JOHN W. NEWLAND and H. GREGORY TORNATORE

NAVY COMMAND, CONTROL, AND COMMUNICATIONS – AN INTRODUCTION

In this article we review the meaning of command and control in terms of a systems-type control process and the Navy's organizational structure that uses this process, both administratively and operationally, to control assigned forces. The expected capability of the Navy Command and Control System to support Navy commanders in an enduring and survivable manner is discussed briefly. APL's role in Navy command, control, and communications encompasses the command and control of both strategic and general-purpose forces, test and evaluation of communications connectivity to the Fleet Ballistic Missile submarines and surface forces on a global basis, analysis of Navy Command and Control System requirements, definition of a future system architecture, and long-range planning to develop this future capability of command, control, and communications.

For the past several years, the growing sophistication and the number of weapon systems deployed by the Soviet Union have posed a substantial challenge to the United States and its allies.[1] To match this unprecedented growth, measures are being sought to ensure that the United States maximizes military effectiveness to maintain reasonable parity. Among the approaches under investigation by the Department of Defense are the development of a wide range of new technologies to improve war-fighting capability; the construction of multipurpose platforms and high-performance, extended-range weapon systems; and the use of unconventional force mixes and tactics to counter a wide variety of postulated threats. Each of the foregoing requires innovative approaches in the employment and control of these assets for maximum effectiveness.

The area of knowledge that is applicable in the employment of military assets is broadly titled command and control (C^2).* The U.S. Joint Chiefs of Staff define C^2 as "the exercise of authority and direction by a properly designated Commander over assigned forces in the accomplishment of his mission."[2] Although precise and agreed-upon definitions are elusive, tactical C^2 generally speaking is the direction and control of general-purpose forces; strategic C^2 deals with the nuclear deterrent elements of the U.S. military forces. Furthermore, the Joint Chiefs of Staff state that "C^2 functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces in accomplishment of the mission." Thus, not only is C^2 the application of appropriate control techniques, but it also includes the subsystems used in executing this function. The arrangement or structuring of these subsystems into a single integral unit can thus be considered to be a C^2 system.

*See Glossary, page 8.

THE COMMAND AND CONTROL PROCESS

A more technical appreciation of C^2 can be obtained by considering a sequential flow of the basic functions characteristic of the C^2 process. Recent efforts by APL[3] in support of the Navy Command, Control, and Communications Program Office have shown that at any level of command, a common pattern of information collection, processing, and action can be found. This pattern can be described in terms of seven fundamental operations: *sense*, *process*, *classify*, *evaluate*, *plan*, *decide*, and *act*. At each level, events are perceived directly by assigned sensors or observers and/or are provided to that command level by designated information sources, such as intelligence and surveillance units. The events are entered into a manual or computer processing subsystem where they are labeled, correlated, and classified with other events and presented as information to an evaluator. The result of the evaluation is compared with established doctrine, alternative plans are developed, and, finally, a decision is made. On the basis of that decision, an action is taken that generates new events in the environment, which in turn are sensed and acted upon. Consequently, the C^2 process may be viewed as a basic control system or a closed-loop process where human controllers act to change the environment.[4] A model for the process is shown in Fig. 1; the *sense*, *process*, and *classify* operations are allotted to command support; the *plan*, *decide*, and *act* operations are allotted to command; and the *evaluate* operation falls under both command and command support. This overlap recognizes that a commander and his staff, as well as designated military analysts, evaluate information sets to determine

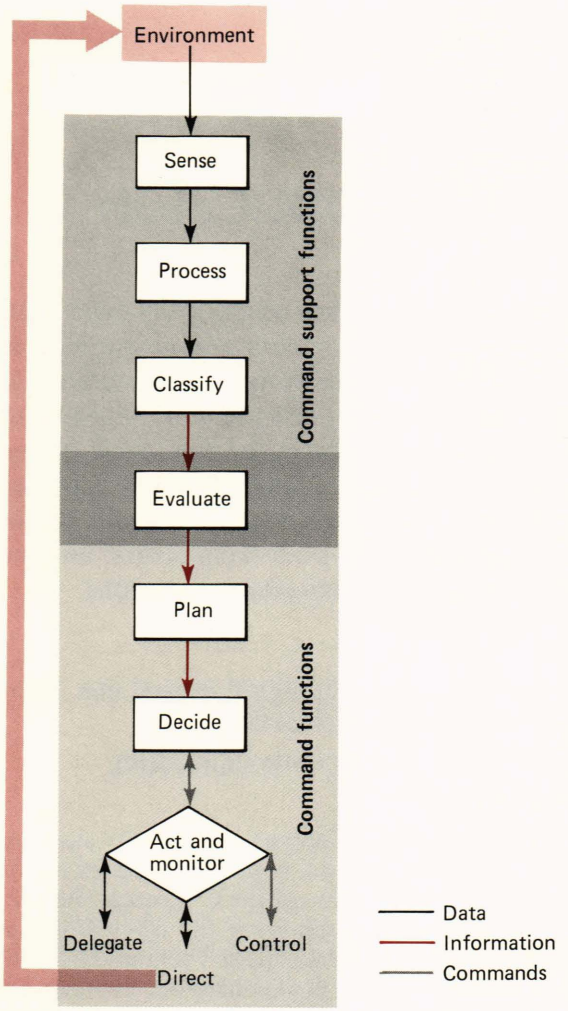


Figure 1 — The command and control process – a control system model showing the basic operations from sense through act.

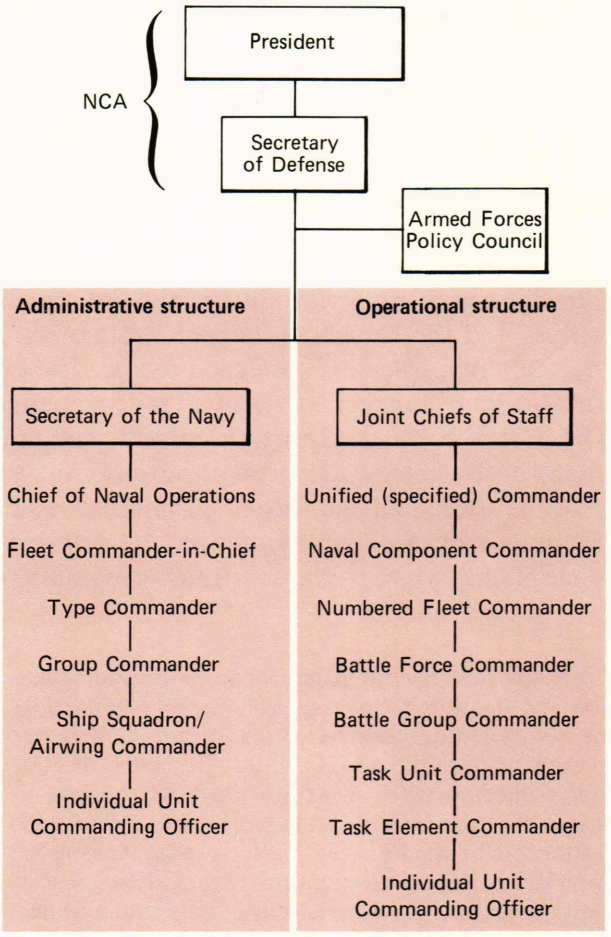


Figure 2 — Command structure of the U.S. Navy, showing the administrative and operational chains of command and their relation to the National Command Authority.

the need for action. The extension of the C^2 process model to multiple levels of command is discussed in the article by Halushynsky and Beam in this issue (page 9).

NAVY COMMAND STRUCTURE

The Navy organizational structure,[5] through which the C^2 process is realized, includes two functionally different chains of command: administrative and operational (see Fig. 2). The administrative chain of command is tasked primarily to maintain Navy force effectiveness. It provides the personnel, materiel, and facilities for the accomplishment of Navy missions. The operational chain of command is tasked to accomplish specific missions and military objectives. The system that supports the Navy command organization is referred to as the Navy Command and Control System. Because of its obvious importance to the C^2 function, this system must function continuously worldwide, in all environmental conditions, in the air, on the surface and subsurface, and adjacent to land mass regions where naval forces could be engaged to further national interests. Furthermore, the system must be designed to be responsive to the entire Navy command structure for the employment of strategic as well as general-purpose forces. It must provide the capability for commanders in all echelons to be responsive to National Command Authority directives as the United States moves by defense condition level between peacetime, crisis, conventional war, and nuclear war environments.

The scope of the Navy Command and Control System is illustrated in Fig. 3. As shown, the National Command Authority interfaces with Naval forces through the World Wide Military Command and Control System via the Joint Chiefs of Staff and the Unified Commander (i.e., the Commander-in-Chief of all U.S. forces in a given theater or area of operations). Naval forces operate under the Naval Component Commander (i.e., the Fleet Commander-in-Chief) subordinate to the theater Unified Commander. The Navy Command and Control System supports Navy commanders from the Fleet Commander-in-Chief to the unit or individual platform commander in his use of assigned sensors, weapon systems, and countermeasure assets. At each level of

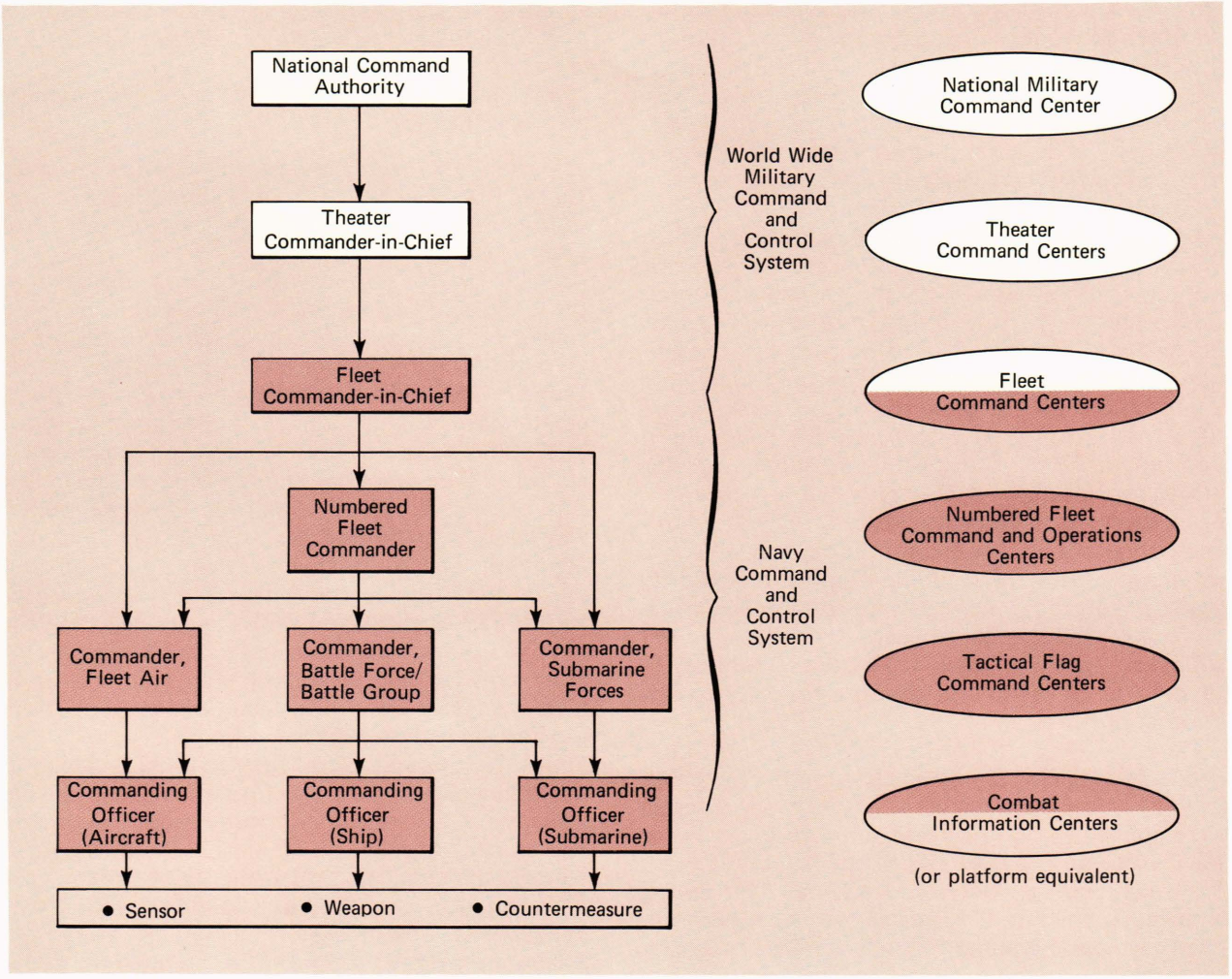


Figure 3 — The Navy Command and Control System extends from the Naval Component Commander level down to the individual United Commander level. Command center facilities support each Operational Commander ashore, afloat, and airborne.

command, the various operational commanders are supported by command center facilities that provide information processing, storage, and display, and communications capabilities. These facilities are identified on the right-hand side of Fig. 3 for each level of command. Figure 4 is a photograph of a Fleet Command Center. This particular facility operates in support of the Commander-in-Chief of the Pacific Fleet, a component commander in charge of all assigned Navy forces in that theater.

APL SUPPORT TO NAVY COMMAND, CONTROL, AND COMMUNICATIONS

APL support to the Navy in the area of command, control, and communications (C^3) began in 1969. This support has covered a wide spectrum of engineering and analytical activity.

The initial Laboratory effort in this area concerned itself with strategic communications. In 1969, Henry Kissinger, then Assistant to the President for National Security Affairs, requested information

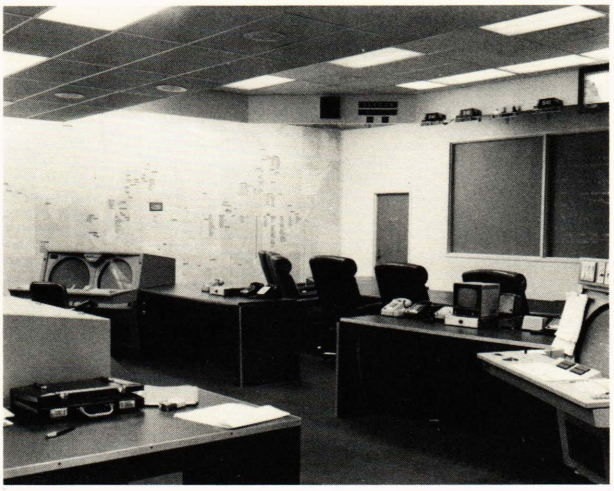


Figure 4 — The CINCPACFLT Fleet Command Center in some ways resembles the nerve center of a large corporation, with group-size displays of tactical information and various means of communications for the receipt of new information and the issuance of orders.

from the Chief of Naval Operations concerning the performance of high frequency radio backup to the primary fixed very low frequency and low frequency communication broadcasts to the Fleet Ballistic Missile submarine force. In an effort to provide quantified empirical data not then available, the Assistant Secretary of the Navy requested APL assistance.

An examination of the problem resulted in the development of the test methodology described by Preziotti et al. (page 37) for automatically collecting communications system data in Fleet Ballistic Missile submarines on patrol and then automatically reducing and analyzing the data to estimate communications system performance. This test and evaluation approach provided information on the specific quantified performance of all operational communications to the Fleet Ballistic Missile submarines deployed worldwide and also provided a high confidence estimate of submarine force C^3 system performance that can be expected for the delivery of a critical message from the National Command Authority to the commanding officers of individual submarines on patrol. Quinn and Cox (page 41) discuss the test equipment that was developed by the Laboratory to support the evaluation of tactical and strategic communications circuits.

During 1974-1976, the methodology, software, and data collection equipment used in the Fleet Ballistic Missile Communications Evaluation Program were applied to Navy surface ships deployed in the Mediterranean Sea and the North Atlantic Ocean. That methodology, developed originally for testing strategic submarine C^3 systems, has now been applied to tactical communications systems, including satellites.

In 1977, under the sponsorship of Rear Admiral Guy Shaffer of the Naval Electronic Systems Command, a long-range project, the C^3 System Engineering Development Program, was initiated. The program, which until 1981 addressed only tactical or general-purpose force C^2, now includes strategic C^2. The goal of the project was to develop top level systems engineering and design specifications that describe the necessary technical performance capabilities of the Navy's C^2 system in the year 2000 for both strategic and general-purpose forces.

In arriving at the goal of a future system requirements specification, the following objectives were achieved:

- Description of the present Navy Command and Control System in an approved system technical requirement specification format
- Description of future C^3 threat and its impact on system design alternatives
- Description of the year 2000 Navy C^2 concept
- Functional description of the year 2000 C^2 system
- War gaming to define the impact of the threat and new weapon systems on C^2 system concepts
- Quantification of future system performance
- Technology assessment and possible application to C^2
- Completion of System Technical Requirement Specification

Halushynsky and Beam (page 9) describe a concept for the year 2000 Navy C^2 that was developed as part of the C^3 System Engineering Development Program.

In 1977, in the same time period as the initiation of the C^3 System Engineering Development Program, a similar program for defining the requirements for an Over-the-Horizon/Detection, Classification, and Targeting capability in support of the cruise missile employment was undertaken. Following a series of procedures similar to those undertaken for the overall Navy C^2 system, a requirements document for future capability was developed. This engineering analysis of over-the-horizon targeting requirements is continuing and now includes various aspects of solving the surface ship correlation and tracking problem. Mitzel et al. (page 28) discuss an algorithm for multiple-source correlation and tracking when the inputs are principally from such wide-area sensors as high frequency direction finding systems and over-the-horizon high frequency radars.

In 1979, as a spin-off of the day-to-day evaluation of communications to the fleet of ballistic missile submarines, a Strategic Communications Continuing Assessment Program was initiated. Employing as a baseline the quantified performance of communications resulting from the Fleet Ballistic Missile Communications Continuing Evaluation Program, the program attempted to look to the future and to develop, for various potential optional changes to the system, measures of improvement that would result from those changes. By modeling system parameters on a computer, an engineering assessment of possible future connectivity options is now being accomplished. In addition, the results of the program are being included in the future Navy Command and Control System specification previously mentioned. Czajkowski and Peri (page 22) discuss this model and its application in assessing the performance of strategic C^2 systems.

In 1981, APL was asked to assist in the preparation of a Navy Command and Control Plan. This 10-year plan and accompanying Navy Command and Control System architecture were intended for the highest levels of the Navy, Department of Defense, and Congress to establish the Navy's long-range goals for C^2. The years of previous effort and experience in strategic and tactical C^2 systems evaluation and assessment and the development of future technical requirements served to take the lead in this effort. The first version of the Navy Command and Control Plan was completed early in 1982 and was promulgated by the Director of Navy Command and Control. Subsequent updates of the plan have been made annually. This Navy policy document contains

the architectural objectives of the Navy Command and Control System and defines the programming actions required to reach these goals. All system engineering effort today is directed toward supporting this long-range plan.

Thus, from a small beginning in 1969, APL's role in Navy C^3 has grown to a level where today not only does APL continue to provide a continuous test and evaluation of strategic communications systems to all Fleet Ballistic Missile submarines, but it also provides principal support in the area of future Navy Command and Control System specification, C^3 requirements analysis for strategic and general-purpose forces, and engineering definition of major surveillance and information processing systems.

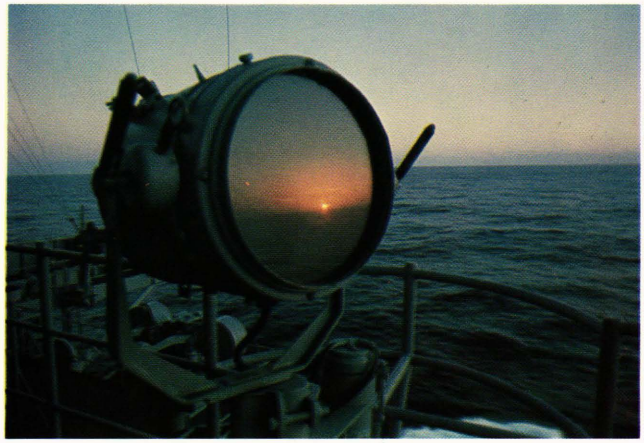
FUTURE PLANS

The Navy has followed a course of evolutionary development of a C^2 capability to support current and projected operational needs. A long-range plan for this effort has been approved and promulgated by the Director of Navy Command and Control (OP-094) and is being used by the Navy Material Command to guide the engineering development of this capability.

APL has been requested by OP-094 to maintain and expand, where possible, its efforts in support of Navy C^3. It will expand its efforts in the areas of both strategic and tactical communications test and evaluation, strategic communications engineering analysis, surveillance and over-the-horizon targeting system specification and modeling, engineering design guidance specification of the Navy Command and Control System, and long-range C^2 planning.

REFERENCES

[1] "Fleet Battle Organization," CNO message 291806Z Aug 77.
[2] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms,* Pub. 1 (1 Jun 1979).
[3] Applied Physics Laboratory, *Year 2000 C^3 Concept Briefing,* JHU/APL FS-79-022 (1979).
[4] S. M. Shinners, *Techniques of System Engineering,* McGraw-Hill Book Co., New York (1967).
[5] *Naval Warfare Publication 2 (NWP2),* Department of the Navy, (Feb 1980).



The venerable signal light continues to be an important element of the Navy C^3 system. During periods of emission control, it still provides a means of secure line-of-sight communications, free of jamming.

GLOSSARY OF TERMS

Airborne Transmitter Monitoring and Recording System — This system automatically measures and records communications parameters that can provide quantitative analysis of TACAMO communications to the Fleet Ballistic Missile submarine with little or no operator attention.

Baud — A unit of data transmission speed equal to 1 bit per second.

Byte — A generic term used to indicate a group (normally eight) of consecutive binary digits often operated on as a unit in digital processing systems.

Chain of Command — The succession of commanding officers from a superior to a subordinate through whom command is exercised and transmitted.

Command and Control (C^2) — The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of his mission. Command and control functions are performed through a command, control, and communications system.

Command and Control Architecture — An arrangement of command and control elements that identifies system functions, structure, functional connectivities, and interfaces.

Command, Control, and Communications (C^3) *System* — An arrangement of facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned.

Communications Connectivity — The medium that joins a commander to upper and lower command echelons and/or directly to assigned forces. For example, strategic communications connectivity links the National Command Authority to the nuclear deterrent force.

Correlation — The partitioning of sensor reports into subsets associated with a single platform or a formation of platforms so closely related that they can be considered a single entity (platform) for surveillance purposes.

Doctrine — A set of procedures relating to or governing the use of assets in various combat situations.

Echelon — This term is synonymous with command level, e.g., Fleet.

Emergency Action Message — A message originated by the National Command Authority for the nuclear deterrent forces of the United States that orders execution of specific preplanned operations.

Modular Data Collection and Recording System — A system that measures bit and character error rates and receiver automatic gain control voltages and records the time of reception of each technical test message in binary format on magnetic tape.

Multiple Source Correlation and Tracking — The process of associating contact reports or tracks from several different sources (radar, electronic support measures, electronic intelligence, communications intelligence, photo intelligence, and human intelligence) with a single platform (e.g., ship, submarine, or aircraft) and estimating its future position.

National Command Authority — The NCA is composed of the President and the Secretary of Defense or their duly deputized alternates or successors.

Operational Chain of Command — The chain of command established for a particular naval operation or series of continuing operations.

TACAMO Aircraft (acronym for Take Charge And Move Out) – An airborne communications relay platform designed to provide survivable and enduring communications connectivity with the SSBN force.

Technical Test Message — A series of 13-bit Barker sequences (a pseudorandom sequence of 0's and 1's chosen for its desirable cross-correlation properties in the presence of bit errors) that is repeated to obtain a 3-minute message. This test message activates the Modular Data Collection and Recording System, which, in turn, measures and records message error and signal amplitude statistics.