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BATTLE GROUP ANTIAIR WARFARE COORDINATION

Considering the demands placed on Naval Battle Group defense by the density and speed of potential air attacks, the coordination of antiair warfare ships and aircraft — now possible through the AEGIS Combat System — becomes essential to the full exploitation of a Battle Group's capability for survival.

INTRODUCTION

Throughout the history of naval warfare, changes in offensive tactics and weaponry have required corresponding changes in defensive tactics and technology. To employ new weapons or to counter new threats, techniques of coordinating military operations must change to keep pace with equipment capabilities. New coordination techniques are essential to survival of Naval Battle Groups in the combat environment of the 1980's, an environment characterized by a potential for large numbers of rapidly evolving, simultaneous missile attacks. The development of such an antiair warfare coordination capability is treated in this article.

BATTLE GROUP ANTIAIR WARFARE COORDINATION PROGRAM

The Battle Group Antiair Warfare Coordination (BGAAWC) Program has evolved as an integral part of the AEGIS development program. Its objective is to improve the overall antiair warfare effectiveness of a Battle Group by building on the capabilities of AEGIS and developing its capability to coordinate other Battle Group weapons. To exploit the full capability of a Battle Group, combat elements of the group must be able to operate as a single, closely integrated force. With such a force, it is possible to gather data over a widespread area by using a versatile array of radars and other sensors, to correlate those data to discover changes in the enemy's condition and tactics, and to apply the resulting information to select the most appropriate of the various weapons designed to thwart the perceived threat and tactics. Benefits provided by the BGAAWC Program are highlighted in Table 1.

The current practice in Battle Groups is to assign the antiair warfare coordination function to a Battle Group Antiair Warfare Commander. The assignment is usually given to the commanding officer of the most capable antiair warfare ship within a Battle Group. The BGAAWC Program is developing the facilities on the TICONDEROGA (CG-47) class ship (including large-screen displays, computers, data links, and command consoles) for automated, semiautomated, and manual control mechanisms to support the Antiair Warfare Commander's use of the antiair forces of the Battle Group. These facilities will be described in greater detail in the discussion of the Command Support System.

Facilities and decision aids for the Antiair Warfare Commander must be augmented with complementary capabilities in all force combatants. Each ship and aircraft in the Battle Group must also be able to share information, exchange status reports, and respond to direction. A system that provides such coor-

Table 1

BENEFITS OF THE BGAAWC PROGRAM

Coordinated Battle Control
Large-screen Battle Group tactical display
Coordination by information exchange
Aircraft/missile coordination
Automated force response
Accurate Real-Time Data Exchange
Continuous automatic gridlock capability
Improved data for non-AEGIS combatants
AEGIS data sharing
Improved Antiair Warfare Effectiveness
Improved application of aircraft
Improved reaction time for non-AEGIS ships
Reduction of missile expenditure per target kill
Improved utilization of AEGIS in Battle Group operations

The Battle Group Antiair Warfare Coordination (BGAAWC) Program improves the effectiveness of antiair warfare by providing accurate and timely data exchange and battle control facilities for the Antiair Warfare Commander. BGAAWC extends AEGIS Combat System techniques in identifying and evaluating threats, displaying information, automatically scheduling and assigning weapons, and assessing antiair warfare proficiency.

dination across the Battle Group, the Naval Tactical Data System (NTDS), has been in use since the early 1960's.[1] Although BGAAWC objectives and requirements exceed current NTDS capabilities, the BGAAWC Program — utilizing the established capabilities of NTDS as a basis — is identifying areas where upgrades are needed to fully exploit new radar and weapon capabilities and is providing the means to implement the required upgrades.

The BGAAWC development plan is illustrated in Fig. 1. The program will be implemented in three phases that successively add to the baseline capabilities of CG-47 (identified programmatically as Phase 0). These phases coincide with the introduction of essential systems to the Fleet. Phase I will provide specialized command displays and decision aids on the AEGIS cruiser to optimize the antiair warfare command of the Battle Group. Phase I will also provide continuous automatic exchange of air warfare data among combatant ships and aircraft. Phase II of the BGAAWC Program will employ advanced data links capable of conveying weapon assignments to widely spaced elements of the Battle Group. Phase III will introduce advanced weapon control techniques. The upgrading provided by these phases requires modifications to antiair warfare combatants to facilitate coordinated data exchange and weapon employment. The principal functional requirements to be met in a Fleet modification upgrade effort are listed in Table 2. Specific coordination capabilities to be achieved include the following:

1. Ability to convey a complete and reliable air picture within the Battle Group. Radar data from AEGIS ships will be usable on other combatants for all the normal internal decision-making processes.
2. Ability of the BGAAWC Commander to designate targets to other ships and aircraft in the Battle Group.
3. Ability to designate a target directly to the fire control and launching system of a remote ship or aircraft.
4. Ability to designate a missile launch from a remote ship using guidance and/or illumination supplied by another ship or aircraft.

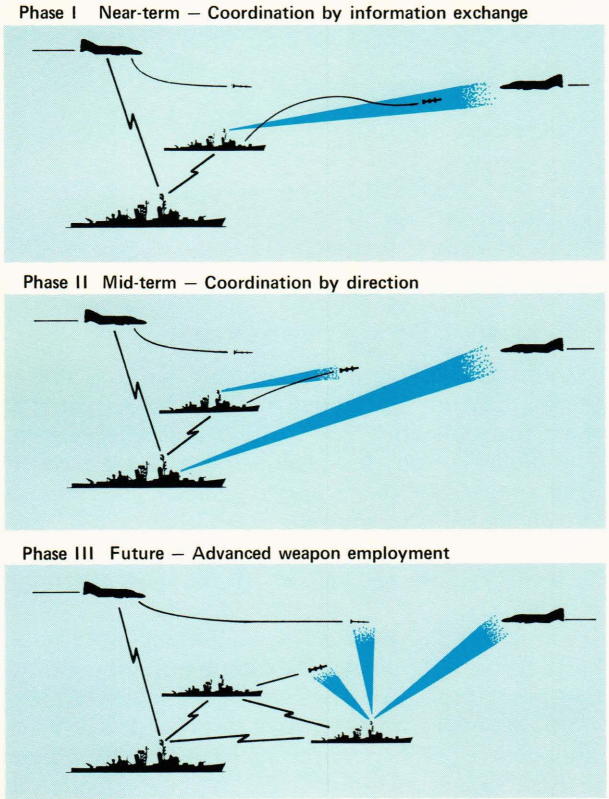

Figure 1 — The three-phase development plan for the Battle Group Antiair Warfare Coordination Program provides for systematic growth in capabilities. The near-term goal is improvement of command capability by providing aids to information exchange. Longer-range goals are provision of improved data links as well as more sophisticated coordination techniques for future weaponry.

Table 2

FUNCTIONAL REQUIREMENTS FOR A BGAAWC SYSTEM

Control Unit

AEGIS Combat System
- Build Battle Group track data base
- Share AEGIS tracks with Battle Group

Antiair Warfare Command Support
- Display antiair warfare situation
- Assimilate extra-force data
- Promulgate antiair warfare doctrine and operations
- Control antiair warfare engagements

Participating Units

Gridlock to AEGIS
Respond to force doctrine
Accept engagement orders
Report engagement status

Data Links

Connect all units in all environments
Transmit tracks, status, doctrine, and commands

Improvements needed to achieve full coordination of Battle Group antiair warfare are defined by the functional requirements listed here. Upgrading is required for implementation in all elements of the Battle Group and of essential supporting systems, including control units of the AEGIS Combat System, participating Battle Group units, and the data links that serve the Battle Group.

CURRENT AREAS OF BGAAWC PROGRAM EMPHASIS

Current effort has been directed into four distinct technical endeavors: BGAAWC system definition and specification, command support system design, Battle Group track data sharing and the Gridlock[2] Demonstration System, and determination of data-link requirements. These will be discussed in detail.

BGAAWC System Definition and Specification

The Navy and the Department of Defense have established an extensive discipline to specify and control the development of complex equipment such as radars, weapon fire control systems, and display systems. In developing a combat system, all important factors (e.g., interfaces, manning, support services, availability, and maintainability), as well as the technical performance of the system, must be considered.

Until recently, the Navy's standard-setting discipline had been generally directed to individual, physically identifiable systems (e.g., a particular radar system). Recent trends have broadened this practice. The AEGIS Program has developed a master specification for the combat system, which includes all elements of the AEGIS ships directly involved in combat. The combat system specification is a controlling document for more than 20 major component systems of the ship, providing for consistent application of standards to the design process.

The BGAAWC Program represents an even broader application of combat system discipline. Here, the system is distributed over many types of ships and aircraft and includes the equipment used among them for communications. The BGAAWC system configuration is consequently required to accommodate a large, indefinite number of variants since any change in Battle Group composition (the specific types and numbers of ships and aircraft assigned) is in fact a reconfiguration of the Battle Group's system for doing battle. Another major challenge in developing BGAAWC system specifications is that nearly all of the component weapon systems already exist or are programmed and specified under other auspices. Thus, the BGAAWC system design must account for the individual performance characteristics of all those elements, as well as specify the gains to be made by coordinating a varying quantity and arrangement of those contributing unit systems.

A formal specification structure analogous to that used for conventional systems is established for the force-wide BGAAWC System. In support of the specifications, a parallel structure of engineering analysis is maintained. Configuration control and design-review procedures are applied equally to analysis and to specification so that a complete record is retained for both the resulting design and the theory behind it. Lessons learned during development can be readily reviewed.

The Requirements Analysis and Operational Mode Analysis that support the BGAAWC specification provide the basis for the data-transfer error budget, which allocates coordination requirements to the various Battle Group ships and aircraft. A wide variety of error sources must be considered in the development of requirements. Applications of data include:

- Correlation
- Weapon selection
- Scheduling
- Designation
- Fire control

Various applications of data require different degrees of precision, filtering, and timeliness. The concept of error budgeting is based on the recognition that BGAAWC depends on the effective transfer of information among Battle Group ships and aircraft. Requirements for precision and timeliness in turn depend on how that information will be used. Errors and delays in information transfer can be caused by the sender, the data link, or the user.

Sources of error having an effect on data application include:

- *Tracking accuracy and rate*
- *Track filtering*
- *Reporting rate and resolution*
- *Data link access and cycle delay*
- *Gridlock error*
- *Conversion error*
- *Processing delay and resolution*

The error-budgeting process identifies the inherent limitations in systems being used and allocates the "error residue" among those system elements that can accommodate them.

Command Support System Design

Command of the antiair warfare battle is one of the primary responsibilities that may be delegated by the officer in tactical command of the Battle Group. The officer given this responsibility has an urgent need for timely and accurate tactical information, knowledge of the status and abilities of all units under his authority, and the means to convey his decisions rapidly and reliably to the units that must respond.

The capability provided by an AEGIS ship is the basis for development of a Command Support System, one of the main elements of the BGAAWC Program. TICONDEROGA, first of the new AEGIS-equipped cruisers to be produced, will offer a comprehensive and accurate track data base founded on the AEGIS radar system, versatile automated support for weapons decision-making, and extensive display capabilities.

The AEGIS prime contractor, RCA Missile & Surface Radar Division, Moorestown, N.J., is developing display equipment for the AEGIS ship's com-

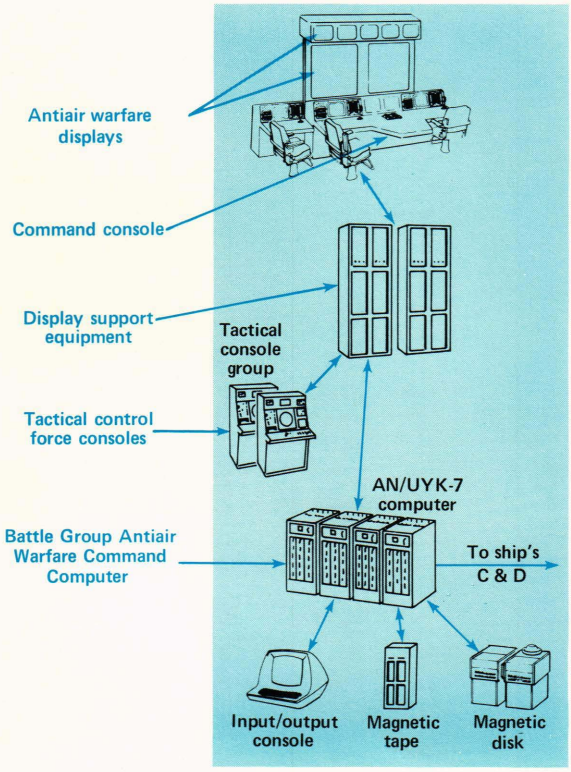

Figure 2 — Development Model 1 of Battle Group Antiair Warfare Display Group has been assembled by APL. Design investigations and computer program development are current ongoing tasks that will lead to at-sea deployment of similar equipment and capabilities aboard the AEGIS cruisers.

manding officer in a subsystem known as the AEGIS Display Group. In parallel with this, and as a part of the BGAAWC Program, APL is developing an antiair warfare command support system called the Battle Group Antiair Warfare Display Group (BADG). The AEGIS Display Group will be updated and combined with APL's BADG for installation on later TICONDEROGA class cruisers. Coordination of the design process is maintained through a joint working group sponsored by the Naval Sea Systems Command AEGIS Shipbuilding Project, PMS-400.

The initial development model of BADG at APL is shown in Fig. 2. It employs the new Display Group equipment [AN/UYQ-21(V)] now being introduced as the latest upgrade of a long line of general-purpose shipboard tactical display systems. This equipment is produced by the Hughes Aircraft Corp., Fullerton, Calif. The BADG includes large-screen displays, automatic status boards, communications facilities, command consoles, display control consoles, and support equipment, which have been installed and tested at the Combat System Engineering Laboratory at APL. Baseline AEGIS Display Group equipment has been installed at the AEGIS Combat System Engineering Development Site at Moorestown. Preparation is also under way at APL for an at-sea demonstration of BADG in USS NORTON SOUND, to take place prior to updating the operational system aboard TICONDEROGA class ships.

The primary objective of BADG is to aid a commander of Battle Group combat systems by keeping him abreast of the operating environment, the status and performance capabilities of his own and enemy resources, and the probable consequences of command decisions. BADG manages a vast amount of diverse information by providing visual aids that allow a rapid assimilation of information about the current battle situation (Fig. 3). Particularly useful to the commander are the large-screen displays. These displays, based on liquid crystal technology, provide a bright, crisp presentation of tactical situations. Each AEGIS ship will have two command stations in the ship's Combat Information Center to provide mutual support, direct communications, and share display facilities between ship's command and Battle Group command.

In presenting command information, the temptation to display every available bit of information is avoided; command displays are tailored to specific decision requirements. Prominence is given to summary information, while detailed information is readily available upon request. The structure of information available for display is shown in Fig. 4. At the top level, only items requiring immediate attention are provided, e.g., force status summaries of enemy activity or antiair warfare trouble areas. On the next level, displays are more detailed, e.g., status of a specific unit in the force or of a specific enemy activity. Lower levels of display provide data pertaining to specific systems or enemy units and visual aids directed to specific problems, such as the commitment of aircraft still on carrier decks.

Battle Group Track Data Sharing and the Gridlock Demonstration System

Underlying all aspects of coordination is the need to maintain a timely, complete, and accurate interchange of radar track information, including both the continued verification of friendly unit locations and all positive contacts with hostile, or potentially hostile, units. Significant improvements in Battle Group radar track exchange are based on the detection and tracking capability provided by the AEGIS AN/SPY-1A radar system. The SPY-1A improves the reliability of track data and the continuity of tracking, even in adverse electromagnetic environments. For a more complete assembly of track information, the scope of the track picture on AEGIS ships can be greatly extended by including data from sources on the perimeter of the group or beyond. The objective of Battle Group radar track sharing, therefore, is to ensure that a complete track picture is available and that the best data on each track in the Battle Group area of operations are made available to all needing the data. Radar track sharing requires the following three processes:

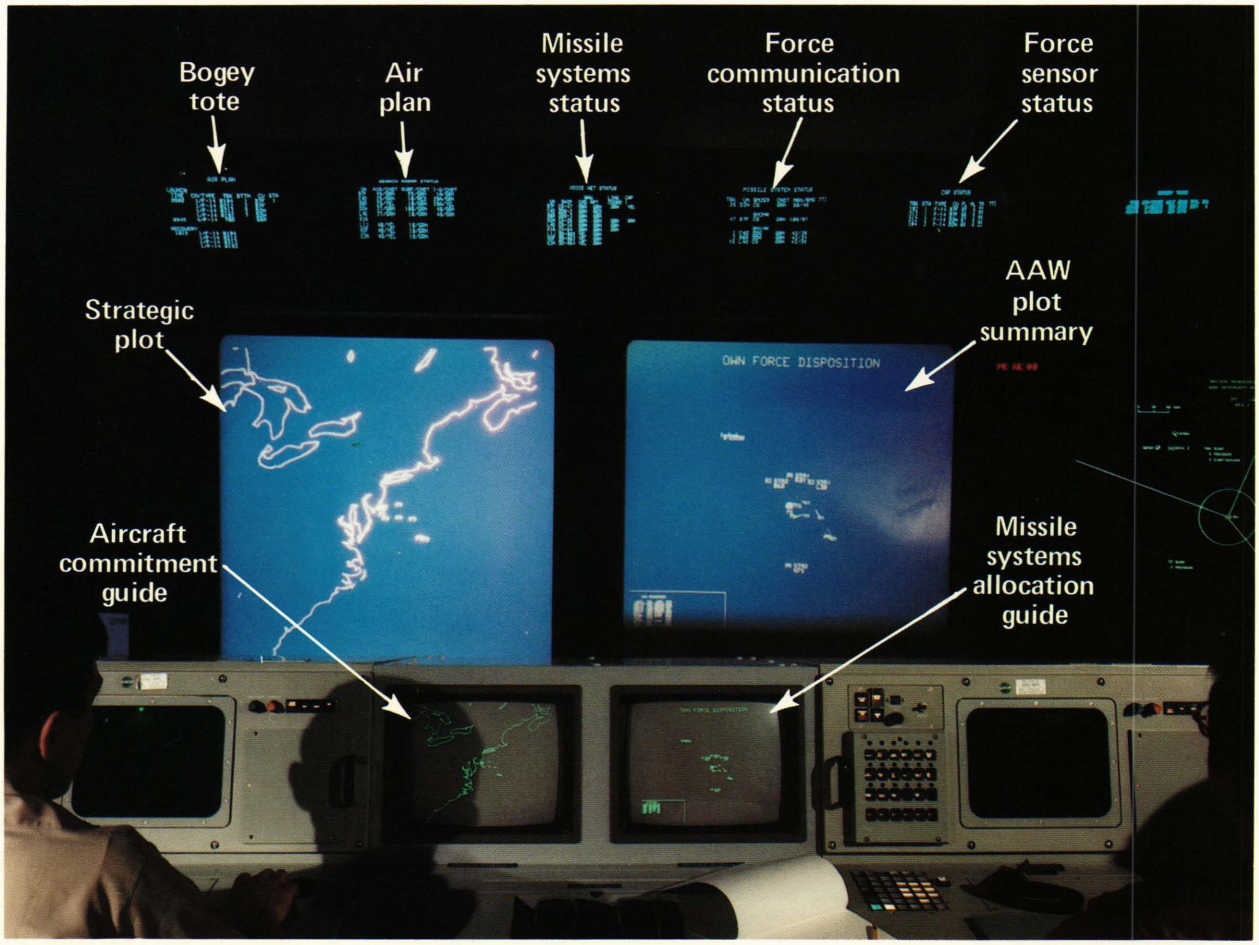

Figure 3 — Displays for the Antiair Warfare Commander are shown here, along with typical kinds of information selected. Battle Group Antiair Warfare Display Group can manage and present large amounts of diverse information about current battle status in a form that is easily assimilated by the Commander.

1. *Reporting responsibility*—the logic used to decide what tracks are reported, by whom, to whom, how often, and how precisely;
2. *Correlation*—the process used by each ship or aircraft to determine whether a track it holds is or is not the same as a track reported by another;
3. *Gridlocking*—the process of aligning track data reported from others within a Battle Group with track data acquired from a ship's own radars to account for all navigation and radar alignment variations.

Development of gridlocking is being pursued by APL as a precursor to the other track-sharing operations and thus as a precursor to any upgrading in coordinated antiair warfare. Gridlocking is fundamental to the effective utilization of Battle Group weapons to ensure the unambiguous exchange of targeting data within the Battle Group.[2]

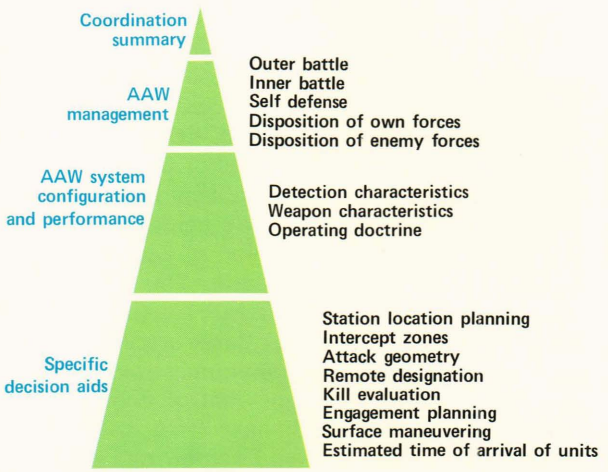

Figure 4 — Displays are made available to the Commander according to a tiered information structure that allows selection of displays to give him complete knowledge of the tactical situation, antiair warfare (AAW) system capabilities and status, and access to specific decision aids for key problems.

Data Link Requirements

Data links transport the essential information and decisions throughout the Battle Group. The BGAAWC Program makes unique demands on data links in terms of data rates, message standards, electronic countermeasures performance, update rates, and accessibility of the link to the participants. These requirements, which have been the subject of extensive development, are a part of the BGAAWC activities at APL. Data-link improvement is closely coupled with other tactical communications improvement programs such as the Joint Tactical Information Distribution System (JTIDS),[3] which strives for compatible Army, Air Force, and Navy data linking and application of the AEGIS radar-to-missile data link to other tactical needs.

SUMMARY

The BGAAWC Program grew out of the effort to apply a comprehensive new shipboard weapons system, AEGIS, to the coordination of antiair warfare. The advanced capabilities of AEGIS combat and command control systems make it readily applicable to this endeavor. Coordinating antiair warfare involves numerous challenges. These include:

- Enhancing the ability of all ships and aircraft in a BGAAWC system to gridlock, correlate, and accept tactical direction;
- Improved, high-performance communications to maintain essential connectivity despite countermeasures;
- Command displays and decision aids to support the Antiair Warfare Commander;
- Procedures and tactics to successfully carry out the assigned mission of the Battle Group.

The antiair warfare coordination problem transcends the scope of AEGIS alone. Consideration must be given to the interaction of other new antiair warfare capabilities, such as the AN/SPS-48E radar, part of the TERRIER New Threat Upgrade Program (see "New Threat Upgrade Program," by T. R. Betzer in this issue). The BGAAWC Program, consequently, is developing into a broad-based Fleet modernization program that provides the requisite command support, intercommunication, and interoperability of ships and aircraft for most effective employment of the Fleet's modern radars and weapons.

REFERENCES and NOTES

[1]The Naval Tactical Data System (NTDS) employs computers, displays, and digital data links, which function to share track and identification tasks among Battle Group elements.

[2]Gridlock is the process of accurately registering remote data into a ship's own coordinate system. It removes or minimizes navigation radar alignment errors and translates data differences between coordinate reference systems. See "Battle Group Gridlock Demonstration," by J. T. Miller and E. W. G. David, in this issue.

[3]JTIDS, in its current definition, is a data link that provides substantial improvements in performance and data capacity over existing links. It is intended to augment the current Naval Tactical Data System links.