

COMBAT SYSTEMS EVALUATION LABORATORY

The Combat Systems Evaluation Laboratory, a major facility at APL, is used for concept evaluation, design, and testing of shipboard radars, combat systems, and associated displays and interfaces. It enables APL to investigate the full spectrum of missile system control concepts from command and control through missile performance.

INTRODUCTION

The Combat Systems Evaluation Laboratory (CSEL) is a facility for the development and evaluation of advanced combat system concepts and prototypes for Navy surface ships. (Another major APL facility is the Guidance System Evaluation Laboratory.¹) CSEL provides a working environment of actual military equipment in which new technology, new concepts, or improvements can be tested in existing Navy systems. It also allows APL's development work to be demonstrated to the Navy and other groups outside APL. The center is a unique tool for performing human factors engineering; man-machine interaction research; display development; Combat Information Center (CIC) layout design; and combat system design, development, and evaluation. CSEL has been closely tied to the development of the AEGIS Combat System and has met the evaluation requirements of the AEGIS program during that system's evolution. Concepts developed and evaluated in the facility include the Advanced Multi-Function Array Radar (AMFAR), command displays, automatic detection and tracking techniques for radar systems, and sensor management. Current efforts concentrate on extending these and other combat system concepts to the level of Battle Group operations.

CSEL has grown from a few consoles with limited computer support to the current configuration, which employs a substantial number of operational consoles, sophisticated tactical computers, and a large complex of tactical display equipment. The present facility is housed in two areas: the Operations Center, which contains the consoles and tactical display equipment, and the Computer Center, which contains the support computers and peripherals. In its entirety, CSEL represents a considerable capital investment in equipment, the major portion of which has been furnished to APL under direct AEGIS project sponsorship.

OPERATIONS CENTER

The CSEL Operations Center contains much of the tactically significant equipment found in a shipboard CIC and serves as a demonstration vehicle for many CSEL activities. Figure 1 is a cutaway view of the Op-

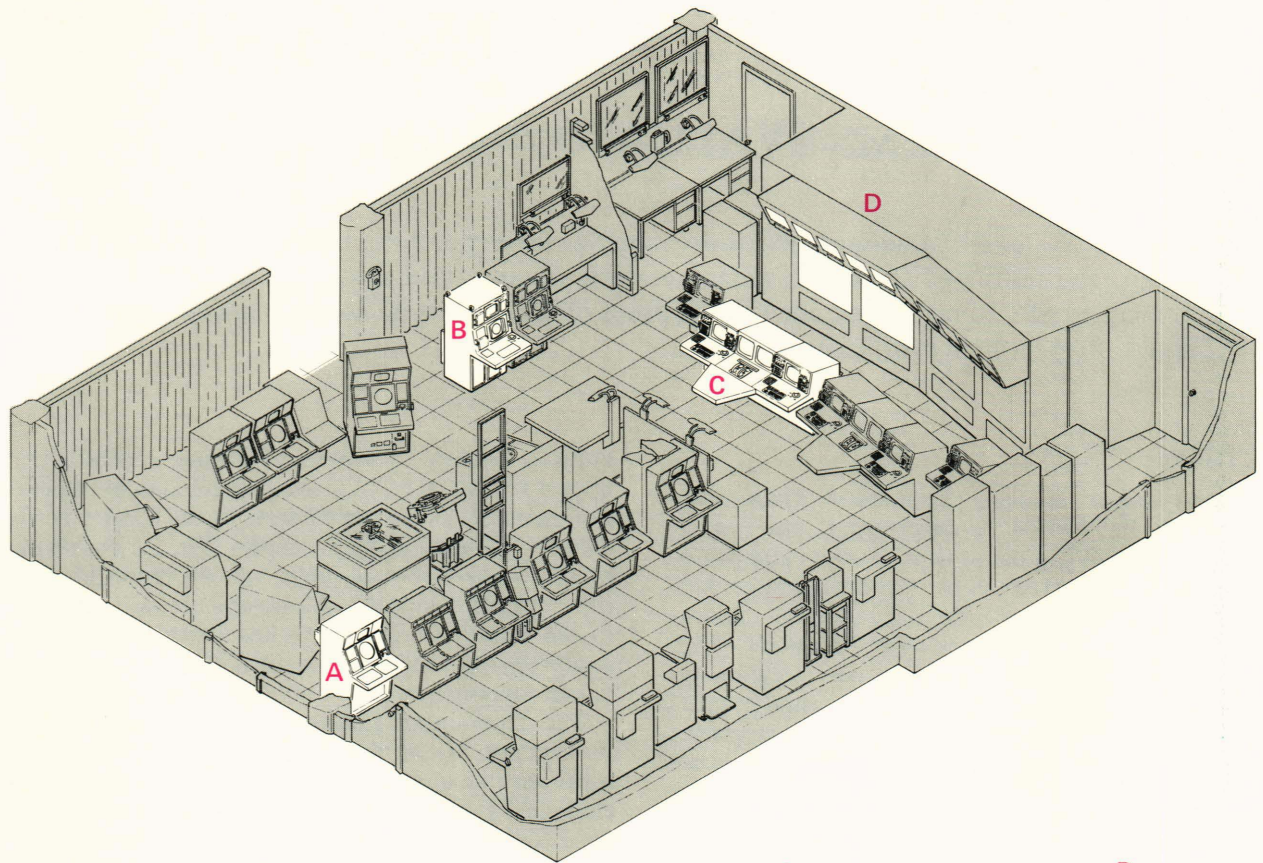
erations Center. Two types of display console (AN/UYA-4 and AN/UYQ-21) are represented in the Operations Center. A central element in the Center is the AEGIS command display complex (Fig. 2), consisting of four large-screen displays, ten TV monitors, and two command consoles. Mock-ups are also included in the Center to simulate some of the operational equipment normally found in a CIC. This permits layout investigations to be conducted realistically.

The Operations Center contains approximately 2100 square feet of floor space, which allows it to be arranged like any one of a number of different ship class CIC's. At this time, the Center is arranged like an AEGIS cruiser Combat Information Center. The utility support for the Operations Center includes 60- and 400-hertz power, cooling water, air conditioning, and overhead conventional white and shipboard blue lighting. The utilities can be rearranged with minimal rework within a short period of time (three to five days). A false floor provides access to the 60- and 400-hertz power networks and the cooling water supply. Both the blue and white overhead lighting installations are controlled on a quadrant basis to allow varying light levels throughout the Operations Center.

Computerized simulations of tactical environments are available to support the evaluation and demonstration activities in the Operations Center. The Combat Environment Generator Program uses CSEL's computers to simulate targets, sensors, weapons, and events external to the decision-making, combat-direction core of the combat system. A new, upgraded simulation capability is being developed to support CSEL applications in the 1980's. The intent of the upgrade is to expand from a functional model of Battle Group operations (i.e., one that primarily supports the investigation of single ship system considerations) to a model that treats the Battle Group as a system. This upgraded simulator will make it possible to analyze the effectiveness of overall Battle Group operations such as anti-air warfare coordination.

COMPUTER CENTER

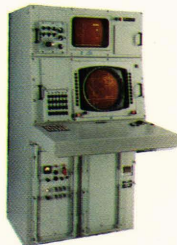
Although the Operations Center is the more visible part of CSEL, the heart of the facility is the Com-



A
AN/UYA-4 console



B
AN/UYQ-21 console



C
Command console,
Large screen displays,
Automated status boards



D
AN/UYQ-21 liquid crystal
large screen display
projector



Figure 1 — CSEL Operations Center. The Operations Center contains much of the tactically significant equipment found in a shipboard Combat Information Center (CIC). It was used as an aid in determining the layout of AEGIS CIC's. The Operations Center is currently arranged as an AEGIS cruiser CIC.

puter Center where CSEL users do most of their day-to-day work. The Computer Center contains the computers that drive the tactical consoles and provide for computer program development. Figure 3 is a cutaway view of the Computer Center. The Center contains a variety of computers used in the surface Navy, including the AN/UYK-7 (single-bay and four-bay configurations), the AN/UYK-20, and two computers of the CP-642 series (a UNIVAC 1230 and an AN/USQ-20(V)). A number of peripherals, including disk drives, terminals, line printers, card readers, card punches, and magnetic tape units, are also available in the Center. Table 1 lists the equipment in the Computer Center.

The UYK-7 and UYK-20 computers are third-generation computers that are currently used for the bulk of the modern Navy's nonavionic tactical processing. They have been designated as the standard embedded computers by the Chief of Naval Material. The UYK-7 computer is a multiple processor system, designed for military applications, that can be assembled to meet medium or large system requirements. It is designed to operate as a single processor or multiple processor system. The UYK-20(V) is a general-purpose militarized computer in a small, rugged package designed to meet the requirements of small-and medium-sized applications in shipboard, mobile shelter, or other military environments.



Figure 2 — Command display complex. The AEGIS Combat Information Center will include a command display complex. This center functions as an information management system designed to support ownship command and the Battle Group Anti-air Warfare Commander. It consists of four large-screen displays, ten alphanumeric displays, and four console-mounted high-resolution graphics monitors.

Table 1

CSEL COMPUTER CENTER EQUIPMENT

Computers

- AN/UYK-7, four bay
- AN/UYK-7, single bay with extended memory
- AN/UYK-20
- UNIVAC 1230
- AN/USQ-20
- UNIVAC 492

Disk Systems

- CDC 9766 disk drive (2), SI 9500 controller
- CDC 9762 disk drive (2), SI 9500 controller

Magnetic Tape Systems

- UNIVAC III c (5), seven track
- Ampex TM 1629 (4), seven track
- UNIVAC RD-358 (2), nine track
- UNIVAC 1840 (2), seven track
- BUCODE 4025 (2), nine track
- RD-243 (2), seven track

Punched Card Equipment

- IBM 360/20, 2560 card reader/punch
- Peripheral dynamics card reader

Printer

- IBM 1403 (NI)
- Data Products 2470
- UNIVAC COP printer

The CP-642 computers, typical of the computers in current ships of the line, are earlier generation units designed for real-time military applications such as missile guidance and tactical control and display. While the UYK-7 and UYK-20 computers are used for most of the new tactical programs in the Computer Center, the CP-642 computers are still heavily used for simulation and data reduction.

In addition to tactical computer systems, the Computer Center contains SHARE/7, a multiprocessor time-sharing system on the UYK-7 computer, which was developed by the Fleet Combat Direction Systems Support Activity at San Diego. SHARE/7 is designed to support the efficient development and maintenance of tactical data system software and is widely used throughout the Navy community. It provides the user with a wide range of software within an on-line, interactive environment. The computer system's monitor program, contained in the UYK-7 computer at all times, is the central unit of the operating system that provides such services as resource allocation and job scheduling. An executive program is also included in the system-supplied software. This program is the prime interface between the user and the remainder of the subsystems, which include a text editor, on-line debugging aids, a background processing capability, a text formatter, and a variety of compilers, assemblers, loaders, and simulators. With SHARE/7, computer programs can be written for the UYK-7, the UYK-20, and the CP-642 series of Navy computers.

INTERFACES

CSEL interacts with other major facilities at APL, including the Radar and Weapon Control Evaluation Center, the Embedded Computer System Evaluation Laboratory, and the Computer Aided Programming Facility. The Radar and Weapon Control Evaluation

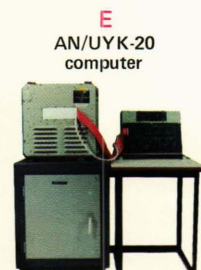
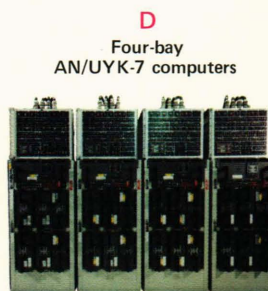
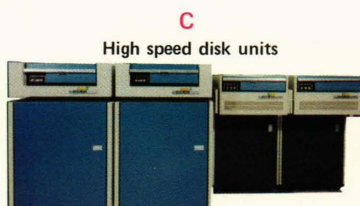
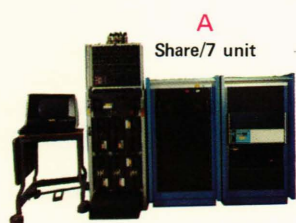
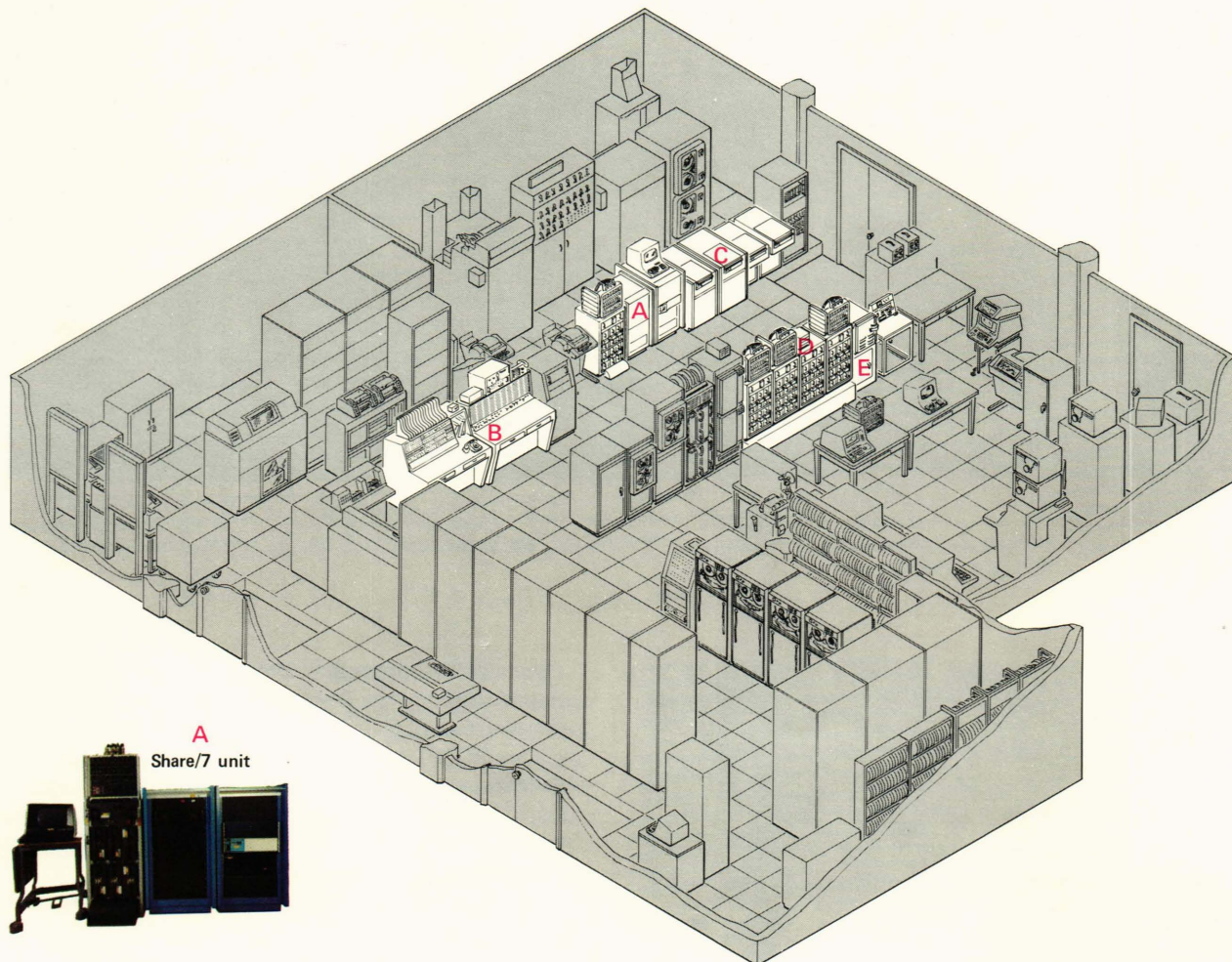


Figure 3 — CSEL Computer Center. The Computer Center contains the computers necessary to drive the tactical consoles in the Operations Center and to host computer program development. Specifically, the Center contains AN/UYSK-7, both single-bay and four-bay configurations, AN/UYSK-20, UNIVAC 1230, and AN/USQ-20 computers.

Center includes several Fleet operational radars as well as the TERRIER and TARTAR Weapon Control Systems. The Embedded Computer System Evaluation Laboratory is used for software development such as the computer programs for the AN/SYS-1 Integrated Automatic Detection and Tracking System. The Computer Aided Programming facility is used as an aid in software development (using PASCAL, FORTRAN, and CMS-2 programming languages). The interfaces include the New Threat Upgrade facility located at APL ; the AEGIS Combat System Engineering and Development Site at Moorestown, N. J.;

and the Fleet Combat Direction Systems Support Activity at Dam Neck, Va.

APPLICATIONS

CSEL has been closely tied to the development of the AEGIS Combat System and has met the evaluation requirements of the AEGIS program during that system's evolution. The facility was upgraded during 1978 to accommodate the mock-up and investigation of larger Combat Information Center arrangements associated with AEGIS cruisers and destroyers. Not all CSEL applications, however, have been AEGIS

related. The facility also has been used for the development and evaluation of a Coast Guard harbor traffic control system and Federal Aviation Administration enroute and terminal air traffic control systems as well as non-AEGIS Navy programs. Currently, a major user of the facility is the Battle Group Antiair Warfare Coordination Program, an extension of AEGIS activities. The following paragraphs describe in greater detail some of the major applications of the CSEL facility to date.

AEGIS Combat System Concepts—CSEL was used to develop and demonstrate command and decision organization and techniques to the Navy through the use of prototype computer programs. Many of the tactical command concepts demonstrated by these programs have been incorporated into the AEGIS Command and Decision Program and the Battle Group Antiair Warfare Coordination Program.

Advanced Radar Development—The Advanced Multi-Function Array Radar, developed at APL, was tested and evaluated in the CSEL. This radar demonstrated advanced signal processing and encoding techniques and served as a baseline design for the AEGIS AN/SPY-1 radar. The computer control processes developed for this radar served as the model for AEGIS radar control programs.

Command Displays—Command display definition is an ongoing task in CSEL. Working sessions, attended by both active and retired Naval personnel, are frequently held in the Operations Center. These sessions evaluate display format, content, and general flow in a realistic shipboard environment supported by CSEL's simulation capability.

Combat Information Center Arrangement—CSEL has been used over the past decade to model the structure of Combat Information Center layouts of nuclear and nonnuclear AEGIS cruiser and destroyer variants. It has been useful in focusing the efforts of the Navy and the contractor design team.

Data Reduction—CSEL is able to reduce and play back AEGIS sea-based test data from the USS NOR-TON SOUND and land-based test data from the AEGIS Combat System Engineering and Development Site. This capability has been used as a demonstration of the unique features of AEGIS, as a source of realistic data to be used in the development and evaluation of other CSEL activities, and as a troubleshooting aid during early AEGIS development.

Automatic Detection and Tracking Processing—APL is a leader in radar automatic detection and tracking processing. CSEL has been used to develop, test, and evaluate automatic detection and tracking techniques for the Navy, the Coast Guard, and the Federal Aviation Administration. Advanced prototypes of the AN/SYS-1 and AN/SYS-2 computer programs were developed in CSEL to demonstrate the process before the Navy requested contractor bids for the production systems.

Battle Group Antiair Warfare Coordination—As part of this program, a land-based development model is being assembled in CSEL prior to an at-sea

demonstration and evaluation. This model extends the automatic control techniques proven in AEGIS development to the Battle Group. The model provides the Antiair Warfare Commander with an information management system and a means to monitor and control his resources effectively in a rapidly changing antiair warfare environment.

New Technology—CSEL is frequently employed to demonstrate and evaluate the application of new technology to shipboard use. Technological advancements under investigation include microcomputers, data buses, electronic switching, fiber optics, display techniques, software tools, computer-generated speech, and distributed processing.

New Navy Equipment Evaluation—As an independent laboratory, APL is contracted by the Navy to evaluate new equipment developed by commercial contractors. This is done by integrating the equipment into CSEL operations and evaluating it from a systems standpoint. Currently under evaluation in the Operations Center are the Hughes Aircraft Corp. AN/UYQ-21 large-screen display projector, tactical console, and display driver unit. Area display devices and, in particular, large-screen display projectors have been incorporated into the Operations Center for several years. An effort related to the projector evaluation investigates the utility of various display driver units. In addition to the Hughes unit, commercially available RAMTEK 9400/50 and 9400/80 units are currently under evaluation. In the Computer Center, APL will be evaluating the AN/UYK-43 Engineering Development Models. The AN/UYK-43 is a general-purpose digital computer intended to replace the currently operational AN/UYK-7 computer. APL will provide the Navy with recommendations as to the relative merits and suitability of the AN/UYK-43 computer for operational use.

Software Development—CSEL has the capability to develop and maintain computer programs written in the standard Navy high-level computer language, CMS-2. Since Navy tactical combat systems presently being designed and built are largely computer controlled, computer software is needed to develop and evaluate these systems. A major support activity of CSEL is the development of an efficient capability to produce tactical software. Paramount among these tools is the SHARE/7 operating system, which was installed in November 1977 and is performing adequately under present work loads.

CONCLUSION

The Combat Systems Evaluation Laboratory at APL has been used for over a decade to aid in the design and analysis of new radar, weapon, and command systems for the Navy and other government sponsors. It has provided a facility to prepare and run real-time computer control programs and to assist in testing the use of display equipment in shipboard weapon control systems. It has played a valuable role in the development of the AEGIS Combat

System by providing an operational mock-up of a Combat Information Center. Most recently, its improved computer-simulation capability has allowed expansion from evaluation of systems designed for a single ship to evaluation of systems designed to coordinate all the units of a Battle Group. CSEL's flexibility, especially its ability to interact with other facilities and its capacity to be upgraded with minimal effort, will continue to prove useful in the development and evaluation of future military equipment and concepts.

REFERENCE

¹W. M. Gray and R. W. Witte, "Guidance System Evaluation Laboratory," *Johns Hopkins APL Tech. Dig.* **1**, 144-147 (1980).

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