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P-3C UPDATE III

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FRONT AND BACK COVERS

Patrol Squadron Thirty-One is the Fleet Replacement Squadron for the Pacific Fleet patrol aviation community. VP-31 is NAS Moffett Field's largest squadron, with a staff of over 90 officers and 500 enlisted personnel. The squadron has approximately 21 aircraft assigned to it at any one time. Through last year, VP-31 conducted courses on the P-3B TACNAV MOD aircraft, the basic P-3C and P-3C Update I and II aircraft, and — beginning during Summer 1984 — the P-3C Update III, the newest and most sophisticated model of the P-3 series.

Known as the "Black Lightning" Squadron, VP-31 was commissioned in June 1960 at NAS North Island, San Diego, as the Combat Replacement Patrol Squadron for the Pacific Fleet. The squadron initiated limited training soon after it was formed, and by early fall 1960 a staff of 20 officers and 300 enlisted men were fully engaged in training fleet replacement personnel in the operation and tactical use of two models of patrol aircraft — the P2V "Neptune" landplane and the P5M "Marlin" seaplane.

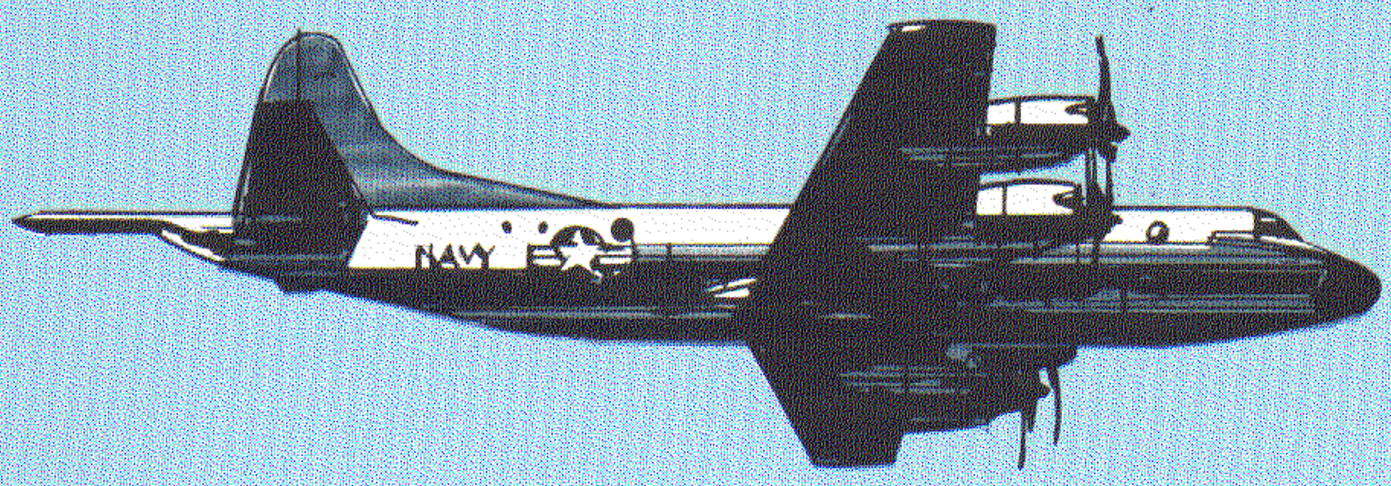
In January 1963, VP-31 Detachment Alpha was established at NAS Moffett Field to introduce the Lockheed P-3 Orion to the Pacific Fleet patrol squadrons. Within the next few years, the majority of the Pacific Fleet patrol squadrons were outfitted with P-3 aircraft, and Detachment Alpha's role had expanded to training fleet replacement personnel for these patrol squadrons. As a result, the Moffett Field detachment was redesignated as Patrol Squadron Thirty-One in January 1967, and the squadron's North Island operation was then given detachment status. The North Island detachment phased out training on the P-5 aircraft in early 1967 and discontinued

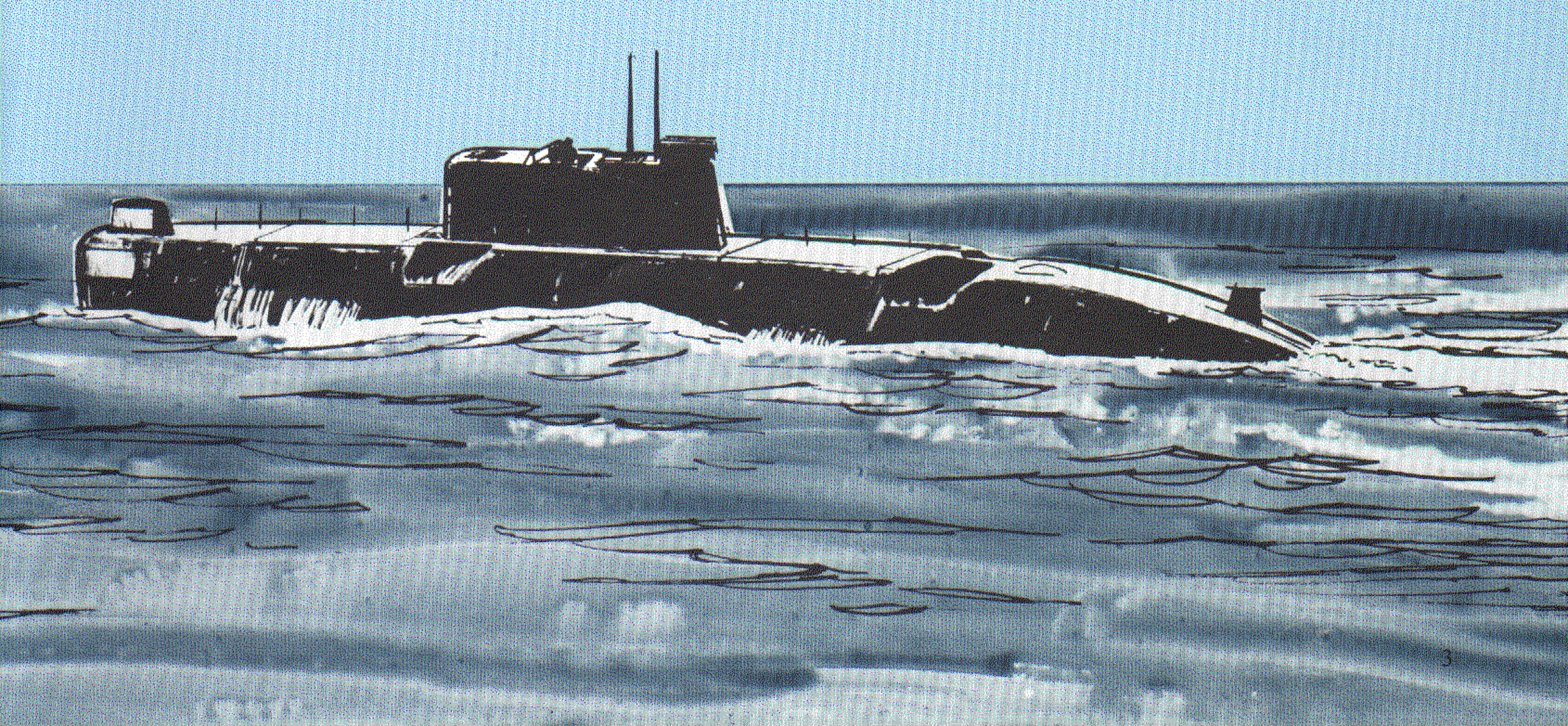
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training on the P-2 aircraft in late 1969. In January 1970, VP-31's detachment at North Island was disestablished. During its decade at North Island, VP-31 trained more than 2,000 pilots, 700 naval flight officers, and 10,600 aircrewmen and maintenance personnel; squadron operations from North Island totaled approximately 90,000 flight hours.

Today, the mission of VP-31 is to train and indoctrinate replacement pilots, naval flight officers, aircrewmen, and maintenance personnel to operate and maintain the P-3 Orion aircraft. Building on this effective and highly technical training, Pacific Fleet patrol squadrons are able to achieve the highest possible degree of combat readiness in their primary mission of anti-submarine warfare.

Patrol Squadron Thirty-One has always been ready to employ innovations in order to better accomplish its mission. In the summer of 1970, the Fleet Readiness Aviation Maintenance Personnel (FRAMP) Department was established at VP-31 in order to expand and improve the maintenance training syllabus. Currently, the FRAMP Department provides familiarization and practical job training on the P-3 aircraft for more than 1,800 maintenance students each year.

In 1975, a CNO-sponsored project called Instructional Systems Development (ISD) was established. Under the direction of VP-31, this program restructured VP Fleet Readiness Squadron aircrew training. The main objective of the ISD project was to create a training program for each of the P-3 aircrew positions, employing state-of-the-art instructional techniques and training devices. This ongoing project has been very successful, and it has helped VP-31 produce highly trained individuals for the fleet. In addition, the squadron has been designated as the Model Manager for the VP Personnel Qualification Standard (PQS) Program. The PQS Program is designed to standardize procedures for qualifying personnel to perform aircrew and maintenance duties within the Patrol aviation community.

Besides conventional fleet replacement training, VP-31 trains pilots and crewmen bound for units equipped with special-use variants of P-3 aircraft. In addition, the Black Lightning Squadron is currently conducting transition training for the VP squadrons based at NAS Barbers Point, who are turning in their P-3B MOD aircraft for newer, more sophisticated P-3Cs. VP-31 has been active in international training, as well. The squadron has trained Australian, New Zealand, Norwegian, and Spanish personnel to operate and maintain various models of the P-3 aircraft. Moreover, the Chief of Naval Operations has designated VP-31 as the NATOPS Model Manager for all P-3 aircraft. Squadron NATOPS officers, representing COMNAVAIRPAC, travel throughout the Pacific conducting annual inspection visits to each operational patrol squadron.

Patrol Squadron Thirty-One takes great pride in producing the most highly- trained P-3 professionals in the world. The squadron has flown more than 21,500 accident-free sorties, including over 143,000 landings and 100,000 flight hours. In 1983, in recognition of sustained superior performance, VP-31 was awarded the CNO Safety Award, the Meritorious Unit Citation, and the Golden Orion Award for Retention Excellence.

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editor WAYNE CRADDUCK

art and production by ALLEN LUDLOFF

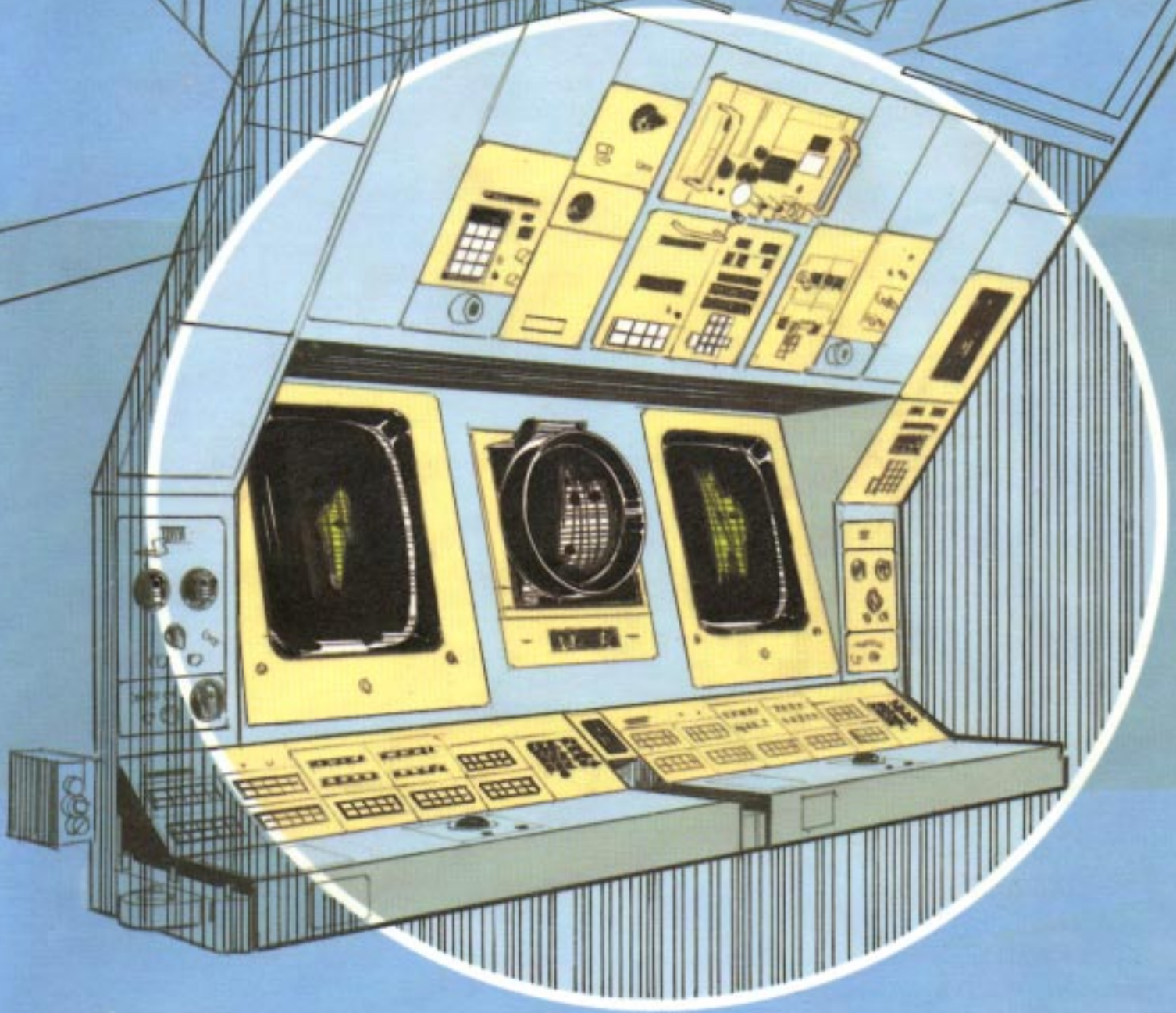
P-3C UPDATE III

By: Lynn J. Woolford
Department Engineer
Military Avionics Design

Bruce Cana Fox
Avionics Programming Analyst
P-3 Project

Henry N. Anderson
Design Specialist
P-3 Avionics

Bruce H. Mau
Electrical/Electronics Engineer
P-3 Avionics



INTRODUCTION

Since the introduction of the P-3C in 1969, there has been a continuing effort to provide the fleet with the most effective ASW tactical system available. The result has been a series of configuration changes to the P-3C to implement improvements in various mission avionics/aircraft systems. These changes have usually been implemented in blocks referred to as "Updates," the latest of which is Update III. The additions and changes that compose Update III include:

- Advanced Signal Processor (ASP)
- Advanced Sonobuoy Communication Link (ASCL) Sonobuoy Receiver
- Provisions for the Adaptive Controlled Phased Array (ACPA) Sonobuoy Antenna Processor Countermeasures Set
- Acoustic Test Signal Generator (ATSG)
- Changes to the Environmental Control System (ECS)

The reader should consider the following description as representative of Update III at its introduction, and anticipate that this configuration is subject to change as the P-3C aircraft continues to evolve. This article addresses Update III as it was incorporated into production on P-3C aircraft SERNO 161762. Figure 1 shows the submarine detection signal flow employed by Update III in this aircraft.

ACOUSTIC DETECTION: A REVIEW

The primary mission of the P-3 Orion antisubmarine warfare aircraft is to detect, locate, track, and – when necessary – attack unfriendly submarines. The primary devices used for detection are acoustic sensors.

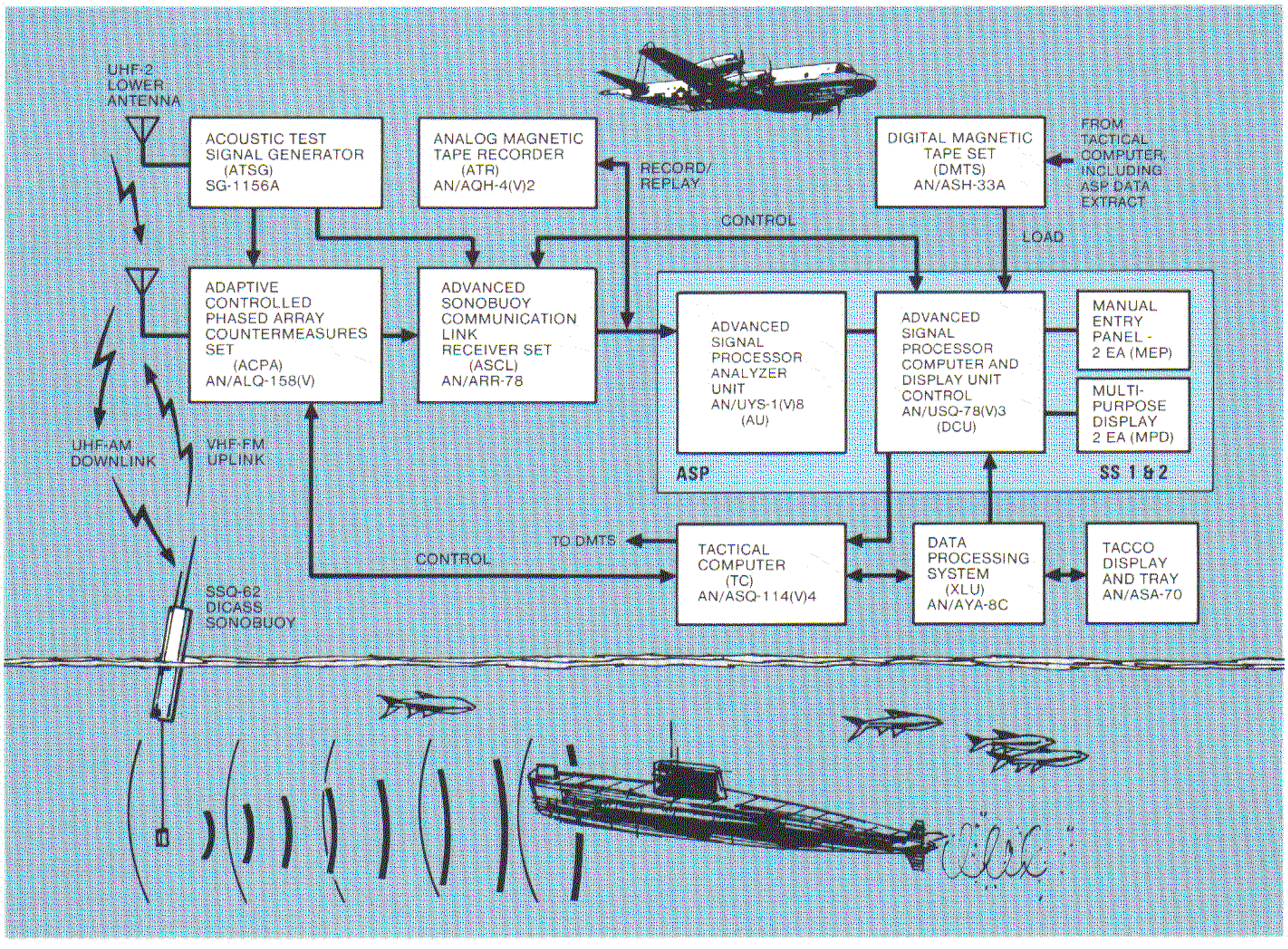


Figure 1. Submarine Detection Signal Flow

Over the years, there has been increasing reliance on using the sound waves emitted during underwater propulsion to detect submarines. This has been due to the improved design of the modern submarine, which enables it to spend more time below surface. Today's diesel submarine has improved engines, generators, batteries, and air purification equipment, which permit it to travel submerged for greatly extended periods. The nuclear-powered submarine has no practical limit on time spent underwater. While submerged, the submarine cannot be detected visually, by radar, or by electronic support measures. This leaves acoustic sensing as the only reliable initial detection method.

The advances achieved in extending the submarine's undersurface endurance have been paralleled by progress in reducing the noise made by the submarine's equipment. Such improvements have challenged the sensitivity, speed and accuracy of airborne acoustic data processing. New sonobuoys and acoustic data processing equipment have been developed to counter these improvements.

PASSIVE AND ACTIVE ACOUSTIC DETECTION During passive acoustic search, the P-3 aircraft (or other detection platform) depends on detecting the sounds generated by the submarine. During active acoustic detection, sound waves generated by the aircraft's deployed sonobuoys are bounced off the submarine's hull, and the acoustic returns are measured.

The basic acoustic sensing technique for passive detection and classification is Low Frequency Analysis and Recording (LOFAR). In this technique, sounds emitted by the submarine are detected by a hydrophone that has been lowered from a sonobuoy. Data regarding the frequency and amplitude of these sounds is then transmitted by the sonobuoy up to the patrol aircraft, where it is analyzed, processed, displayed, and recorded. The basic LOFAR display plots the frequency of the sound waves against the intensity of their acoustic energy, and against the duration of the sound emission. This information can be displayed on a video screen and printed out. The data is also recorded on magnetic tape for storage and retrieval.

Directional LOFAR (DIFAR) is an improved passive acoustic sensing technique. DIFAR operates by detecting directional information and frequency multiplexing it to the acoustic data transmitted by the sonobuoy to the patrol aircraft. This information is processed by the aircraft's acoustic analysis equipment to compute a bearing, and then displayed. Subsequent bearing information from the sonobuoy can be used to pinpoint by triangulation the location of the sound or signal source.

Active sonobuoys use a transducer that radiates a sonar (sound) pulse that is bounced off the hull of the submarine. The time interval between the ping (sound pulse) and the echo return to the sonobuoy is measured. Taking into account the Doppler effect on the pulse frequency, this data is used to calculate both the range and the speed of the submarine relative to the sonobuoy.

Older model active sonobuoys, called Range Only (RO) sonobuoys, are set to ping for a limited period, starting from the time that they are deployed. The Command Activated Sonobuoy System (CASS) allows the aircraft to deploy the sonobuoy, but the sonobuoy remains silent until it receives a command signal to radiate a sound pulse. This technique allows the aircraft to surprise the submarine. CASS sonobuoys equipped with directional hydrophones (DICASS) allow the aircraft acoustic analysis equipment to determine both the range and bearing to the target with a single sonobuoy. DICASS sonobuoys are replacing the older RO and CASS sonobuoys.

ACOUSTIC SIGNAL ANALYSIS Acoustic operators are highly-trained professionals who know the acoustic characteristics of submarines and other underwater objects. They carefully assess the various signals received from the sonobuoys to determine if the signals were generated by a submarine. If a submarine is detected, the acoustic operator can further analyze the signals to determine the submarine's country of origin, class, course, speed, and depth — information upon which all antisubmarine warfare tactics are based. With this information, the patrol aircraft mission commander can locate and track the target. Modern computer analysis techniques can process some of this data automatically, eliminating the need for the acoustic operator to continually review all of the data received from the sonobuoy. When these techniques are employed, the data processor alerts the acoustic operator when a submerged contact of suspicious nature is detected.

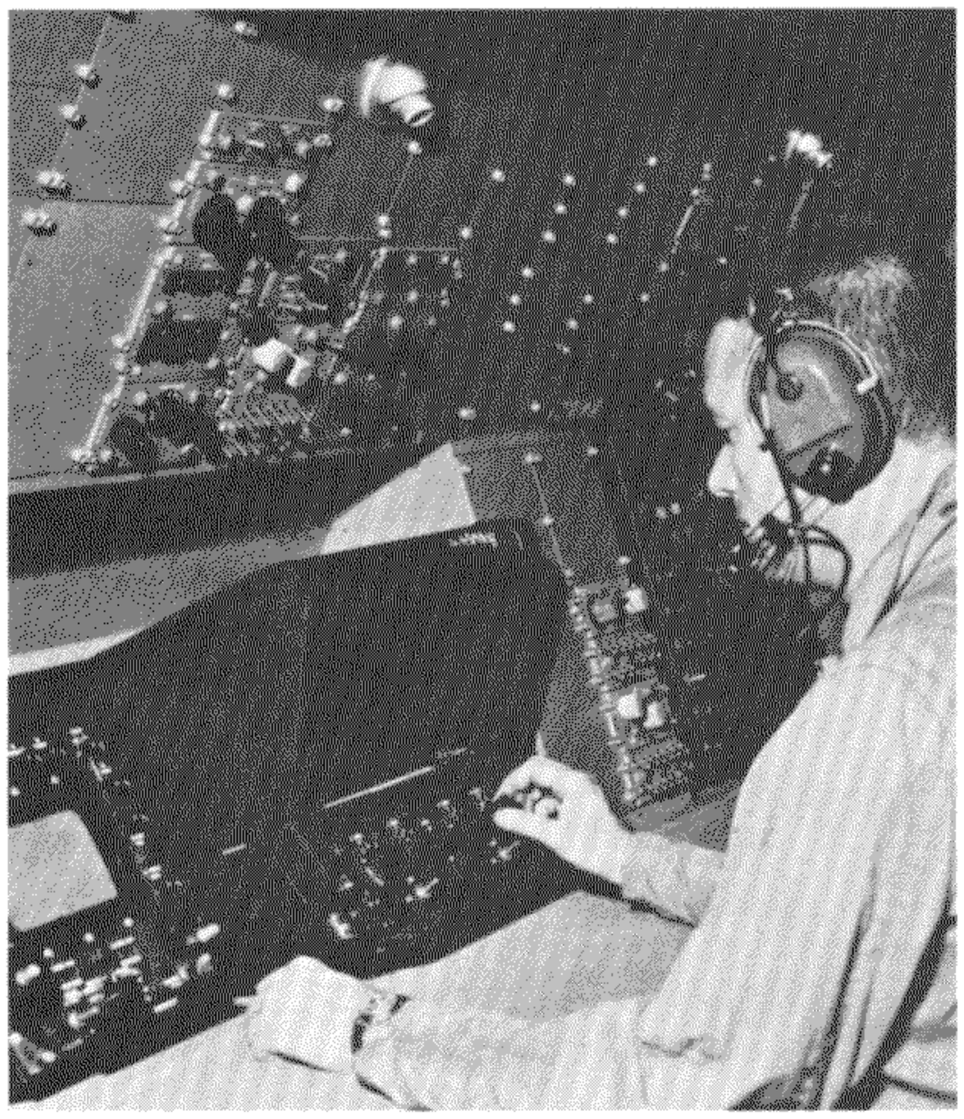


Figure 2. AQA-3/AQA-4 Jezebel Sonobuoy Indicator System Installation on Early P-3A Aircraft

ACOUSTIC PROCESSORS IN P-3 SERIES AIRCRAFT: A HISTORY

During the early 1960s, the first P-3A aircraft were equipped with the AQA-3A or AQA-4(V) ASW indicator group system (Figure 2). These early signal processors and data recorders enabled one operator to examine only four acoustic chart recordings (grams) in very limited modes. Later, in the middle 1960s, Delayed Time Compression (DELTIC) was a major ASW system improvement. This feature was incorporated into the AQA-5 Jezebel sonobuoy indicator system (Figure 3), which replaced the AQA-4(V) system. During this period, the AQH-1 analog tape recorder was added to enhance inflight and postflight acoustic signal analysis.

The AQA-7 family of acoustic processors and display equipment was introduced in 1969 with the P-3C (Figure 4), and has been retrofitted into P-3A and P-3B aircraft. The AQA-7 acoustic processor and display system includes:

- DIFAR processing and display
- A dual-operator acoustic station, with both gram and video displays at each sensor station. This effectively quadruples the number of sonobuoys that can be processed at any given time.
- A computer-controlled miniature sonobuoy receiver group
- An acoustic test signal generator
- An updated analog tape recorder

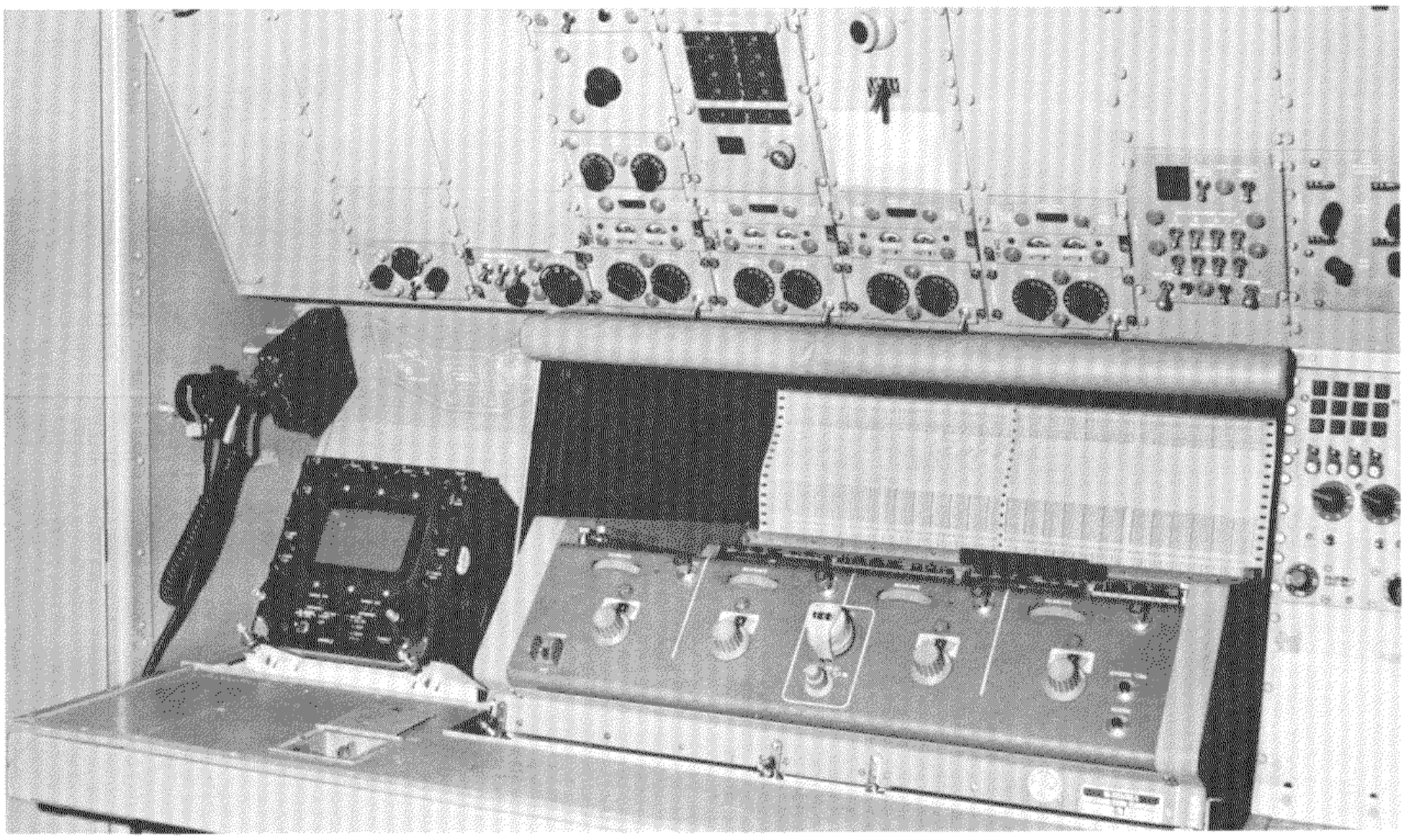


Figure 3. AQA-5 Jezebel Sonobuoy Indicator System Installation on Later P-3A Aircraft and on P-3B Aircraft

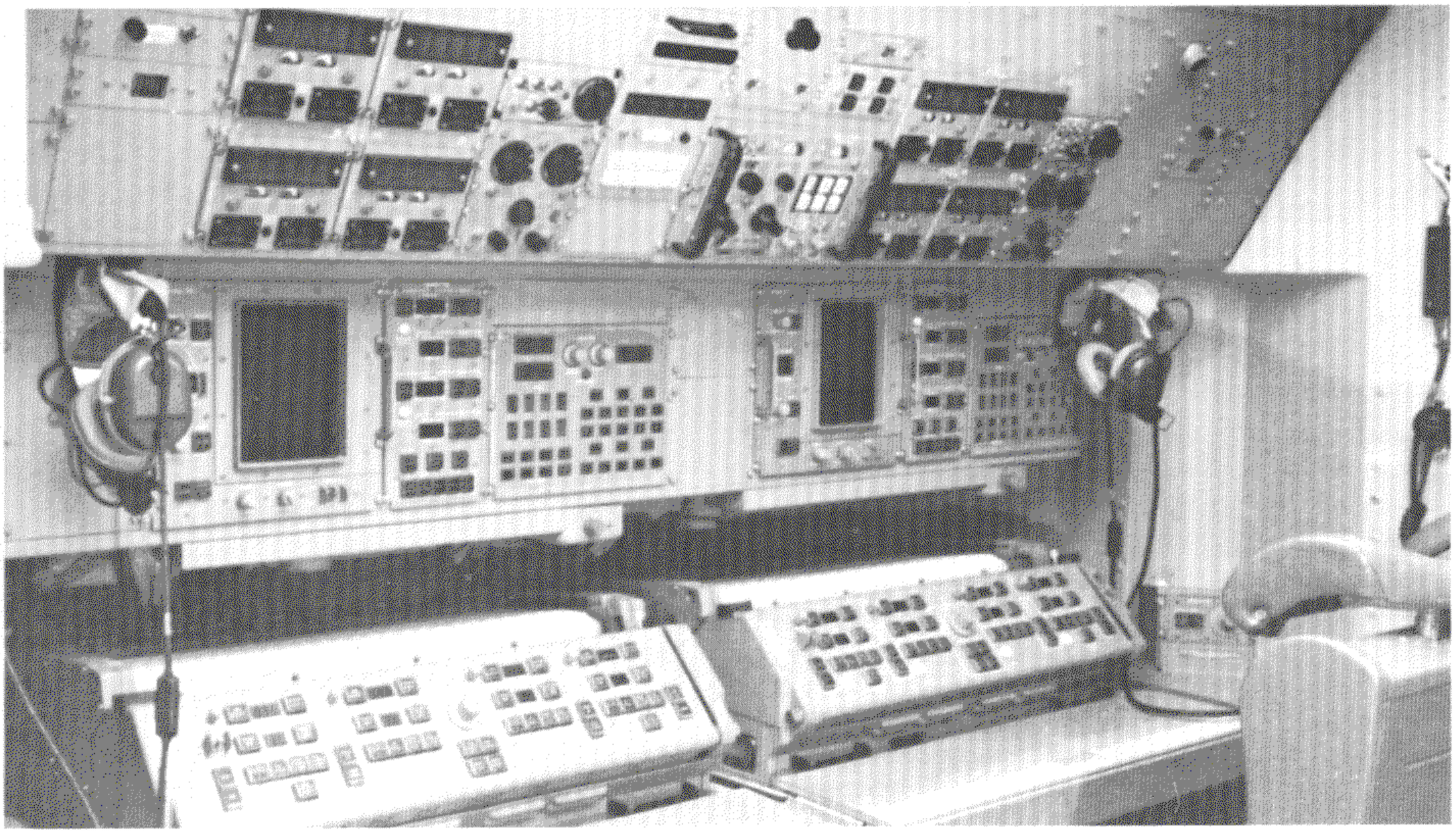


Figure 4. AQA-7 Acoustic Processor and Display System Installation on Basic P-3C Aircraft at Sensor Stations 1 and 2

These advances, coupled with the processing capability of the ASQ-114(V) Tactical Computer, made the P-3C the most effective land-based airborne ASW platform of the 1970s.

The capability of the AQA-7 system has been increased by continuous updates such as DICASS and triple-vernier processing (Figure 5), both of which have been retrofitted into earlier P-3C air-

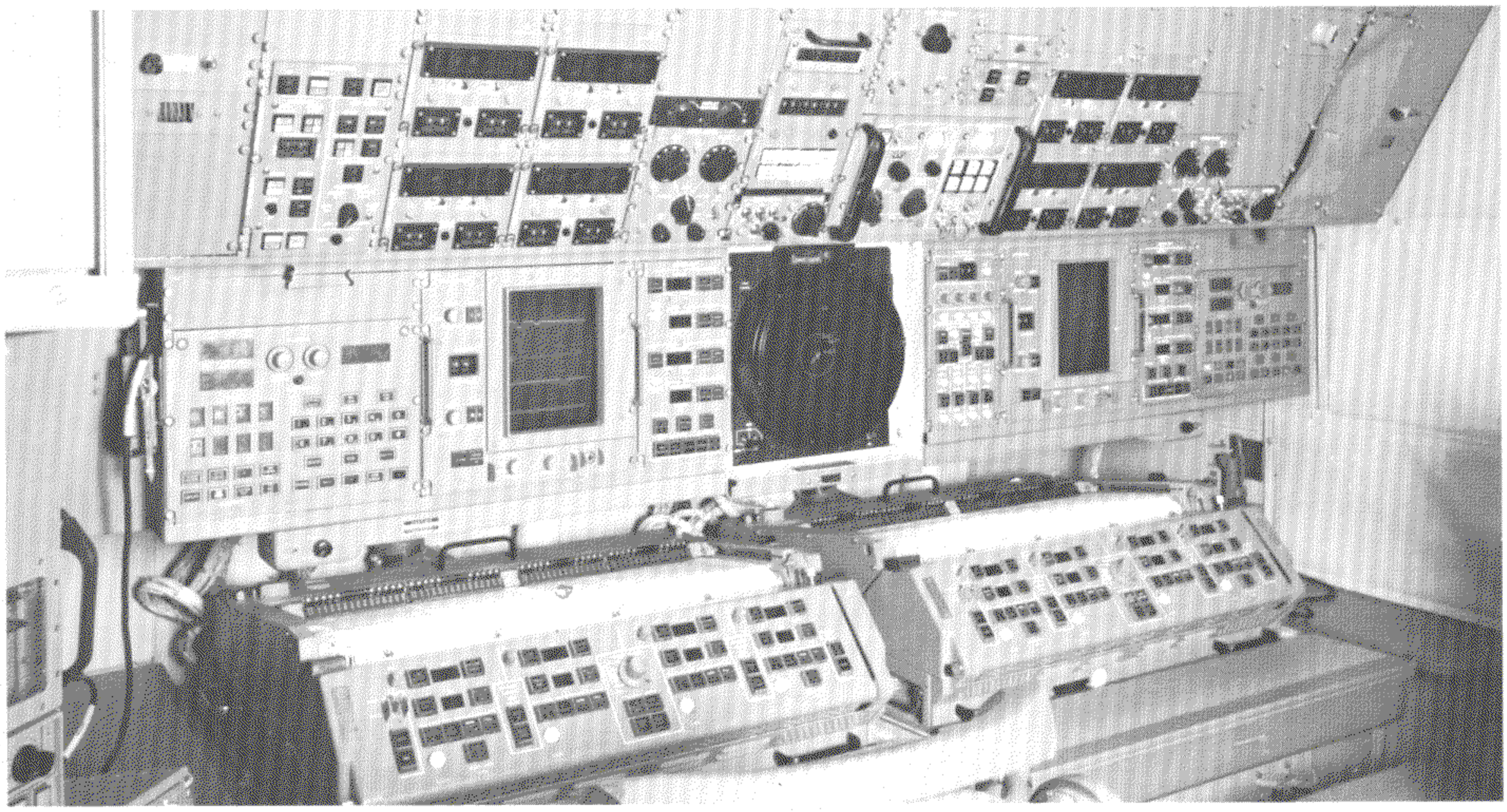


Figure 5. AQA-7 Acoustic Processor and Display System Installation on P-3C Update II Aircraft at Sensor Stations 1 and 2

craft. The latest AQA-7 system update is designated AQA-7A(V) 10, 11 – enhanced DIFAR, which adds interactive control panels and an embedded processor for passive tracking (Figure 6).

Today, more modern acoustic processing techniques have become available in smaller packages. This compact packaging, along with the advantages of hardware commonality, improved reliability and advanced computer techniques, has led to the development of an AN/UYS-1 Advanced Signal Processor Analyzer Detecting Set and an AN/USQ-78 Advanced Signal Processor Display and Control Set for the P-3C Update III aircraft. The ASP has four decibels greater sensitivity than that of its predecessor, and the P-3C Update III aircraft acoustic system is twice as effective as that of the Update II-1/2 system.

Implementation of Update III required the processing of more sonobuoy acoustic channels than could be monitored individually by one or two acoustic operators. This problem was resolved by applying the versatility and the throughput of the programmable ASP computers to speed up and multiply the acoustic signal processing. The ASP has doubled the number of sonobuoys that can be monitored concurrently, and it has provisions to process signals from advanced digital array-type sonobuoys when they become available.

The Advanced Signal Processor evolved through the following phases:

- Advanced Development Model (ADM)
- Service Test Model (STM) Dual Advanced Signal Processor (ASP) – Installed in Update III Flying Testbed, P-3C aircraft SERNO 159889
- STM Single ASP (SASP) – P-3C aircraft SERNO 159889 reconfigured for SASP. NAVAIR determined that the P-3C mission requirements could be satisfied by the SASP, and at great savings. Following two years of flight tests, the U.S. Navy granted provisional approval for production of SASP. Subsequently, the first "S" was dropped from the acronym SASP, and the Advanced Signal Processor has since been identified as ASP.

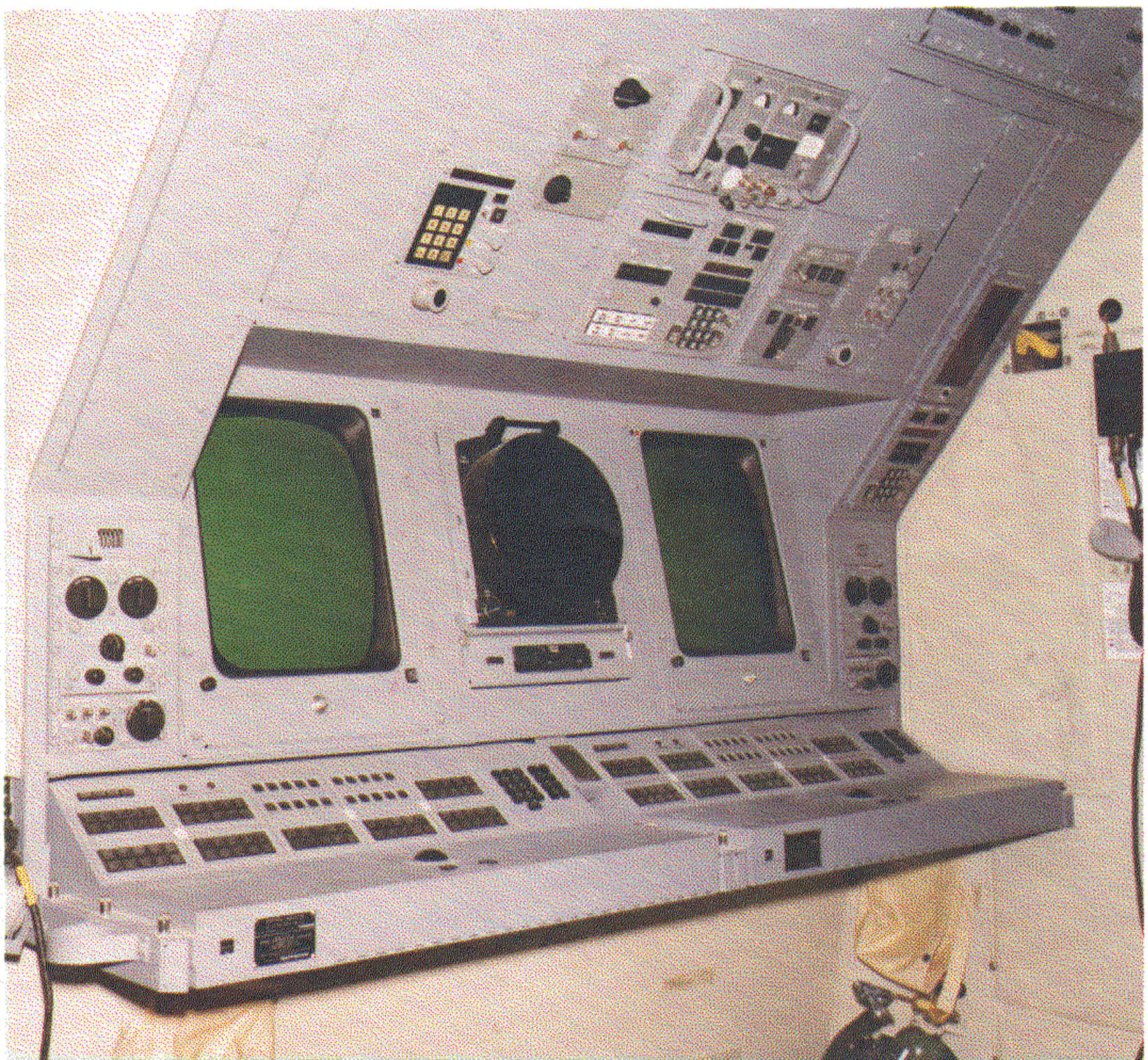
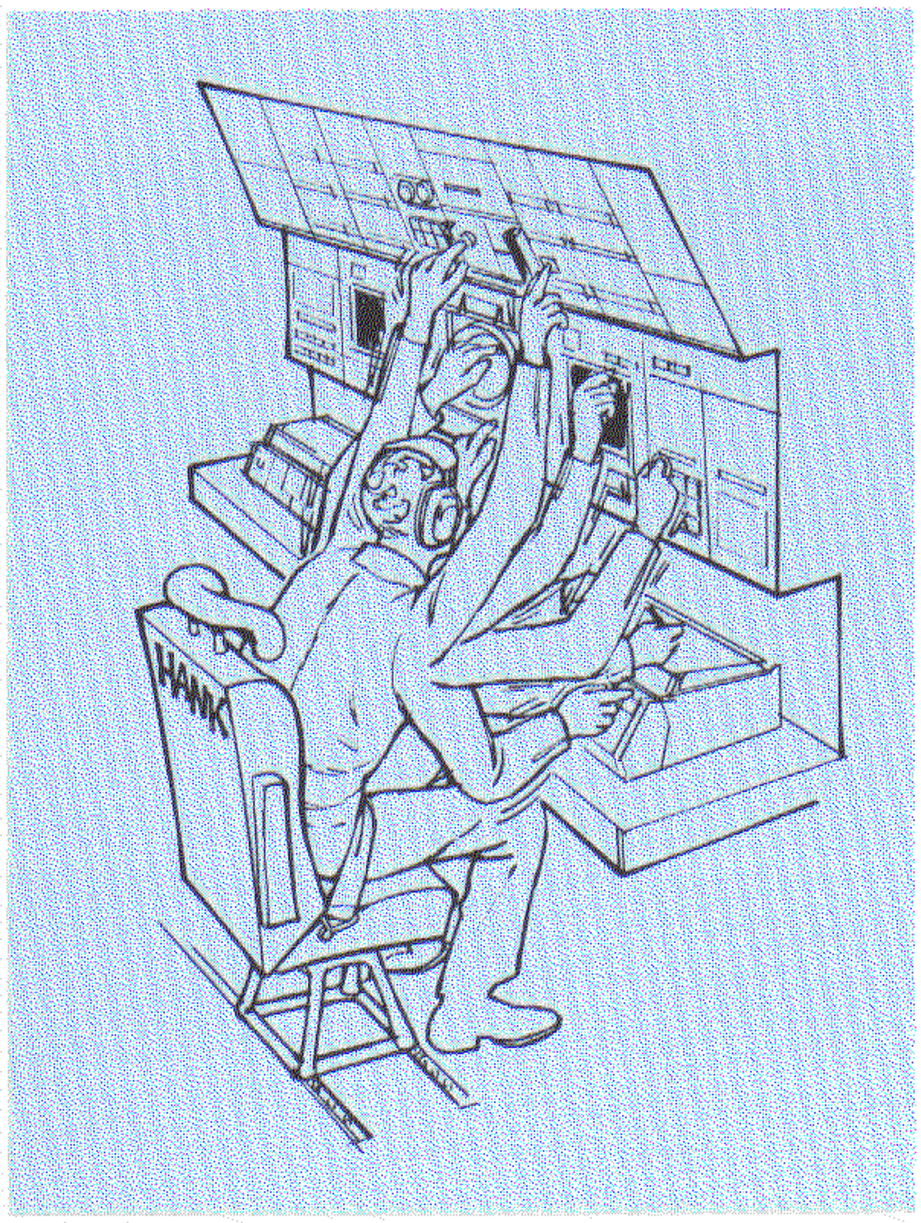
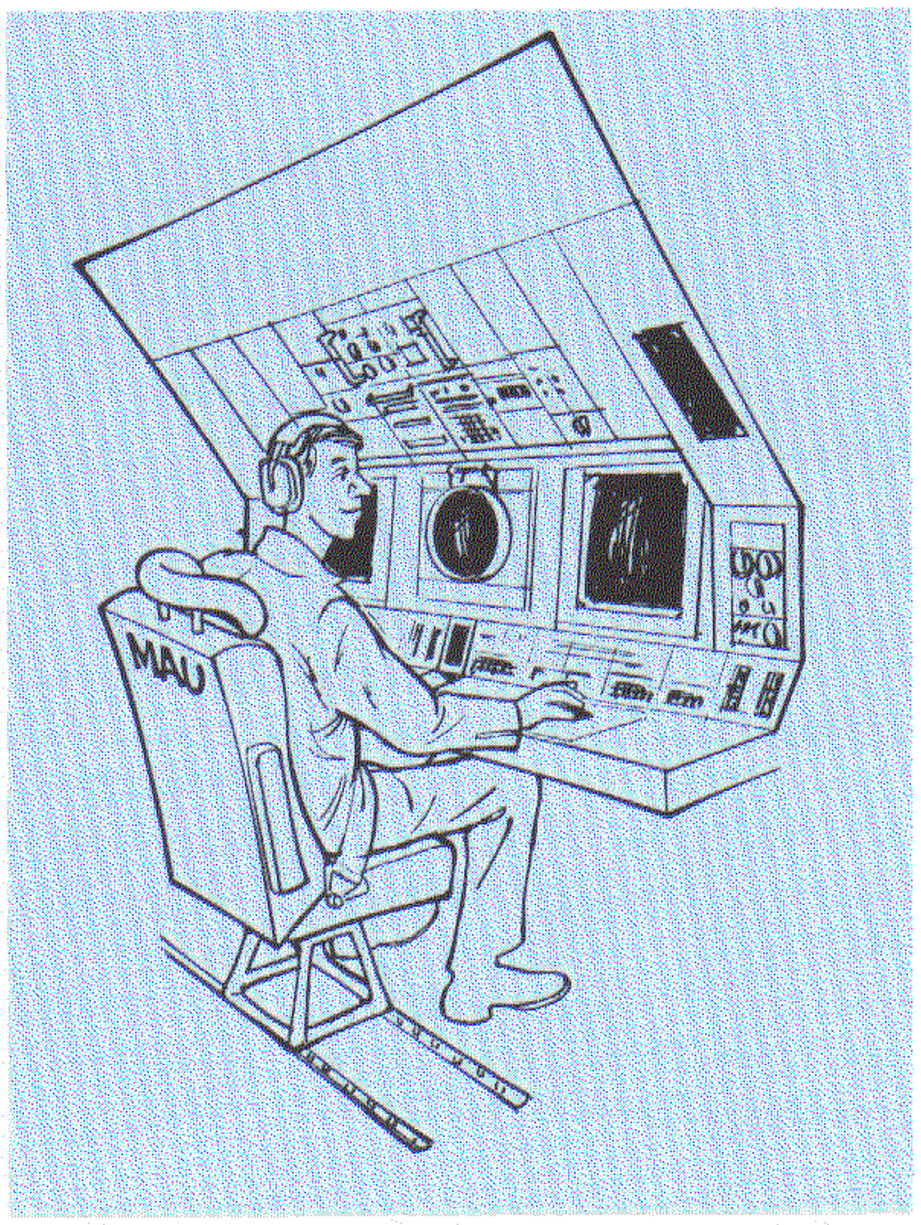


Figure 6.
P-3C Update III Advanced Signal Processor Installation at Sensor Stations 1 and 2





- ASP Production Line Configured Aircraft (PLCA) — The U.S. Navy used P-3C aircraft SERNO 161410 for initial design and installation of the ASP. After follow-on operational testing and evaluation, the U.S. Navy granted approval for limited production of ASP avionics.

- ASP Production — Based upon successful completion of another follow-on U.S. Navy operational test and evaluation program, production of ASP-equipped aircraft began with P-3C aircraft SERNO 161762.

The Advanced Signal Processor offers a high degree of automation and flexibility with a design that uses three large programmable computers. All ASP controls are centralized on the acoustic operator's Manual Entry Panel. Many tasks that were previously the responsibility of the acoustic operator are now processed automatically by the ASP.

The main improvement in P-3C Update III acoustic signal processing takes place at Sensor Stations 1 and 2. The UYS-1/USQ-78 Advanced Signal Processor is pre-programmed before each mission to recognize the signals of interest for that mission. Signal analysis modes are set by the Preflight Data Insertion Program (PDIP) prepared by the ASW Operations Center (ASWOC). The ASP will analyze the signals received from all of the deployed sonobuoys and, using the PDIP, will detect signals of interest and automatically alert the acoustic operator.

All of the Advanced Signal Processor's configuration and processing options and signal analysis modes are displayed to each acoustic operator on his Multipurpose Display (MPD). The ASP provides tableaux of over 25 types of acoustic and alphanumeric data that can be presented on the MPD. Much of the tableaux display data is related to post-processing tasks such as detection, tracking and classification — tasks that are done simultaneously on all sonobuoy acoustic channels. The ASP system has more signal analysis modes available than do the older systems. Selection and implementation of these modes during actual tactical prosecution has been simplified.

On earlier acoustic processing equipment, the operator changed processing modes by pressing switches or rotating thumbwheels. In the Update III system, the operator can store complex signal analysis mode settings and implement them simply by keying in changes to the tableaux presented on his MPD. The monitor shows all available mode settings that are currently in effect, as well as the mode settings that he has stored for later use.

P-3C UPDATE III AVIONICS SYSTEMS

The general interior layout of the P-3C aircraft shown in Figure 7 indicates the locations of the major changes associated with Update III. The Update III avionics systems include:

- AN/UYS-1 Advanced Signal Processor Analyzer Detecting Set and AN/USQ-78 Advanced Signal Processor Display and Control Set
- AN/ALQ-158 Electronic Countermeasures Set – Adaptive Controlled Phased Array (ACPA)
- AN/ARR-78 Receiver Set – Advanced Sonobuoy Communication Link (ASCL)
- SG-1156/A – Acoustic Test Signal Generator (ATSG)

For the pilots, NAV/COMM, Sensor Station 3 operator and ordnanceman, there are few significant changes in the Update III avionics system. However, fundamental improvements in the acoustic processing system used by the operators at Sensor Stations 1 and 2 have changed the data exchange and interface between the acoustic operators and the TACCO. Streamlined maintenance procedures and the increased reliability of the acoustic sensor equipment have also simplified the responsibilities of the inflight technician. To date, this system is the U.S. Navy's best effort at designing "hands off" computer-diagnostic maintenance, thus reducing off-line (manual) testing to an absolute minimum.

The provisonal Adaptive Controlled Phased Array (ACPA) sonobuoy antenna system will provide omnidirectional and directional sonobuoy signal reception. The ACPA countermeasures set will pre-process the incoming signal to reduce the effects of interfering signals (jamming). The Advanced Sonobuoy Communication Link (ASCL) receiver processes 16 sonobuoy audio/acoustic channels simultaneously. Unlike the ARR-72 receiver that it replaces, each of the ASCL receiver channels is tunable to all 99 sonobuoy radio frequency channels (RFs) so that the loss of a receiver channel does not result in the loss of a sonobuoy operating on that RF.

The Advanced Signal Processor is composed of a group of three self-contained data processing computers that analyze acoustic data. Contact detection and classification have been off-loaded from the ASQ-114 Tactical Computer. The ASP data is displayed on the Multipurpose Display screen. Control and data channels link the ASP to the ASQ-114 Tactical Computer, which allows the computers to automatically control and transfer data. This linkage permits the TACCO two-way communication between himself and the acoustic sensor stations, enabling him to transmit instructions and receive data efficiently. Table I shows the differences between the P-3C Update II and Update III avionics.

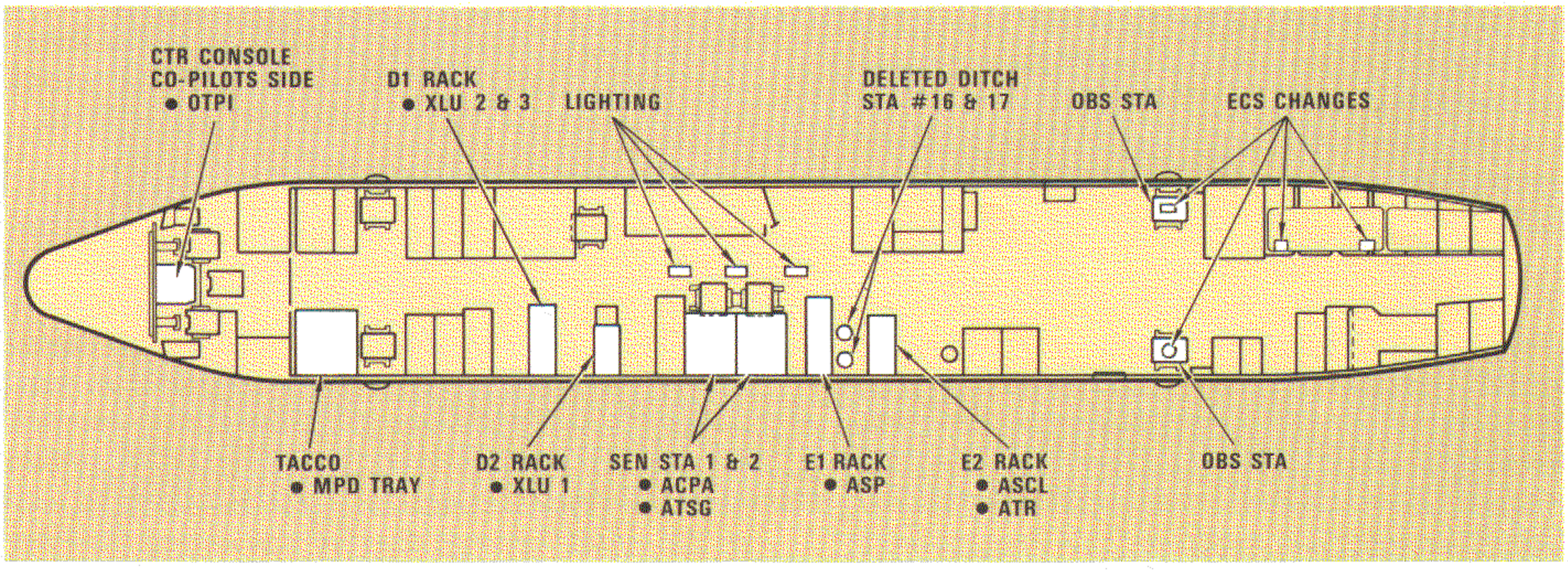


Figure 7. General Interior Layout of the P-3C Update III

TABLE I. P-3C Update III Avionics vs. P-3C Update II Avionics

DELETED EQUIPMENT	ADDED EQUIPMENT				
	NOMENCLATURE	SUPPLIER	WEIGHT	SIZE (IN.)	POWER
ARR-72 SONO RECEIVER	ARR-78 ASCL RECEIVER	HAZELTINE CO., NEW YORK	103 LB	12W x 20D x 12H	410W
ARR-72 SONO ANTENNAS	ALQ-158 ACPA COUNTERMEASURES SET	HAZELTINE CO., NEW YORK	70 LB	21W X 12D X 9H	430W
R-1651 OTPI RECEIVER	INCLUDED IN ASCL	—	—	—	—
ARR-72 ASSG	SG-1156/A ATSG	EDMAC CO., NEW YORK	24 LB	12W X 14D X 7H	53 W
AQA-7(V) 10, 11 SONAR COMPUTER-RECORDER GROUP	TS-4008/UYS-1 ASP ANALYZER UNIT	IBM, VIRGINIA	265 LB	24W X 9D X 65H	1470 W
	CP-1525/USQ-78 ASP DISPLAY & CONTROL UNIT	IBM, VIRGINIA	272 LB	24W X 10D X 65H	1875 W
	C-11118/USQ-78 ASP MANUAL ENTRY PANEL (2)	IBM, VIRGINIA	45 LB	35W X 18D X 7H	160 W
	IP-1423/USQ-78 ASP MULTIPURPOSE DISPLAY (2)	IBM, VIRGINIA	87 LB	16W x 24D x 20H	85 W
ASA-76 CASS RSG & RSG CONTROL	INCLUDED IN AU	—	—	—	—
ID-1872 AMBIENT SEA NOISE METER	INCLUDED IN AU	—	—	—	—
RO-308 BATHYTHERMOGRAPH RECORDER	INCLUDED IN AU	—	—	—	—
C-7627/AYA-8 KEYSETS	INCLUDED IN MEP	—	—	—	—
MX-8023/AYA-8 LOGIC UNIT 1	MX-10518/AYA-8C TRANSPARENT LOGIC UNIT 1	GENERAL ELECTRIC, NEW YORK	119 LB	UNCHANGED FROM LU	360 VA
MX-8024/AYA-8A LOGIC UNIT 2	MX-10519/AYA-8C TRANSPARENT LOGIC UNIT 2	GENERAL ELECTRIC, NEW YORK	115 LB	UNCHANGED FROM LU	280 VA
MX-8036/AYA-8 LOGIC UNIT 3	MX-10520/AYA-8C TRANSPARENT LOGIC UNIT 3	GENERAL ELECTRIC, NEW YORK	114 LB	UNCHANGED FROM LU	390 VA

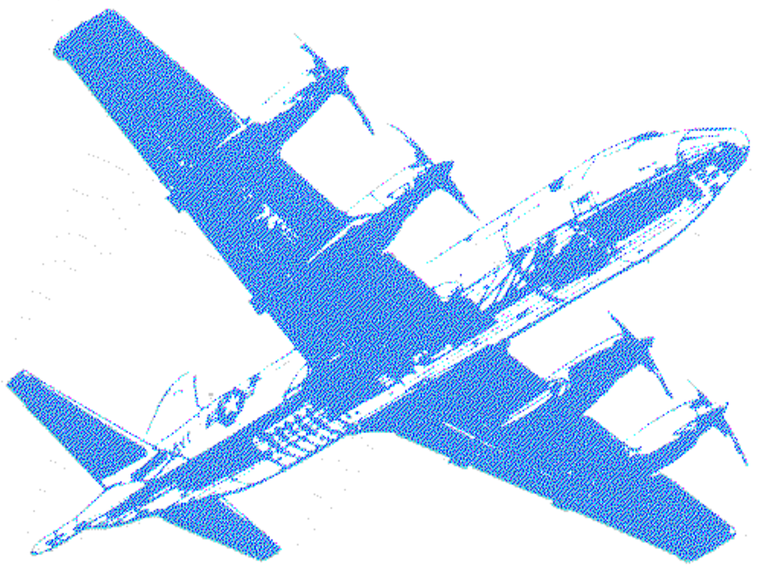
The Update III system design includes the following provisions for future developments:

- Provisions for a second ASCL receiver, which will provide a total of 32 sonobuoy audio-acoustic operating channels
- Provisions for the ACPA antenna/ countermeasures system
- Provisions for a second AQH-4(V)2 analog tape recorder to accommodate the increased sonobuoy monitoring capability.

The Advanced Signal Processor's bulk memory storage capacity will be increased to accommodate the software required for these improvements.

Concurrent with Update III, the P-3C aircraft has been equipped with logic units of improved design, called Transparent Logic Units or "XLUs." A brief description of the XLUs is included in the Update III avionics functional description.

Since the cooling and ventilation requirements for the P-3C Update III avionic acoustic equipment are different from that of equipments on earlier P-3C aircraft, the avionics cooling fans at Sensor Stations 1 and 2 have been deleted. This has reduced the noise level significantly at these locations. A new underfloor exhaust duct arrangement is used to supply cooling air for the ASP equipment in electronics Rack E-1. The changes to the aircraft Environmental Control System (ECS) required to support the Update III modifications are described in more detail later in this article.



P-3C UPDATE III AVIONICS FUNCTIONAL DESCRIPTION

Beginning with the external sonobuoy radio frequency (RF) uplink operation, the acoustic subsystem can process the signals from all of the standard sonobuoys and it can be upgraded to process the signals from digital array-type sonobuoys (see Figure 8). The very high frequency (VHF) uplink signals are received via the four Adaptive Controlled Phased Array antennas and their countermeasures set. Under the control of the ASQ-114 Tactical Computer, the ACPA system applies various pre-processing techniques to the incoming data — RF and sub-band filtering, sector beam-forming, and adaptive null-steering — to combat interfering signals (jamming). The ACPA antenna array provides more gain to the sonobuoy input signal than provided previously by the single sonobuoy antenna. This signal is sent to the Advanced Sonobuoy Communication Link receiver set. An On-Top Position Indicator (OTPI) module within the ASCL set receives the uplink VHF signal from the sonobuoy through the ARA-50 direction finder. The resulting processed OTPI signal provides the pilot with a directional pointer to the sonobuoy.

The 20-channel Advanced Sonobuoy Communication Link receiver set demodulates the VHF signals received from the sonobuoys, and outputs the information to 16 standard acoustic channels and 4 auxiliary channels. Each ASCL receiver channel is tunable by the Advanced Signal Processor to any one of the 99 sonobuoy operating frequencies. Backup control is available from the ASCL receiver control panel. The ASCL sonobuoy receiver also has two digital frequency-shift-keying (FSK) output channels with provisions for a total of four FSK output channels. The ASP has provisions for FSK processing.

Acoustic data is recorded by the Analog Tape Recorder (ATR), and can be replayed from the ATR remote control panel by using the Advanced Signal Processor Tape Replay Operational Program. The Update III system software stops all real-time acoustic processing system operation during replay of the four available channels, because acoustic data cannot be recorded during tape replay.

The Advanced Signal Processor consists of two major units: the Analyzer Unit (AU) and the Display and Control Unit (DCU). The ASP AU performs all signal processing and storage under the control of the DCU. The ASP generates sonobuoy downlink command signals and sonar ping signals that are output to the T-1234/ASA-76 Radio Transmitter and DICASS antenna. Sonic gates are supplied to the Analog Tape Recorder to synchronize the signals received from the active sonobuoys. The ASP supplies four channels of active sonobuoy audio signals to the Sensor Station 1 and 2 operators' headsets for aural monitoring. DIFAR null-steer processing can be selected on up to four channels simultaneously, and can be monitored aurally on one channel at a time. The acoustic sensor station operators use the controls on their Manual Entry Panels (MEPs) to select the channels to be monitored.

The Analyzer Unit supplies data on demand to the Display and Control Unit's System Controller/Post-Processor Unit (SC/PPU) and Display Formatter (DF) computers. Data is processed in octave and/or vernier thresholds, time integrated, and formatted in LOFARGRAM and Automatic Line Integration (log or linear amplitude scale) for presentation on the Multipurpose Display (MPD).

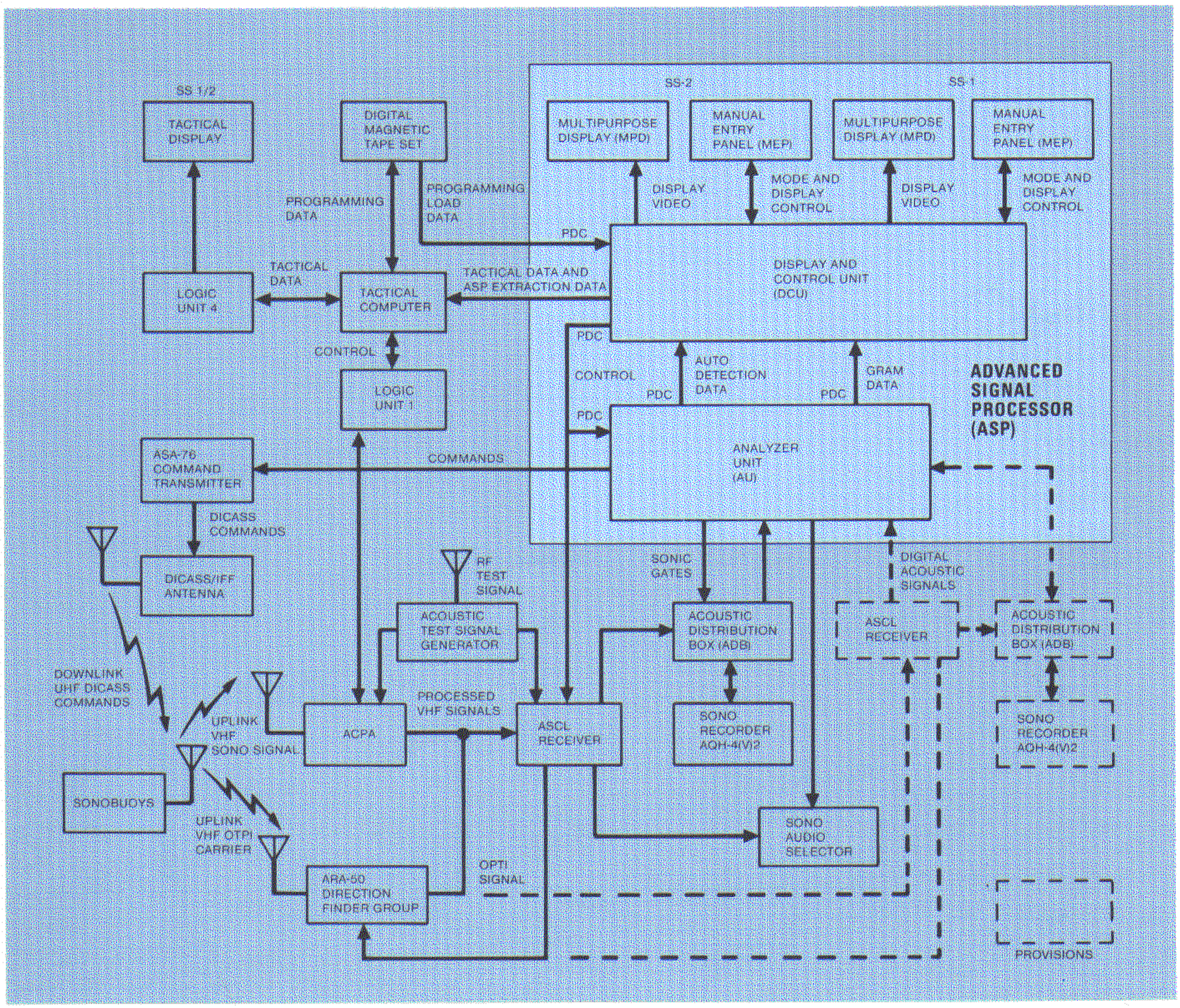


Figure 8. Advanced Signal Processor Functional Flow Diagram

The Advanced Signal Processor Display and Control Unit performs the following functions:

- System Controller/Post-Processor
- Display Formatter
- Display Generator
- Manual Entry Panel Interface
- Bulk Store

The System Controller/Post-Processor Unit computer exercises the interface with the Display Formatter and with the Advanced Signal Processor peripherals, including the Tactical Computer, the Digital Magnetic Tape Set (during initial load), and the Advanced Sonobuoy Communication Link receiver set. The SC/PPU computer determines what information will be displayed to the operator in the post-processing alert area of the Multipurpose Display, and it maintains the various tableaux associated with post-processing. The DF computer accepts formatted data from the Analyzer Unit and arranges the display/refresh functions selected by the operator on his Manual Entry Panel. The MEP interface is operated by the DF computer, through which data is passed to the SC/PPU computer. Target contact, sonobuoy tuning, and signal strength information is passed

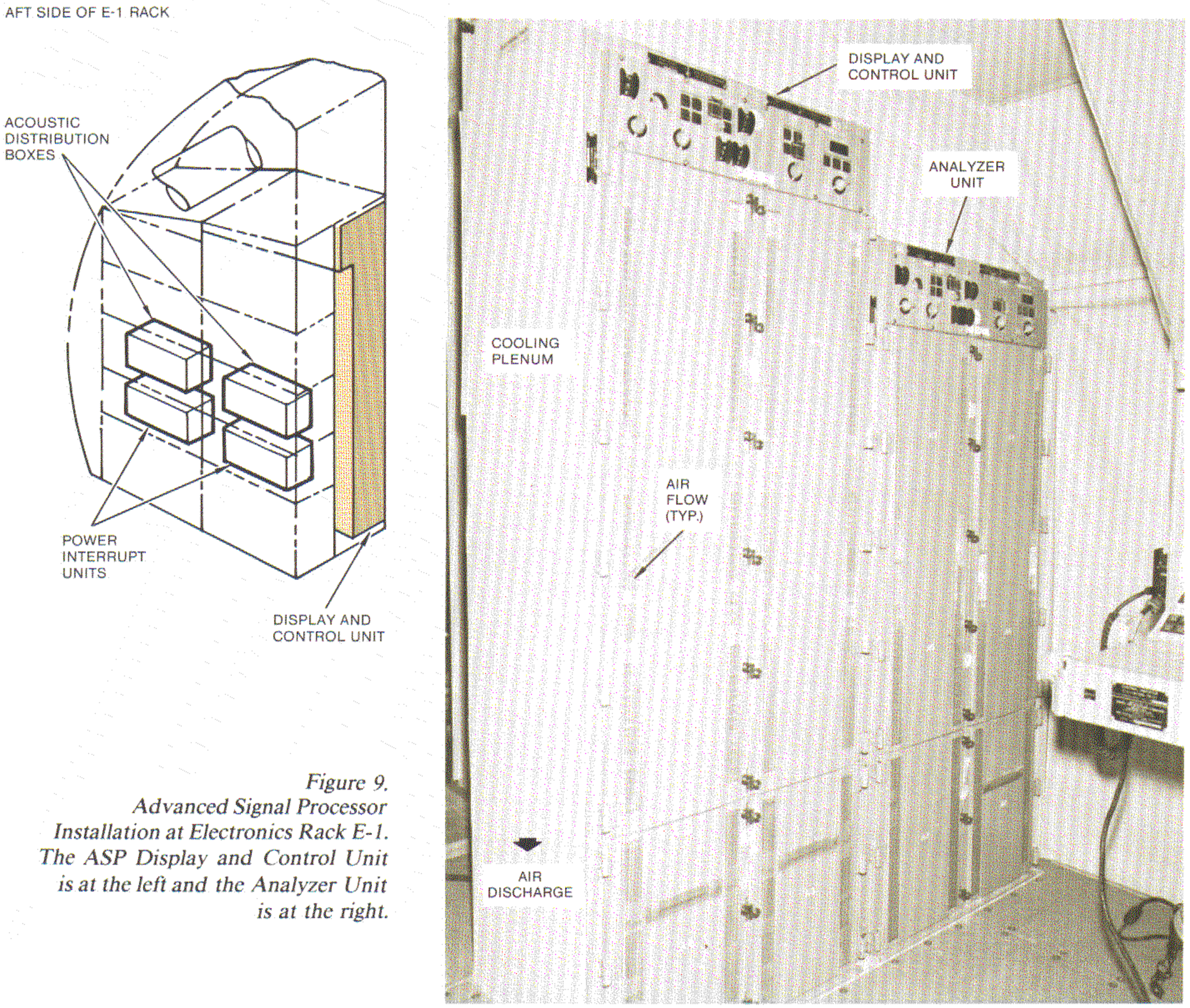


Figure 9. Advanced Signal Processor Installation at Electronics Rack E-1. The ASP Display and Control Unit is at the left and the Analyzer Unit is at the right.

from the SC/PPU computer to the TACCO via the Tactical Computer and data processing subsystem. Data extraction and tactical display are controlled through the SC/PPU-to-Tactical Computer link.

Lockheed ORION Service Digest

ADVANCED SIGNAL PROCESSOR The Advanced Signal Processor consists of two basic elements: the Analyzer Unit and the Display and Control Unit. Each of these main elements, in turn, is composed of several subunits and panels. In addition, each acoustic sensor station is equipped with a Manual Entry Panel and a Multipurpose Display. The MEP and MPD enable the acoustic sensor operator to communicate with the Advanced Signal Processor, and vice versa. In many respects, the ASP operator interface is like a modern computer terminal that is used in any large commercial application.

Both the Analyzer Unit and the Display and Control Unit are mounted in their own large individual chassis, each of which slides into the aircraft E-1 Electronics Rack (Figure 9). This improved mechanical and packaging design of the Advanced Signal Processor is an outgrowth of earlier studies conducted by the Navy and by various suppliers to devise a rack that is integral with the aircraft. The advantages realized from this design include sharing common power supplies by the ASP functional subunits, a less complex aircraft installation, and greater immunity of the ASP to the aircraft environment.

The Analyzer Unit is designed to use modular components, and is capable of accepting new technology as it becomes available. Recent Advanced Signal Processor Bulk Store/Program Store (BSPS) upgrades with 64K word modules, the very latest military memory technology, have demonstrated software transportability that is inherent in the design. The plug-in module configuration is based on the use of 36 each 64K x 1-bit dual-in-line-package components. As will be shown later in this article, the new Transparent Logic Units (XLUs) also have several functional subunits contained in one large chassis.

In normal use, the Advanced Signal Processor Analyzer Unit and Display and Control Unit are generally left alone, because all operations other than actual repair are conducted from Sensor Stations 1 and 2. Power cannot be applied to the ASP unless aircraft cooling air flow is detected by the aircraft airflow sensor.

When the Advanced Signal Processor is to be initialized, the ASP Tape 1 is inserted into the Digital Magnetic Tape Unit. This tape cartridge contains the ASP System Test Program, and the Display and Control Unit SC/PPU and DF Diagnostic Programs. Thereafter, program load operations can be initiated from the Digital Magnetic Tape Control. If the Tactical Computer has been placed in the ASP Coordinated mode, the TACCO, NAV/COMM and Sensor Station No. 3 operators can initiate program load operations. The System Test Program Main Test Selection tableau is displayed on the ASP Multipurpose Display after the ASP-DF Operational Program has been loaded. The acoustic sensor station operator has the option to select DF diagnostics to be run. When DF Diagnostics are performed, the operator is required to verify that the test patterns presented on the Multipurpose Display are correct.

After the tests on ASP Tape 1 have been completed, the ASP Tape 2 cartridge is inserted into the DMTU. This second cartridge contains the Analyzer Unit Diagnostics and the ASP Operational/End-to-End Test/Tape Replay Program (AOP). Program load operations proceed in much the same way as for Tape 1, to the extent that Analyzer Unit Diagnostics and AOP load can be initiated from any one of several places.

The Advanced Signal Processor Operational Program contains security screening that requires entry of a five-number password before the system will respond. Since the ASP Tape 1 DF diagnostics does only a limited test on the Manual Entry Panel, the operator may wish to run the Manual Entry Panel on auto-BITE before beginning the test. The DF Diagnostics checks Multipurpose Display operation by presenting a test pattern; however, again, the operator may opt to run the Multipurpose Display on auto-BITE.

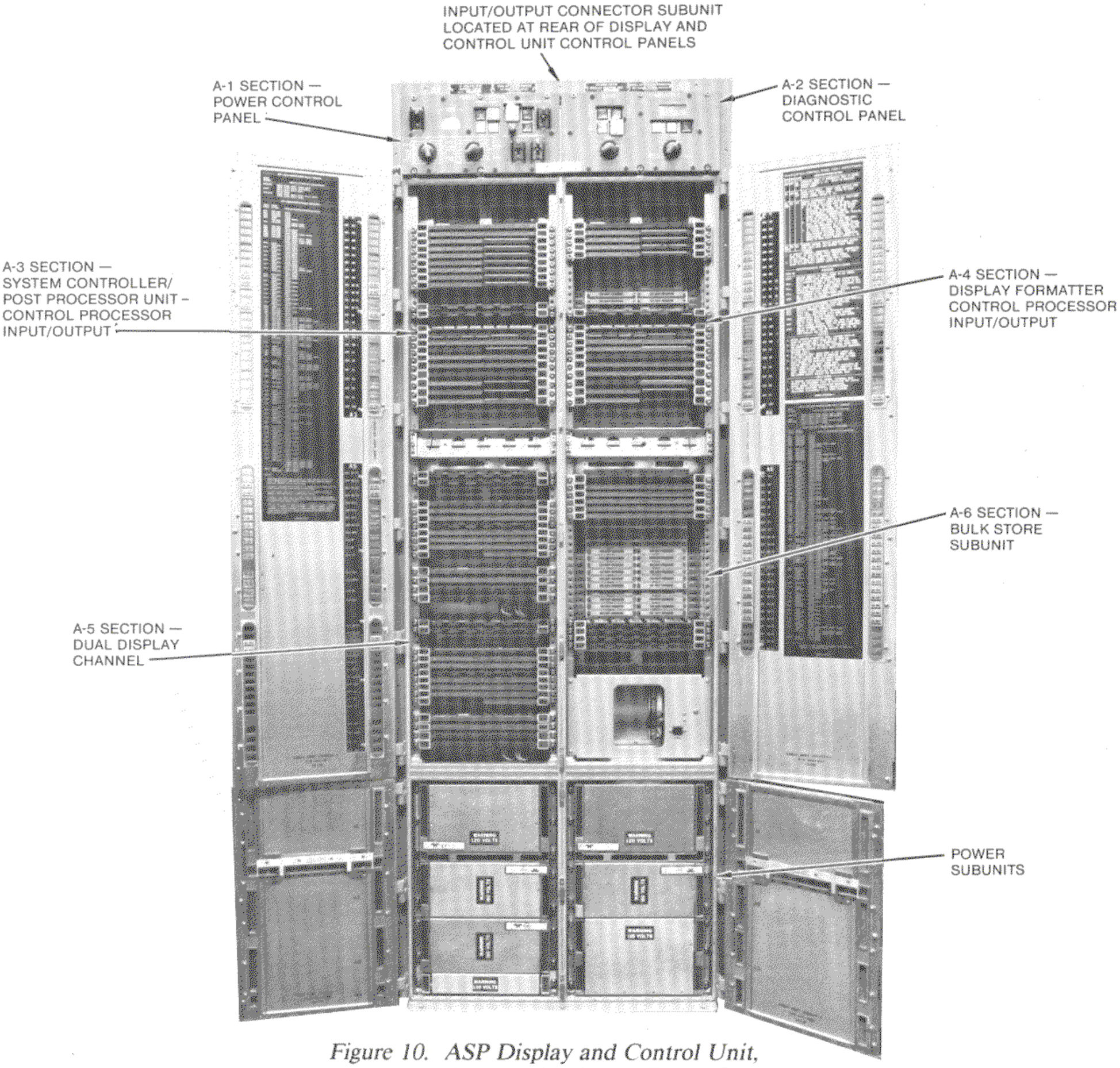


Figure 10. ASP Display and Control Unit, Shown with Access Doors Open

As shown in Figure 10, the Display and Control Unit's doors swing open to provide access to the modules. Similar access is provided to the Analyzer Unit's modules. Maintenance instruction decals are affixed to the inside of the doors to provide guidance when faults are detected during Initial Micro-Program Load (IMPL), Initial Program Load (IPL), Unit Loader phase, and program load. Other than these hard-core fault groups, faults are detected automatically by the Diagnostics Programs, at which time the number of the failed backpanel and module are displayed to the operator.

The Advanced Signal Processor is designed to have parts commonality throughout the Navy, to implement a several times greater mean-time-between-failure rate, and to significantly reduce the equipment's mean-time-to-repair. Because the ASP performs functions that were previously done by the Tactical Computer, the size of the code in the Tactical Computer and the number of data storage overlays have been reduced.

Four functional subunits or backpanels are contained within the Display and Control Unit, plus power modules that are located at the bottom of the unit. The Analyzer Unit is of similar construction, except that the subunits differ as follows:

- A3 - Bulk Store Subunit
- A4 - Control-Processor/Input-Output (CP/IO) Computer Subunit
- A5 - Input Signal Conditioner (ISC) Subunit
- A6 - Arithmetic Element Controller/Two Elements Subunit

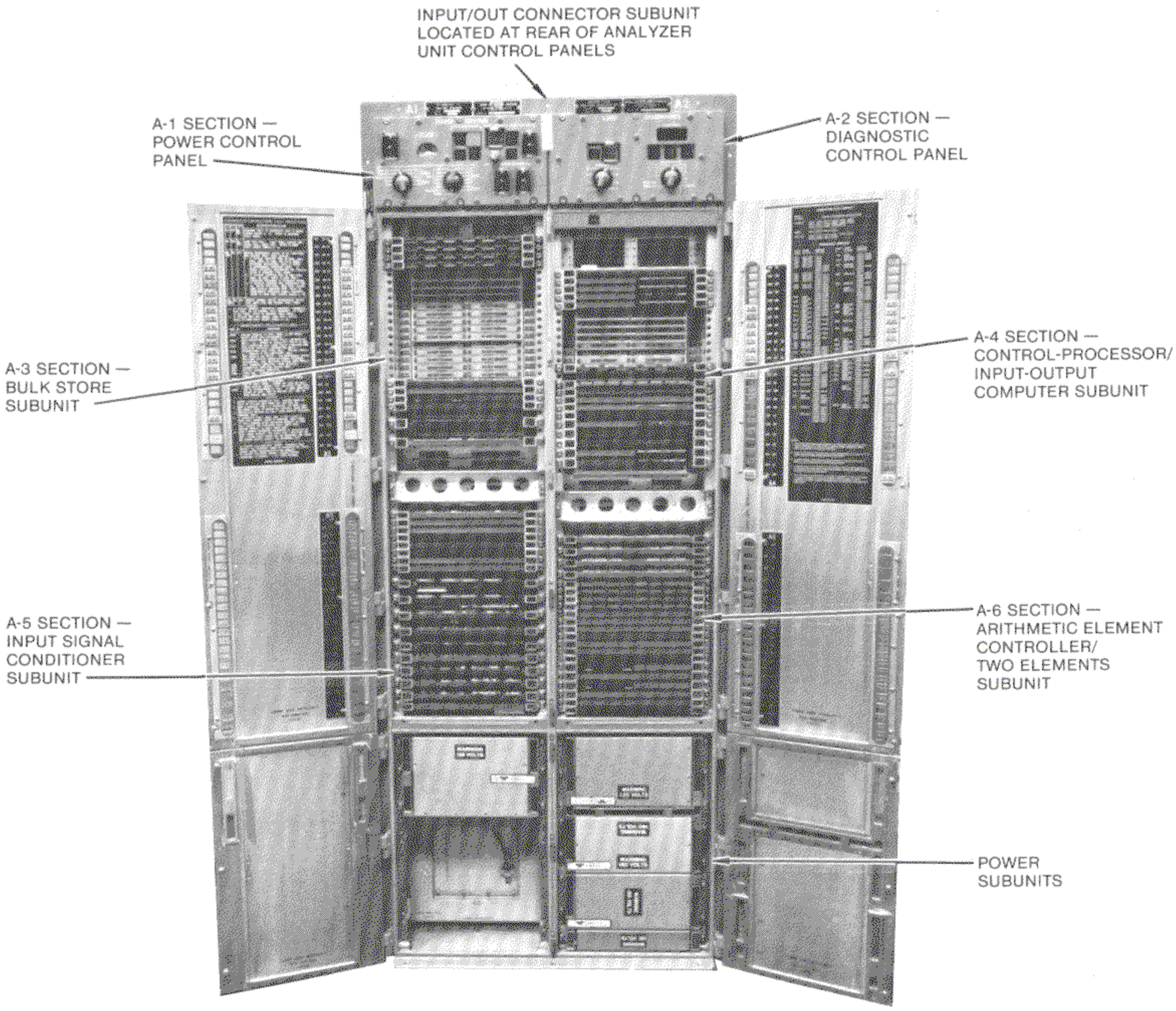


Figure 11. ASP Analyzer Unit, Shown with Access Doors Open

Module Commonality There is a high level of commonality between the modules used by the Advanced Signal Processor Analyzer Unit and the Display and Control Unit, as well as multiple usages of one type of module within the same unit. Of the roughly 77 modules within the Display and Control Unit (excluding the power supply modules, which are common), there are only 32 module types. And of these 32 module types, roughly 15 are also used in the Analyzer Unit. Of the roughly 66 modules within the Analyzer Unit, there are only 41 module types.

Maintenance Assist Modules Maintenance Assist Modules (MAMs) are an integral part of the Advanced Signal Processor's maintenance concept. MAMs are replaceable modular electronic assemblies that are packaged in kit form. They are used in conjunction with diagnostic software programs and official maintenance publications to isolate faults in the ASP. During troubleshooting, the technician substitutes MAMs progressively and/or selectively for modules that are suspected of being defective. When there is a fault callout of two or more modules, modules from the MAM kit are substituted to reduce the fault group size to one module. Through use of MAMs, maintenance personnel can more effectively troubleshoot faults on the ASP. In addition, they can be confident that the modules returned for repair are actually faulty. At present, there are tentative plans to furnish two MAM kits to each P-3C Update III squadron, and to provide on-board MAM spares for squadron aircraft.

Analyzer Unit The TS-4008 Analyzer Unit, shown in Figure 11, performs a full range of signal processing functions for the U.S. Navy's newest

ASW acoustic systems. The design parameters of the Analyzer Unit are listed in Table II. Overall operation of the Analyzer Unit is supervised by its Control Processor Subunit, a programmable signal processor that controls signal processing, data storage management, internal data transfer, and input/output operations (see Figure 12). The Control Processor has its own program storage memory modules, independent of the Analyzer Unit's Bulk Store.

Incoming analog sensor inputs are received by the Analyzer Unit Input Signal Conditioner, which pre-processes the signals. A module is installed to process four digital sensor input channels with growth provisions to eight channels. These digital channels are the frequency-shift-keying (FSK) type that are planned for advanced array-type sonobuoys. After the signals have been pre-processed, the Input Signal Conditioner directs them to the Storage Controller for transfer to the Bulk Store and subsequent processing by the Arithmetic Processor. The standard I/O channels provide full cycle duplex I/O operations between bulk storage or program storage and external equipment.

Operation of the Analyzer Unit is organized around its high throughput Arithmetic Processor and a compatible data storage hierarchy. The Analyzer Unit achieves high-speed signal processing throughputs by overlapping bulk store/working store data transfers with its Arithmetic Processor's computation operations.

TABLE II. ASP Analyzer Unit Design Parameters

Program Store (64K words per module)	– 64K (128K maximum)
Bulk Store	– 256K (1024K maximum)
Throughput	– 20 million 16 x 16 bit multiplies and 40 million two-way 32-bit adds per second – 850K ops per second – 175K words per second per each of 4 I/O modules (8 maximum), full duplex – 32-bit words plus four-bit error correction code for bulk storage
Reliability	– 900 hours
Mean-Time-to-Repair	– 20 minutes
Diagnostic Detection	– 93 percent
Processor Input Channels (P+E)	– 16 channels
LOFAR-Only PICs	– 16 channels
DICASS Channels	– 2 channels (8 maximum)
DICASS Omni (CASS) Channels	– 4 channels
DIFAR Channels	– 4 channels (8 maximum)

The Arithmetic Processor is a micro-programmed special purpose processor that performs signal processing functions at very high throughput rates. It consists of a common controller and two arithmetic elements, each arithmetic element with its own high-speed working data store.

The Analyzer Unit's data storage hierarchy consists of the large Bulk Store which has a high block data-transfer rate, the Storage Controller, and the Arithmetic Processor's two high-speed working stores. The Bulk Store serves as a buffer for data during signal processing. The Storage Controller regulates data transfer to and from the Bulk Store.

The Storage Controller can perform formatting and scaling operations on data while it is being transferred between the Bulk Store and the Arithmetic Processor. During Analyzer Unit operation, the Arithmetic Processor's working stores operate as a swinging buffer, with the Storage Controller transferring blocks of data from and to one working store while the arithmetic elements operate on data in the other working store.

By changing the Analyzer Unit's software, its configuration and module population can be adapted to each data analysis application in order to perform some combination of the important signal processing functions. Examples of these functions are beamforming, filtering, spectral analysis, detection and data normalization, and target tracking and classification.

- "Beamforming" consists of coherently combining target signals received by different sensors in order to enhance target detection and localization.

- "Filtering" is used to select specific portions of the total input spectral band to enhance signal detection performance and/or improve the efficiency of subsequent signal processing.

- "Spectral Analysis" processing performs a fine-grain analysis of the energy content in the selected band as a function of the frequencies within that band.

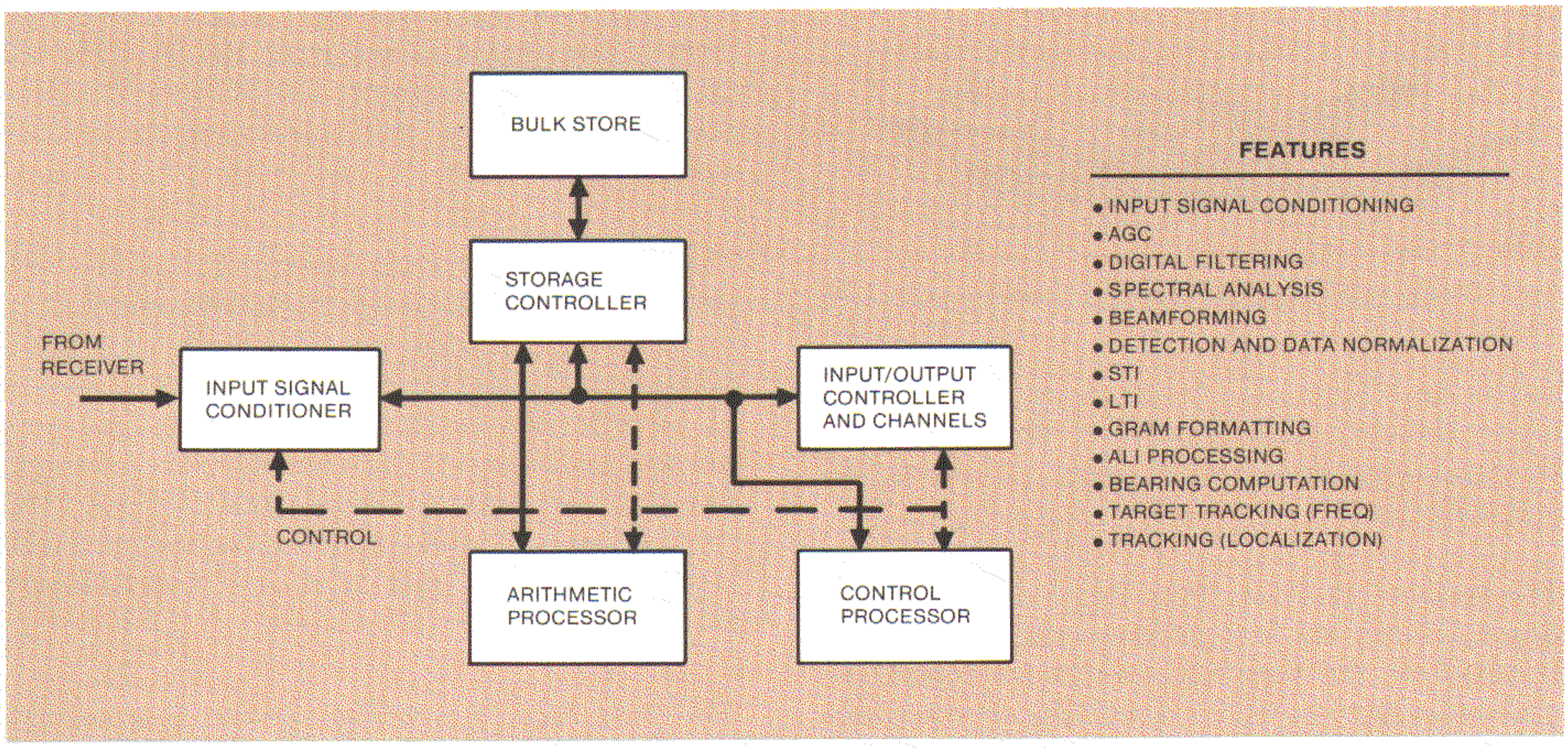


Figure 12. ASP Analyzer Unit Functional Flow Diagram

- "Detection and Data Normalization" adaptively scales, refines, and in general prepares the processed signal data for the display and post-processing functions associated with general purpose computer-aided detection and classification decisions.

- "Target Tracking and Classification" functions measure the target's signal bearing, range, and frequency content as a function of time in order to identify the target type and locate its position.

The fully programmable characteristics of the Analyzer Unit permit the Navy to use the latest and most efficient software algorithms available for processing acoustic signals in the P-3C's tactical environment. For example, passive tracking algorithms and broadband processing software are currently under development for use by the Analyzer Unit. By the end of calendar year 1987, changes will be incorporated in the Display and Control Unit software that will enable the Analyzer Unit to employ these new capabilities.

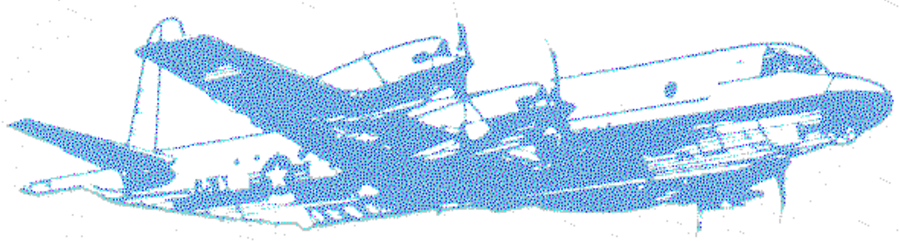
The Proteus Analyzer Unit is the Navy's standard signal processor, and is used on 26 different Navy platforms. Analyzer Units are also used in Army and Air Force programs, but details of such use are restricted.

Display and Control Unit The CP-1525 Display and Control Unit interprets operator commands, generates Analyzer Unit controls, formats and updates display data, generates and refreshes the operator displays, provides storage for processed acoustic data, and performs post-processing functions. The DCU design parameters are listed in Table III.

The Display and Control Unit is a derivative of the Analyzer Unit. It uses the same modules as the Analyzer Unit, plus modules for its Dual-Display Channel subunit. The DCU functions are

TABLE III. ASP Display and Control Unit Design Parameters

SC/PPU Program Store	– 128K
DF Program Store	– 64K
Dual Display Channel Store (each)	– 192K
Bulk Store	– 256K
Reliability: DCU, MPD, and MEP	– 400, 3000, and 6000 hrs, respectively
Mean-Time-to-Repair	– 16 minutes
Diagnostic Detection	– 95 percent
Multipurpose Display BITE	– Included
Manual Entry Panel BITE	– Included



shown on Figure 13. This equipment achieves a higher signal-to-noise ratio than can be provided by current systems, and is easier to understand and operate.

The System Controller/Post-Processor Unit functional subunit is a fully programmable computer. It performs the functions of system controller, post-processor controller, sonobuoy receiver tuning, analyzer unit signal processing control, system data management, display format control, and operator command processing. The SC/PPU post-processes the data detected by the Analyzer Unit and interfaces with the Tactical Computer. Data is transferred to and from the SC/PPU via the standard I/O channels. The SC/PPU has program store memory that is independent of bulk store.

The Display Formatter functional subunit is a fully programmable computer with program store memory that is separate from both bulk store memory and dual-display channel refresh memory. It processes display formats, manages bulk storage, and controls the Dual-Display Channel. The standard Proteus Digital Channel (PDC) I/O channels provide full duplex operations between program store or bulk store and the Analyzer Unit.

The Bulk Store functional subunit is a special-purpose controller used for storing processed acoustic data. The data in Bulk Store is formatted as requested by the operator and presented instantaneously on the Multipurpose Display.

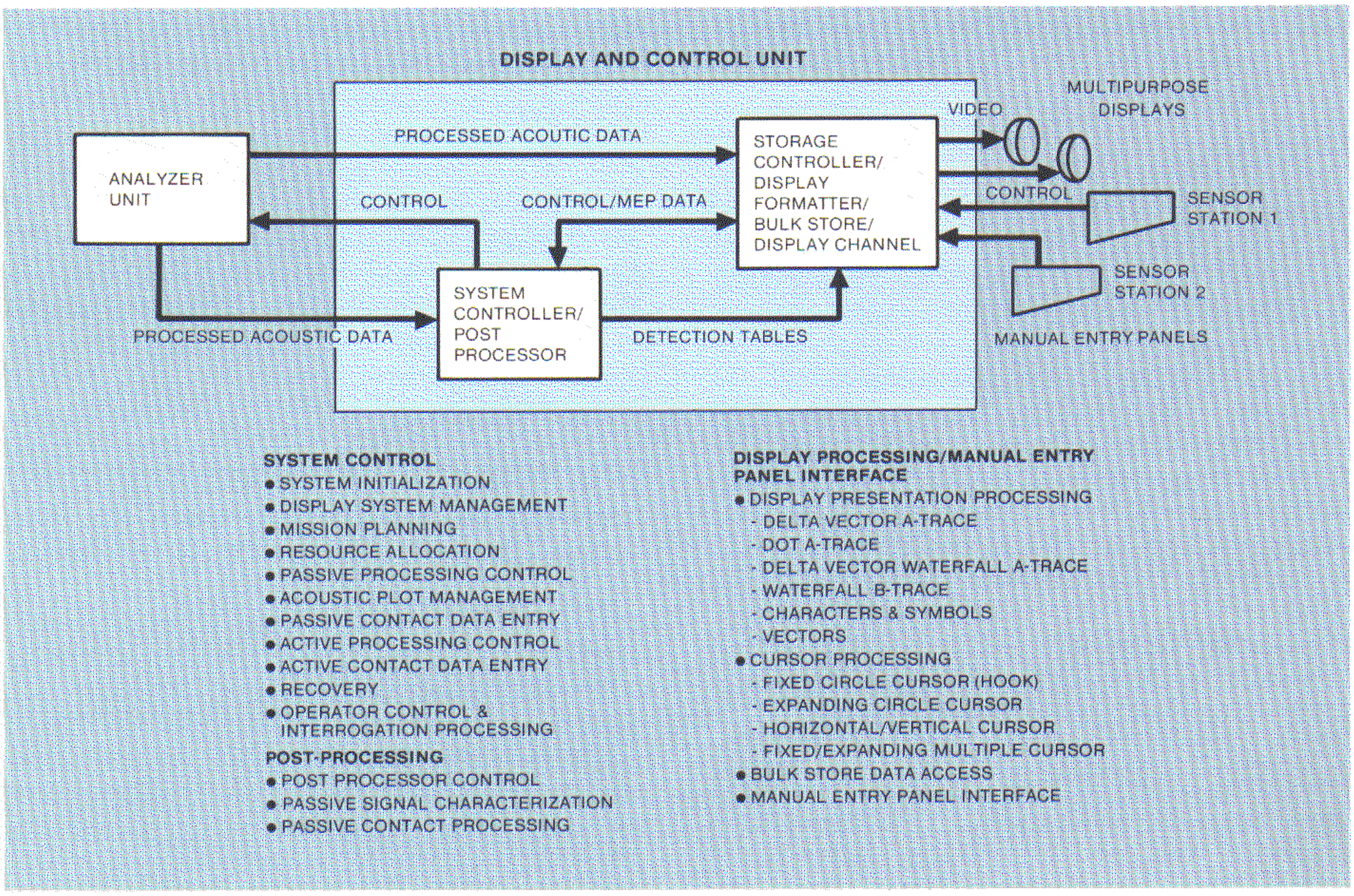


Figure 13. ASP Display and Control Unit Functional Flow Diagram

The Storage Controller regulates the data transfers to and from bulk storage, and provides certain combining operations on data transferred to the Dual-Display Channel. The Storage Controller also provides the interfaces to the Manual Entry Panels.

By processing display format and graphics commands, the Dual-Display Channel generates and refreshes the display presentation. The DDC uses a digital TV architecture to obtain maximum format flexibility and information content, and to provide an extremely stable display. The DDC generates a composite video signal for the Multi-Purpose Display.

ACOUSTIC OPERATOR INTERFACE The output from the Advanced Signal Processor is presented to the acoustic operators on two sensor station IP-1423 Multipurpose Displays (see Figure 14). Tactical data is presented to them on the ASA-66 Tactical Display (via the Tactical Computer) located between Sensor Stations 1 and 2. The functions of the Tactical Display will be discussed later in this article in the Tactical Computer Interface section.

The acoustic sensor station operators receive all their visual acoustic information from their Multipurpose Displays. This display system's main advantage is its ability to show a variety of types of contact information. It can be configured to display information from as many as 32 buoys or from as few as one buoy.

The Multipurpose Display is a high-resolution, raster-type video display. It has a usable display area of 11.6 inches by 9.25 inches, with 1452 vertical by 1088 horizontal resolution elements. Acoustic data, alphanumeric and special symbol information, vectors, cursors, and video images are presented on the MPD. There are two video input and output channels. Either acoustic station operator can switch video channels to view the image displayed at the other acoustic operator's station.

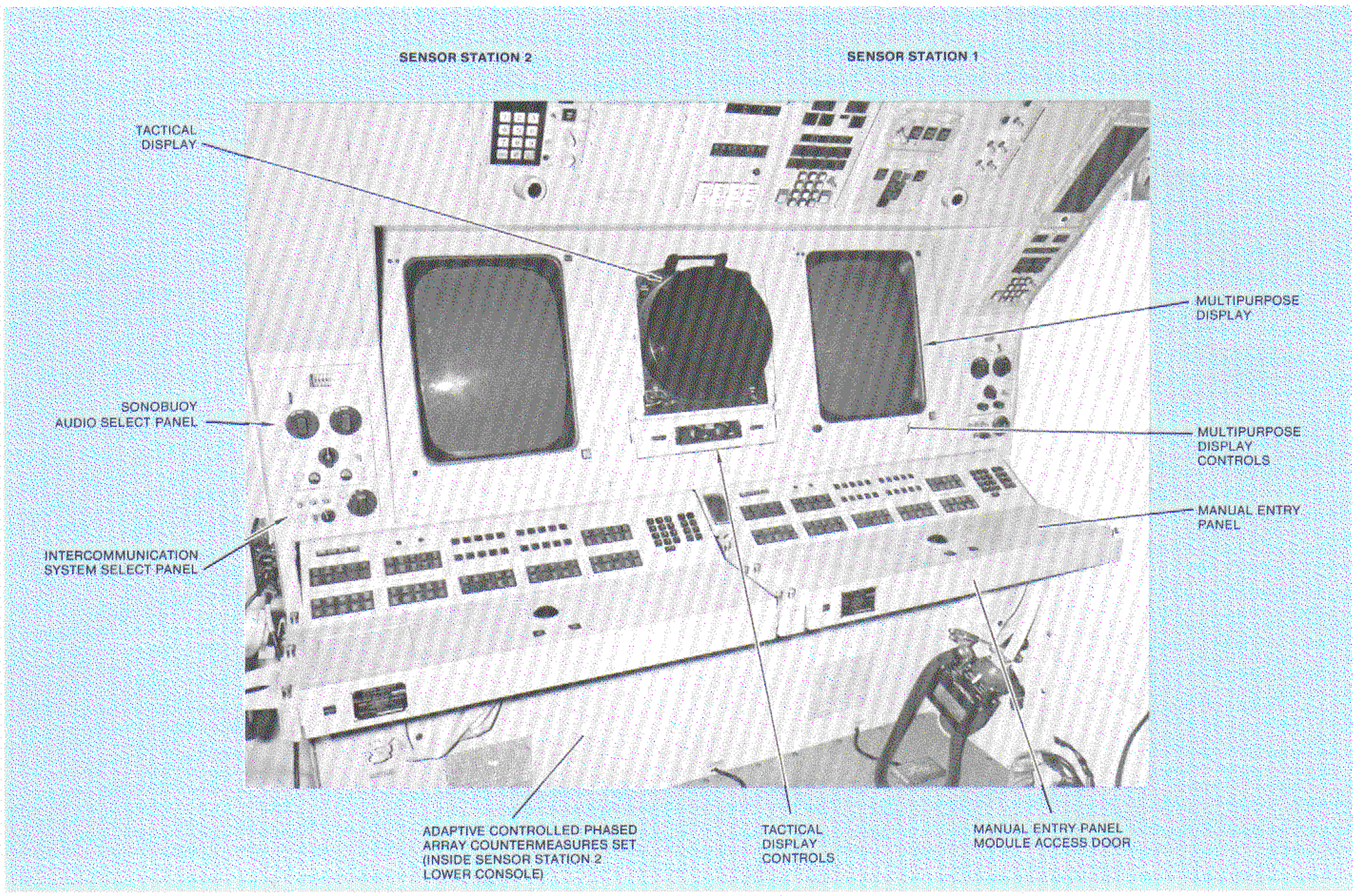


Figure 14. Multipurpose Displays and Tactical Display Installation at Sensor Stations 1 and 2

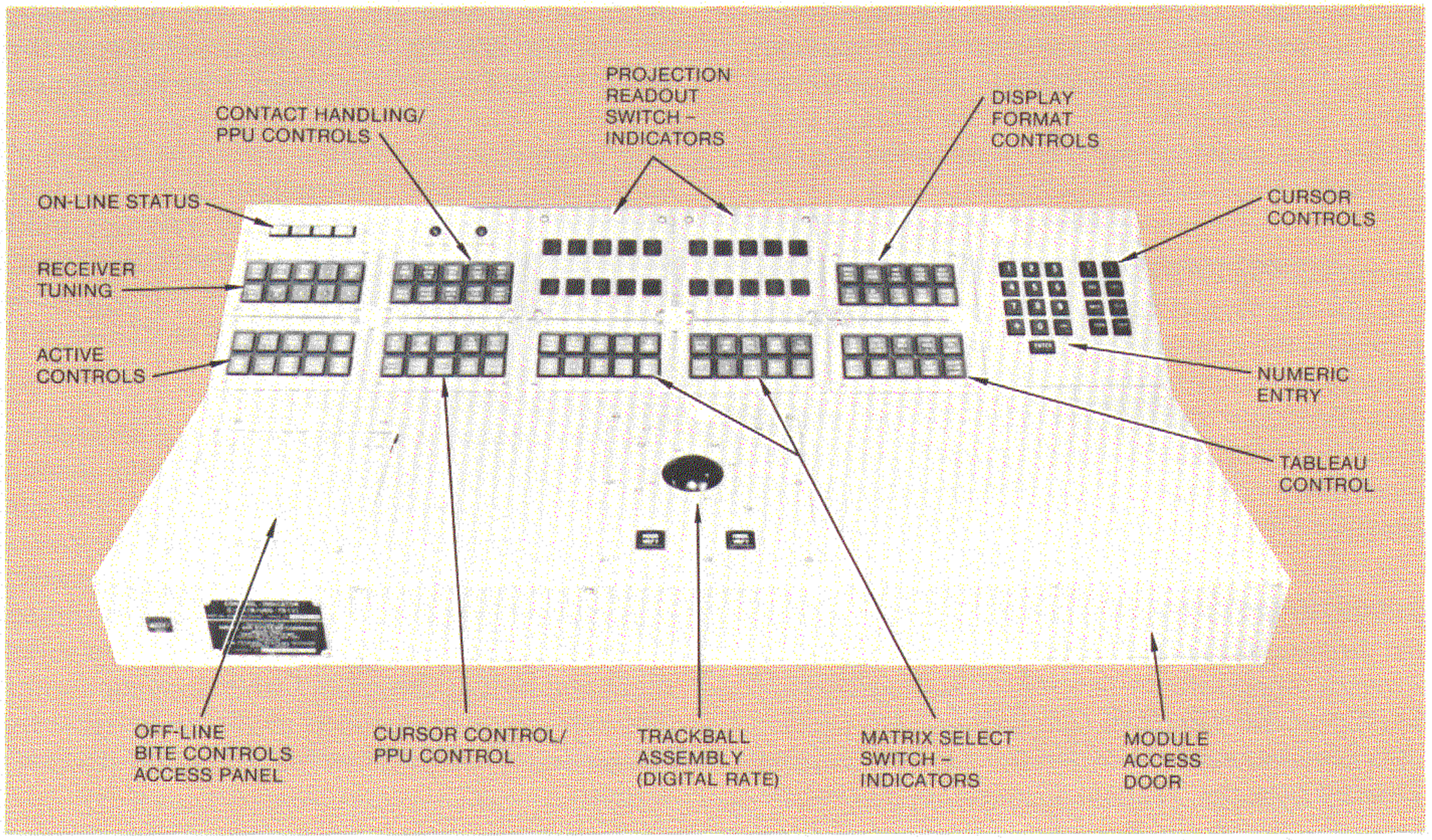


Figure 15. Acoustic Sensor Station Operator's Manual Entry Panel

The C-11118 Manual Entry Panel (Figure 15) allows the acoustic station operator to control the system by depressing switches, moving cursors, and positioning the hook symbol with the trackball. The switch logic is much like that of the TACCO station. There are three types of switches — mono-function, matrix select, and matrix readout. The mono-function switches always have the same function. The 20 matrix select switches do not activate any functions, but rather they enable the operator to select one of 24 functions that are illuminated on the multi-function matrix readout switches. The MEP also features a numeric keypad and cursor controls, and a new digital rate-type trackball. In addition, the MEP also has off-line BITE controls (Figure 16).

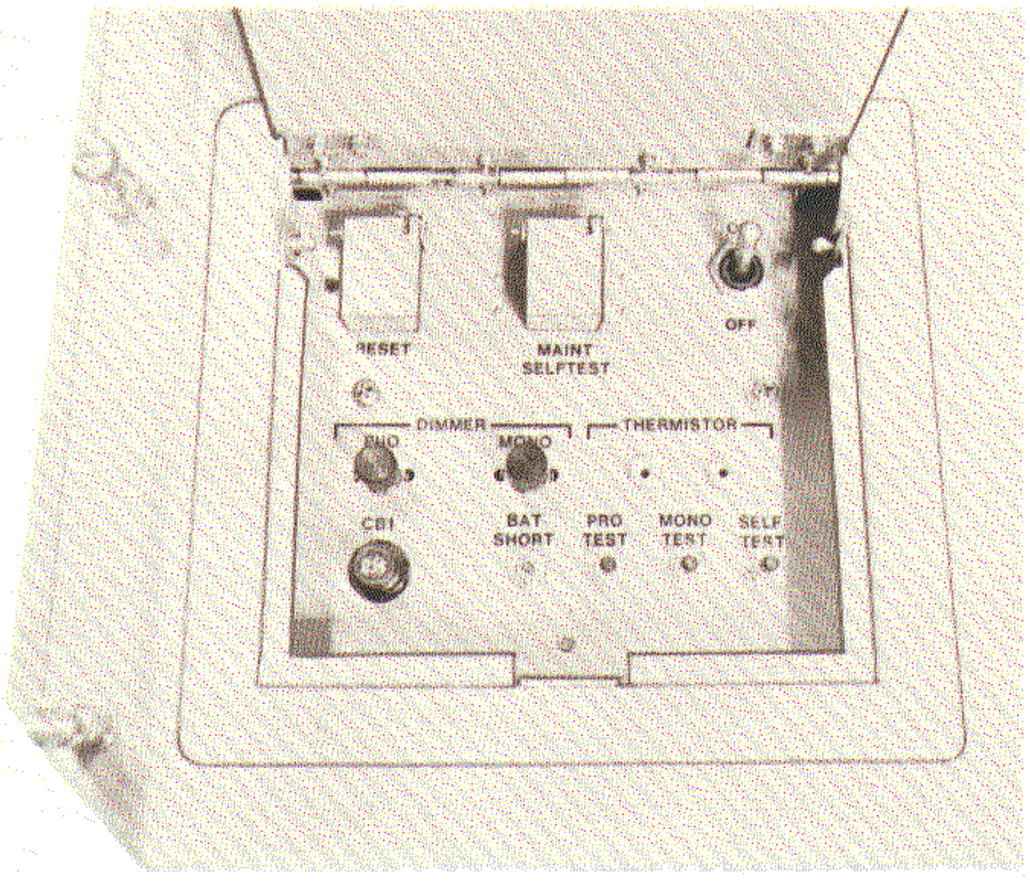


Figure 16. Manual Entry Panel Off-Line BITE Controls

The functional design of the acoustic subsystem embodies an automated approach, and the Manual Entry Panel is effectively the subsystem's only control. The control panels for the Adaptive Controlled Phased Array countermeasures system and for the Advanced Sonobouy Communication Link receiver are available for back-up (see Figure 17). Operations at Sensor Stations 1 and 2 are comparable to computer terminal operations where tabular displays are displayed and modified.

- Some data tableaux are modifiable all or in part by line and/or by column.
  - Auto reconfiguration occurs in the system for entries that affect sonobuoy tuning, etc.

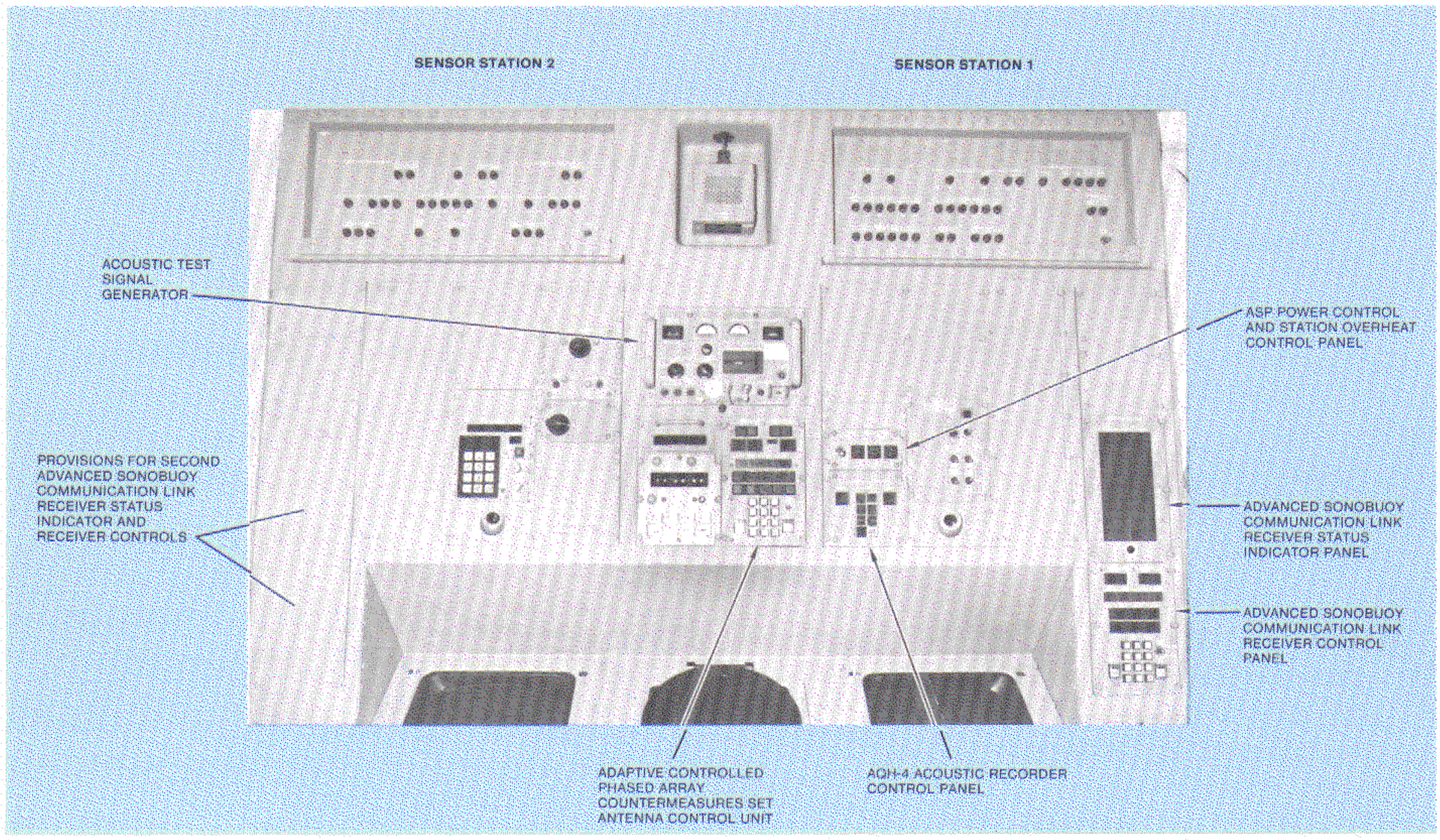


Figure 17. Sensor Station 1 and 2 Overhead Control Panels

- ASWOC Preflight Data Insertion Program data can be updated.

- Processed data is stored and sequentially paged onto the Multipurpose Display, where the operator can change the processing or confirm auto-detection alerts originated by the System Controller/Post-Processor Unit and displayed to him.

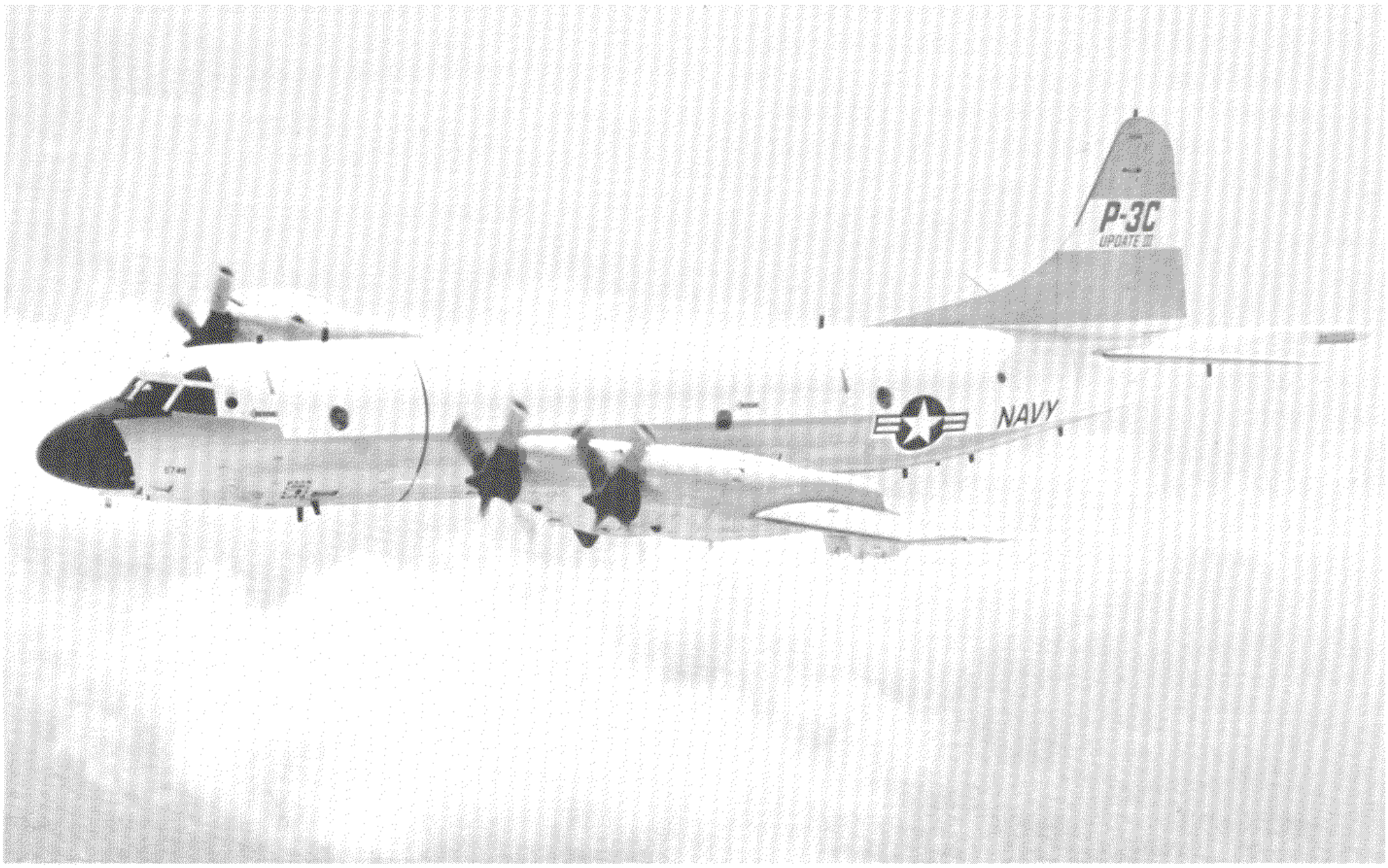
The following types of data are displayed:

- Analyzer Unit Analysis Mode Related Tableaux
  - System Analysis Mode Directory
  - Vernier and Octave Assignment
- Processing Related Tableaux
  - Sonobuoy Tuning Criteria
  - Sonobuoy Status
  - Processing Status
- Post-Processing Criteria Related Tableaux
  - Threat Lines
  - Contact Criteria Directory
  - Contact Criteria
  - Signal Characteristics Directory
  - Signal Characteristics Amplify
- Post-Processing Results-Related Tableaux
  - Contact Summary for an RF (Buoy)
  - RF (Buoy) Summary for a Contact
  - Contact Expansion for an RF (Buoy)
  - Threat Criteria Summary
  - Post-Processing Unit Alerts
  - Post-Processing Unit Contact History
  - Frequency by RF (Buoy)

- End-to-End Test Tableaux
- Miscellaneous Tableaux
  - Adaptive Controlled Phased Array
  - Interface Status
  - Status Alerts
  - Ambient Noise Measurements
- System automatically provides default criteria and system presets in the absence of PDIP and operator data.
- PDIP data automatically enters aircraft mission parameters.
  - Sonobuoys On-Board
  - Sonobuoys In-Water
  - Signatures Directory
  - System Analysis Mode Director, which includes Detection Threshold, Type of Integration, Minimum Detection Range, Convergence Zones, and Sea Noise
  - Others
- System Defaults and Presets
  - Post-Processor Unit Update Cycle
  - Contact Criteria
  - Standard System Analysis Modes
  - Others

The benefits of the operator interface with the Advanced Signal Processor are:

- Operator workload is reduced by automation of both mundane record-keeping and ASW decision criteria
- System configuration controls are easily accessible at one location



- Display aids exist for contact detection and threat files, and for buoy-to-buoy correlation

- System Analysis Modes are easily set up to establish signal processing in the full, vernier, or mixed octaves/vernier modes for each sonobuoy

- The same signal from a sonobuoy can be processed in several different ways

- Cueing sequences are displayed to the Sensor Station 1 and 2 operators

Typical Scenario for Sensor Stations 1 and 2 The scenario for a typical ASW flight requires performance of initial set-up and inflight duties. The following is a typical scenario for Sensor Stations 1 and 2.

- Receive PDIP download from TACCO/Tactical Computer/ASWOC
  - Sonobuoys In-Water, Sonobuoys On-Board
  - Contact Criteria Directory
  - System Analysis Mode Directory
  - Signature Characteristics Directory
- Make changes/create special mission plan
  - System Analysis Mode Amplify - Create new SAMs (99 maximum)
  - Contact Criteria Tableau - Assign verniers, octaves, select required lines
  - Sonobuoy Tuning Criteria Tableau - Modify amplifying data for tuning (processing) each sonobuoy
  - Sonobuoy Status Tableau - Select sonobuoys to be tuned (processed)
  - Processing Status Tableau - Modify processing option (i.e., DIFAR, LOFAR, DICASS Omni) Post-Processor Unit detection setup



- Work the Detection Problem

  - Analyze Post Processor Unit Alerts - Display these tableaux and review their associated analog displays.

  - Tune new buoys, review contact history, review contact criteria, create new verniers (System Analysis Modes)

  - Analyze buoy-to-buoy correlation data that is automatically assimilated and that can be displayed in tableau format

  - Pass on threat contacts to TACCO for correlation

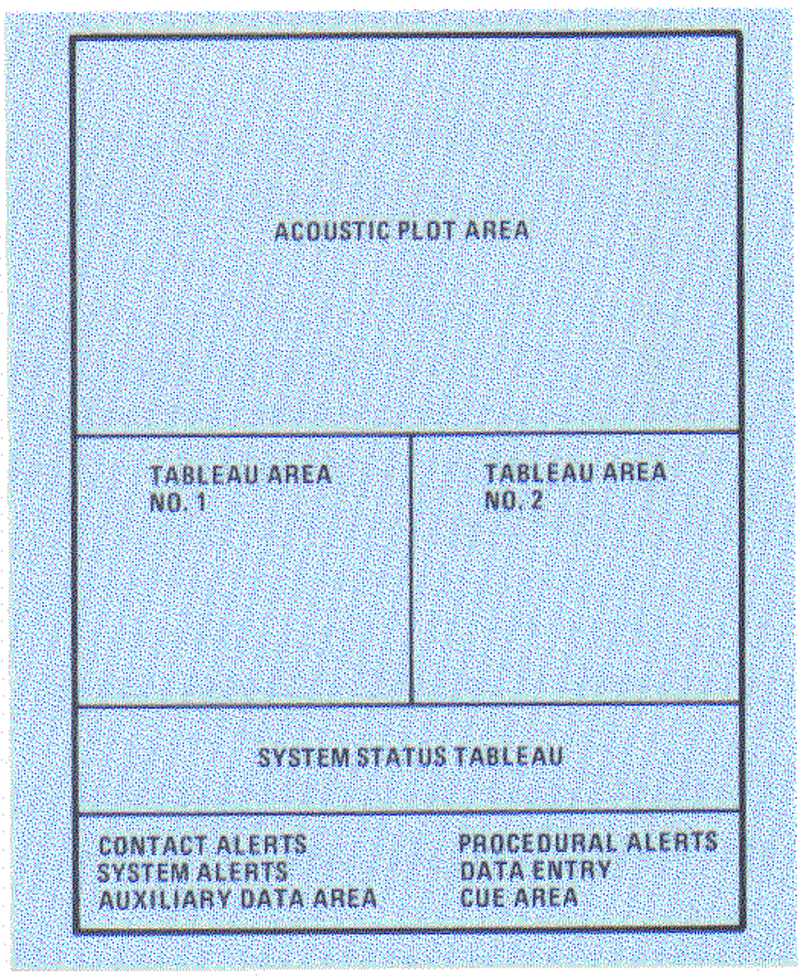


Figure 18a. ASP Multipurpose Display — General Format

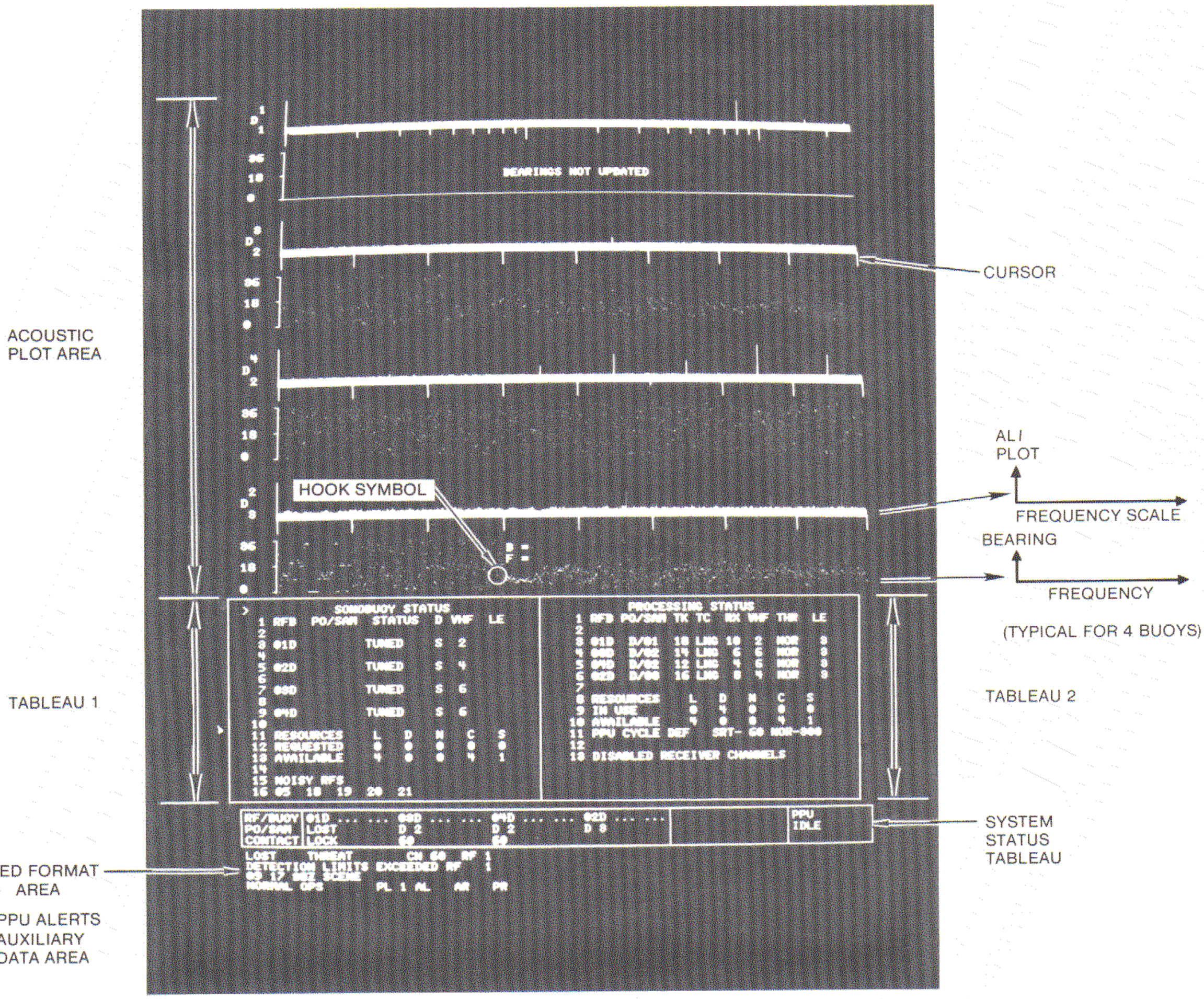
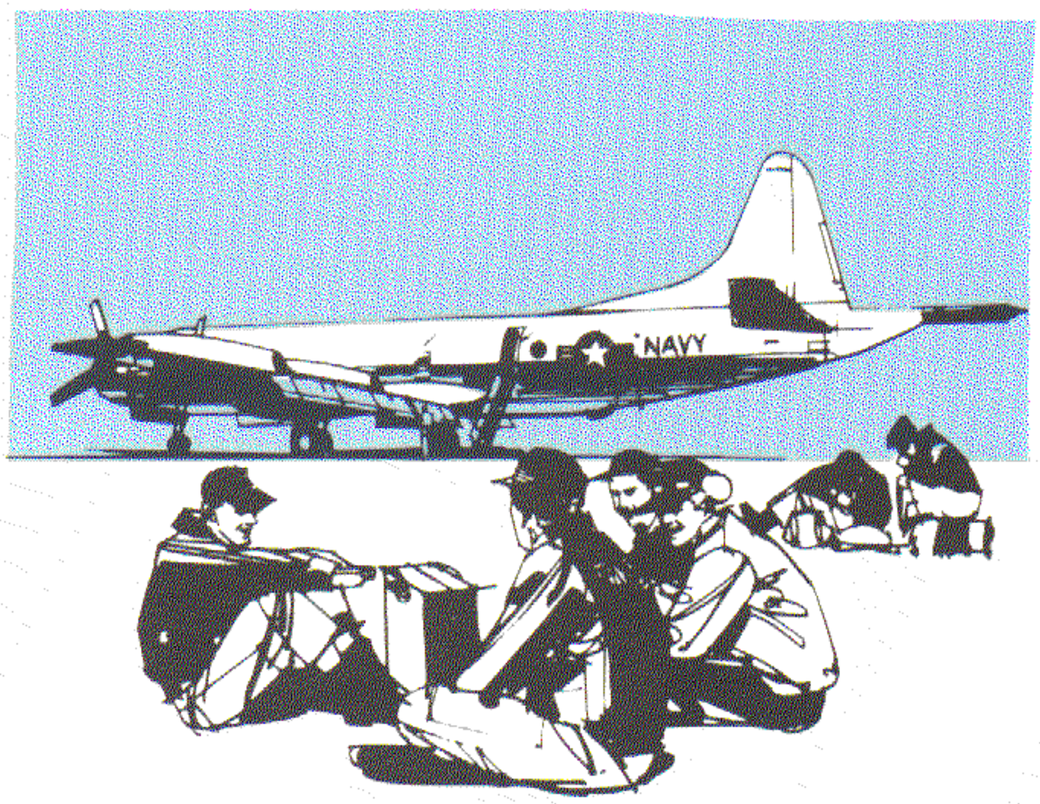
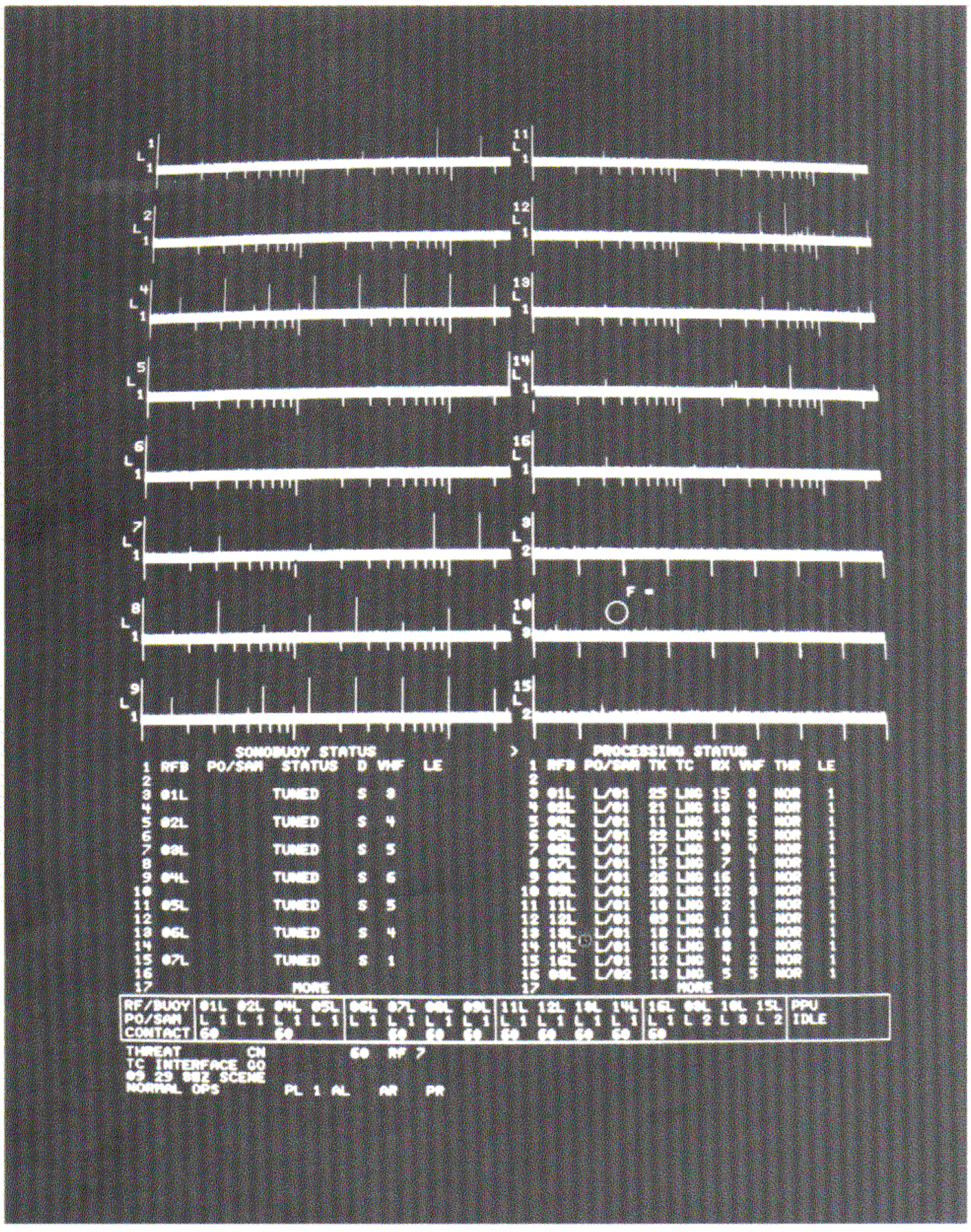


Figure 18b. Typical Multipurpose Display Format — Passive Overview (DIFAR Buoys)

Typical Display Formats The Multipurpose Display is a digital, raster-type cathode ray tube device that displays acoustic and tabular data to the sensor station operator. The screen image is partitioned into three display areas: the acoustic plot area, the tableau areas, and the fixed format area that displays the system tableau, cues, and alerts. The format of a typical display is shown in Figure 18.

The acoustic plot area is used to present various formats of passive or active acoustic data. Automatic paging of plots is available. The number of acoustic plots may range from a single plot of expanded data from one buoy, to a plot displaying condensed data from 16 buoys simultaneously.

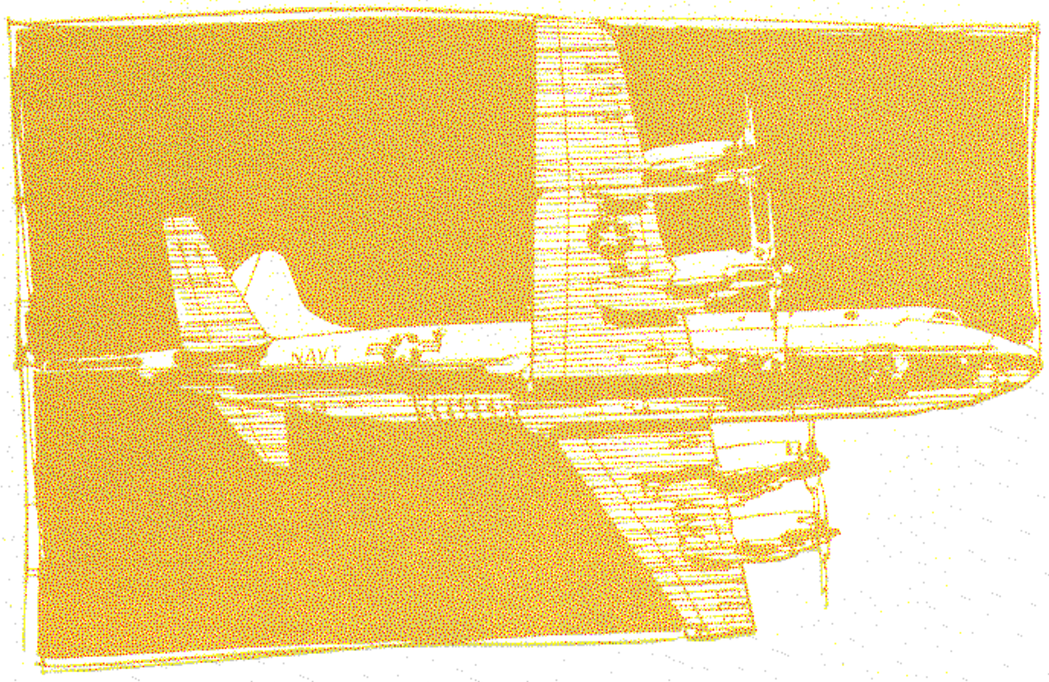




ALI
PLOT

FREQUENCY SCALE
(TYPICAL FOR 16 BUOYS)

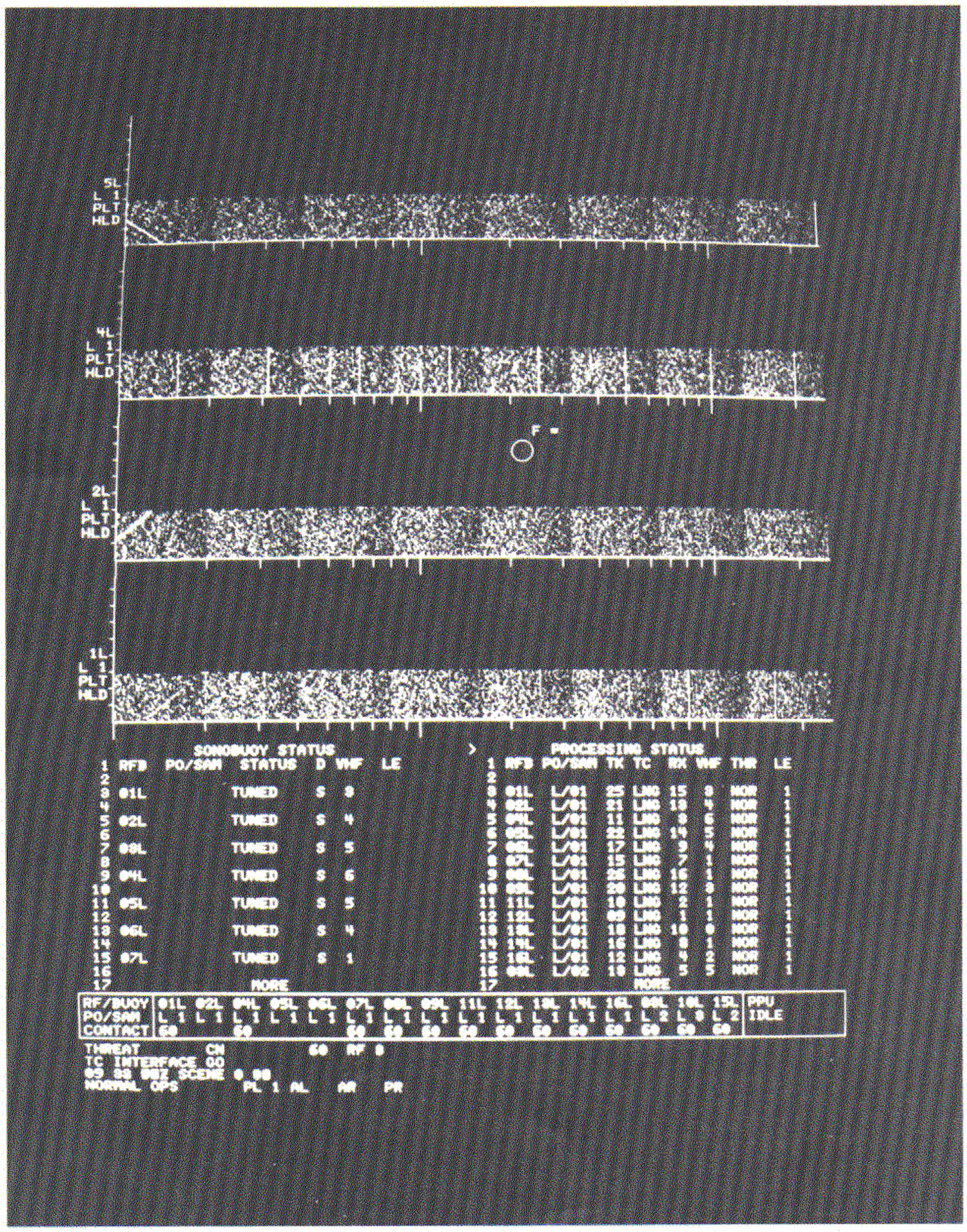
Figure 19. Multipurpose Display Format — Passive Overview of 16 Buoys



The operator uses this latter plot to monitor overall operation of the Advanced Signal Processor when a larger field of buoys is deployed. When there is interest in data from a particular buoy, the operator can select an expanded display of data from that buoy.

The acoustic plot formats that can be presented in the acoustic plot area are:

- Gram Search
- ALI Search
- One Channel
- Two Channel



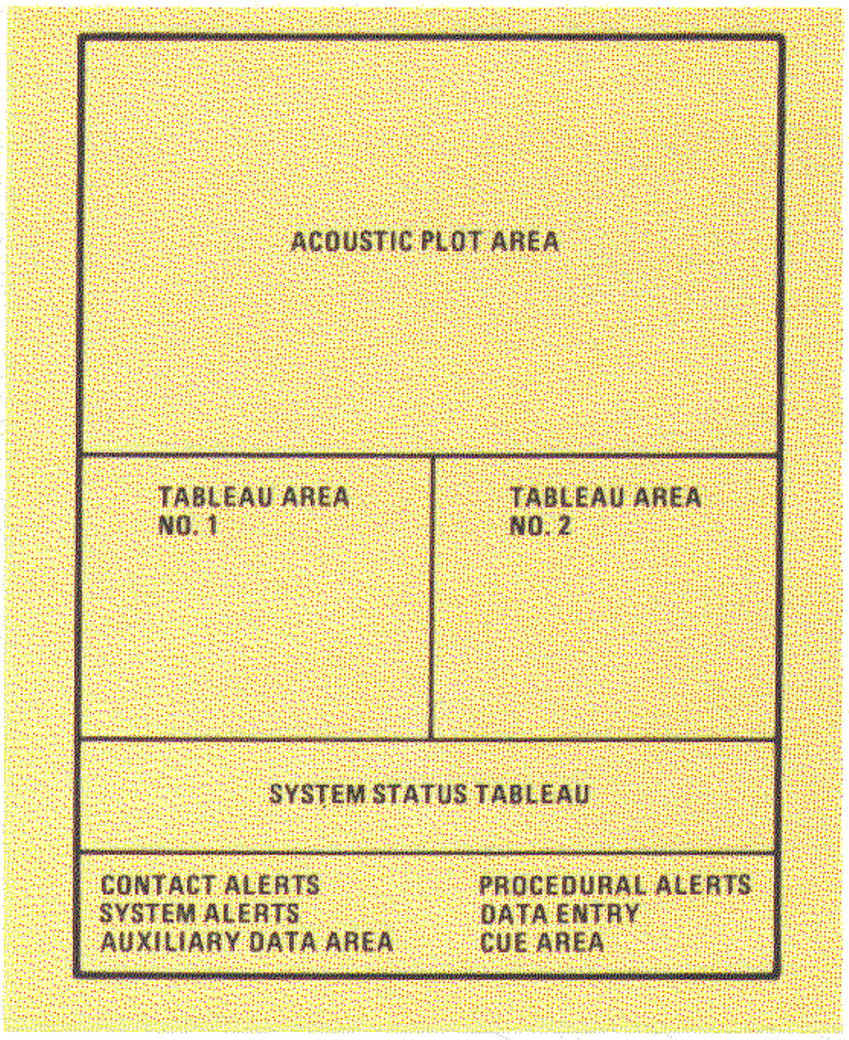
GRAM
TIME HISTORY

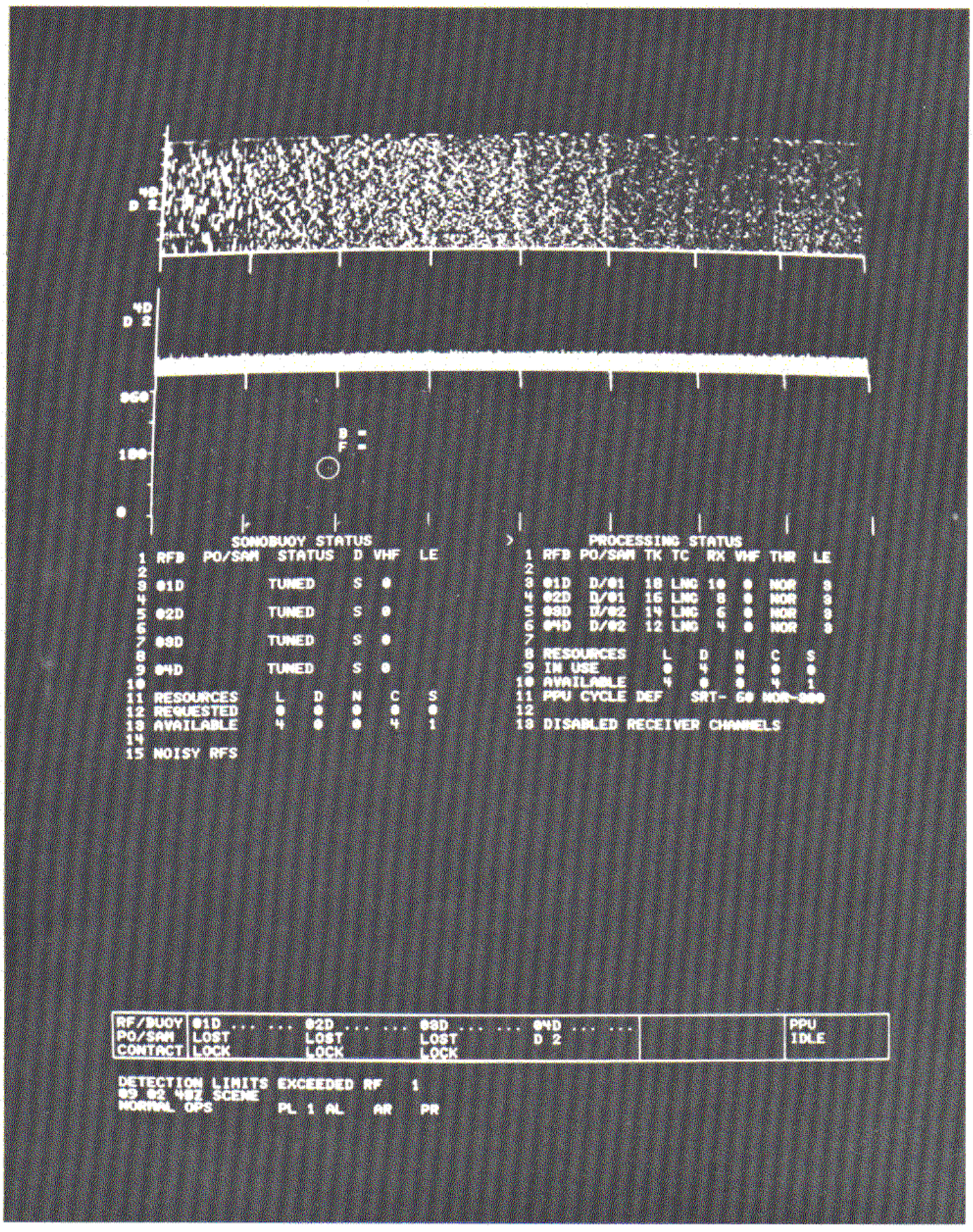
FREQUENCY SCALE IN Hz
VS.
INTENSITY OF SIGNAL STRENGTH
(TYPICAL FOR 4 BUOYS)

Figure 20. Multipurpose Display Format — Passive 4-Buoy Gram Plot

- DIFAR Null Steering
- Passive Overview
- Active Plot
- Two Plot
- BT (Bathythermograph)
- Full Tableau[1]

[1]The Full Tableau format extends the tableau display area into the acoustic plot area so that no acoustic plots can be displayed when this format is selected.





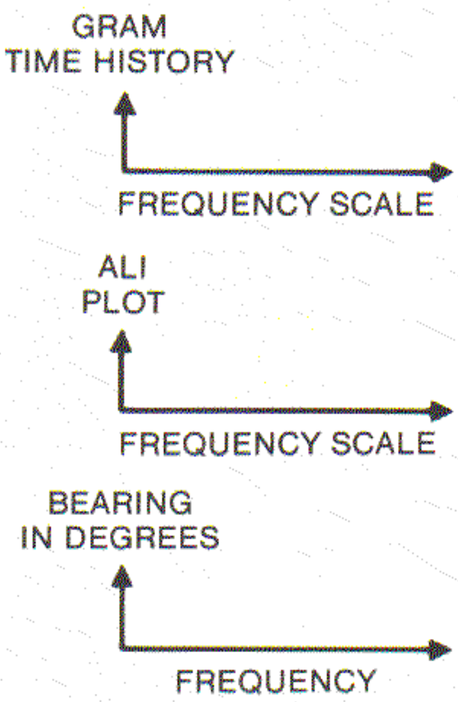
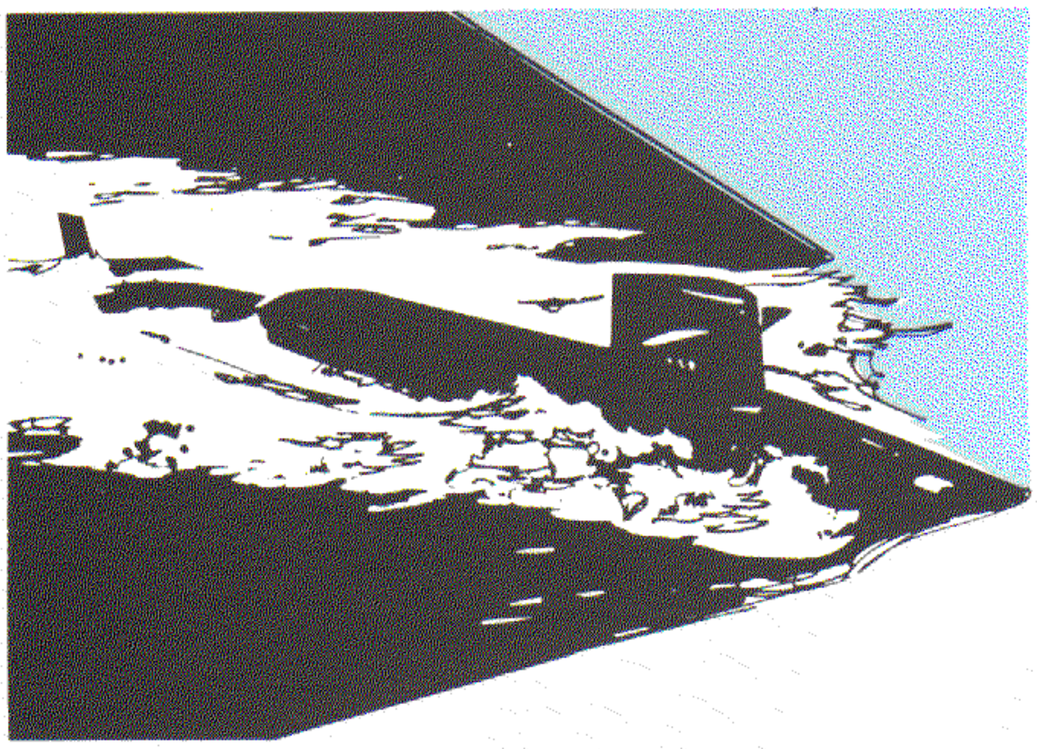


Figure 21. Multipurpose Display Format — Single-Buoy Gram with ALI and Bearing Frequency



A typical acoustic plot format is shown in Figure 19. This figure is representative of the Passive Overview (multiple-plot) Format. This format permits up to 16 passive Automatic Line Integration (ALI) acoustic plots to be displayed at one time. In the case of DIFAR processing, the ALI plots and associated BVF (bearing versus frequency) plots are displayed, which reduces the number of ALI plots displayed by one-half.

The type of acoustic plot available for display in the acoustic plot area is determined by the type of sonobuoy being processed. Acoustic plots available for passive sonobuoys are Gram (amplitude/

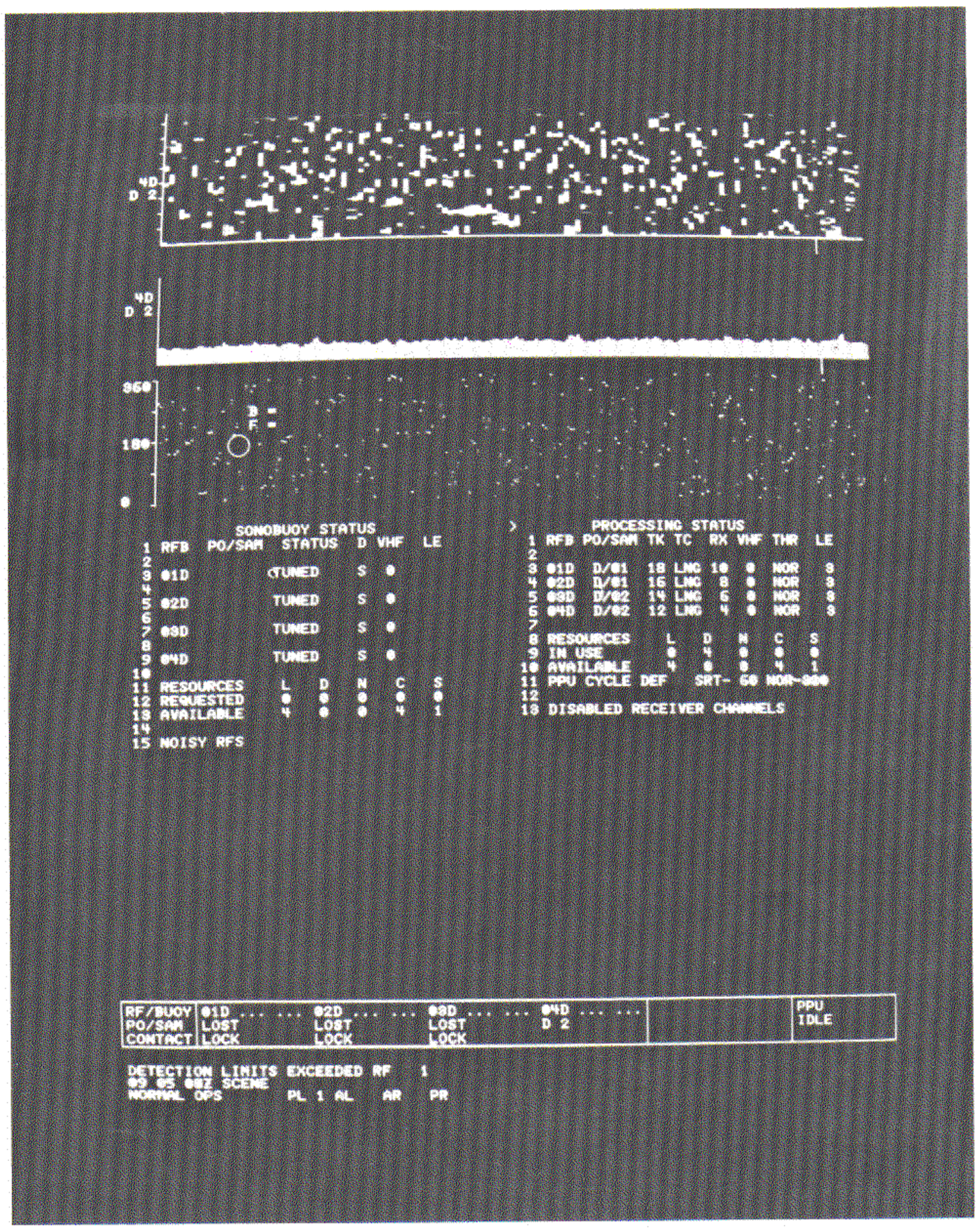
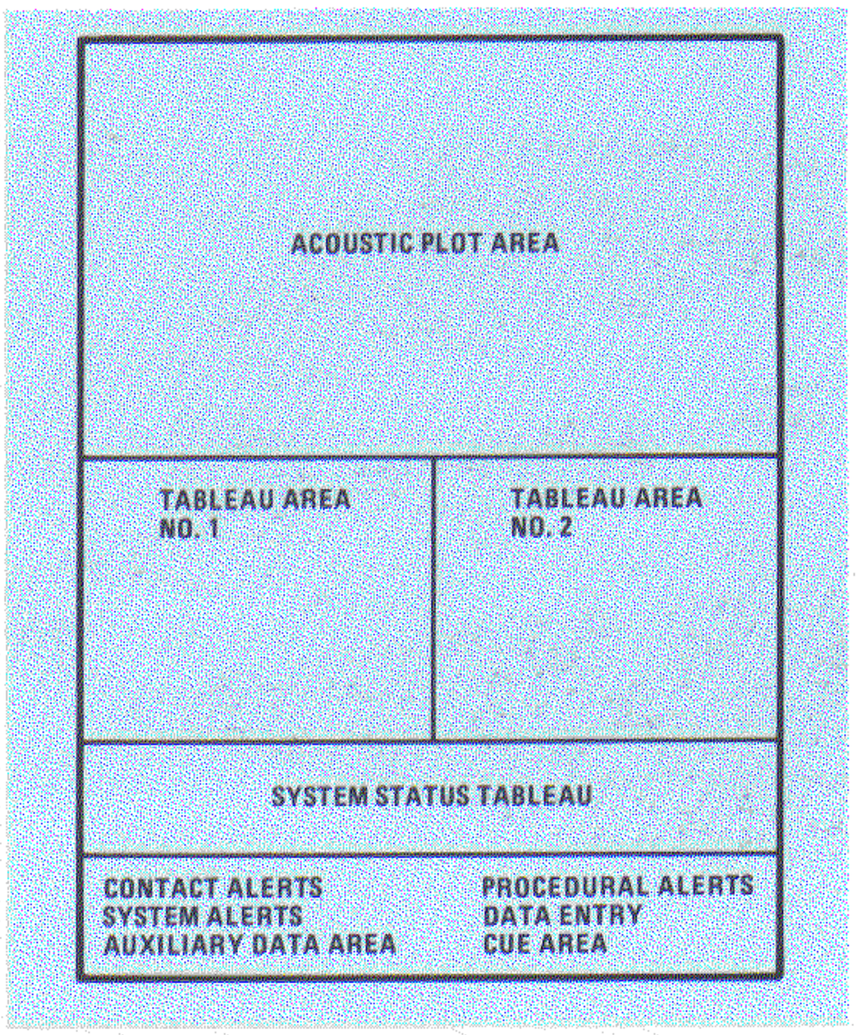


Figure 22. Multipurpose Display Format — Expanded Single-Buoy Gram with ALI and Bearing Frequency

time versus frequency), ALI (amplitude versus frequency), and BVF (bearing versus frequency). The acoustic plots available for active sonobuoys are Range/Doppler (range versus Doppler frequency) and Range/Bearing (range versus bearing). The Bathythermograph (BT) plot is used for BT sonobuoys. Several examples of acoustic plots are shown in Figures 20 through 23.

The tableau display areas present alphanumeric lists of data that the operator can manipulate to control the Advanced Signal Processor. By modifying this control data, the operator can control how the system processes the sonobuoy acoustic



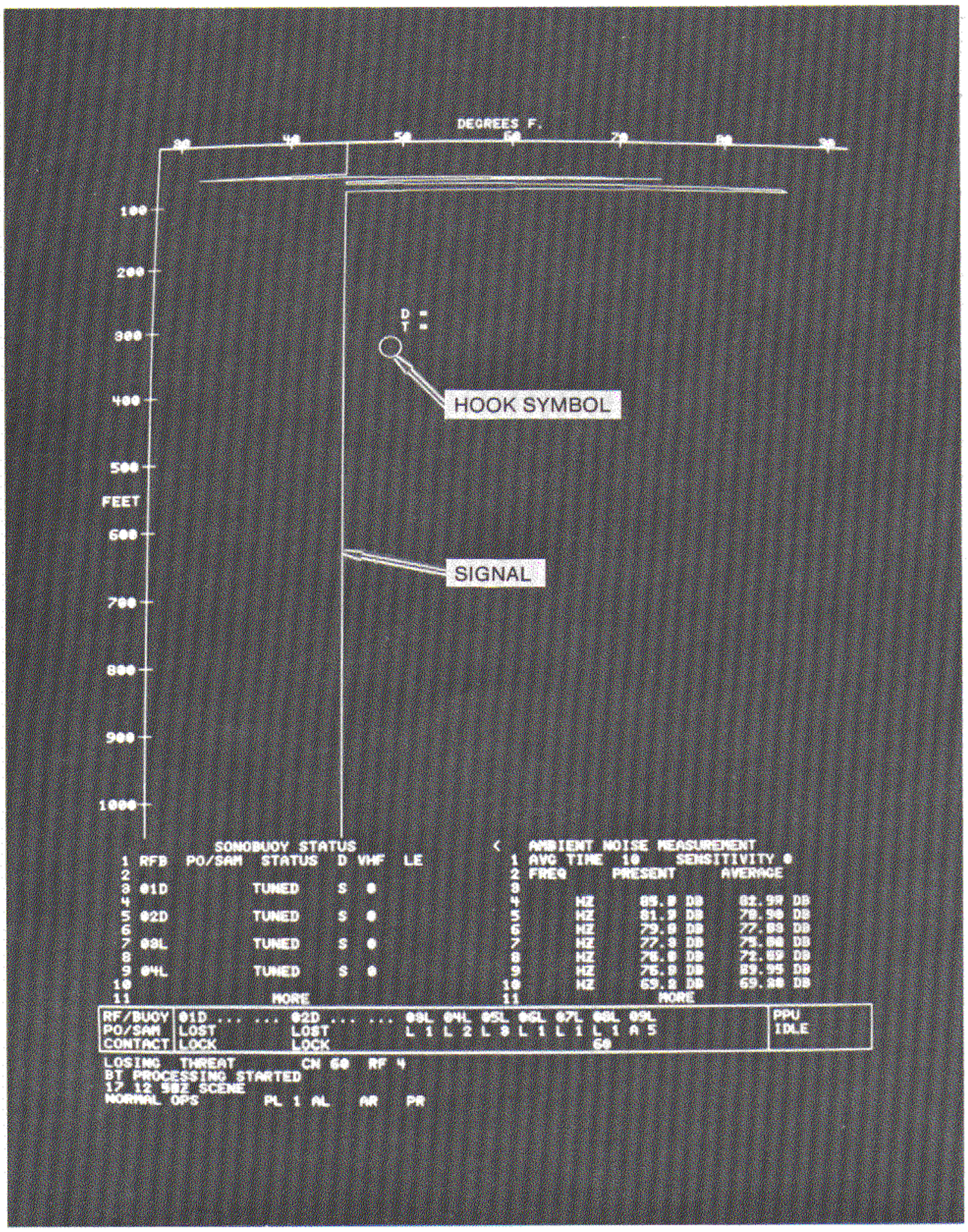
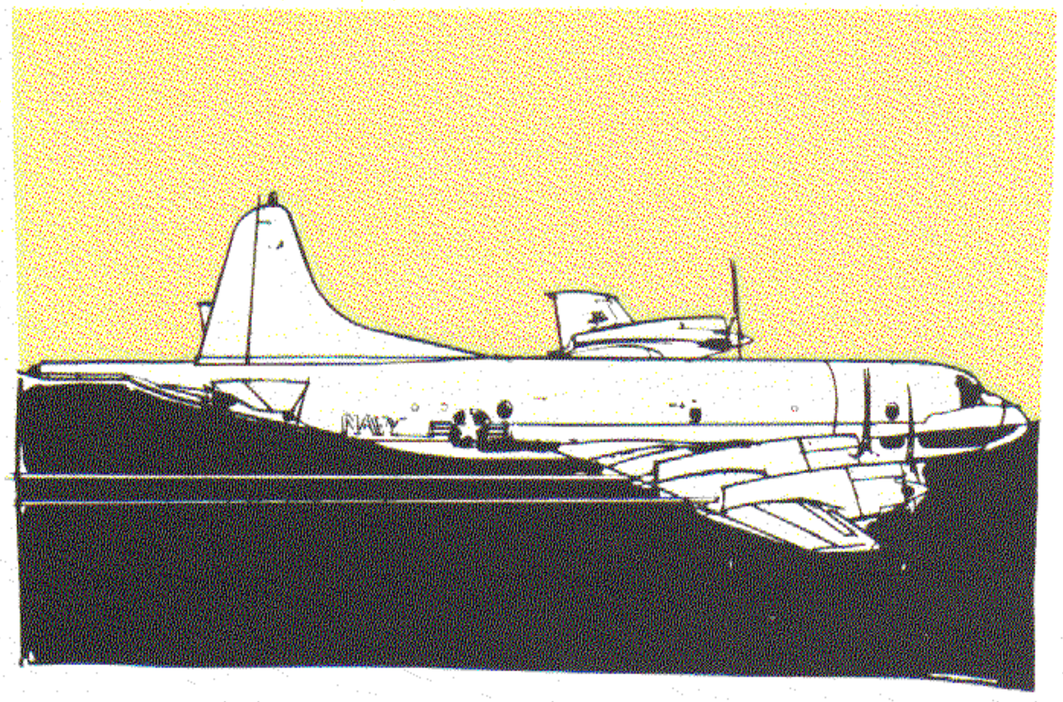


Figure 23. Multipurpose Display Format — Bathythermograph (BT) End-to-End Test



signals. Two areas on the display (see Figures 24 and 25) permit two tableaux to be displayed simultaneously. This gives the operator access to information in two different areas of memory, with minimal operator action. It also permits the operator to compare the contents of one tableau with those of another tableau, and permits him to modify the second tableau if necessary. The Multipurpose Display uses alphanumeric symbols and some special characters to present tabular data, contacts, and alerts.

The fixed-format area at the bottom of the display is reserved for processor-driven communication

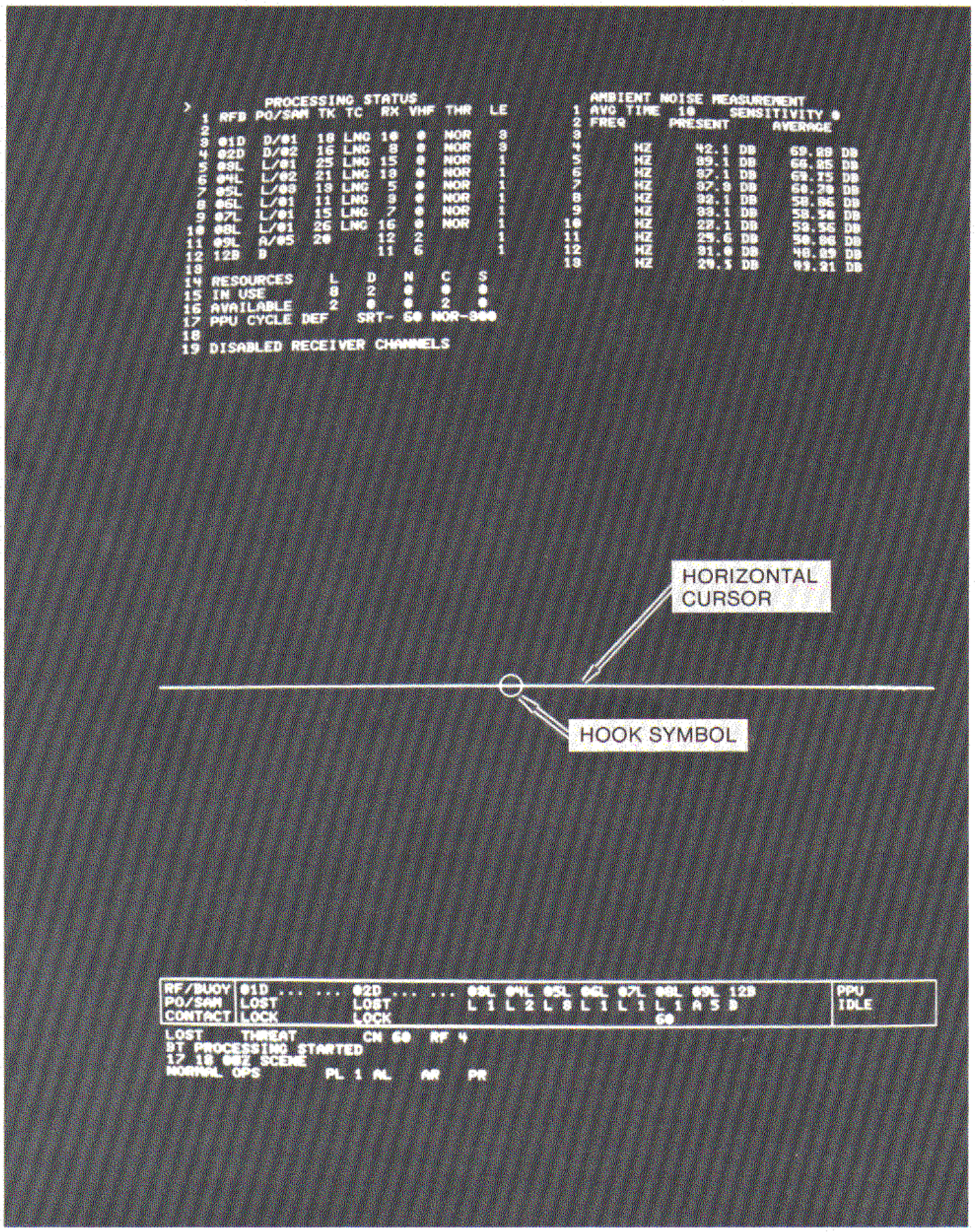
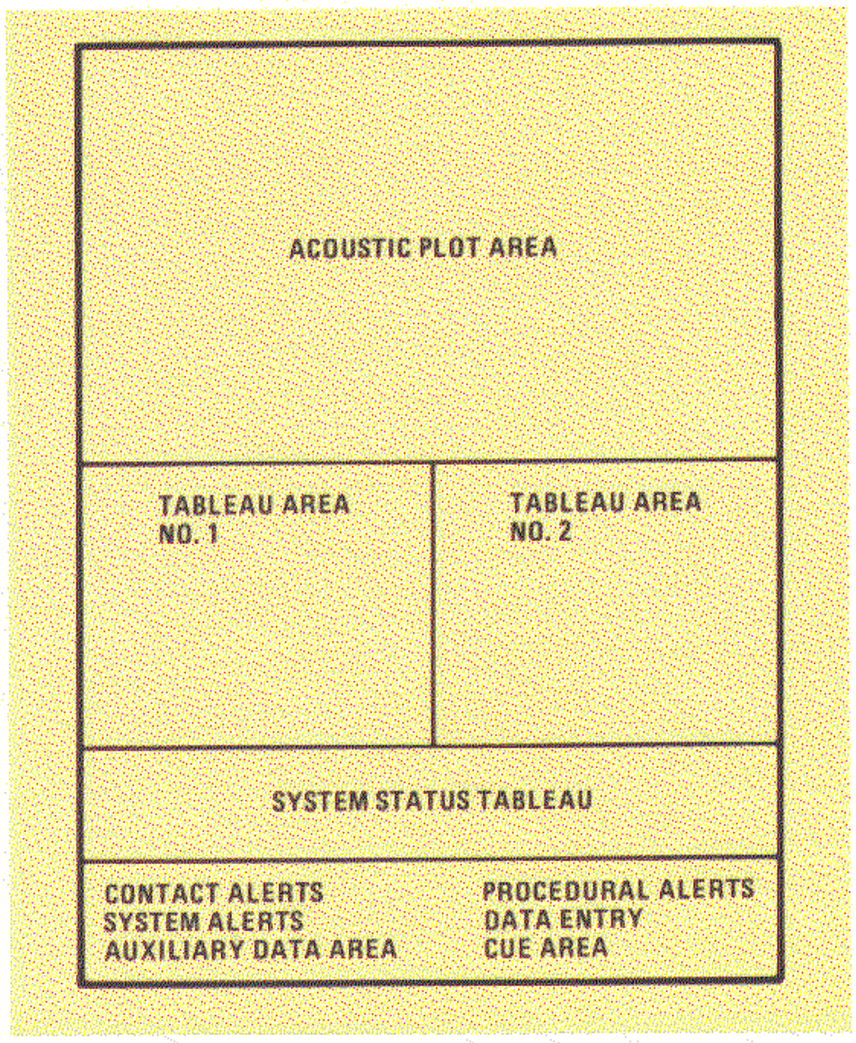


Figure 24. Multipurpose Display Format — Typical Two-Tableaux Display

with the sensor station operators. This includes the system status tableau, cues, and alerts.

The system status tableau (see Figure 26) occupies the first three lines of the fixed- format area. The first line shows the RF/Number and the sonobuoy type. The second line indicates the Processing Option and System Analysis Mode currently in use. The third line displays a summary of the contact situation of each deployed sonobuoy. This data is displayed for each processor/option. If a sonobuoy (such as a DIFAR buoy) requires more complex processing than a LOFAR sonobuoy, the display space on the first line is filled



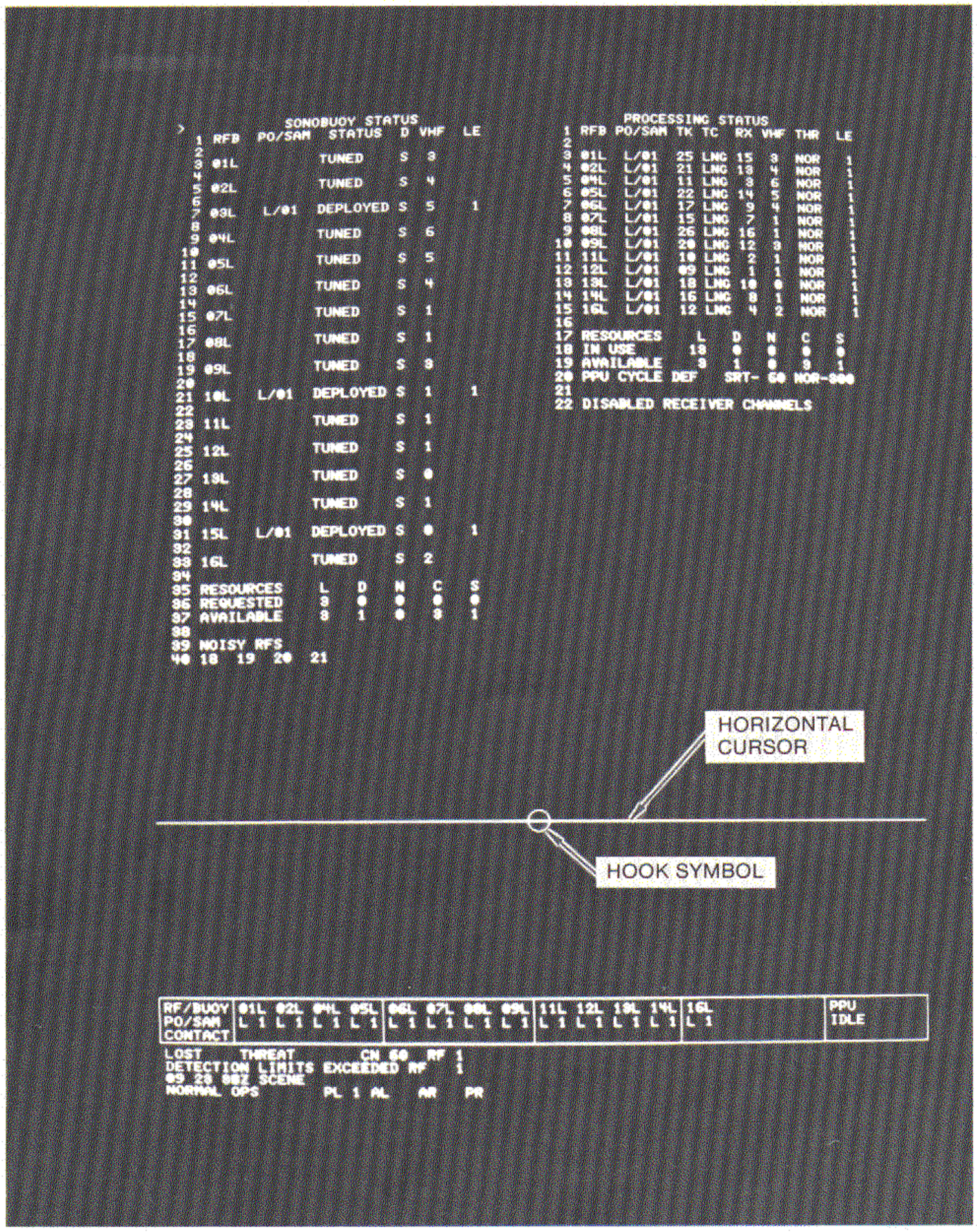
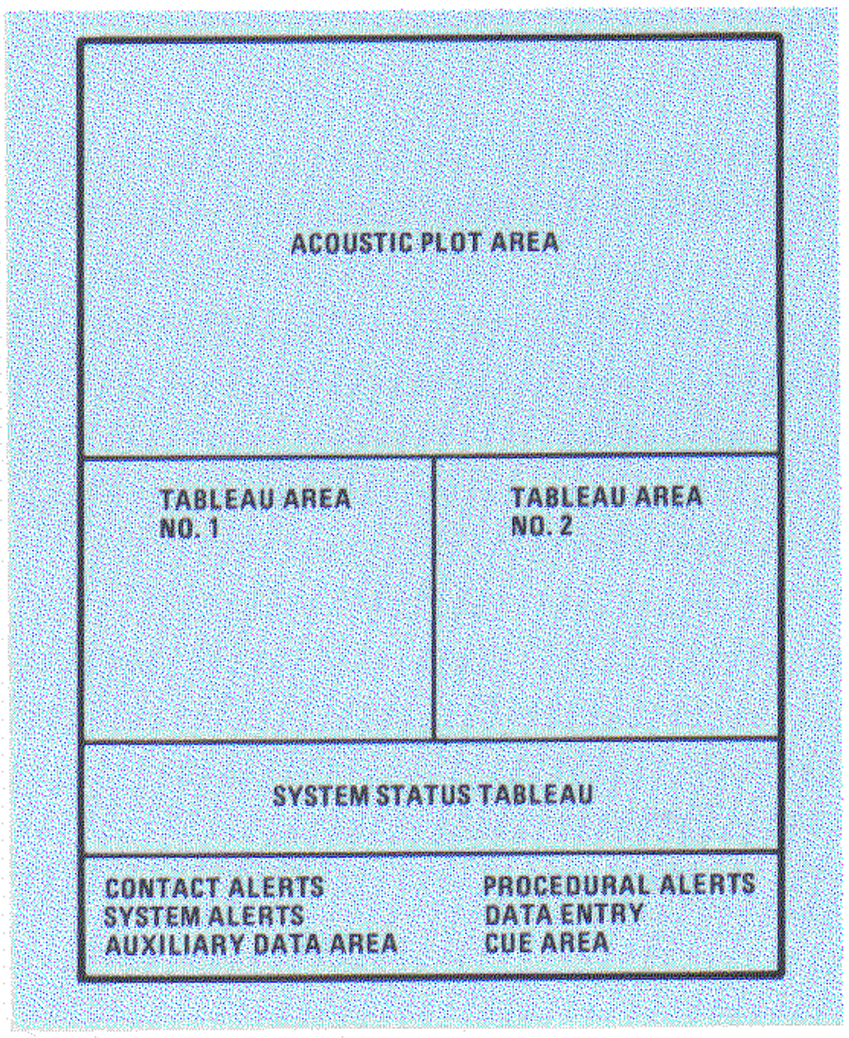


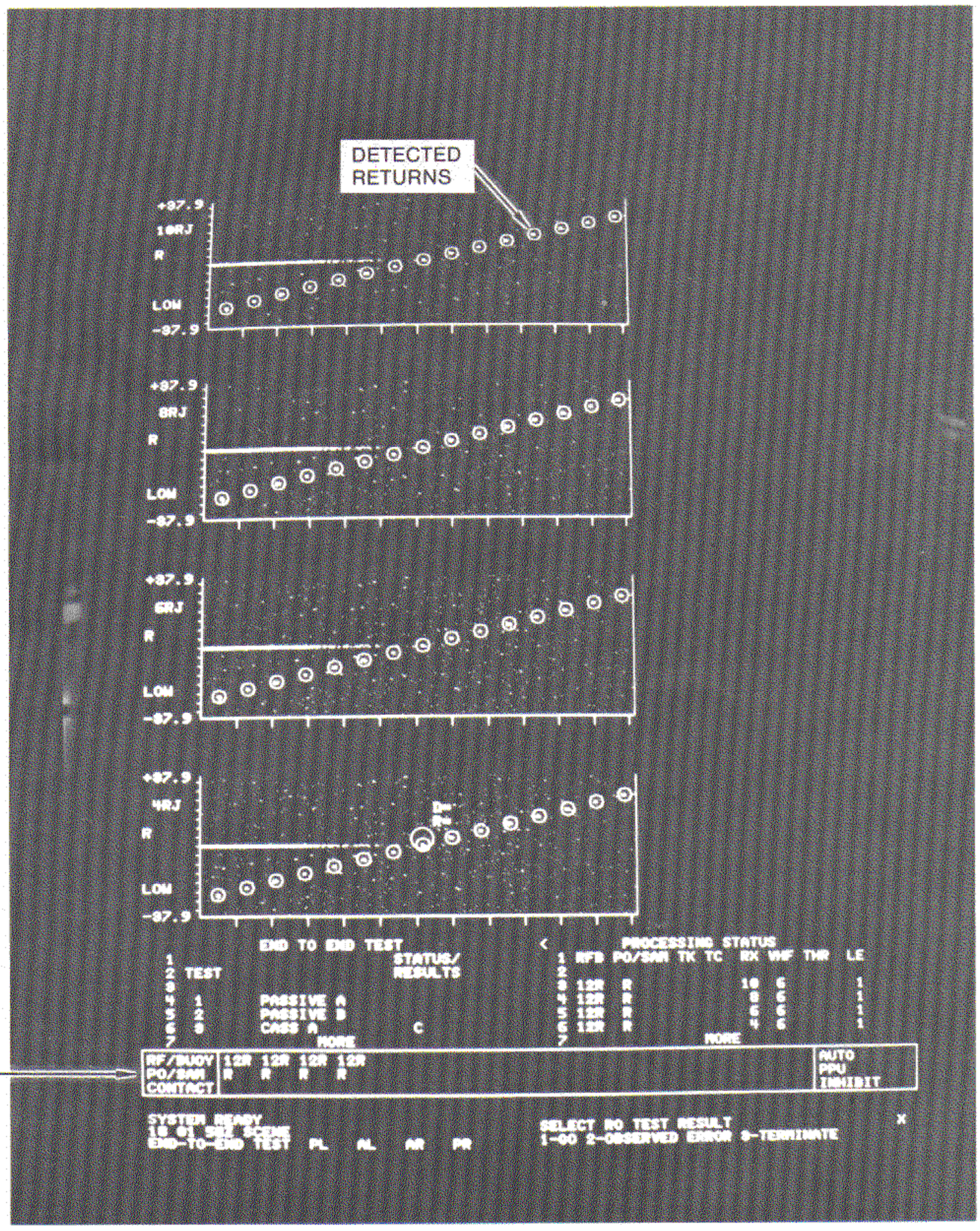
Figure 25. Multipurpose Display Format — Typical Two-Tableaux Display

with dot symbols to give an estimate of processor loading. The right-hand portion of the system status tableau displays the status of the post-processing operation. The status may be: Idle, In Progress, or Inhibit.

The bottom three lines of the fixed-format area display specific temporary data produced by conditions sensed during signal processing, such as threat alerts, equipment changes of status, and any auxiliary data that may be required.

As with all P-3C Update aircraft, the ASA-66 Tactical Display (Figure 27) displays the buoy patterns, the relationship of buoy locations to air-





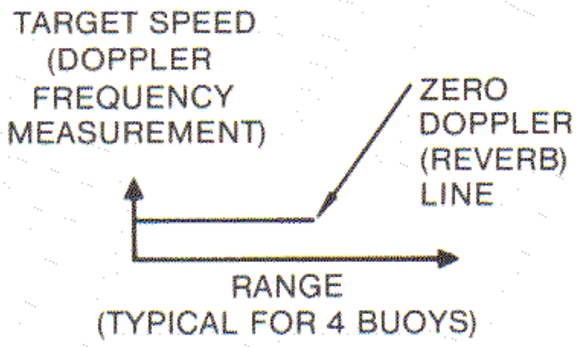


Figure 26. Multipurpose Display Format — Typical CASS End-to-End Test/System Status

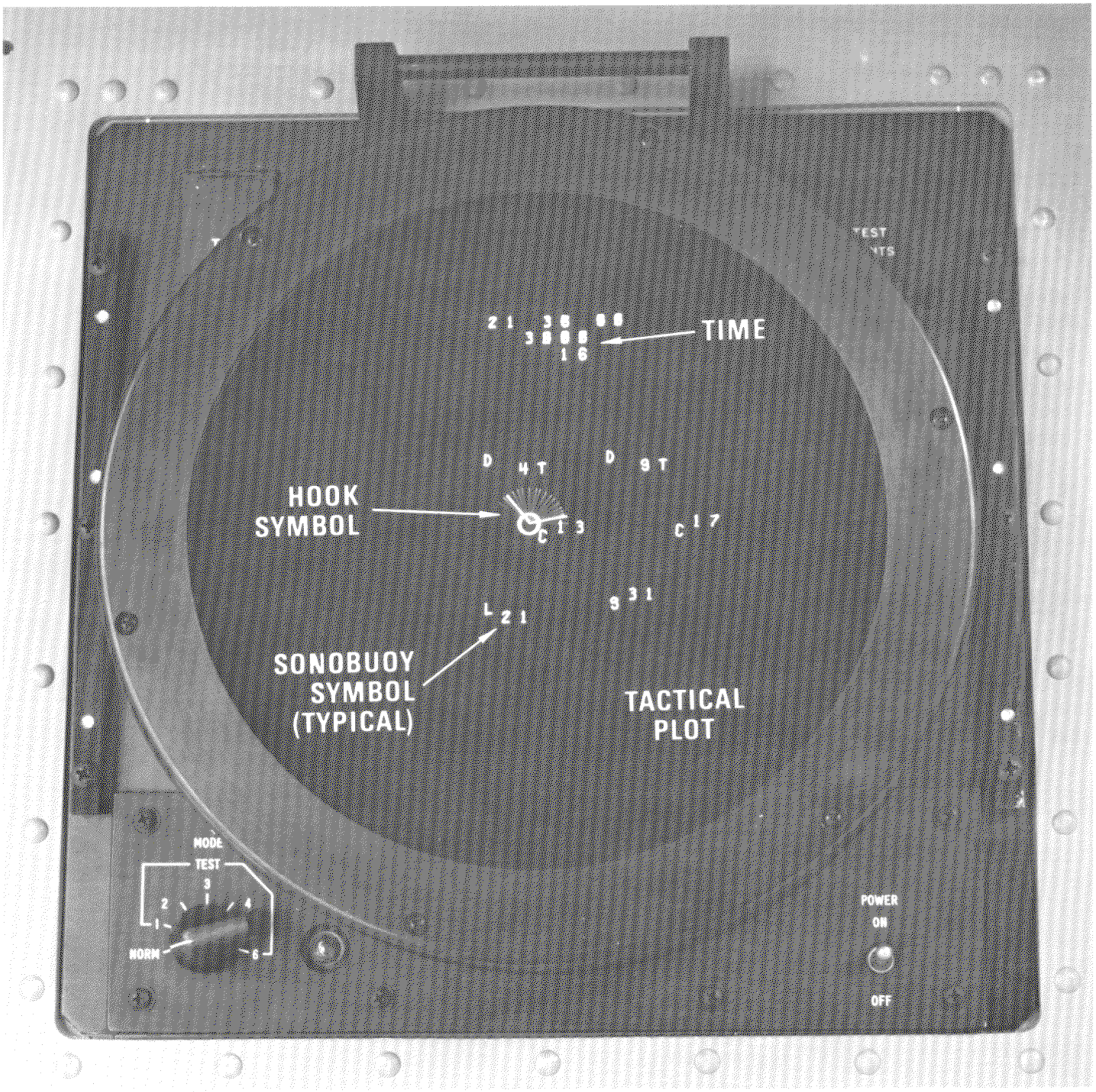


Figure 27. ASA-66 Tactical Data Display Installation Between Sensor Stations 1 and 2

craft location, and the target information generated by the TACCO. This vital information is presented to the acoustic sensor station operators to assist them in chosing which buoys to monitor. The selection of data presented on the tactical display is controlled by the TACCO, including the display of contacts and stores. The acoustic sensor station operators can control the scale of the tactical display, image centering, and display of the aircraft RF horizon.

TACCO INTERFACE CHANGES The TACCO station interface has been modified to incorporate several new functions. Among these modifications is the switch matrix for the Adaptive Controlled Phased Array countermeasures system, which has

been added to the multipurpose data display tray (Figure 28). The TACCO's capability to passively monitor sonobuoy audio signals has been retained. However, the TACCO's audio is slaved to the sonobuoy audio channel that the Sensor Station 1 and 2 operators select as the Passive Left aural monitor channel. Figure 29 shows the TACCO Station Matrix B acoustic and ACPA select-and-readout switch layout.

TACTICAL COMPUTER INTERFACE Modern ASW is a complex business. Much data has to be exchanged between the aircraft's tactical decision maker and the sensor station operators. In the past, this data was passed by voice on the ICS, shouting, arm waving, and by passing notes. As the aircraft was equipped with more data processing equipment, this new equipment enabled the acoustic operator to send important data from the acoustic signal processing system to the tactical data processor with a few keypresses at his keyset. Now that both the TACCO and the acoustic sensor operator stations are equipped with sophisticated computer hardware, it has become necessary to increase the ability of the aircraft's computers to talk to one another in order to further automate tactical data processing.

For example, in the older models of the P-3C, the acoustic sensor station operator updates DIFAR bearings by making several keypresses each time an update is appropriate. With the Advanced Signal Processor, once a target is detected and a control number assigned to it, the DIFAR updates will be sent to the Tactical Computer automatically and displayed at the TACCO station. This function requires far less intervention by the operator during the busiest part of an ASW prosecution.

The TACCO and the sensor station operators communicate to manage the tactical engagement, localize contacts, deploy stores, and make precise delivery of weapons. For example, the TACCO determines what sonobuoys to deploy and where to deploy them, then the sensor operators are informed automatically when the sonobuoys are deployed. The Advanced Signal Processor sends the RF activity data to the Tactical Computer. This ensures that the sonobuoys selected for deployment by the Tactical Computer use RF channels that are free of interfering signals.

During operation of the P-3C Update III, as with all other P-3Cs, all tactical data is under the control of the Tactical Computer. The Advanced Signal Processor Display and Control Unit exchanges digital data with the Tactical Computer. The Tactical Computer provides all the information to the ASA-66 Tactical Display (Figure 27) located between Sensor Stations 1 and 2. This two-way flow of information consists of:

- Communications to and from the TACCO
- Presentation of the current tactical situation to the Sensor Station 1 and 2 operators
- Contact management and processing
- Data extraction

The Advanced Signal Processor needs to know much of the information that is available in the Tactical Computer, and vice versa. During initialization of the Advanced Signal Processor, some of the items needed are:

- The Median Detection Range
- Information on Convergence Zones
- Preflight data on the targets of interest and threats
- Preflight data on the desired modes of operation of the Advanced Signal Processor system

During a mission, the Tactical Computer will send a variety of information to the Advanced Signal Processor, including:

- Time
- Magnetic Variation
- Nearest RFs
- Contact Criteria Directory
- Signature Characteristics Directory
- System Analysis Mode Directory
- Threat Lines

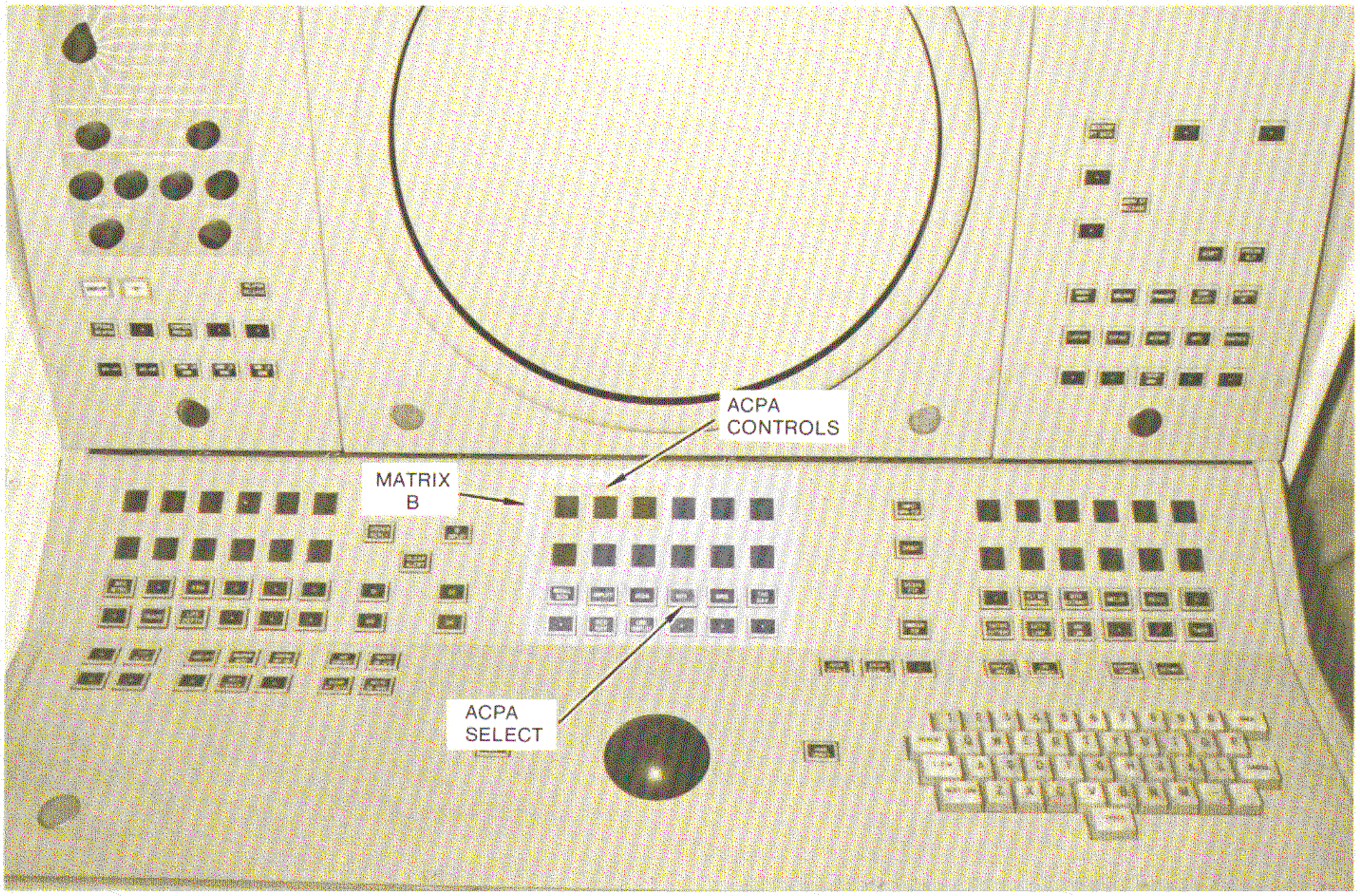


Figure 28. TACCO Station Multipurpose Display and Tray, Showing the ACPA Countermeasures System Controls

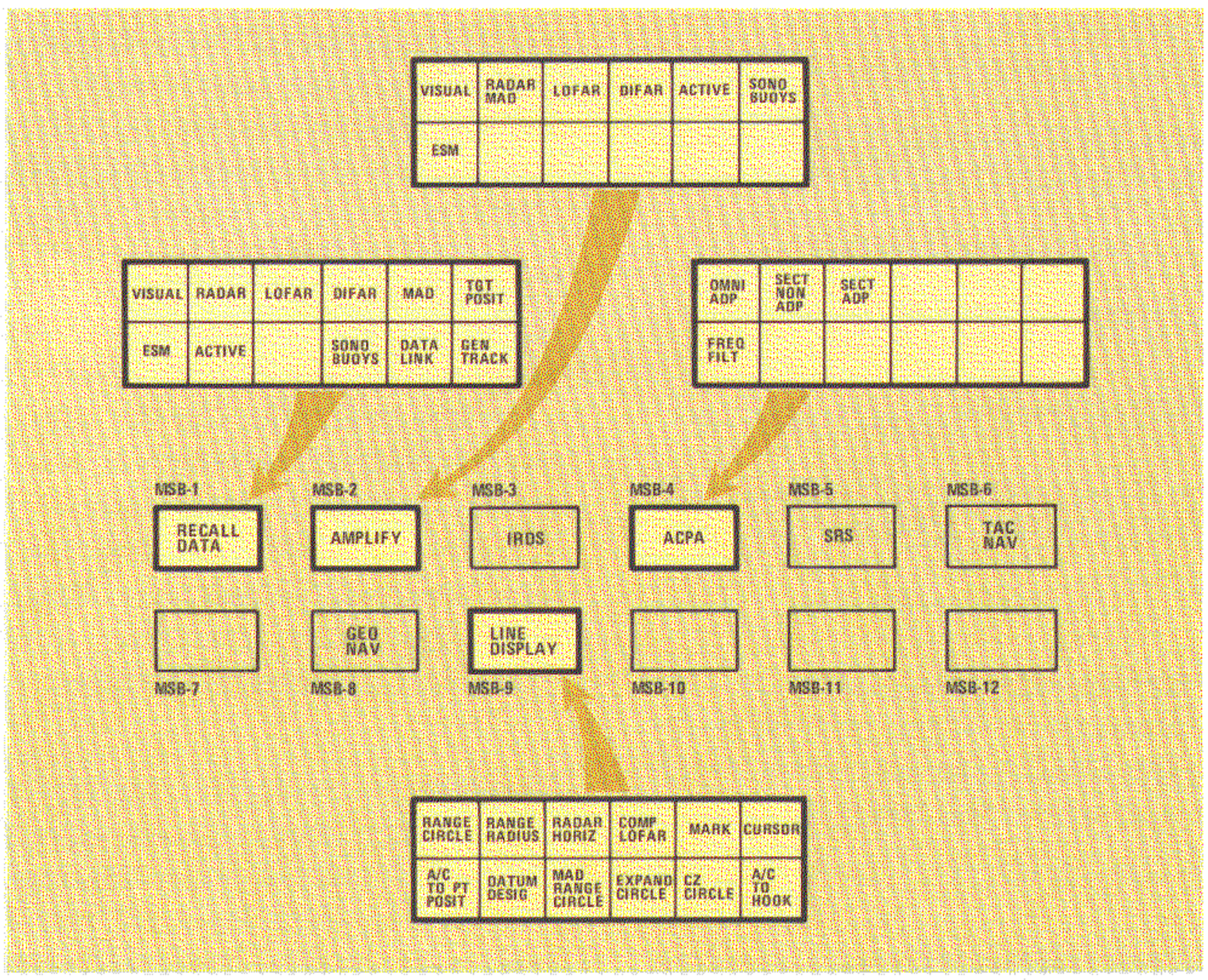


Figure 29. TACCO Station MPD Tray, Showing Matrix B Acoustic and ACPA Select-and-Readout Switch Layout

- Buoys deployed or deleted
- Buoys planned for deployment, and deletions to that list
- Adaptive Controlled Phased Array countermeasures system status

During initialization of the Tactical Computer, it will request the status of the Advanced Signal Processor. If the Advanced Signal Processor has been initialized, it will send its status to the Tactical Computer. Once communication between the two systems is established, the Advanced Signal Processor will send to the Tactical Computer such information as:

- Sensor Station 1 and 2 status
- Buoy parameters planned for the mission
- Sonobuoy Status Tableau
- Processing Status Tableau
- Status of DICASS operation
- Directory of acoustic signatures to be used during the mission

During the mission, the Advanced Signal Processor will send to the Tactical Computer such information as:

- Contact information and updates
- Current buoy noise data
- Data on the Advanced Signal Processor set-up for recovery at the ASWOC for post-mission replay

The Tactical Computer uses information on contacts to manage prosecution of the tactical problem, and to assist the TACCO to determine which contacts are real and where the target of interest is located.

Many formatted data transmissions are required to transfer this amount of information. The system operators need to know what information is being sent to them and how to use the information, but not necessarily how the data transfer takes place. Passing this much data automatically requires more effort at each end during the initial setup, but it results in significant savings of valuable time during the actual prosecution of the tactical problem.

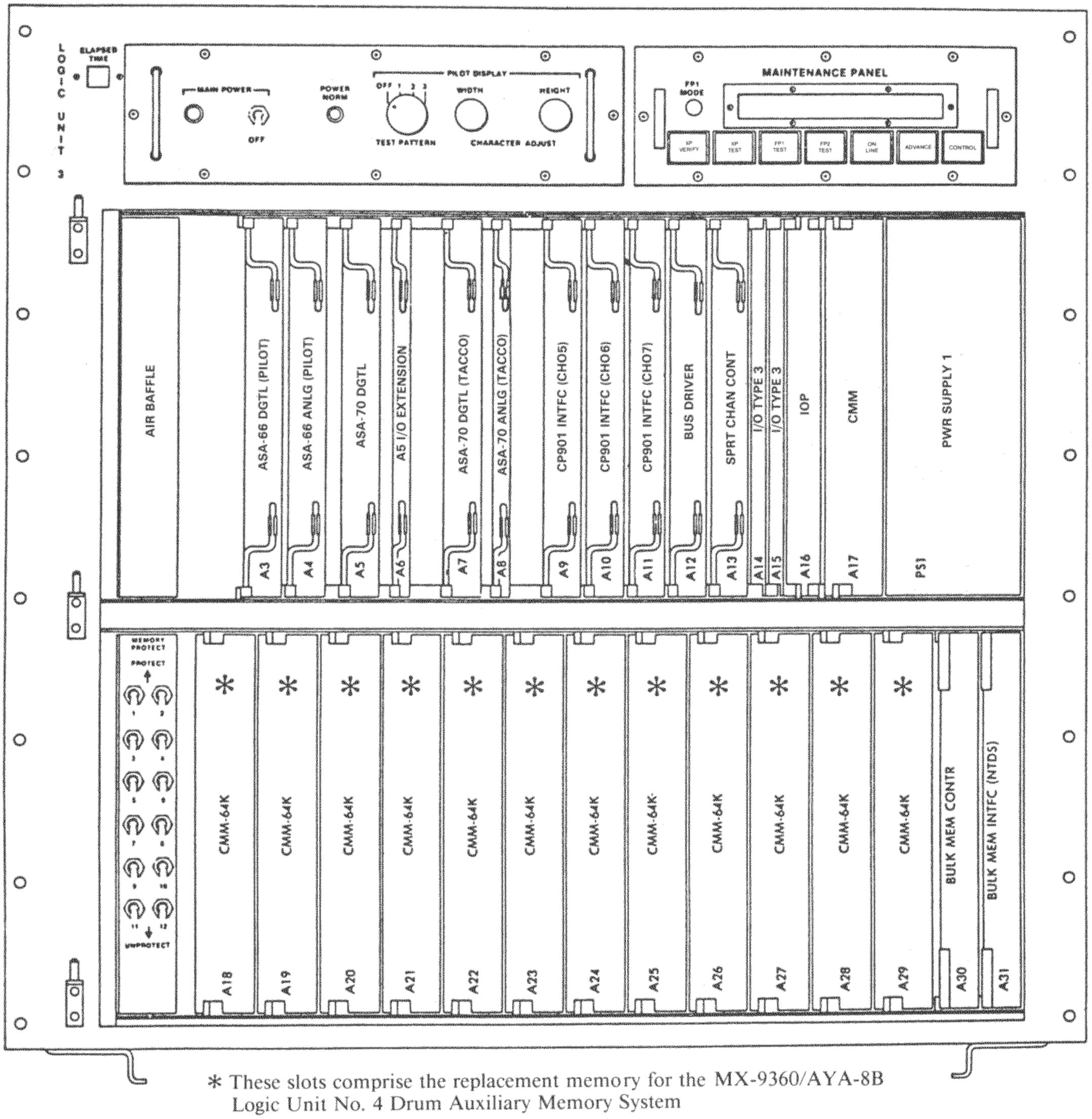
TRANSPARENT LOGIC UNITS Beginning with Update III, P-3C aircraft are being production equipped with AYA-8C logic units of improved design (Figure 30). Although not actually part of the Update III program, introduction of these new logic units coincides with that of the first P-3C Update III production aircraft, SERNO 161762. These new logic units are called "transparent logic units" (XLUs) because, as far as the tactical computer operational program and the operational interface are concerned, there is no significant functional change between the new and old logic units. Those functional changes that are apparent are maintenance functions, which are designed to enable the Flight Technician to perform his tasks more efficiently.

The change from the old to new logic units was made because components in the old logic units were becoming obsolete to the point that spares were not available. On the other hand, state-of-the-art electronics made it possible to design a logic unit system that is smaller, lighter, and uses less power. General Electric has produced a new logic unit system that requires no Tactical Computer hardware changes, and few Tactical Computer operational program changes.

The transparent logic units perform all the functions of their predecessors, have space for expansion, and have the added maintenance capability provided by their Built-In Test Equipment. The logic unit on-line testing concept remains the same – the Tactical Computer requests logic unit operational status and the individual transparent



Figure 30. AYA-8C "Transparent Logic Unit" (XLU) Installation in Electronics Rack D-1. XLU No. 2 is above and XLU No. 3 is below, XLU No. 1 (not shown) is installed in Electronics Rack D-2, behind the Tactical Computer.



* These slots comprise the replacement memory for the MX-9360/AYA-8B Logic Unit No. 4 Drum Auxiliary Memory System

Figure 31. AYA-8C Logic Unit No. 3 Slot Identification

logic unit replies to that request. Module populations in the transparent logic units are obviously different from the old logic units (Figure 31).

However, it is in the off-line testing that the transparent logic unit shines. Here, the Flight Technician can request a test, and the transparent logic unit's LED readout will inform the technician what is wrong, not only with the logic unit itself, but also with all the peripherals interfaced to the logic unit. Some changes have been made to the system test program in the Tactical Computer to implement changes in the display test patterns and other tests that have been made possible by use of the transparent logic units.

The transparent logic unit system is designed to be expandable to a Modernized Logic Unit

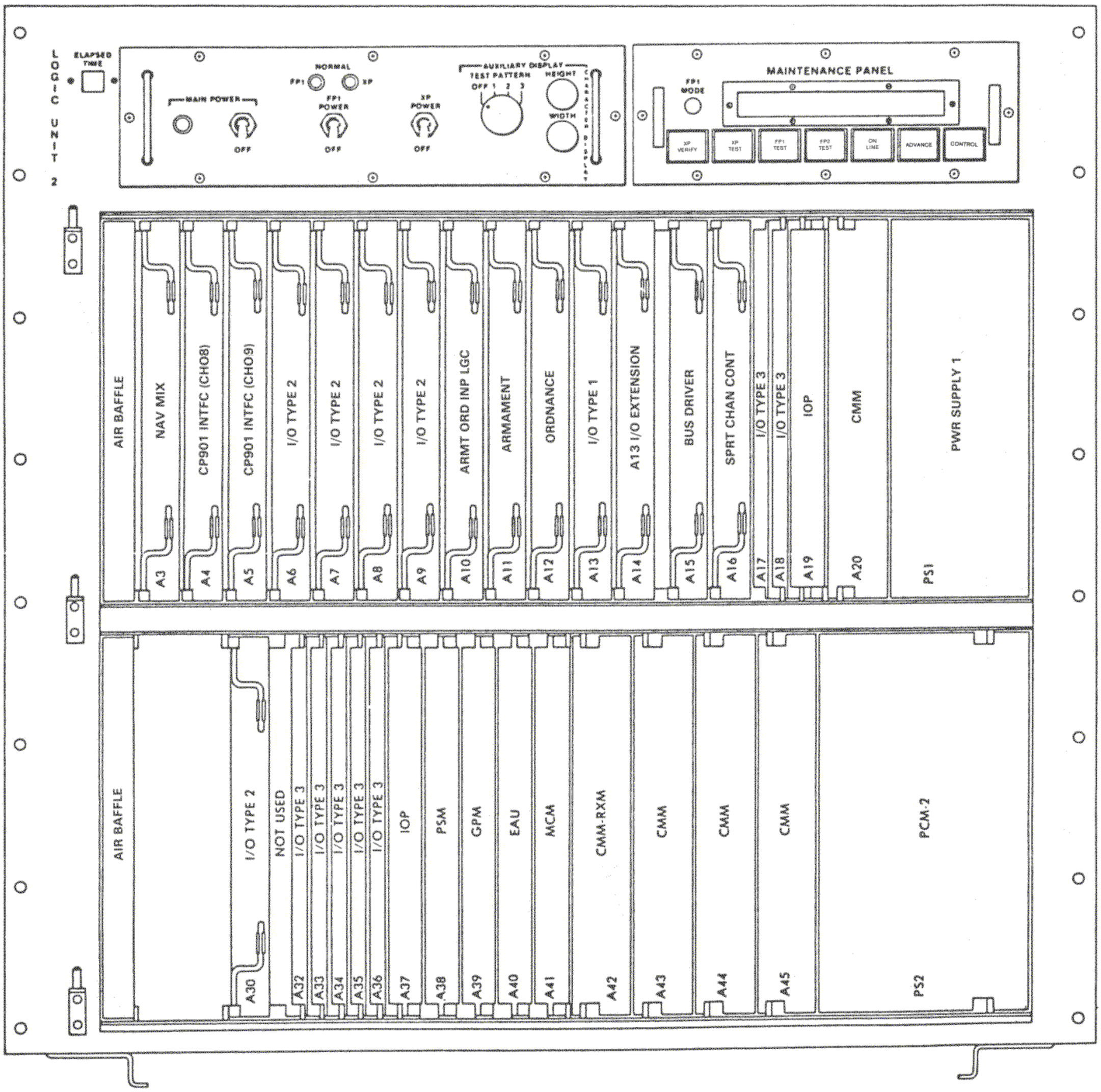


Figure 32. AYA-8C Logic Unit No. 2 Slot Identification. XLU No. 2 is shown populated with the AN/AYK-14 Standard Airborne Computer module set.

(MLU) system which will include cards from the AN/AYK-14, the Navy's standard airborne computer. Figure 32 shows XLU No. 2 populated with the AN/AYK-14 module set. In the future, the modernized logic units may become more powerful than the Tactical Computer, and it is envisioned that they will replace the Tactical Computer's functions and implement additional processing functions.

ADAPTIVE CONTROLLED PHASED ARRAY COUNTERMEASURES SYSTEM Generally, much of the interference in the sonobuoy RF channels is unintentional and not directed at the P-3. Taxicab radios, a variety of other land-based RF sources, and uncoordinated tactical buoys are examples of RF interference sources encountered during peacetime. These signal sources are usually easy to localize.

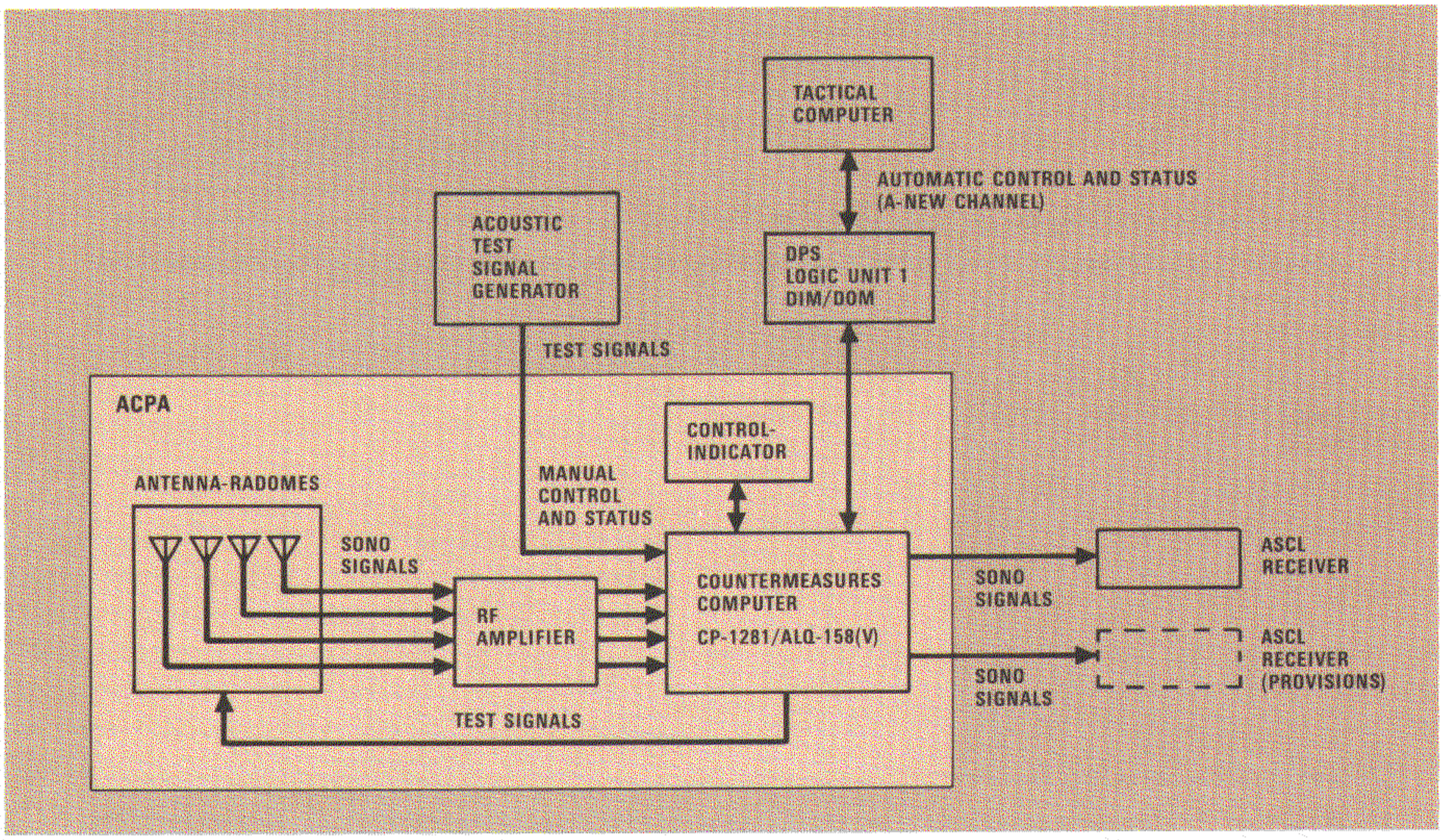


Figure 33. Adaptive Controlled Phased Array (ACPA) Countermeasures System Signal Flow Diagram

In a low level of hostilities, surface ships might deliberately jam the sonobuoy RF channels. Such jamming would be more difficult to locate, since they are mobile and could be located on one of several contacts in the search area.

The number of possible jamming situations, unintentional interference, and the range of RF channels to be protected make reception of sonobuoy RF signals difficult. The Adaptive Controlled Phased Array countermeasures system was developed to help deal with these difficulties. At the preparation date of this article, NAVAIR had not yet determined whether Update III aircraft will be delivered with the Adaptive Controlled Phased Array countermeasures system.

The Adaptive Controlled Phased Array countermeasures system (Figure 33), in conjunction with the Advanced Sonobuoy Communications Link sonobuoy receiver, replaces the ARR-72 sonobuoy receiver system. It adds receiver RF gain and a capability to null RF interference or signal jamming on the sonobuoy frequencies. The ACPA countermeasures system is automatically controlled by the TACCO via the Tactical Computer, but it can also be controlled off-line from the Antenna Control Unit at Sensor Stations 1 and 2.

Theory of Operation The Adaptive Controlled Phased Array countermeasures system offers four basic modes of operation: omni non-adaptive, sector non-adaptive, omni adaptive, and sector adaptive. These modes combine the uses of selectable beamforming (Figure 34) and spatial filters to effectively cancel RF interference and to receive the desired sonobuoy signals. Also available is an adaptive tuned notch filter, which is a very narrow-band frequency filter that can be used in any of the four basic modes.

The omni non-adaptive mode is the default operational mode of the Advanced Controlled Phased Array countermeasures system. This operational mode uses the omni-directional antenna beam in more than one direction from the aircraft, and it employs no spatial filters. The ACPA countermeasures system is "transparent" to the operators when it is functioning in this mode.

The sector non-adaptive mode also employs no spatial filters, but it uses an antenna beam that is



directed toward one of the four quadrants relative to the aircraft: fore, aft, right, or left. This directed antenna beam allows better reception of RF signals from sonobuoys deployed in one quadrant (up to 6 dB antenna gain over the omni non-adaptive mode), while it non-adaptively reduces signals from other directions (up to 20 dB). For example, this mode can be used when the aircraft is arriving on-station, with the buoys deployed in the operational area ahead of the aircraft.

The omni-adaptive mode is the most commonly used signal cancellation mode. It should be enabled when buoys are deployed in all directions from the aircraft and signal jamming is detected. This mode uses the omni-directional antenna beam along with one, two, or three activated spatial filters. Once a jamming source is located and "hooked" by the TACCO, navigational inputs from the Tactical Computer will select the spatial nulling beam towards the jamming source, and the Adaptive Controlled Phased Array countermeasures system will automatically steer the null as the aircraft maneuvers. This mode is best employed when the jamming source and the source of desired RF signals can be isolated into different quadrants.

The fourth basic operational mode is called the sector adaptive mode. It employs both directional beam forming and active spatial filters. This mode is best used when all the buoys of interest are in one quadrant and the jamming sources are in another. Although up to three spatial filters can

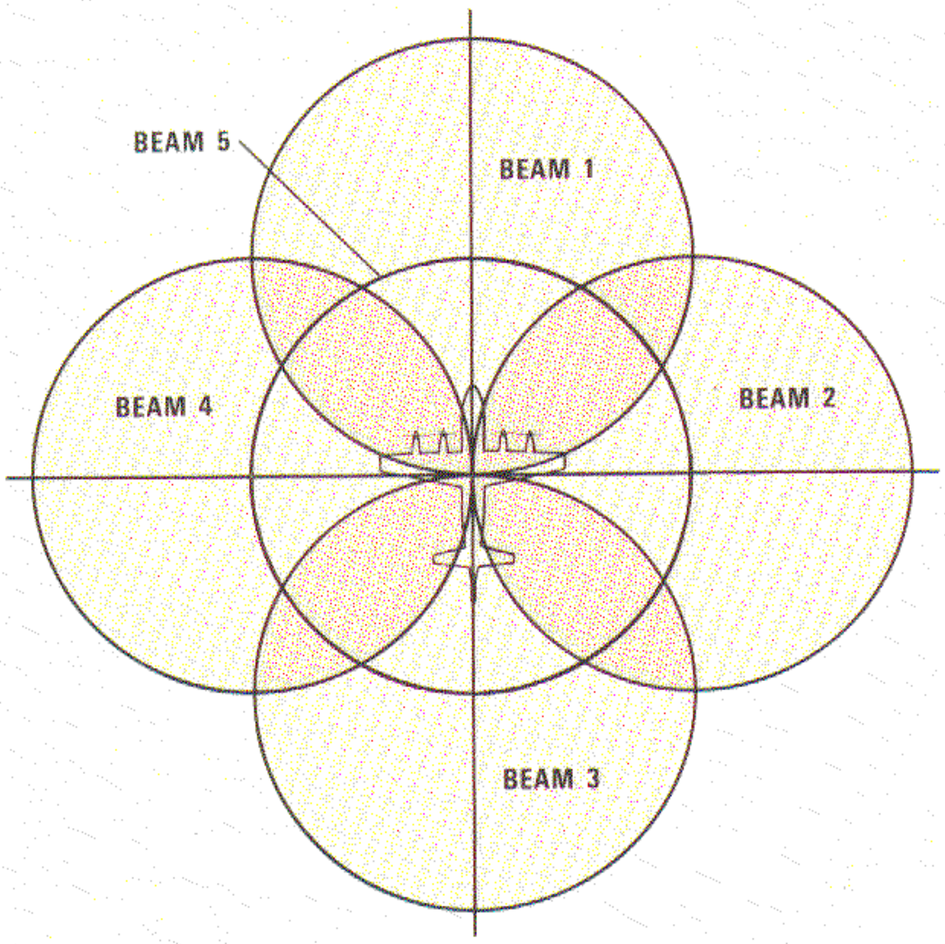


Figure 34. ACPA Countermeasures System Selectable Beam Patterns (View From Above Aircraft)

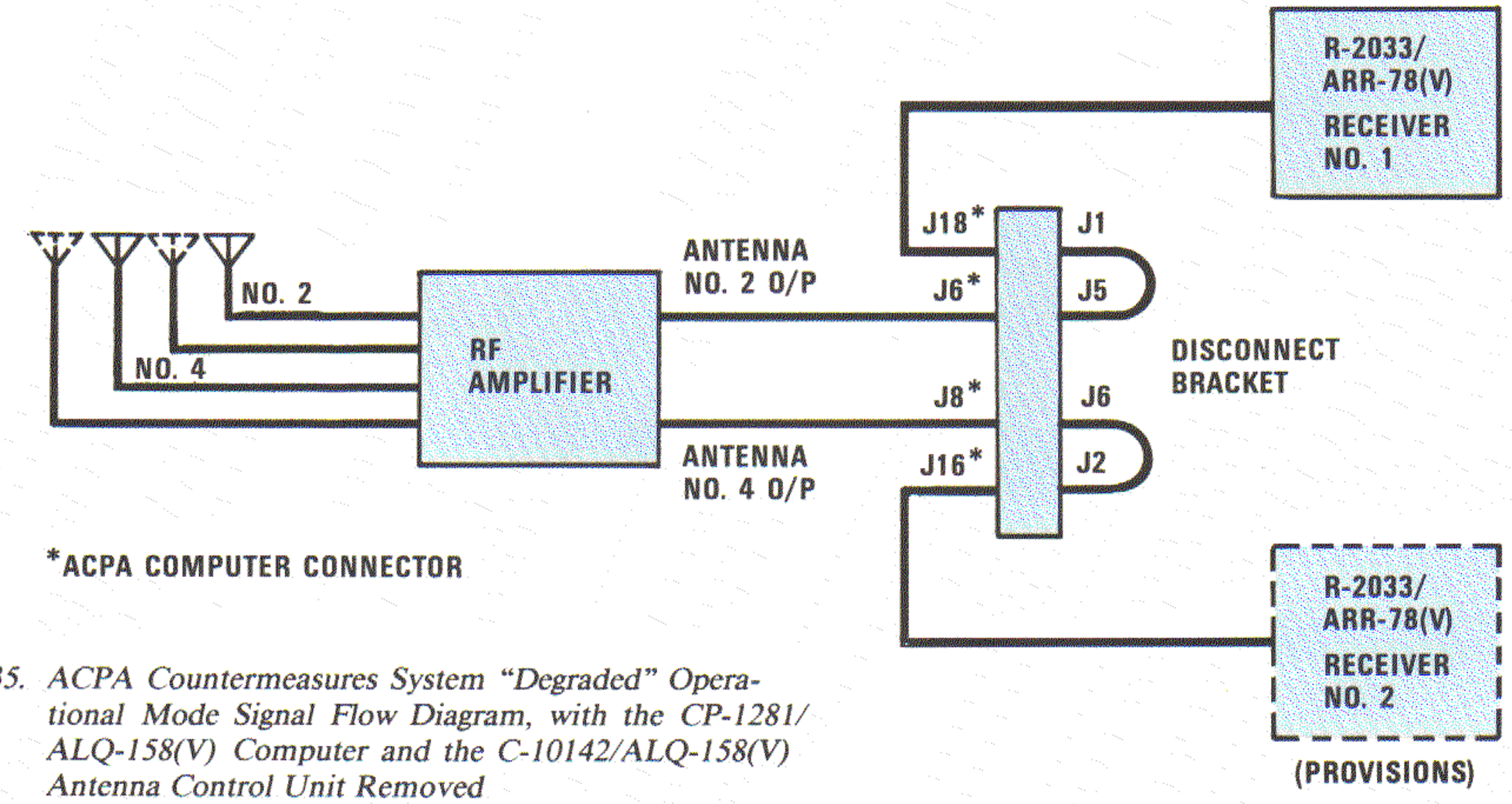


Figure 35. ACPA Countermeasures System "Degraded" Operational Mode Signal Flow Diagram, with the CP-1281/ALQ-158(V) Computer and the C-10142/ALQ-158(V) Antenna Control Unit Removed

be used when the Adaptive Controlled Phased Array countermeasures system is controlled manually, software limits the TACCO to using just one spatial filter at a time. Automatic control, however, allows the ACPA countermeasures system's beams to be selected by the Tactical Computer, and spatial nulls to be steered by the ACPA countermeasures system.

The adaptive tuned notch filter can be used in all four modes of system operation. When in use, the adaptive tuned notch filter cancels any narrow bandwidth signal that exceeds a specified amplitude. This frequency filter is omni-directional. It can be tuned to a fixed frequency or programmed to scan a selected bandwidth. When in the scan mode, the notch filter will scan the preselected bandwidth until it locks onto an interfering signal above the specified amplitude "threshold". If the interfering signal changes frequency, the notch filter will resume its bandwidth scan and reacquire the interfering signal.

Figure 35 shows the Update III equipped with the ACPA bypass circuit, in which the CP-1281/ALQ-158(V) Computer and the C-10142/ALQ-158(V) Antenna Control Unit are removed. Antennas Nos. 1 and 3 are also removed, with antenna No. 2 feeding signals directly to the Advanced Sonobuoy Communication Link receiver No. 1, and antenna No. 4 feeding into the antenna circuit for provisional ASCL receiver No. 2. In this degraded mode, ASCL receiver No. 1 operates in an omnidirectional mode, without use of any anti-jamming techniques.

Built-In Test Equipment The Adaptive Controlled Phased Array countermeasures system has an extensive built-in test capability. Under manual control, one can run the preflight built-in-test program through the Antenna Control Unit (ACU) located at Sensor Stations 1 and 2. This will test all of the ACPA countermeasures system components sequentially, including the antenna radomes, the preamp, the SRA modules in the computer, and the ACU. One can also test the system components individually through the ACU by entering the test command of the desired component. The third available antenna system test option is through the Tactical Computer system test program.

Hardware The Adaptive Controlled Phased Array countermeasures system consists of:

- Four AS-3153/ALQ-158(V) antenna radomes
- One AM-6878/ALQ-158(V) RF amplifier
- One C-10142/ALQ-158(V) Control-Indicator (also called the Antenna Control Unit)
- One CP-1281/ALQ-158(V) Countermeasures Computer

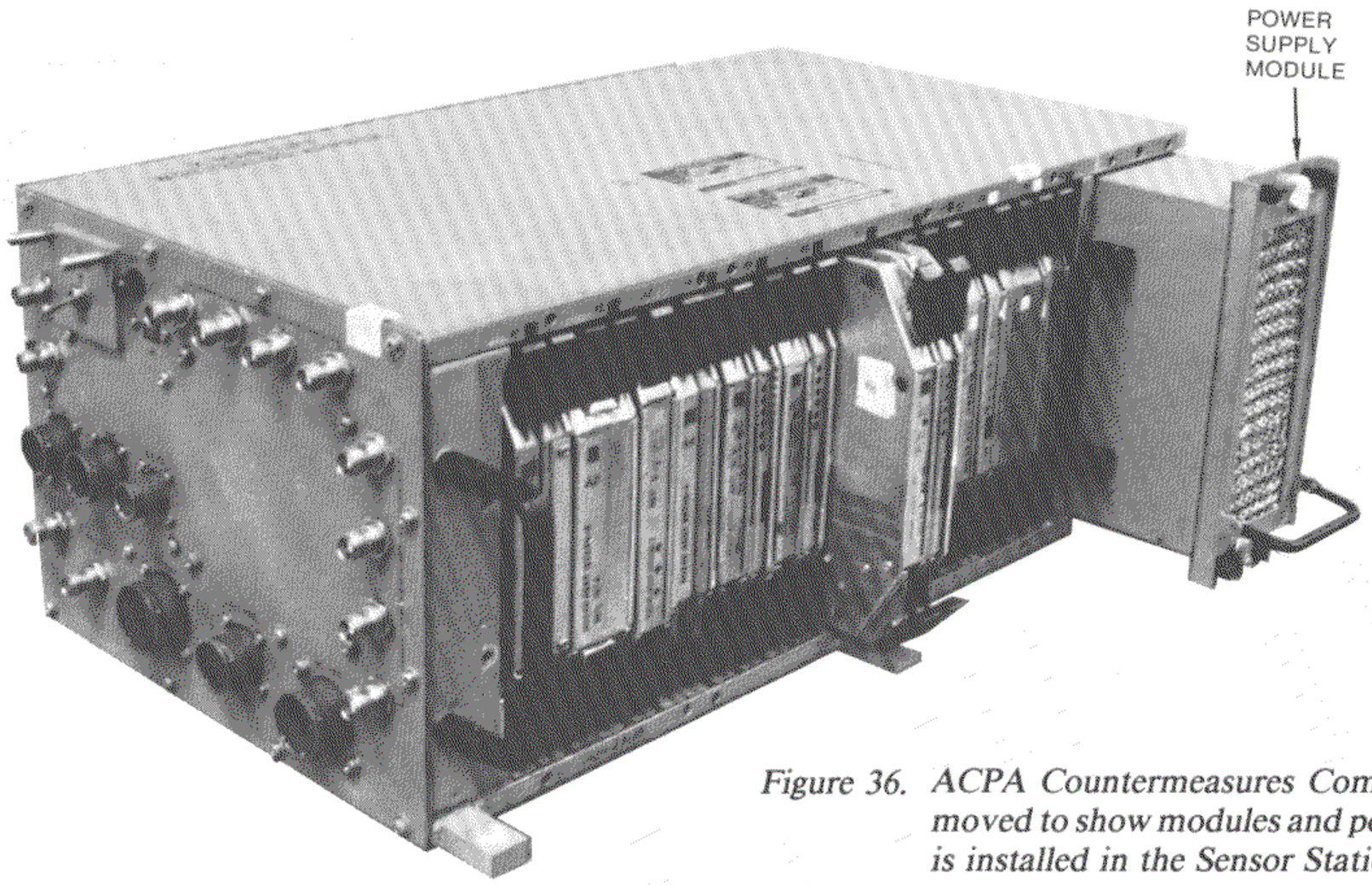


Figure 36. ACPA Countermeasures Computer. Access panel is removed to show modules and power supply. The computer is installed in the Sensor Station No. 2 lower console.

The Countermeasures Computer Unit (Figure 36) performs all the functions of beam forming, spatial nulling, built-in test, bandwidth preselection, and interface with the Tactical Computer. This modular computer is installed at floor level in the lower Sensor Station 2 console. Table IV lists the Countermeasures Computer Unit modules.

The Antenna Control Unit (Figure 37) is located in the Sensor Stations 1 and 2 overhead console.

TABLE IV. Adaptive Controlled Phased Array Countermeasures Computer Module Identification

MODULE	FUNCTION
A1	Input/Output Module
A2	Preselector Module
A3	BITE Module
A4	Microwave Front End (MWFE) Module
A5	Control Loop Module 1 (Spatial Filter)
A6	Control Loop Module 2 (Spatial Filter)
A7	Control Loop Module 3 (Spatial Filter)
A8*	Control Loop Module 4 (Spatial Filter)
A9	Main Channel Module
A10	Adaptive Tuned Notch Filter (ATNF) Module 1
A11*	Adaptive Tuned Notch Filter (ATNF) Module 2
A12	Reference Generator Module
A13	Power Supply Module

* ACPA Countermeasures Computer Unit is delivered less Modules A8 and A11 (dummy modules are installed).

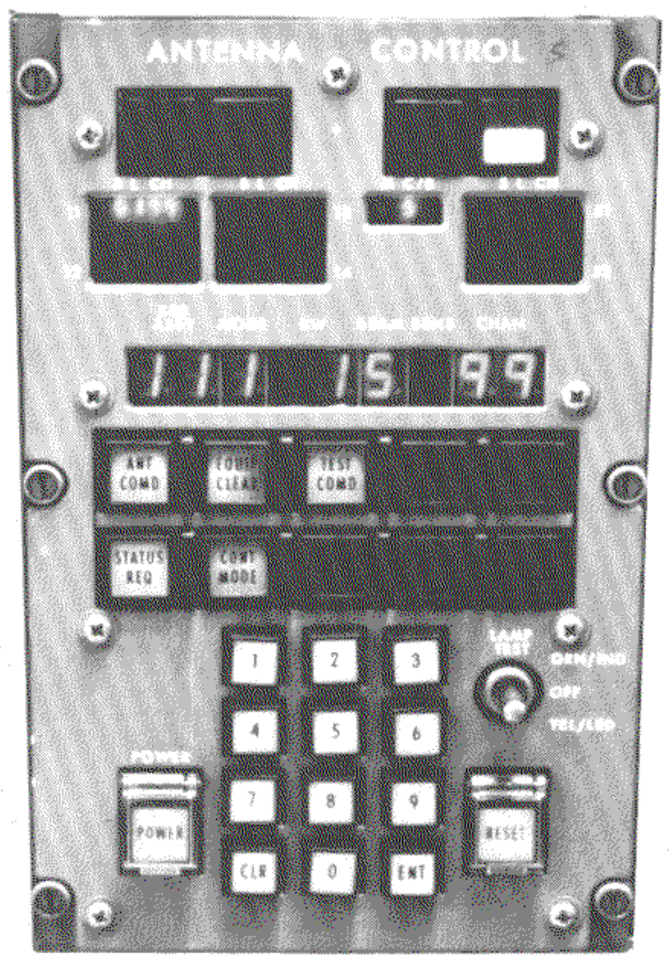


Figure 37. ACPA Countermeasures System Antenna Control Unit

It is the means by which the Adaptive Controlled Phased Array countermeasures system can be controlled off-line. Although primary operation of the ACPA countermeasures system is automatic through the Tactical Computer, the ACU displays the status of all important ACPA system functions, whether it is in manual or automatic control.

The system's four antennas are located on the belly of the aircraft and are arrayed in a diamond



Figure 38.
ACPA Countermeasures System Antenna Installation on Aircraft Lower Fuselage

shape (Figure 38). The RF amplifier interfaces the Countermeasures Computer with the antennas, using sets of carefully matched coaxial cables; it also allows external test signals sent from the Acoustic Test Signal Generator to the four antennas to feed back into the Countermeasures Computer and the Advanced Sonobuoy Communication Link receiver.

Operation by the TACCO The TACCO exercises main control of the Adaptive Controlled Phased Array countermeasures system. Currently, the Tactical Computer will only recognize sonobuoy channels 1 through 31. The ACPA countermeasures system itself will operate on all 99 channels. Update III adds a matrix select switch for the ACPA countermeasures system, and four matrix readout switches: OMNI ADP, SECT NON ADP, SECT ADP, and FREQ FILT.

The omnidirectional non-adaptive mode is the default mode of the Adaptive Controlled Phased Array countermeasures system. This mode can be entered by taking no action, or by deselecting any of the other ACPA countermeasures system switches. In this mode, there is no spatial filtering, and the whole sonobuoy antenna system operates as do the sonobuoy antenna systems in earlier P-3C aircraft.

When the omnidirectional adaptive mode (OMNI ADP) is selected, it will cancel up to three interfering signals by steering a nulling beam with spatial filters. In this mode, the source of the interfering signals must either have its position hooked or the TACCO must input its latitude and longitude to the Tactical Computer. Once the location of the jamming source has been hooked or entered, the operator must select the RF bandwidth to be nulled. If he selects wide bandwidth, he is done with that operational sequence. If the operator selects narrow bandwidth, he must enter the sonobuoy RF channel that he wants nulled. He can then select decision switches to remove jamming sources, add jamming sources, or terminate operation in the OMNI ADP mode. During operation in the OMNI ADP mode, the Tactical Computer will keep track of the hooked positions of the interfering signals, and it will automatically direct the use of the correct countermeasures system antenna beam. The Adaptive Controlled Phased Array countermeasures system will automatically steer the antenna null toward the interfering signal as the aircraft maneuvers.

During operation in the sector non-adaptive mode (SECT NON ADP), the TACCO can select the quadrant from which he wants to receive RF signals, and the Adaptive Controlled Phased Array countermeasures system will non-adaptively reduce RF signals received from other quadrants. The TACCO will be cued for the "hook" position of the sector that contains the RF signal source of interest, and the ACPA countermeasures system

will automatically steer the directional antenna beam toward that sector as the aircraft moves.

In the sector adaptive mode (SECT ADP), the TACCO can choose to employ the Adaptive Controlled Phased Array countermeasures system to improve directional listening, or he can choose to cancel a single jamming signal. As during operation in the sector non-adaptive mode, the TACCO must choose the area of interest by hooking the data transmission source of interest. He must then choose whether he wants to use a wide-band filter or a narrow-band one, and (if appropriate) the narrow-band channel that he wants to cancel.

By activating the FREQ FILT or adaptive tuned notch filter, the TACCO can cancel any narrow-band jamming source within a channel bandwidth. After selecting FREQ FILT, the TACCO enters the signal amplitude threshold level, then selects either the fixed-frequency mode or scan mode. If the fixed-frequency mode is selected, then an RF channel must be entered. If the TACCO selects the scan mode, then the scan bandwidth must be selected. The only operational limitation to the adaptive tuned notch filter is that it cannot be applied to a channel on which an active spatial filter is in use.

The Adaptive Controlled Phased Array countermeasures system is the first sonobuoy receiver anti-jamming system that has been installed on production P-3 aircraft. It offers a variety of resources to help the P-3C Update III flight crew cope with RF signal jamming situations, whether the interference is intentional or not.

ADVANCED SONOBUOY COMMUNICATION LINK RECEIVER SYSTEM The Advanced Sonobuoy Communication Link receiver system consists of a Radio Receiver Set, a Receiver Control/On-Top Position Indicator, a Control-Indicator, an RF Amplifier, and a Receiver Indicator. The Radio Receiver Set accepts RF signals from the Adaptive Controlled Phased Array countermeasures system, amplifies and demodulates the signals, and passes the demodulated signals to the Advanced Signal Processor Analyzer Unit. The Radio Receiver Set also produces signals that are displayed by the Receiver Indicator and the Control-Indicator to indicate sonobuoy RF signal levels. The ASCL receiver system flow is shown in Figure 39.

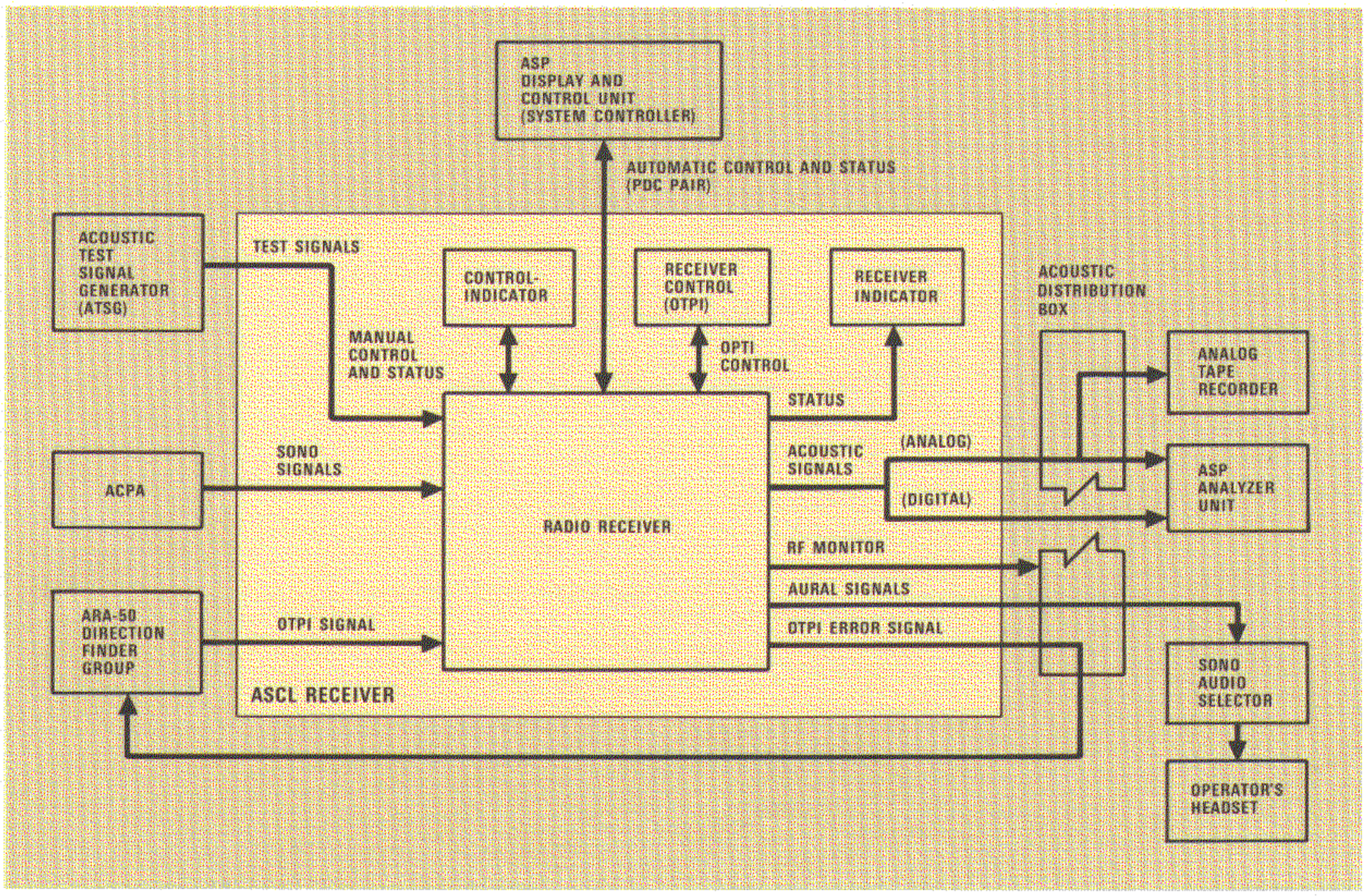


Figure 39. Advanced Sonobuoy Communication Link (ASCL) Receiver System Signal Flow Schematic



Detail "A."

The AN/ARR-78 Advanced Sonobuoy Communication Link receiver set is a 20-channel radio receiver system designed to detect the RF signals transmitted by sonobuoys now in use and those that are in development for future deployment. Sixteen channels are available for receiving acoustic information for the Advanced Signal Processor, and four channels are dedicated to auxiliary functions. Four of the acoustic channels have provisions for supplying digital frequency-shift-keyed (FSK) output to the Advanced Signal Processor. Each channel is an individual radio receiver that can be tuned to any one of the 99 sonobuoy operating frequencies.

One ASCL receiver set is shared by the two acoustic sensor stations. The ASCL receiver set and an AQH-4(V)2 Analog Tape Recorder are installed in Electronics Rack E-2 (Figure 40), which also has provisions for a second ASCL receiver set and a second Analog Tape Recorder.

The On-Top Position Indicator channel is one of the four auxiliary receiver channels. OTPI RF signals from the AN/ARA-50 Direction Finder Group are processed by the OTPI channel receiver, and the resulting audio output is used for automatic control of the Direction Finder Group. OTPI operation is controlled by either the copilot (with the Receiver Control/OTPI) or the acoustic sensor operator (with the Control-Indicator).

The remaining three auxiliary channels are assigned as follows:

- One channel contains provisions for monitoring RF signal levels on any of the sonobuoy frequencies

- Two channels provide aural signals to the acoustic sensor operators and the TACCO for passive acoustic signal monitoring.

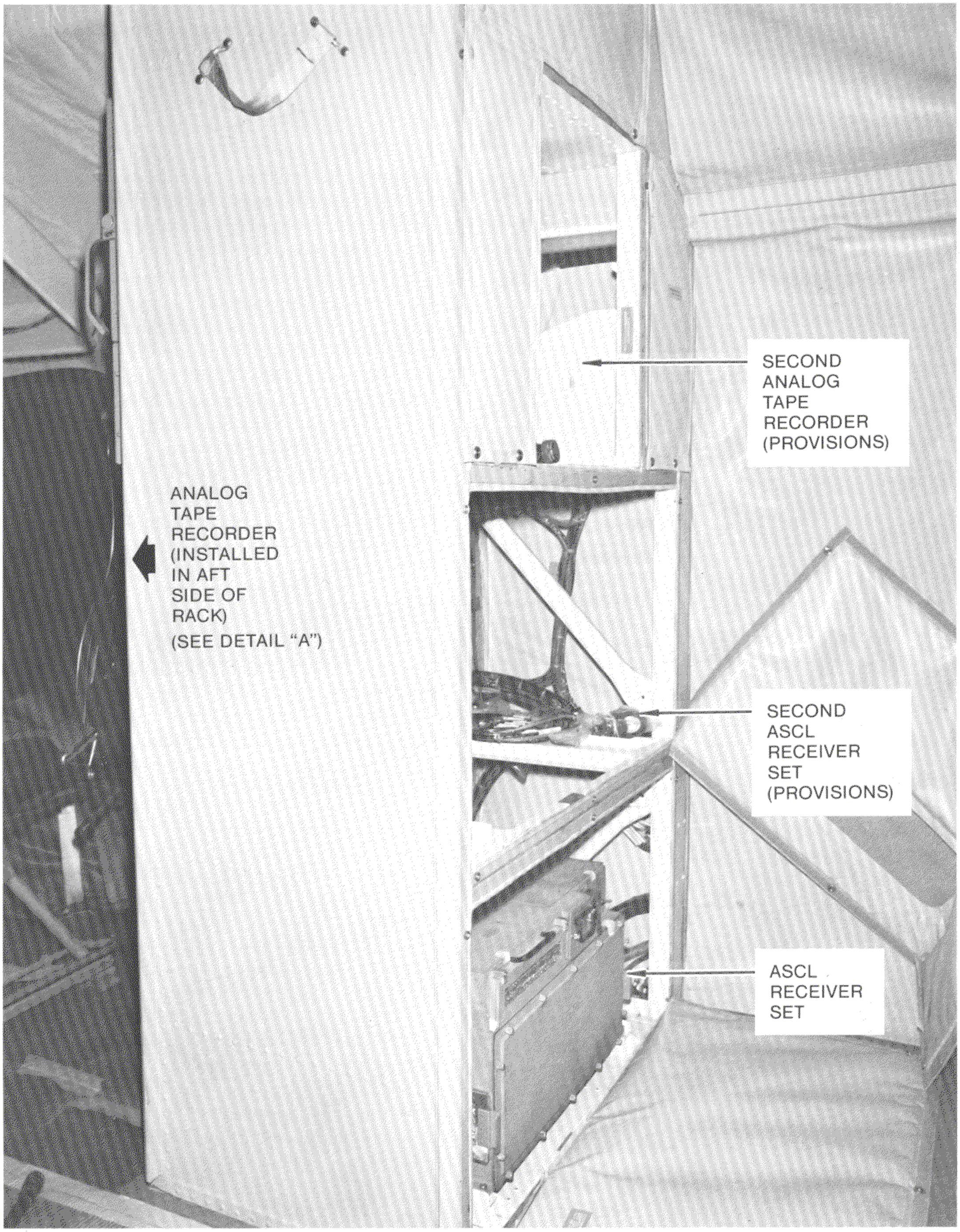


Figure 40. ASCL Receiver Set and AQH-4(V)2 Analog Tape Recorder Installation in Electronics Rack E-2. Figure also shows provisions in Electronics Rack E-2 for a second ASCL Receiver Set and a second Analog Tape Recorder.

The Advanced Sonobuoy Communication Link receiver routinely operates in the automatic mode under control of the Advanced Signal Processor's Display and Control Unit, but it can also be operated in the manual mode.

Controls and Displays The Advanced Sonobuoy Communication Link receiver system includes three units that provide manual control and/or display the operational status of the ASCL receiver set: the Control-Indicator, the Receiver Indicator, and the Receiver Control/OTPI.

The Control-Indicator (Figure 41) at Sensor Station 1 is the primary manual control for the Advanced Sonobuoy Communication Link receiver set. It controls the application of power to the ASCL receiver set and has additional controls that enable the operator to select and program each of the receiver set's 20 receivers. Programming consists of assigning a sonobuoy RF channel (1 to 99) and a sonobuoy type (e.g., AN/SSQ-41) to a selected receiver. Programming automatically sets the selected receiver to a center frequency, bandwidth, demodulation mode (FM or FSK-provisions), digital decode and clock frequency (provisions-FSK sonobuoys) appropriate to the sonobuoy signal to be processed by the selected receiver.

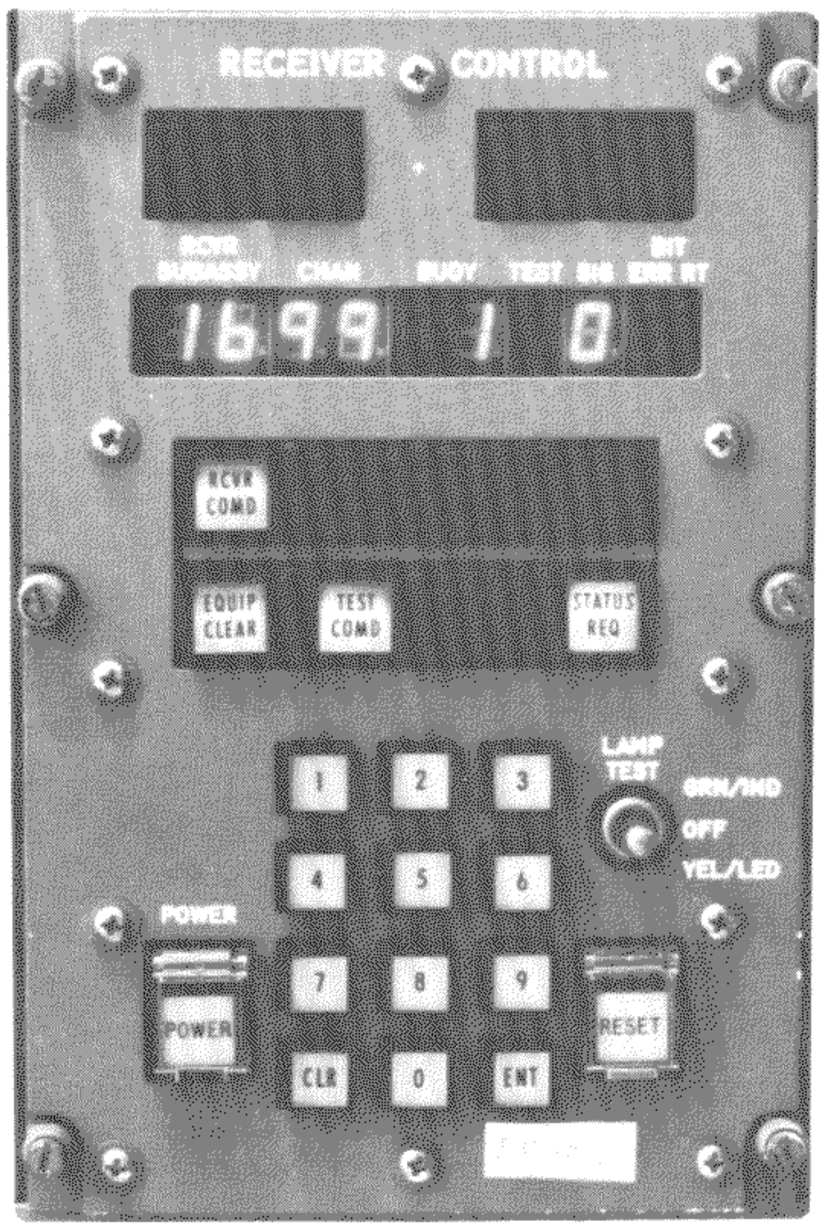


Figure 41. ASCL Receiver Control-Indicator

The Control-Indicator also enables the operator to select manual or automatic control for each receiver, to display the status of each receiver (sonobuoy RF channel, sonobuoy type, signal level), and to initiate tests to determine the operational readiness of the Advanced Sonobuoy Communication Link receiver set.

The Receiver Control/OTPI in the flight station provides manual control of only the OTPI receiver (Figure 42). This control enables the copilot to select the OTPI receiver, and to tune the selected receiver to any one of the 99 sonobuoy operating channels. An indicator light on the panel illuminates when the RF signal strength of the selected channel is adequate for the OTPI function. Until deselected, the copilot-selected OTPI receiver cannot be controlled by the acoustic sensor station operators' Control-Indicator or by the Advanced Signal Processor Display and Control Unit.

The Receiver Indicator at Sensor Station 1 continuously displays the status of all 20 receivers simultaneously (Figure 43). The LED display associated with each receiver (1 through 20) indicates the control mode (manual or automatic), the RF signal level (not displayed for the OTPI receiver), and the sonobuoy RF channel for that receiver.

The Advanced Sonobuoy Communication Link receiver set can be controlled automatically by the system controller function of the Advanced Signal Processor Display and Control Unit. In the automatic control mode, the ASP Display and Control Unit is interconnected with the ASCL receiver set by a Proteus Digital Channel pair. The PDC pair establishes a two-way data channel that enables the Display and Control Unit to send control instructions to the ASCL receiver set, and allows the ASCL receiver set to return operating status information to the Display and Control Unit.

Although all 20 receivers are initialized to automatic control at power turn-on, the acoustic sensor station operator can override automatic con-

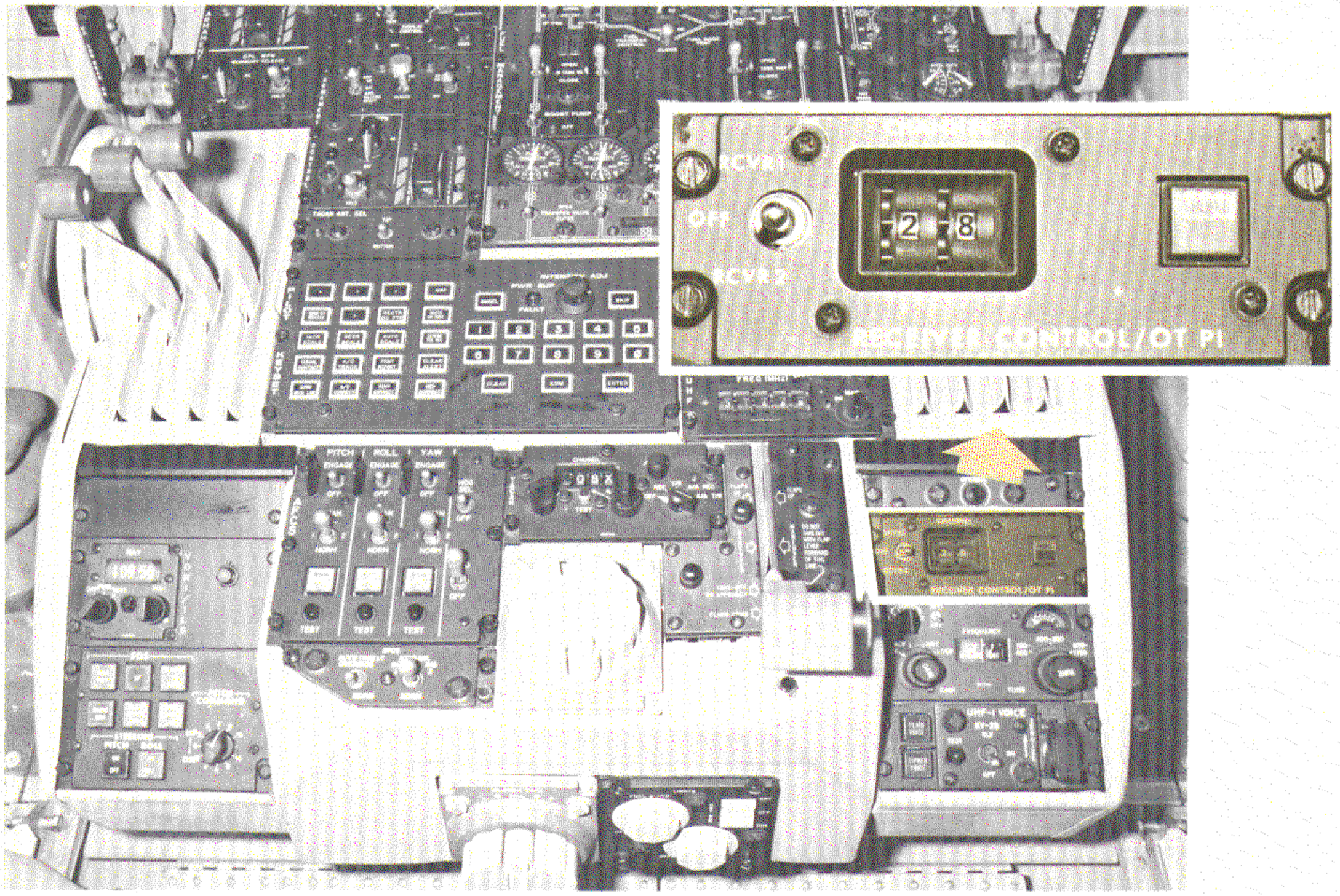


Figure 42. ASCL Receiver Control/OTPI Installation on Copilot's side of Flight Station Center Control Stand

trol for any one or more receivers by entering control instructions at the Control-Indicator.

The selected receiver(s) will remain in the manual control mode until the acoustic sensor station operator chooses to return the receiver(s) to automatic control.

ACOUSTIC TEST SIGNAL GENERATOR The SG-1156/A Acoustic Test Signal Generator is a manually-controlled, precision signal source that simulates passive and active sonobuoy signals. It provides test signals to the Adaptive Controlled Phased Array countermeasures set, the ACPA antennas, and the Advanced Sonobuoy Communication Link receiver set to permit end-to-end and intermediate testing of the Sensor Station 1 and 2 acoustic systems.

The Acoustic Test Signal Generator external test output is normally transmitted to the ACPA antennas through the new UHF-2 Lower Antenna installed on the aircraft belly at Fuselage Station

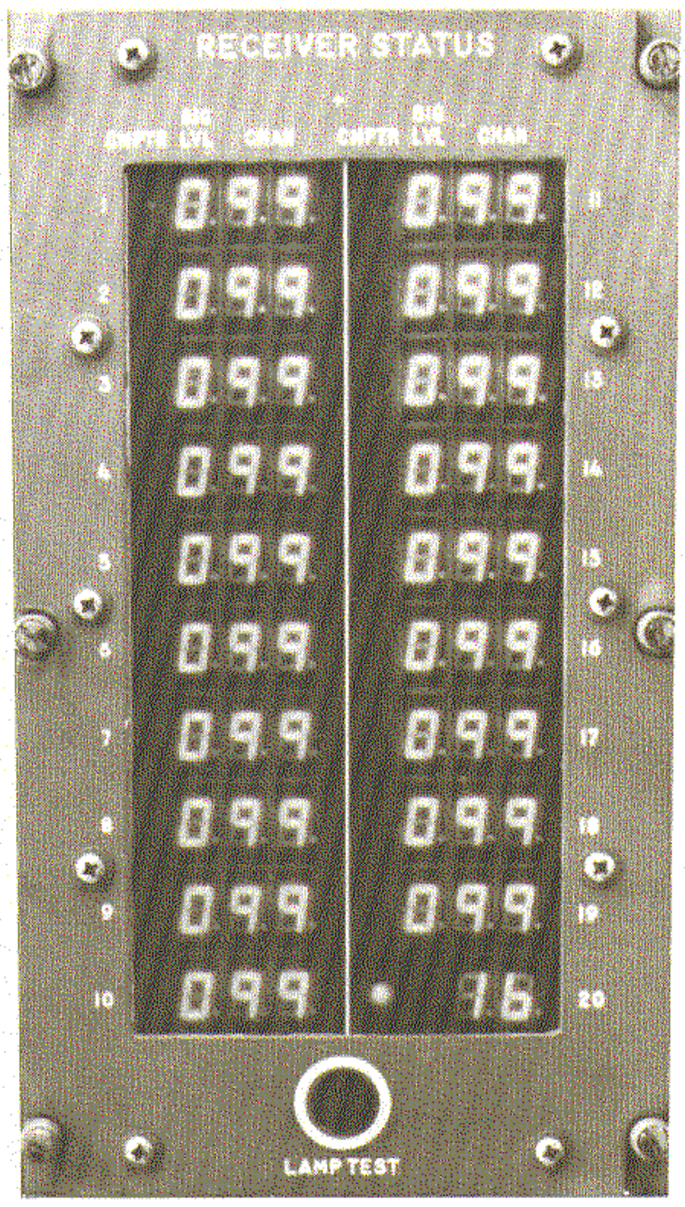


Figure 43. ASCL Receiver Indicator

1007. The ATSG external test output is switched to the existing UHF-2 tail cap antenna whenever the NAV/COMM operator selects the UHF-2 Lower Antenna for dedicated UHF-2 operation.

The Acoustic Test Signal Generator is a single-unit equipment. It is located between Sensor Stations 1 and 2, permitting either operator to select the type, amplitude, sonobuoy channel, and destination of the test signals.

The Acoustic Test Signal Generator has 15 modes of operation, all of which can be selected by the operator. Two of these are external modes (one analog and one digital) which are used when the baseband modulation signal originates in sources external to the ATSG. The remaining 13 modes are internal modes that use baseband modulation signals generated internally in the ATSG. Table V lists the ATSG operating modes.

The baseband modulation signals are used to modulate an internally generated RF signal that the operator can set to any one of the 99 sonobuoy channel frequencies. The modulated RF signal simulates a sonobuoy signal. The particular sonobuoy signal simulated is determined by the test mode selected.

TABLE V. Acoustic Test Signal Generator Operating Modes

MODE POSITION	SONOBUOY SIGNAL SIMULATED
1. EXT ANALOG	Determined by External Modulation Signal Source
2. DIFAR	AN/SSQ-53
3. LOFAR	AN/SSQ-41
4. DEMON	Demodulated Noise
5. RO	AN/SSQ-47
6. CASS CW	AN/SSQ-50
7. CASS FM UP	AN/SSQ-50
8. CASS FM DOWN	AN/SSQ-50
9. DICASS CW	AN/SSQ-62
10. DICASS FM UP	AN/SSQ-62
11. DICASS FM DOWN	AN/SSQ-62
12. BT 1	AN/SSQ-36
13. BT 2	AN/SSQ-36
14. FSK EXTERNAL	Determined by External Modulation Signal Source
15. FSK INTERNAL	To Be Determined – Advanced Digital Array – Type Sonobuoys

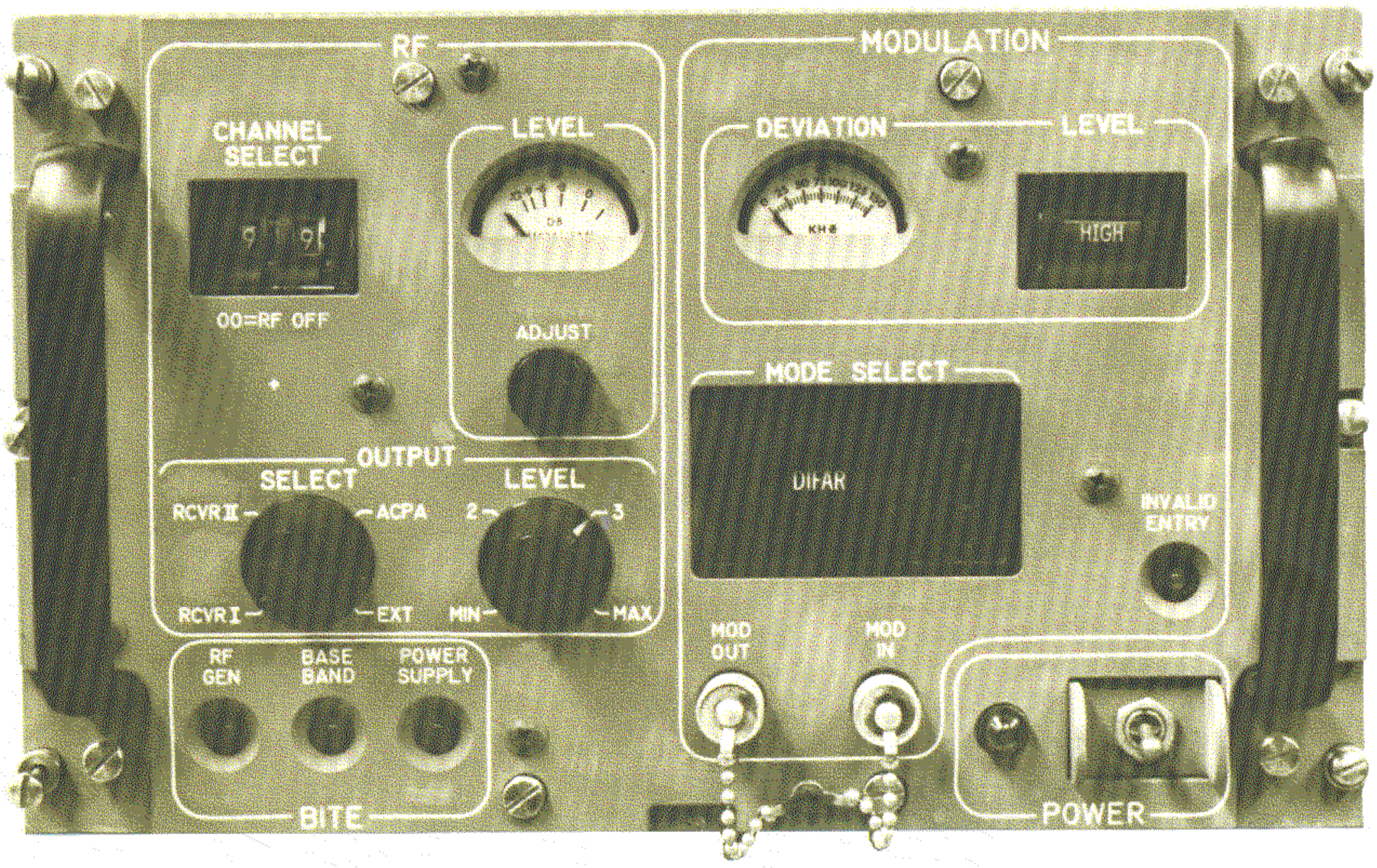


Figure 44. Acoustic Test Signal Generator

Controls and Indicators All Acoustic Test Signal Generator controls are located on the front panel of the set (Figure 44). These controls enable the Sensor Station 1 and 2 operators to select the operating mode, modulation level (high or low), RF channel (1 to 99), output level (1 of 4), and output signal destination (1 of 4). Two meters on the ATSG front panel provide the operator with test signal RF level and modulation indications. Three BITE lamps inform the operator of malfunctions in the RF Generator, Baseband Generator, and Power Supply functions of the ATSG. An Invalid Entry lamp alerts the operator to an invalid combination of control settings.

Lockheed ORION Service Digest

SUMMARY OF P-3C UPDATE III AVIONICS IMPROVEMENTS

- Complete digital signal processing, including Fast Fourier Transform (FFT) techniques
- Fully programmable and micro-programmable processors can be changed as new sensors become available and mission objectives change
- Micro-programmable sub-controllers in the hardware can be changed, based on mission and objectives
- Twice as effective as the Update II-1/2 acoustic system
- Increased acoustic sensitivity by 4 db
- More verniers available, with flexibility for simultaneous broadband and sensor processing
- All processing is continuous, regardless of what is being displayed
- Built-in automatic detection capability
- Same number of receive and processing channels, with growth to double the current number
- 99 RF channel-capability in the acoustic processor
- Provisions for anti-jamming capability in the countermeasures/antenna system
- Contact classification assistance built into the acoustic processor
- Higher and faster resolution of DIFAR bearings
- Automatic receiver control in the acoustic system
- More DICASS processing capacity, with provisions for double capacity
- Provisions for Advanced Digital Array Sonobuoy Processing
- Commonality of parts within the Navy supply system
- Commonality of parts within Navy acoustic processors
- Increased Mean-Time-Between-Failures and reduced Mean-Time-to-Repair

ENVIRONMENTAL CONTROL SYSTEM DESCRIPTION

The P-3C Update III Environmental Control System (ECS) has the following functions: to supply and circulate fresh air throughout the pressurized areas of the aircraft; to regulate the temperature, humidity, and air pressure in the cabin and flight station; and to provide an adequately cool avionic equipment environment.

The Environmental Control System performance is based on a maximum avionics heat load (including flight station instruments and electrical load centers) of 30 kW. The objective is to limit the average avionics exhaust temperature to 110° F. However, in no case should the exhaust temperature exceed the following values during normal ECS operation with both engine driven compressors functioning at normal engine rpm.

- Retained UPDATE II Equipment
  - 14 Racks 131°F
- ASP - Rack E-1 120°F
- New Equipment - Racks D-3 and H-1/H-2 128°F
- Average Avionics Exhaust 116°F

The design crew load is 10 people. The cabin and flight station temperatures using EDCs at normal engine rpm are within the comfort zone of 60°F to 80°F (as defined in MIL-P-18927) from sea level to 30,000 feet of altitude, and through the outside ambient temperature range of a MIL-STD-210A military standard "hot" day to a military standard "cold" day.

High pressure air for air conditioning during static ground operation can be supplied to the aircraft's Environmental Control System by the GTCP 95-3 Auxiliary Power Unit (Figure 45), which is set for a maximum exhaust gas tempera-

Courtesy The Garrett Corporation

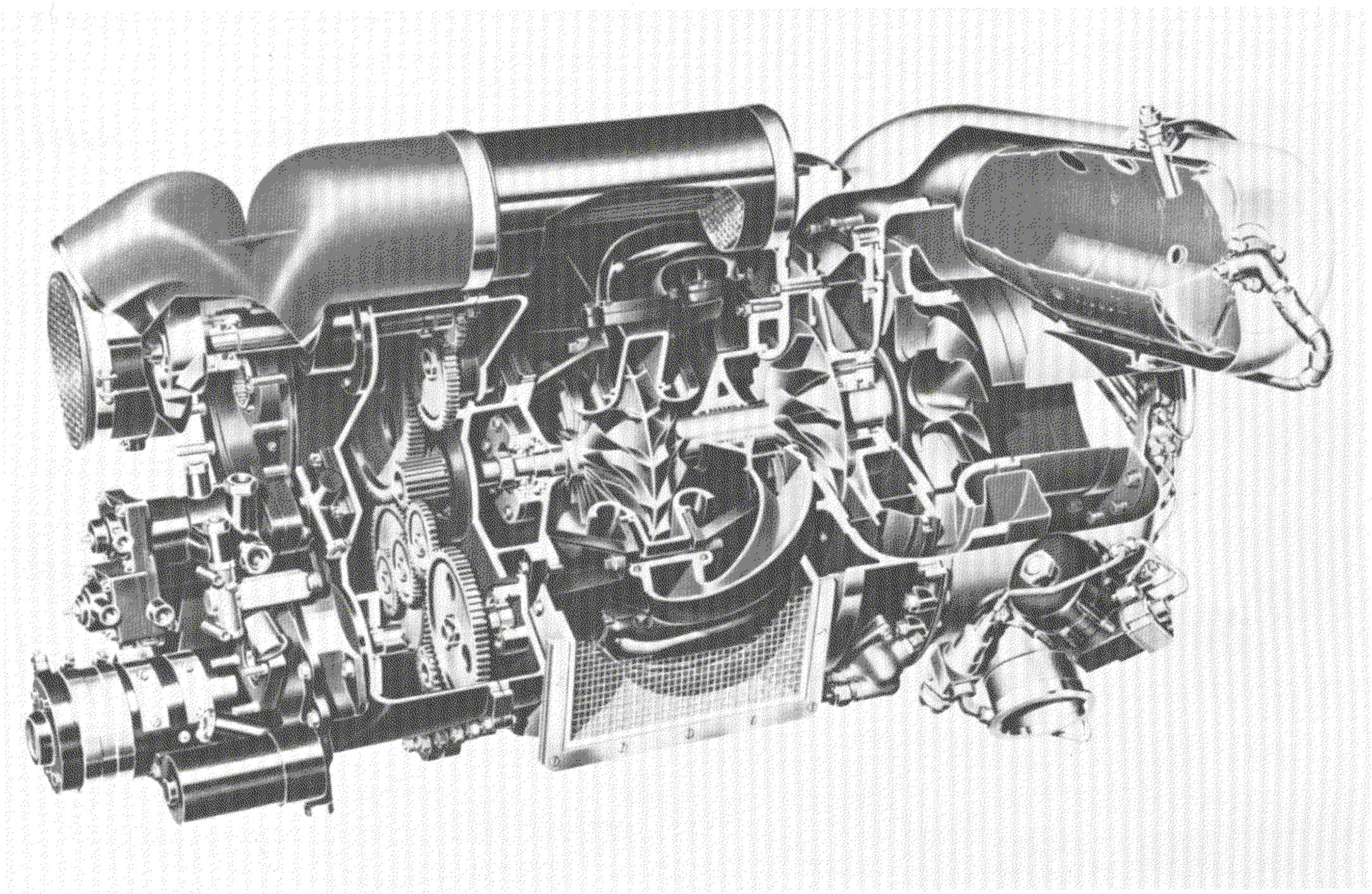


Figure 45. GTCP 95-3 Auxiliary Power Unit

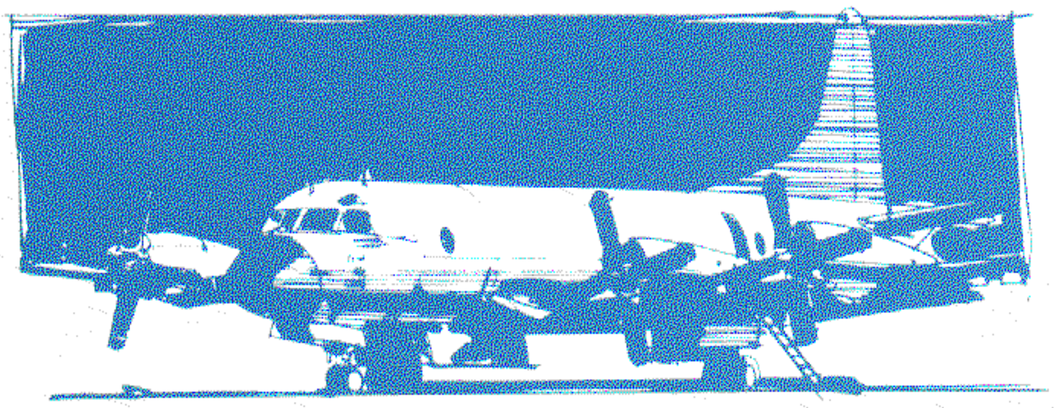
ture of 649°C (1200°F). When the APU is coupled with the Air Turbine Multiplier, the environmental control system provides conditioned air to maintain an average steady-state temperature of 80°F to the flight station and cabin at sea level on a MIL-STD-210A hot day. Under these conditions, the average avionics exhaust temperature will be approximately 110°F, when the total avionic heat load is 30 kW.

Pressures in the cabin and flight station areas are automatically controlled by the cabin pressure controller and its subordinate outflow valve, except during ground operation or ram air auxiliary ventilation of the aircraft when the outflow valve is fully open. The cabin safety relief valve located in the flight station provides these areas with positive pressure relief protection. Protection from negative pressure is provided by the negative pressure relief valve, located on the aft pressure bulkhead.

ENVIRONMENTAL CONTROL SYSTEM MODIFICATIONS Although the Update II P-3 Environmental Control System has been modified to provide increased avionics cooling capacity for the Update III, there remains a high degree of hardware commonality between the two systems. The Update III ECS modifications may be grouped as follows:

- Basic System Cooling Capacity Increase
  - Water Spray
  - Uprated Engine Driven Compressors
  - Uprated Ice Limit Sensors
  - Improved Auxiliary Power Unit
- Air Distribution System Improvement
  - Optimum Cabin/Flight Station Airflow Split
  - Two-speed Cabin Exhaust Fan
  - Optimized Air Distribution and Exhaust Duct Metering Orifice Sizes





The first four items increase the basic cooling capacity and reliability of the Environmental Control System: water spray reduces the temperature of the air leaving the ECS refrigeration unit under high-temperature, high-humidity ambient conditions; the uprated engine driven compressors increase the flow rate of air to the ECS; the increased air flow rate requires uprated ice limit sensors; and the improved auxiliary power unit has greater reliability because the operating temperatures in its turbine section are significantly lower than those in the earlier model APU.

The air distribution system modifications are designed to increase the avionics cooling capacity of Update III simply by making more efficient use of the basic cooling capacity of the ECS. This has been achieved by replacing the existing exhaust fan with a new two-speed exhaust fan. A higher rate of air flow has been realized by operating the newly-developed exhaust fan at low speed, and the high-speed capability of the fan is available to accept future growth in avionics heat loads. In addition, the service life of the Air Turbine Multiplier has been increased by incorporating bearing and lubrication improvements.

Air for cabin pressurization and air conditioning in the P-3C Update III airplane is furnished by two uprated Engine-Driven Compressors. As with earlier P-3 aircraft, the EDCs are mounted on the inboard engines and receive air tapped off the engine inlet ducts. The constant-speed Allison T-56 engine drives the compressors. The maximum power extracted from the engine accessory drive by the uprated EDC is approximately 101 HP (mean) ± 2 HP. Airflow to the EDC is regulated by inlet pre-swirl vanes, which are automatically positioned by a scheduled controller. A spill valve operated by an automatic controller prevents the EDC from surging, and provides a means of diverting the compressor air overboard when necessary.

The EDCs supply air for air conditioning during taxi, takeoff and in flight, and for cabin pressurization during flight. During static ground opera-



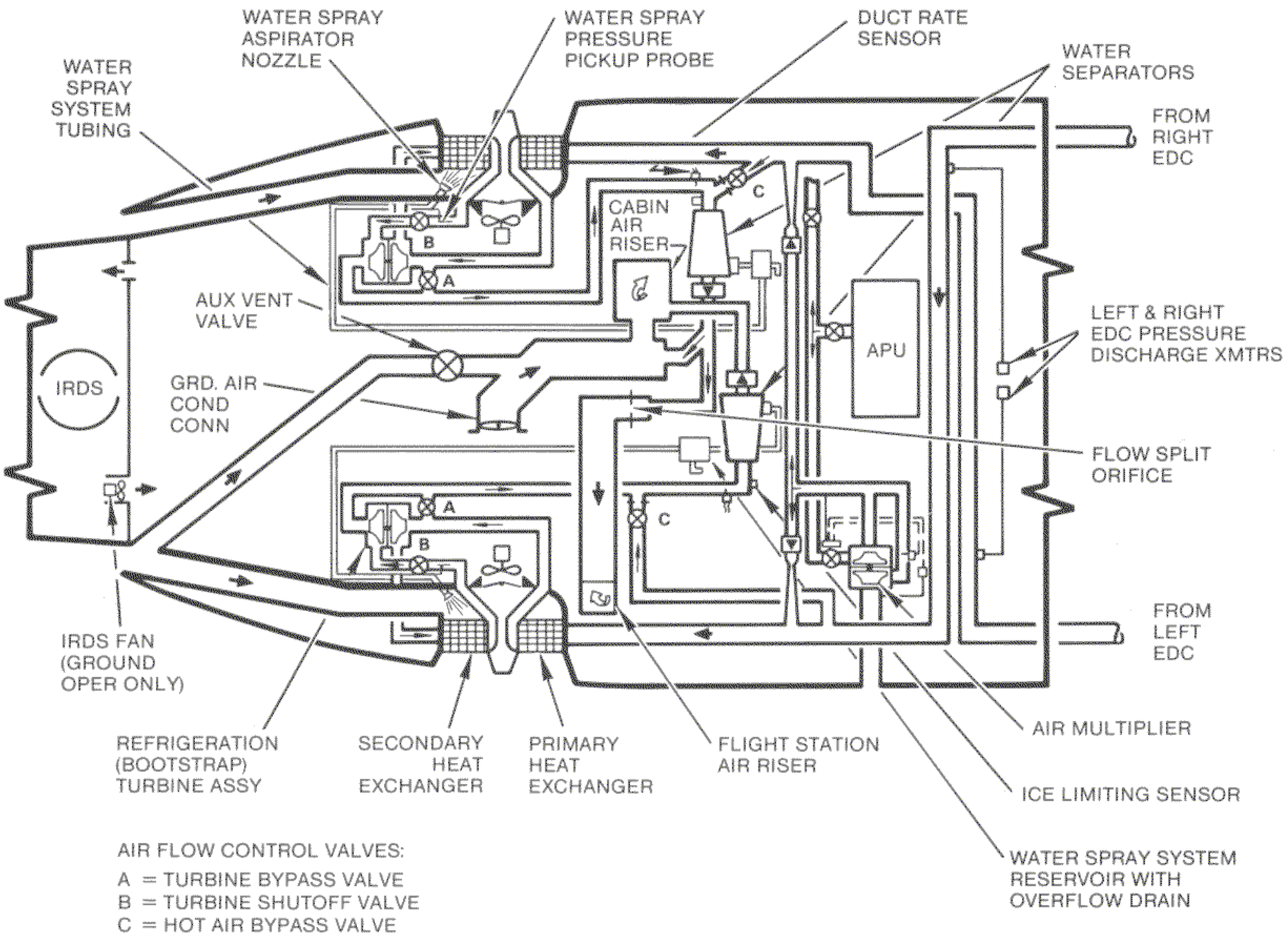


Figure 46. P-3C Update III Air Conditioning System, Featuring the Water Spray System

tion, air for air conditioning is supplied by either the Auxiliary Power Unit/Air Turbine Multiplier package or the EDCs. Each uprated EDC can supply approximately 70 lb/min of air at 1500 ft altitude, 210 KIAS, decreasing to approximately 45 lb/min at 30,000 ft. The water separator non-icing controllers (ice limiting sensors) are adjusted to be compatible with the higher airflow rate and pressure differentials associated with the uprated EDCs. The APU/Air Multiplier package supplies approximately 130 lb/minute of air at sea level.

Two bootstrap air cycle refrigeration subsystems furnish conditioned air for cooling the cabin and flight station. When the EDCs are the source of air, each bootstrap air cycle refrigeration subsystem is supplied air from one of the EDCs. When the APU/Air Turbine Multiplier package is the source of air, this package supplies air to both bootstrap air cycle refrigeration subsystems.

On hot, humid days during low-altitude flight operations, a substantial portion of the Environmental Control System's cooling capacity is expended in condensing water vapor from the conditioned air as the air is cooled. Approximately 80 percent of the water vapor in the conditioned air is removed by directing the air through a water separator. The water discharged from the water separator is directed to the water spray system. The water spray system sprays the discharge water into the heat exchanger ram cooling air, which cools the conditioned air stream as it passes through the secondary heat exchanger (see Figure 46). In this process, most of the injected water re-evaporates, which reclaims a portion of the ECS's cooling capacity used to condense the water vapor.

In each air cycle refrigeration system, the degree of cooling is regulated by two bypass valves and a cold air shutoff valve. These valves are regulated according to the temperature controller's predetermined program schedule in response to separate cabin and flight station temperture control signals.

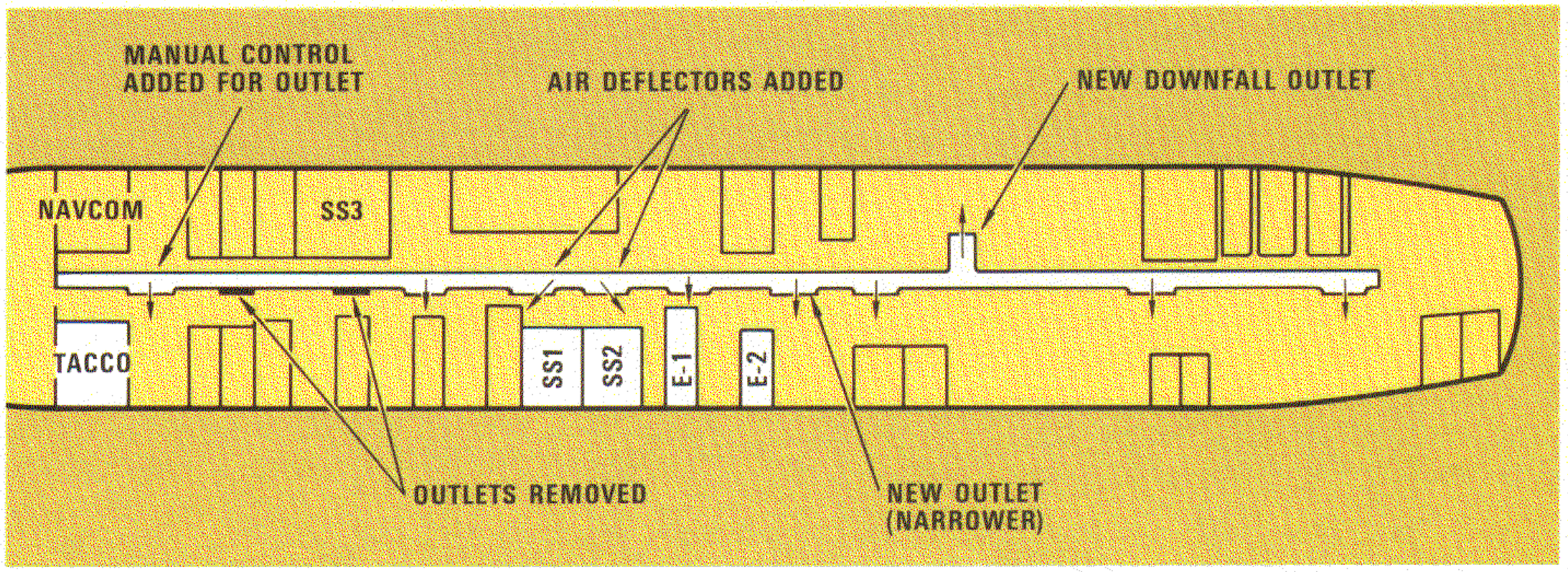


Figure 47. P-3C Update III Overhead Air Distribution Outlets

The conditioned air is distributed throughout the occupied zones through overhead outlets (as shown in Figure 47) and adjustable velocity outlets (gaspers) at each crew station. A manually-adjustable overhead outlet located in the forward cabin can be regulated to improve the uniformity of temperature within the cabin.

The enclosed electrical and electronic racks are cooled by flight station and cabin discharge air. The avionics cooling air exhaust system delivers this discharge air into the avionic enclosures and circulates it throughout the heat-producing areas.

The exhaust/recirculation subsystem consists of main exhaust ducting running fore and aft in the cabin, and in the aft cabin underfloor area (see Figure 48). Air enters the exhaust system through orificed exhaust ports (tuskers) in the equipment racks. The tusker orifices govern the flow of air through the racks. The exhaust fan, installed in the underfloor main exhaust ducting, draws the cabin air through the racks. The exhaust recirculation air orifice allows excess fan exhaust air to circulate through the underfloor area and back into the cabin. Warm recirculated air can be diverted to the cabin directly through manually-regulated return air outlets located in the aft cabin when heating is required. Unrecirculated air is exhausted overboard through a cabin pressure regulating (outflow) valve.

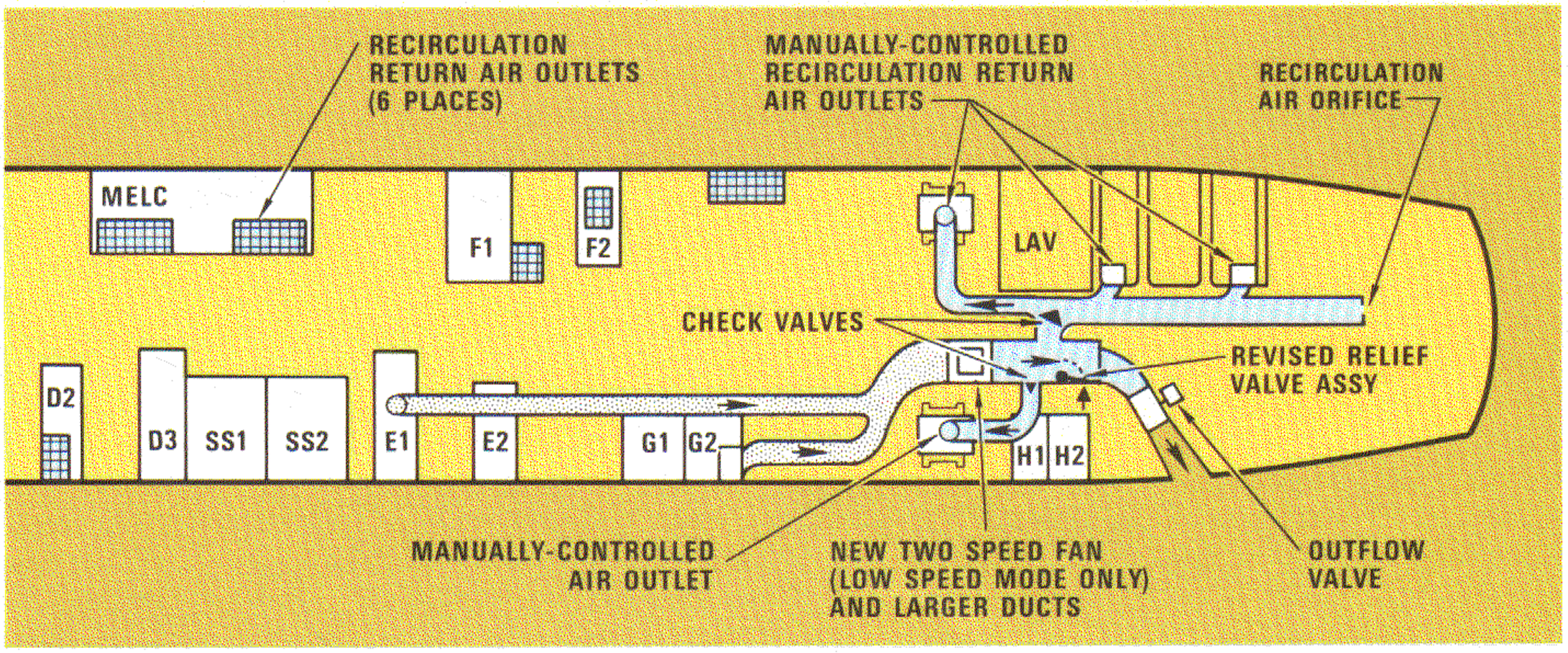


Figure 48. P-3C Update III Under-Floor Exhaust Duct Layout

During operations at low ambient temperatures, the conditioned air for the cabin and flight stations is heated by hot air supplied by the engine-driven compressors, supplemented by heat losses from operating electrical and avionics equipment. Electrically-heated floor panels are provided at each crew station (except flight station, observers, dinette, and galley), just as in P-3C Update II aircraft.

The temperature control system is identical to the P-3C Update II system, except that (1) ice limiter protection in the manual mode is accomplished without the use of diodes and (2) pressure ratio limiter protection is also provided in the manual mode. There are two temperature control subsystems, one for the flight station and another for the main cabin.

Each temperature controller responds to signals from its zone temperature sensor. In both zones, the temperature can be selected between 65°F and 85°F. The selected temperatures are automatically maintained as long as the air cycle refrigeration subsystem cooling or heating capacity is sufficient. Each controller has a manual operating mode to move the three control valves of its air cycle refrigeration subsystem to any desired valve program position between full hot and full cold, as determined by the selector setting.

Cabin pressurization is controlled by the cabin pressure controller, which regulates the pneumatically-operated pressurization system outflow valve with pressure signals.[2] The controller maintains pressurization to a specified cabin altitude when it is operated in the isobaric control mode; it regulates cabin pressure differential in accordance with the cabin pressure schedule when it is operated in the pressure differential control mode.

The cabin pressure is limited by the outflow valve to a normal operating differential of 6.55 psi, corresponding to approximately 8000 feet cabin altitude at 30,000 feet flight altitude. The cabin altitude and cabin pressure rate-of-change controls are selectable. If the cabin pressure controller fails, a safety relief valve limits the maximum pressure differential to 7.07 psi.

The cabin altitude selection control may be set from 1000 feet below sea level to 10,000 feet above sea level. A ground check test selection is provided below the -1000 ft. selection. A barometric correction similar to that provided on altimeters is adjustable from 28.0 in. Hg to 31.0 in. Hg. A ground check test selection is provided above the 31.0 in. Hg selection. Maximum differential pressure is limited by the controller to 6.70 psi above 15,500 ft altitude. The rate of cabin pressure change can be controlled by a knob on the controller, through which rates from 180 to 2200 feet per minute may be obtained. Controller operation is identical to that on the P-3C Update II.

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[2]Orion Service Digest No. 41, August 1983, presented an in-depth description of the P-3 Environmental Control System. Beginning on page 37 of that issue was a discussion entitled "P-3C Update III Stepped Pressurization Schedule," which described a modified pressurization control system that was planned for installation in the P-3C Update III aircraft at the time that Orion Service Digest No. 41 went to print. Subsequently, the design of the production P-3C Update III environmental control system was revised to use the same pressurization control system and pressurization control schedule used on the P-3C Update II aircraft. Consequently, the reader should disregard the description entitled "P-3C Update III Stepped Pressurization Schedule" published in Orion Service Digest No. 41.

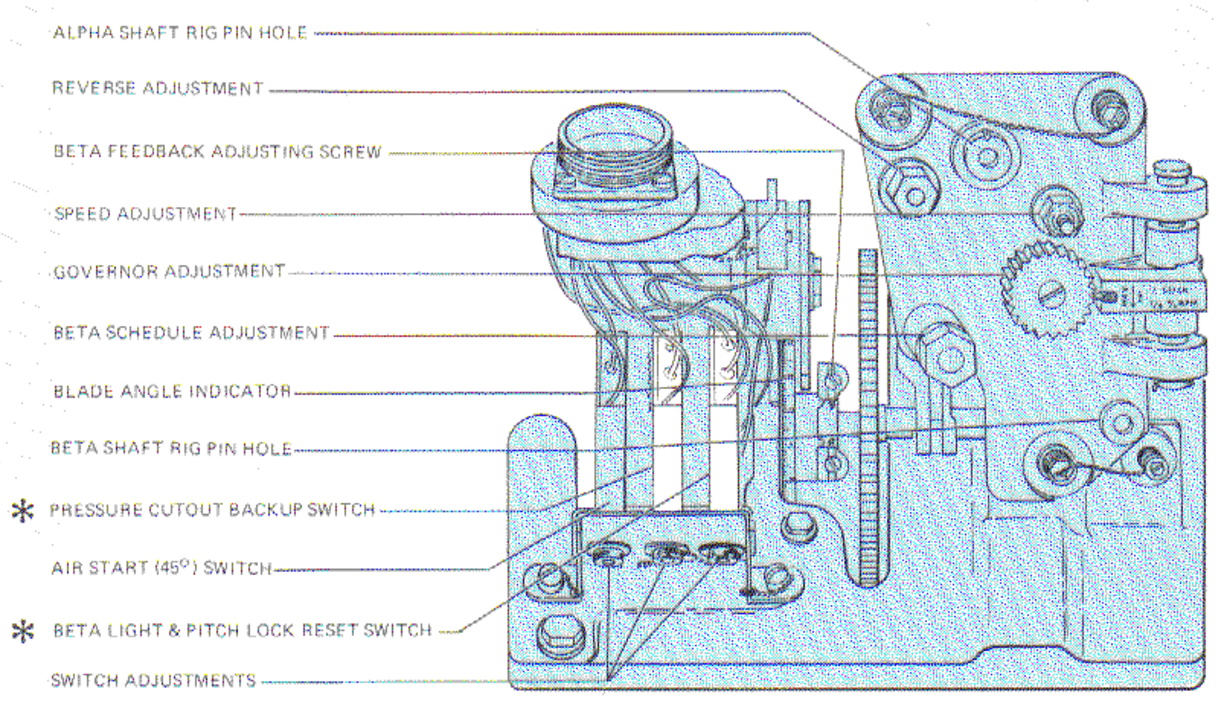
Lockheed ORION Service Digest

GLOSSARY

ACPA	Adaptive Controlled Phased Array Countermeasures Set
ACU	Antenna Control Unit
A/D	Analog-to-Digital
ADB	Acoustic Distribution Box
AE	Arithmetic Element
AGC	Automatic Gain Control
ALI	Automatic Line Integration
AOP	ASP Operational Program
AP	Arithmetic Processor Subunit
ASCL	Advanced Sonobuoy Communication Link Receiver Set
ASP	Advanced Signal Processor
ASW	Antisubmarine Warfare
ASWOC	ASW Operations Center
ATNF	Adaptive Tuned Notch Filter
ATR	Analog Tape Recorder
ATSG	Acoustic Test Signal Generator Unit
AU	Analyzer Unit
BS	Bulk Storage
BSC	Bulk Storage Controller Subunit
BSPS	Bulk Store/Program Store
BT	Bathythermograph
BUOY	Sonobuoy
BVF	Bearing Versus Frequency
CH	Channel
CP	Control Processor Subunit
CPIO	Control Processor Input/Output
CRT	Cathode Ray Tube
CSG	Command Signal Generator Module
DC	Display Channel Subunit
DCU	Display and Control Unit
DDC	Dual-Display Channel
DEMON	Demodulated Noise (Processing)
DF	Display Formatter Subunit
DFG	Direction Finder Group
DICASS	Directional Command Activated Sonobuoy System
DIFAR	Directional Frequency Analysis and Recording
DIM/DOM	Digital Input Multiplexer/Digital Output Multiplexer
DMTC	Digital Magnetic Tape Controller Unit
DMTS	Digital Magnetic Tape Set
DMTU	Digital Magnetic Tape Unit
DPS	Data Processing System
ECS	Environmental Control System
FFT	Fast Fourier Transform
FM	Frequency Modulation
FSK	Frequency Shift Keying
ICS	Intercommunication System
IMPL	Initial Micro-Program Load
I/O	Input/Output
IPL	Initial Program Load
ISC	Input Signal Conditioner Subunit
LOFAR	Low Frequency Analysis and Recording
LTI	Long Term Integration
LU	Logic Unit
MEI	Manual Entry Interface
MEP	Manual Entry Panel
MLU	Modernized Logic Unit
MPD	Multipurpose Display Unit
MWFE	Microwave Front End
NAV/COMM	Navigator/Communicator
OPS	Operational Program Software
OTPI	On-Top Position Indicator
PDC	Proteus Digital Channel
PDIP	Preflight Data Insertion Program
PIC	Processor Input Channel
PIU	Power Interrupt Unit (ASP Power Supply)
PPU	Post Processor Unit
RO	Range Only
SAM	System Analysis Mode
SC	System Controller Subunit
SC/PPU	System Controller/Post Processor Unit
SONO	Sonobuoy
SS	Sensor Station
STC	Storage Transfer Controller Subunit
STI	Short Term Integration
SYGNOG	System Go No-Go
TACCO	Tactical Coordinator
UHF	Ultra High Frequency
VHF	Very High Frequency
XLU	Transparent Logic Unit

ERRATUM

In Orion Service Digest Issue 42, the callouts in Figure 4, page 17, for the "Pressure Cutout Backup Switch" and the "Beta Light and Pitchlock Reset Switch" are transposed. The correct locations of these switches are shown at the right.



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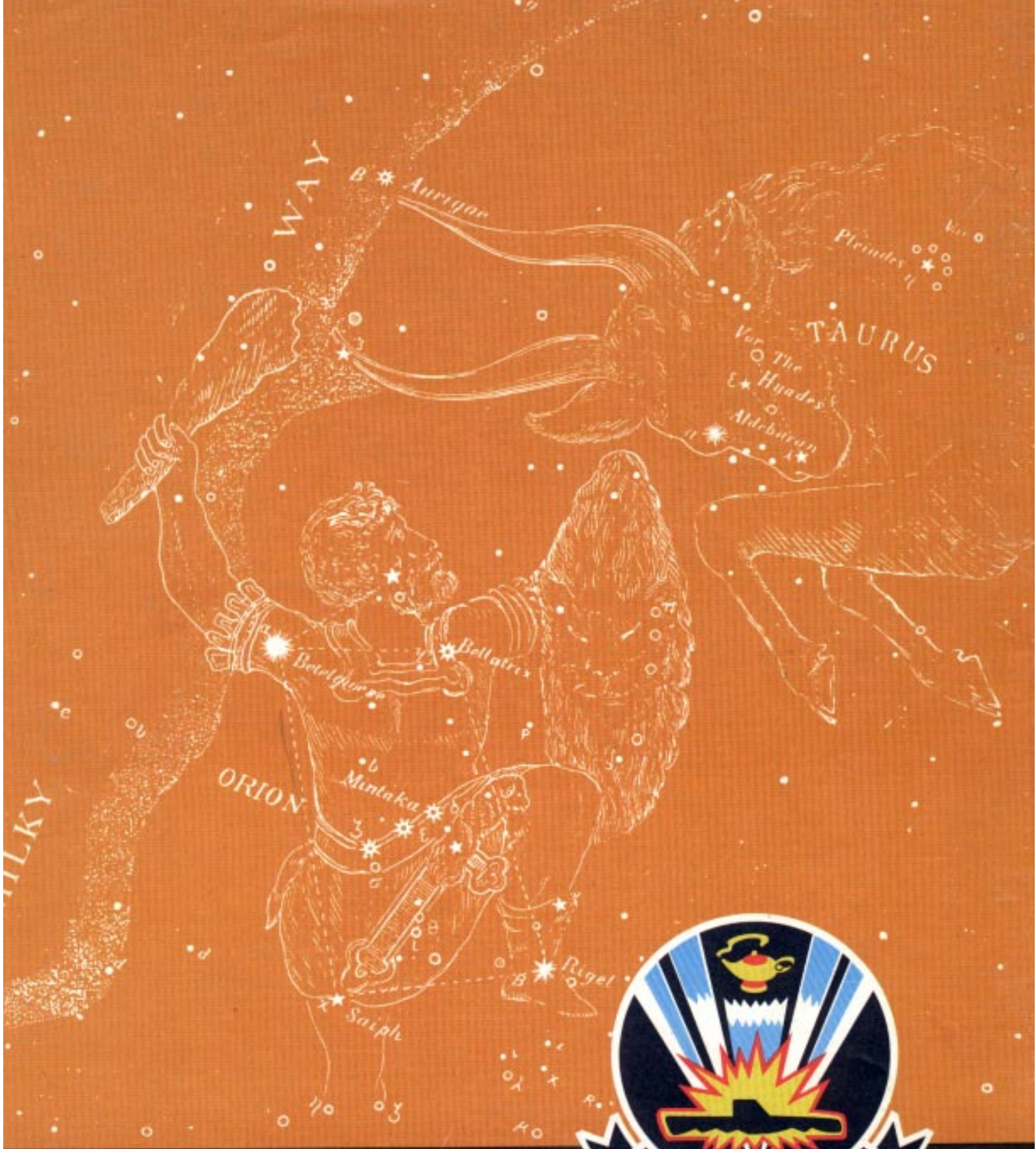
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