locations. To meet these requirements, mobile or airborne systems, which can provide GPS and other telemetry support for TSPI and range safety functions, are desirable. As shown in Figure 4, alternative sites for TMD testing are being considered to include Eglin AFB, the Western Range, and Kwajalein Army Missile Range, and off-range corridors to WSMR. THAAD will conduct Limited User Testing (LUT) in 1997 and Engineering Manufacturing and Development (EMD) testing beginning in 1998. The Navy Area Defense will conduct DT/OT testing starting in 1999. The goal is to finalize the location and test resource requirements for all of these tests by the end of 1994.

To reduce the risk of integration of these TMD programs the BMC3 system is building on the existing Air Defense BMC3 structure. Near term demonstrations and CINCs experiments are being conducted with the CINCs around the world using existing systems such as the Defense Support Program (DSP) satellites, Patriot, and Aegis with evolving systems such as JTAGS and Talon Shield (ALERT) to address the interoperability of the systems. A TMD System Exerciser is being developed to provide a test control and global environment which can project any threat scenario anywhere in the world to distributed program exercisers. A distributed interactive simulation, the TMDSE located at the National Test Facility in Colorado would be able to project a common scenario of a tactical ballistic missile attack in Korea to an Aegis Exerciser at CSED in New Jersey, and an Army enclave consisting of THAAD and Patriot firing batteries at the Software and Engineering Directorate (SED) in Alabama. The systems would function as if they were participating in a joint battle in Korea with the exception the missiles would not be fired. The TMDSE will be used to conduct Command, Control, and Communications Integration Tests (C3IT). The System Integration Tests (SIT) would include the integration of flight test of TMD programs with the BMC3. The TMDSE may also be used to stress the system during these SITs by adding nuclear effects and increasing the number of targets in the threat. A TMDSE proof of principle demonstration was conducted in June 1994 with the

TMDSE test control and global environment located at the Advanced Research Center (ARC) in Huntsville, Alabama and a JTAGS located in California and a Patriot unit in Bedford, Massachusetts. The TMDSE will be developed through a series of incremental builds with Aegis and CRC nodes added along with other upgrades as part of build 1 in 1995. THAAD and other components will be added in build 2 in 1996.

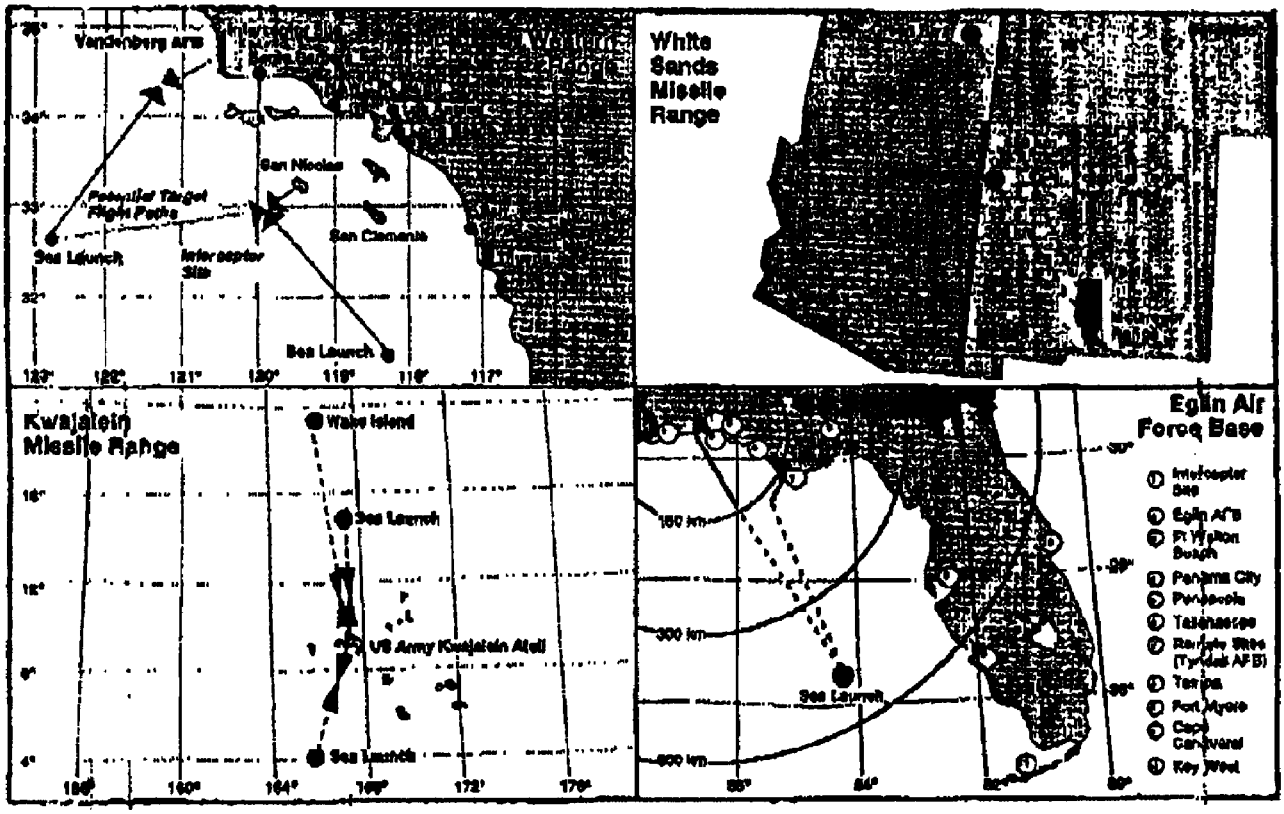

FIGURE 4. ALTERNATIVE SITES FOR TMD TESTING

An integrated test program concept has been defined which incorporates development and operational testing. Risks are identified and reduced through early component testing, supported by progressively larger scale simulations and hardware in the loop capabilities. A sound flight test program validates the ground test facilities and simulations.

CONCLUSION

The complexity of the BMDO Theater Missile Defense program necessitates a comprehensive test program that will support acquisition and fielding decisions. The Test and Evaluation program emphasizes the use of models, simulations and various degrees of ground testing prior to conduct of flight tests. Developing and testing these systems will require new or improved digital models and simulations, signature information on theater ballistic missiles, ground test facilities, signal and data processing and data fusion, accurate time, space and position information capabilities

over extended ranges, measurement capabilities for hit-to-kill lethality, and passive and active data collection capabilities. The telemetry community will play a significant role in this Test and Evaluation program, and ultimately, in the fielding of the nation's future Theater Missile Defense capability.

REFERENCES

"Test Resources Master Plan," Version 12/29/93, Ballistic Missile Defense Organization, Washington, D.C., January 1994.