SECURE, MULTIPLE-SHIP OPERATIONAL EW TRAINING

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INTRODUCTION

It is now possible to perform realistic, multiple-ship area EW defense training for a task force of ships, or even a full fleet, without transmitting threat signals and without going to sea.

The principle involves the use of on-board threat simulators and radar target simulators which reproduce a full, dynamic multiple-threat environment and are controlled and synchronized from a single command position via narrowband radio links. The individual ships can be in port, or underway for reasons totally unrelated to EW training during the exercise. The simulators aboard each ship reproduce the signal and radar environment as it would be seen by that ship, including consideration of:

- All types of threats (ships, aircraft, missiles).
- Friendly emissions.
- Modulation and antenna scan characteristics of each signal reproduced.
- Range and azimuth of each threat relative to that individual ship.
- Appropriate changes in the modes of threat signals as functions of time and distance from the ship.
- Maneuvering of the ship on which the EW receiver and radar equipment is located.

A multiple-ship, multiple-threat simulation, such as that shown in simplified form in Figure 1

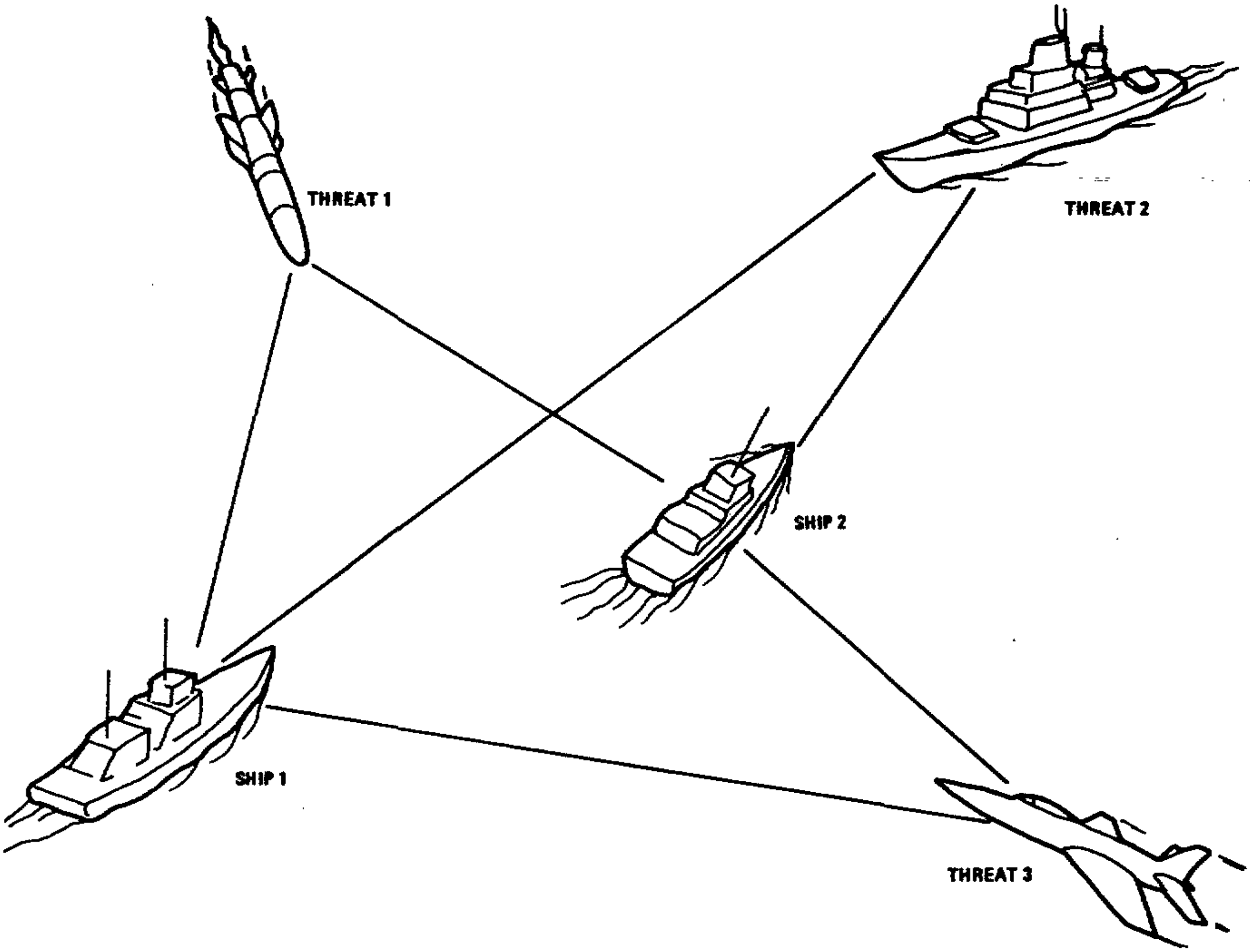

Figure 1. Relative Threat Position Diagram

is analyzed by a computer to yield the moment-by-moment signal environment from the point of view of each of the ships. The ships and threats are moved at realistic rates; and the signal environment is reanalyzed often enough to provide realistic dynamic performance on the displays of the EW equipment in the ships.

Naturally, the faster moving missile and aircraft threat signals must be updated more often than the slower moving ship related threat signals.

The computer then generates a simulator command cassette tape for use in each of the individual on-board simulators, with synchronizing file markers at preestablished points in the program to simplify later synchronization of the simulation on the individual ships.

The same steps are applied to the analysis of of the radar responses as seen by each ship, and the appropriate radar target commands are added to the threat signal scenario.

Each remote simulator then generates its output signals and displays in response to these commands using its own cassette tape player, so no threat signals need to be transmitted. Only control and periodic synchronizing signals for the tape players need be sent from the central control station. Since these signals are intrinsically narrowband and are formatted for full compatibility with any audio link, they can be easily sent over existing, secure ship-to-ship radio links, or over cables, or even commercial telephone circuits if desired. Further, since the control signals are not phase critical, they can be sent

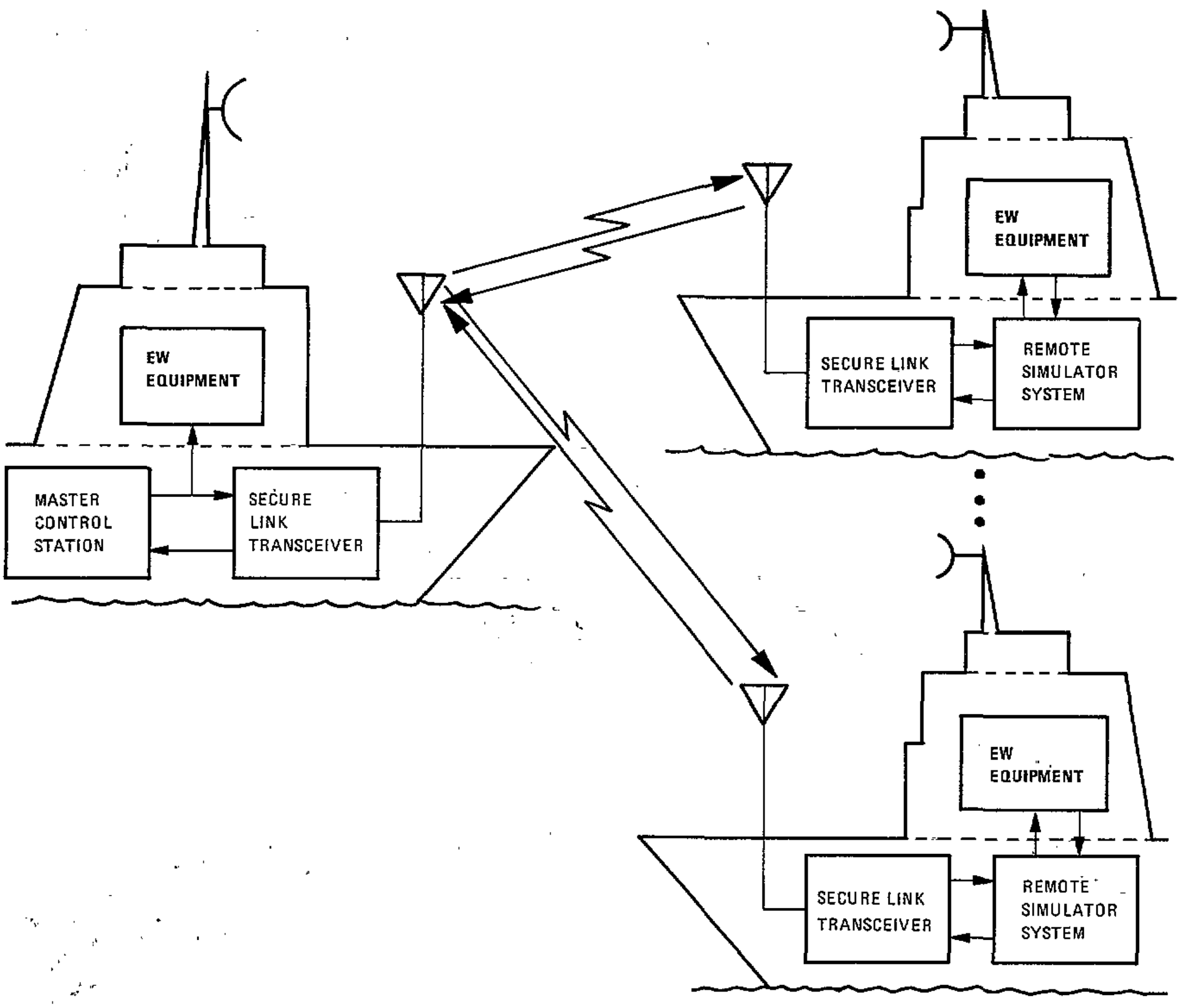

Figure 2. Multiple Cooperative Station Simulator Configuration

over satellite links to allow cooperative training of EW operators on widely separated ships without any performance degradation.

Because the threat and maneuver scenario seen by each of the participating ships reflects the same situation from different points of view, all are participating in the same exercise and can perform the normal operational reporting functions. If the full scenario is displayed to an instructor by a minicomputer (such as the AN/UYK-20) at the control station he can score the exercise in real-time by comparing the reported information and conclusions with the actual situation represented by the exercise scenario.

THE SIMULATOR SYSTEM

Figure 2 shows the full simulator system, including a single master control station and a number of remote simulator stations on-board individual participating ships. From this figure, it will be noted that two-way communication must exist between each of the participating ships and the master control station.

This allows use of a maximally efficient "non-redundant" command scheme by assuring that each command sent is received properly by its intended remote system (through an automatic acknowledgement technique). Also note that signals to remote simulator equipment on board the ship in which the master control station is located are connected to the command station by cables. As will be seen below, this technique does not require several dedicated links, but can use a single net frequency for the whole exercise; the same net can be used for voice communication (although somewhat degraded) in one of the operating modes.

MASTER CONTROL STATION

The master control station, as shown in Figure 3, comprises:

- A master control console on which the instructor plays a tape to control the cassette players at the remote simulators and to synchronize the scenarios. It also allows the instructor to make real-time changes to the scenario through keyboard commands.
- A link interface unit which converts the serial RS-232 output from the control console into a form that can be easily and accurately transmitted over any audio link.

There are two system operating modes which can be selected by the instructor, a narrowband mode and a wideband mode. In the narrowband mode, the master control console outputs data at 300 bits per second; only recorder control commands are passed to the remote simulator systems. These commands include:

- Start
- Stop
- Rewind
- Go to file number XX (100 file numbers available).

In this mode, the link interface unit outputs a narrow band On-Off keyed (OOK) signal at 3200 Hz. This signal is high passed, so that low-passed voice signals can be mixed with the control signals on the same voice grade link if desired. Because of the narrow bandwidth of the control signals in

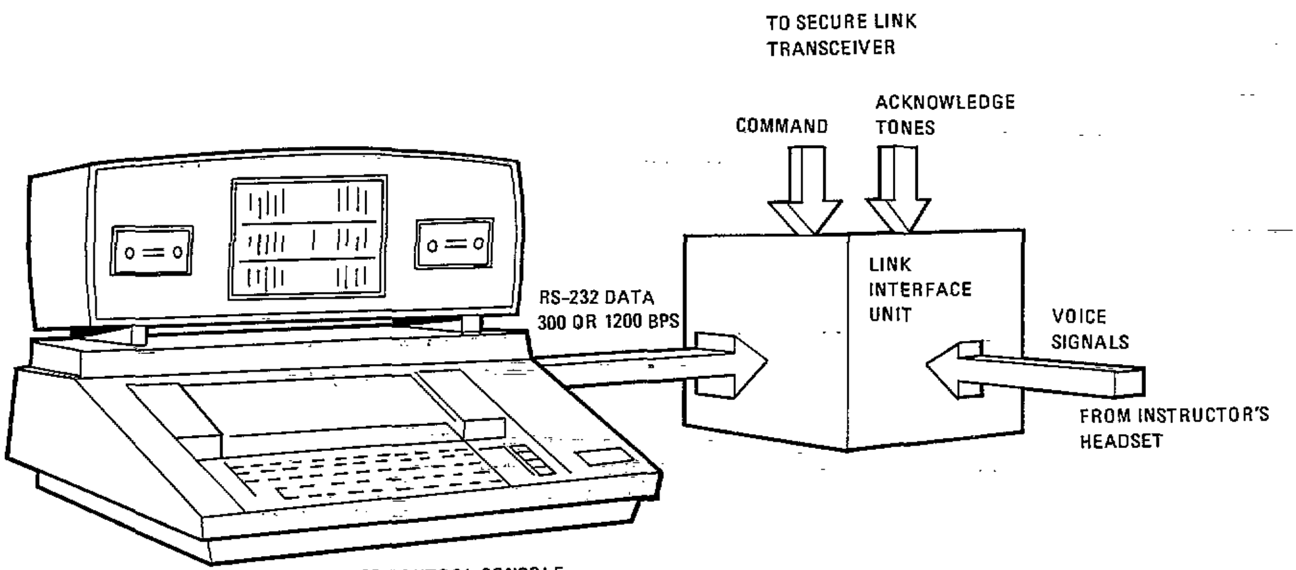

Figure 3. Master Control Station

the narrowband mode, signals must be sent at a very low rate (although adequate for control and synchronization of the scenarios) but the narrow bandwidth also allows the system to work to full performance even over very poor quality links. All of the actual signal parameter or target position data passed to the simulation equipment in the narrowband mode is stored on tapes at the remote locations.

In the wideband mode, the instructor (or an on-line computer) can generate commands which will directly alter the signal parameters output by the remote simulators. In this mode, the link interface unit converts the RS-232 serial data into a frequency shift keyed (FSK) signal for transmission to the remote simulators over the voice grade link. Since the FSK signal occupies most of the bandwidth of a voice grade channel, it cannot share the channel with voice signals as described for the narrowband mode.

Both modes would probably be used during any sort of training operation, but in a short term, highly dynamic problem (a battle scenario for example) the system would be in the narrow-band mode most of the time with the instructor switching into the wideband mode for brief periods to change some parameter for a specific reason. For longer term problems (for example, a medium activity, 24-hour problem) the wideband mode might be used most of the time with commands coming directly from an on-line computer to provide maximum flexibility to the problem.

In either mode, the RS-232 data comes from the control console in serial form, and is collected by the link interface unit into formatted output words with synchronizing, address, and parity bits. When the command words are received by the remote simulator system or systems to which they are addressed, coded acknowledgement tones are sent back to the master station link interface unit. If no acknowledgement tone is received, the command word is sent again until the proper answering tone (identifying the addressed remote system) is received. If a command is not properly received and acknowledged within 5 seconds, the system notifies the instructor that one of the links is out. Since secure links often drop out suddenly with loss of synchronization of encrypters, this is an important feature of the system.

The design of the link interface equipment allows the system to operate accurately with virtually any level of signal-to-noise ratio in the communication links used to transmit and acknowledge commands. A degraded link will just require more and more repeated commands as the signal-to-noise ratio drops; but since multiple parity bits are checked, no false commands will be accepted by the remote systems. This creates a graceful degradation of performance with link degradation.

REMOTE SIMULATOR SYSTEM

Figure 4 is a block diagram of one of the remote simulator systems. The Link Interface Unit in this system receives and demodulates the FSK or OOK signals from the master control station, checks the parity bits to determine that the signal was correctly received, and sends a properly coded acknowledgement tone back to the master control station. It also separates the low-passed voice channel from the command signals if the system is in the narrowband mode.

In a narrowband operation, the control signals go to the cassette tape player which then controls the signal simulator. In wideband operation, signals are passed directly to the signal simulator to modify signal parameters.

The signal simulator subsystem generates large numbers of simultaneous signals which are coupled into the inputs of the shipboard EW equipment so that the equipment can receive both its normal input signals (from its antennas) and the

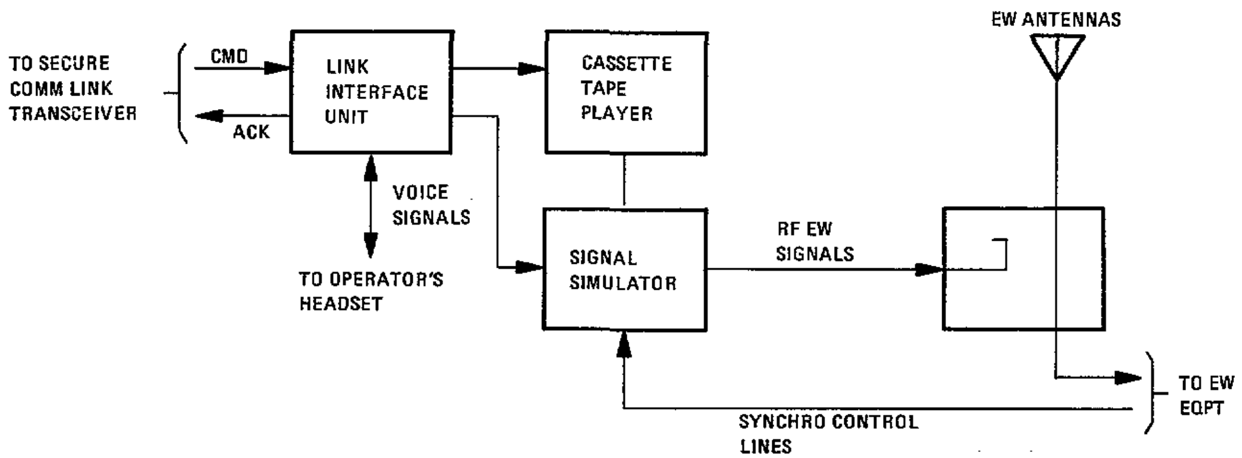

Figure 4. Remote Simulator System

simulated signals generated on board. The signal simulator also interfaces with the antenna control synchro system to provide realistic stimulation of the direction finding functions of the EW equipment. A third function performed by the signal simulator is the generation of the control signals required to display simulated targets on one or more radar PPI scopes.

SIGNAL SIMULATOR

The signal simulator portion of the remote systems actually generate the RF environment seen by the EW equipment and the return images of the radar PPI scopes on-board the individual ships taking part in the training exercise, as shown in Figure 5. It comprises pulse/scan generators, RF generator/modulators, an antenna simulator, and a radar target simulator. This subsystem is made up of standard GSA-listed simulation equipment very similar to that used in the 7B1 training facility at New London (see Figure 6) and in the 10A3 facility at Pearl Harbor (see Figure 7) which have been in use for over 5 years with a 98 percent availability record. However, these units will be selected from the newest product lines, which by use of new designs and components generate significantly higher density environments using fewer modules. They will also be from the 6000 series portable dynamic simulator hardware line to make them compatible with shipboard operation. (See Figure 8.) The whole subsystem is modular and can provide any desired signal density by the addition of equipment modules.

The pulse/scan generators create many pulse signals in response to the commands received from either the cassette player unit or the link interface unit. All signal parameters are stored in a dedicated memory circuit in each generator so commands need be given only to change parameters. Each generated signal has a unique pulse modulation and scan characteristic, but the signals are interleaved on a pulse by pulse basis, onto a single set of output lines. To allow the interleaved pulses to be sorted out by the other equipment in the simulator, a set of parallel current target address (CTA) lines are provided to identify each pulse with the signal to which it belongs.

The RF generator/modulators rapidly tune to the correct RF frequency for each of the signals on a pulse by pulse basis. The pulses are attenuated to provide the correct scan-related signal level for each pulse, and are also attenuated to simulate the effects of receiving antenna pointing. CW signals, if required, are generated in the RF generator/modulator subsystem and are independently modulated with the receiving antenna characteristics before being summed with the pulsed signals.

The receiving antenna attenuation factors are provided by the antenna simulator unit. It determines the antenna pointing angle by sensing the five-wire synchro control outputs. Since the correct azimuth of arrival of each of the simulated signals is stored in a memory circuit in the antenna simulator, it can calculate the angle "off-of boresight" for each pulse of a signal, and can apply the correct attenuation factor (including the effect of antenna sidelobes) to the control line from which the RF generator/modulators derive their information.

The radar target simulator accepts command data from the cassette recorder or link interface

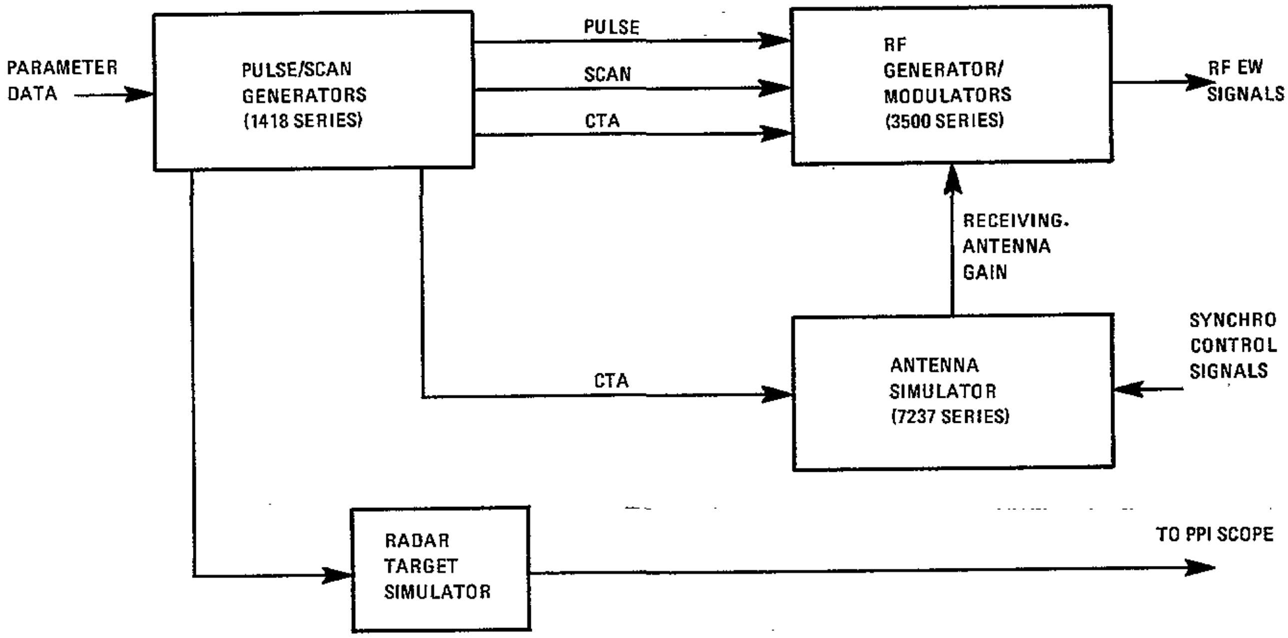

Figure 5. Signal Simulator

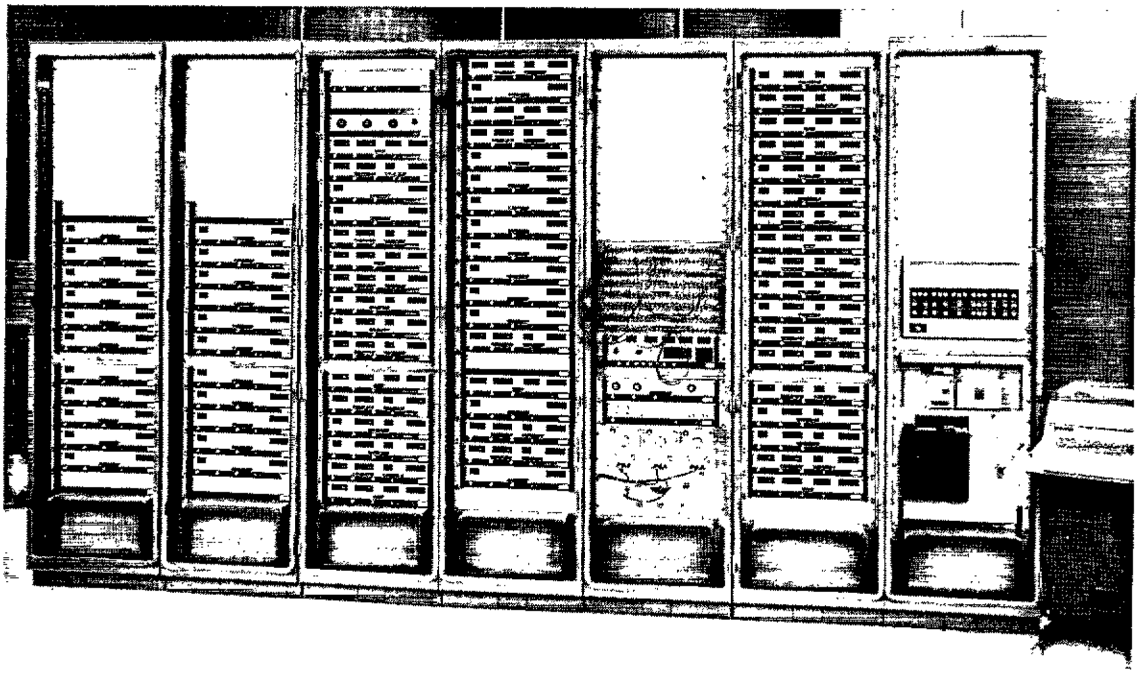

Figure 6. 7B1 Simulator

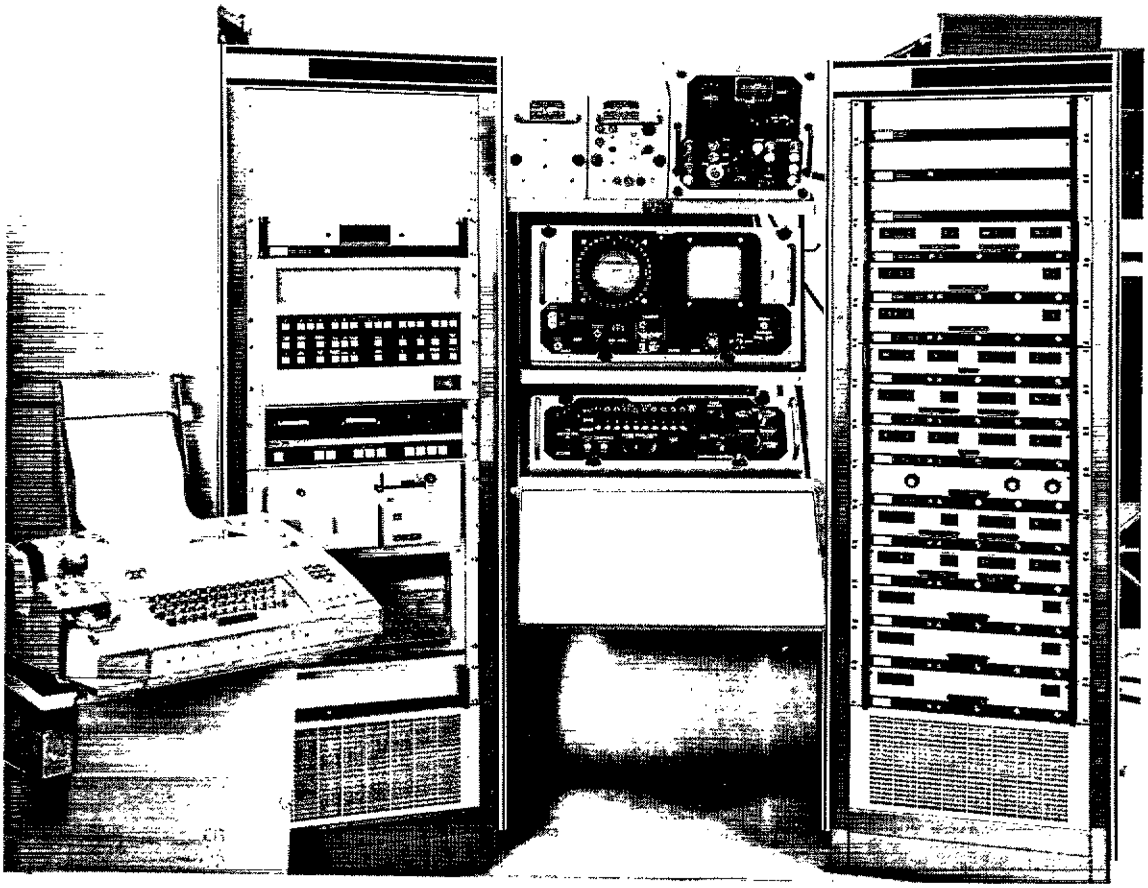

Figure 7. Part of 10A3 Simulator Facility

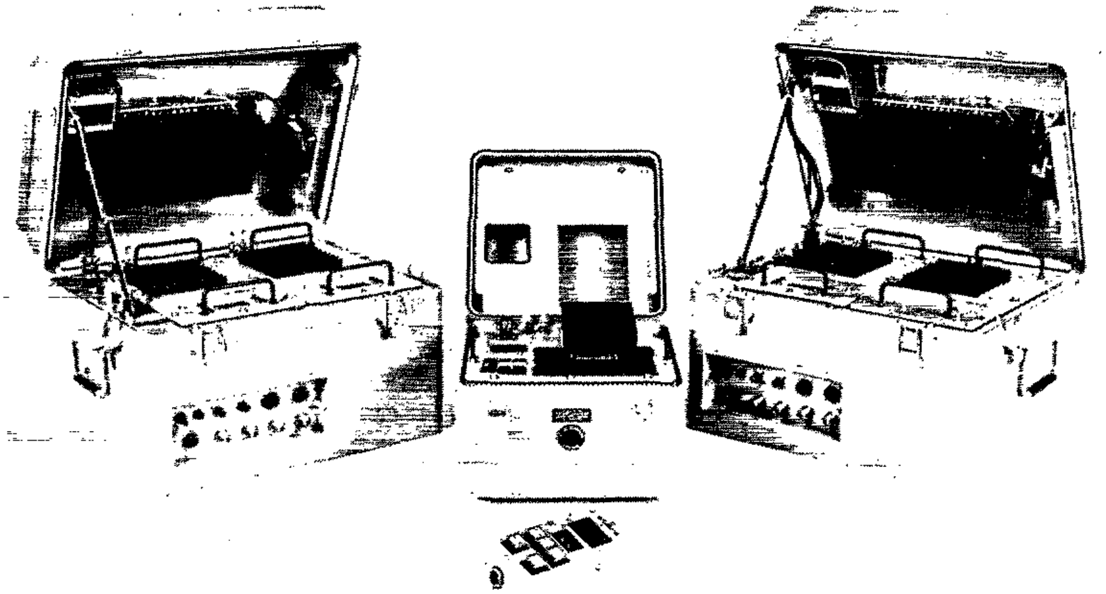

Figure 8. Typical 6000 Series Modules and Mounting Cases

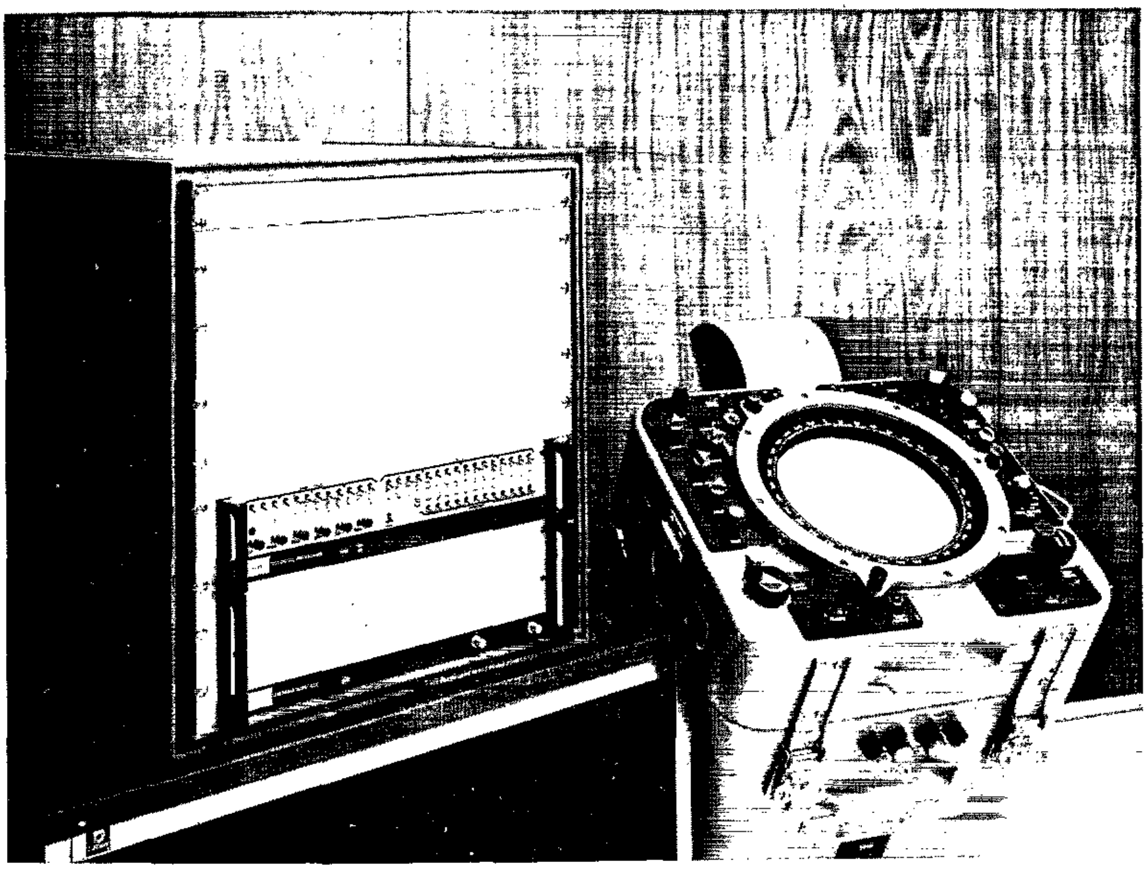

Figure 9. PPI Radar Scope Driven by Radar Target Simulator

unit through the data interface circuitry in the Pulse/Scan generator equipment. It generates all of the control signals necessary to display simulated targets on a slave PPI radar scope such as the one shown in Figure 9 (part of 10A3 Simulator). Since the placement and simulated radar cross section of these targets is coordinated with the threat signal data commands to the EW signal simulator units, the EW personnel involved in the exercise get a fully coordinated picture of the battle scenario as it unfolds.

EXPANSION OF BASIC CAPABILITY

The simulation thus far described has related only to surface ships, but it is easily extended to include submarine platforms. The only difference here is that the simulated signals must be interrupted during any time the submarine is submerged (either actually or in simulation if it is not at sea). If the submarine is actually underway during the exercise, a slight modification to the commanding scheme must be made to allow an update dump of commands to the submarine on demand. This allows the simulator in the submarine to be updated to include any parameter changes which might have been sent while it was submerged, and hence had its communication link interdicted.

EW aircraft can also be added to the problem, since flight line equipment capable of stimulating the aircraft's EW equipment and compatible with the multiple-ship simulation configuration is also available. However, at the moment, this equipment can only be used with the aircraft on the ground (or carrier deck) since it is not designed to be carried aboard the aircraft.

CONCLUSIONS

With the introduction of the Area EW defense management concept and its increasing importance in modern warfare, it is becoming ever more important to provide EW operators with realistic, cooperative, multiple-ship training in the search for, identification and location of, and proper reaction to threat signals. Further, it must be provided in the most cost effective way possible; so it can be repeated often enough to achieve not only competence but excellence of performance by EW operators.

The presented concept is a classic example of resource conservation through simulation, since the cost of installing this type of remote simulator system on a ship is less than the cost estimated by the Office of the Chief of Naval Operations for taking that same ship to sea for a single 1-week exercise. Further, this concept allows EW and radar operators to be cooperatively trained under high density, "hot war" engagement conditions, with large numbers of friendly ships maneuvering against large numbers of enemy ships which are firing anti-ship missiles, and large numbers of enemy aircraft; conditions that can (in peace-time) only be created through simulation. Therefore, this simulator based training is not only less expensive than that which could be provided by maneuvering ships against emitting signal sources, but its quality and realism are superior.

ABOUT THE AUTHOR

MR. DAVID L. ADAMY is a Systems Engineering Manager at Antekna, Incorporated. He is responsible for the design of EW target simulator systems and the conduct of simulator system study activities. For the past 15 years, he has been a systems engineer and program manager in the EW field designing (and managing programs to develop) communication receivers, radar warning and automatic jammer interface systems, and remotely controlled direction finding receiver systems. While an Army officer, he was a technical instructor at the National Security Agency. Mr. Adamy holds a B.S.E.E. degree from Arizona State University and an M.S.E.E. degree from the University of Santa Clara.