Antiballistic Missile System Evaluation

By MAJ Craig R. Ailles

Long lead times required to develop, produce and field weapons systems—often as long as 10 years or more—as well as the current rapid increase in costs, emphasize the need to demonstrate that a system will perform to design objectives in a cost-effective manner before production begins.

Accordingly, an extensive system evaluation, using a combination of analytical studies, simulations and prototype testing, is conducted to validate that a system's design responses will meet performance specifications.

If the system fails to meet some part of the specification, the design is changed and the system is modified and retested. After demonstrating that the design performance specifications can be met with high confidence, the system design is released to production.

Because of unique features of the Safeguard ABM (Antiballistic Missile) System, the function of evaluation is to estimate total system responses in order to validate, with high confidence, that design objectives will be achieved.

The primary mission of the Safeguard System Command is to establish an ABM site complex for defense of the land-based United States retaliatory forces in the vicinity of Grand Forks Air Force Base, ND (Figure 1).

Based on this mission and reasonably stated, the Safeguard System must be able to detect and intercept multiple nuclear-tipped reentry vehicles in a nuclear environment. Within threat capabilities system designers have met these requirements, using phased-array radars, data processors and nuclear armed missiles.

Many factors prevent validating the tactical Safeguard System by testing alone. For example, the system must be able to operate in a nuclear environment, but the Nuclear Test Ban Treaty prohibits atmospheric testing. The system must defend against a mass attack of ICBMs, but producing this environment at a test site is impractical and costly.

Full operational testing at the Grand Forks site is not possible because of safety requirements imposed by its location in the Continental United States (CONUS), its close proximity to the Canadian Border, and costs and schedule restraints.

Because of these factors and for other reasons, a balanced combination of live tests, both field and laboratory, and computer simulations were employed to evaluate the Safeguard System design.

System evaluation involves two major phases of activity which, in some instances, are conducted concurrently. The first phase focuses attention on the performance and functional requirements specified by the tactical designer. The purpose is to verify that subsystems, such as phased-array radars, missiles and data processors, will work in the system context.

System and subsystem computerized simulations are developed to model the system response, to insure that critical system performance characteristics are identified and reflected in the system requirements.

Simulations are validated with field-test data and then "exercised" to insure that critical performance and operational characteristics can be met.

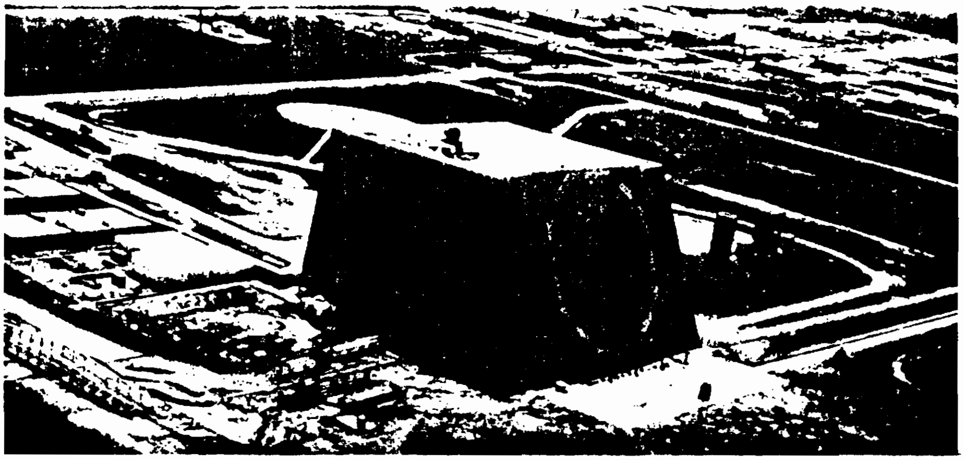

Fig. 1. SAFEGUARD SYSTEM under construction at Grand Forks, ND.

The second-phase evaluation focuses upon the system's capability to perform in a specific configuration, such as the Grand Forks site deployment. System and subsystem simulations are used to validate tactical system response.

These simulations are first validated by data collected from a selective set of field and laboratory tests configured to be representative of the specific system deployment. Models then are exercised over the full range of system deployment response to validate the tactical system's ability to meet design performance specifications and/or demonstrate where design modifications are required.

Evaluation proceeds from system requirements to design implementation, with the objective of obtaining adequate data to permit a realistic, confident and cost-effective assessment of system capability.

This Safeguard System objective has been met by first identifying the requirements that define the collecting and use of "live" test data produced at Meck Island at the Kwajalein Missile Range in the Pacific (Figure 2), the Tactical Software Control Site in Madison, NJ, and the Tactical Site at Grand Forks.

The next step has been to establish how these data and the Safeguard System Simulation (SAFSIM) and subsystem simulations, i.e., Sprint Engagement Simulation (SES), Missile Site Radar Simulation (MSRSIM), Perimeter Acquisition Radar Simulation (PARSIM), Spartan Simulation (SPARSIM), provide a balanced and realistic compromise to extensive and costly statistical testing as proof of design capability.

Ideally, detailed system analyses and sensitivity studies should be conducted before defining the integrated test plan. Practically, the pressure of schedules required that the identification of test objectives proceed in parallel with the development of simulation tools and preliminary analyses of system requirements.

Consequently, the test program is continually reviewed in terms of the additional information obtained from increasingly detailed system simulations.

Figure 3 diagrams the primary interfaces between the design, evaluation and test activities for the Safeguard System. The output of System Design is documented in the form of Performance Requirements provided to designers of both hardware and software. Their responsibility is to implement designs that satisfy the performance requirements in the most efficient and practical manner possible.

Clearly, this task involves continual interaction among the design, evaluation, and test groups. Performance Requirements for both hardware and software are a primary input to System Evaluation.

Evaluation must rely heavily on both simulation and analytical analysis. For simplicity, system evaluation is also represented in Figure 3 in terms of the major simulation tools that are continually being updated and extended.

The SAFSIM is designed to provide insight into over-all system operation, with particular emphasis on the battle-planning functions.

Initially, the simulated system is made to operate in accordance with the Performance Requirements. Since, quite properly, the Performance Requirements often permit the designer considerable latitude, modeling of the system simulation in this initial phase often entails considerable invention.

Again, the goal is to ensure that the defense objectives will be achieved if the system operates in accordance with the Performance Requirements; also, that inadequacies in sys-

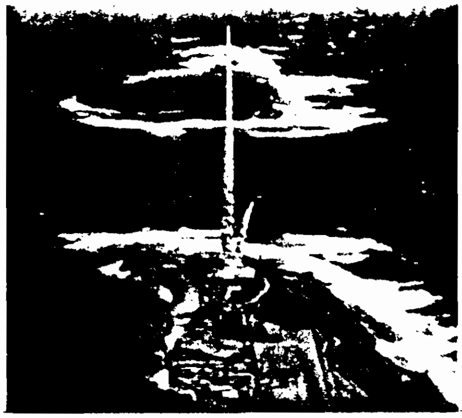

Fig. 2. MULTIPLE Sprint launching from Meck Island in the Kwajalein Range.

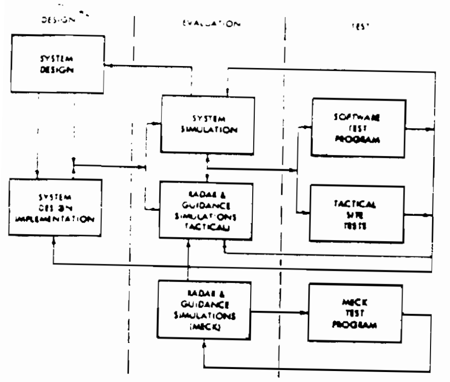

Fig. 3. System Evaluation Procedure

tem design will be identified and corrected before extensive resources are committed to implementing a faulty design.

Practicality limits the level of detail in which the various weapon system functions can be modeled in SAFSIM. Supplemental effort includes far more detailed simulations of the particularly critical functions of surveillance, tracking, target selection and guidance.

Considerable insight can be gained into detailed system operation by properly employing these simulations in concert. For example, SAFSIM can be used to examine the total system response to a representative attack scenario. External environment affecting the tracking history of a particular threat object of interest, such as location and time history of defensive bursts, can be determined from examination of SAFSIM output and provided as input to the detailed Sprint Engagement Simulation.

Two Sprint Engagement Simulations, the Tactical Version and the Meck Version, are used because of the differences between the tactical deployment and the "live" test facility at Meck Island. The latter is used primarily for testing guidance and data-gathering functions by intercepting ICBM targets, tailored to program requirements, with Sprint and Spartan missiles under the control of the Prototype Missile Site Radar (MSR) and data processor.

The tactical SES uses the input from SAFSIM to determine the performance of Sprint in a multitude of engagement situations, all of which will take place in a specified volume. The results are analyzed and a matrix produced that identifies the "live" tests essential to validate the model.

All combinations of tests required for physically validating the model cannot be performed; only a representative subset is actually tested. This subset bounds system performance and closely approximates engagements the deployed system must be able to perform.

Figure 4 is a representation of the intercept volume of the Sprint missile. The points designated P1 through P4 represent the intercepts which bound system performance.

The next step is to simulate the "live" test using the Meck SES, with all applicable inputs from SAFSIM and the Tactical SES, to insure that the Meck system can perform the intercept and that the data required for validating the various models will be produced.

After the "live" test is conducted, the Meck SES is exercised, using the environmental parameters that existed during the test. Results are compared with the test data and the Meck SES modified, as required, to reflect actual performance. Once the Meck SES is validated, these results are extrapolated to the Tactical SES with a high degree of confidence. In turn, the Tactical SES is used to validate the more approximate engagement model incorporated in SAFSIM.

As the designs of the tactical hardware and software solidify, these simulations are continually updated to provide a more accurate representation of tactical operation, and the evolving system is continuously evaluated. Validity of these simulations depends upon the fidelity with which tactical software, external environment and system components are modeled. Confidence in these models can be achieved only through carefully designed tests on appropriate test facilities.

In addition to validating the capability of the Tactical System to defend against a variety of representative attacks, SAFSIM provides a means of defining requirements for tests to be conducted at the Tactical Software Control Site (TSCS) and a frame of reference with which to compare the results of such tests.

The TSCS is used to test the tactical data-processing hardware and software for both the Perimeter Acquisition Radar (PAR) and Missile Site Radar (MSR). Full-load tests of the tactical software in which the external environment is faithfully simulated are required to validate that the tactical data processor will function as represented in SAFSIM.

The requirement for effective system evaluation is met, using extensive computer simulations and a bare minimum of "live" testing. The goal is to enable the United States to deploy an ABM system at Grand Forks that will meet national objectives at a minimum of costs and within the required time frame.

Experience gained in evaluating the Safeguard System by live testing and simulations is directly applicable to the site defense system prototype development. The Strategic Arms Limitation Treaty (SALT I) between the United States and the Soviet Union allows only two ABM sites to be constructed in each country. Deployment in the United States is limited to the Grand Forks site and one site in the Washington, DC area.

National policy is to develop an ABM system to protect the Minuteman Forces and be able to responsively deploy the system in the event the treaty is modified or abrogated. The Site Defense System, consisting of internetted radars, data processors, and Sprint missiles, has been selected to fulfill this mission.

The concept of prototype development is to design the Site Defense System to protect the Minuteman Forces, validate by live testing only those important, critical system uncertainties, and be prepared for a responsive deployment.

As with the Safeguard System, total validation of the Site Defense System will be by extensive computer simulations and minimum live testing. This will insure that the United States has a viable defense of its Minuteman Forces at minimum costs.

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During 1970–73, he also was responsible for engineering and scientific research in the area of national effectiveness for the Safeguard System at SAFSCOM. Additionally, he participated in the Source Selection Evaluation Board for the Site Defense Prototype Demonstration Program and design review of the Safeguard System.

MAJ Ailles served a tour of duty as S2/3 with the 99th Combined Services Support Battalion, 3d Brigade, 9th Infantry Division in Vietnam, subsequent to service (1968–69) with U.S. Army Europe (USAREUR) as chief, Operations and Training Division, Advanced Weapons Support Command; chief, Support Services Division, Advanced Weapons Support Command; and CO, 529th Ordnance Company, Advanced Weapons Support Command.

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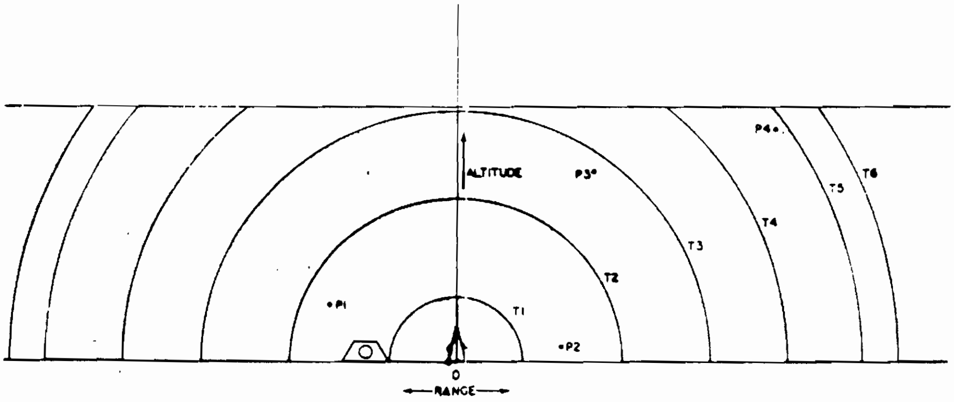

Fig. 4. SPRINT TIME of Flight Contours—Intercept Volume