THE U.S. NAVY - LOCKHEED S-3A

Carrier - Based ASW for the 70's

Contents

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COMPUTER GENERATED ART COURTESY UNIVAC.

Introduction

To meet the submarine threat of this decade – the quieter, faster nuclear submarines of the 1970's – the United States Navy has authorized production of a new antisubmarine weapon: the carrier-based S-3A aircraft, whose operational effectiveness will far exceed that of the current S-2 "Tracker."

Development and production of the new S-3A are the prime responsibility of the Lockheed-California Company, teamed with the Vought Aeronautics Division of LTV Aerospace and the UNIVAC Federal Systems Division of Sperry Rand. With its combined capabilities, this team provides an ideal balance of experience in ASW systems integration, carrier suitability and computer technology.

When the new aircraft joins the fleet in 1974, its four crewmen will be operating the first carrier-based ASW airplane equipped with a general-purpose digital computer. The computer not only facilitates tactical calculations, but also routes instructions to

Threat •

capture, store and recall data from all of the available ASW sensors. In addition, the computer will be used to monitor the plane's avionic equipment for malfunctions, and to increase the accuracy of tactical maneuvers.

The communications system will enable classified data to be transmitted by secure voice or data link to other ASW airplanes, as well as to shipboard commanders and land-based tactical support centers.

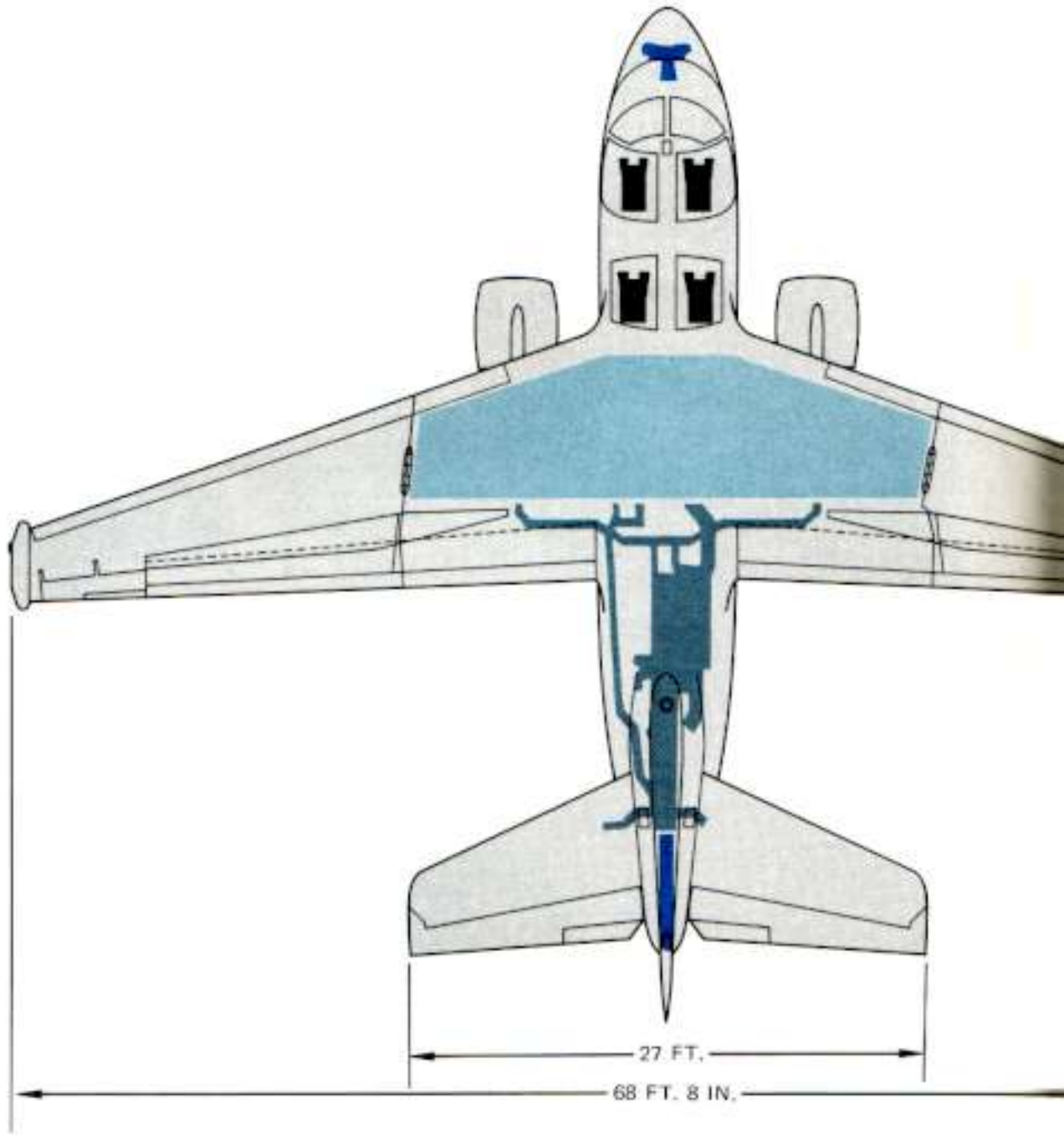
The acoustic sensors incorporate equipment capable of looking deep into the ocean's background noise.

The tactical coordinator (TACCO) will be able to follow the complete situation and rapidly solve the tactical problems logically and methodically. The computer will allow sufficient time for the assimilation of tactical information, including automatically programmed cues, during target presentation.

The pilot will be operating a highly maneuverable and responsive airplane, capable of 160 knots for sea-level loiter as well as 440 knots for high-speed dash. Sea-level rate of climb is in excess of 4,000 feet per minute, and descent from 40,000 feet can be made in less than two minutes. The pilot can use either the Automatic Carrier Landing System or the Shipboard Instrument Landing System for accurate course and glideslope information during the recovery sequence.

The S-3A promises to be a truly outstanding carrier-based ASW airplane. This report describes the new aircraft, with special emphasis on its integrated avionic system.

Counter threat.....



Airframe Design

Principal recognition features of the Lockheed S-3A are a moderately swept high wing, two pod-mounted, high-bypass, turbofan engines, sonobuoy chutes aft in the fuselage, a retractable MAD boom, and a large vertical stabilizer. The spotting factor is 1.05, referenced to the S-2E.

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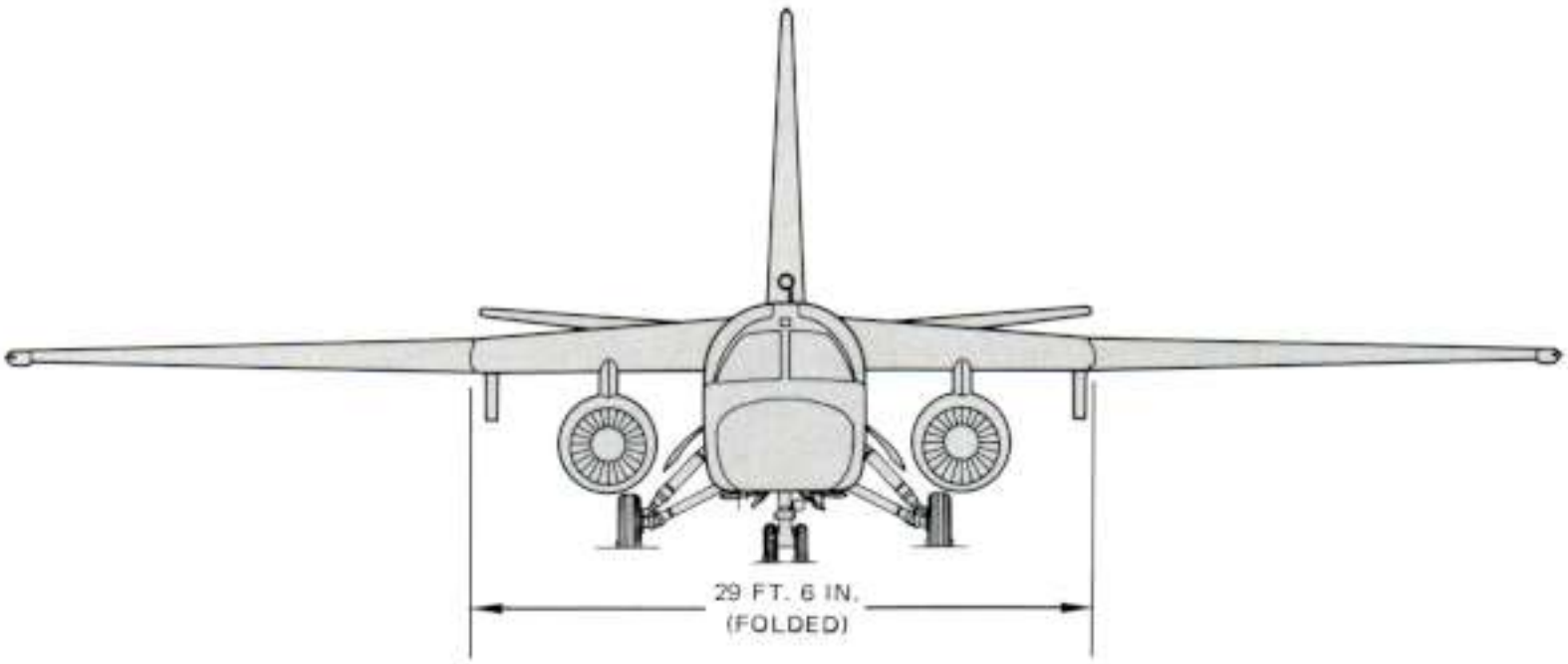
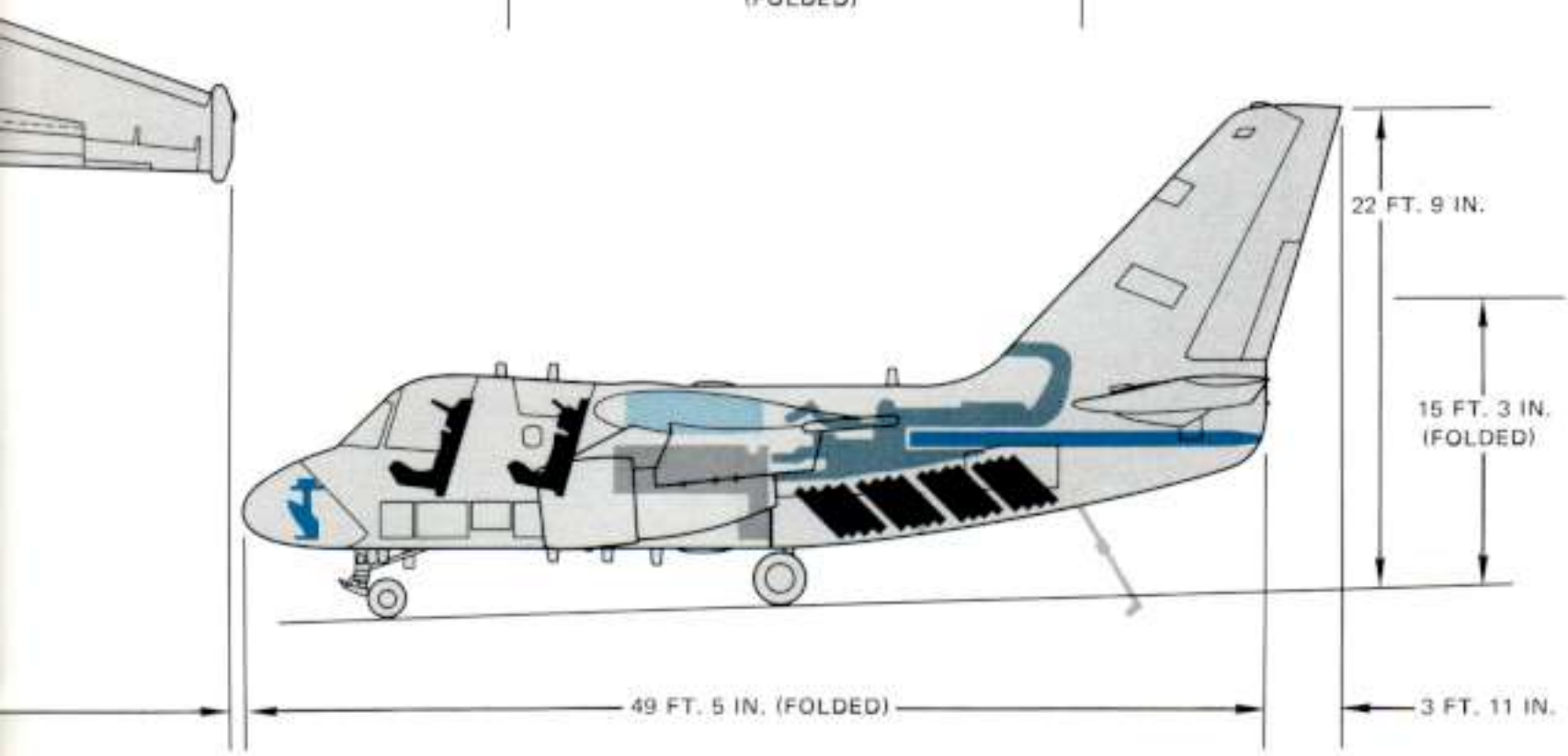




length of the S-3A from nose gear to tail-hook. This construction strengthens the fuselage and improves cabin structural integrity by distributing catapult and arresting loads throughout the airframe.

Vought Aeronautics Company is applying its many years of carrier aircraft experience to the design, production and testing of the S-3A to ensure its carrier suitability. The nose-tow and tail-hook are of Vought design and manufacture. The nose gear and main landing gear are modifications of the A-7 and F-8 designs. Vought is also responsible for the wing, engine nacelle package, stores pylon, the aft section of the fuselage, and the empennage.

Propulsion and Performance

The S-3A is powered by two General Electric TF-34-GE-2 engines. These are high-bypass-ratio, twin-spool turbofans, each capable of more than 9,000 lbs sea-level static thrust. They can "spool up" to 95% (intermediate thrust) from normal approach power setting in less than 3.5 seconds. The TF-34's specific fuel consumption at low altitude is considerably less than that of conventional turbojet engines. This economy allows nearly the same time-on-station at low altitudes as at high altitudes. Start-up requires only 30 seconds, using either a ground air source, the Auxiliary Power Unit (APU), or bleed air from the other engine.

The S-3A is designed to operate at loads between +3.5g and -1.0g, and will accept gust loading to +4.3g at flight design gross weight. By extending speed brakes, a 30-degree dive from more than 35,000 feet to Sea Level can be made in less than two minutes. As noted earlier, maximum high-speed dash approximates 440 KTAS, and low-altitude performance is impressive also. The plane can maintain a buffet-free 2g turn at 60 degrees angle of bank, while flying at sea-level loiter speed – approximately 160 KTAS.


S-3A
157594
NAVY

Pilot

Sensor Operator

Interior Arrangement and Crew Stations

The S-3A incorporates cathode-ray tube (CRT) displays for the presentation of sensor and tactical data, an automatic flight-control system that can maneuver the aircraft in response to computer-generated signals and an integrated control system that permits the four-man crew to control various systems and displays through the computer.

The **Pilot** has the responsibility for overall command and control of the crew. He monitors the tactical situation on his CRT display. This tactical data can include sonobuoy positions, fly-to points, time, aircraft position and track, fixes and predicted target positions. The lower portion of his display is used to provide various cues and alerts and to indicate required sequences of action. The pilot can engage automatic flight-control and power-compensation systems that accurately maneuver the plane in response to computer-generated commands.

The **Copilot**, in addition to his flying functions, performs the duties of navigator, communicator and nonacoustic sensor operator (Radar, MAD, FLIR and ECM). However, navigation and communication duties may be performed alternatively by the tactical coordinator or the pilot. Any sensor function may be assumed by the tactical coordinator or assigned to the sensor operator. The copilot's CRT display presents the tactical situation, as does the pilot's, but it can also be used to view outputs from the nonacoustic sensors. The copilot can indicate to the computer, and to the other crewmen, the location of a detected contact

CoPilot

Tactical Coordinator.

by using his Integrated Control System (INCOS) track-ball to move an electronic hook across his display until it encircles the contact. Then, activated by the push of a button, the computer memorizes the contact and makes it available to the other crewmen's displays and for data-link transmission to other vehicles.

The **Tactical Coordinator** (TACCO) is a Naval Flight Officer who directs the subhunting mission. The TACCO follows the tactical situation presented on his CRT display to make mission decisions. He communicates with the computer, and with the crew members, through his INCOS panel and track-ball. He can view the output of any sensor, and he is automatically presented tactical cues and alerts to assist him in making decisions during target prosecution. The TACCO is able to oversee the entire tactical flight. Because the computer gives him sufficient time and information, he can solve the tactical problem logically and methodically.

The **Sensor Operator** (SENSO) is primarily responsible for the operation of the acoustic data processor, but he can also back up the copilot by monitoring the nonacoustic sensors. The combined facilities of an automatic target-detection and computer-aided classification program, increased-frequency coverage, and a full range of acoustic signal-processing functions significantly increase the effectiveness of the S-3A, even against very quiet submarines.

ASW Data Processing, Control and Display

In recent years, the development of new avionic systems, plus the refinements incorporated into previous systems, have combined to present ASW crewmen with an abundance of signal data. The S-3A weapon system, by completely integrating the individual avionic systems through the use of a multiprocessor computer, makes it possible now to utilize this data efficiently, for maximum effectiveness throughout the ASW mission.

GENERAL-PURPOSE DIGITAL COMPUTER

The UNIVAC 1832 General-Purpose Digital Computer is the nerve center of the S-3A. It is twice as fast as today's operational systems, and is designed to operate reliably in the carrier environment.

Software, the computer's intelligence, is divided into three major categories of programs: Operational, System Test and Weapon System Support:

1. Operational Programs – those that fly with the crewmen and enable them to solve tactical problems.

2. System Test Programs – either System Readiness Tests or Diagnostic Tests – are used to determine the readiness of the avionic systems and to locate any malfunctions.

3. Weapon System Support Programs, the third major software group, contain preflight insertion and post-flight reduction and analysis programs that facilitate the building of an operational tape and the extraction of data from the tape for post-flight analysis. Training programs for in-flight use, as well as for Naval Air Maintenance Trainers and Weapon System Trainers, are also part of the Support Programs.

ACOUSTIC DATA PROCESSOR

The Acoustic Data Processor (ADP) processes sonobuoy output signals with markedly increased sensitivity. The ADP recognizes many levels of a particular signal, automatically time-integrates that signal, and then presents it in Automatic Line Integration (ALI) or gram format to the SENSO and TACCO on their CRT displays.

During the search, classification and initial localization phases of an ASW mission, the system is normally operated in one or more of the passive modes. Two magnetic memory drums are used to store incoming information temporarily. A major advantage of this system is that, by having continuously updated displays, the SENSO can see comparable signal build-ups on different sonobuoys, and then, with the aid of the computer's Passive Acoustic Classification Program (PACP), identify targets of interest.

When final localization is commenced, the system is switched to an active mode, and active sonobuoys may be deployed. The ADP unit uses input of these active buoys to process and update target position automatically.

SONOBUOY MONITORING AND CONTROL

The sonobuoy receiver, a command signal generator (CSG) and an analog tape recorder make up the sonobuoy monitoring and control equipment. The sonobuoy receiver is a fixed-tuned unit. Assignment of its output channels is normally automatic, controlled by the computer, but may also be set manually.

The command signal generator uses the plane's UHF transmitters to order the active sonobuoys into the appropriate mode of operation. The analog recorder provides the ability to record the sonobuoy receiver outputs, ICS information, MAD data, control and time information, reference signals and computer commands.

Nonacoustic Sensors

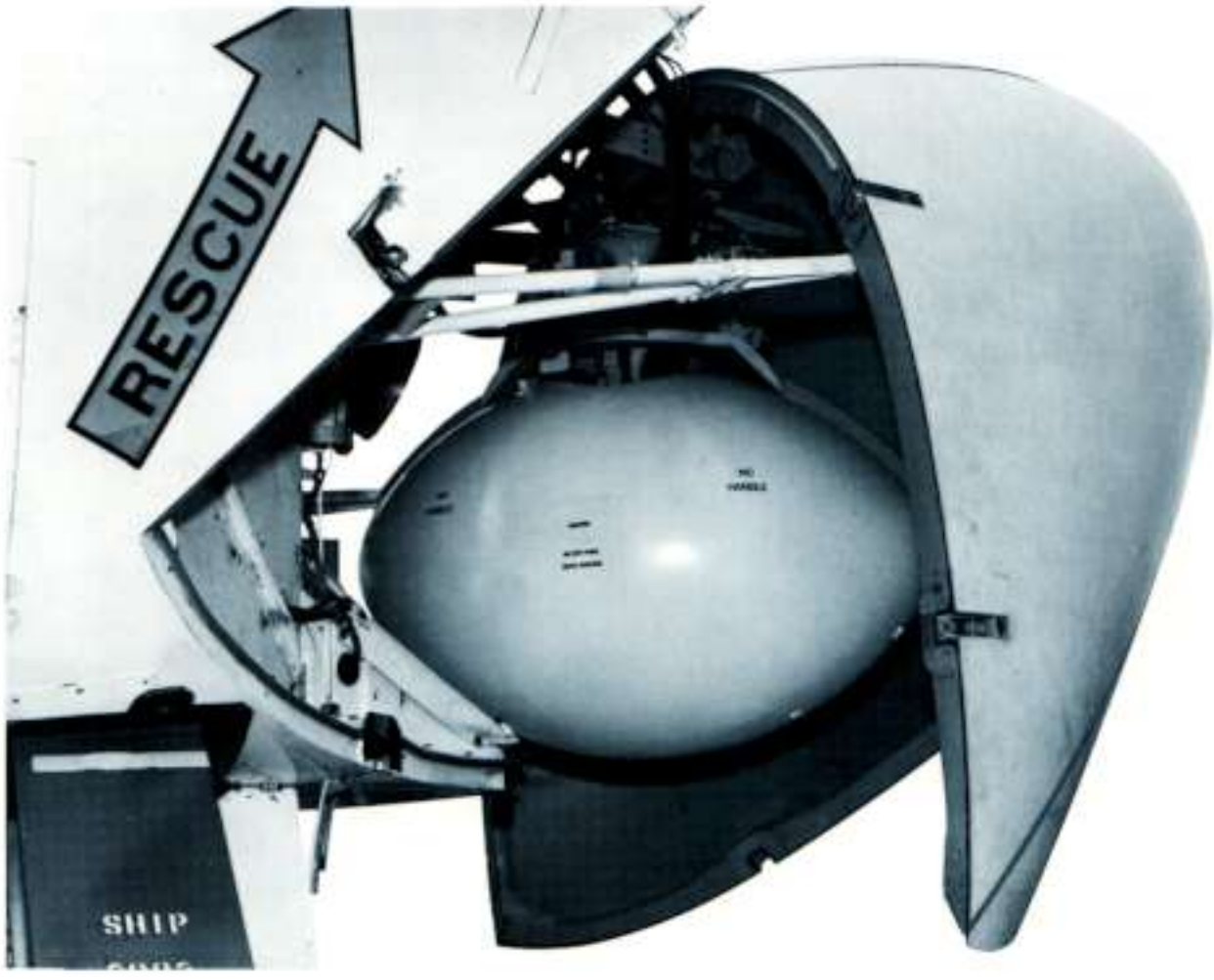
The S-3A's effectiveness is increased by the use of nonacoustic sensors which provide alternative sources of information. The Radar, Infrared, MAD and ECM systems all complement the plane's acoustic processor with their abilities to detect, confirm or record the presence of submarines.

HIGH-RESOLUTION RADAR

The AN/APS 116 high-resolution radar is the first true ASW radar designed to detect small-size targets in high sea states. Three primary modes are available with this system: Small-Target Search, Navigation and High-Resolution Navigation.

The normal radar display is processed (scan-converted) information which can be shown on any of three displays: copilot, TACCO or SENSO. Raw radar is also available as a TACCO or SENSO selection, or as an off-line backup for the copilot.

The radar's nose-mounted antenna is in an enclosed structure which reduces



azimuth synchronization problems at its high scan rate, and is stabilized for pitch, roll, azimuth and tilt. The APS-116 is normally operated through the general-purpose computer in response to the operator's inputs with the INCOS. The special off-line control provided the copilot is for flight safety, however, and gives him direct control of the radar in Mode II, Navigation.

INFRARED SYSTEM

Because it is completely independent of ambient illumination and can penetrate haze and light fog, the plane's infrared system provides high-quality resolution, day or night. The sensor unit is mounted in a retractable turret on the underside of the plane. It is positioned automatically by means of the computer. Two sets of lenses provide either a wide-angle or "zoom" presentation. Once detected, targets can be automatically tracked. This feature is especially helpful in reacquiring a target that has moved from the field of view.

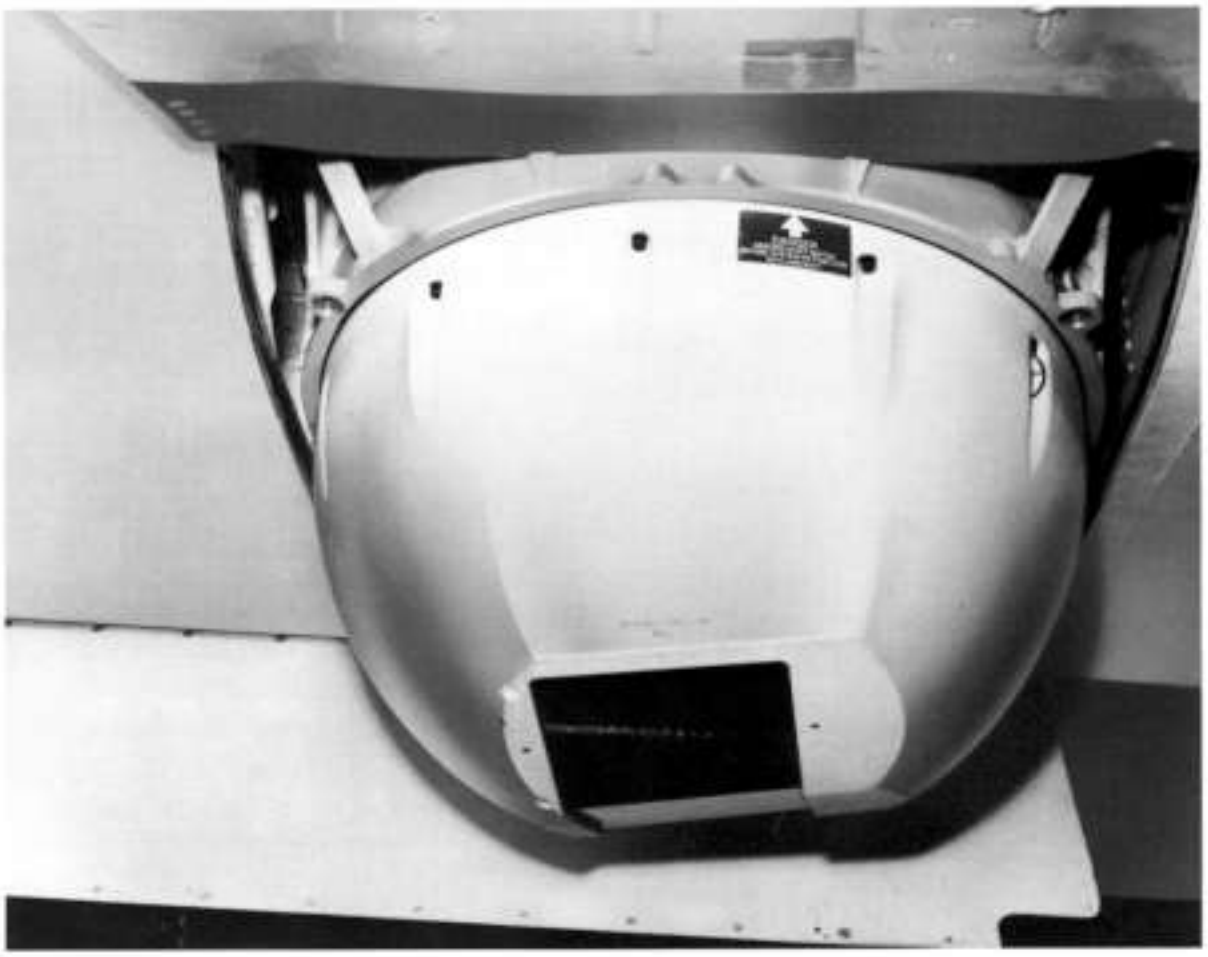
MAGNETIC ANOMALY DETECTION

The S-3A's Magnetic Anomaly Detection and Compensation equipment provides a positive means of localizing and classifying submerged submarines. When MAD contact is made and classified, the computer program memorizes the target's position, predicts the next contact point, and presents its prediction to the crewmen as to "fly-to-point" on their tactical displays. If the pilot then selects "computer-aided flight path," the automatic flight-control system maneuvers the aircraft to the designated point, and thereafter continues to direct effective MAD tracking patterns.

ELECTRONIC COUNTER-MEASURES

The radar intercept ECM system uses wing-tip antenna arrays to provide automatic, instantaneous, omnidirectional and simultaneous bearing determination in a multidensity signal environment. An incoming signal will be compared with the Computer's library; and "unknown" or "threat" identification by the computer must be confirmed and verified by the operator.

As a result of the ECM system's sensitivity and precise output, the computer can correlate emissions from the same transmitter and plot target areas of probability, even though the transmissions originate from different locations over lengthy time periods.



Navigation System

The navigation subsystem is composed of a varied group of navigational sensors, computers and displays under the control of the general-purpose digital computer. The primary navigation system is composed of the Carrier Aircraft Inertial Navigation System (CAINS) and the Doppler Ground Velocity System (DGVS). Supporting subsystems include the Central Air Data System (CADS), Attitude Heading Reference System (AHRS), Sonobuoy Reference System (SRS), Radar Altimeter and Altitude Warning System (RAAWS), radio Nav-aids, and the plane's Flight Displays and Interface System (FDIS).

PRIMARY NAVIGATION SYSTEM

Normal operation of the navigation system provides present-position information derived from Doppler-inertial data for long-range navigation, and Doppler velocities and inertial heading for tactical navigation. An operationally important feature of the S-3A's inertial system includes its ability to align rapidly following power application, using a UHF data link with the ship's inertial system. CAINS is also capable of in-flight alignment....important to an airplane operating out of radio Nav-aid range. The system is equipped with an integral navigation computer.... independent of the plane's general-

purpose computer. This feature, together with the CAIN's control unit, which is also independent of the general-purpose computer, affords autonomous, full system operation regardless of the status of the computer. In other words, the general-purpose computer normally uses velocity inputs from the Doppler radar with true heading and attitude input from the CAINS to provide present-position information and to drive the tactical plots. However, CAINS' computer is simultaneously employing inertial accelerations with its true heading data to derive present-position information. Additional navigational redundancy is provided by the AHRS which supplies precision attitude and heading data to the computer in the event of inertial system failure.

CENTRAL AIR DATA SYSTEM

A dual, digital, central air data system measures static and ram air pressure and temperature. It supplies airspeed, altitude and temperature data, in analog and digital form, to the central computer, to certain flight instruments, and to the autoflight control and IFF systems for altitude reporting.

SONOBUOY REFERENCE SYSTEM

Using a passive technique, the sonobuoy reference system employs an interferometer to locate buoys by measuring the changing relative bearings of their VHF signals as the S-3A flies along its track. In addition, the system's active technique, to be used in active localization, incorporates the transmission of distinct tones over a UHF link via the Command Signal to modified CASS sonobuoys which, in turn, retransmit the signal via VHF. Measuring the delay between transmission and reception yields a DME range to the buoy. The SRS inputs to the general-purpose computer are used during tactical navigation to bias out errors caused by sonobuoy drift. This system will provide much greater TACNAV accuracies than currently operational sonobuoy positioning equipment provides; and will do so without requiring the S-3A to maneuver directly on top of the buoys in order to "fix" them.

RADAR ALTIMETER AND ALTITUDE WARNING SYSTEM

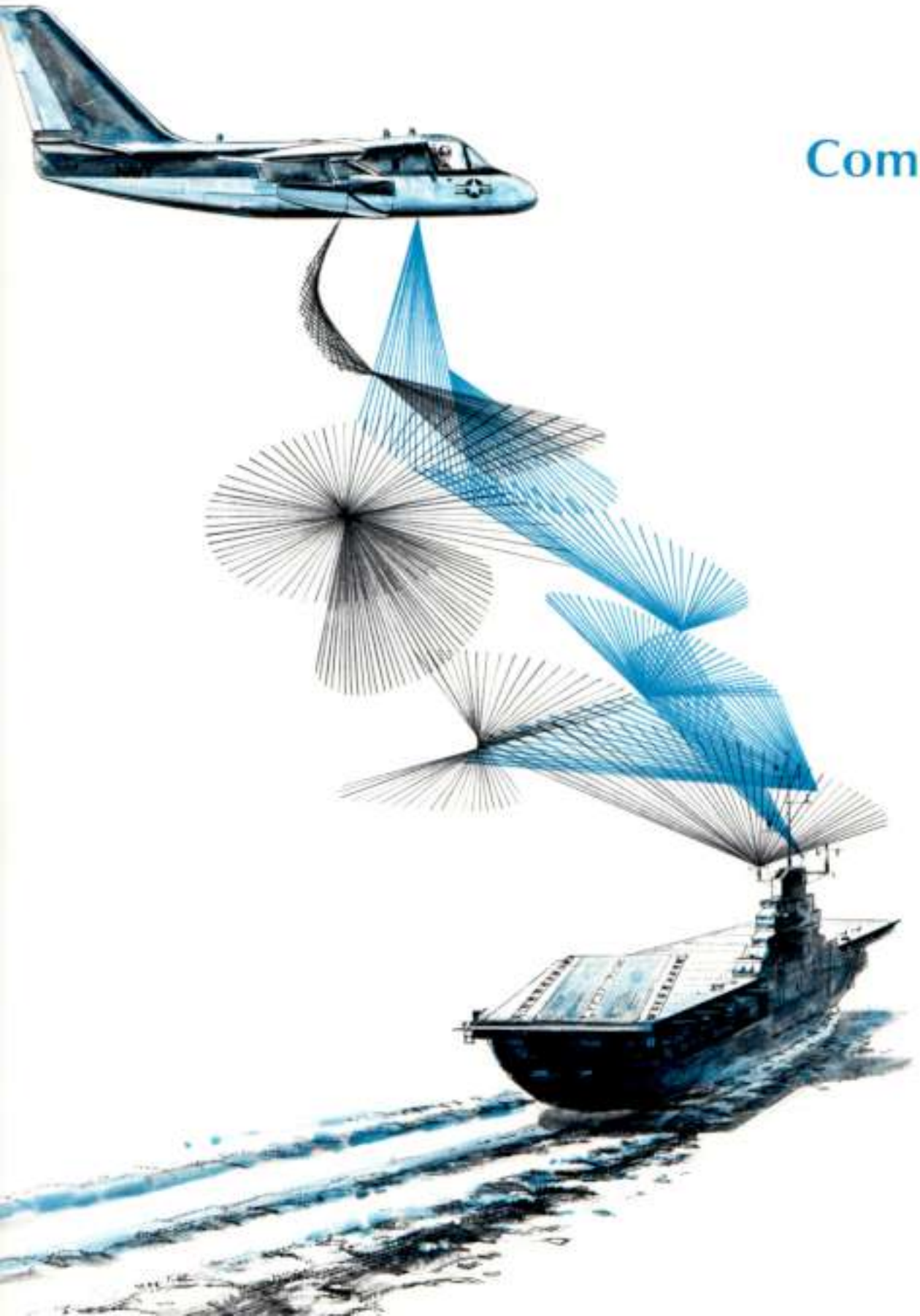
The Radar Altimeter and Altitude Warning System assists the pilots in maintaining a safe altitude during low-level operations. It operates between 10 feet and 5,000 feet absolute altitude with an accuracy of ±5 feet plus 3% actual. A minimum safe altitude between 10 and 300 feet is set on the ground and cannot be changed in flight. When the airplane is at or below this altitude, cockpit warning lights and audible warning signals in both pilots' headsets are activated. An altitude "bug" can be set on both control indicators, and will trigger these same warnings for three seconds when the airplane descends through the "bug" set altitude.

RADIO NAVIGATION AIDS

Radio navigation aids supplement the primary navigation system. The LF/ADF and the UHF/DF units provide bearings to transmitters. The TACAN is used for terminal and airways navigation.

FLIGHT DISPLAYS AND INTERFACE SYSTEM

The flight displays and interface system uses two primary instruments to present a comprehensive picture of the S-3A with respect to the navigation situation and the airplane's attitude. The Vertical Director Indicator provides basic gyro-attitude information. It also displays speed error (fast, slow and on-speed), ILS cross needles, and turn-and-bank indications. The Horizontal Situation Indicator displays aircraft true or magnetic heading, bearing and distance to target or station, true airspeed or groundspeed, drift angle, and true or magnetic course with course deviation.



Communication System

The S-3A's fully computerized communication system provides the ability to transmit and receive secure and clear voice and data in LINK 11 format, over either HF or UHF. In addition, the plane is fitted with landing data Link 4A for use as a backup to the AN/SPN-42 automatic carrier landing system (ACLS). An AN/ARA-63 receiver/decoder set is installed for use with shipboard SPN-41 ILS systems. Integral ICS and IFF/SIF units (with altitude reporting) round out the S-3A's complement of communications equipment.

TRANSCEIVERS

A 1000-watt HF transceiver is used for long-range communication. The set provides upper and lower sideband for voice or data, standard AM equivalent for voice, and diversity for data. Frequency operating range is 2.000 to 29.999 MHz with 280,000 channels available. A notch antenna, located in the base of the vertical stabilizer, provides a vertically polarized pattern. Two UHF transceivers are installed. They cover the frequency range of 225 to 400 MHz in 50 KHz steps. These solid-state units

transmit 30-watt AM and 100-watt FM carriers. Primary operating modes include: (1) voice plus guard – for AM reception/transmission and guard reception; (2) voice only, clear and secure; (3) FSK – for ACLS Link 4A backup; (4) FM – to receive and transmit data, clear and secure, and (5) ADF.

INTERCOMMUNICATION SYSTEM

The major functions of the S-3A's Intercom System (ICS) include control and transmission of internal audio, access to the receivers, and provisions for pilot, copilot, and TACCO access to the plane's transmitters. These three crewmen can select either secure or clear UHF or HF transception, and the pilots can also receive TACAN, RAAWS and IFF signals. Although the SENSO is able to monitor all receivers and employ all interphone functions, he does not have "transmit" access to any radio set. TACCO and SENSO have independent, split-aural sonobuoy receiver audio.

COMPUTER-ASSISTED COMMUNICATION

Computer assistance is provided to increase command and control efficiency during coordinated operations. Switching logic, the system's software, gives the crew the option of complete manual control through the Integrated Radio Control (IRC) panel or computer-assisted control through individual INCOS panels. Computer assistance is accomplished by the operator's entering commands, modes, or functions on his INCOS panel. These are then transferred by the general-purpose computer to specific equipment. Manual selection of modes, frequencies and other elements of the system configuration are made on the IRC panel which is mounted on the flight-station center pedestal. This provides a backup to the computer and allows in-flight changes (such as frequency/channel alterations) to the communication system's previously loaded software program. All functions associated with the HF and UHF radios are integrated into the IRC panel. In addition, a separate UHF No. 1 control is located on the pilot's side panel and is hardwired to his ICS. It can be used as a backup in the event of total failure of both the IRC and the switching logic unit.

DATA TERMINAL SET

The Data Terminal Set (DTS) provides an interface for the Link 11 data and crypto equipment, performs the data interchange and supervisory control for the Link 11 system, and provides interface and control of the UHF and HF radios during net control and picket operations.

The crypto equipment eliminates tedious and time-consuming manual encryption, and the data security allows an encrypted on-line, real-time or computer-dump capability.

AUTOMATIC CARRIER LANDING SYSTEM AND INSTRUMENT LANDING SYSTEM

Two UHF radios provide alternative means for reception of Link 4A data for use by the automatic carrier landing system (ACLS) or for on-deck inertial system alignment. The primary ACLS communication set is the AN/ASW-25B which operates with shipboard AN/SPN-10/42 dual-channel tracking radar to control the S-3A directly through the plane's autopilot, and to provide cross-needle glideslope and center-line indications for pilot response during uncoupled approaches. With both radar channels in operation, the ACLS can provide a maximum landing rate of two planes per minute. A 29-channel shipboard ILS (AN/SPN-41) compatible system is also installed in the plane as a backup, to be used for approaches to non-ACLS equipped carriers, and to serve as a precision approach system in the event of ACLS failure.

Flight Controls

The S-3A's primary flight controls are fully powered, and they are integrated with the automatic flight-control system to relieve the pilot of routine ASW maneuvering. All systems are completely redundant for combat safety, and the pilot can revert to manual operation for emergency control in the event of a complete system failure.

PRIMARY FLIGHT-CONTROL SYSTEM

Primary flight controls are actuated by irreversible servos powered by dual hydraulic systems. The loss of either hydraulic system results in loss of half the available hinge moment, but the remaining system can meet all control requirements. Automatic reversion to manual control takes place if both hydraulic systems are lost. During this emergency manual operation, the pilot can extend his control stick to obtain increased mechanical advantage. In normal powered operation, series inputs to the elevator and rudder servos compensate for pitching moments and provide turn coordination and yaw damping. In normal autopilot operation, parallel inputs to the power servos permit the pilot to anticipate the automatic maneuvers of the plane, an important consideration in low-altitude maneuvers and landing approach.

The roll axis is controlled by ailerons augmented by upper and lower surface spoilers. The irreversible servo actuators have artificial "feel" to minimize the variation in maneuvering forces throughout the flight envelope. Ailerons and spoilers act together for roll maneuvers, and the spoilers act alone as speed brakes, controlled by a switch on both No. 2 throttle levers. In emergency manual operation, with no hydraulic power, the spoilers are inactivated and the pilot's stick force operates only the ailerons.

The pitch axis is controlled by an hydraulically powered elevator servo and is trimmed by an electrically powered stabilizer trim actuator. The elevator power servo can be operated in normal powered, series, or parallel modes. In the emergency manual mode (which automatically takes over below 500 psi hydraulic pressure), and in the normal powered mode, the servo is controlled by the pilot. In the series mode, during manual approach with the Approach Power Compensator (APC) on, the servo is under joint control of the pilot and the Automatic Flight Control System (AFCS). In parallel mode, the AFCS controls the position of both the elevator and the pilot's control, thereby giving him a "preview" of the automatic maneuver.

The rudder (yaw axis) control provides the ability to cope with engine failure at low speed or with asymmetric release of stores. The rudder servo, like the elevator servo, can operate in normal power, series, parallel, or emergency manual modes. During the fin-folding sequence, the pedal input to the rudder servo is disconnected so that the pilot can steer the nosewheel with the rudder pedals.

TRIM SYSTEM

Trim controls in the pitch and roll axes, as well as a system cutoff switch, are located on each stick grip. The fact that the pitch trim rate is proportional to the deflection of the horizontal stabilizer makes possible precise incremental control at high cruise speeds without compromising the ability to make large and rapid trim changes at low speeds, for wave off, etc. The roll trim rate is constant under all conditions. Trim control in

the yaw axis is entirely mechanical. Full pitch and yaw trim authority is retained during emergency manual control following the loss of both hydraulic systems.

LIFT AUGMENTATION SYSTEM

For lift augmentation, leading and trailing-edge flaps are operated by a lever on the left-hand console near the pilot's throttle quadrant. The leading-edge flaps are positioned by electrically powered actuators, while the trailing-edge flaps are controlled by an hydraulically powered servo with an integral electric motor for emergency operation. The trailing-edge flaps are interconnected mechanically to prevent asymmetric extension or retraction. Leading-edge flaps are fully extended after 15 degrees of trailing-edge flap movement.

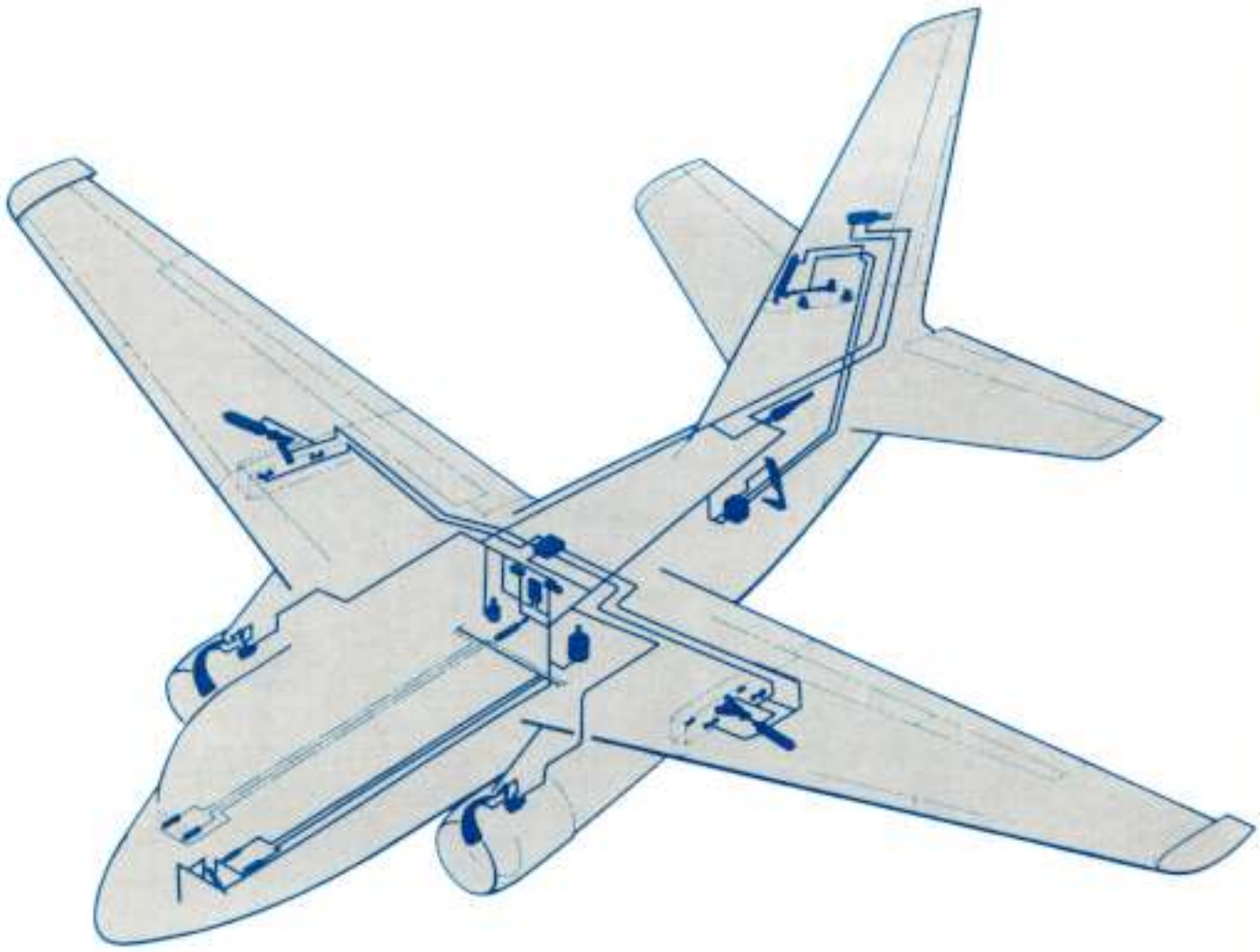
AUTOMATIC FLIGHT-CONTROL SYSTEM

The Automatic Flight-Control System is a dual, fail-safe, flight-mode selection system employing an analog computer. The AFCS is fail-safe in that it provides detection and warning of failure in the AFCS computer or sensors with which it interfaces, and automatically disengages that failed subsystem with no significant fluctuations in electric power. The AFCS functions through the Autopilot System (APS) and the Automatic Thrust System (ATS). The APS provides pitch, roll, attitude and heading hold, heading preselect, barometric altitude hold, and automatic guidance, including automatic carrier landing. The ATS provides approach power control and indicated airspeed hold. The tactical steering program for the AFCS is under the control of the TACCO, but the pilot can disconnect the AFCS from the steering program if desired.

APPROACH AND LANDING SYSTEM

Two elements of automatic flight control that are particularly important during the carrier landing approach are the Approach Power Compensator (APC) and the Automatic Carrier Landing System (ACLS). The ACLS/SPN-42 system measures the position of the approaching aircraft with reference to the ideal approach path, and sends pitch and roll corrections to the autopilot. Before entering the radar acquisition window, the pilot turns on the ACLS data link receiver and the beacon augmenter, and if the carrier has an Instrument Landing System, he turns on the ILS receiver/decoder. When he receives the "Land CHK" message on his telepanel, he lowers flaps, landing gear, and tail hook, and turns on the APC switch. This approach power control mode references the Automatic Thrust System to inputs from the angle-of-attack transmitter. By controlling the power levers, the ATS maintains a constant angle of attack, predetermined to provide the same stall margin and proper approach speed for every landing configuration and weight.

In normal use, the system will complete a hands-off approach and touchdown. Both pilots can cross-check approach accuracy, monitoring the vertical and lateral displacement of the airplane from the desired path by simultaneously referring to the ACLS and ILS cross needles on their vertical display indicators. If the system is disengaged either on the order of the Landing Signal Officer or because of system malfunction, the ACLS sends a WAVE OFF discrete signal, which appears on the pilots' telepanels along with a flashing red light on the failure annunciation panels. The pilot then takes over manually and either completes an ILS landing or a "wave off," as appropriate.



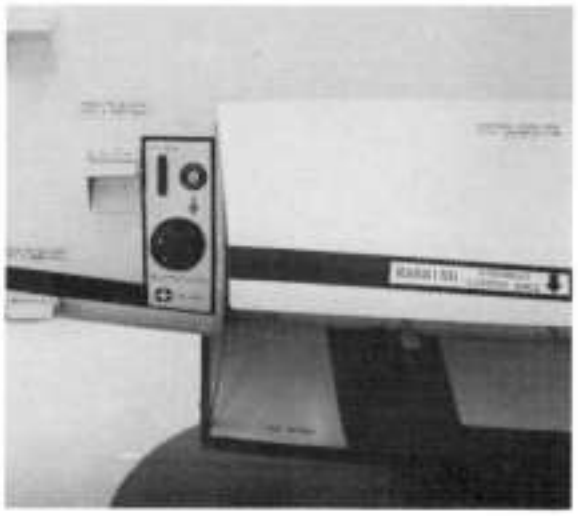
Hydraulic Systems

The S-3A has two completely independent 3000-psi hydraulic systems with pumps mounted in the engine accessory pods. The systems are isolated from each other for combat and flight safety, on opposite sides of the fuselage.

The port system (No. 1) feeds the utility systems – landing gear, flaps, brakes, wing and tail fold, arresting hook, and weapons bay doors. Its secondary function is to power one side of the primary flight controls' servos (elevators, ailerons, rudder, and spoilers).

The starboard system (No. 2) powers only the primary flight controls, energizing one side of the dual servo actuators while the port system energizes the other. Ground cart couplings are provided for both systems.

Either system will provide adequate power to the primary controls with the other inoperative. Priority valves within the system ensure uninterrupted hydraulic pressure to the control servo packages during normal or emergency operations. Pressure gages and caution lights are located in the flight-station center instrument panel. The caution lights, which respond to low pressure, are tied into the master caution network.



Fuel System

The fuel system is state-of-the-art, simple, and reliable. It requires a minimum of maintenance. In operation, it requires little fuel management and no manipulation of system controls during a normal mission. Provisions are made for ground and in-flight refueling, system cross feed, in-flight dump and ground defueling.

Fuel is stored in two symmetrical tank systems, one on either side of the fuselage centerline. They are entirely within the wing box beam and inboard of the wing fold. Each system consists of an integral transfer, and an integral feed tank marked "left" or "right" to show which engine it normally supplies. The systems have a usable fuel capacity of about 1900 gallons. Two 300-gallon, jettisonable tanks can be mounted on wing stores pylons for extended missions.

Engine fuel consumption is measured and displayed in the flight station, and a warning light on the annunciator panel indicates low fuel pump inlet pressure. The pump is installed in the sump box formed by a surge baffle in each feed tank. This ensures steady fuel flow under abnormal flight conditions such as uncoordinated turns, steady side-slip, nose-down on low fuel, and negative-g load. A bleed-air heater on the engine keeps the temperature of incoming fuel above 40°F.

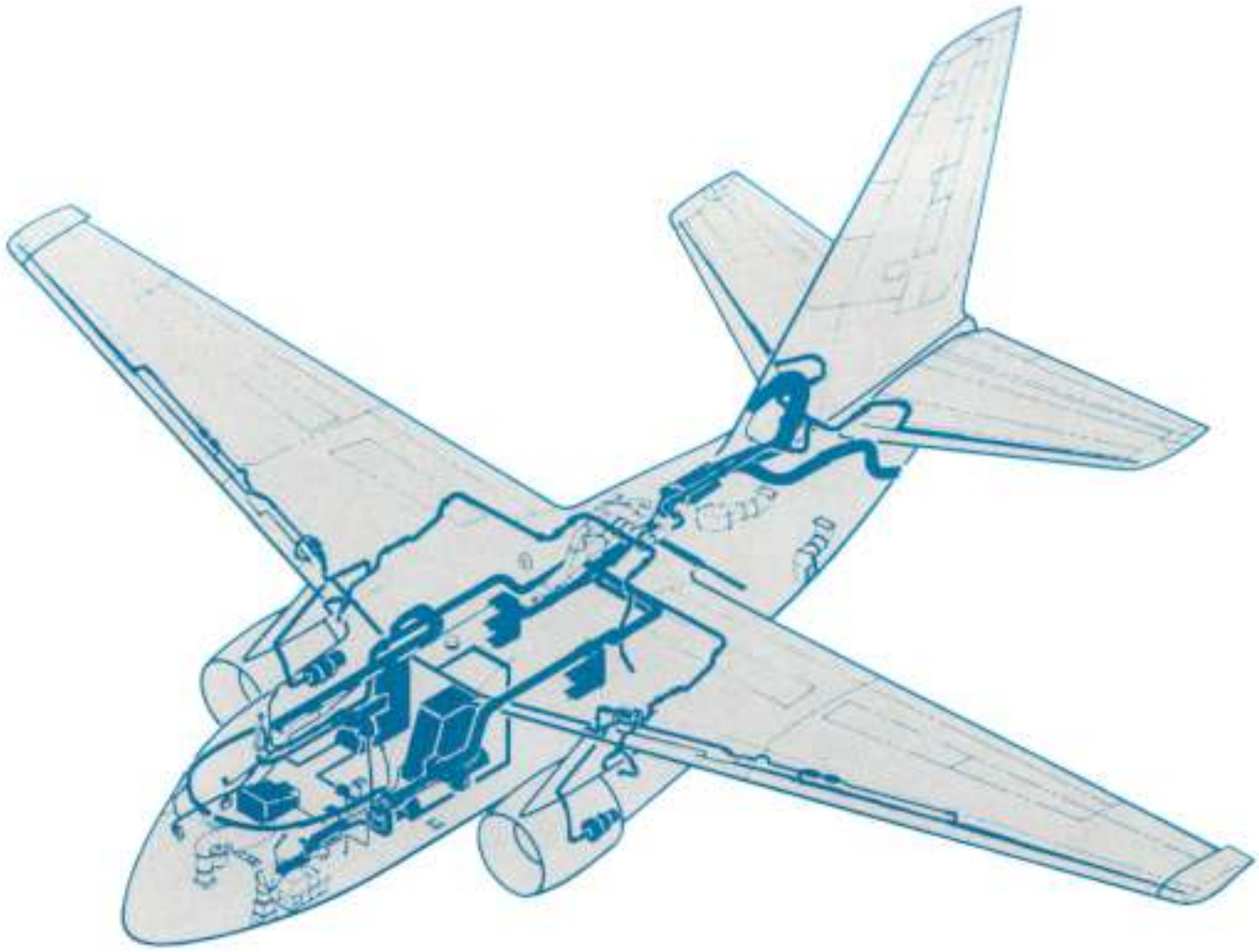
Pressure fueling of all internal tanks can be completed in 5.3 minutes, using a single fueling adapter located on the starboard side of the fuselage aft of the main landing gear door. Internal tanks can also be gravity filled using a hose for each over wing filler opening. For pressure fueling of the external pylon mounted tanks, a 28-volt D.C. power supply is required.

The internal tanks are defueled either by applying suction to the fueling adapter, or by conventional pumping with access through the over wing filler openings. External tanks are defueled by applying pressure.

Tank interconnect valves, actuated by a manual control in the cockpit, make it possible to combine in effect, the two tank systems and to crossfeed either engine from this common source in an emergency.

An illuminated, in-flight refueling probe is mounted within the fuselage on the top centerline. It is fully retracted by an electric drive and protected by a positive-seal door. In an emergency, the probe can be extended or retracted by a hand crank.

Jettison of internal fuel is by gravity flow through a fixed dump chute in the tail. It is equipped with a flame arrester. The fuel dump rate exceeds 1350 pounds per minute at normal flight attitudes. All but 200 pounds of the fuel in each transfer tank is jettisonable, and none of the fuel in the feed tanks can be jettisoned. The system, therefore, retains about 4500 pounds of fuel after a complete dump.



Electrical System

Two integrated-drive, 75-KVA generators supply 115-120 volts A.C. power at a frequency of 400 Hz. The units can be overloaded to 90 KVA for periods up to two minutes. Secondary D.C. power is obtained through the use of two transformer rectifiers that deliver 28 volts D.C. at 200 amps. The rectifiers derive their power from the primary A.C. bus.

An emergency power system is operated by a 5-KVA generator mounted on the auxiliary power unit. The emergency generator delivers multiphase, 115-120-volt A.C. power at 400 Hz to the essential A.C. bus and 28-volt D.C. power at 30 amps through the transformer rectifiers. When the airplane is operating on emergency electrical power through the essential power buses, it has only essential capabilities, i.e., for night flying under instrument conditions. Emergency system operation is indicated by a control panel light.

External A.C. power can be connected to the aircraft for ground operations. All required D.C. power is obtained through onboard transformer rectifiers. External power is controlled by a switch on the control panel on the pilot's center console, and the EXTERNAL POWER AVAIL light indicates that the connection is made and power is available.

The electrical power control panel also includes controls for emergency power from the auxiliary power unit. Generator warning lights are included on both the control panel and the master caution panel. Port and starboard primary bus disconnect switches are provided for isolating buses without affecting the essential bus or generators during emergency situations.

Two electrical distribution and service centers are located within the pressurized cabin area aft of the SENSO and TACCO crew stations. This puts the load centers in the most nearly ideal electrical environment and facilitates wiring and maintenance from within the aircraft.

Environmental Control

The Environmental Control System (ECS) consists of an engine bleed-air supply system, an air-cycle refrigeration unit (used for air-conditioning and pressurization), an engine inlet anti-icing system, and a wing and empennage deice system. The ECS also provides several services not dependent on bleed air, including transparent-area protection and flight instrument probe anti-icing.

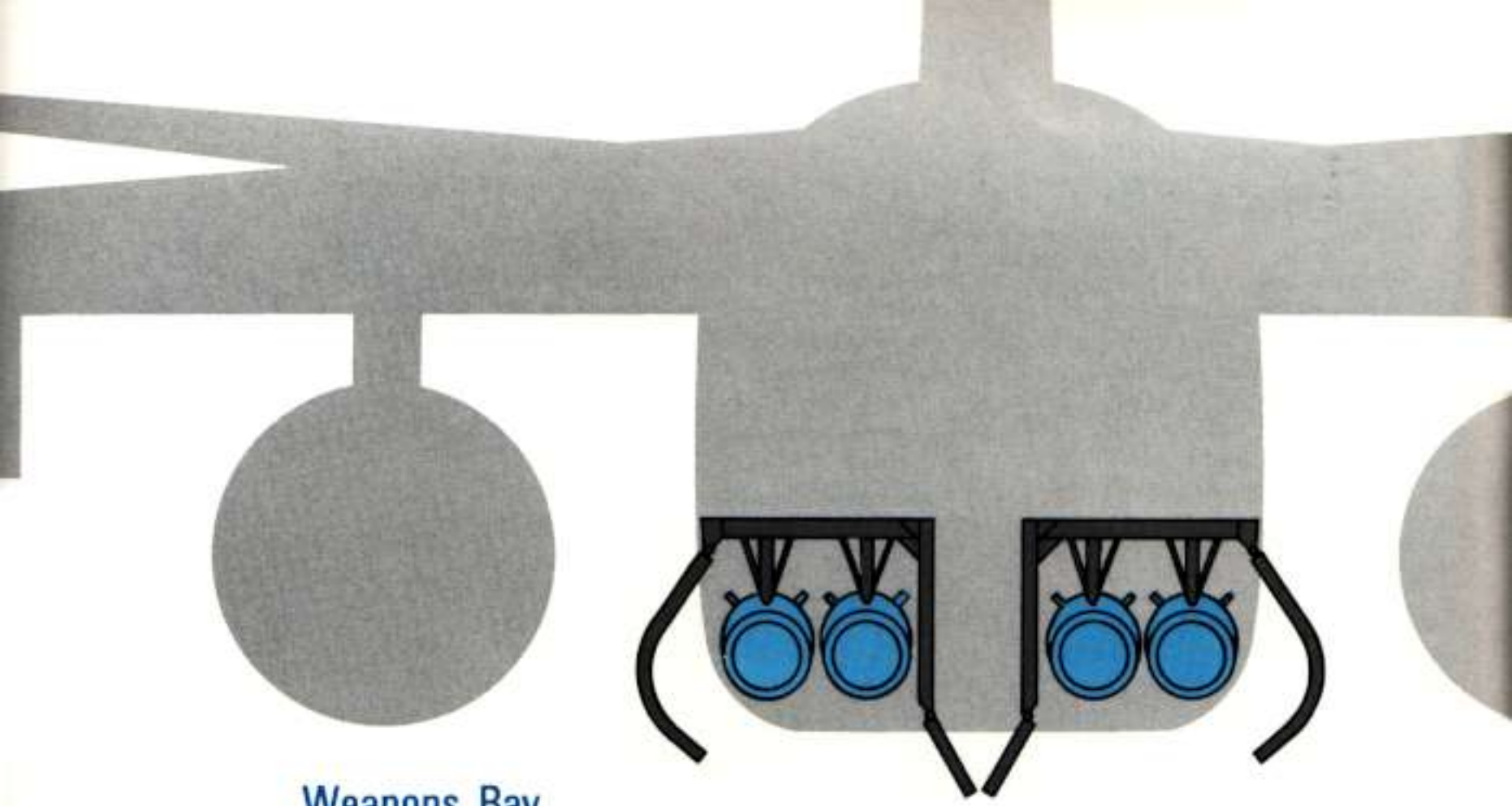
The plane's air-conditioning system incorporates a single-cycle package located in the upper aft fuselage. In addition to maintaining the temperature around avionics at designed operating levels, the system provides each crewman with adjustable foot-level and face-level outlets and a separately adjustable supply for his anti-exposure suit. Temperature controls for the cabin and survival suits are located on the pilot's side console.

Avionics units are cooled by a method called Cold Plate Cooling. Conditioned air flows through ducting in each avionic unit, not directly over the electronics modules themselves. This provides a cleaner environment for the equipment and a more stable temperature control throughout. Discharged air from the avionics equipment is routed to the weapons bay and search stores to provide a minimum temperature of 32°F in the weapons bay and 4°F through the sonobuoy launch tubes.

The pressurization schedule operates on 6-8 psi differential. This results in a cabin altitude of 5000 feet at a flight level of 25,000 feet and 11,500 feet at 40,000 feet.

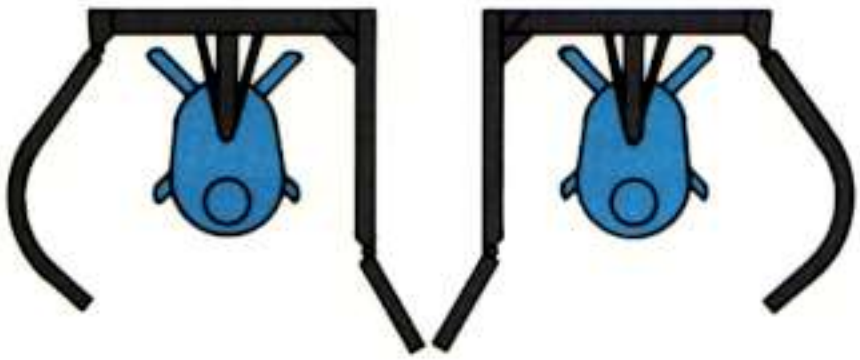
Bleed-air anti-icing is provided for the wing leading edges, horizontal stabilizer leading edges, engine inlet nozzles, and air-conditioner ram air-scoop. Since bleed-air utilization relates to fuel consumption and therefore diminishes range or endurance, symmetrical areas (such as portions of wing leading edges) are cyclically heated. This minimizes bleed-air consumption while providing protection even in a severe icing environment.

The windshield wipers are electrically driven and operate independently. Windshield surfaces are electrically heated, and the side canopy is defogged with conditioned air. A liquid rain-repellent system, which augments the wiper system, treats the windshield surface so that impinging raindrops are prevented from spreading into a vision-distorting film.

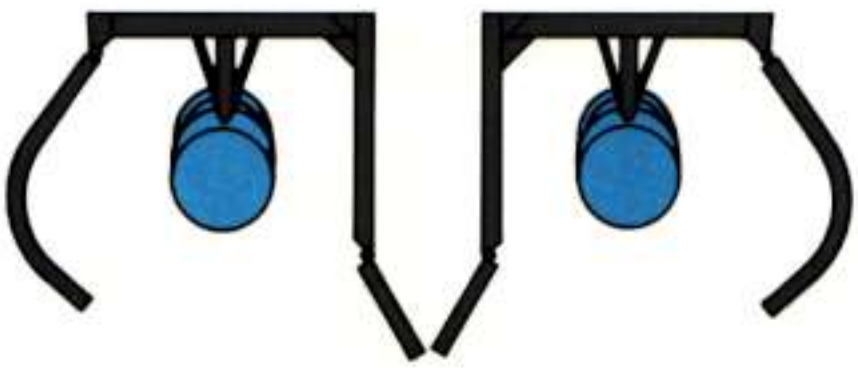


Weapons Bay Configurations (Four Bomb Rack Assemblies BRU-14/A With Brackets)

4 DESTRUCTORS - MARK 36
4 TORPEDOES - MARK 46
4 BOMBS - MARK 82



2 DEPTH BOMBS - MARK 57



4 DEPTH BOMBS - MARK 54 OR 4 MINES - MARK 53
(IN TANDEM)

Armament System

WING LOADING CONFIGURATIONS
(BOMB RACKS - BRU-11/A)

2 Pods, Rocket - Including:

- 2 LAU-68/A (7 FFAR - 2.75 Inches)
- 2 LAU-61/A (19 FFAR - 2.75 Inches)
- 2 LAU-69/A (19 FFAR - 2.75 Inches)
- 2 LAU-10A/A (4 FFAR - 5.0 Inches)

2 Launchers, Flare, SUU 44/A

2 Mines - MK-52, MK-55, or MK-56

2 Bombs, Cluster, MK-20-2

2 Tanks, Fuel - Aero 1 D(300 gal ea.)

or

With 2 TER-7 Triple Ejector Racks Installed

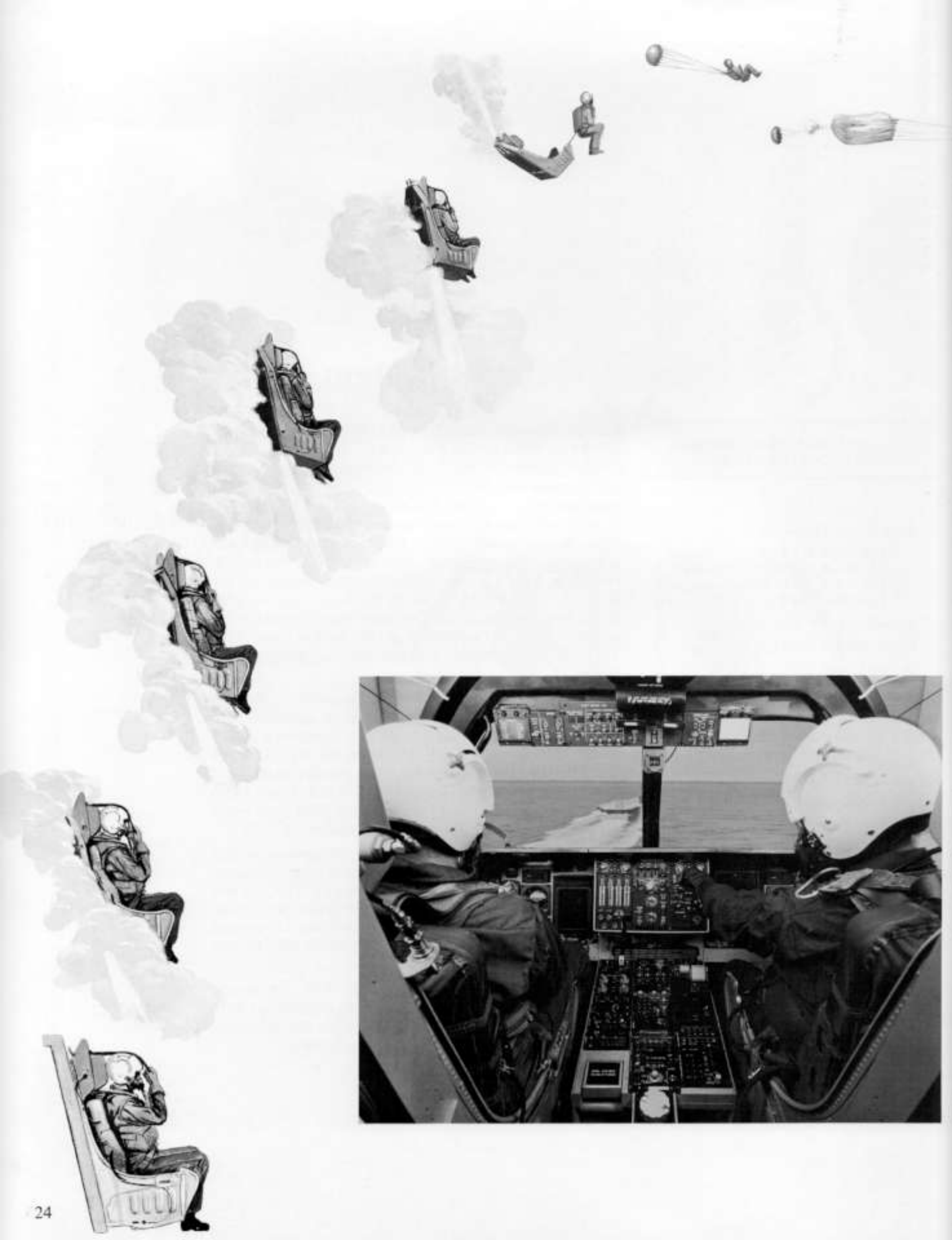
- 6 Pods, Rocket
- 6 Launchers, Flare
- 6 Bombs, Cluster, MK-20
- 6 Bombs, MK-82
- 6 Destructors, MK-36
- 6 Practice Bombs MK-76-5 and MK-106-4

Search stores are designated as LOFAR (SSQ-41), R/O (SSQ-47), DIFAR (SSQ-53), CASS (SSQ-50), DICASS (SSQ-62), and BT (SSQ-36) sonobuoys. Normally they are released automatically by the computer after it is programmed by the TACCO, SENSO or copilot. Manual, off-line armament control is also provided. The sixty A-size search stores, prepackaged with the gas generator cartridges that eject them, are carried in launching chutes in the underside, waist section of the plane. In an emergency, 59 of the buoys can be jettisoned within 10 seconds. One sonobuoy is retained for possible use as a locator in sea/air rescue operations. There is no provision for in-flight reloading of the chutes.

A wide variety of attack stores can be carried in the two independently operated weapons bays, including torpedoes, mines and special weapons. Additional attack stores can be carried by installing BRU-11/A bomb racks on the two wing pylons. The installation of triple ejector racks (TER-7) on the BRU-11/A bomb racks makes it possible to carry three rocket pods, flare pods, or MK-20, MOD-2 cluster bombs on each wing.

Armament controls are a part of the integrated control system. In the automatic mode, the operator communicates with the armament system through the INCOS and selector panels to deploy mines, destructors, torpedoes, and bombs. The pilot also has provisions for manual control of these stores, just as he has for all forward-firing weapons.

Electrical interlocks, in conjunction with the master arming switch, sono safety switch, and the stores jettison switch prevent release of stores when the airplane is on deck or is in flight with landing gear down.



Safety Equipment—Visibility

The plane is equipped with four McDonnell-Douglas ESCAPAC 1-E ejection seats. They can be successfully fired at any speed/altitude combination, including zero/zero. A rigid seat survival kit (RSSK) is attached to the seat and to the torso harness. In effect, the kit is part of the restraining harness and assists in keeping man and seat together during initial phases of the ejection sequence.

Later in the sequence, man and seat are automatically separated. During descent, the RSSK can be opened and the life raft inflated if necessary.

Each crewman's anti-exposure suit is ventilated with conditioned air from the plane's system. Suit temperature control is located near the pilot. Individual air-volume controls for the suit are installed at each station.

Throughout the S-3A's interior, potentially dangerous projections, especially those ahead of each crewman, have been carefully shrouded. The plane's double-keelson construction gives an additional safety dividend through the strength it provides should a ditching or gear-up landing be necessary.

Visibility from the cockpit is excellent. The pilots can easily see wing leading edges, engine nacelles, refueling probe, and main landing gear. The plane's large windshield allows a line of sight 17 degrees below horizontal plane, giving a full view of the ship's optical landing aid throughout the approach. Polarized windows give the TACCO and SENSO control over the amount of light entering their stations. The windows can be adjusted to an infinite number of light levels. They can be "opened" to alleviate vertigo by providing an external reference, or they can be made completely opaque to eliminate reflections on the CRT display.

Maintenance

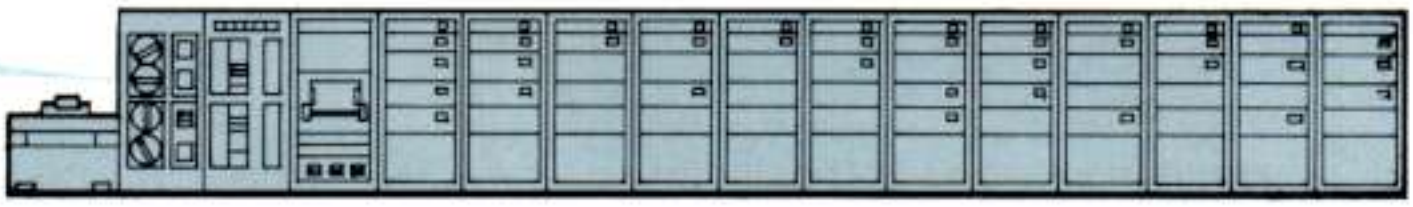
Improved S-3A trouble-shooting procedures and the refinement of repair and replacement criteria will minimize maintenance man-hours per flight-hour. Compared to earlier systems, the S-3A will have a greatly increased probability of completing a typical ASW mission without significant avionics failure. Advanced techniques of computerized fault isolation, using ground and flight test programs, plus improved shop testing equipment, will also make possible a lowering of required maintenance skill levels.

All avionic equipment is easily accessible, externally through four access doors and internally through the bay aft of the crew stations. All maintenance, except jury strut installation and windscreen cleaning can be accomplished from deck level.

Avionics fault-isolation techniques include System-Readiness Tests, Built-In Test Equipment, In-Flight Performance Monitoring, and computer-initiated Diagnostic Routines. Readiness tests will determine and display the status of each subsystem, cue the operator to whatever pertinent diagnostic routine should be initiated, or indicate the required corrective action. Built-In Test Equipment (BITE) is included in the design of each Weapon Replaceable Assembly (WRA) to detect, locate and indicate 95% of all failures. BITE provides a visual "Go" or "Defect" indication on the WRA and on the operator's scope, and will be operated in either the "Activated" or "Continuous" mode. In selecting the Activated mode, the operator must also select the WRA to be BITE-tested. When this is done, a discrete command from the computer initiates the test and registers results on the assembly's status readout and on the operator's display. In the Continuous mode, the computer automatically initiates BITE sequentially for each WRA, and if a fault is detected, indicates on the operator's display, a "Defect" status for that unit.

In-Flight Performance Monitoring is an automatically initiated computer program that periodically determines equipment operability. If a failure is indicated by IFPM, the operator may command, via INCOS, that a particular diagnostic routine be initiated. These routines are stored on the digital magnetic tape unit and are available at any time during the mission.

Once a WRA has been identified as inoperative, it will be sent to intermediate-level maintenance for repair, using the Versatile Avionic Shop Test (VAST). This computerized facility will allow identification to the "card" or Shop Replaceable Assembly (SRA) level. Depending on the criteria used, it will indicate the warranted action, either repair or replacement. This system is currently being introduced into fleet service in support of the A-7E and will be used for the E-2C and F-14 as well as for the S-3A.



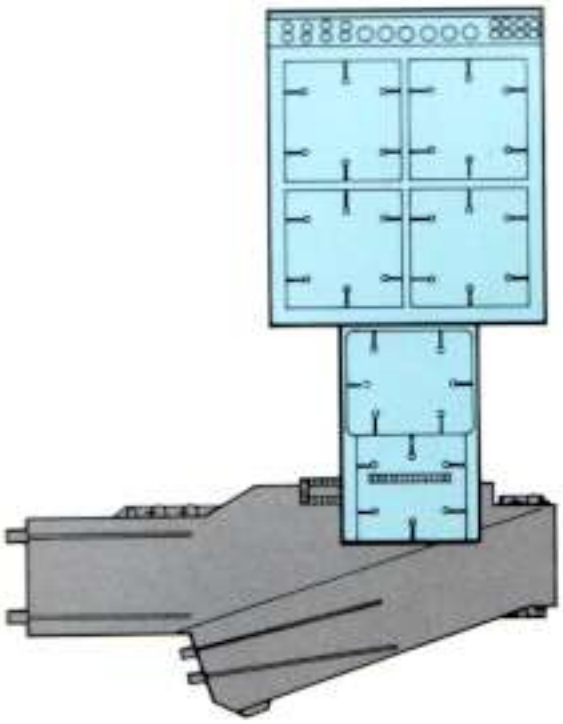
Testing and Training

Before the S-3A is delivered to the fleet in February 1974, its avionic systems will have undergone nearly 2-1/2 years of flight testing aboard a specifically modified P-3A. An assessment of the S-3A's flying qualities and performance, including compatibility of its avionics system with the airframe, will have been accomplished more than a year before the first plane is put into operational use. Naval Air Maintenance Trainers (NAMT) and Weapon System Trainers (WST) will be in operation before fleet delivery. Interim measures will be set up to provide spares and maintenance support for the time period between first deliveries to the fleet and December 1974 when the Navy formally assumes support responsibility.

Factory training of fleet cadre and NAMT instructors will be performed on the NAMT. Airframe trainers will consist of silhouetted animations on vertical panels, cutaway components, and schematic diagrams with back-lit plumbing and wiring to demonstrate system functions. The S-3A's intermediate-level avionics maintenance system trainers will be of the electronic workbench type. The organizational-level trainer will be an integrated avionics system, consisting of seven operationally interconnected panels.

Use of Weapon System Trainers minimizes the high cost of operating the aircraft for training missions. The WST's allow the students to develop increased proficiency in handling the large volume of target data which the new system provides, and does so without incurring the high cost of aircraft operation.

The WST will have facilities for training aviators and tactical personnel either individually or simultaneously as requirements dictate. The trainer will consist primarily of student station, instructor station and computer. It will be able to simulate all flight conditions, aircraft auxiliary systems, communication and navigation systems, as well as the all-important ASW avionics systems. The Weapon System Trainer will provide both comprehensive initial training and low-cost refresher training for operational crews.



The Computerized "VS" Mission

A multitude of advances in sensor design, human engineering concepts and data handling techniques are embodied in the S-3A. These improvements result from the need to maintain, as a minimum National commitment, the ability to forcefully deter aggression by constantly-improving enemy submarines. The S-3A system is capable of defeating any current enemy submarine, as well as those of the 1980's.

The extremely high data rates associated with the tracking of these quiet, high-speed targets requires that thousands of bits of intelligence be memorized and made available for instant recall. Thought processes on the part of the hunter must be logical, simply organized and imaginative .. an impossible requirement for the "precomputerized" Tactical Coordinator. The S-3A will solve the problems of the ASW TACTICIAN who has previously been immersed in piles of charts and logs, who has had to twist numerous knobs and throw many switches, while simultaneously attempting to interpret incoming raw intelligence and formulate an effective tactical plan of action.

The following model illustrates how the new weapons system will function:

The S-3A's data processing system catalogues and stores such information as high-probability areas, types of targets to expect, ordnance loading, sonobuoy frequencies and monitoring cycles. This essential information is immediately available for use as *a priori* background data in the selection of the most appropriate tactics.

During preflight the computer calculates required headings, distances and en route time. After launch, when engaged with the autopilot, the computer automatically flies the airplane in accordance with the preprogrammed flight plan. The communications system, in conjunction with the computer, can transfer data to other participating units or report weapon system performance via the digital data-link.

Once in the OPEREA, after oceanographic conditions have been sampled, the computer determines noninterference of RF channels, and instructs the sonobuoy receiver to "channelize" to the proper frequency for reception of sonobuoy signals, and through its switching matrix, for routing to the proper acoustic data processor channel. The computer memorizes the position, time of release, channel and depth, for the buoy just dropped. This information is then placed on the digital magnetic tape unit for post-flight data reduction.

Throughout the mission, the TACCO's display provides either a surface tactical plot, complete with sonobuoy positions, channel numbers, time dropped and other significant data; or sensor data from the acoustic processor, radar, ECM, infrared, or MAD, as he chooses. When the crew detects a submarine, self-contained software and circuitry in the acoustic processor aid in sorting the threat from a multiple-target environment. The acoustic processor can automatically track acoustic bearings, and the computer can store them until called up for presentation on the multipurpose displays. Automatic tracking of radar, MAD, ECM or infrared targets is also available.

During MAD tactics, the computer-generated scope markings assist the operator in recognizing and evaluating the signal. In the attack phase, the computer searches out attack stores inventory, selects and arms weapons, cues the pilot to turn on the master arming switch, calculates the release point and, unless overridden by the pilot, releases the weapon.

Throughout the flight, each crewman converses with the computer and subsystems through INCOS keysets, thus keeping ICS traffic to a minimum. Equipment logs, records, tactical plot and navigation tracks are automatically recorded on either the analog tape recorder or the digital magnetic tape unit, and thereby relieve the crew of the requirement for manual log keeping.

The S-3A truly provides a giant state-of-the-art advancement for the "VS" effort. This plane, with its highly trained crew will effectively counter any undersea threat.

The S-3A Team

Development and Operator	U. S. Navy
Prime Contractor	Lockheed
Associate Contractors	
General-Purpose Digital Computer	UNIVAC
Airframe Portions, Wing and Landing Gear	Vought Aeronautics
Sub-Contractors	
AVIONICS	
Flight Displays and Interface System	Bendix
Auto Flight Control System	Bendix
Central Air Data System	Bendix
High-Frequency Transceiver	Collins
Ultra-High-Frequency Transceiver	Collins
Data Terminal Set	Collins
Sonobuoy Reference System	Cubic
Digital Magnetic Tape Unit	Echo Science
Analog Tape Recorder	Genisco
Integrated Control System	Hartman Systems
TACAN and RAAWS	Hoffman
ECM	IBM
Inter Communications System	ISC/Telephonics
Attitude Heading Reference System	Lear-Siegler
*Carrier Aircraft Inertial Navigation System	Litton
Tactical Displays System	Loral
Doppler Ground Velocity Set	Ryan
Acoustic Data Processor	Sanders Associates
*Radar (APS-116)	Texas Instruments
Infrared	Texas Instruments
*MAD (ASQ-81)	Texas Instruments
AIRCRAFT SYSTEMS	
Environmental Control System	AiResearch
Flight Control System Power Servos	Bertea
*Engines (TF-34-GE-2)	General Electric
Ejection Seat	McDonnell-Douglas
Constant Speed Drive	Sundstrand
Generator	Westinghouse
Auxiliary Power Unit	Williams Research

*Government-Furnished Equipment (GFE)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