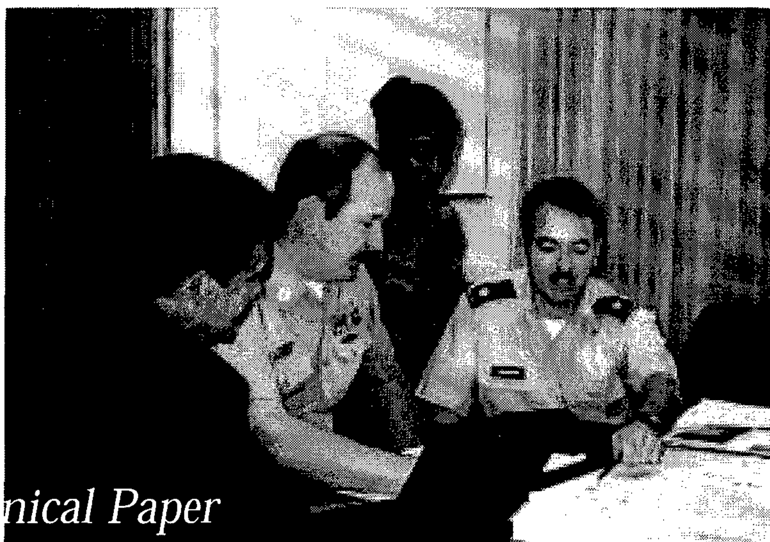
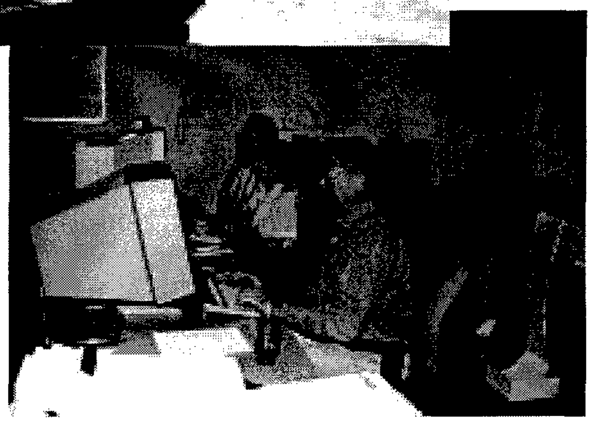
An Advanced Distributed Simulation Inclusive Test Planning Methodology



A Technical Paper from the Joint Advanced Distributed Simulation Joint Test Force



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An Advanced Distributed Simulation Inclusive Test Planning Methodology

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The methodology described in this paper is couched in terms of operational test and evaluation (OT&E). But, as OT&E moves left on the acquisition timeline and as new systems demand ever more complex test environments, the process can benefit Development Test and Evaluation (DT&E) as well.

Historically, OT&E planners have had to live with severe test asset and cost limitations. As a result, the tendency during test concept development has been to analyze the operating environment from the bottom up. Typically, the process involved identifying the set of entities in the operating environment which has direct interaction with the system under test and culling that group down to a minimum set. The historical approach resulted in a consistent collection of test limitations which are found in test report after test report, e.g., insufficient numbers and types of targets; insufficient numbers and types of friendly players; and inadequate representation of command, control, communications, intelligence, surveillance, and reconnaissance assets on friendly and opposing sides.

The advantage, at the cost of test limitations, of the historical approach to test concept development and planning was that uncontrolled variables were kept to a minimum, and cause and effect relationships were relatively straightforward. That was not a trivial advantage, but it was an advantage for the analysts not the system under test (SUT) users. In combat operations the users sometimes found that factors not included in operational testing had significant bearing on the ability of a system to do its intended job.

It is a plausible working assumption that advanced distributed simulation (ADS) can technically support representation of the military operating environment at the campaign or theater level. If ADS is included in the test planning tool kit from the outset, it is possible to begin the test concept development process at the top rather than the bottom. (The "top" may not be at theater level; it is established by the relevant operational task.) The methodology described in this paper is a top-level methodology. It is an approach which is compatible with the "strategy to task" philosophy. It is also a methodology for test planning which incorporates the consideration of ADS --- it is not an ADS planning methodology. This methodology is designed to provide insights on whether to use ADS and where in a test program the use might fit.

The advantage of a top-down approach to test concept development is that the whole gamut of interactions is available for consideration even if many of those interactions are assessed as irrelevant and excluded from the final concept. The top-down approach doesn't require that every possible interaction be included in the test, but it does require an item by item assessment of each interaction. Decisions to exclude interactions are conscious decisions not default decisions as a function of a bottom-up approach.

Mission or task level evaluation is explicitly a top-down approach. The top level, for test planning purposes, may be much lower than campaign or theater. Just how high the top level is, is a function of the task being evaluated. Some systems may have little or no interaction beyond a unit boundary, and others may interact closely with the theater and campaign levels. In the case of DT&E, it may make sense to substitute "specification sets" for "tasks". The methodology should still be useful, but the cast of players for most DT&E would be small relative to the OT&E cases.

NOTE: A top-down approach won't help much if it is implemented with a mind set fixed on historical limitations. It's necessary for the test planners to understand that ADS provides opportunities which weren't previously feasible.

In order to lend structure to the methodology, I have elected to assume a SUT which is a hypothetical air-ground attack aircraft. Please bear in mind that this is just an example of a process. Some of the terminology may be dated or inaccurate, but I trust the logic for the process will hold up. I believe the reader will have little difficulty tailoring the steps of the process to update the terminology or to apply them to other kinds of systems. The logic flow for the initial elements of the planning methodology is shown in Figure 1.

Step 1. Understanding the System Under Test. Step 1 requires the test planners to research the acquisition documentation to gain a thorough understanding of the SUT and its intended operating environment. This understanding incorporates the operational tasks the system is designed to perform, the critical system parameters, the system and operational requirements, the concept of operations, the logistical support concept, and the top level or general operating environment. One piece of the understanding deals with the technical or specification aspects of the system. The other piece deals with the interactions between the technical characteristics of the system and the world it operates in from a strategic perspective --- the friendly and supporting forces, the natural environment, and the threats posed by the enemy. In the case of a hypothetical close air support (CAS) aircraft, the cast of potential players from a theater perspective is pretty extensive:

- Joint force headquarters
- Air operations centers (AOC)
    - Air task orders
        - Fragmentary orders
- Wing operations centers (WOC)
- Tactical operations centers (corps, division, brigade, etc.)
- Theater air defense structures
    - Air defense units
    - Control centers
        - Safe passage procedures
- Tactical air control parties
- Forward air control posts
- Airborne battlefield command and control centers (ABCCC)
- Forward air controllers-air (FAC-A)
- Forward observers (FO)

- Air and naval gunfire liaison companies (ANGLICO)
- Direct/indirect support units (suppressive fires)
- Logistical support agencies/units
  - Munitions
  - Consumables
- Air support assets
  - Combat Air Patrol
  - Escort
  - Suppression
  - Refueling
  - Combat search and rescue
- Airborne Warning And Control System (AWACS)
- Joint Surveillance Target Attack Radar System (Joint STARS)
- Airborne laser (ABL)
- Rivet Joint, Guardrail, and other stuff
- Allied forces
- Threats
  - Airborne interceptors
  - Surface-to-air missiles (SAM)
  - Anti-aircraft artillery (AAA)
  - Small arms
  - Ground forces
    - Airborne
    - Special forces
  - Naval forces
    - At sea
    - Ashore
- Targets
  - Troop units
  - Vehicles
  - Fixed targets
  - Weapon emplacements

Obviously not all of the listed players play in every task; as the task changes, the relevant players list changes.

Technical measures are straightforward and map directly to system requirements and specifications. The technical measures tend to remain constant through the range of operational tasks, although some of them may be stressed in some tasks and not in others.

Operational measures map to the ability of a system to perform its intended tasks. The environment and the player set may change significantly between tasks (e.g., day to night or interdiction to close air support). The operational measures may vary significantly from task to task.

Once the test planners have a thorough understanding of the system, its tasks, its operating environment and its interactions in that environment, they can proceed to the next step.

Step 2. **Select a Task**. This step involves the selection of a specific task. A complex system may be assigned many operational tasks. Some tasks may be very similar, while others may be vastly different. It is possible that similar tasks may be grouped for evaluation purposes and tested on the basis of a single task. In our hypothetical case we might choose a task of CAS in daylight and good weather with communications jamming (comjam), and a moderate threat environment.

Step 3. **Develop Relevant Measures**. Once a specific task is selected, the planners can develop relevant measures for the task and a task-specific operating environment. The operating environment in combination with assigned objectives and missions provides a context for the test measures and defines the cast of players. Let's assume for our illustrative case that we have measures associated with the following areas of SUT performance:

- Ability of the pilot in the CAS aircraft to communicate effectively with controlling, coordinating and supporting agencies in a comjam environment

- Survivability

- Ability to navigate to, identify, and attack the appropriate target

- Circular error probable (CEP), circular error average (CEA)

- Weapons effects

Given those kinds of measures, the relevant task player list might look something like the following:

- System under test (SUT)
- Air operations center (AOC)
  - Air task order
    - Fragmentary order
- Wing operations center (WOC)
- Corps tactical operations center
- Theater air defense structure
  - Control center
    - Safe passage procedure
- Airborne battlefield command and control centers (ABCCC)
- Airborne forward air controller (FAC)
- Forward observers (FO)
- Air support assets
  - Suppression

    - Refueling
- Airborne Warning And Control System (AWACS)
- Joint Surveillance Target Attack Radar System (Joint STARS)
- Allied forces
- Threats
    - Airborne interceptors
    - Surface-to-air missiles (SAM)
    - Anti-aircraft artillery (AAA)
    - Small arms
- Targets
    - Troop units
    - Vehicles

In order to structure a test, the player cast has to be embedded in a dynamic operational scenario. The scenario supports detailed mission layout activities and time-sequenced events for the SUT. Some of the players on the list have very tightly coupled interactions with the SUT. Examples include friendly ground forces, enemy ground forces (targets), terminal threats, and the airborne FAC. Other agencies such as AWACS, Joint STARS, or the WOC have more loosely coupled interactions but may be important to SUT performance.

Step 3 is finished when the cast of players has been whittled down to those who play a role in the performance of the SUT in the selected task, and the measures of performance (MOP) and measures of effectiveness (MOE) have been developed for the SUT evaluation. The scenario developed in Step 3 is an operational scenario --- not a test scenario. That comes later.

Step 4. Consider Using ADS. The activity described to this point is simply a test planning or test concept development approach. Step 4 is a switch point --- to include or not to include a detailed consideration of ADS use as part of the planning methodology. In a few cases, the operating and test environments may be relatively simple. An example might be the testing of a new side arm. A test of such a system can be done live, in open air, and affordably. The example I have chosen is complex and highly interactive with a wide cast of players. In the complex case, it is reasonably clear that live, open air testing with the full cast of players is not affordable. Because of the large number of man-in-the-loop (MITL) interactions, it is also reasonably clear that representation of the environment in a stand-alone simulation will suffer credibility problems because we don't model human decision making very well. If the test planners are reasonably certain that the test environment cannot be adequately represented using the traditional test approaches, then they have two choices: accept the test limitations or explore ADS to see if the technology can make a better test within the fiscal constraints.

Stated succinctly, the decision associated with Step 4 is about the adequacy of the test scenario as compared with the operational scenario. In a world with no fiscal or safety constraints, the operational scenario and the test scenario would be identical. In the real world, the issue becomes "do we have to approximate reality to have a satisfactory test." If the test planners cannot provide an appropriate test environment using traditional test approaches, then the answer is "no," and the planners should explore whether ADS can do anything to improve the situation. If the answer is "no," then the process moves along to step 5. If the answer is "yes," then the planners can proceed with a traditional test plan for that particular operational task. Other tasks may require different approaches.

Step 5. **Select a Player**. Traditional testing shortfalls often include an insufficient number of test articles, insufficient number of threats, and inadequate representation of friendly force interactions. The process of ADS exploration begins with a visit to the player list developed in Step 3, and the first player on that list is the SUT. Depending on where the program is, the SUT may be available in a variety of forms. Early in the program, the SUT may only be available as a digital system model (DSM). Later the SUT may exist in brassboard form with a variety of subcomponents scattered among a variety of vendors. Eventually the SUT will be available in prototype or production version form, and a flight simulator version will emerge. (The DSM version is still available at this stage.)

Step 6. **Other Players**. Let's assume that we have a prototype version of the SUT and a flight simulator exists. We also have a DSM form of the SUT. If the operational doctrine calls for a two-ship flight, then we have a requirement to represent two SUT. One approach could be to couple the SUT manned flight simulator with another manned simulator that could represent the SUT and the communications types and channels for interflight communications. A facility like the Tactical Air Command and Control Simulation Facility (TACCSF) at Kirtland Air Force Base, New Mexico, could represent a second version of the SUT at a reasonable cost. Most manned dome simulators could provide the visual representation of the TACCSF generated wingman. The technology exists to input or overlay jamming energy on the communications link.

After looking at the SUT configuration choices, the planners can move on to the other players. If the player list is prioritized on the basis of the more direct interactions, then the more important players are addressed first. For each player, the test planners must have access to information about the various manifestations of the player. They must know what forms are available, and they must learn what they can about capabilities and costs for each form.

A facility like TACSSF could represent the airborne FAC complete with man-in-the-loop. If there was a higher fidelity requirement, a manned simulator of the FAC aircraft could be used. The communications links could be subjected to jamming in the same manner as the interflight links.

The targets and the friendly ground forces in the vicinity of the strike also have tight interactions with the SUT. Individual targets can be simulated in large numbers by a number of constructive simulations --- Janus serves as an example. Target visual representations can be piped to the simulator dome for the SUT. Friendly command and control centers of all types can be represented at a level of fidelity tailored to test needs and cost. A corps tactical operations center (TOC), for instance, could be represented by a full-up, fielded TOC if testing was done in conjunction with some exercise. The TOC could also be represented, at decreasing levels of fidelity and cost, as a partially manned TOC in garrison; as an emulation of a TOC in TACCSF or a similar simulation facility; or by a single individual reading from a script. The same approach can be applied to other command and control elements such as the tactical air control party.

Another tight interaction involves the SUT and the threat systems in the strike area. The threats can be represented at any level from constructive to live. If high fidelity is a requirement (and in our hypothetical example it is) and since survivability is a measure of interest, then hardware-in-the-loop may be a minimum requirement.

As the players (the AOC and the WOC, for instance) become more and more peripheral, fidelity requirements decrease and scripted inputs or constructive models will suffice.

Step 6 involves a lot of research and learning.

Step 7. Fidelity Versus Cost. Step 7 involves the art of compromise between fidelity and cost. With the information gleaned in Step 6, the test planners are in a position to make reasoned choices about the players in the test and the appropriate form of representation for each of them.

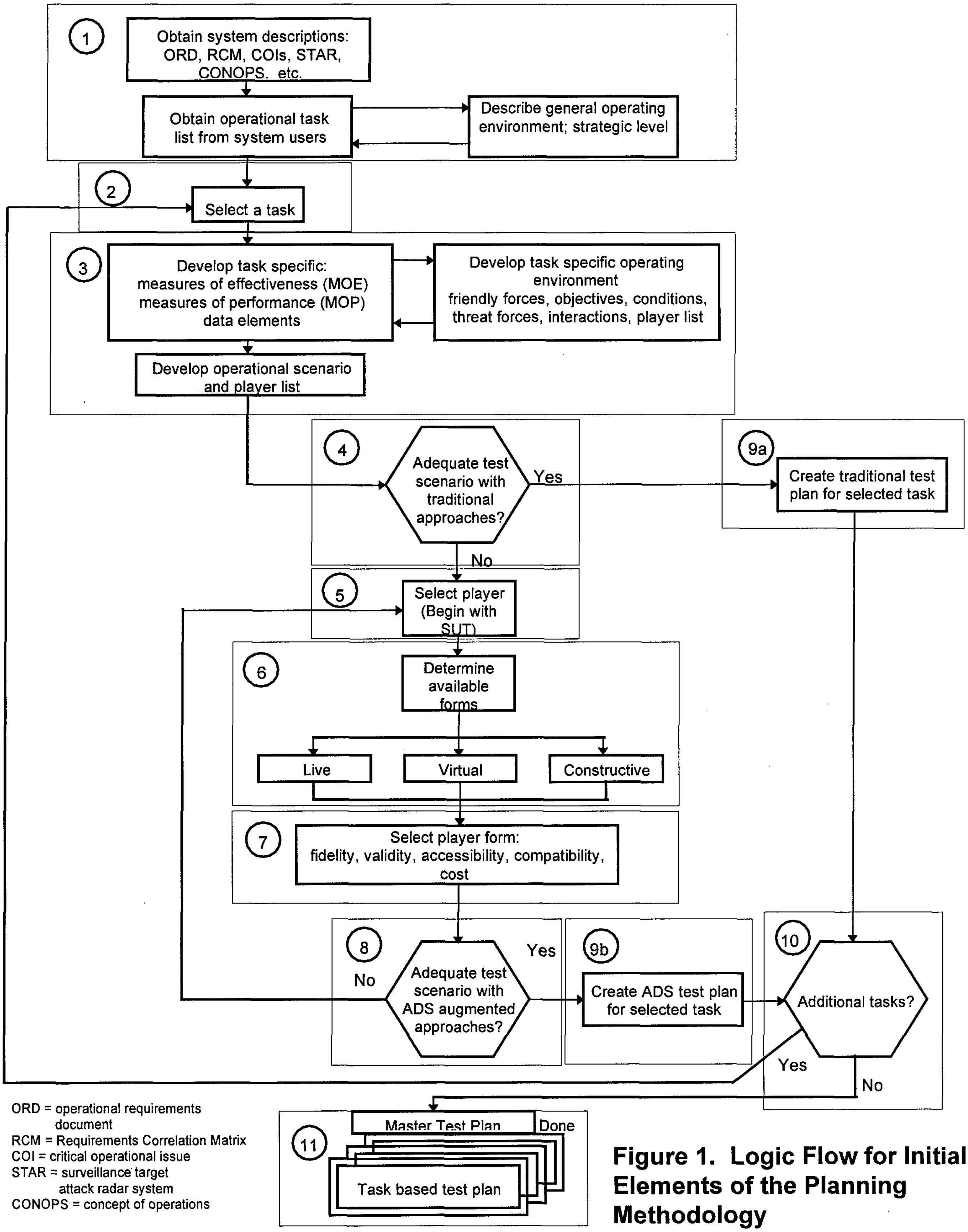
Step 8. Evaluate Adequacy of the Environment. When the process reaches Step 8, the question facing the planners involves the adequacy of the environment which will be created by the interactions of the players selected. Each time steps 5 through 7 are executed, the planners must ask whether more players are needed. If so, they return to Step 5. Step 5 is executed repeatedly until the test planners are satisfied that the test environment is rich enough in terms of meaningful interactions to support a sound test.

Step 9. Detailed Planning. When the test planners are satisfied they have a sound test framework for a task oriented test, they can press on with detailed planning to include networking, instrumentation, data collection systems, scheduling, etc.

Step 10. Additional Tasks. Step 10 can be performed sequentially after each iteration of Step 9 is completed, or if there are enough planning resources, planning for additional tasks can go on in parallel. In any case, test planning is not complete until all of the relevant operational tasks have been addressed.

Step 11. Develop Master Plan. The task associated with step 11 involves the deconfliction and coordination of each of the individual task oriented test segments. Essentially step 11 involves the development of the master plan and schedule.

In summary, this is a top-level planning process which incorporates decision elements associated with ADS for test and evaluation. It is only intended as an example, and each test program is going to have unique aspects which will require planners to use creativity and imagination. Hopefully this outline approach provides the test planners with an understanding that ADS offers test opportunities that were never there before. ADS can be used to good effect at reasonable cost if it is used intelligently. There are many things ADS won't remedy, but there are many things it will. ADS is a technology set which should be considered during test planning. If it doesn't make sense to use it, don't use it. On the other hand, don't dismiss it just because you think it's too hard, or too exotic, or too expensive.



ORD = operational requirements document
RCM = Requirements Correlation Matrix
COI = critical operational issue
STAR = surveillance target attack radar system
CONOPS = concept of operations

Figure 1. Logic Flow for Initial Elements of the Planning Methodology

Acronyms and Definitions

AAA	anti-aircraft artillery
ABCCC	airborne battlefield command and control center
ABL	airborne laser
ADS	advanced distributed simulation
ANGLICO	air and naval gunfire liaison companies
AOC	air operations center
AWACS	Airborne Warning and Control System
CAS	close air support
CEA	circular error average
CEP	circular error probability
COI	critical operational issue
comjam	communications jamming
CONOPS	concept of operations
DSM	digital system model
DT&E	developmental test and evaluation
FAC	forward air controller
FO	forward observer
Janus	interactive, computer-based simulation of combat operations
Joint STARS	Joint Surveillance Target Attack Radar System
MITL	man-in-the-loop
MOE	measure of effectiveness
MOP	measure of performance
ORD	operational requirements document
OT&E	operational test and evaluation
RCM	Requirements Correlation Matrix
SAM	surface-to-air missile
STAR	Surveillance Target Attack Radar System
SUT	system under test
T&E	test and evaluation
TACCSF	Tactical Air Command and Control Simulation Facility, Kirtland AFB, New Mexico
TOC	tactical operations center
WOC	wing operations center

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