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I am submitting herewith a thesis written by Raymond J. Griffith entitled "A Feasibility Study of Using a Modified Lockheed S-3A Viking Aircraft for the Long Range Insertion Missions of Special Operations Forces." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for a degree of Master of Science, with a major in Aviation Systems.

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A Feasibility Study of Using a Modified Lockheed S-3A Viking Aircraft for the Long Range Insertion Missions of Special Operations Forces.

A Thesis

Presented for the

Master of Science

Degree

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Raymond J. Griffith

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ABSTRACT

In 1987 the Department of Defense contracted for the development of two derivative aircraft for the specific purpose of Special Operations Forces Missions. The MH-60K helicopter was designated for the short range mission requirement, the MH-47E helicopter was designated for the medium range requirement, and the V-22 tilt rotor aircraft was to be assigned to meet the long range mission requirements. Although the MH-60K and MH-47E are now going into production, the V-22 program is in danger of being cancelled by congress in an effort to cut the defense budget. This thesis examines a possible interim solution to the long range Special Operations Aircraft shortfall caused by the delay or cancellation of the V-22 program.

The proposal is a derivative of the Lockheed S-3A Viking aircraft. The derivative design will stress equipment commonality with existing fleet assets and the MH-47E and MH-60K. Design requirements considered include: all weather, day/night, low level, and high altitude Special Forces delivery. Mission requirements also include the capability to operate from short runways and aircraft carriers. Topics included in the discussion include: avionics design and modification, project management, mission performance, and logistics considerations.

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PART I

INTRODUCTION OF THE CONCEPT

CHAPTER 1

INTRODUCTION

Middle-east terrorist operations and successful Israeli commando operations early in the 1980's reaffirmed to United States military commanders that small specially trained military units are a great asset and will continue to be in any future armed conflict. Limited wars such as those experienced in Viet Nam, Afghanistan, the Falkland Islands, and Granada proved the value of "Special Forces". In Viet Nam, U.S. Navy SEAL (sea-air-land) Teams, Marine Corps Rangers, and U.S. Army Green Berets proved their value time and again while conducting Riverine operations, advanced patrols, deep penetration patrols, and many interdiction roles throughout North and South Viet Nam. The Soviet Union very adeptly employed their Spetsnaz units in intelligence gathering and search and destroy roles in the Afghanistan Civil War. British and American Special Forces units captured and held vital airports in action in the Falklands and Granada respectively. More recently, the U. S. Army invasion of Panama against Manual Noriega was lead from every angle by Special Forces troops.

During the 1980's, there was a large strengthening of the Special Operations Forces of the United States Armed Forces. Navy SEAL Teams, Army Green Berets, and Marine Corps Rangers all benefited from large military budgets of the Reagan presidency. Special Operations Forces contingency plans were developed for operations in every conceivable theatre of operations and many different types of missions.

The mission of the Special Operations Forces is to autonomously perform unconventional warfare missions throughout the world. Although specific Special Forces missions are all classified, they are the same types of missions that were used in past armed conflicts. Special Forces missions include the classic World War II commando raids that were used by both the Allies and the Axes to remove or eliminate specific targets, capture and defend specific targets until larger forces arrived, snatch operations (abduction of enemy operatives), intelligence gathering patrols, and hundreds of specific "special" missions including all-weather, day and night, clandestine, deep penetration missions.

As mentioned previously, the Special Operations Forces of the United States Armed Forces include the U.S. Navy SEAL Teams, the U.S. Marine Corps Rangers, and the U. S. Army Green Berets. Although there are major differences in the conduct of operations and overall basic missions for each of these forces, there are also major similarities. Each unit is designed and trained to work in small teams with a maximum of 8 personnel per team. All are designed around the principle of a seven or eight man stick which can operate independently for extended periods whether in intense combat or on a covert operation. Primary insertion methods employed by all three units include helicopter drops and parachute drops.

Aircraft that are presently used for Special Operations Forces insertion include the C-130 Hercules, the C-141 StarLifter, OV-10 Bronco, and nearly all military helicopters. In 1987, pentagon plans included a three part plan for Special Operations Forces aircraft procurement. Plans included a derivative of the UH-60A Black Hawk, designated the MH-60K, which was to perform short-range missions. The medium-range mission requirements were to be met by a derivative of the CH-47 Chinook, designated the MH-47E. The V-22 tilt-rotor aircraft was to fill the long range mission requirements. The MH-60 and MH-47 were developed in parallel at Sikorski Aircraft and Boeing Helicopters with the first MH-47E rolled out in December of 1989 and the first MH-60K due out in April of 1990. Both aircraft are derivatives of existing aircraft and are being procured under an acquisition process stressing commonality of equipment. On December 1, 1989, the Navy cancelled advanced production contracts for the V-22 program. At best, this will mean extensive delays in the V-22 aircraft production. In the worst case, the V-22 program will be cancelled entirely by Congress during the spring 1990 session.

The delay or cancellation of the V-22 Osprey will leave a large gap in the long range capabilities of the Special Operations Forces aircraft. Although many of the requirements of the Special Forces missions can still be met by the aging fleet of C-130's, the Hercules' large size, relatively slow speeds, high fuel consumption, and aircraft carrier incompatibility warrant looking into other alternatives. The subject of this paper will be to analyze and design a derivative of the S-3A Viking for the long range Special Forces Operations mission.

In considering a derivative of the S-3A Viking aircraft for the Special Operations Forces mission, there are several basic concepts that will guide my reasoning throughout. First, the S-3A modification is not a final solution. That is, the S-3A modification is to be a filler between the present and the time when the V-22 is funded or another specifically designed aircraft is developed. Secondly, the modification is being planned around a four aircraft conversion. Each aircraft will be chosen form the existing Navy fleet S-3A aircraft. The aircraft chosen for the modification will be low time airframes and each will be completely modified with the Increased Capacity Auxiliary Power Unit (ICAPU). Third, off-the-shelf technology and equipment will be used whenever possible. Additionally, every effort will be made to retain equipment commonality with current Navy airwing aircraft and the MH-47E and MH-60K.

In considering a modification to the S-3A, there are many areas where previous lessons can be used to our benefit. The lessons learned during the S-3B, US-3 and ES-3 modifications of the basic S-3A will obviously be important to this discussion. Additionally, the experience gained during the F-18 Night Attack program and the MH-60 and MH-47 Special Operations Forces Aircraft programs will be drawn upon throughout.

In keeping with standard designations, the Special Operations Forces derivative of the S-3A will be designated as the MS-3C. The goal throughout this discussion will be to present a complete proposal for the MS-3C which will aid the Special Operations Forces in performing their mission throughout the world, in all types of weather, day or night, from land bases or from carrier decks.

CHAPTER 2

REASONS TO CHOOSE THE S-3A FOR THE MISSION

2-1: ALTERNATIVES

After one concludes that a long range Special Operations Forces Aircraft is needed now and will be needed in the future, one must look at different alternatives to fulfill the mission requirement. The first and most obvious aircraft to consider is the V-22. The Osprey was specifically designed for Special Operations Forces mission requirements and is the most desirable option. Unfortunately, it does not appear to be a realistic option at this time. Although the first two developmental aircraft are now flying; budget cuts, congressional infighting, and soaring development costs have all but killed the V-22 program.

The next obvious candidates for the long range Special Operations Forces mission are the MH-47E and MH-60K helicopter variants. Although these aircraft will undoubtedly be of great value in performing the medium and short range requirements, their maximum ranges fall significantly short of mission requirements. The maximum mission range of the short range MH-60K is predicted to be 200 nautical miles and the medium range MH-47E is predicted to be approximately 350 nautical miles, both far short of the long range mission requirements of 1000 nautical miles. Additionally, even if these helicopters could meet the maximum range requirements, the transit time required at top speeds would be prohibitive to mission success. Following this reasoning, all conventional helicopters can be eliminated from consideration for the long range mission.

Next to be considered for the long range Special Forces mission is the venerable C-130 Hercules. The "Herc" has been successfully performing a wide range of Special Forces missions for over 30 years. There can be no doubt of the C-130's ability to perform the long range mission within certain limitations. First is the Herc's fuel requirements. A full internal load of fuel is approximately 67,000 pounds of JP-5 which gives the C-130 an impressive range in excess of 3,400 miles at optimum altitude. Although the 3400 mile range is a great asset, this high fuel consumption is a problem when fuel must be obtained at a remote site. A full 25,000 pounds is required for a 1000 mile flight at sea level. A second negative for the C-130 is it's speed. Although the maximum speed is 350 knots, realistic fast cruise speeds are on the order of 270 knots. In addition to requiring long transit times, this relatively slow speed increases exposure, detection times, and vulnerability. The last limitation of the C-130 that shall be discussed is the inability to operate form an aircraft carrier. Special Operations Forces on board an aircraft carrier greatly increase the battle group commanders options in crisis situations. It has been proven in the past that a C-130 can operate from the deck of an aircraft carrier if specially modified, but it is doubtful that routine carrier operations with such a large aircraft will become a reality in the near future.

2-2: S-3A OPTION

The S-3A was chosen for consideration for the long range Special Operations Forces mission because it is a highly versatile airframe which has proven to be easily adapted to different missions. The aircraft, shown in figure 2-1, is a high wing, twin engine, jet powered, aircraft carrier based antisubmarine warfare aircraft. The wings and vertical tail fold in order to reduce the size of the aircraft for aircraft carrier deck operations and confined area taxiing. The aircraft is also equipped with sequential crew ejection seats, an in-flight refueling probe, and a self starting auxiliary power unit (APU). The two General Electric TF-34 high-bypass turbofan engines are mounted under the wings on pylons inboard of the wing fold stations and each provide approximately 9275 pounds of static, sea level, uninstalled standard day thrust (S-3A NATOPS Flight Manual, reference 6). The principal dimensions of the S-3A are shown in table 2-1.

The principal advantage of converting the S-3A into a Special Operations Forces Aircraft is that the S-3A is an off-the-shelf, proven airframe. During the US-3A and ES-3 modification programs, the basic S-3 airframe proved to be easily modified and capable of a wide variety of missions. The airframe is similar to a flat bed truck. It is easy to unload one cargo and put another on board. The cargo of the basic S-3A is Antisubmarine Warfare Equipment. The US-3 model carries cargo and passengers; and the ES-3 version of the S-3A "Airtruck" carries Electronic Countermeasures Equipment.

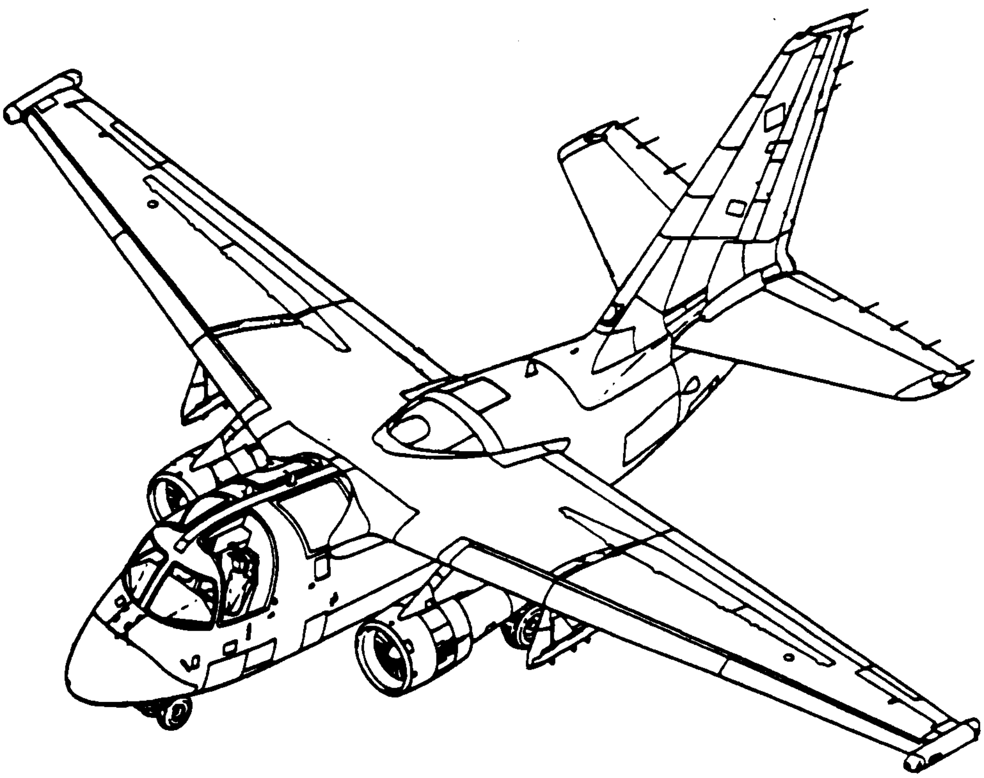


Figure 2-1

S-3A Aircraft

Table 2-1

S-3A Dimensions

Dimension	Measurement
Wing Span (spread)	68 feet 8 inches
Wing Span (folded)	29 feet 6 inches
Length	53 feet 4 inches
Length (tail folded)	49 feet 5 inches
Height	22 feet 9 inches
Height (tail folded)	15 feet 3 inches
Tread, Main landing Gear	13 feet 9 inches
Wheel Base	18 feet 9 inches
Turning Radius (wings spread)	41 feet 2 inches
Turning Radius (wings folded)	31 feet 0 inches

Data taken from S-3A NATOPS Flight Manual, reference 6.

Past performance of the S-3A has proven that it is very dependable and requires relatively low maintenance time for the airframe and engines. These factors combined warrant a closer look at the S-3A airframe for modification.

As mentioned earlier, the S-3A is an aircraft carrier based aircraft. Being carrier based allows the Special Operations Force Aircraft to be forward deployed in many situations when conventional land based aircraft must maintain excessive standoff distances. Forward deployment cuts down on reaction times and increases coordination between participating military forces. Additionally, when operations out of small land bases are required, the S-3A also appears to be a good choice for modification. As will be discussed in chapter 6, the S-3A can safely and consistently operate from a 3,000 foot runway. This capability, coupled with the small on deck turn radius and the low FOD (Foreign Object Damage) rate of the TF-34 engines, allows the S-3A to operate from many third world airstrips. Additionally, the S-3A is equipped with a self starting Auxiliary Power Unit (APU) which is capable of starting the engines. Because of this, the S-3A operates in a completely self contained manner and requires no ground support equipment.

The S-3A's performance specifications also point it out as a good candidate of conversion to a Special Operations Forces aircraft. The aircraft's top speed of 450 knots would make it one of the fastest aircraft used for Special Operations missions. Of military aircraft currently used for Special Forces insertion, only the C-141 has a faster cruise speed. The 450 knot maximum airspeed along with stall speeds below 90 knots will allow for a wide range of mission scenarios. Additionally, the S-3A's maximum range of well over 2,000 miles, maximum endurance of over eight hours, and in-flight refueling capability also allow for considerable flexibility in mission planning.

Other attributes of the S-3A which make it a good option for the Special Operations Forces Aircraft are all weather and weapons capabilities. The aircraft is equipped with leading edge deicing on the wings and horizontal tail, engine anti-icing, and antiskid brakes which permit operations in extreme adverse weather conditions. The S-3A weapons system includes the capability for a wide range of bombs and rockets which would be very useful in many special operations missions.

Although a modified S-3A is not going to be the optimal solution to filling the gap in the long range Special Operations Forces mission, it will be a great asset and will be a fairly inexpensive interim aircraft. The proven capabilities and dependability of the airframe make it an excellent choice for an off-the-shelf modification for this specific purpose. Subsequent chapters will examine what is considered to be the best modification configuration for the mission, project management considerations, mission performance, and logistics. It is the author's hope that this will prove to be a viable interim solution to a long term aircraft mission problem.

PART II

AIRCRAFT MODIFICATION

CHAPTER 3

INTERNAL MODIFICATIONS

3-1: REMOVAL OF UNNECESSARY EQUIPMENT

The modification of a basic S-3A into an MS-3C Special Operations Forces Support Aircraft begins with the removal of all equipment unnecessary for the mission. This procedure will be very similar to the US-3 modification and will yield similar results. Like the US-3 modification, the MS-3C modification will start with the removal of all Antisubmarine Warfare (ASW) related equipment. This will include the AN/AYK-10 General Purpose Digital Computer (GPDC), all five Multipurpose Displays, the Display Generator Unit (DGU), the Digital Magnetic Tape Unit (DTMU), all acoustic processing equipment, the APS-116 Multipurpose Radar, Electronic Support Measures equipment, the Forward Looking Infrared (FLIR) turret and recorder, the Magnetic Anomaly Detector (MAD) set and boom and all equipment associated with these major subsystems. Detailed figures showing the location of equipment to be removed during the modification are presented in appendix A, figure A-1.

In addition to removing the unnecessary equipment listed in the preceding paragraph, all the controls and indicators associated with these and other unneeded equipment must be removed. With the exception of the Internal Communications (ICS) control panels, all controls and indicators associated with the Tactical Coordinator (TACCO) and Sensor Operator (SENSO) crew stations will be removed entirely. Table 3-1 lists the equipment that will be removed from the pilot and copilot crew stations. Additionally, figures A-2 through A-10 of appendix A show the location of this equipment.

Table 3-1

Equipment Removed From Pilot and Copilot Stations

Integrated Radio Control	Film Recorder
Radar Off-line Control Panel	LF DF Control Panel
Mad Control Panel	Pilot INCOS
Copilot INCOS	KY-58 Control Panel
KG-40 Control Panel	Mad Boom Control Switch Panel
ARA-63 CILS Control Panel	ASW-25 ACLS Control Panel
AMAC Panel	IFF Interrogator
ACLS Radar Control Panel	TACAN Control Panel
Navigation Control Panel	IFF Control Panel
FLIR Retract Switch	Search Power Switch

After all the equipment is removed, the TACCO and SENSO equipment racks can be removed entirely. Removal of these racks will increase the size of the passenger compartment similar to that of the US-3. All equipment remaining on the starboard (right) aft internal equipment rack will be shifted over to the port (left) aft internal equipment rack. The starboard aft internal equipment rack will then be removed to create an internal under wing cargo compartment as shown in figure 3-1. This compartment will be able to carry approximately 40 cubic feet of cargo and equipment during transit to an area of operation.

With the removal of the unnecessary electronic equipment and equipment racks complete, next to be removed are the rear (TACCO and SENSO) ejection seats. Both rear cockpit ejection seats, their rails, and support structure are to be removed. The front cockpit, pilot and copilot, ejection seats are to be modified to incorporate a "NO EJECT" option. This will be done by reducing the length of the seat safety levers, shown in figure A-11 of appendix A, to a length that will not protrude from the headrest when in the safe position. This modification will allow the pilot and copilot to fly with the safety levers in the safe (no ejection) position and thus have safe ejection seats whenever passengers are on board. At the same time, the flight crew will have the option of arming their seats after passenger drop off or when no passengers are aboard.

3-2: PASSENGER COMFORT AND SAFETY ADDITIONS

Since the standard Special Forces team is composed of a maximum of eight members, the MS-3C must be capable of accommodating eight passengers. To do this, the rear crew compartment will be modified in the

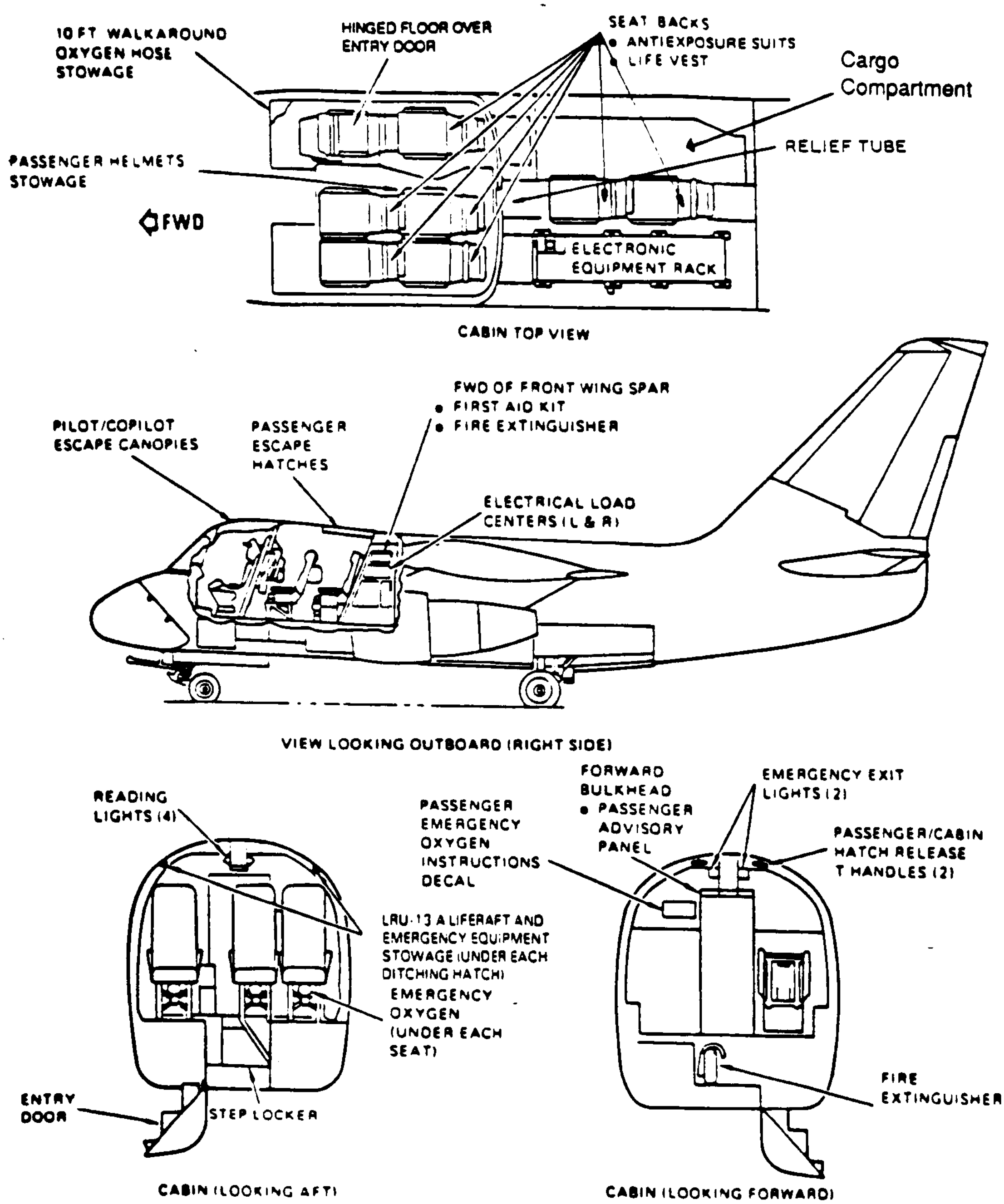


Figure 3-1

MS-3C Interior Compartment Layout

same manner as the US-3. In addition to these six passenger seats, two more will be added in the rear compartment equipment access aisle as shown in figure 3-1. These two seats will be hinged on the right side with quick release mechanisms on the left side to allow normal use of the aisle and quick access in case of emergency. The two extra seats will only be used when necessary and will not normally be required. All eight passenger seats will be fully removable and capable of being folded for easy stowage. The six regular and two hinged passenger seats are shown in figures 3-2 and 3-3 respectively.

In addition to the seats, there are several passenger safety items which must be incorporated in this design. First are the "Cabin and Passenger Alerts Lights" which are shown in figure 3-4. The lights on this panel will be controlled by the copilot through a control panel on the copilot overhead control panel. Second is a cabin loudspeaker which will be controlled by the TACCO internal communications panel. This speaker system will allow the aircrew to communicate with all passengers simultaneously without requiring the passengers to wear special communications equipment. Next will be the addition of a pair of Navy standard LRU-13A seven man liferafts including the normal full survival equipment package. The two rafts will be stowed beneath the aft emergency escape hatches as in the US-3A. A final addition to passenger safety

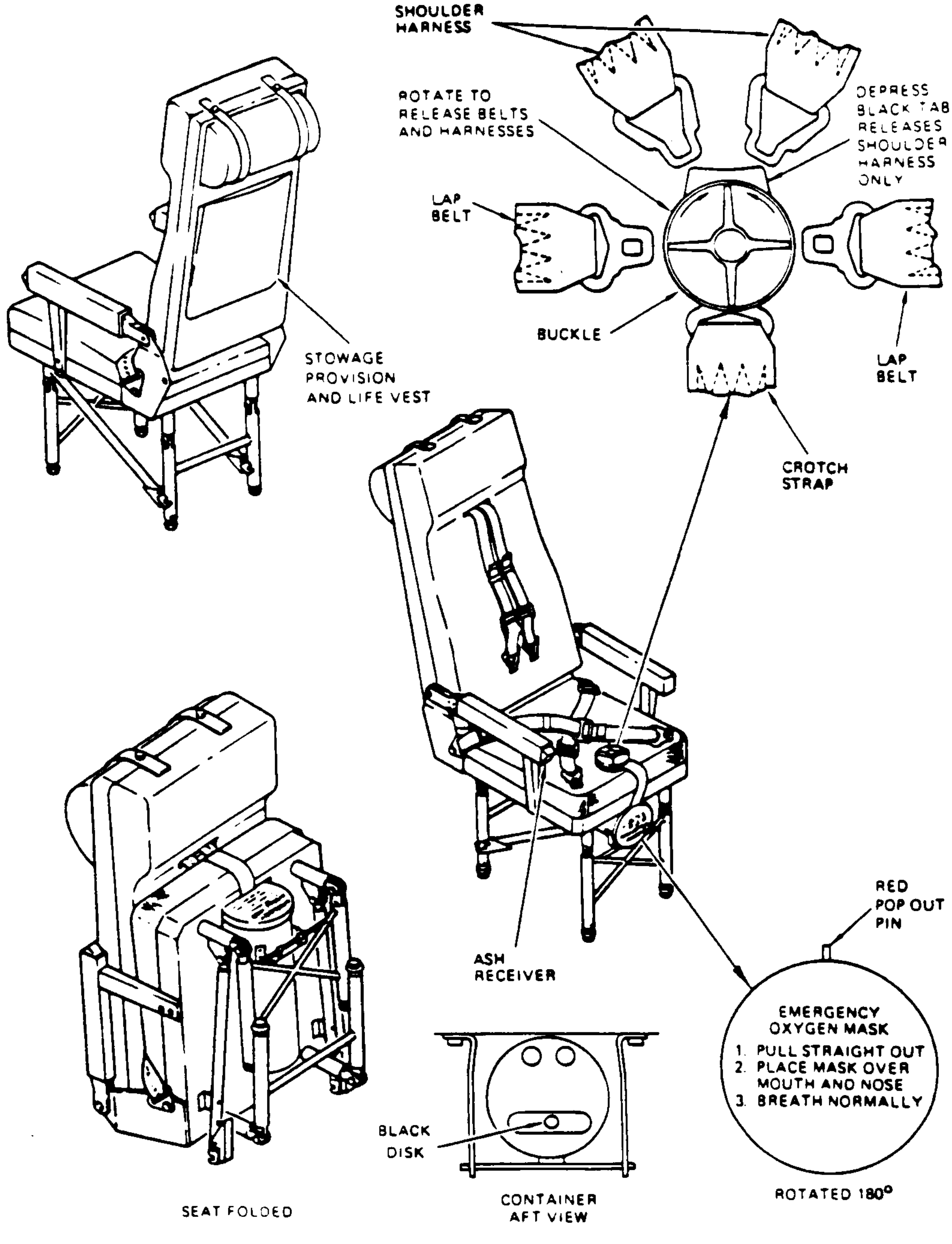


Figure 3-2

Standard Passenger Seats

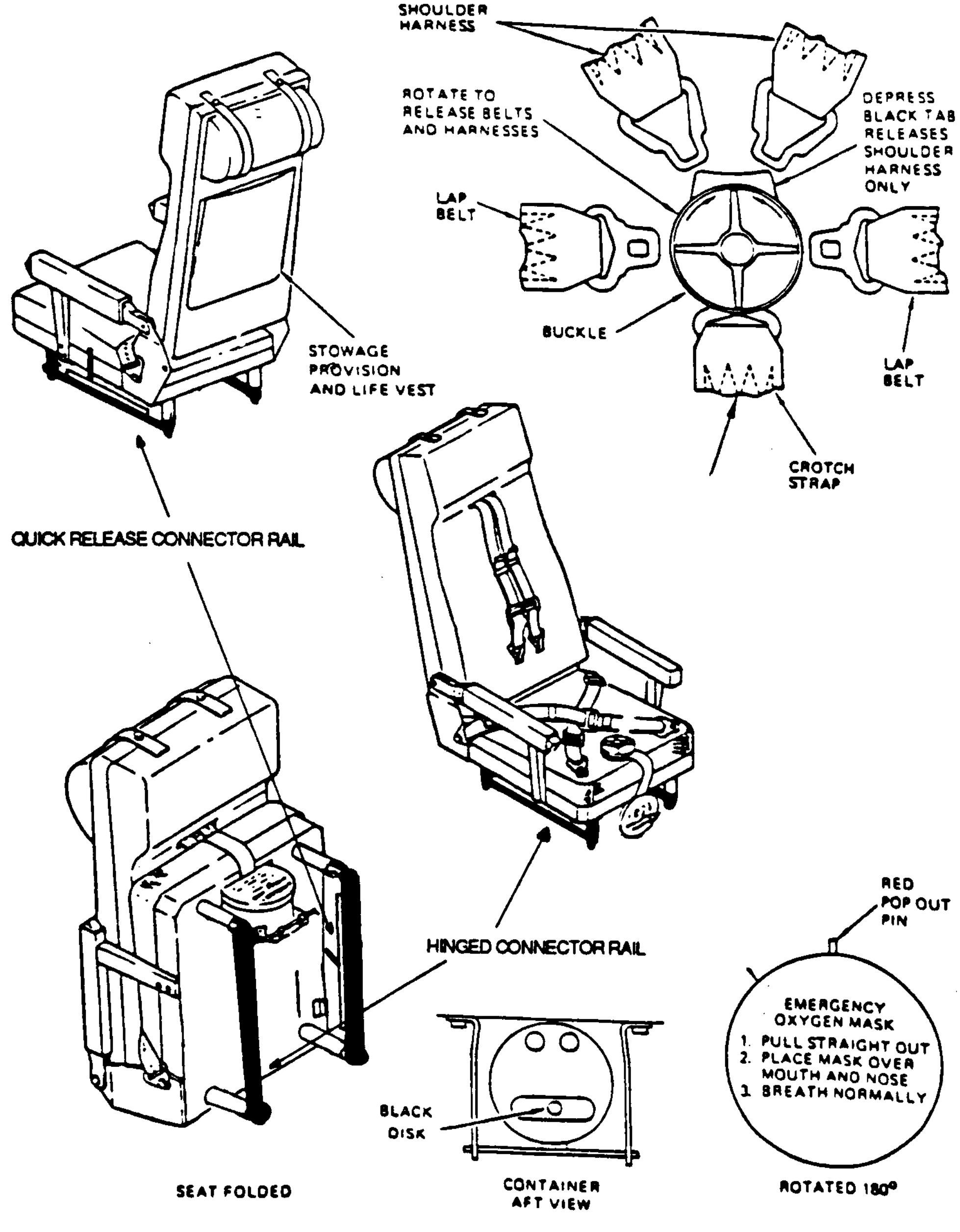


Figure 3-3

Hinged Passenger Seats

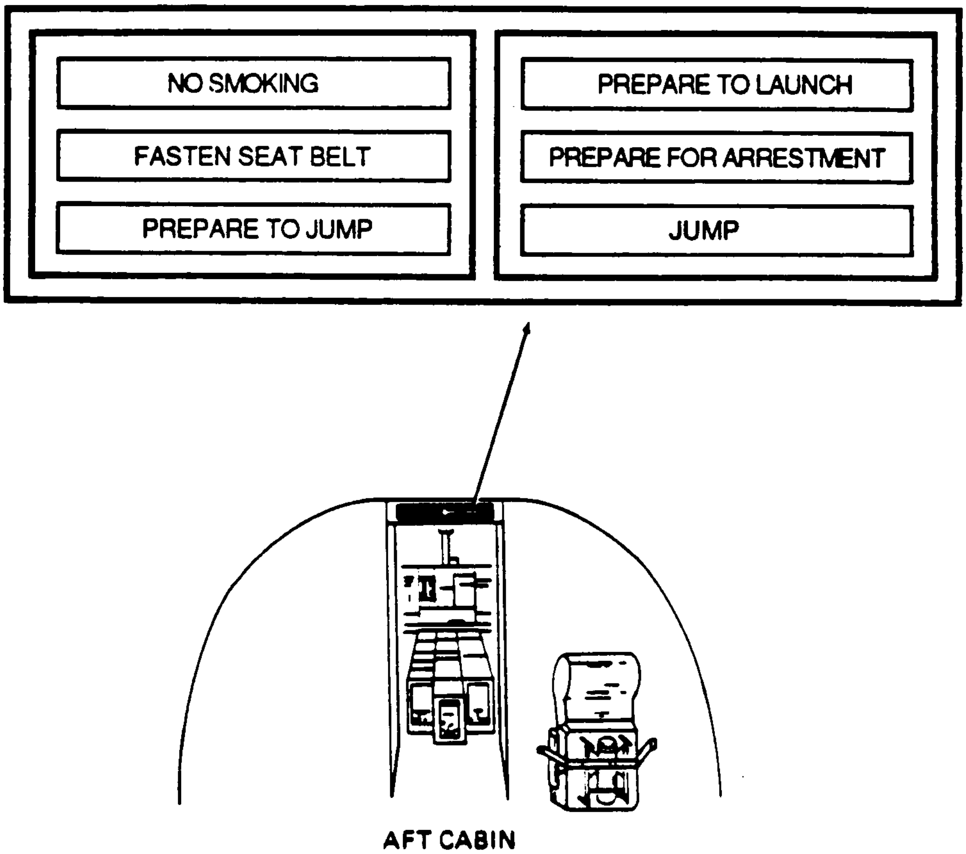


Figure 3-4

Cabin and Passenger Alert Lights

equipment will be the addition of emergency oxygen bottles under each of the passenger seats as indicated in figure 3-2 and 3-3.

3-3: CREW ACCESS HATCH

The S-3A crew access hatch is shown in figure 3-5 and the dimensions of the access hatch opening are shown in figure 3-6. Although the opening is large enough for a large man with a fully loaded pack and a parachute to jump out of, the access hatch blocks most of the opening when it is in the open position. In order to alleviate this problem and provide ample room for parachute jumps, the entry hatch must be redesigned. The most obvious solution is to hinge the door at the top so that it will swing out rather than down. A second solution is to totally redesign the door such that it operates in a clamshell manner and opens forward into the wind stream and partially protects the jumpers as they go out. A third solution is to redesign the door such that it opens up into the cabin and stows out of the jumpers path. These are just three of many options available as a solution to entry hatch interference and in the author's view this is a very minor problem.

In order to ensure an adequate opening is available for parachute drops, a team of design engineers will be assembled to redesign the crew entry access hatch early in the modification process. In redesigning the door, the team will have available the aircraft hydraulic and electrical systems should a powered door be deemed necessary. A further consideration in door

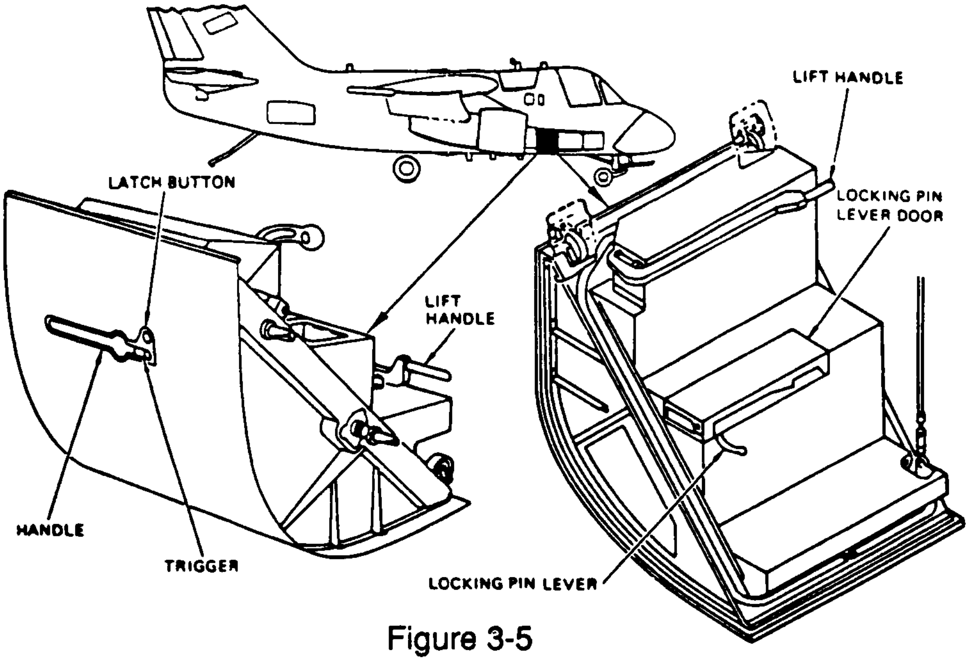


Figure 3-5

S-3A Crew Access Hatch

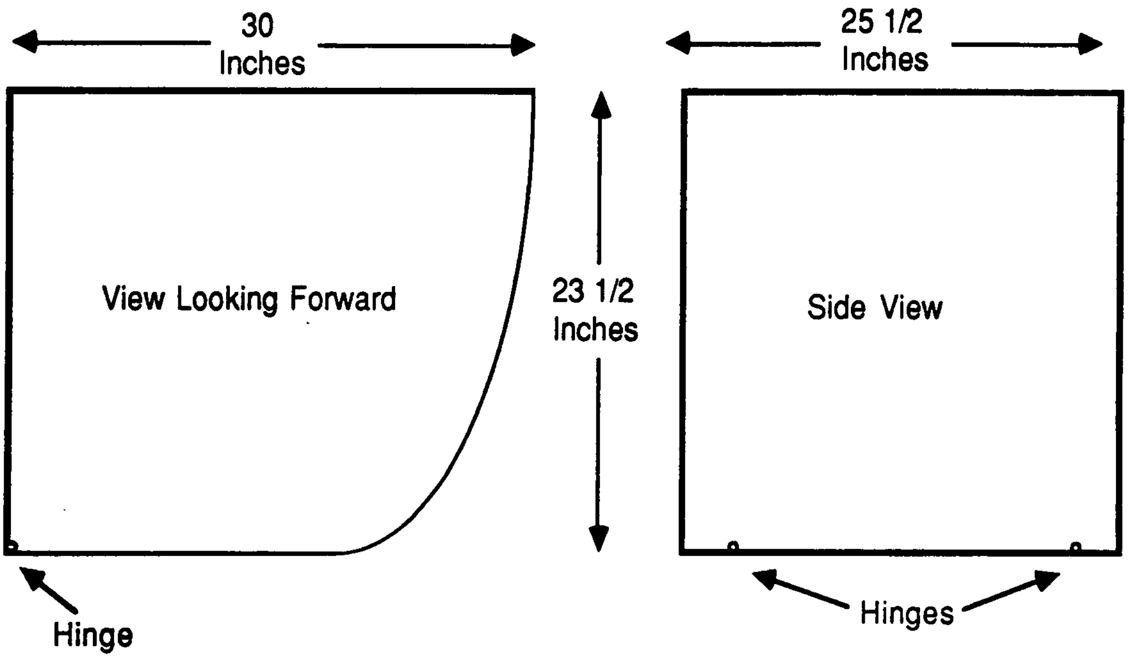


Figure 3-6

Crew Access Hatch Opening Dimensions

design is the position of the door opening relative to the number two engine. The closest point of the engine inlet is 16 inches aft and 30 inches outboard of the door opening. Since the inlet is 30 inches outboard, there should be no problem with airflow disturbance nor foreign object damage to the engine. As the door design may be a "show stopper", the design process will begin early as indicated in chapter 5.

3-4: AVIONICS

The mission avionics of the MS-3A will be based around dual AN/AYK-14 Mission Computers and dual redundant MIL-STD-1553A multiplex busses which will provide the interface for all subsystems. An avionics subsystems block diagram is shown in figure 3-7. As can be seen in the block diagram, the principle crew interfaces will be dual Digital Display Indicators (DDI), dual Multipurpose Color Displays (MPCD), a pilot's Head-Up-Display (HUD), and an electronic equipment control unit. Appendix A, table A-1 is a complete listing of the avionics to be incorporated in the MS-3C.

3-4-1: Data Processing

Avionics subsystems data transfer will be accomplished via dual redundant path MIL-STD-1553A time multiplexed digital data communications buses (MUX buses). Two U. S. Navy standard airborne

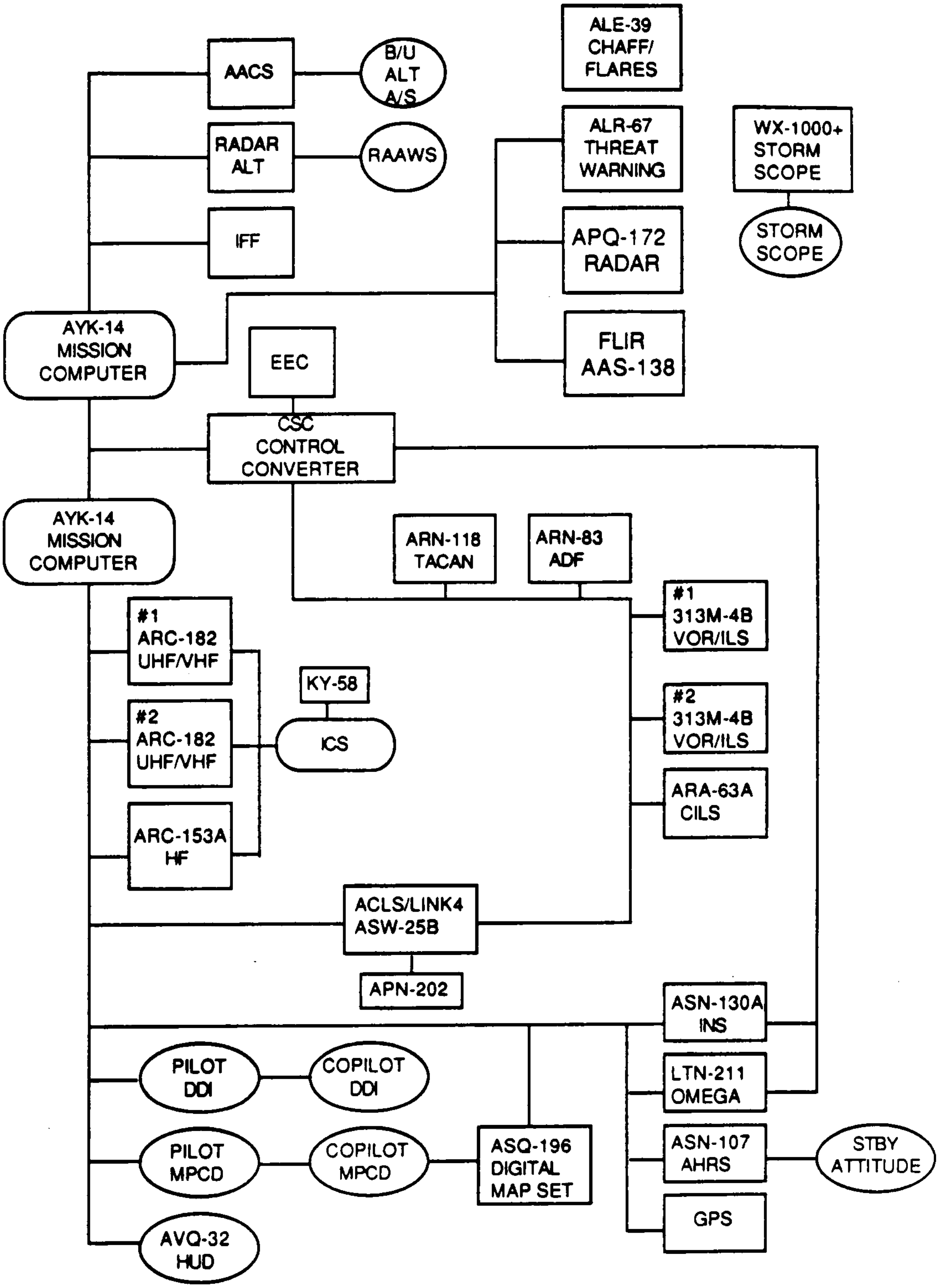


Figure 3-7

Avionics Subsystem Block Diagram

computers, AN/AYK-14's, will be used to perform processing for navigation, control and display management, and systems status monitoring. The AYK-14 is a low cost, high speed, modular, microprogrammable computer produced by the Control Data Corporation. Options include main programmable memory modules of up to 1M 16 bit words and input/output to and from 1553 A or B buses. The computers will receive inputs for navigation and steering commands from the Inertial Navigation System (INS), Global Positioning System, Omega system, TACAN, Attitude Heading Reference System (AHRS), and the Airspeed Altitude Computer Set (AACS). The number one mission computer will primarily control display symbology and information presented to the pilot and copilot by the multipurpose display group and the number two mission computer will primarily perform navigation functions and provide mode control, option select, and interface for the mission avionics subsystems. Each computer will be fully capable of backing up the other with only partial systems degradation if a single computer should fail.

The multipurpose display group will consist of the pilot and copilot Digital Display Indicators (DDI), the pilot and copilot Multipurpose Color Displays (MPCD), and the pilot Head Up Display (HUD). The multipurpose display group will convert navigation, aircraft attitude, and subsystem information from the mission computers into symbology for display to the pilot and copilot. The IP-1318A DDI's and IP-1535A MPCD's will be identical in every way to those used in the F/A-18. There are 20 pushbuttons on each DDI and MPCD which are used to select the function and mode of the display. The MPCD's will primarily be used to present a horizontal situation indicator (HSI) display of navigation information superimposed over the digital map set color projection to the pilot and copilot. The DDI's will primarily be used for display of the radar and forward looking infrared presentations and data management through the mission computer. Figures 3-8, 3-9 and 3-10 show an MPCD, a representative HSI display, and a DDI respectively. Both the DDI's and MPCD's are fully compatible with night vision goggles.

The AN/AVQ-32 head up display (HUD) will receive navigation, situation, and steering commands from the pilot's MPCD symbology generator and project it in a holographic display on the combining glass for head up viewing. It incorporates a night vision goggle compatible raster display capability which will allow it to display forward looking infrared video in the pilot's primary field of view. As shown in figure 3-11, the HUD will display all primary flight data including aircraft attitude, altitude, airspeed, mach number, load factor, angle of attack, true or magnetic heading, track, ground speed, TACAN bearing, ILS glideslope and azimuth, and waypoint steering. Although the HUD will be the pilot's primary flight instrument, the S-3A standard flight instruments will remain on the instrument panel as backup instruments.

In addition to the option select buttons on the MPCD's and DDI's, the

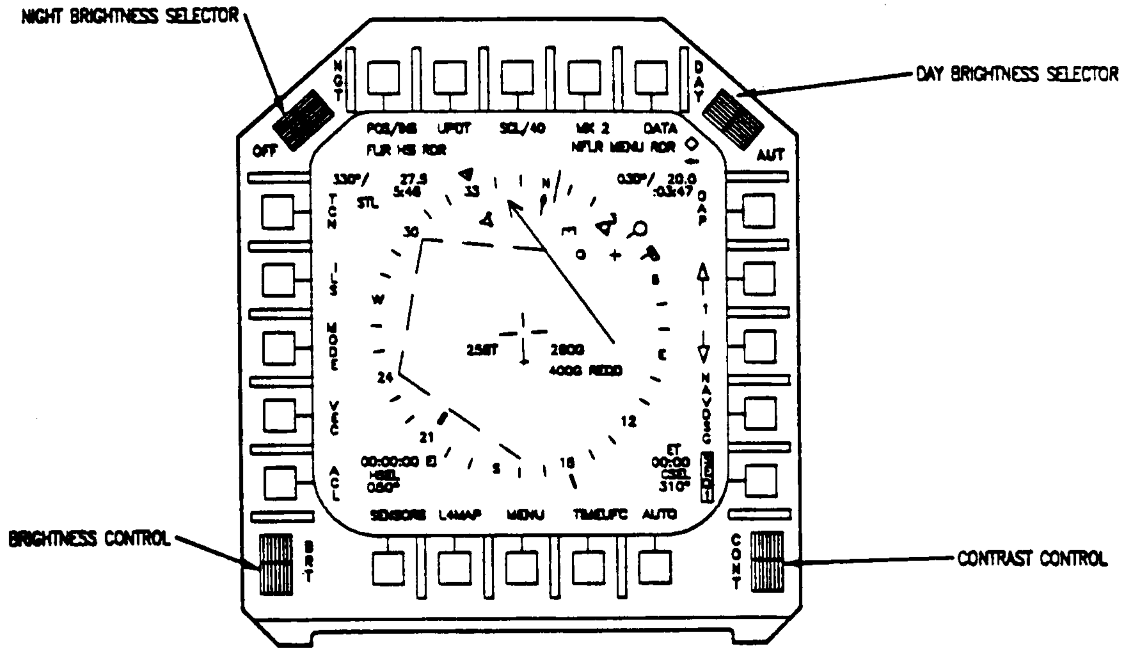


Figure 3-8

Multipurpose Color Display

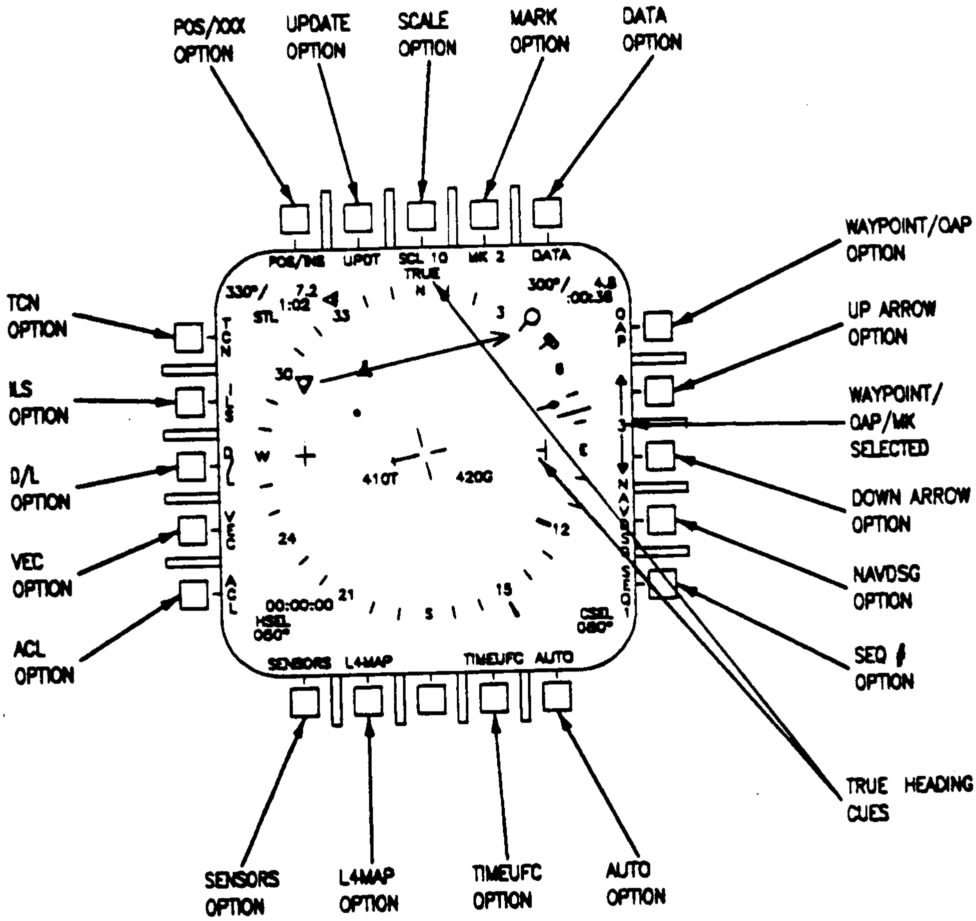


Figure 3-9

Typical HSI Presentation

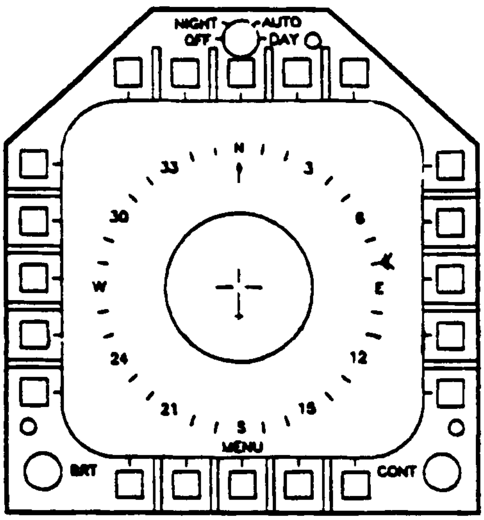
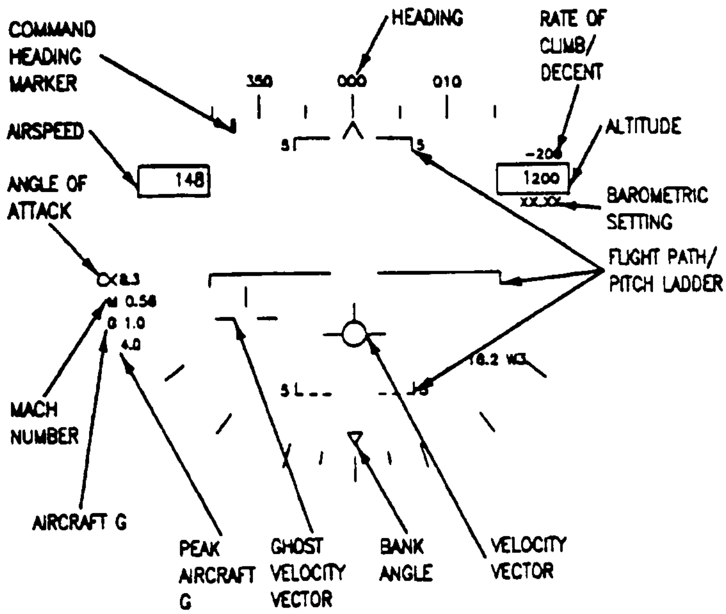
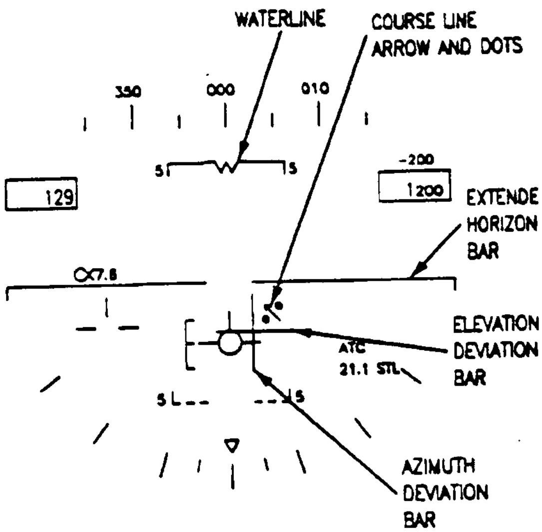


Figure 3-10

Digital Display Indicator



GREAT CIRCLE STEERING



GEAR DOWN
ILS STEERING
COURSE LINE STEERING

Figure 3-11

Head Up Display (HUD) Symbology

crew will be able to enter navigation and sensor data through the CC-10380/ASQ Electronic Equipment Controller (EEC), figure 3-12. Data and options entered through the electronic equipment controller will be transmitted directly to the communications system control for discrete control of the communications, navigation or identification equipment or to the mission computer. The EEC will be single point control of the TACAN, IFF, VOR/ILS, CILS, ACLS, navigation beacon, ADF, UHF/VHF radio, and HF radio. Direct control of the AN/ARC-182 UHF/VHF radio will be accomplished through the comm 1 and comm 2 volume control and channel select knobs. An included option which will be critical to covert missions is the emission control pushbutton. Selecting "emission control on" will inhibit all transmissions from the TACAN, IFF, radar beacon, and radar. Using the MPCD's, DDI's and the electronic equipment controller, the pilot and copilot will be able to control options and input data to all radar, forward looking infrared detector, communications, navigation, and identification equipment. This will eliminate the need for an individual control panel for each piece of equipment and provide easy access and standard input formats.

3-4-2: On-line Navigation

The navigation and communications equipment modification will start with the updating of the Inertial Navigation System (INS). This will be accomplished by a one for one swap of replacing the AN/ASN-92 INS with

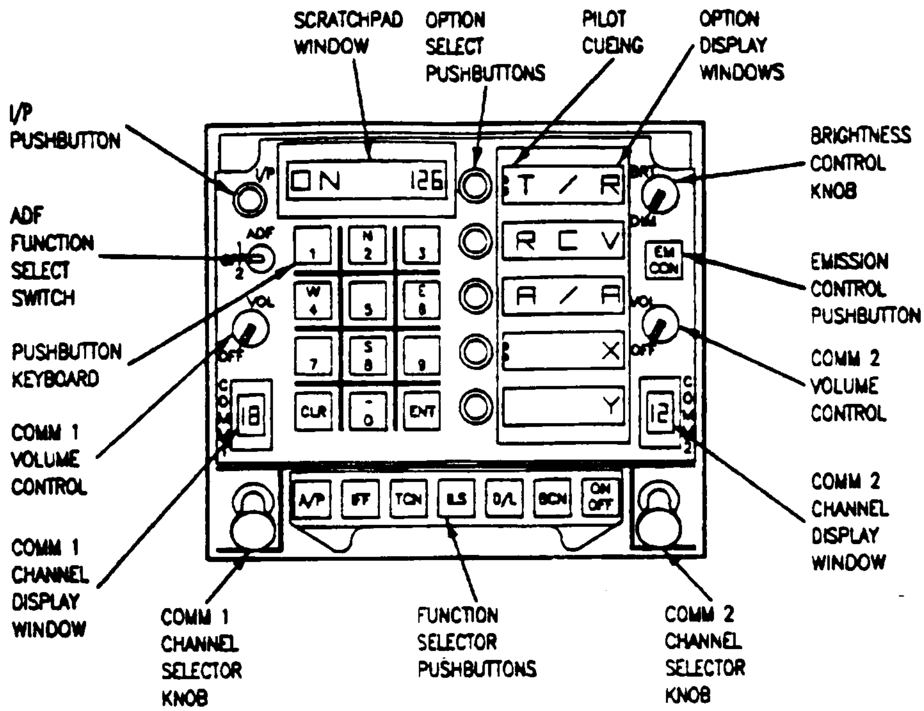


Figure 3-12

CC-10380/ASQ Electronic Equipment Controller the Litton AN/ASN-130A INS. The INS is a fully self contained automatic dead reckoning system which will detect aircraft motion and provide acceleration, velocity, present position, pitch, roll, and true heading to the mission computer and related systems. The ASN-130A is a wheel and gimbal system which outputs in the standard 1553 data bus format. It has a one nautical mile per hour maximum drift rate and a predicted mean time between failure (MTBF) of 1950 hours. Data transfer to and from the INS will be through the electronic equipment controller, the DDI's and the MPCD's.

The next addition to the navigation system will be the Litton LTN-211 OMEGA/VLF Navigation System and a Global Positioning System (GPS). The OMEGA system is a worldwide, all-weather, navigation aid which supplies continuous accurate position, navigation and guidance data for long range navigation. It is a user passive radio navigation system which uses the hyperbolic propagation of VLF radio frequencies in the band of 10 to 14 kHZ from several stations simultaneously to accurately determine receiver position. The LTN-211 will provide the following data to the mission computers: latitude and longitude, track angle, ground speed, heading, drift angle, cross track distance and angle, wind speed and direction, magnetic heading, true airspeed, OMEGA station status, and Greenwich mean time and date. The GPS system is a satellite navigation system which will use passive ranging doppler frequency shifts to provide the mission computers with position and velocity in three dimensions. The GPS will provide the following data to the mission computers: latitude and longitude, track, groundspeed, true heading, true airspeed, aircraft altitude, vertical velocity, Greenwich mean time and date.

Navigation functions will be performed primarily by the #2 mission computer with the #1 AYK-14 acting as a back up unit. The mission computer will use the best available position from one of the three navigation systems; GPS, INS, and OMEGA. Data from the three systems will be cross compared with error status presented to the pilot and copilot on the MPCD's and electronic equipment control. In the event that all three primary navigation systems fail, the mission computer will use the dead reckoning navigation from the last known position. In this case, the Attitude Heading Reference System (AHRS) and Airspeed Altitude Computer Set (AACS) become the heading and velocity sources. The combination of the GPS, INS, and OMEGA will provide the crew with state of the art extremely accurate navigation at all times, anywhere in the world.

The next step in the modification is to effectively present the navigation data. In addition to the standard HSI display with waypoint navigation, a Digital Map Set will be use to present the aircraft position on a map to the pilot and copilot. The AN/ASQ-196 Digital Map Set (DMS) will utilize the MPCD's to display to the pilot and copilot a high resolution color map for use in day and night navigation. The DMS consists of a Digital Map Memory Unit (DMU) and a Digital Map Computer (DMC) . The DMU contains a programmable laser disk which is designed to hold 90,000 square miles of chart. Three types of chart are are stored on the disk and present the following four scales: (1) Jet Navigation Chart (JNC) at a scale of 1:2,000,000nmi, (2) Tactical Pilotage Chart (TPC) at a scale of 1:500,000 nmi, (3) Joint Operations Graphic (JOG) at a scale of 1:250,000, and (4) a 1:1,000,000 scale by zooming the JNC scale. The DMC converts the TPC, JOG, or JNC charts into raster symbology for presentation on the MPCD's. The Digital Map Set receives aircraft position from the mission computer. The normal HSI display can be superimposed over the map display on the MPCD as shown in figure 3-13. Additionally, the DMS will provide a monochromatic image for display on the DDI's should an MPCD failure occur. The system will also have the capability of displaying the Terrain Following Radar image or Forward Looking Infrared image superimposed over the monochromatic map image.

On-line navigation using the GPS, INS, and OMEGA and presented on the MPCD digital map image will provide the capability of passive, accurate navigation anywhere in the world. This capability will greatly aid the pilots during long transits and will be especially important during low level ingress and egress. By presenting the digital map on his MPCD, the pilot will have the capability to access his positional situation quickly and accurately. This will allow him to avoid terrain features and enemy surface-to-air missile sites which can be real time programmed onto the programmable laser disk

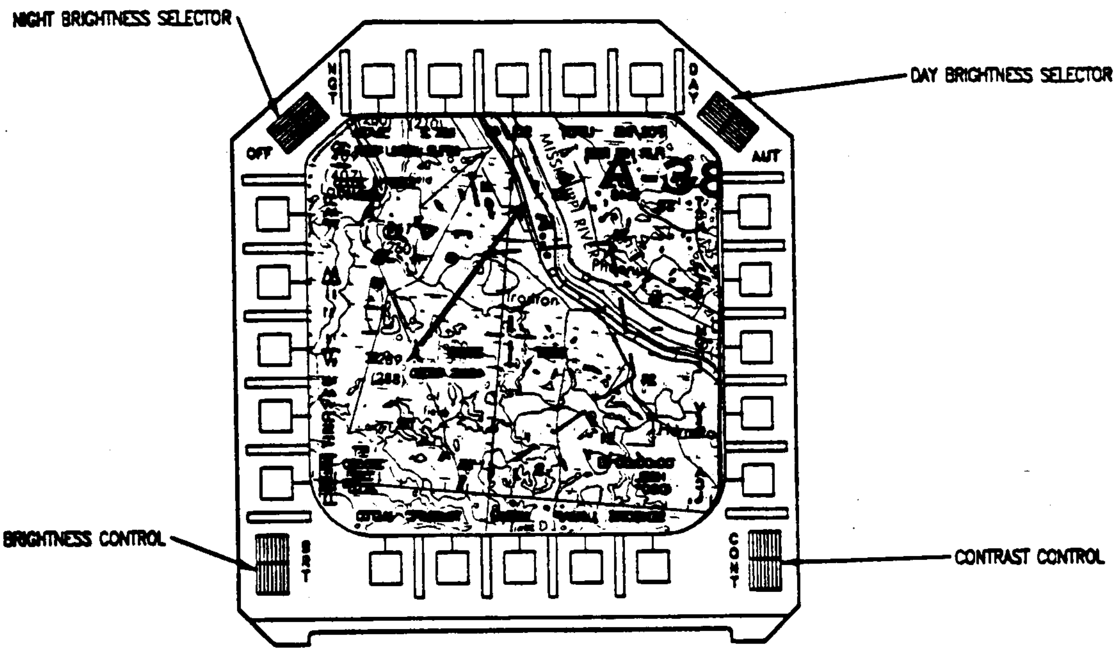


Figure 3-13

HSI and Digital Map Display on Multipurpose Color Display prior to the flight. This accurate on-line navigation system will minimize pilot work load and let him maximize his performance.

3-4-3: Radio Aids To Navigation

Airways and approach navigation will be accomplished using dual VHF Omnidirectional Range and Instrument Landing System (VOR/ILS) navigation sets, an updated Tactical Air Navigation (TACAN) set, and the Automatic Direction Finder (ADF). Two 313M-4B VOR/ILS navigation sets will be added for airways and non-precision approach navigation. The 313M-4B VOR/ILS has been employed in the US-3 with very good results. Both VOR/ILS units will be controlled through the electronic equipment controller and the DDI's. The VOR will provide the pilots with bearing, to/from relationship, and left-right position relationship to VOR stations which operate in a frequency range of 108.0 to 117.95 MHz. The ILS is a precision approach system that will provide the pilots with azimuth and glideslope information. The ILS ground system consists of a highly directional course localizer and glideslope transmitter which operates in the 108.1 to 111.9 MHz range. Associated with the ILS are integral Marker Beacon receivers which will receive the 75 MHz marker beacon signals.

The ARN-84 TACAN will be replaced with the more capable ARC-118 TACAN. The ARC-118 is a digital input/output capable system which has proven itself very reliable in the F-14 and F/A-18 aircraft. It will be controlled through the electronic equipment controller and the DDI's. The TACAN will provide the mission computers with bearing and distance information to selected ground stations up top a maximum of 390 nm distant for presentation to the pilots. The TACAN transmits in the frequency range of 1,095 MHz and receives in the frequency ranges of 962 to 1,024 and 1.151 to 1,213 MHz on any of 252 channels.

The standard S-3A AN/ARN-83 Automatic Direction Finder (ADF) will also remain in the MS-3C. The ADF will be used to provide the pilots with bearing information to radio beacons and commercial broadcasting stations on the ground. The receiver operates in a frequency range of 109 to 1750 kHz. The ADF receiver will be controlled by the standard S-3A control panel and will provide bearing and frequency information to the mission computers.

In addition to the radio aids to navigation described above, the MS-3C must have the necessary approach aids that will provide the ability to make precision approaches to the aircraft carrier in all weather conditions. This capability will be identical to that of the S-3A and US-3. The AN/ASW-25B Automatic Carrier Landing System (ACLS) will provide the pilots with reliable approach information and automatically controlled approaches to a minimum of 200 feet and one-half mile. This system uses a precision tracking radar and a computer on board the carrier to provide precise position data with respect to the carrier. The computer calculates desired position of the aircraft and generates a control signal which is transmitted to the aircraft by a data link system. The aircraft subsystem (ASW-25B) then takes the control signals and couples them to the aircraft Automatic Flight Control System (AFCS), autopilot, which controls the aircraft to minimums. The ASW-25 will also transmit its signals to the mission computers for display to the pilot and copilot on the DDI's or MPCD's, and the HUD. As a backup to the ACLS, the aircraft will have a Carrier Instrument Landing System (CILS). The AN/ARA-63 CILS will receive azimuth and glideslope information from a transmitter on board the carrier on one of 20 discrete frequencies, and present it to the pilots in much the same way as the ACLS. Both the ACLS and CILS are proven dependable systems operating in several different U.S. Navy aircraft models. The ACLS and CILS will be controlled by the mission computers through the EEC.

The TACAN, VOR, and ADF information will be presented to the pilots on the MPCD's in the HSI format shown in figure 3-9. ILS, CILS, and ACLS displays will be presented to the pilot on the MPCD's and the HUD in the format shown in figure 3-11. With the TACAN, VOR, and ADF, the MS-3C will be capable of airways enroute navigation and nonprecision approaches to airfields throughout the world. Precision instrument approach capability to both civilian and military airfields will be provided by the ILS system. Finally, the precision approach capability to the aircraft carrier will be accomplished using the ACLS and CILS. These capabilities will give the MS-3C the freedom to operate to and from landing sites anywhere in the world under nearly all weather conditions.

3-4-4: Communications Systems

The communications systems of the MS-3C must be as versatile as possible. In order to improve on the already versatile communications system in the standard S-3A, the AN/ARC-156 UHF radios will be replaced with UHF/VHF capable AN/ARC-182 radios. The ARC-182 is currently being used in the F/A-18 and F-14A+ aircraft in the fleet . It is capable of both frequency and amplitude modulation in the frequency bands listed in table 3-2. ARC-182 features include 20 preset channels, preset UHF and VHF guard channels, secure voice capability through a AN/KY-58 secure voice unit, and a relay mode. The UHF/VHF radios will be controlled through the comm 1 and comm 2 volume control and channel select knobs on the electronic equipment controller as shown in figure 3-12. The UHF/VHF radios will allow communications on nearly all military aviation and ground networks and most civilian aviation communications frequencies.

Long range communications will be accomplished using the AN/ARC-153A HF radio set. The ARC-153, the S-3A standard HF radio, receives and transmits at a power output of 1000 watts in the frequency range of 2.0000 to 29.9999 MHz. It can transmit and receive in upper sideband, lower side band, or both side band modes. Additionally, it has an Amplitude

Modulation Equivalent mode for communications with stations that do not have single side band capability. Like the UHF/VHF radio, the HF radio has a secure voice capability and will be controller through the EEC.

Table 3-2

AN/ARC-182 Radio Frequency Capabilities

FREQUENCY	MODULATION	BAND
30 to 87.975 MHz	FM	
108 to 155.975 MHz	AM	VHF
156 to 173.975	FM	
225 to 399.975	AM/FM	UHF

The combination of the ARC-153 and the ARC-182 radios will provide the MS-3C with the capability to communicate on on every usable frequency between 2.0 and 399.975 MHz. This capability will greatly contribute to operational flexibility and real time coordination. Additionally, the HF capability will allow for long range mission updates at distances thousands of miles from command headquarters.

3-4-5: Weather Avoidance System

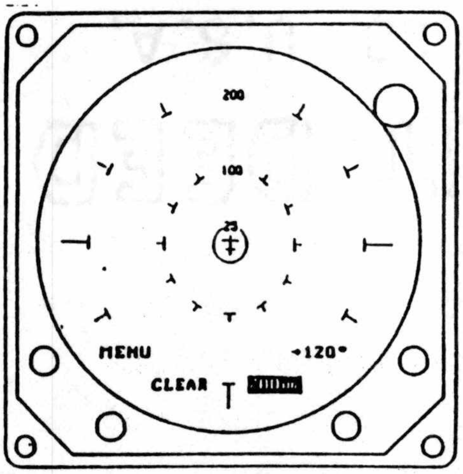
As a passive aid for weather avoidance during navigation, the MS-3C will have a 3M WX-1000+ "Stormscope". This system is a self contained thunderstorm avoidance system which displays the most recent 256 atmospheric electrical discharges within the displayed range. The scope display options include four ranges, 200, 100, 50, and 25 nautical miles, and either a 360 degree circular or 120 degree sector display. The display is presented on it's own high resolution multifunction CRT and is gyro stabilized to the aircraft's heading. Additional features of the Stormscope are six programmable checklist presentations, and a real time clock with elapsed time, and stop watch functions. Since the Stormscope is fully passive, it will be extremely valuable during operations in severe weather conditions when a covert status must be maintained. The 3M WX-1000+ "Stormscope" is shown in figure 3-14.

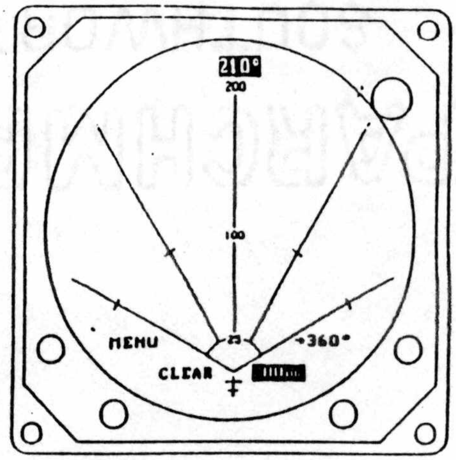
3-4-6: Retained S-3A Systems

In addition to the communications and navigation systems discussed previously, the MS-3C will retain several other S-3A systems. Retained subsystems are listed in table 3-3. These subsystems will interact with other subsystems through the mission computers as shown in the avionics block diagram, figure 3-7.

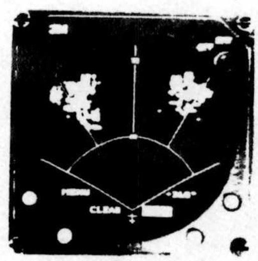
3-5: TERRAIN AVOIDANCE RADAR

A system that will be of primary importance to the special operations forces mission of the MS-3C will be the AN/APQ-172 Multi-mode Radar





Series II 360° View



Series II 120° View

Figure 3-14

3M WX-1000+ STORMSCOPE

Table 3-3

S-3A Avionics Retained in the MS-3C

DESIGNATION	EQUIPMENT
AN/APN-201	Radar Altimeter and Altitude Warning Set (RAAWS)
AN/ASW-25B	Automatic Carrier Landing System (ACLS)
AN/ARC-153A	HF Radio Set
AN/APX-72	IFF/Mode 4 AN/APN-202
ACLS	Radar Beacon
AN/ASN-107	Attitude Heading Reference System (AHRS)
LS-601	Internal Communications System (ICS)
AN/ASW-33	Automatic Flight Control System (AFCS)
KY-58	Secure Voice Set
AN/ARA-63	Carrier Instrument Landing System (CILS)
AN/AYN-84	Central Air Data Computer
CP-1077/AYN-5	Airspeed Altitude Computer Set (AACS)

System. This system, which is made by Texas Instruments, was originally designed as the APQ-168 Radar for the F-16 LANTERN system. It was later modified for use in the MH-47E and MH-60K. The system was then renamed the APQ-172 Multi-mode radar, a few minor modifications were made, and it was slated to go into the V-22 Osprey. The size of this system, 109 cm long and 33 cm in diameter, is such that the entire unit will easily fit in the S-3's nose radome in place of the APS-116 Radar antenna. With a design specification of 144 hours mean time between failure (MTBF), this system offers dependability along with availability and excellent capability.

The APQ-172 has six primary modes of operation. They are terrain following, terrain avoidance, ground map, air-to-ground ranging, and two cross scan modes. The terrain following mode has the ability to operate in turning flight and an ECCM mode which uses the principle of high power burn through. The terrain avoidance mode features the detection of all obstacles or terrain above the aircraft's altitude in a cone of plus or minus 30 degrees of the nose. It uses a scan rate of 60 degrees per second and operates in ranges of 3,10 or 15 nautical miles. The ground mapping mode uses pencil beam ground mapping and presents a depressed center PPI display with scales of 3, 15, 30, or 45 nautical miles. The cross scan modes are time sharing modes of terrain following and terrain avoidance or terrain following and ground mapping modes. The cross scan modes present various combination displays and data.

The radar system incorporates a terrain-storage facility which permits the radar to have a reduced duty cycle thereby reducing the probability of detection by enemy electronic support measures (ESM). Also included is a power management system which is used for semi-covert operations. A final feature which makes this radar system attractive is the extensive Built-in-test equipment (BIT) which will provided a large degree of fault detection and isolation. The system is digital input and output and fully MUX 1553A/B compatible which makes it ideal for this application. The AN/APQ-172 will greatly aid the crew in low level operations in all types of terrain. This capability will permit low altitude operations at night and in all weather and thereby increase mission effectiveness and the number of mission options.

3-6: NIGHT CAPABILITY

The night operations capability of the MS-3C will be built around the AN/AAS-38 Forward Looking Infrared (FLIR) System and the MK-IIIC Cats Eye Night Vision Goggles. The AAS-38 FLIR is a pod mounted system which will be mounted on the port wing weapons station of the MS-3C. It was designed for the F/A-18 Night Attack Hornet and is fully compatible with the 1553A/B multiplexed digital data bus and the AYK-14 mission computers. It was designed to provide day, night or adverse weather low level attack capability by presenting real time thermal imagery to the pilot and copilot. The FLIR imagery will be presented to the crew in a television format on the DDI's and the pilot's HUD. Crew selectable features include field-of-view (FOV) of 3 degrees by 3 degrees or 12 degrees by 12 degrees and line-of-sight over a field spanning +30 degrees to -150 degrees in elevation.

The MK-III Cat's Eye Night Vision Goggles (NVG), shown in figure 3-15, is a helmet mounted low light image intensifying system which will allow the pilot and copilot to see terrain features under very low light conditions. The NVG's contain an image intensifier tube assembly which has a gain of

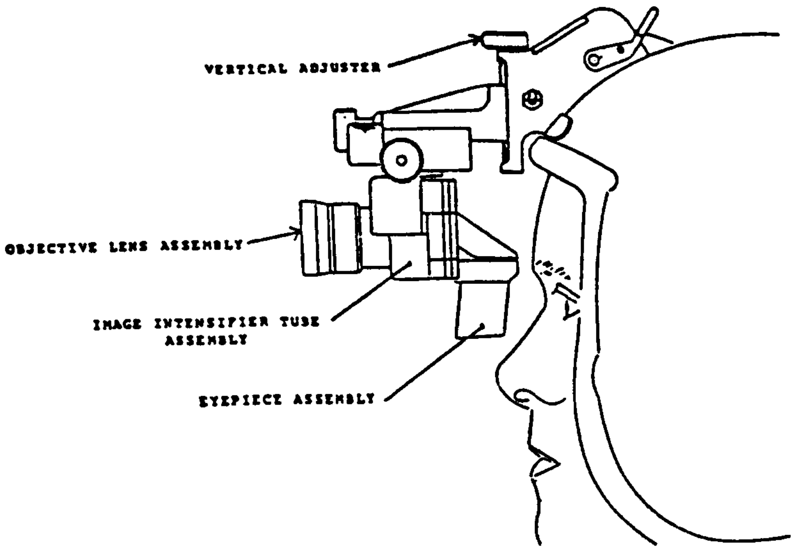


Figure 3-15

MK-III Cat's EyeNight Vision Goggles (NVG)

30,000. The image intensifier's image is collimated on a glass combiner and superimposed on the pilot's direct view of the outside world. When looking through the goggles, the pilot will see a monochromatic (green) electro-optical image of the outside world in light conditions where the unaided eye could see little or nothing. The MK-III Cat's Eye contains it's own power supply with a battery life of six hours and has a 30 degree circular FOV. The combination of the NVG's and the FLIR will allow the pilots to operate and navigate at low level in all conditions of darkness and will greatly increase the number of options available for mission planning.

3-7: SURVIVABILITY SYSTEMS

In order to enhance the survivability of the MS-3C in hostile territory, it will be equipped with the AN/ALR-67 Threat Warning System and the AN/ALE-39 Electronic Countermeasures system. The ALR-67 Threat Warning System (TWS) is designed to detect and identify threat air defense system emitters and display them to the pilots. It is designed to detect both high band (E and J band) and low band (C and D band) emitters using both pulse or continuous wave emissions. This system uses amplitude comparison between four circularly polarized antennas to determine the direction to an emitter and displays the emitter to the pilots visually and aurally. Additionally, the system will classify the threat and present it's classification to the pilots. In the MS-3C, the threat bearing and classification will be presented to the crew on the DDI's and/or the MPCD's depending on the crew's preference. An aural tone will also accompany each new detection in order to insure that the crew is aware of the detection.

The ALE-39 Electronic Countermeasures system will be added into the MS-3C identically as it is currently incorporated in the S-3B. This system will provide self protection against enemy radar and missiles by dispensing expendable chaff, flare, and jammer payloads. It is capable of dispensing up to 90 payloads, 30 from each of three dispensers, individually or in programmed sequences. The three dispensers are located as shown in figure 3-16. Payloads will be dispensed as programmed on a control panel located on the pilots console aft of the throttle quadrant. Payload initiate switches on the pilot and copilot right throttles will control the firing circuits. The pilot will have ultimate control of the system using his ECM arm/safe switch located immediately in front of the throttles. As mentioned above, this system will be identical to that of the S-3B. With the warning of a threat coming from the ALR-67 and the ability to use chaff and flares, the pilot will be able to greatly increase aircraft survivability in the hostile arena.

3-8: MS-3C COCKPIT

The MS-3C cockpit will be optimized for the all weather, low level ingress and egress portions of the mission. The S-3A pilot and copilot instrument panels will be partial modified in the MS-3C modification. Figures

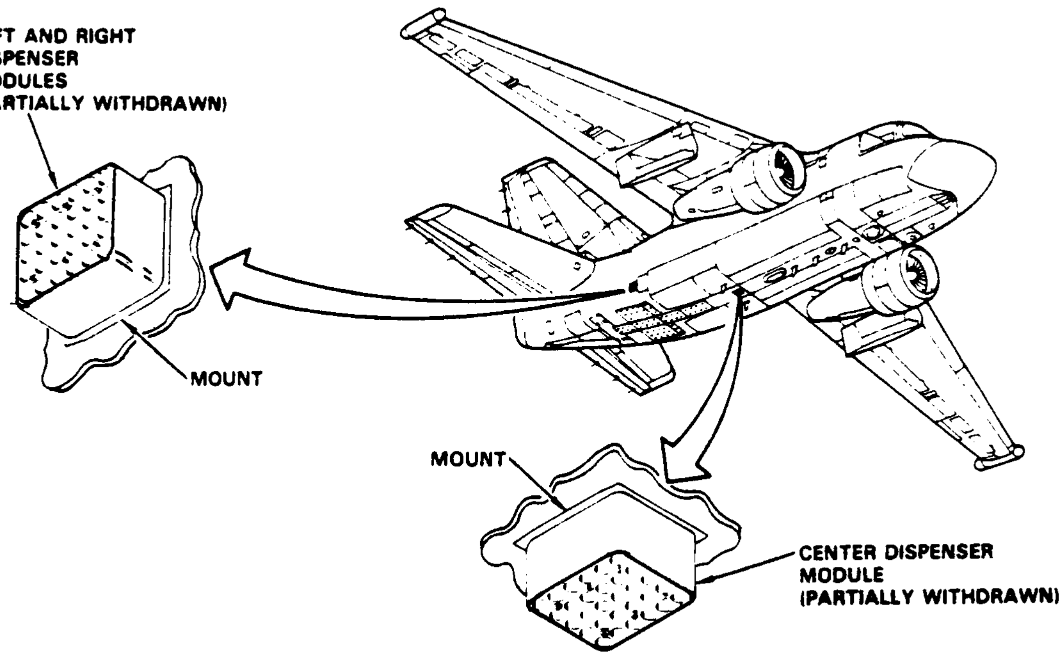


Figure 3-16

AN/ALE-39 Electronic Countermeasure
Dispenser Module Locations

A-12 through A-14 of appendix A show the proposed instrument panel layout. The large space vacated by the removal of the pilot and copilot display units will be filled with the MPCD's and DDI's along with the HUD control panel on the pilots side. The pilot's HUD will be mounted on top of the pilots glare shield in his primary field of view. Other additions to the cockpit include the marker beacon lights and sensitivity switch, the AHRS control panel, the storm scope, the ALE-39 Chaff/Flares control panel, the electronic equipment controller, and the cabin lights control panel.

3-9: SYSTEMS INTEGRATION

Integration of the MS-3C avionics subsystems will require interfacing of various input/output formats. The MIL-STD-1553A time multiplexed digital data communications busses solve many of these difficulties, but will require further interfacing. Total interfacing of all avionics subsystems shown in the avionics block diagram, figure 3-7, will be accomplished through the use of a Bus System Interface Unit (BSIU). The BSIU will be designed to incorporate the control converter and separate Subsystem Interface Modules (SIMS) for each of the various subsystems that require interfacing with the 1553A format. Included within the control converter will be an analog to digital and digital to analog card compatible with 8 and 16 bit data input. The various SIMS will convert the RS-232, RS-422, and ARINC-561 formats and any other existing data formats into the required MIL-STD-1553A format prior to sending signals to the control converter and hence to the two data busses. A BSIU of similar requirements is incorporated in the ES-3A at the present time. Although this particular BSIU will be custom designed for the MS-3C, all of the components will be available off-the-shelf. The experience gained during the ES-3A project design and implementation will be of great value in the MS-3C design process.

CHAPTER 4

EXTERNAL MODIFICATIONS

The external modifications required to convert the S-3A into the MS-3C are much more straight forward than the interior modifications. The removal of unnecessary equipment and the addition of a few extra antennas is all that will be required. The overall effects of the modification on aircraft drag, weight, and center of gravity will also be discussed in this chapter.

4-1: EQUIPMENT REMOVAL AND RELOCATIONS

The external modification will begin with the removal of unnecessary items. Items to be removed include the ESM antenna pods on each wing tip, the ten SRS/SRX antennas, the sonobouy chutes, and the Magnetic Anomaly Detector Boom (MAD Boom). Each of these items can be seen in figure 2-1 on page 10 or figure 4-1. Removal of the ESM pods will include removing all the wiring that is associated with the system. After the removal of the ESM pods, the wing tips will be capped with a tip cap identical to that of the US-3. The result will be a smooth semi-elliptically shaped wing tip. The sonobouy chutes, their rails and firing circuitry will be completely removed. The MAD Boom, it's housing, and all associated wiring and hardware will then be removed. Additionally, the sonobouy chute area and MAD Boom exit area will be sealed with a thin pieces of sheet metal in order to maintain the

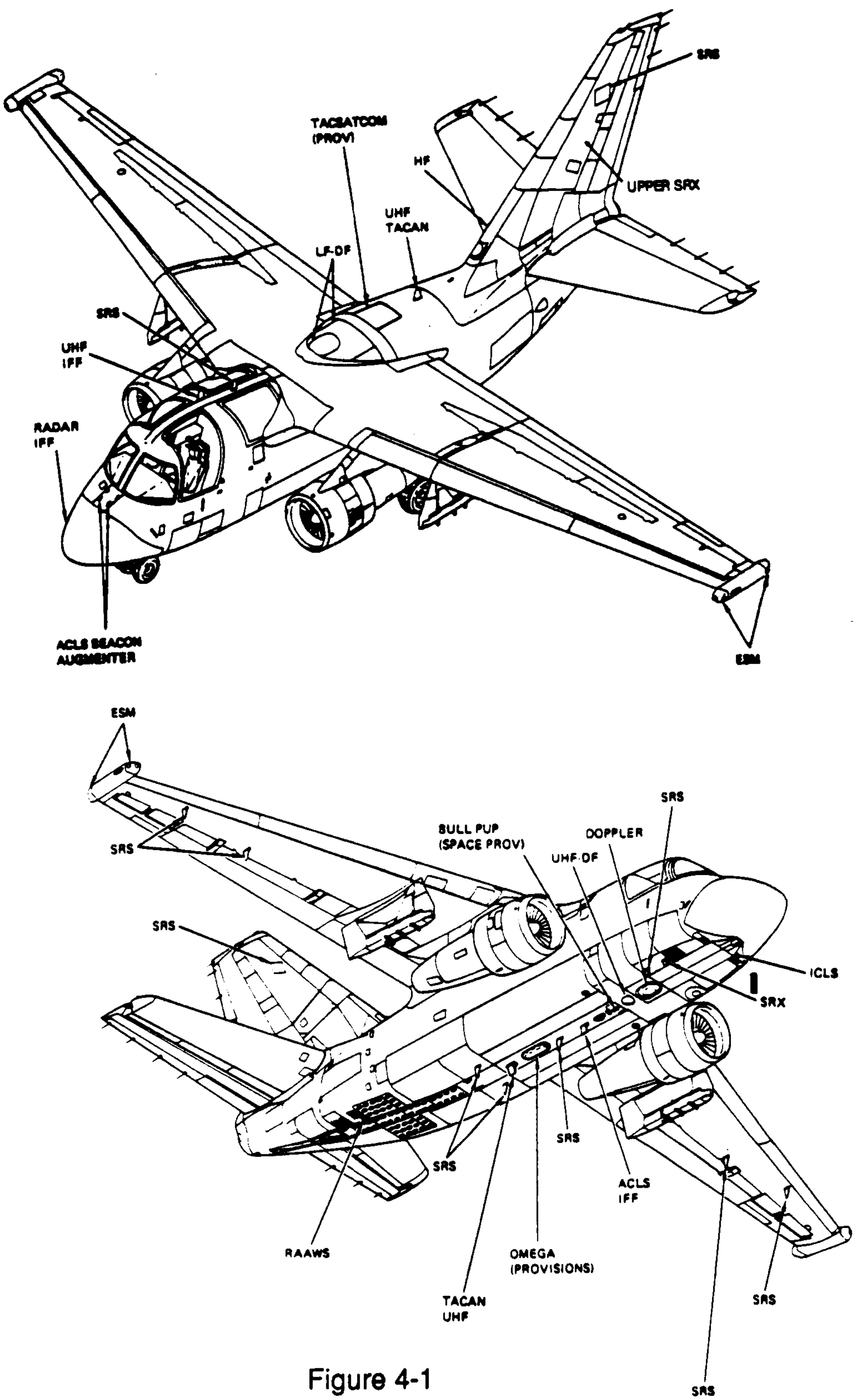


Figure 4-1

S-3A Antenna Locations

minimum drag configuration. After removal of all ten of the SRS/SRX antennas, five of the antenna locations will be sealed with blanking plates. The SRS antenna location furthest outboard on each wing and the furthest aft and furthest forward on the fuselage will be used as locations for the AN/ALR-67 Threat Warning System antennas. The SRS antenna furthest forward on the under side of the aircraft will be used as a relocation site for the lower UHF/TACAN antenna as explained in the following paragraph

In order to facilitate paradrops, two other antennas must be relocated because their present locations present a danger of entanglement during parachute drops. These two are the lower TACAN/UHF antenna and the ACLS/IFF antenna. As noted above, the TACAN/UHF antenna will be relocated to the location of the furthest forward SRS antenna on the under side of the aircraft. The ACLS/IFF antenna will be relocated to the location of the furthest forward SRX antenna on the nose of the aircraft. These locations will be fully compatible with the systems and should present no problems in implementation.

4-2: EXTERIOR EQUIPMENT ADDITIONS

Seven new antennas will be added to the external configuration of the MS-3C. They are the Global Positioning System (GPS) antenna, the Omega antenna, the stormscope antenna, and the four ALR-67 antennas. The GPS antenna will be added on the upper surface of the aircraft aft of the canopies at the location labelled "Tacsatcom" in figure 4-1. The Omega antenna will be added at the provisional location on the under side of the aircraft as shown in figure 4-1. As mentioned previously, the SRS antenna location furthest outboard on each wing and the furthest aft and furthest forward on the fuselage will be used as locations for the AN/ALR-67 Threat Warning System antennas. These locations were chosen because they represent the greatest angular split possible using existing locations. The stormscope antenna will be placed on the aircraft's under side at the provisional location labeled "Bull Pup" on figure 4-1. One other exterior modification that will be visible will be the addition of the three ALE-39 Chaff/Flares "buckets" as shown in figure 3-16. As previously mentioned, these will be identical to those of the S-3B system. In addition to adding the new antennas, the wiring for each of these systems must be put in place. The newly installed wiring will follow the routing of the previous wiring whenever possible. The central location of the Omega, GPS, and stormscope antennas will make the routing of their wiring short and relatively simple.

4-3: FUEL SYSTEM MODIFICATIONS

The MS-3C will require two modifications to the basic S-3A fuel system. The first will be to add reticulated foam into the wing tanks. The reticulated foam has proven itself effective in reducing ballistic vulnerability of fuel tanks. When the fuel tank is struck by a projectile, the foam minimizes damage by preventing passage of the flame front within the fuel tank and confining the pressure rise to a small volume. Foaming the aircraft fuel tanks will greatly increase the aircraft's ability to sustain a hit from small arms fire and increase mission survivability at a cost of less than five percent of total fuel. Other options which may also be used to reduce fuel tank vulnerability are HALON injection, bottled nitrogen systems, and the on-board inert gas generating system (OBIGGS).

The second fuel system modification will be to add an "over the wing" refueling capability. The S-3A is designed for single-point pressure fueling only. However, in emergency situations, the aircraft can be gravity fueled by removing a capacitance probe from each wing tank as shown in figure 4-2. These probes are provided with sufficient wire to facilitate their removal. The main difficulty with this procedure is that it requires the removal of six bolts and sealing with calk after fueling is complete. The MS-3C modification will include modifying the mounting plates of the probes and the upper wing skin to a standard filler cap configuration. This small change will eliminate pressure fueling requirements and will allow the aircraft to be fueled with conventional gravity systems at airfields throughout the world.

4-4: EFFECTS OF THE MODIFICATION

The conversion of an S-3A into an MS-3C will change the drag, center of gravity, and weight of the basic airframe. Since there is a net reduction

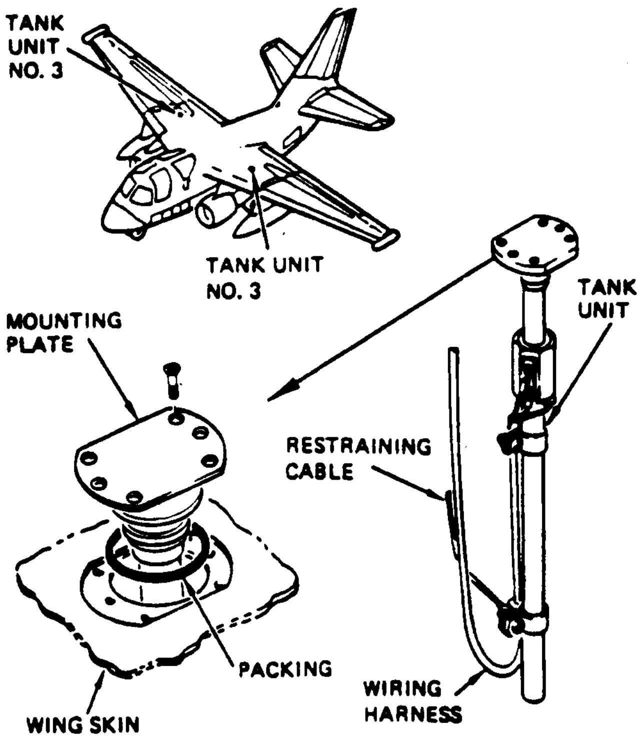


Figure 4-2

S-3A Emergency Procedures for Gravity Fueling in the total number of external antennas and the large wingtip ESM antennas are removed, the total drag of the MS-3C therefore should be lower than the basic S-3A. Although there is no firm data concerning this drag reduction, this assumption is supported by operational experience of the US-3. The US-3 external configuration is very similar to that of the MS-3C. Operational US-3 pilots report an increase in maximum range and cruise airspeed of approximately five percent over the S-3A. The author's personal experience conducting side-by-side operations with an S-3A and a US-3 on several occasions supports this estimate. The approximately five percent increase in performance of the MS-3C over the basic S-3A will allow performance estimates of the MS-3C using S-3A charts with all errors falling on the conservative side. Stated another way, the MS-3C will always perform equal to or better than the performance obtained using S-3A performance charts.

The basic weight and center of gravity of the MS-3C can only be approximated at this time because the complete final configuration has not been established. However, after making a few basic assumptions, an initial estimate of the empty weight and center of gravity of the MS-3C are 27,000 pounds and 19 to 20 percent mean aerodynamic chord (% MAC). The empty weight of approximately 27,000 pounds will yield takeoff weight approximately 42,500 pounds with full internal fuel, crew of two, eight passengers and 1000 pounds of additional cargo. With full external fuel, the takeoff gross weight is approximately 46,500 pounds under the same conditions. Both of these takeoff weights fall well below the S-3A maximum takeoff weight of 52,500 pounds and also below the normal operational takeoff weight of approximately 48,000 pounds. While a center of gravity of 19 to 20 % MAC is slightly further forward than that of an S-3A, it is well within the S-3A center of gravity limits of 15.5 to 30 % MAC. Therefore, the MS-3C modification should have little or no effect on flying qualities of the basic airframe due to CG shifts.

CHAPTER 5

PROJECT MANAGEMENT

An undertaking of the magnitude of the MS-3C modification program will require a well organized approach and a modification team consisting of many diverse organizations and assets. Experience gained during the US-3, S-3B, and ES-3A modifications will dominate the discussion of the management of the MS-3C project. Lessons learned will be knitted into project management ideas and organizations with S-3 experience will dominate the project. This discussion will begin by setting up a prospective project team, proposing a timeline, making a rough estimate of the cost of a four aircraft conversion, and conclude with testing requirements. <u>The author wishes to stress at this point that any mention of contracts or work agreements with any civilian or governmental agency is purely speculative on his part and in no way represents the wishes, desires, policies, or future plans of the United States Navy. Additionally, cost and time estimates are of his own experience and do not represent nor obligate any other party.</u>

5-1: PROJECT TEAM

As mentioned earlier, the MS-3C modification project team will be made up of organizations both civilian and military which have experience in the modification of S-3 aircraft. The primary project team members from the

Navy will be Naval Air Systems Command, Naval Air Test Center, Naval Air Development Center, and Naval Avionics Command. As with most U.S. Naval Aviation projects, the Naval Air Systems Command (NAVAIR) will head up the team. The major functions of NAVAIR will be program management and technical management of the modification. NAVAIR will provide the team with the mission requirements, designate mission priorities, manage all contracts, provide technical support to all contractors, provide all government furnished equipment (GFE), and provide integrated logistics support to the project. The Naval Air Test Center (NATC), located at Patuxent River, Maryland, will be responsible for the weapons system test and evaluation, reliability and maintainability testing, and performance effectiveness testing. The Naval Air Development Center (NADC), located at Warminster, Pennsylvania, will have overall control of software development and implementation. The Naval Avionics Center (NAC), located in Indianapolis, will have overall responsibility for systems architecture, operate the avionics simulation lab, and provide flight test support to NATC.

The primary civilian contractor for the modification will be Lockheed Aeronautical Systems Company (LASC-Burbank). They are the logical choice to have the civilian lead on the modification team since they built the S-3A, and have managed every major modification since the aircraft's introduction to the fleet in 1978. LASC will design and install the modifications, conduct ground and flight tests of the first modified aircraft, and be responsible for systems integration. The Lockheed Austin Division will be responsible through contracts to design and fabricate the avionics equipment racks and wiring required for the modification. Additional civilian contractors will be required to aid NADC and NAC in systems and software design and integration. Two companies that have performed this function with the S-3 and the AN/AYK-14 mission computer in the past are Sanders Associates, and Softech, Inc. These organizations plus several other minor contributers will make up the MS-3C modification team. The previous modification experience of this broad based team should aid in an efficient modification project.

5-2: MODIFICATION TIMELINE

In setting up a time line for the modification of four S-3A aircraft into MS-3C aircraft, all plans and dates were based upon one assumption. It was assumed that Washington, the Pentagon and NAVAIR specifically, is hardily decided that this is a priority project and that it will not be delayed due to congressional infighting, inhouse budget battles, indecision, nor good old fashioned federal government foot dragging. Although this is a big assumption, it is not unreasonable and has actually occurred in the recent past.

The starting point of the project time line is an initial design proposal acceptance in mid-April 1990 and all dates are calculated from that point.

The time line for the modification of four S-3A aircraft into four MS-3C aircraft is shown in figure 5-1. Important milestones in the modification program are indicated by a diamond, and shaded areas indicate slack time in the program. After the 16 April 1990 design proposal acceptance, there is to be a preliminary design review scheduled two weeks later. At this review, NAVAIR will set down the basis for all further design requirements, initiate contracts, delegate responsibility and authority, and establish the project team. A major consideration in the time line is the acquisition of four fleet S-3A aircraft for the conversion. This process will begin immediately upon design proposal acceptance and continue until all four aircraft are delivered. The first aircraft will be required at LASC Burbank for modification early in September of 1990. The remaining three aircraft are to arrive at LASC at six to eight week intervals with the last arriving in early March 1991.

It can be seen from figure 5-1 that the critical path of the project goes through software development and avionics simulation. In order for the project to meet completion goals, the avionics simulation must be set up in an operational status by 1 October 1990. This date will allow adequate time for simulation testing and design corrections for systems and software prior to the first aircraft avionics installation.

The first aircraft modified will serve as the systems and aircraft modifications test bed. After preliminary testing, any necessary modifications will be incorporated and the aircraft will be retested. Delivery of the first

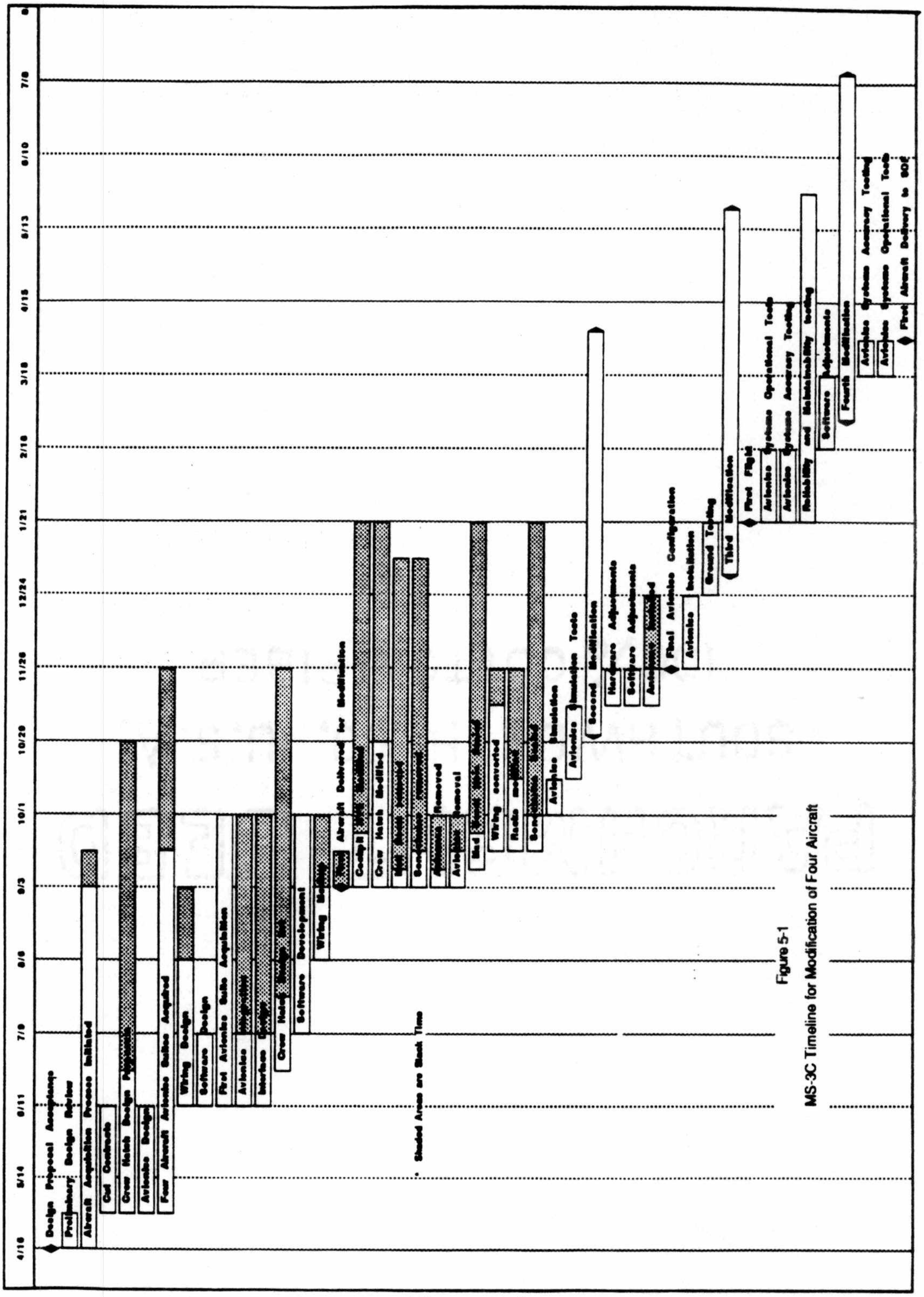


Figure 5-1

MS-3C Timeline For Modification of Four Aircraft

aircraft to the Special Operations Forces is scheduled for 01 April 1991; less than one year after project initiation. The second aircraft will be modified and delivered directly to the Special Operations Forces approximately one week after the first unit. The second and third aircraft will be delivered at approximately six week intervals with project completion scheduled for mid-July 1991.

5-3: PROJECT COSTS

The most obvious cost of the project will be that of four S-3A aircraft. Although there are approximately 130 S-3's in the fleet, 16 are designated as ES-3A aircraft and 4 are US-3's. Additionally, more than half the remaining S-3A's have already been converted into the S-3B. The remaining aircraft are all currently scheduled for S-3B conversion within the next two years. With Antisubmarine Warfare (ASW) becoming increasingly important in the Navy, there will be some reluctance to giving up more ASW assets. This will be a political problem that will be overcome only by a persistent logical presentation of the project to the Joint Chiefs of Staff by Special Operations Forces Commanders and Naval Air Systems Command. Once the conversion has been decided upon at the upper levels of the Navy, the aircraft will be acquired through the normal depot level maintenance schedule. That is, the four most logical low time airframes will have their depot level maintenance scheduled at the dates required by the modification timeline. This method will have the minimum effect on the fleet S-3A squadrons as the aircraft will have already been scheduled for depot maintenance.

The next major cost of the modification will be that of avionics subsystems acquisition. Initially, five full systems will be required; one for the systems mock-up and one for each aircraft. Additionally, the naval supply system will require enough spares to allow for normal mean time between failure and wear and tear on the equipment. That is, the supply system must contain enough spare equipment to replace aircraft equipment that fails due to normal use. Since this design was built around off the shelf equipment and equipment commonality with current fleet aircraft, the MH-47E, and the MH-60K, few problems should occur in this area. All major systems are currently in the supply system and will require only NAVAIR acquisition management for delivery to the modification team. The cost of the actual equipment will necessarily be charged to the project at cost to the government.

Direct costs of a project of this magnitude are very often difficult to estimate in advance. All the pieces of a very complex puzzle are interrelated and a delay in one area will cause cost overruns in another area. Also, it is difficult to estimate the cost of a contract that another organization is going to complete. For these and other reasons, only rough estimates of the direct costs of the MS-3C modification can be made at this time. Table 5-1 lists best guess estimates for each of the major tasks in the modification. Direct cost represent the estimated cost of materials, manpower, and equipment required to complete each task. It must be stressed that these are only estimates and are drawn from the author's limited experience in government project costs. Table 5-1 indicates a total direct project cost of approximately 3.8 million dollars. A more prudent approach to the cost of the four aircraft modification is that it will cost approximately 5 million dollars. This figure allows for the cost of all the small unknowns that inevitably will show themselves in the early design phases of the project.

Strong project support from the Pentagon, NAVAIR, and the Special Operations Forces can make this project proceed as indicated in previous paragraphs. At a cost of four S-3A aircraft, off the shelf avionics, and approximately five million dollars; four long range support aircraft can be delivered to the Special Operations Forces in approximately one year. This will be a relatively cheap interim solution to the short fall in long range support aircraft caused by the delay of cancellation of the V-22 program.

Table 5-1

Estimated Project Direct Costs For Modification of Four Aircraft

Task Name	Estimated Direct Cost
Avionics Design	$60K
Avionics Integration	$50K
Interface Design	$50K
Avionics Simulation and Tests	$150K
Final Avionics Configuration Design	$30K
Hardware Adjustments	$50K
Software Design	$50K
Software Development	$250K
Software Adjustments	$50K
Cockpits NVG Modified	$175K
Crew Hatch Design and Modifications	$250K
Mad Booms Removed and Sealed	$80K
Sonochutes Removed and Sealed	$80K
Antennas Removed	$20K
Avionics Removal	$20K
Wiring Design	$50K
Wiring Mockup	$80K
Wiring Converted	$400K
Antenna Installations	$30K
Racks Modified	$240K
Avionics Installation	$800K
Ground Testing	$120K
Flight Testing	$200K
Avionics Systems Operational Tests	$225K
Avionics Systems Accuracy Testing	$225K
Reliability and Maintainability Testing	$50K
Software Adjustments	$25K
Total Estimated Direct Costs	**$3,810K**

PART III

MISSION CONSIDERATIONS

CHAPTER 6

S-3 PROVEN PERFORMANCE

The ability of the MS-3C to meet mission requirements will largely be dependent upon the aircraft's performance characteristics. This chapter will focus on the proven performance of the S-3 airframe in the areas which will concern mission performance. As was discussed in chapter four, it will be assumed that the MS-3C performance will be as good as or better than the performance of the S-3A. This assumption should be valid since the MS-3C will have less drag than than the S-3A and the weight and center of gravity are approximately the same. Performance data was gathered from the performance section of the S-3A NATOPS Flight Manual, reference 6. Drag configurations A and B will be discussed. Configuration A includes the basic aircraft with no external stores and the basic aircraft with the FLIR pod on wing station 5. Configuration B includes the basic aircraft with two 300 gallon Aero 1D external fuel tanks or the basic aircraft with one external tank and the FLIR pod. Mission considerations will be discussed throughout with emphasis placed on performance as it relates to the mission.

6-1: OPERATIONAL ALTITUDES

The operational altitudes of the MS-3C will be fully compatible with the Special Operations Forces mission. The aircraft will be capable of routine operations at any takeoff gross weight at altitudes up to 35,000 feet MSL. Of primary importance is the MS-3's low altitude performance (altitude less than 1000 feet AGL). The aircraft was originally designed with low altitude performance as a critical factor. It's handling qualities, range and endurance are excellent at low altitudes . High altitude operations will be aided by the fully pressurized cabin and available normal and emergency oxygen systems. The operational altitudes of the MS-3C will be fully compatible with all mission requirements of the Special Operations Forces, including HALO and low altitude parachute drops.

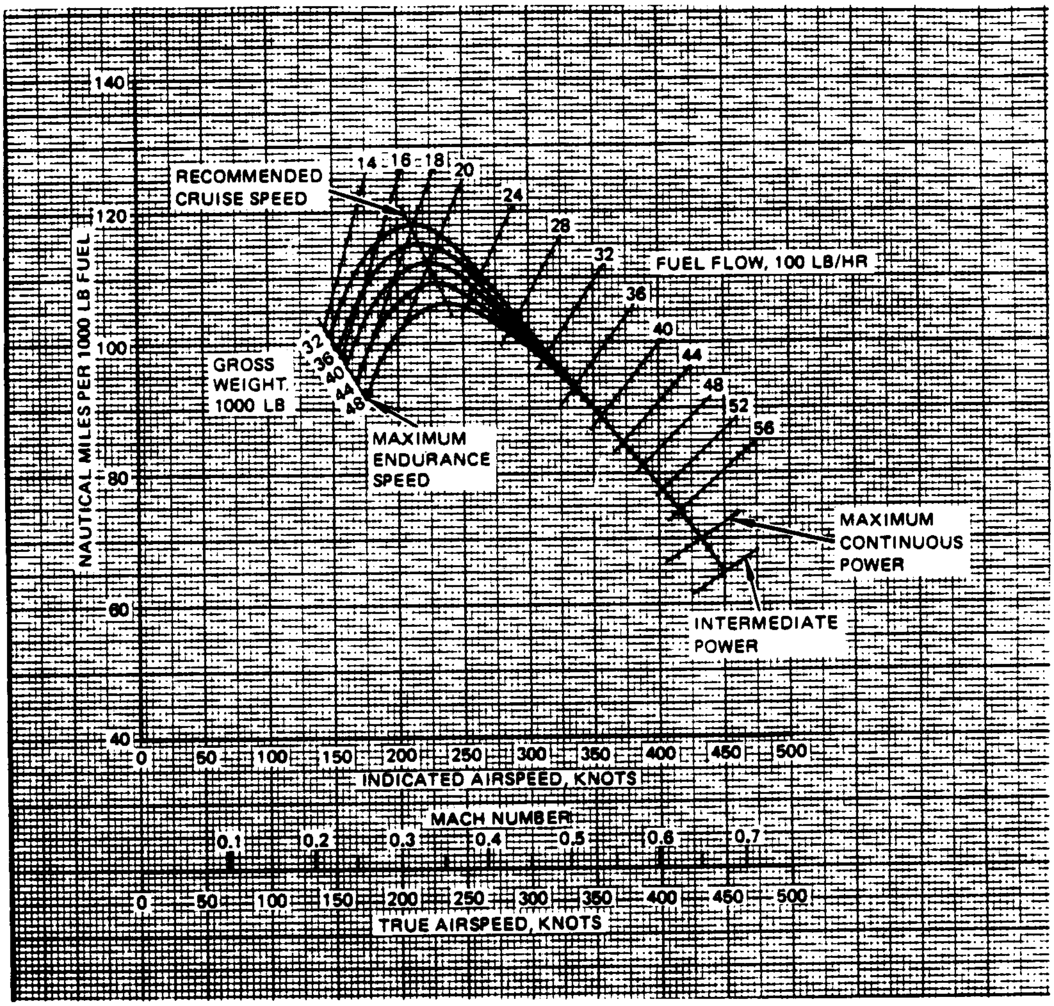
6-2: OPERATIONAL AIRSPEEDS

The operational airspeeds of the MS-3C also will be fully compatible with the Special Operations Forces mission. As can be seen in figures 6-1 and 6-2, in configurations A or B, the MS-3C will easily be able to sustain 360 knots indicated airspeed at sea level during low level ingress and egress. Additionally, in each configuration, 420 knots is available at less than the maximum continuous power setting. Using 360 knots as a base airspeed for low altitude insertions, the MS-3C will be capable of flying at low altitude at mission survivable airspeeds and still have a sufficient margin of airspeed increase to allow for deviations in flight path without missing mission time on target. The MS-3C's high altitude cruise mach of 0.6 to 0.7 mach number will also allow for rapid transit between operational areas and minimal lead time between missions separated by large distances.

At the slow end, the MS-3C stall airspeeds at sea level are approximately 120 knots with no flaps and 90 knots with maneuver flaps selected. These airspeeds will allow the pilot sufficient stall margin to easily maneuver the aircraft at desired parachute drop speeds of 100 to 150 knots. Additionally, the aircraft's stall characteristics are very benign should the pilot mistakenly get too slow. The MS-3C's high dash speed of up to 450 knots indicated airspeed and low stall airspeeds make it very compatible with the special operations forces mission.

6-3: MISSION RANGE

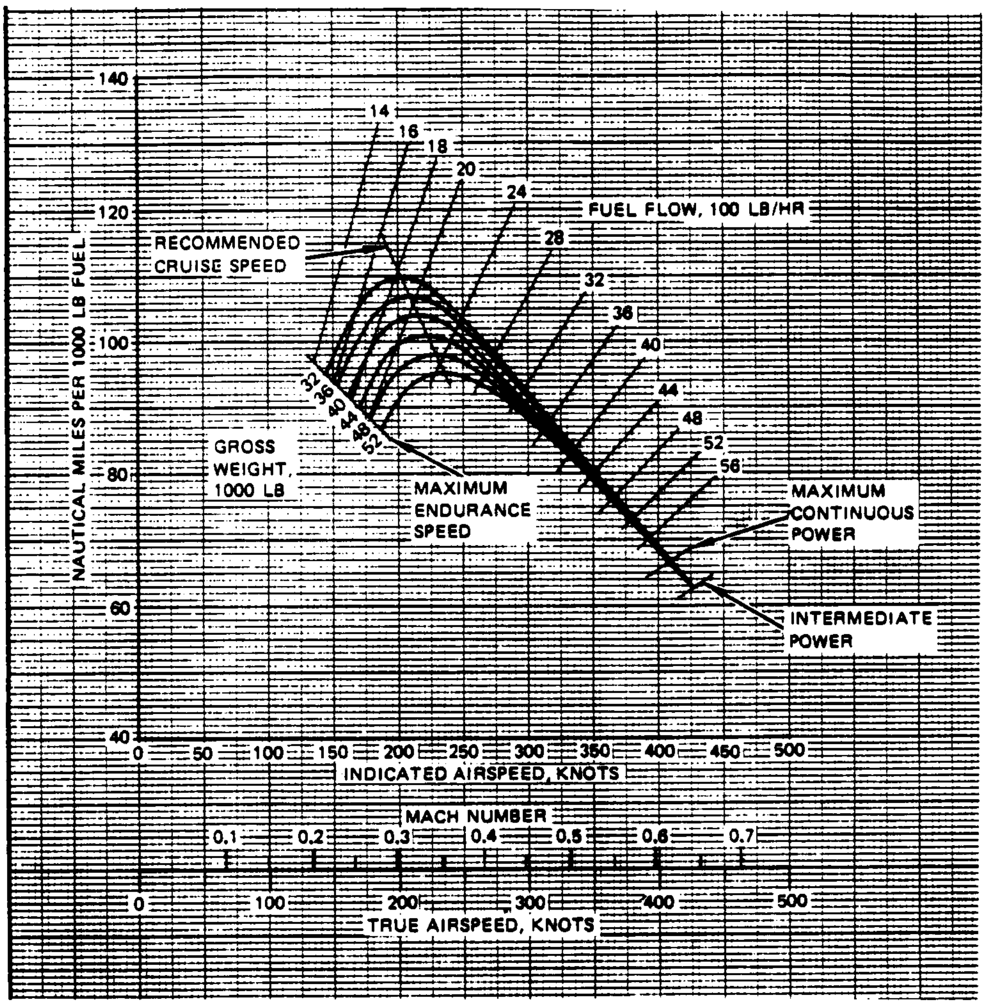
In order for the MS-3C to be a viable alternative, it must have sufficient range for mission requirements. To get a complete picture of the aircraft's range capabilities, one must look at several different mission profiles. Although a complete look at all mission scenarios is beyond the scope of this paper, three common profiles will be reviewed. Calculations of aircraft range are based on the data presented in the performance section of the S-3A NATOPS Flight Manual, reference 6. Figures 6-1 through 6-4 present aircraft range in nautical miles per 1,000 pounds of fuel in configurations A and B and at sea level and 35,000 feet MSL. Maximum ranges were calculated using maximum range climbs, maximum range descents, and optimum



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-89.

Figure 6-1

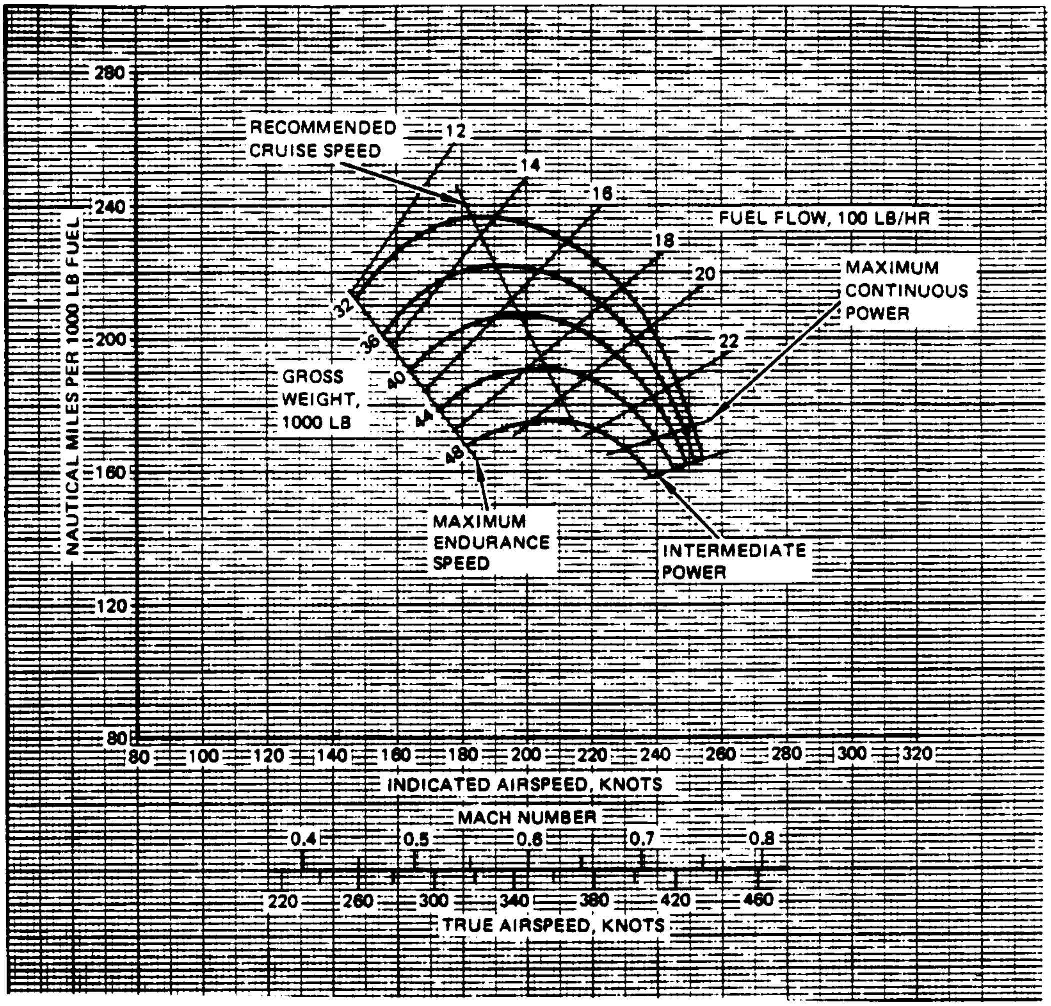
Nautical Miles Per 1,000 Pounds of Fuel, Configuration A, Sea Level, Standard Day, Flaps Up



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-95.

Figure 6-2

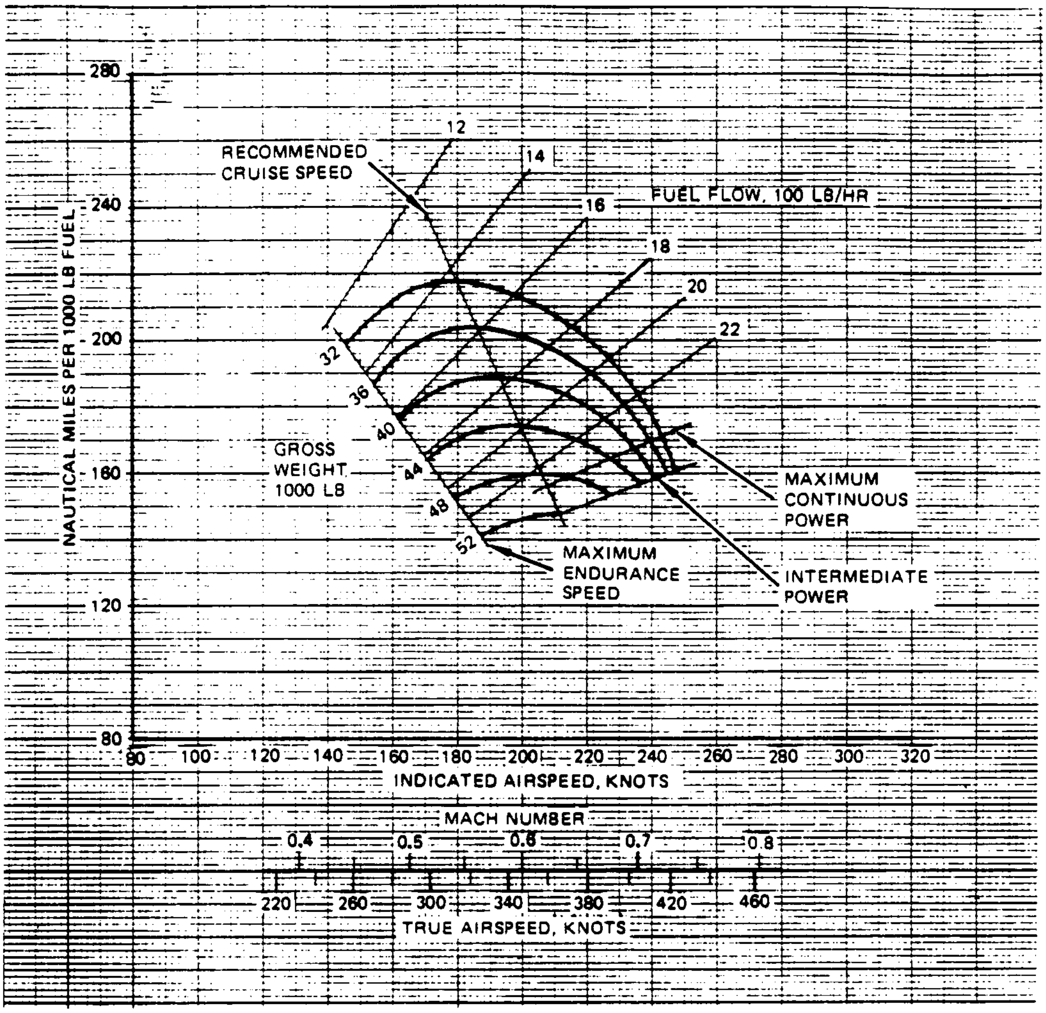
Nautical Miles Per 1,000 Pounds of Fuel, Configuration B, Sea Level, Standard Day, Flaps Up



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-93.

Figure 6-3

Nautical Miles Per 1,000 Pounds of Fuel, Configuration A, 35,000 Feet MSL, Standard Day, Flaps Up



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-99.

Figure 6-4

Nautical Miles Per 1,000 Pounds of Fuel, Configuration B, 35,000 Feet MSL, Standard Day, Flaps Up airspeed, constant altitude cruise. All ranges were rounded to the nearest 5 nautical miles and a minimum of 2,000 pounds of on deck reserve fuel was assumed in all cases. A 2,000 pound fuel reserve is considered to be a safe reserve for approximately one hour flight time at sea level. Ranges for drag configurations A and B were calculated where applicable.

The maximum ferry range of the aircraft will be of primary importance in determination of deployment bases and logistics. Ferry ranges with full internal fuel of 13,100 pounds of JP-5 and full internal fuel plus full external fuel for a total of 16,000 pounds of JP-5 are of interest. Assuming 2,000 pounds reserve fuel and an optimum cruise altitude of 35,000 feet MSL, the maximum range profile is 2,105 nautical miles with full internal fuel. A similar profile using full internal plus full external fuel gives a maximum range of 2320 nautical miles. Unrefueled ranges in excess of 2000 nautical miles will give the MS-3C Trans-Atlantic and Trans-Pacific ferry capability using established military and civilian routes without tanker support. If the aircraft is in-flight refueled at the point of one half usable fuel (total fuel minus reserve fuel), internal fuel only range becomes 3,250 nautical miles and internal plus external becomes 3,540 nautical miles. The long ferry ranges of the MS-3C will greatly contribute to flexibility of deployment and minimize support requirements. Additionally, the long range will allow for a minimum number of enroute stopovers. It must be considered that each stopover greatly increases the probability of detection on long range covert deployments.

The mission radius of the MS-3C using an entirely low level, high airspeed profile must be examined. Low level flight is flight below 1,000 feet AGL and is usually flown at 200 feet AGL. The low level mission radius is defined as the distance that the aircraft can transit at sea level and 360 KIAS, paradrop the Special Forces Unit, transit back to the starting point at sea level and 360 KIAS, and land with a 2,000 pound fuel reserve. Low level mission radii are presented in table 6-1.

Table 6-1

MS-3C Low Level Mission Radius at Sea Level and 360 KIAS

Takeoff Fuel (pounds)	Mission Radius (nautical miles)	
	Configuration A	Configuration B
10,000	375	250
13,000	475	425
16,000	N/A	540

Includes 2,000 pound fuel reserve.

The 10,000 pound takeoff fuel mission radius was listed in table 6-1 because this takeoff weight allows for operations from 4,000 foot runways as discussed in section 6-6 of this chapter. In order to put the low level range of the MS-3C into perspective, the following example is presented. The MS-3A will have the low level range capability to takeoff from Jacksonville, Florida; fly at 360

KIAS and 200 feet AGL to Baton Rouge, Cincinnati, or Washington, D.C.; drop it's passengers; and return to Jacksonville at 200 feet AGL without refueling.

A more realistic long range mission profile is a high-low-high profile. In this profile, the aircraft transits at optimum range altitude to a point approximately 100 nautical miles from the drop zone. The remaining 100 nautical miles of ingress and 100 nautical miles of egress are then flown at low level. The remaining return transit is then flown at optimum altitude. Since much of this profile is flown at high altitudes, the range with in flight refueling top-off of all tanks conducted prior to the low altitude portion of the profile was also considered. High-low-high mission radii are listed in table 6-2. The high-low-high mission radius of the MS-3C is long by any standards. The 915 nautical mile mission radius without refueling will allow the MS-3C to takeoff from Jacksonville, drop the Special Operations Team at Boston, Milwaukee, Dallas, or Bermuda, and return to Jacksonville. Operations from a base that is over 900 miles from the drop zone will greatly decrease the probability that a mission will be detected prior to launch. The added advantage of the 200 nautical miles of low level flight will also contribute to the covert posture of any mission.

6-4: MISSION ENDURANCE

The S-3A was truly designed for long endurance times at low altitudes. The relatively high aspect ratio of 7.7 and high engine fan bypass

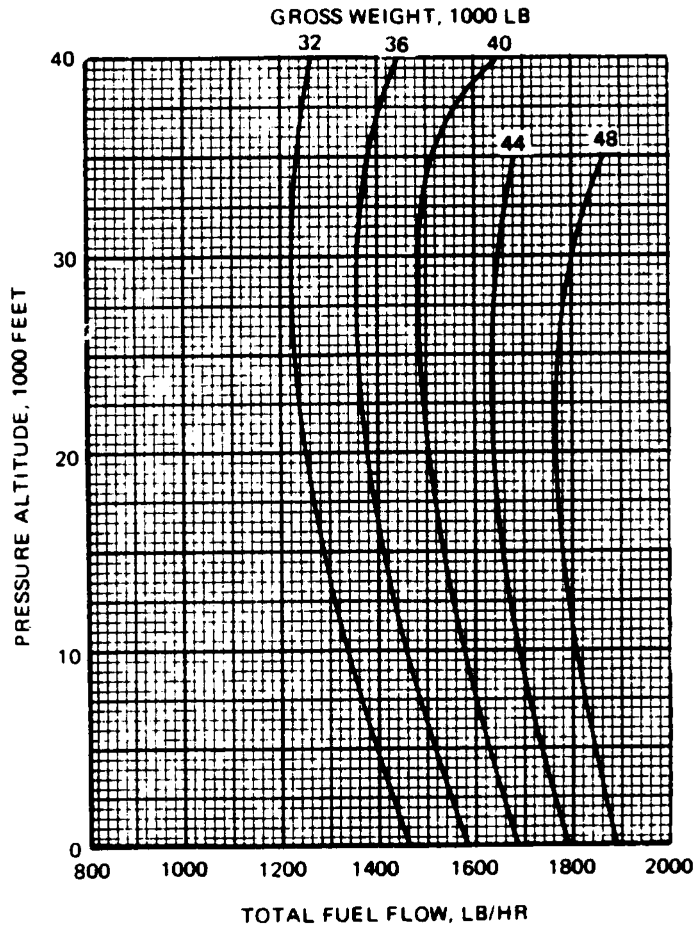
Table 6-2

MS-3C High-Low-High Mission Radius

Takeoff Fuel (pounds)	Mission Radius (nautical miles)	
	No Refueling	Inflight Refueling Prior to Low Ingress
10,000	520	1090
13,000	825	1400
16,000	915	1525

Mission radius includes 200 nautical miles at 360 KIAS and sea level and 2,000 pounds of reserve fuel.

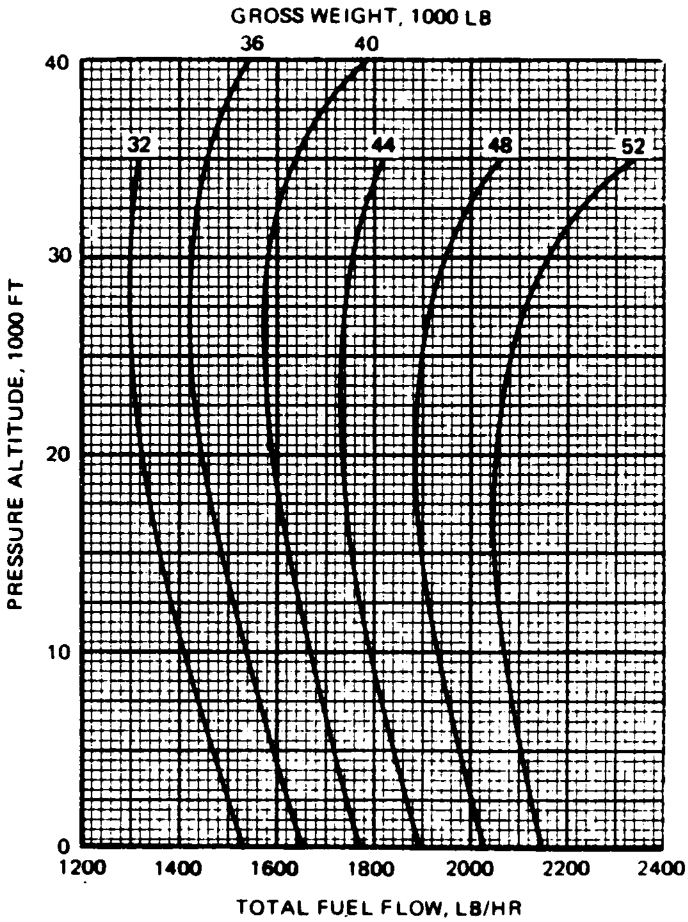
ratio of 6.23 to 1 give the aircraft excellent endurance qualities at all mission altitudes. As can be seen in figures 6-5 and 6-6, the maximum endurance fuel flow varies less than 200 pounds per hour from sea level to the optimum endurance altitudes between 25,000 and 32,000 feet MSL. With a 2,000 pound fuel reserve, the MS-3C will be capable of holding for over 6 hours on internal fuel and over 7 1/2 hours with internal and external fuel. Since the aircraft can hold at sea level with only minimal degradation in endurance, it will be able to effectively maintain minimum standoff distances while holding below the horizon of hostile radars . This will allow for quick reaction times that are required by many Special Operations missions. The aircraft will have the capability to launch, transit to the area of operations, and hold for extended periods of time while situations requiring special forces develop.



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-72.

Figure 6-5

Maximum Endurance Summary, Configuration A
Two Engines, Standard Day



SOURCE: S-3A NATOPS Flight Manual, reference 6, page11-73.

Figure 6-6

Maximum Endurance Summary, Configuration B
Two Engines, Standard Day

6-5: IN-FLIGHT REFUELING

The S-3 has the capability to refuel in flight from any U. S. Navy tanker asset, the KC-130, the KC-135, and the KC-10. This capability greatly increases mission flexibility. The effects of in-flight refueling on mission range were briefly discussed in section 6-3 of this chapter. In an actual mission flown in 1987, an S-3 used in-flight refueling to fly nonstop from the Mediterranean Sea east of Italy to the East Coast of the United States. Missions such as this demonstrate the long range capabilities that the MS-3C will have using in-flight refueling. Endurance characteristics will be affected by in-flight refueling in the same manner. With the proper tanker assets, the limiting factor for mission range and endurance is aircrew fatigue rather than aircraft performance. Mission lengths of over ten hours are fairly common in the fleet and normally flown with only one pilot. It should be noted that the long range mission mentioned above was flown by a single pilot crew.

6-6: SHORT FIELD OPERATIONS

The Special Operations Forces mission will require the MS-3C to operate out of small airfields. Throughout the world, runway lengths of three to five thousand feet are very common. It is desirable that the MS-3C have the capability to operate effectively out of these airfields. Table 6-3 summarizes MS-3C critical field length, takeoff and landing distances compiled from the performance section of the S-3A NATOPS Flight Manual,

Table 6-3

S-3 Takeoff and Landing Distances

	Gross weight Fuel weight	31,000 lb 3,000 lb	38,000 lb 10,000 lb	41,000 lb 13,100 lb	44,000 lb 16,000 lb
Standard day, Sea level	Takeoff Ground Run	1150 ft	1750 ft	2100 ft	2400 ft
	Takeoff, 50' obs	1700 ft	2400 ft	2750 ft	3100 ft
	Critical Field Length	3500 ft	3650 ft	3800 ft	4200 ft
	Normal landing	2950 ft	3450 ft	-------	-------
	Minimum Run Landing	1850 ft	2250 ft	-------	-------
100 deg F, 5,000 feet MSL	Takeoff Ground Run	2400 ft	3800 ft	4400 ft	5100 ft
	Takeoff, 50' obs	3100 ft	4650 ft	5300 ft	6100 ft
	Critical Field Length	3600 ft	4800 ft	5600 ft	6500 ft
	Normal landing	3500 ft	4150 ft	-------	-------
	Minimum Run Landing	2600 ft	2750 ft	-------	-------

reference 6. Critical field length is defined as the total runway required to accelerate on two engines to the critical engine failure speed, experience an engine failure, and then stop on the runway or takeoff. Under normal conditions, this is the minimum runway length that should be used for a takeoff. It can be seen that at sea level a 4,000 foot runway will meet MS-3C requirements for critical field length and normal landing distance at an aircraft gross weight of 38,000 pounds. On a typical day in the desert or jungle at 5,000 feet MSL at 100 degrees fahrenheit, approximately 5,000 feet of runway length will be required. If operational necessity requires the use of shorter runways, the critical field length requirement can be waived and maximum braking can be used to achieve the minimum landing rollout. The very low failure rate of the TF-34 engines will allow the waiving of the critical field length requirement without undue hazard. Maximum braking for minimum landing rollout in the S-3 is easily achieved due to the the aircraft's excellent antiskid brakes. This procedure can be repeatedly used with no blown tires and no other adverse condition developing other than reduced time between brake changes. These adjustments will reduce the required field length to 3,000 feet at sea level and 4,000 feet at 5,000 feet MSL.

The short runway requirements of the MS-3C will allow it to operate out of thousands of front line airfields throughout Europe, the Middle East, Asia, and most third world countries. Operating at a fuel weight of 10,000 pounds will give the MS-3C a round trip low level mission (sea level and 360 knots indicated) of over 750 nm in configuration A and over 500 nm in configuration B, as discussed in section 6-3. These mission radii combined with the ability to operate at short, on location airfields will give the MS-3C great flexibility in operations throughout the world.

6-7: GROUND PERFORMANCE

Runway length is only a portion of the demands of operating out of small airfields. Once on deck, the aircraft must be capable of operating in confined spaces and on narrow runways and taxiways. The excellent nose wheel steering (NWS) of the S-3 combined with the wheel base of under 14 feet allows for operations where precise control and tight turns are required. This is best exemplified by the aircraft's great safety record in the confined areas of the aircraft carrier fight deck. Another important consideration is that the aircraft has the ability to fold it's wings and fin. Aircraft turning radii with the wings folded and spread are shown in figure 6-7. This figure shows that only 62 feet is required for a 180 degree turn on deck in the S-3. This will allow for taxi operations is tight areas and minimize aircraft support requirements. With the wings and fin folded, the aircraft's wing span is less than 30 feet and the tail height is less than 16 feet. The aircraft's small size when "folded up" will make aircraft concealment and/or camouflage on deck at covert locations easier than for larger aircraft.

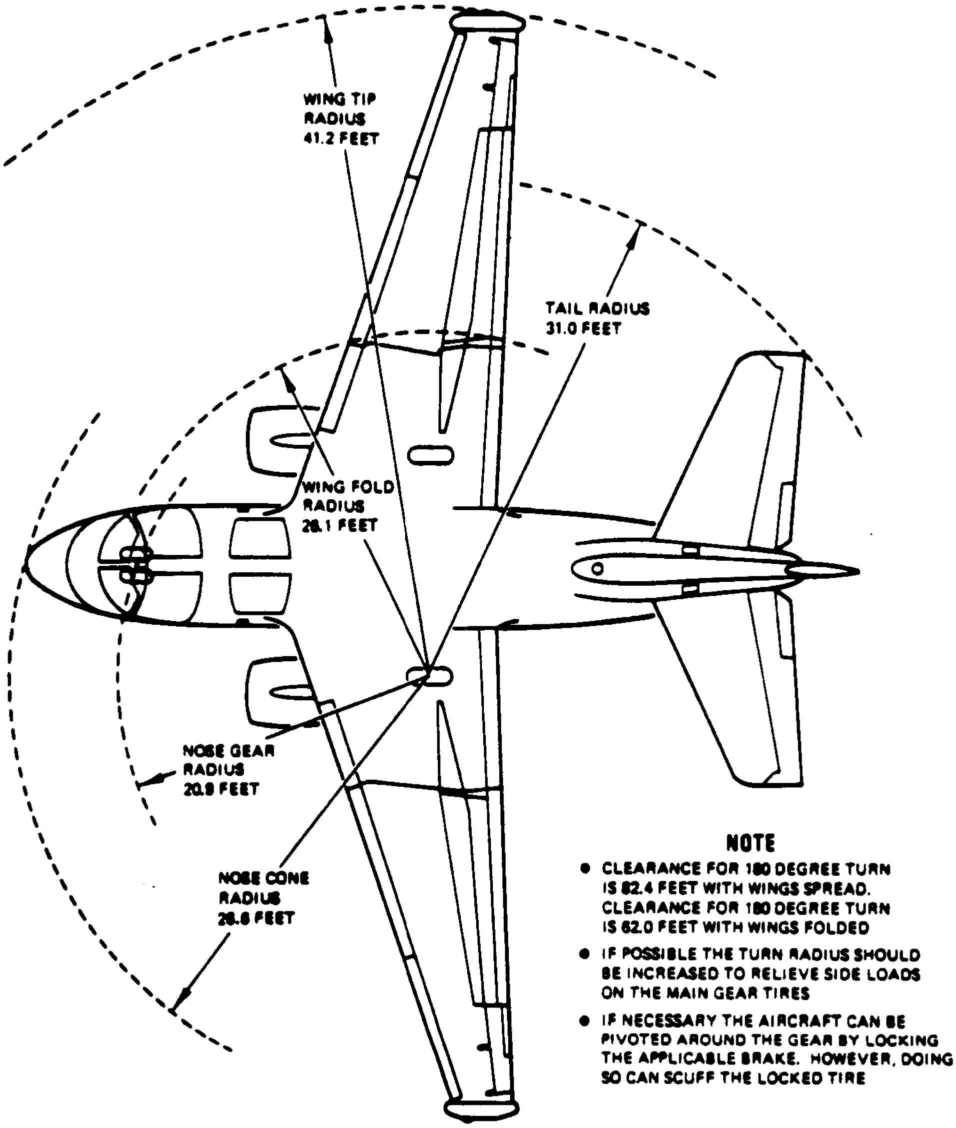


Figure 6-7

Aircraft Ground Turning Radius

6-8: WEAPONS AND CARGO CAPABILITY

The S-3 is capable of carrying and delivering a variety of ordnance that may be applicable to Special Operations Forces missions. Ordnance is carried on two wing stations and four internal bombbay stations. Each wing station is capable of carrying up to 2,500 pounds of ordnance and ejector racks. Each bombbay station is capable of carrying up to 600 pounds of ordnance. With a full loadout, the aircraft is capable of carrying ten Mark 82 500 pound bombs. Additional capabilities include five inch rockets, 1000 and 2000 pound bombs, cluster bombs, and several varieties of mines. Ordnance carried in the bombbays causes no increase in drag, can not be detected until the bombbays are opened, and do not use wing stations that may be required for the FLIR pod or external fuel. The wide variety of ordnance carried by the MS-3C will be an added bonus item to the mission. Although most Special Operations missions do not require direct support from the drop aircraft, the MS-3C will have the capability should a need arrive.

The MS-3C will have the capability of carrying a large amount of cargo for the special operations support or for aircraft support at remote locations. As mentioned in chapter 3, the right under wing internal cargo compartment will have a 40 cubic feet cargo capacity. Not only is this enough space to carry the mission equipment of a typical Special Operations Team, but it is also large enough to carry all the fluids, servicing equipment, and tools required for normal servicing of the aircraft. The external aft cargo bay also provides 36 cubic feet of storage space. This space will also be used for forward deployment logistics cargo. When necessary, the MS-3C will have the capability of carrying one or two external cargo pods. Each of these pods has cargo capacity of 90 cubic feet or 1000 pounds. The cargo carrying capability of the MS-3C will greatly add to the mission and deployment possibilities. Since the aircraft has the ability to carry it's own support items and requires no ground support equipment, it will have the ability to deploy anywhere that there is a suitable runway.

6-9: PERFORMANCE SUMMARY

The flight envelope of the MS-3 of sea level to 35,000 feet MSL and 90 to 450 knots will allow for a wide range of mission approaches. The aircraft's long mission range and endurance times add to this flexibility and increase mission options. The short runway operations and excellent ground operations add small airfields throughout the world to mission planning. Finally, the ability to carry weapons and cargo in addition to the Special Forces personnel adds self deployment to the flexibility equation. All these factors combined make the performance of the MS-3C outstanding for the Special Operations Forces support mission.

CHAPTER 7

LOGISTICS AND SUPPORT

7-1: AIRCRAFT HOME BASE

There are two obvious choices for home basing of the MS-3C aircraft; Naval Air Station North Island in San Diego, California and Naval Air Station Cecil Field in Jacksonville, Florida. These two are the most obvious choices because they are the two master bases for fleet S-3A and S-3B aircraft. No other bases can offer the maintenance and logistics support that North Island and Cecil Field offer. Of these two, North Island seems to be the stronger choice. North Island is located two miles from Naval Amphibious Base Coronado which is the home SEAL Team One and the SEAL training facilities. It is also the home of the Naval Amphibious Command which has overall command of many Special Operations Forces Missions. Approximately 50 miles north of North Island is Camp Pendleton which is the west coast home base of the Marine Corps Rangers. The close proximity of these three organizations clearly makes NAS North Island the best choice for MS-3C home basing.

7-2: MAINTENANCE SUPPORT

MS-3C maintenance support will be provided by currently existing maintenance structures. At NAS North Island, Airantisubron-41 (VS-41) will provide all maintenance support. VS-41 is the west coast fleet replacement squadron for the S-3 aircraft. The squadron does not deploy and is permanently based at North Island. VS-41 is the largest S-3 squadron and their maintenance assets are such that only minor adjustments in manning will be required in order for the maintenance department to be able to accommodate the MS-3C maintenance requirements. Since North Island is the master base for the S-3A and the depot level maintenance center for the F/A-18, maintenance department logistics support is optimized at that location. Additional maintenance personnel with expertise in AN/AYK-14 mission computers, digital display indicators, multipurpose color displays, and MIL-STD-1553 data bus operations will be required. Since VS-41 is shore duty, transferring personnel with the required skills from fleet F/A-18 squadrons at normal rotation periods will easily meet the VS-41 requirements.

Aircraft maintenance during carrier deployments will be performed by the maintenance department of the host S-3A/B squadron. This will represent approximately a ten percent increase in the maintenance performed by the squadron. Over the past ten to twelve years, all the maintenance on the four fleet US-3's has been conducted in this manner with good success. Two other important deployment bases should also be mentioned at this time. The fleet US-3 assets have permanent maintenance detachments forward deployed at Cubi Point in the Philippines and at Naples, Italy. Each of these bases are ideally located for special forces missions jump off points. The maintenance assets stationed at these bases will be used as necessary for MS-3C support.

Operational S-3A squadrons often self deploy to bases that have no S-3 maintenance support. They do this by taking two highly cross trained aircraft mechanics and all the necessary support equipment in the aircraft. These two technicians, along with a properly packed deployment kit, can handle all but the most sever maintenance problems. It is fairly common for two personnel to perform a complete engine change on an S-3. (Of course, the main problem at that extreme is in finding a spare engine.) This technique can be effectively used in conjunction with the MS-3C's large cargo carrying capacity to give the MS-3C a very good self deployment capability.

7-3: PILOT TRAINING

Pilot acquisition will be through the normal pilot training pipeline. After advanced jet training, pilots will be designated for MS-3C training. They will go through the normal familiarization, instrument, in-flight refueling, and carrier qualification training at VS-41. After completion of VS-41 training, the pilots will be assigned to the Special Operations Forces and undergo any additional training deemed necessary by the operational commander. VS-41 assets will be used continually for turnaround training and operational refreshers. Mission training will be primarily be conducted at the Fallon, Nevada weapons training facility, the Nellis AFB training facility, the Yuma military operating areas, and the Twenty-nine Palms desert operations areas. Operations at these facilities offer a wide range of terrain as well as several expeditionary landing fields.

Operating out of the North Island home base, the MS-3C aircrew will have access to training facilities and military training routes throughout the west. The maintenance and logistics support structure that is in place for S-3A/B and F/A-18 aircraft at North Island and on board the fleet aircraft carriers will be able to handle the additional load of maintaining the four MS-3C aircraft. The close proximity of NAB Coronado and Camp Pendleton will insure a close relationship between the pilots and their passengers. In light of these factors,the logistics, training and support of the MS-3C project will require little high level management for day to day operations.

CHAPTER 8

SUMMARY AND CONCLUSIONS

The cancellation of the V-22 project has left a large gap in the long range insertion mission of the Special Operations Forces. Presently, the C-130 Hercules and various helicopters are used to perform this mission. The low cruise speed, fuel consumption, and size of the C-130 and the short range and low speed of the helicopters make them inadequate for the long range mission. In searching for alternatives that can meet mission requirements, the S-3A comes quickly to mind.

The intent of this paper was to design an MS-3C to meet the mission requirements of the long range Special Operations Forces insertion mission. All design considerations were tempered with the idea that this is a stop-gap solution intended to fill a void until the V-22 program gets back on track or another specifically designed aircraft comes along. The total modification program is for four aircraft. It is felt that this number represents enough assets to supplement present day assets. A combined team of the MS-3C assets, helicopter assets, and C-130 assets will be able to meet all the mission requirements that were to be met by the V-22.

The modification process is to start with proposal for avionics configuration, software design, wiring design, and hatch design and replacement. A full system mock up will then be tested and adjustments will be made prior to retesting. The first aircraft modification will start with the removal of all internal and external equipment that will not be necessary for the mission. Next wiring, avionics, and antennas will be added in sequence. At the same time, seats will be modified and installed, the new hatch configuration will be installed, the sonobouy chutes and MAD boom will be sealed, and all other small jobs will be completed. Finally, the first aircraft will be flight tested and systems performance will be examined and adjusted. The remaining three aircraft will begin and end the modification process at six to eight week intervals. The entire modification process for all three aircraft is designed to be complete within approximately one year.

The modification team will consist of the same major organizations that have made all the S-3A modifications to date. Naval Air Systems command will head up the team. Other Navy organizations with major parts in the modification will be Naval Air Test Center, Naval Avionics Command, and Naval Air Development Center. The civilian team will be lead by Lockheed Aeronautical Systems Company. Others involve to various degrees include Lockheed Austin Division, Sanders Associates, and Softech, Inc. One of the basic principles of the project time line was that the experience of the project team will cut delays to a minimum.

The MS-3C avionics design was revolved around all weather, day/night low level insertion requirements. The system revolves around dual AN/AYK-14 digital mission computers and dual redundant MIL-STD-1553 data busses. Data is displayed to the pilot and copilot on dual Digital Display Indicators, dual Multipurpose Color Displays, and the pilot's Head Up Display. Navigation is performed by the mission computers using inputs from the Inertial Navigation System, the Global Positioning System, and the OMEGA. Dual VOR/ILS sets, TACAN, ADF, ACLS, and CILS make up the radio aids to navigation. The communications suite consists of dual UHF/VHF, AM/FM ARC-182 radio sets and a 1,000 watt ARC 153 HF radio set.

In order to maximize mission effectiveness in the bad weather, night environment, the MS-3C will be equipped with the APQ-172 Multi Mode Radar, the AAS-138 Forward Looking Infrared , and a Night Vision Goggles capability. Modes of the APQ-172 include ground mapping, terrain following and terrain avoidance. The NVG's and FLIR will give the MS-3C the ability to operate in low light and total darkness conditions. These two pieces of mission equipment will allow low altitude insertion techniques to be employed at night in all weather condition, thus greatly increasing the probability of mission success.

The performance of the MS-3C will be such that it will be very capable of performing the long range Special Operations Forces mission. The aircraft flight envelope will include altitudes from sea level to 35,000 feet MSL and airspeed from 90 to 450 KIAS. Unrefueled ferry ranges of over 2,000 nautical miles, high-low-high mission radius of over 900 nautical miles, and low level mission radius of over 500 nautical miles all meet or exceed the range requirements of the mission. The in-flight refueling capability extends the range and endurance of the aircraft to the limits of crew fatigue. Since the aircraft can operate from fields as short as 3,000 feet and can be logistically self supporting, small airfield throughout the world can be used as forward deployed staging areas.

The potential of the MS-3C to meet the requirements of the long range Special Operations Forces mission have been presented in this paper. Design, modification, project management, performance, and logistics considerations have been discussed. Although this is only a first look at a possible solution to a mission requirement, it is an option that is both feasible and viable. Estimations of both time and assets required for a four aircraft modification are rough, but they should prove to be within a reasonable error. Avionics design, while by no means complete, is such that an excellent mission capability is gained using a maximum of off the shelf equipment. This paper is submitted in hopes that reasonable consideration be given to the project as an interim solution.

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LIST OF REFERENCES

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6. Naval Air Training and Operations Procedures Standardization Flight Manual, Navy Model S-3A Aircraft, NAVAIR 01-S3AAA-1, Dated 15 September 1987.

7. Naval Air Training and Operations Procedures Standardization Flight Manual, Navy Model US-3A Aircraft, NAVAIR 01-US3AA-1, Dated 15 April 1985.

APPENDIX A

TABLE OF CONTENTS

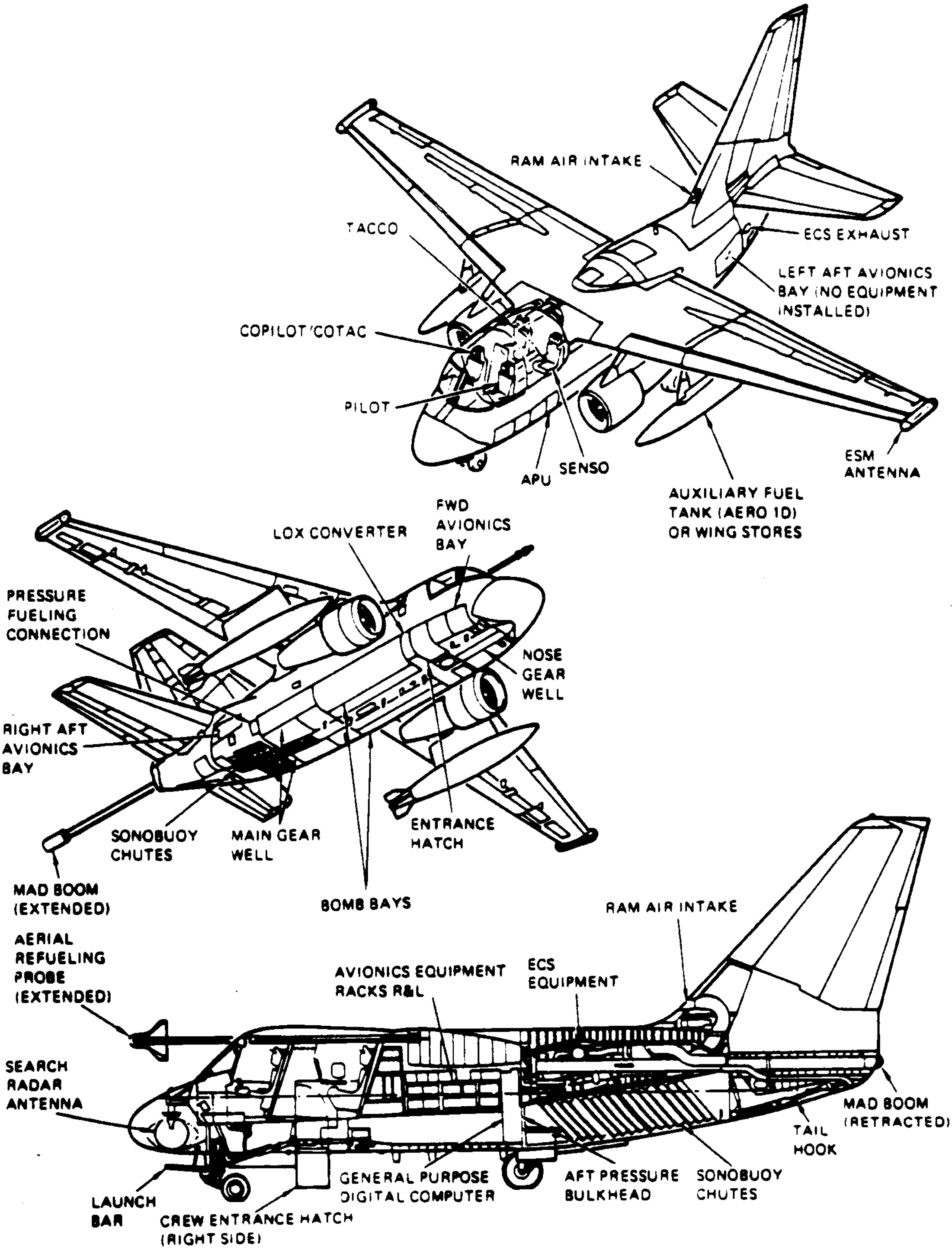


Figure A-1

S-3A Equipment Layout

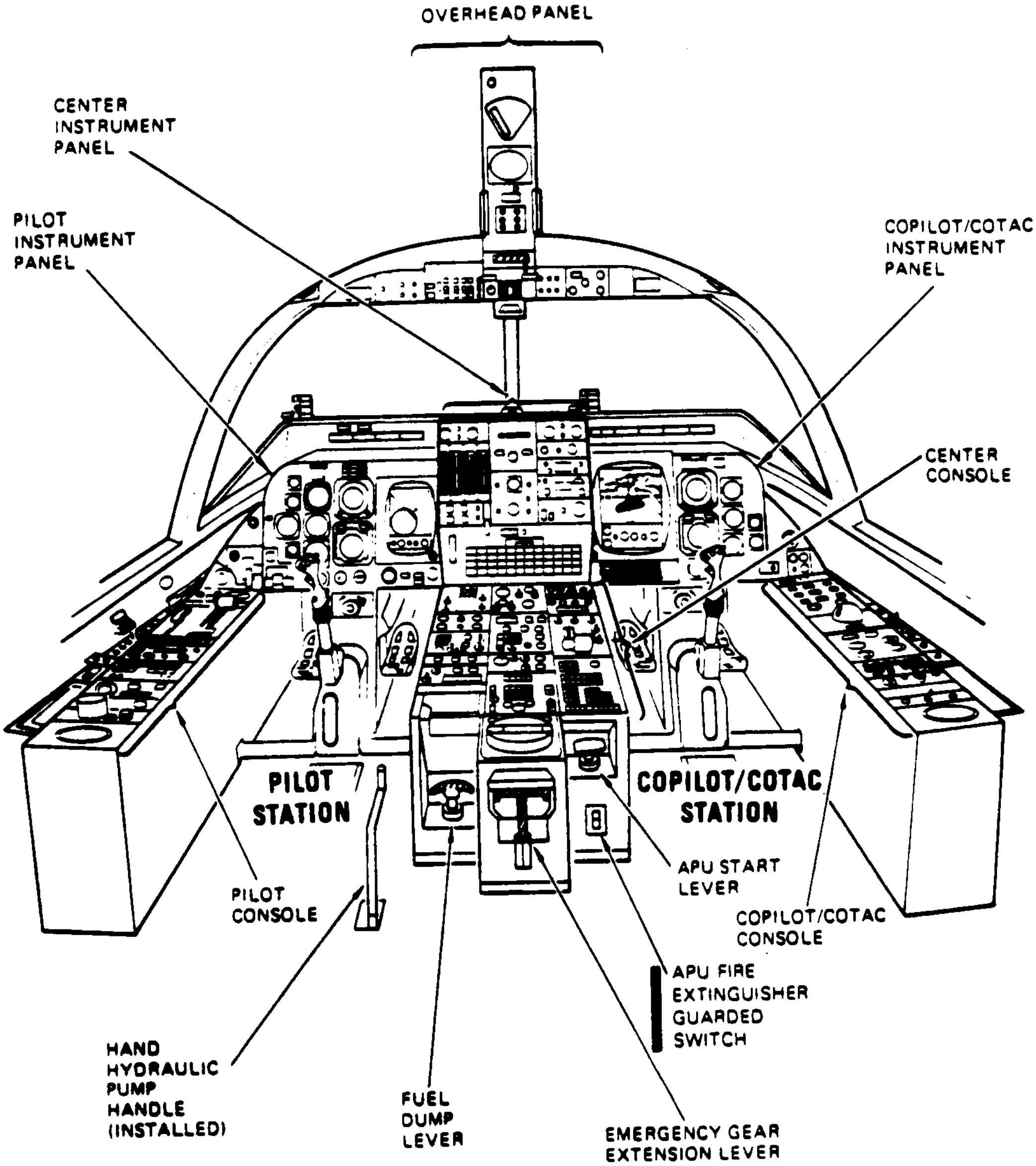


Figure A-2

S-3A General Cockpit Layout

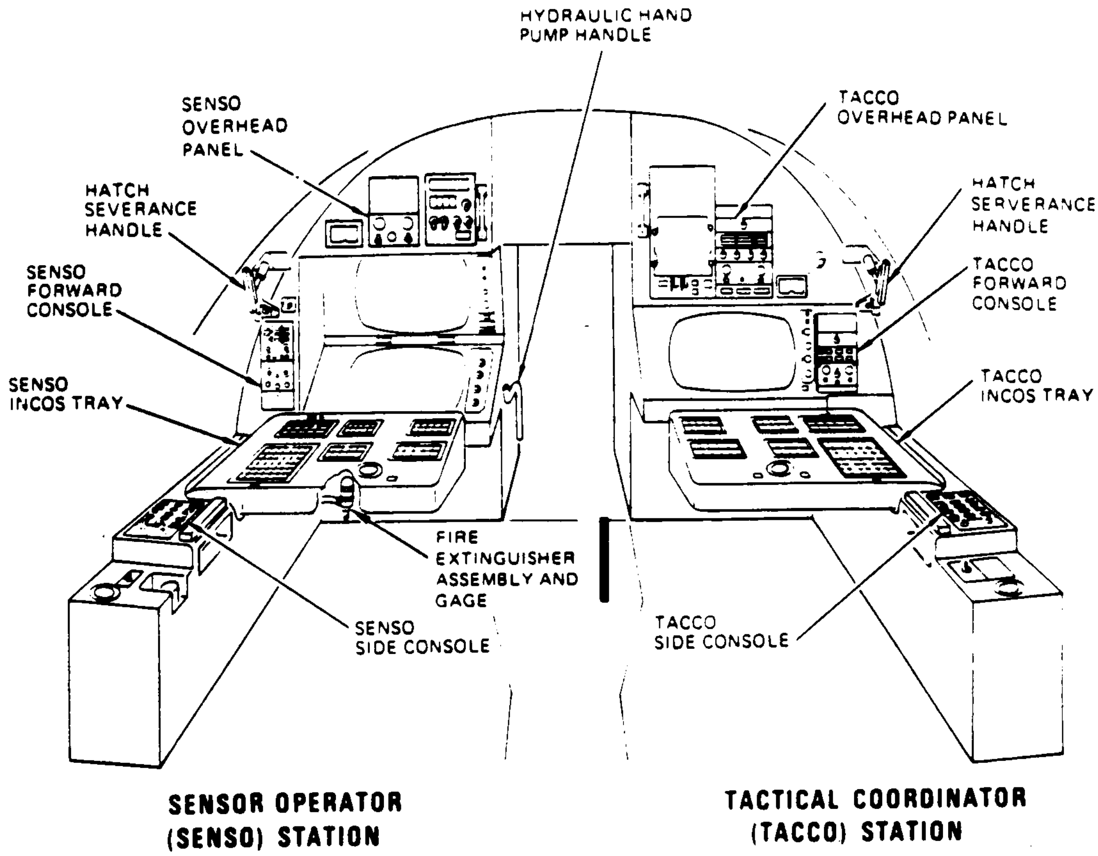
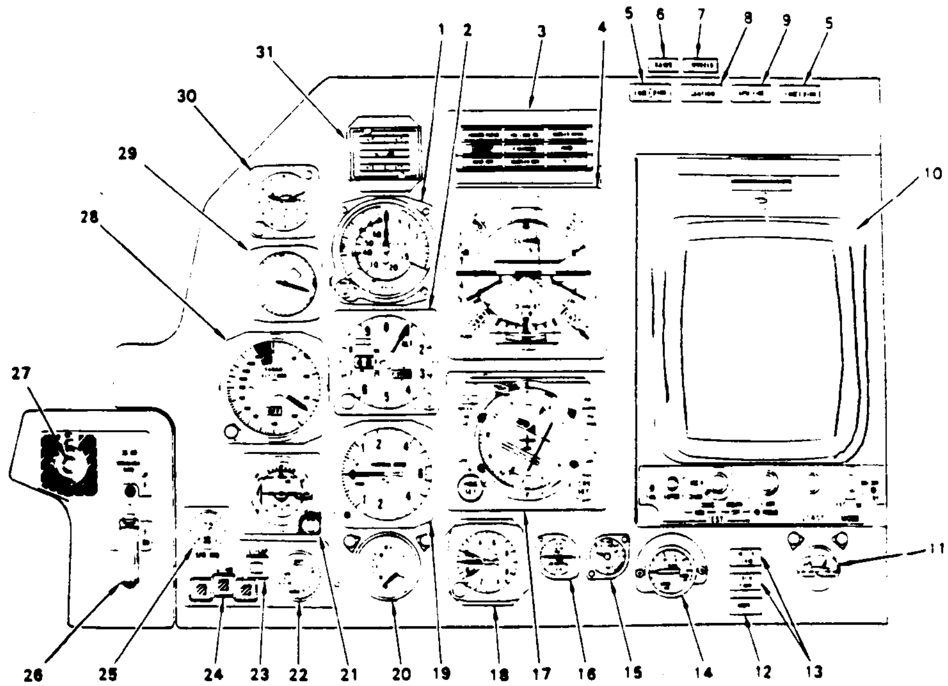


Figure A-3

S-3A Tacco and Senso Crew Stations

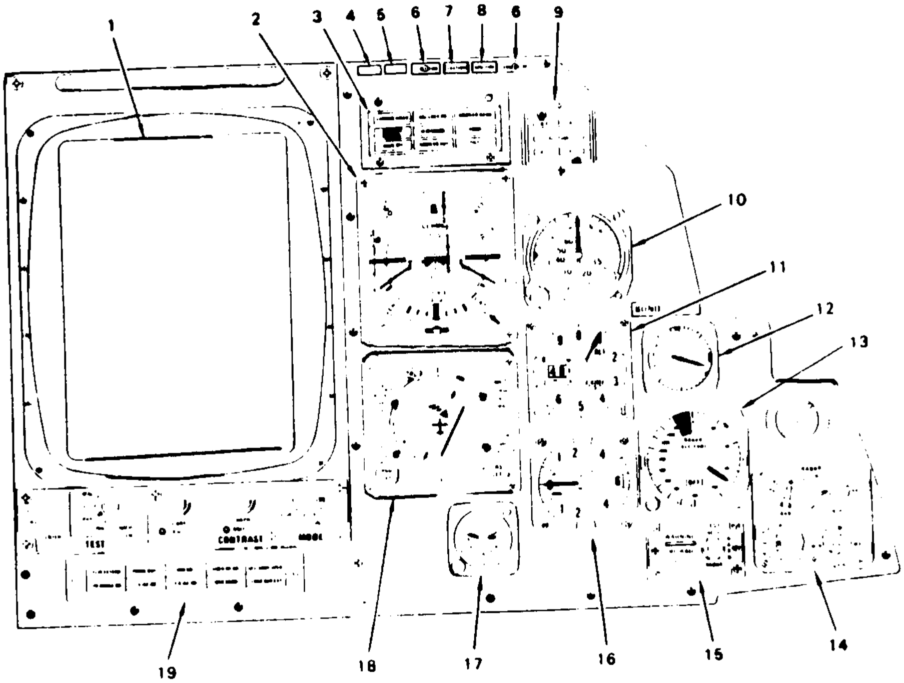


1 AIRSPEED/MACH INDICATOR
2 ALTIMETER
3 AUTOMATIC CARRIER LANDING SYSTEM (ACLS) DISCRETE WORD DISPAY PANEL
4 VERTICAL DIRECTOR INDICATOR
5 FIRE WARNING LIGHTS
6 RADAR ALTIMETER WARNING SYSTEM
7 LANDING GEAR WARNING LIGHT
8 MASTER CAUTION LIGHT
9 APU FIRE WARNING LIGHT
* 10 PILOT DISPLAY PANEL
11 EMERGENCY BRAKE PRESSURE INDICATOR
12 NWS LIGHT
* 13 MASTER ARM/SEARCH POWER CUE LIGHTS
14 PITCH TRIM INDICATOR
15 FLAPS/ELEV INPUT
16 ROLL TRIM INDICATOR
17 HORIZONTAL SITUATION INDICATOR
18 ACCELEROMETER
19 VERTICAL SPEED INDICATOR
20 OAT INDICATOR
21 STANDBY ATTITUDE INDICATOR
22 TRAILING EDGE FLAPS POSITION INDICATOR
23 LEADING EDGE FLAPS POSITION INDICATOR
24 LANDING GEAR POSITION INDICATOR
25 SPEEDBRAKES POSITION INDICATOR
26 LANDING GEAR HANDLE INDICATOR
27 EXTERNAL STORES JETTISON SWITCH
28 RADAR ALTIMETER
29 ANGLE-OF-ATTACK (AOA) INDICATOR
30 CLOCK
31 FAILURE ANNUNCIATOR (FA) PANELS

* EQUIPMENT TO BE REMOVED

Figure A-4

S-3A Pilot Instrument Panel

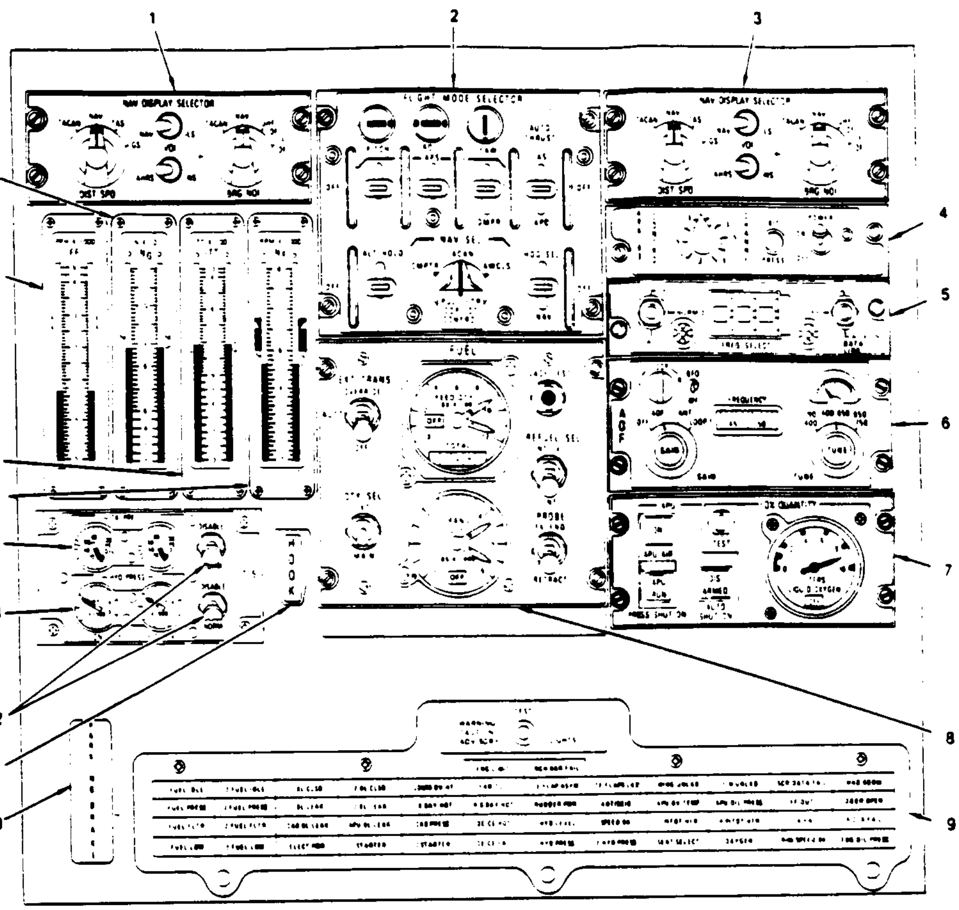


* 1 COPILOT/COTAC MULTIPURPOSE DISPLAY (MPD) PANEL
2 VERTICAL DIRECTOR INDICATOR
3 AUTOMATIC CARRIER LANDING SYSTEM (ACLS) DISCRETE WORD DISPLAY PANEL
4 RADAR ALTIMETER WARNING SYSTEM (RAWS) LIGHT
5 LANDING GEAR WARNING LIGHT
6 FIRE WARNING LIGHTS
7 MASTER CAUTION LIGHT
8 APU FIRE WARNING LIGHT
9 FAILURE ANNUNCIATOR (FA) PANELS
10 AIRSPEED/MACH INDICATOR
11 ALTIMETER
12 ANGLE OF ATTACK (AOA) INDICATOR
13 RADAR ALTIMETER
*14 RADAR OFF LINE CONTROL PANEL
*15 ACLS TEST PANEL
16 VERTICAL SPEED INDICATOR
17 CLOCK
18 HORIZONTAL SITUATION INDICATOR
19 ADVISORY PANEL

* EQUIPMENT TO BE REMOVED

Figure A-5

S-3A Copilot Instrument Panel

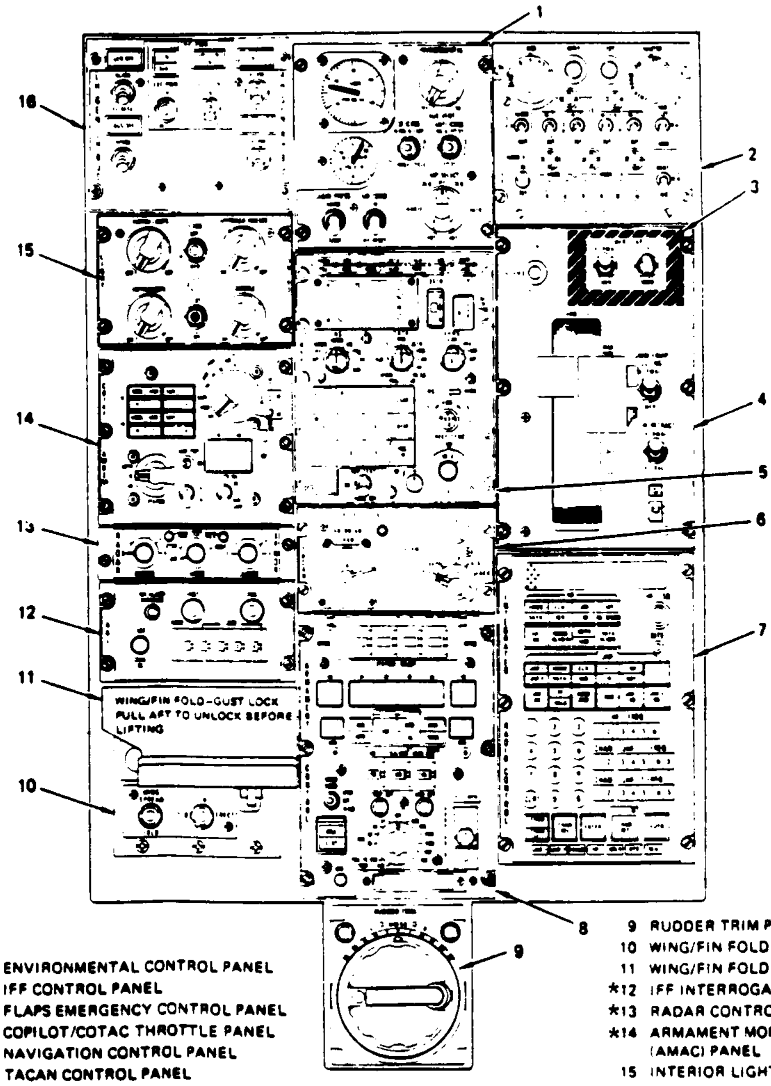


1 PILOT NAVIGATION DISPLAY SELECTOR PANEL
2 FLIGHT MODE SELECTOR PANEL
3 COPILOT/COTAC NAVIGATION DISPLAY SELECTOR PANEL
★ 4 CARRIER INSTRUMENT LANDING SYSTEM (CILS) RECEIVER DECODER PANEL
★ 5 DATA LINK SELECTOR PANEL
★ 6 LF ADF CONTROL PANEL
7 CREW OXYGEN QUANTITY/APU CONTROL INDICATORS PANEL
8 FUEL SYSTEM CONTROL PANEL
9 MASTER CAUTION PANEL
10 PARKING BRAKE HANDLE
11 ARRESTING HOOK HANDLE
12 T-5 DISABLE (ITT) SWITCHES
13 HYDRAULIC SYSTEM PRESSURE INDICATORS
14 ENGINE OIL PRESSURE INDICATORS
15 ENGINE FAN SPEED (N_F) INDICATOR
16 ENGINE INTERTURBINE TEMPERATURE (ITT) INDICATOR
17 ENGINE FUEL FLOW (FF) INDICATOR
18 ENGINE GAS GENERATOR SPEED (N_G) INDICATOR

★ EQUIPMENT TO BE REMOVED

Figure A-6

S-3A Center Instrument Panel



1 ENVIRONMENTAL CONTROL PANEL
*2 IFF CONTROL PANEL
3 FLAPS EMERGENCY CONTROL PANEL
4 COPILOT/COTAC THROTTLE PANEL
*5 NAVIGATION CONTROL PANEL
*6 TACAN CONTROL PANEL
*7 INTEGRATED RADIO CONTROL PANEL
8 ARMAMENT CONTROL PANEL
9 RUDDER TRIM PANEL
10 WING/FIN FOLD CONTROL PANEL
11 WING/FIN FOLD GUST-LOCK COVER
*12 IFF INTERROGATOR PANEL
*13 RADAR CONTROL PANEL
*14 ARMAMENT MONITOR AND CONTROL (AMAC) PANEL
15 INTERIOR LIGHTS PANEL
16 ELECTRICAL SYSTEM CONTROL PANEL

*EQUIPMENT TO BE REMOVED

Figure A-7

S-3A Center Console

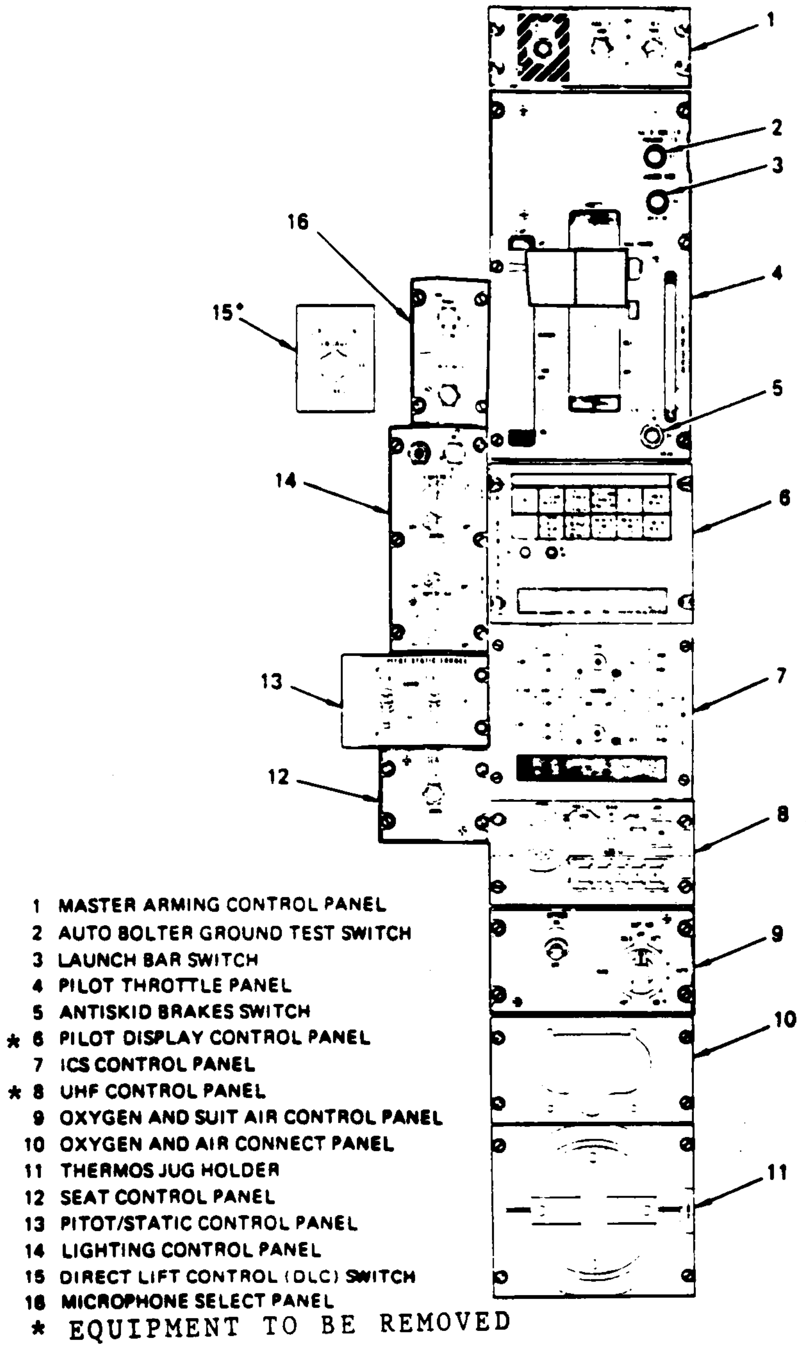
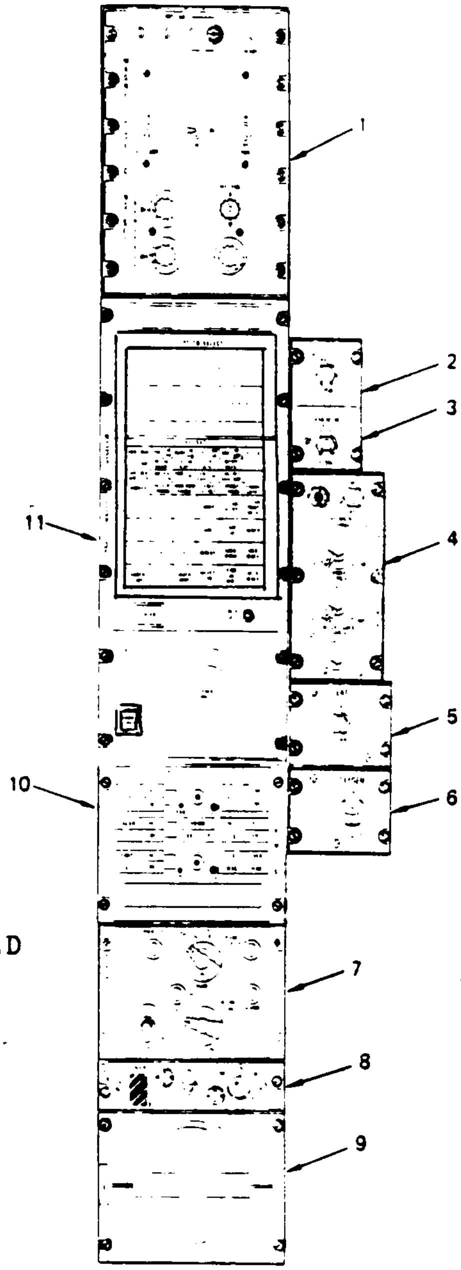


Figure A-8

S-3A Pilot Console



LEGEND

- * 1 MAD CONTROL PANEL
- 2 MICROPHONE SELECT PANEL
- * 3 MAD BOOM CONTROL PANEL
- 4 LIGHTING CONTROL PANEL
- 5 SEAT CONTROL PANEL
- 6 OXYGEN CONTROL PANEL
- * 7 KG-40 CONTROL PANEL
- 8 KY-58 CONTROL PANEL
- 9 THERMOS JUG HOLDER
- 10 ICS CONTROL PANEL
- *11 KEYSET PANEL

* EQUIPMENT TO BE REMOVED

Figure A-9

S-3A Copilot Console

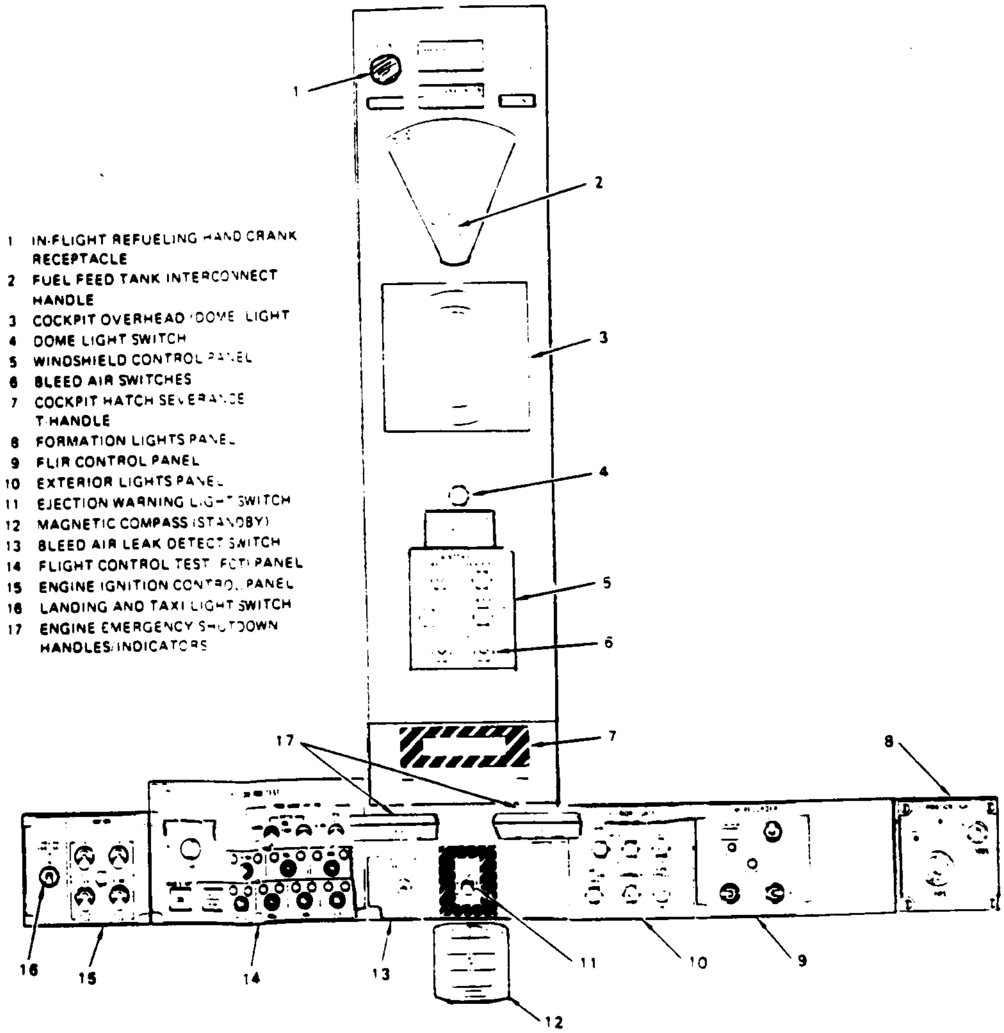


Figure A-10

S-3A Overhead Panel

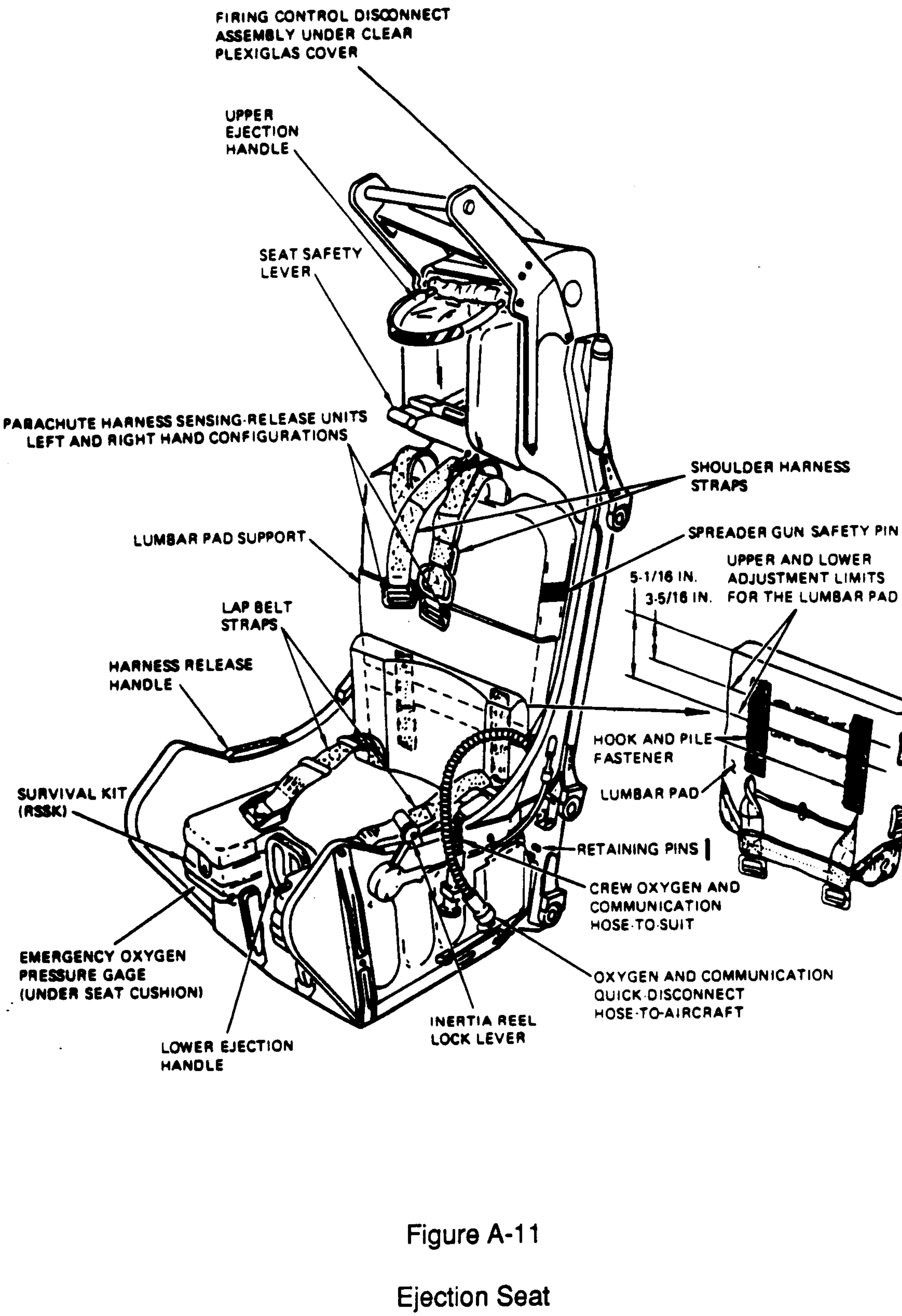


Figure A-11

Ejection Seat

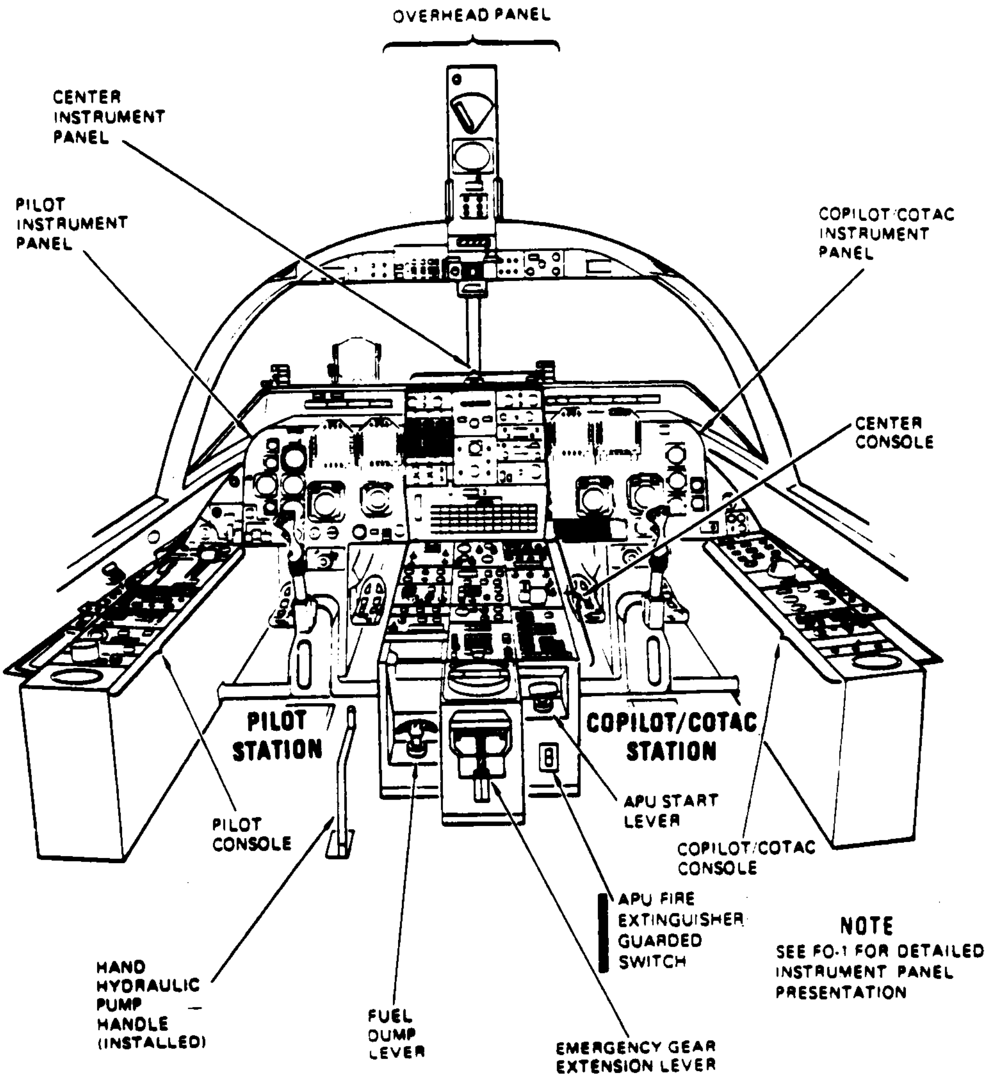
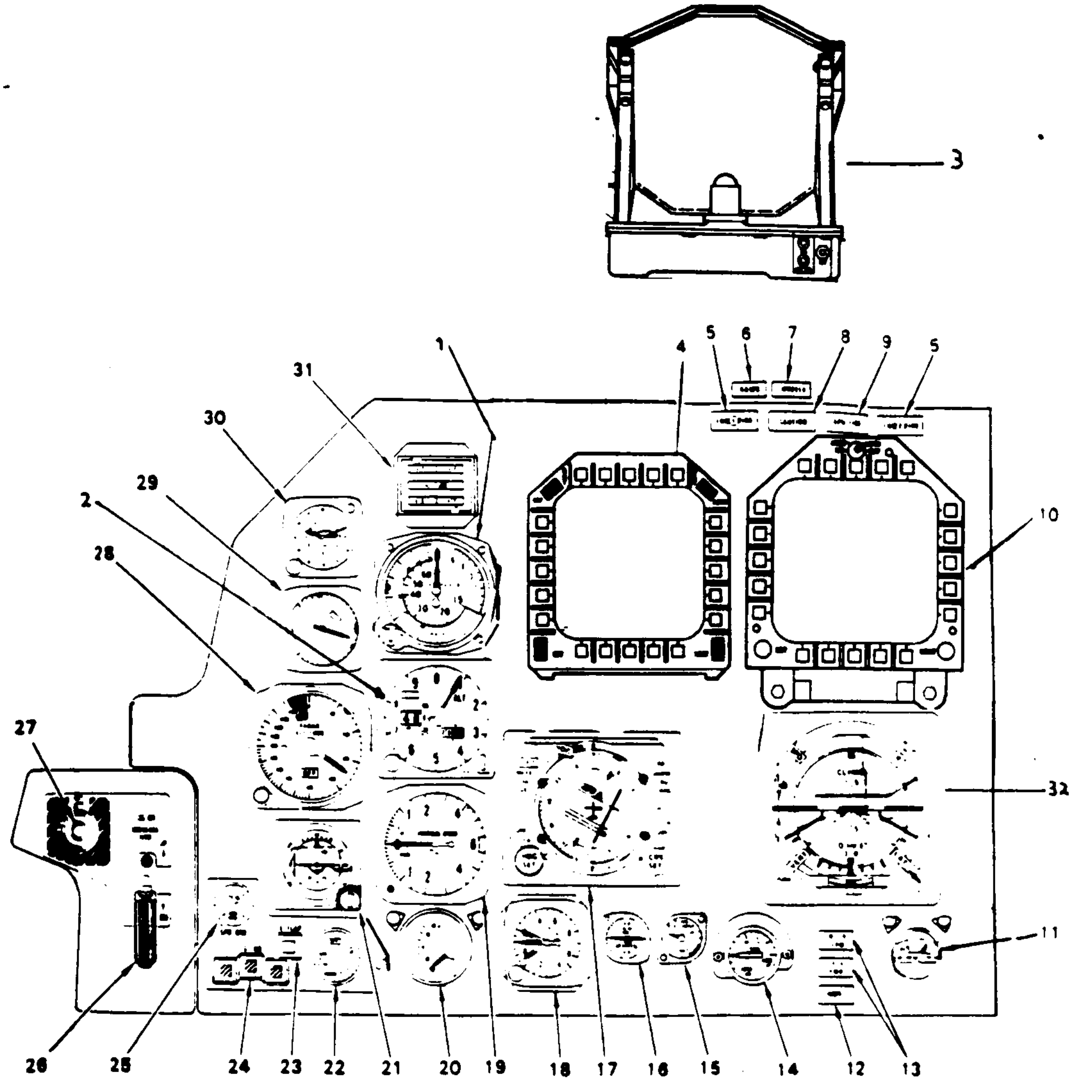


Figure A-12

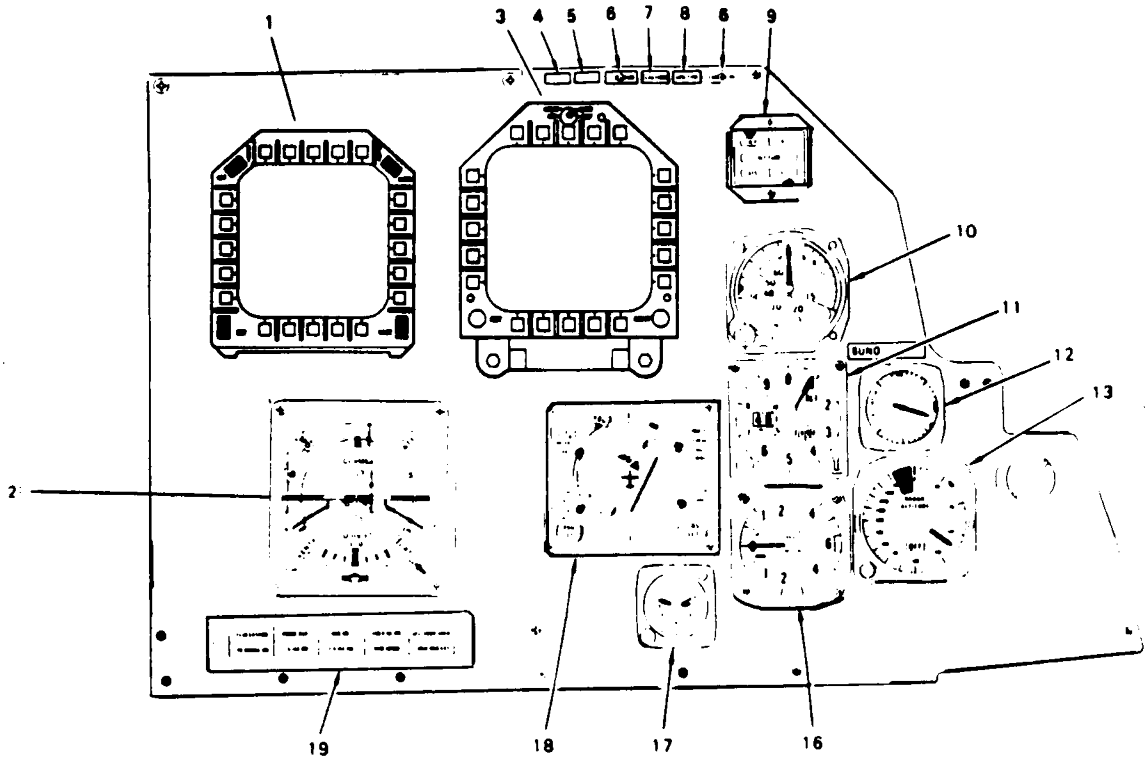
MS-3C General Cockpit Layout



1 AIRSPEED/MACH INDICATOR
2 ALTIMETER
3 HEAD UP DISPLAY (HUD)
4 MULTIPURPOSE COLOR DISPLAY
5 FIRE WARNING LIGHTS
6 RADAR ALTIMETER WARNING SYSTEM
7 LANDING GEAR WARNING LIGHT
8 MASTER CAUTION LIGHT
9 APU FIRE WARNING LIGHT
10 DIGITAL DISPLAY INDICATOR (DDI)
11 EMERGENCY BRAKE PRESSURE INDICATOR
12 NOSE WHEEL STEERING LIGHT
13 MASTER ARM CUE LIGHT
14 PITCH TRIM INDICATOR
15 FLAPS/ELEV INPUT
16 ROLL TRIM INDICATOR
17 HORIZONTAL SITUATION INDICATOR
18 ACCELEROMETER
19 VERTICAL SPEED INDICATOR
20 OAT INDICATOR
21 STANDBY ATTITUDE INDICATOR
22 TRAILING EDGE FLAP POSITIN INDICATOR
23 LEADING EDGE FLAP INDICATOR
24 LANDING GEAR POSITION INDICATOR
25 SPEED BRAKE POSITIN INDICATOR
26 LANDING GEAR HANDLE
27 EXTERNAL STORES JETTISON SWITCH
28 RADAR ALTIMETER
29 ANGLE-OF-ATTACK INDICATOR
30 CLOCK
31 FAILURE ANNUNCIATOR PANEL
32 VERTICAL DIRECTOR INDICATOR

Figure A-13

MS-3C Pilot Instrument Panel



1 MULTIPURPOSE COLOR DISPLAY
2 VERTICAL DIECTOR INDICATOR
3 DIGITAL DISPLAY INDICATOR (DDI)
4 RADAR ALTIMETER WARNING SYSTEM
5 LANDING GEAR WARNING LIGHT
6 FIRE WARNING LIGHTS
7 MASTER CAUTION LIGHT
8 APU FIRE WARNING LIGHT
9 FAILURE ANNUNCIATOR PANEL
10 AIRSPEED INDICATOR
11 ALTIMETER
12 ANGLE OF ATTACK INDICATOR
13 RADAR ALTIMETER
16 VERTICAL SPEED INDICATOR
17 CLOCK
18 HORIZONTAL SITUATION INDICATOR
19 ADVISORY PANEL

Figure A-14

MS-3C Copilot Instrument Panel

Table A-1

MS-3C Avionics Listing

EQUIPMENT	QUANTITY	DESIGNATION
Attitude and Heading Reference System	1	AN/ASN-107
Automatic Carrier Landing System	1	AN/ASW-25
Automatic Direction Finder	1	AN/ARN-83
Automatic Flight Control System	1	AN/ASW-33
Carrier Instrument Landing System	1	AN/ARA-63
Digital Display Indicator	2	IP-1318A
Digital Map Set	1	AN/ASQ-196
Electronic Equipment Controller	1	CC-10380/ASQ
Forward Looking Infrared	1	AN/AAS-138
Global Positioning System	1	To Be Determined
Head Up Display	1	AN/AVQ-32
HF Radio	1	AN/ARC-153A
IFF/Mode 4	1	AN/APX-72
Inertial Navigation System	1	AN/ASN-130A
Internal Communications System	4	LS-601
Mission Computer	2	AN/AYK-14
Multi Mode Radar	1	AN/APQ-172
Multipurpose Color Display	2	IP-1535A
OMEGA	1	LTN-211
RAAWS	1	AN/APN-201
Secure Voice	1	KY-58
Storm Scope	1	WX-1000+
TACAN	1	AN/ARN-118
Threat Warning System	1	AN/ALR-67
UHF/VHF/FM Rado	2	AN/ARC-182
VOR/ILS	2	313M-4B

APPENDIX B

LIST OF ABBREVIATIONS

AACS	Airspeed Altitude Computer Set
ACLS	Automatic Carrier Landing System
ADF	Automatic Direction Finding
ADP	Acoustic Data Processor
AGL	Above Ground Level
AHRS	Attitude and Heading Reference System
AM	Amplitude Modulation
AMAC	Armament Monitor and Control
APC	Approach Power Control
APS	Autopilot System
ASW	Antisubmarine Warfare
CILS	Carrier Instrument Landing System
DDI	Digital Display Indicator
DGU	Display Generator Unit
DMC	Digital Map Computer
DMS	Drum Memory System
DMTU	Digital Magnetic Tape Unit
ECM	Electronic Counter Measures
ESM	Electronic Support Measures
FLIR	Forward Looking Infrared
FOV	Field Of View
FM	Frequency Modulation
GPDC	General Purpose Digital Computer
GPS	Global Positining System
HALO	High Altitude Low Opening
HF	High Frequency
HUD	Head Up Display
ICS	Internal Communications System
IFF	Identification Friend or Foe
INCOS	Integrated Control System
INS	Inertial Navigation System
IRC	Integrated Radio Control
JNC	Jet Navigation Chart
JOG	Joint Operations Graphic
KIAS	Knots Indicated Airspeed
LF DF	Low Frequency Direction Finder
MAD	Magnetic Anomaly Detection

MPCD	Multipurpose Color Display
MPD	Multipurpose Display
MSL	Mean Sea Level
MTBF	Mean Time Between Failure
MUX	Multiplex
NATOPS	Naval Air Training and Operations Procedures Standardization
NAVAIR	Naval Air Systems Command
NM	Nautical Miles
NVG	Night Vision Goggles
RAAWS	Radar Altimeter and Altitude Warning Set
SENSO	Sensor Operator
TACAN	Tactical Air Navigation
TACCO	Tactical Coordinator
TPC	Tactical Pilotage Chart
UHF	Ultra High Frequency
VHF	Very High Frequency
VLF	Very Low Frequency
VOR	VHF Omni Range

VITA

Raymond John Griffith was born in Camden, New Jersey on November 13, 1954. After attending elementery schools in New Jersey and Delaware, he graduated from H. C. Conrad High School in Wilmington, Delaware in 1973. The following winter, he enlisted in the U. S. Navy and was later accepted into the United States Naval Academy. He received a Bachelor of Science Degree in Physics from the Naval Academy in 1979.

After the completion of pilot training, he was designated as a Naval Aviator in September 1981. Following two aircraft squadron tours, he attended the U.S. Naval Test Pilot School in Patuxent River, Maryland and graduated in June, 1988.

The author has over 2500 flight hours in over 40 different types of aircraft. He is presently on the staff of the U. S. Naval Test Pilot School.