Synthesizing The Big Picture

Digital maps worth a thousand words in theaterwide system.

By Henry S. Kenyon

A prototype command and control technology allows joint task force commanders to plan and coordinate air defenses across broad operational areas quickly. The system combines a task force's radars and datalinks into an easily understood graphic representation of the combat zone. Hostile aircraft as well as cruise and theater ballistic missiles are identified, and their headings and impact zones are indicated in near real time, providing officers with a complete view of the action.

As the U.S. military moves toward a network-centric battle capability, the ability to picture a battlefield and its relation to the larger operational space quickly becomes paramount. Although previous systems provided planners with slices of data, the capability to view an entire theater's air defense picture and coordinate operations in real time did not exist, experts say. By providing military planners with a battle management tool offering rapid analysis and war-gaming functions, mission scenarios can be created and changed swiftly, giving allied forces greater agility in reacting to and countering attacks by hostile forces.

The Area Air Defense Commander (AADC) capability evolved from lessons learned during the Gulf War, according to Capt. Bradley Hicks, USN, branch head, Network Systems/Integration Branch, Naval Surface Warfare Directorate, Office of the Chief of Naval Operations N766, Arlington, Virginia. During that conflict, the Navy discovered it needed better methods to coordinate air defense planning and deployment in joint or coalition environments.

The Area Air Defense Commander (AADC) capability permits joint task force commanders to plan and command the air defense of an entire operational theater.

The AADC is being installed aboard U.S. Navy command ships and Aegis cruisers. Operated by a staff of officers supporting a task force commander, the system allows rapid planning and deployment of air defense assets.

In 1996, the Navy contacted Johns Hopkins University's Advanced Physics Laboratory (APL), Laurel, Maryland, to develop a prototype system. The facility was asked to leverage existing capabilities such as airspace visualization and advanced processing into a new command and control system. The goal of

All known hostile and friendly aircraft are represented on the commander's screen in the AADC. Friendly units are shown in white, with silhouettes exactly matching the type of aircraft. Hostile units appear in red, commercial aircraft are green and unidentified craft are yellow.

the project was to create a technology with both air defense execution capabilities and the ability to plan operations in a joint air defense environment, Capt. Hicks says.

The AADC features planning and execution components that allow commanders to allocate resources to defend selected sites. Four factors are taken into account. First the commander must decide which major assets to protect. This list is usually short and prioritized. The enemy order of battle is the second factor—what the opposing force possesses in terms of aircraft as well as cruise and theater ballistic missiles. Weapons and sensor systems operated by the defending force form the third realm of concern. This includes standard missiles of all types fired from Navy ships and various types of land-based interceptors such as Patriot missiles. The final factor is the enemy's course of action. "How will they use their equipment, and what are their capabilities? For example, is it an aggressor nation's doctrine to fire a single [missile] or multiple ballistic missiles? Will the warheads be conventional, chemical, biological or nuclear?" asks AADC project team member Lt. Gen. Marvin L. Covault, USA (Ret.).

A number of complex issues surround planning and coordinating wide-area air defense. Gen. Covault notes that these fall into two categories: tactical and theater. Practiced for decades, tactical air defense refers to force protection and is the responsibility of unit commanders. Theaterwide application consists of protecting places such as cities, ports, airfields and logistics centers that the task force commander believes are essential to the mission's success. "The problem has been that we've never developed a capability for the joint task force commander to be able to plan for and execute theater air defense," the general says.

These variables represent hundreds of courses of action combinations that planners must consider. Adding or removing sites, altering their priority or interdicting enemy airfields changes the system's operational parameters. These considerations determine coverage—the defending force's ability to protect sites successfully against aircraft and theater ballistic missiles. "Every time you change a variable, you change the results. In order to do that quickly and efficiently, you need tremendous processing power. You cannot do this with individuals sitting around a table looking at map sheets. You cannot do this with a personal computer-based system. You must have the best technology that American society can provide," Gen. Covault maintains.

To drive this computing power, each AADC system employs a number of 32-processor Silicon Graphics Incorporated (SGI) Origin 3400 servers, SGI Onyx 3000 series high-performance graphics systems, SGI Octane2 visualization workstations and SGI O2+ graphics workstations. The combined efforts of these computers process up to 300 billion instructions per second, reducing planning tasks that once took days to several hours, explains Capt. Larry Newton, USN, AADC program manager, Naval Sea Systems Command, Washington, D.C. "A commander can see the output and ask questions. 'What if we make this change or that change?' And in a very short time, we have a revised plan that can be discussed. Something like this was just never available before," he maintains.

Planning is the system's other major processing requirement. The AADC can repeatedly war game a plan against possible enemy attacks, running a complete scenario up to 25 times to verify results. This process determines the percentage of enemy forces that get through a site's defenses. A commander may discover that out of six sites, only five can be fully defended and the sixth may be only partially protected, Gen. Covault says. The system then reports how many enemy missiles or aircraft penetrated the defenses and from which directions they came. This feature permits commanders to weigh the risks in a situation. If it is decided to neutralize an enemy site in a high-risk strike operation, planners can immediately quantify the benefits of the mission.

To develop a planning capability that can automatically generate forces and scenarios, APL engineers created a database containing the performance characteristics for a range of weapon and sensor systems, explains Frederick R. Facemire, program manager, APL battle group projects. High fidelity is a key requirement for all the data models in the AADC because warfighters must have an accurate understanding of how their weapons behave. "We didn't want to put them in a position where we were using low-fidelity models that would make assumptions about the environment they were operating in. Our models have to account for that," Facemire explains.

The AADC's operational purpose is to provide commanders with an intuitive view of the battlespace, explains AADC project team member Maj. Gen. Lee A. Downer, USAF (Ret). "If we give him a good enough view, with enough detail and capability, it becomes a predictive decision capability," he explains. To accommodate this, a large

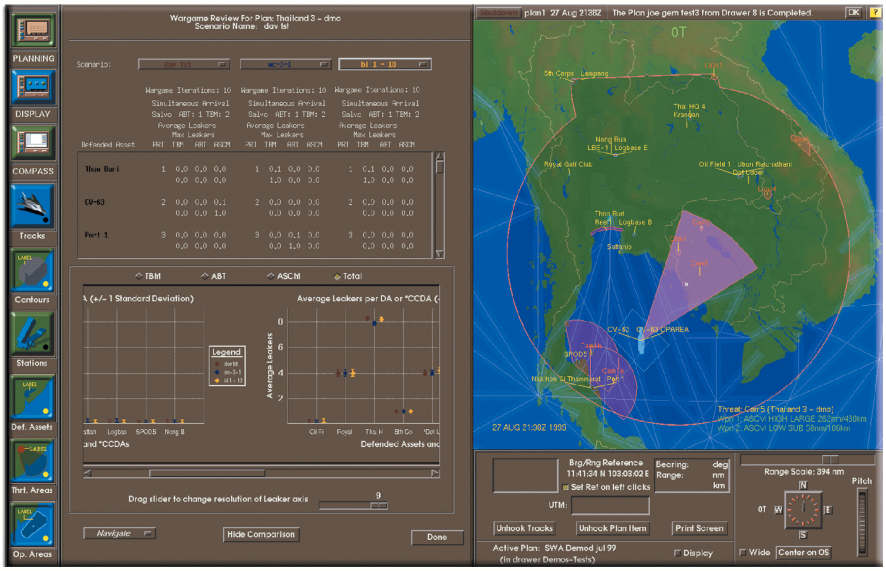
screen in each AADC operations center provides realistic representations of missiles and aircraft. The core technology for the system evolved from an APL-developed Navy system fielded in the early 1990s called force track, evaluations, weapons and assignment (Force TEWA). Deployed aboard aircraft carriers, the system presents a three-dimensional view of the battlespace with realistic, easy-to-understand icons representing aircraft and missiles.

Previous command systems used abstract symbols to represent friendly and enemy units, but the services all use slightly different images, Gen. Downer notes. While Navy personnel may all be familiar with their representation, an Army officer commanding a joint task force may not. "When a commander has to make a decision that might take the nation into a war, you want him to have an intuitive view of what goes on without a lot of training to get up to speed on what the symbols mean," the general explains.

A handheld tracking globe allows the commander to zoom in and around the battlespace. The entire world is represented geographically on the screen, permitting strategic, theater and tactical level views of an operation. Geographic features such as mountains are represented because of their blocking effect on radar. Enemy units also will use the terrain to hide in, notes Gen. Downer.

Every airborne aircraft and missile in the theater is represented by symbols called tracks. Each track records vital information such as heading, air speed, altitude, identification friend-or-foe transponder status, and whether it is a friendly, enemy or neutral aircraft. Friendly aircraft also have air tasking and other mission data listed for immediate access by the commander. The AADC represents everything in the theater that reports its position via datalink such as aircraft carriers, cruisers, destroyers, Patriot missile batteries and ground- and air-based radar platforms.

Position tracks are updated every few seconds to provide near-real-time data. All friendly military aircraft in the theater are white and identified by their actual silhouettes. Hostile aircraft and missiles also are identified in a similar, though slightly more generic, manner—missiles, helicopters and fast and slow attack aircraft are represented by specific images regardless of type—and appear in red. Civilian aircraft operating on known air routes are shown in green as generic airliners. Unknown aircraft in the theater appear as yellow silhouettes until their specific type is confirmed. Questionable aircraft operating in the theater also may appear as a green or yellow symbol with a smaller red image in their center. This is to alert operators about their uncertain status and also to prevent accidental missile launches until their status is verified.



The planning feature of the AADC allows operations to be repeatedly practiced to determine where the major risks lie. Entire exercises may be recorded and later replayed for analysis and training purposes.

In the event of an attack by a theater ballistic missile, a launch track indicating its arc, target area and time to impact is displayed. For example, a missile launched at Kuwait City would call up various alerts. But because its track and impact area are known, only the personnel in the immediate target area would be alerted. Defensive missiles from ground-based Patriot batteries or ships then present intercept tracks superimposed onto the hostile missile's launch arc. A slightly different view is presented for naval task forces under attack by sea-skimming cruise missiles—an intercept track is shown, and arrows indicating single or multiple interceptor missile firings by the defending ships at the incoming cruise missiles are presented. "It will tell you what is actually being attacked, where your defenses are—their locations—and give you quick updates. Do I have airplanes coming into these airfields that I need to divert somewhere? There are a million things that you can get out of this," Gen. Downer explains.

The system is menu- and window-driven, allowing planners to drill down to the appropriate levels of data they require without being overwhelmed, says AADC project team member Maj. Valerie J. Meadows, USAR. Viewers can assess the situation and location of defenses immediately with little or no training. Planners click and drag missile and radar coverage templates, place them on a map and get immediate feedback on the location's suitability.

The AADC also permits planners to share information with each other and with other headquarters. Users can switch to and observe other screens within the command center and share data using low-bandwidth commercial office programs. Operators may share graphical interchange format, or GIF, images and use whiteboard and chat functions via the secure Internet protocol router network (SIPRNET). This feature allows commanders to communicate in real time to establish air defense sites without using telephones. Operators also can browse Web sites on the SIPRNET and automatically download data from the Web. Operational plans are stored, sorted and edited in electronic folders that may be passed on to various component commanders, Facemire says.

Support from high-ranking naval officers was critical in the program's success, explains AADC project team member Adm. Leighton W. Smith Jr., USN (Ret). By transferring the prototype to commercial development and working closely with warfighters at the site, developers were able to cut through the acquisition process and speed up delivery. The entire process went from planning to an operational prototype in 14 months, the admiral explains.

The AADC is operated by staff-officer-level personnel. During the system's early stages, planners determined that large numbers of enlisted personnel were not sufficient to operate a theater-level system. "Enlisted people are the backbone of the Navy, but they're not planners at the operational level," explains Adm. Smith.

APL designers settled on a staff of 35 people to operate a theater-level deployment seven days a week, 24 hours a day. The development team had to boil down a force commander's requirements and thinking during an operation. The same mentality also went into determining how a plan is created. The team questioned the type of personnel a commander needed for planning, their expertise and knowledge of enemy tactics and weapons systems.

Once the staff make-up was determined, the number had to be reduced to fit in an Aegis cruiser. Staff personnel all rank captain or above because they have the most experience with large unit operations. "We're not talking about lieutenants here. They're smart people, but they operate on a plane a bit below what we're trying to do. To use the term, you've got to think gorilla—you've got to think like the man [the commander]. What does he want, when does he need it and what priority does he need it in? You need to have a little seasoning under your belt to get that," Adm. Smith says.

The initial deployment plan called for the AADC to be installed on 12 Aegis cruisers. However, feedback from high-ranking Navy officials indicated that it was more effective as a force commander's tool, leading to a prototype system being deployed aboard the USS *Mount Whitney*, flagship of the 2nd Fleet. The system was subsequently installed aboard the Aegis cruiser USS *Shiloh* and the 7th Fleet command ship USS *Blue Ridge*. The program has since been awarded to General Dynamics as a prime contractor to manufacture and install the AADC systems at its Greensboro, North Carolina, facility.

According to Capt. Newton, the near-term goal is for General Dynamics to assume full responsibility for the program and to begin a training cycle. The next system will be installed at the Aegis Training and Readiness Center in Dahlgren, Virginia. The captain also hopes to install the technology on at least one cruiser in 2003, and tentative plans include placing a facility in Bahrain for regional command and control.

• • • — • —