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DEFINITION OF REQUIREMENTS FOR INTEGRATING USER EQUIPMENT SET Z--ETC(U)

JUN 75 B G MCELHANEY, K J BRAMAN F09603-75-A-3001

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Final Report

DEFINITION OF REQUIREMENTS FOR INTEGRATING USER EQUIPMENT SET Z INTO GLOBAL POSITIONING SYSTEM PHASE I TEST AIRCRAFT

Volume II: Test Aircraft Integration Requirements

June 1975

Prepared for

Deputy Program Manager for Logistics (AFLC)
and
Deputy Program Manager for the Navy
NAVSTAR Global Positioning System
Joint Program Office
SAMSO, Los Angeles AFS, CA 90009

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ABSTRACT

This report presents the results of a study by ARINC Research Corporation to identify and define the requirements for integrating Global Positioning System User Equipment Set Z into specified Air Force and Navy aircraft for GPS Phase I Initial Operational Test and Evaluation. The report is divided into three volumes:

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ABBREVIATIONS

ADF	–	Automatic direction finder
ADI	–	Attitude Director Indicator
AFCS	–	Automatic flight control system
AIMS	–	A - Air traffic control radar beacon I - Identification, friend or foe M - Military equipment S - Special systems
APU	–	Auxiliary power unit
ASD	–	Aeronautical Systems Division
ASC II	–	American Standards Association Code ASC II
ATCRBS	–	Air Traffic Control Radar Beacon System
ATR	–	Air transport racking
AWADS	–	Adverse Weather Aerial Delivery System
AWLS	–	All-weather landing system
BDHI	–	Bearing, distance, heading indicator
BW	–	Bandwidth
CADC	–	Central air data computer
CDI	–	Course indicator
CDU	–	Control display unit
DIFAR	–	Directional frequency and ranging
DPGM	–	(Part number)
DPJM	–	(Part number)
DPX	–	(Part number)
DT&E	–	Development Test and Evaluation
EMC	–	Electromagnetic compatibility
EMI	–	Electromagnetic interference
FD	–	Flight director
FDS	–	Flight director system
FLIR	–	Forward-looking Infra-red
FS	–	Fuselage Station
GPS	–	Global Positioning System

HSI	–	Horizontal situation indicator
IAS	–	Indicated airspeed
IF	–	Intermediate frequency
IFF	–	Identification, friend or foe
IM	–	Integration Module
INS	–	Inertial navigation system
IOT&E	–	Initial Operational Test and Evaluation
JPO	–	Joint Program Office
J/S	–	Jamming/signal
LBL	–	Left buttocks line
LO	–	Local oscillator
LORAN	–	Long-range aid to navigator
LRU	–	Line replaceable unit
MSU	–	Mode selector unit
OCALC	–	Oklahoma City Air Logistics Center
OMEGA	–	(Navigation system)
PAVE LOW III	–	Advanced configuration of Rescue Helicopter HH-53
ppb	–	Parts per billion
PSD	–	Power spectral density
RAFB	–	Robins Air Force Base
RBL	–	Right buttocks line
RF	–	Radio frequency
RGA	–	Rotation-go-around
RMI	–	Radio magnetic indicator
RS	–	Right side
R/T	–	Receiver/transmitter
SM	–	System Manager
TACAN	–	Tactical air navigation
TAS	–	True airspeed
TBD	–	To be determined
T.O.	–	Technical order
UE	–	User Equipment

VERNAV	–	Vertical navigation system
VOR	–	VHF omni-directional range
VSWR	–	Voltage standing wave ratio
WRALC	–	Warner Robins Air Logistics Center
YPG	–	Yuma Proving Grounds

SUMMARY

Individual and composite integration requirements and checklists have been defined for the installation of User Equipment Set Z of the Global Positioning System into IOT&E test aircraft. The aircraft types selected by the GPS Joint Program Office were the Air Force HC-130H, KC-135A, C-141A, and HH-53B/C; and the Navy P-3C. For the four USAF aircraft, a presently installed TACAN set will be removed and the existing TACAN wiring used for a portion of the GPS Set Z interconnections. At the direction of the GPS JPO, the TACAN in the P-3C is to remain installed and Set Z will be considered as additional equipment.

The installation concept for each aircraft was developed to provide a near-operational configuration with minimum installation cost and minimal impact on existing aircraft wiring.

Composite integration requirements were determined from an analysis of the individual aircraft configurations and the related checklists for each aircraft type. These composite requirements were developed into an integration specification for Set Z installation in the IOT&E test aircraft.

The design of Set Z was not finalized by the user equipment contractor during the term of this study. Consequently, it was necessary to make certain assumptions concerning the form, fit and function of the equipment line replaceable units to identify connector types, call out installation hardware, and specify the interfaces.

Lists of Group A items considered necessary to permit installation of a standardized Set Z equipment in the various aircraft were compiled. Special test requirements were developed for the installations described and specified. The test requirements include those related to the natural environment, antenna installation configuration, and potential Set Z performance degradation due to EMI.

CONCLUSIONS

As a result of this integration study, it is concluded that:

a. Installation space is adequate in the avionics racks of all five aircraft to mount the GPS Set Z receiver/processor unit.

b. The Set Z control/display unit can be located in the aircraft cockpit on the center pedestal area for all test aircraft except the KC-135A, where space limitations necessitate an installation at the navigator's station.

The antenna/preamplifier assembly can be located on top of the fuselage except on the HH-53 helicopter, where a horizontal tail stabilizer location may be necessary to prevent pattern anomalies.

d. Installations will not require splicing into, or removal of, any existing aircraft wiring.

e. Antenna/preamplifier temperatures may exceed the design and qualification test limits specified in Specification SS-US-101B for the user equipment.

f. Low frequency vibration of the CDU on the P-3C may exceed the design and qualification test limits of SS-US-101B.

g. All other environmental service conditions specified in SS-US-101B are suitable for Phase I IOT&E on the five aircraft studied.

RECOMMENDATIONS

Based on the integration study results, it is recommended that:

a. The Set Z receiver/processor be mounted in the avionics racks of the aircraft, replacing a TACAN transmitter/receiver unit in all aircraft except the P-3C, where it should be installed in a space available in cabinet C-1/C-2.

b. The GPS Set Z CDU be mounted on the center pedestal of all aircraft, except in the KC-135A, where it should be mounted on the navigator's table.

c. The GPS antenna/preamplifier be located on the top fuselage area of all aircraft except the HH-53, where it should be mounted on top of the horizontal stabilizer. Helicopter antenna pattern tests should be accomplished prior to IOT&E.

d. A special mounting be designed in accordance with ARINC Specification 404A to accommodate the receiver/processor unit and the integration modules.

e. Warning harnesses be fabricated to enable coupling into altitude and true-airspeed signal wires without destructive splicing.

f. Temperature requirements for the antenna/preamplifier assembly be broadened to match anticipated extreme test environments.

g. Low-frequency vibration specifications for the CDU be increased as design goals.

h. Form, fit and function factors for the Set Z LRUs be specified in accordance with ARINC Specification 404A to ensure standardization and compatibility with eventual civilian installations.

i. EMI/EMC considerations be reviewed when the Set Z IF and LO frequencies are being selected.

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ILLUSTRATIONS

TABLES

1
INTRODUCTION

Engineering services contributing to the development of aircraft integration requirements for user equipment of the Global Positioning System are being provided by ARINC Research Corporation to the GPS Joint Program Office of the USAF Space and Missiles System Organization. Under Contract F09603-75-A-3001-0001, the Corporation was tasked to study the integration of User Equipment Set Z into the aircraft host vehicles for Phase I Initial Operational Test and Evaluation of the GPS equipment.*

1.1 STUDY SCOPE AND APPROACH

For Phase I testing, five aircraft types were identified by the GPS JPO as potential host vehicles – three Air Force transport types, one Air Force helicopter, and one Navy land-based patrol plane. The Navy aircraft was added to the Air Force group as an addendum to the original task effort.

The integration study was intended to identify pertinent factors that might influence Set Z design and installation in a manner that would minimize test vehicle integration costs and simplify the GPS Phase I test effort. Requirements for equipment installation, electronic integration, and special integration testing were to be defined, in conjunction with an Integration Module (IM) that would provide the necessary interface signals between Set Z and the aircraft. Detailed examination of the host vehicles and interfaces relating to Set Z installation was to be conducted to permit identification of environmental and and antenna installation problem areas at a sufficiently early stage of the development of GPS hardware to allow timely corrective action.

The integration study involved a detailed review of technical orders and maintenance manuals of the five host aircraft. T.O.s and specifications that described related or interfacing electronics systems and instruments were examined and the data were verified by ARINC Research during visits to aircraft system managers and manufacturer facilities. The proposed form, fit, and function of Set Z equipment were derived from manufacturers' proposals and both ARINC and GPS specifications, and through engineering discussions with GPS UE Set Z contractor (Magnavox Corporation) personnel. The test aircraft configurations of radio navigation systems were then developed, environmental conditions were determined, and a physical installation was described for each vehicle.

The GPS JPO directed that a TACAN equipment be removed from each USAF aircraft so the Set Z would have adequate installation space and so that integration could be simplified through the use of existing TACAN wiring. If possible, the CDU was to be located in the aircraft cockpit, available to the pilot and copilot. In the

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*In this report, the term "Phase I testing" will be used as a short form for Phase I IOT&E of GPS user equipment.

case of the Navy P-3C, the TACAN set would not be removed and Set Z integrated with that equipment as well as the other radio navigation systems and flight instruments.

During the course of the study, and based on the progressing definition of IM requirements (see Volume III), it was determined that integration costs could be kept to a minimum by interfacing with only those flight instruments normally driven by the TACAN set. Accordingly, the postulated integration of Set Z was essentially limited to interface connections with horizontal situation navigation instruments to supply bearing, distance, course deviation and flag (warning) information at the instrument panel. Required inputs for TACAN-type capability include course set and heading information. In addition, true airspeed and altitude input data were included when available to simplify operator control of the system.

The physical design and packaging of Set Z had to be defined before detailed installation criteria could be developed. Since the equipment design effort is in its early stages, many elements of the Set Z configuration were estimated. These estimates were based on discussions with Magnavox engineers, a desired compatibility with standard airline configuration, and engineering judgment. Included are coaxial cable types and CDU wiring as suggested by Magnavox; cooling configuration, connector types, mounting, and holddown details as derived from airline standardized racking and mounting specifications; and unit dimensions obtained from manufacturers' proposals and estimates. Miscellaneous connectors and other Group A items were identified to be military qualified parts acceptable to all department users and/or mating to existing test aircraft harness connections.

This report of the integration study is organized so that each aircraft section will "stand alone", with minimum requirement for referring to other sections or volumes for data concerning a particular aircraft type. As a result, much of the information herein is repetitive from aircraft type to aircraft type. This is particularly true concerning the exposure time history and natural environment information in the various sections.

1.2 DESCRIPTION OF SET Z

The UE Set Z for Phase I is classified as an engineering development model and is designed to meet the form, fit, and function of Mil-specification production hardware. The Set Z single receiver channel operates only on the clear signal at 1575 MHz with sequential tracking of satellites. Set Z is intended for low-to-medium dynamic users, i.e., those having relatively modest performance requirements in terms of system accuracy and fix times. To reduce system costs, a combined receiver/processor unit and a single antenna channel will be used in Set Z, and interconnections with other navigation sensors will be minimized.

The following paragraphs describe the current concept of Set Z configuration, including the equipment line replaceable units, the IM, and the receiver/processor mounting, which are applicable to all IOT&E test aircraft. LRU descriptions are generally based on information supplied by Magnavox and relate to the specification and proposal for the GPS user equipment segment. The IM requirements were defined as a result of the test aircraft integration study (see Volume III). The receiver/processor mounting concept is based on the environment and available space of the test aircraft, and on the airline-user concept of standardization as described in ARINC Specification 404A. Other Group A items relating to particular test-aircraft types will be described in the report sections dealing with specific aircraft. Physical characteristics of the Set Z elements are presented in Table 1-1.

TABLE 1-1. GPS SET Z PHYSICAL CHARACTERISTICS

Item	Dimensions (w x l x h, cm)	Weight, kg	Power Consum., W
GPS Receiver/Processor Unit	19.10 x 31.9 x 19.4 (max); 3/4 ATR(S)	13.6	120
Control/Display Unit	14.7 x 10.2 x 15.2	2.27	10
Preamplifier Assembly	10.2 x 10.2 x 3.8	1.09	1
Antenna			
Conformal	12.7 x 12.7 x 5.0	1.36	–
Volute	5.1 dia, 30.5h	2.3	–
Integration Module		2.3	120
Converter	5.7 x 32 x 19.5		
Driver	25 x 11.4 x 11.7		
Receiver/Processor Mounting	25.4 x 43.8 x 7.5	3.0	–

1.2.1 Set Z Receiver/Processor

The Set Z receiver/processor unit provides the user equipment receiving and signal-decoding functions and a digital processing capability for receiver control, navigation data processing, and display formatting. The unit also provides Set Z calibration and self-test. It contains the user equipment power supply, which will function with either a 28 Vdc or 115 Vac/400 Hz input from the aircraft.

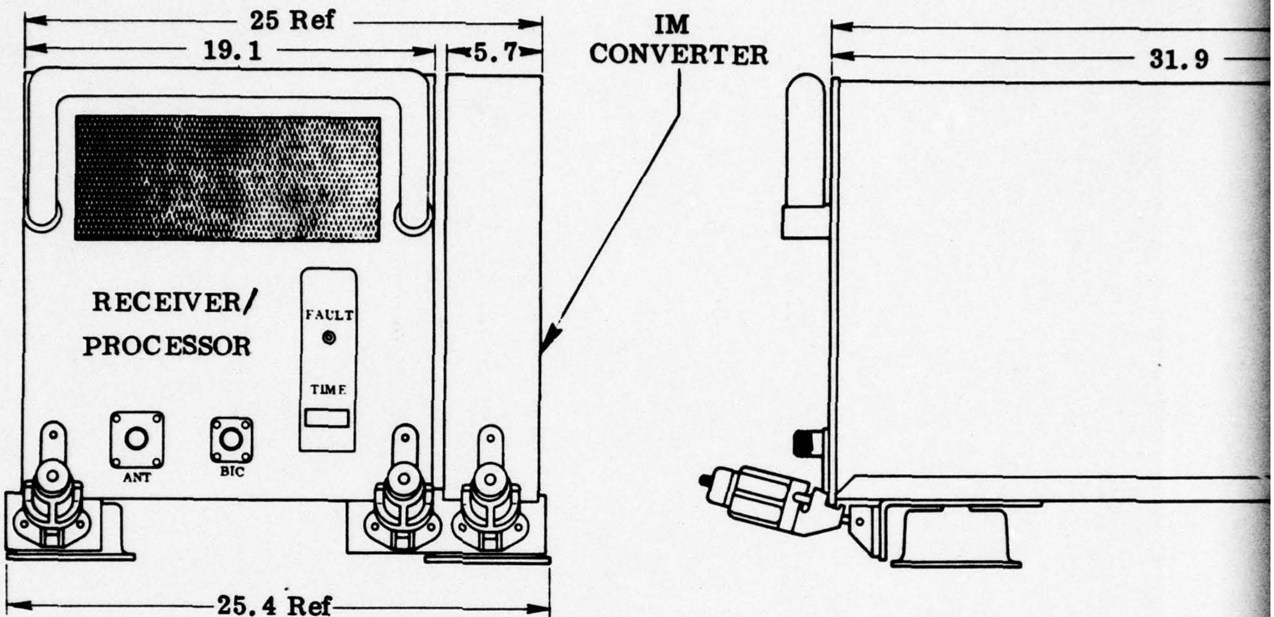
The receiver/processor is packaged in a 3/4 ATR (short) case to ARINC standards. Unit weight is estimated at 13.6 kg. A rack-and-panel, DPX-type connector is used on the unit, and ARINC-type cooling passages are utilized. Figure 1-1 is an outline drawing showing a possible arrangement of the receiver/processor unit.

1.2.2 Antenna/Preamplifier Assembly

Two configurations of the antenna/preamplifier assembly will be used with Set Z installations for Phase I testing. These have similar functions but different antennas; a conformal type for fixed-wing aircraft installations and a volute type for helicopter application.

The antenna/preamplifier assembly is designed for operation in an unpressurized environment, but must be capable of providing a pressure seal when mounted in a pressure hull or bulkhead. Coaxial-cable connections will carry the calibration signal input to the preamplifier, and the output for the amplified RF to the receiver/processor unit. DC power to the preamplifier will be transmitted via the RF signal coaxial cable.

Antennas are designed for hemispherical pattern coverage at an operating frequency of 1575 MHz. Postulated outline drawings of the two types of assembly are presented in Figures 1-2 and 1-3.



FRONT

Dimensions in cm

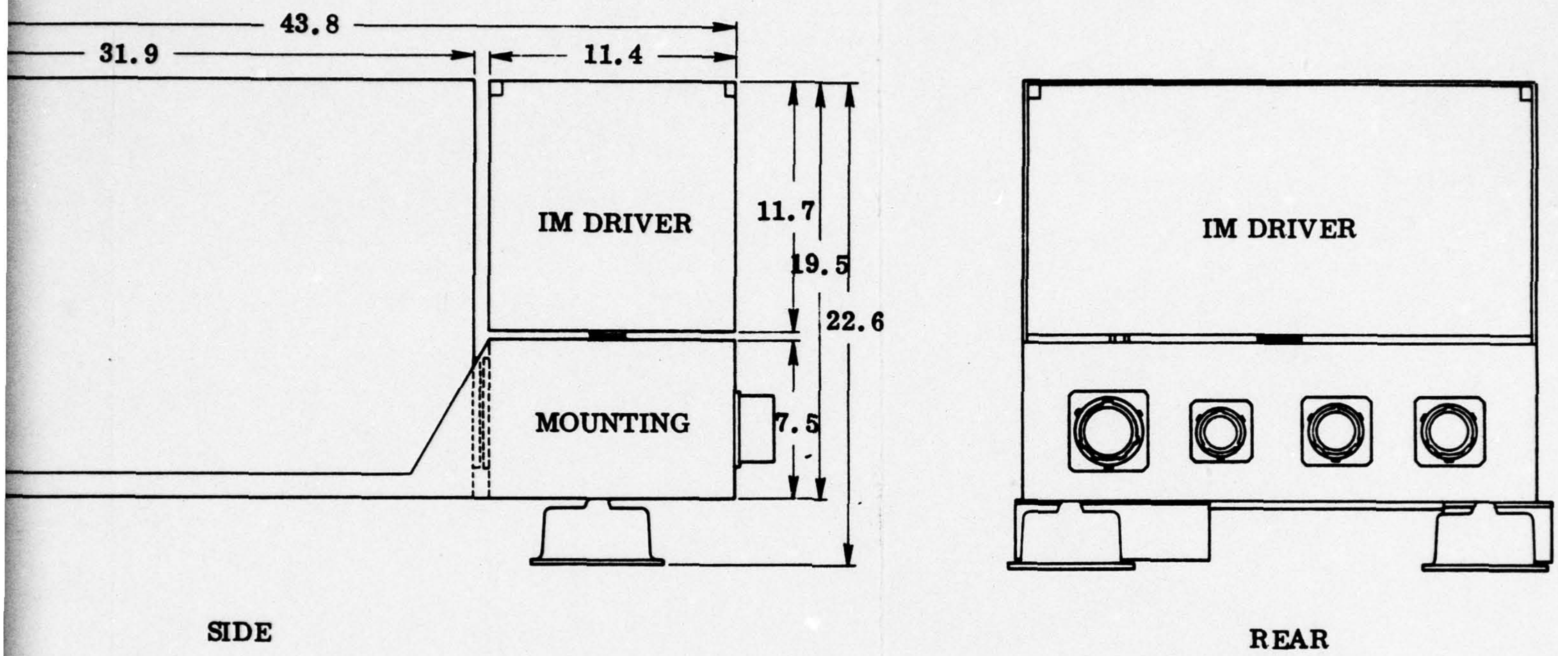


Figure 1-1. GPS Set Z Receiver/Processor and Mounting (Typical)

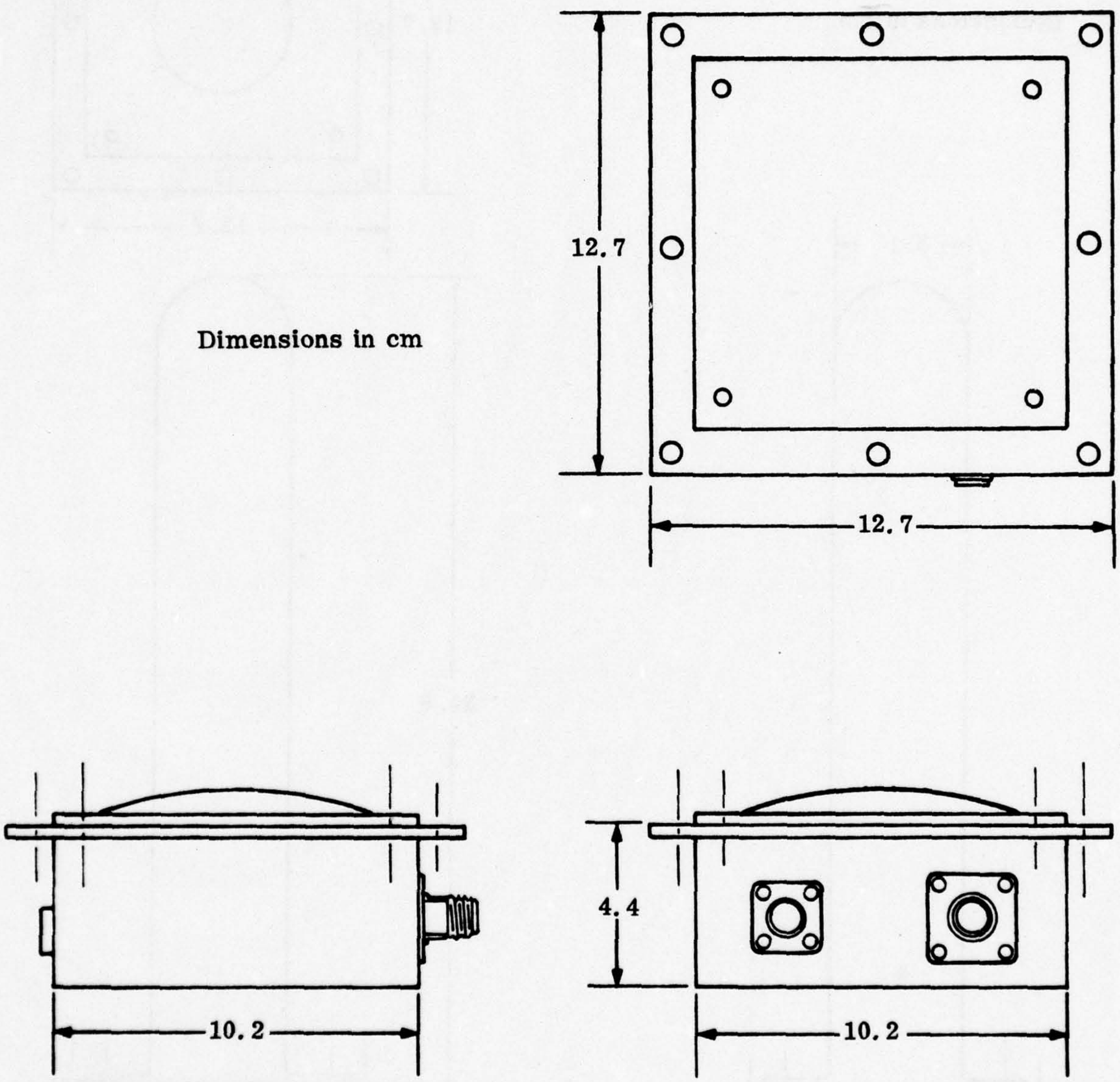


Figure 1-2. Typical Outline Drawing, Set Z Antenna/Preamplifier Assembly (Conformal Configuration)

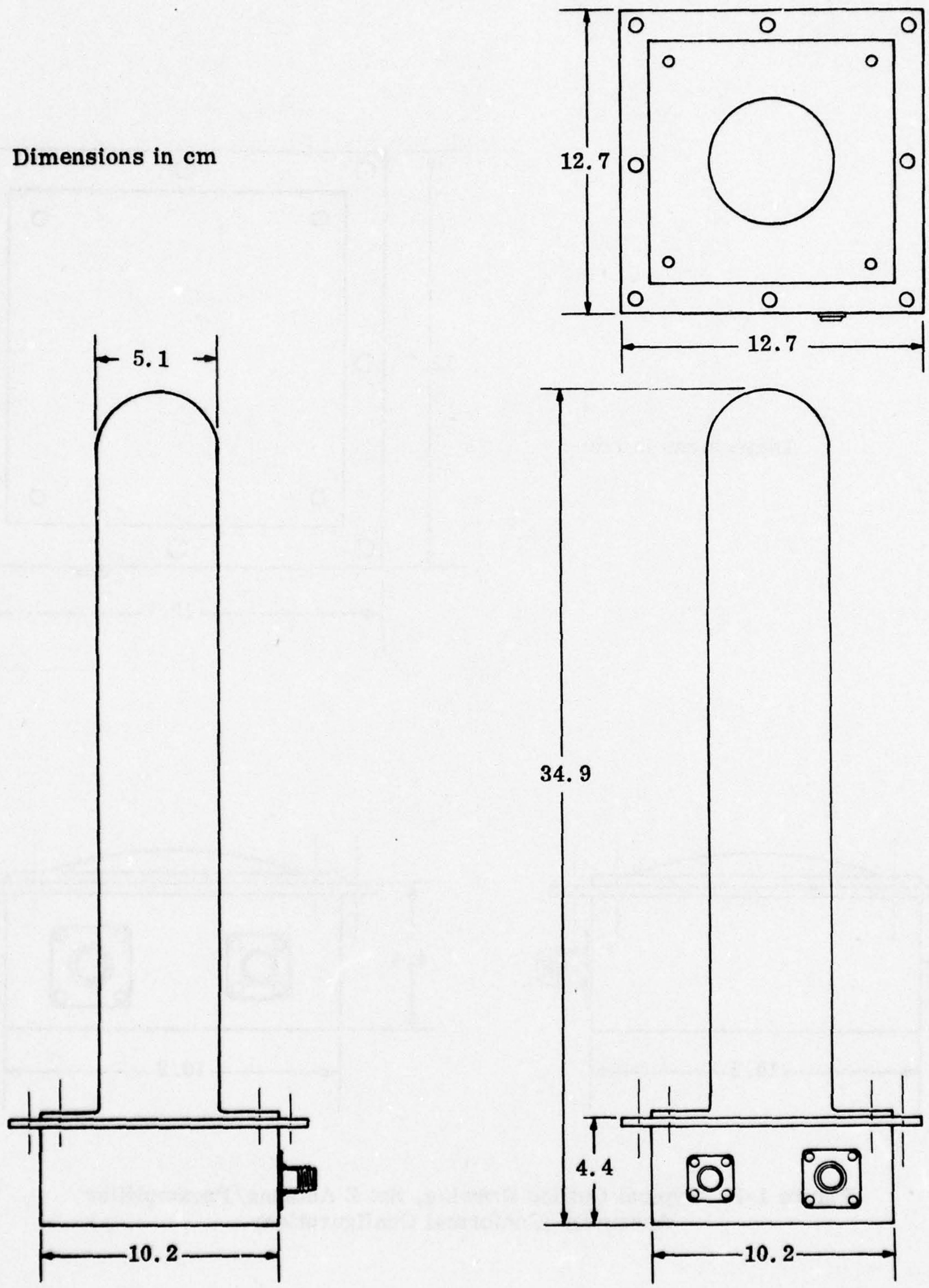


Figure 1-3. Typical Outline Drawing, Set Z Antenna/Preamplifier Assembly (Volute Configuration)

1.2.3 Control/Display Unit (CDU)

The GPS control/display unit provides the man-machine interface for Set Z. The CDU is configured for alphanumeric presentation in a two-line readout display, and has selector switches and a numeric keyboard to permit operator input of a large variety of navigation information. All Set Z functions can be controlled from the CDU, and all GPS navigation data may be displayed on it. Using the CDU, Set Z can be operated independently of all other aircraft control or display features. The interface between the CDU and the receiver/processor unit is digital, probably ASCII code (pending a final design decision).

The CDU is dimensioned to fit in a standard control panel rack, per MIL-F-25173. Panel height is approximately 15 cm, and unit weight is an estimated 2.27 kg. Figure 1-4 depicts a possible CDU configuration.

1.2.4 Integration Module

Two units are associated with the Integration Module: a converter and a driver.

The IM converter will be mounted alongside the receiver/processor unit on a common mounting. The converter will connect into the Set Z system via a rack-and-panel DPX connector and intramount wiring. The converter unit will transform GPS navigation information from the Set Z digital format into the analog signals necessary to interface with the flight instruments.

The IM driver will be mounted behind the receiver/processor unit, plugging into the same mounting with a rectangular rack-and-panel module connector. This unit will provide the high current necessary to drive existing multiple flight instruments on the various aircraft types. The IM driver must be considered as part of the mounting, since the limited access at the rear of the receiver/processor will make removal difficult in most installations. The designer of the driver unit must take into account this maintainability problem, for example, by designing the driver for the highest feasible reliability.

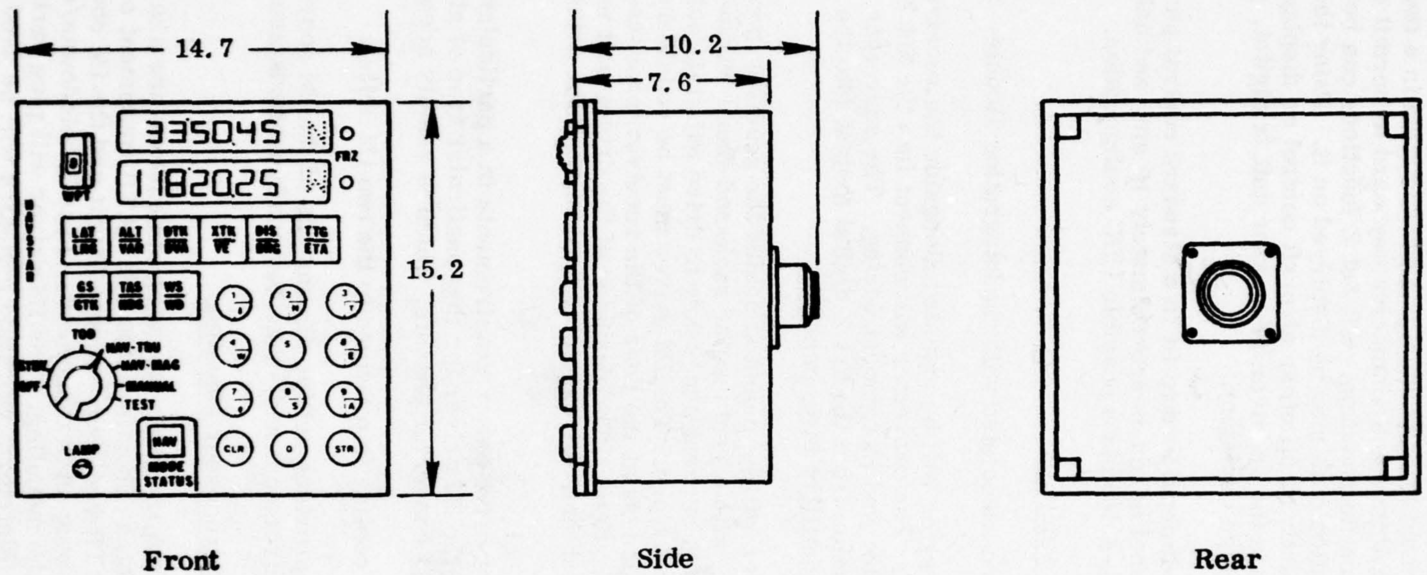
If instrument drive power requirements in a particular installation will permit a smaller package, the IM driver for that particular type of aircraft could be incorporated into the IM converter chassis, which is readily accessible and easily replaced.

No internal cooling is provided to the two IM units.

Figure 1-1 provides outline dimensions of the IM converter and driver units. Detailed unit requirements and suggested configurations are described in Volume III.

1.2.5 Receiver/Processor Mounting

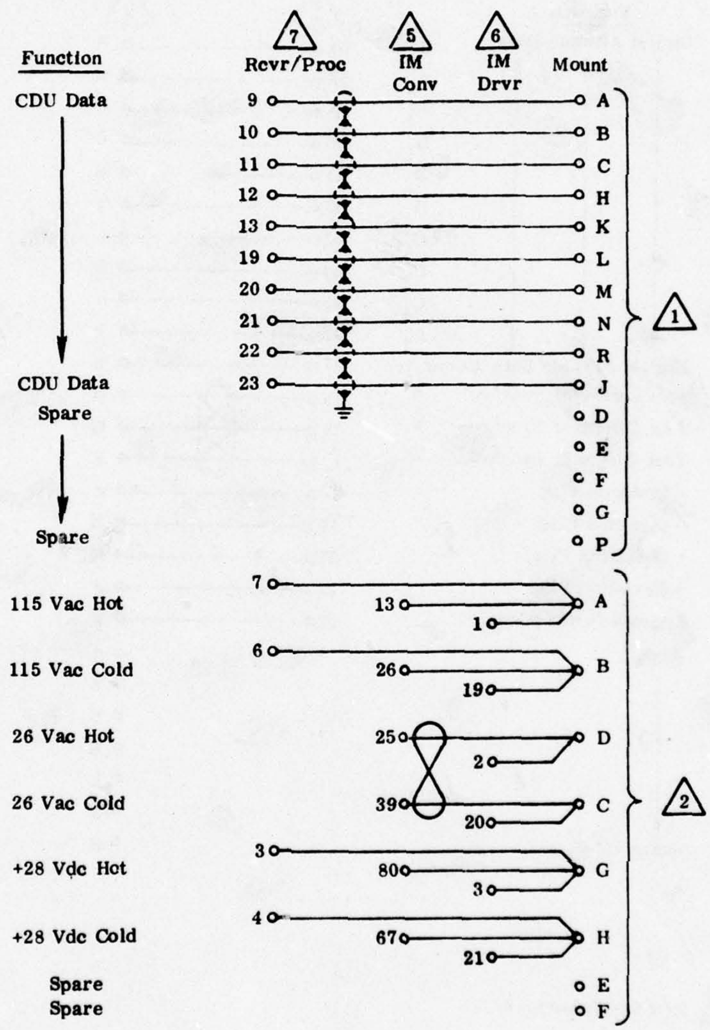
The receiver/processor mounting dimensions are similar to the AN/ARN-21 R/T mounting, which accommodates a full ATR equipment case. The mounting width permits the 3/4 ATR receiver/processor unit and the IM converter to be mounted side-by-side in a plug-in arrangement. Type C holddowns/extractors will be used to hold the units in the mounting. The IM driver will plug vertically into the after part of the mounting. Plateform vibration isolators will be used to support the mounting and fasten it to the rack structure (see Figure 1-1).



Dimensions in cm

Figure 1-4. Typical Outline Drawing, GPS Control Display Unit

Mount wiring will interconnect the receiver/processor unit, the IM converter, the IM driver, and four circular connectors on the back of the mounting. All external connections are via these circular connectors, except for coaxial cable inputs on the receiver/processor front. Figure 1-5 depicts mounting wiring and intraconnections.



1 P/N M83723-01R14-15N

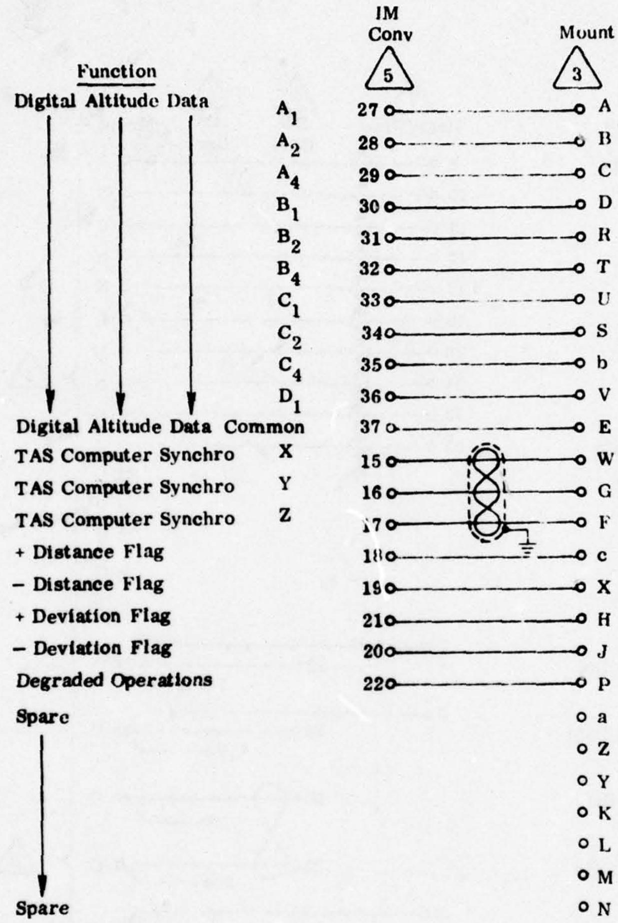
2 P/N M83723-02R16-8N

5 P/N M81659/31A2-0041 (IM converter), M81659/29A2-0042 (mount)

6 P/N M24308/4-4 (IM driver), M24308/2-4 (mount)

7 P/N M81659/31A2-0033 (rcvr/proc), M81659/29A2-0034 (mount)

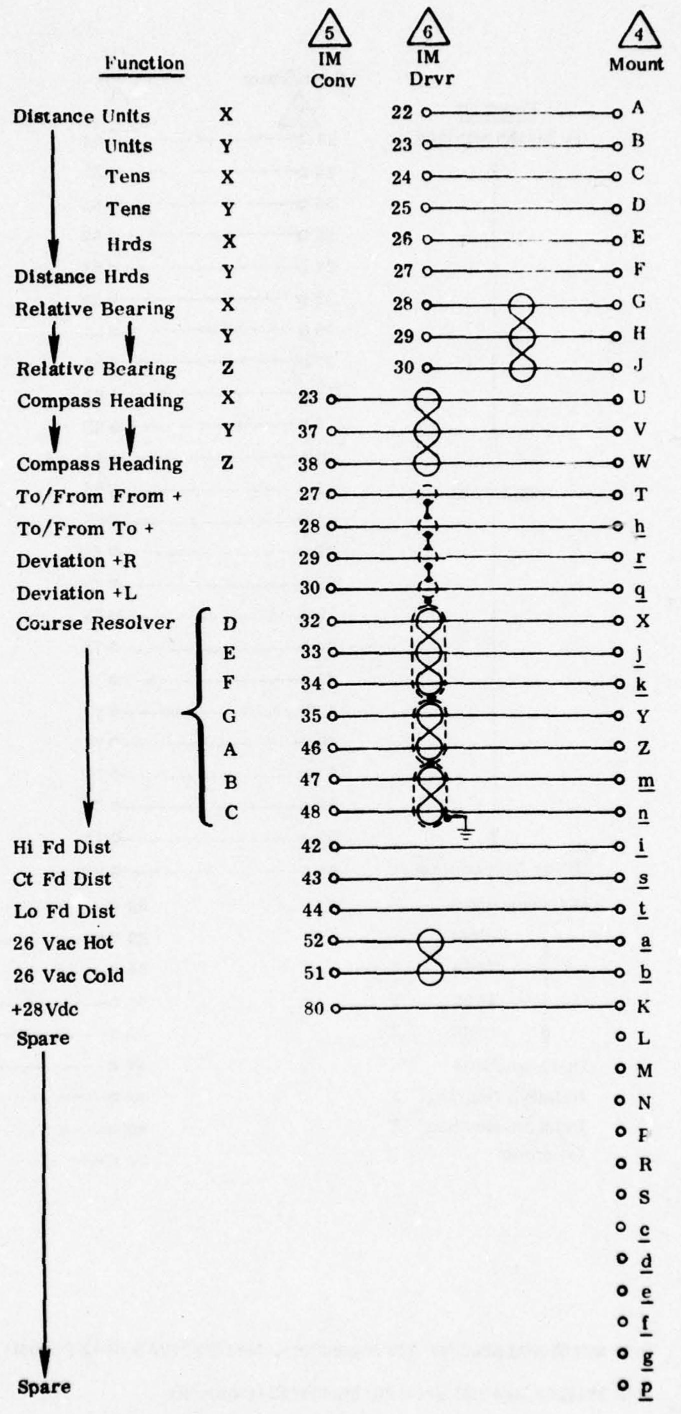
Figure 1-5. Wiring Diagram, Set Z Receiver/Processor Mounting (Sheet 1 of 4)



3 P/N M83723-02R16-26N

5 P/N M81659/29A2-0042 (mount)

Figure 1-5. (Sheet 2 of 4)

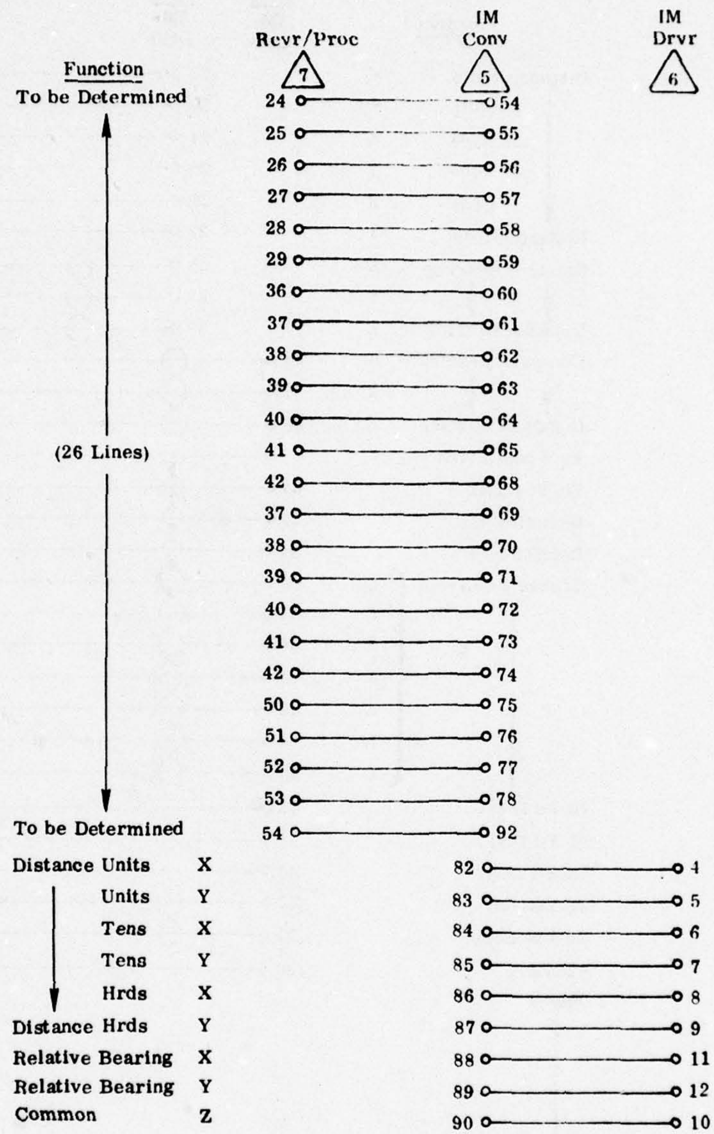


4 P/N M83723-13R16-26N

5 P/N M81659/31A2-0041 (IM converter), M81659/29A2-0042 (mount)

6 P/N M24308/4-4 (IM driver), M24308/2-4 (mount)

Figure 1-5. (Sheet 3 of 4)



5 P/N M81659/31A2-0041 (IM converter), M81659/29A2-0042 (mount)

6 P/N M24308/4-4 (IM driver), M24308/2-4 (mount)

7 P/N M81659/31A2-0033 (rcvr/proc), M81659/29A2-0034 (mount)

Figure 1-5. (Sheet 4 of 4)

2
TEST AIRCRAFT INTEGRATION, C-141A

This section provides detailed information concerning the integration of UE Set Z into the C-141A aircraft for GPS Phase I testing. The section provides information pertaining to the derivation of requirements; a description of the test installation, cabling and connections, and electronic interfaces; and a summary of Group A items that will be required for installation and interface. All items considered relevant to installation requirements of Set Z into the the C-141A are presented in checklist format in Appendix B.

2.1 INTEGRATION REQUIREMENTS DERIVATION

The integration requirements information contained in this section was derived from a study of technical orders and reports for the C-141A aircraft (see bibliography, Volume I, Appendix A). Additionally, information and data were collected during trips to the C-141 System Manager's office at Warner Robins Air Logistics Center and Lockheed-Georgia Company, Marietta, Ga. (see trip and contact list, Volume I, Appendix B).

2.1.1 Physical Installation Requirements

As discussed in Section 1.2, Set Z consists of three LRUs: receiver/processor, antenna/preamplifier, and CDU. The physical configuration of the C-141A and its associated avionics, the environment onboard the aircraft, the GPS Phase I Test Plan, and direction from the GPS JPO have imposed requirements on the physical installation of these three LRUs. The same considerations impact on the IM physical installation. The specific rationale for the installation of each unit will be described along with the installation descriptions presented in the following sections.

2.1.2 Avionics Configuration

Table 2-1 lists the C-141A avionics relevant to the integration effort. Relevancy is based upon replacement by, interface with, or potential interference to or from Set Z.

During visits to the SM at WRALC, ARINC Research determined that 278 C-141A aircraft are currently in the Air Force inventory, and that all but three of these aircraft have functionally identical avionics suites. Thus, there are currently no special requirements or considerations for integration of Set Z into the C-141A fleet to accommodate variations in the avionics suite configuration. However, several changes in avionics suite configuration are currently under consideration which could impact on the Set Z integration effort. Of these potential configuration changes, one would entail replacement of several onboard navigation systems with a dual inertial navigation system. Removed and replaced by the dual INS would be the compass, LORAN, doppler radar, and present onboard navigation computers, which would affect GPS interfaces with the flight director and automatic flight control system.

TABLE 2-1. C-141A AVIONICS EQUIPMENTS AFFECTED BY SET Z TEST INSTALLATION

Item Removed	Item Interfacing	Potential Interference
Rcvr/Trans No. 1 (RT-220C/ARN-21)	Pilot's HSI (AQU-4/A)	IFF (AN/APX-64)
	Pilot's BDHI (ID-798/ARN)	
Mount No. 1 (MT-928A/ARN-21)	Copilot's BDHI (ID-798/ARN)	
TACAN Cont. No. 1 (3K11289-101)	Navigator's BDHI (ID-798/ARN)	
	Pilot's FD Computer (3K91002)	
Indicator Cplr No. 1 (9616-13-03)	AFCS	
Antenna No. 2 (AT-741/A), if still installed	Compass (C-12)	
	AC Nav Bus No. 1	
	Main DC Avionics Bus No. 1	
	26 Vac Isolated Avionics Bus	
	Annunciator Panel	
	CADC (CPU-43/A) (2 ea)	
	Transponder (RT-731( )/APX-64)	
	Computer (CP/641/ASN-24)	
	Pilot's Navigation Selector Panel	
	BDHI Selector Panel (2 ea)	

The precise impact of these changes on Set Z integration and interfaces cannot be determined at this time. However, the adoption of the dual INS could affect the installation of the Set Z CDU on the cockpit console. From the information available in current Air Force change-data estimates, it has been concluded that proposed changes will not affect the physical location of the remainder of the Set Z units as delineated in this report.

2.2 PHYSICAL INSTALLATION DESCRIPTION

The following sections describe the physical installation of the various LRUs of UE Set Z in the C-141A aircraft. For each LRU, the rationale for selection or design of its installation approach is given.

2.2.1 Receiver/Processor

The receiver/processor of Set Z will be mounted in the cavity presently occupied by TACAN No. 1 in the left hand underdeck avionics equipment rack of the C-141A. TACAN coupler No. 1 will be removed. Installation at this location is dictated by available avionics space and by direction of the JPO.

The Set Z receiver/processor installation is illustrated in Figure 2-1. The unit will be mounted on vibration isolators, along with its Integration Module. Filtered cooling air is presently circulated through the avionics rack area and exhausted overboard by a large fan. An internal fan within the Set Z receiver/processor draws compartment air into the unit and directs the exhaust air through the bottom of the mounting tray. The heat dissipated in the unit, which has a power consumption of 120 watts, is not of a level that will necessitate the ducting of cooling air directly to the unit.

2.2.2 Antenna/Preamplifier Assembly

The Set Z antenna will replace the deactivated TACAN No. 2 antenna on top of the aircraft at FS 741.53, RBL 5.0. The preamplifier unit will extend inside the aircraft, below the antenna. Since the center wing compartment is unpressurized and the void has no cooling or airflow through it, the preamplifier circuitry must be able to withstand large temperature and pressure variations. Short service loops of coaxial cable must be used to connect the antenna/preamplifier assembly to pressure bulkhead adapters at the forward side of the compartment.

The antenna location takes advantage of an existing antenna site to minimize GPS installation cost. Since the TACAN and GPS antennas operate at similar frequencies, the TACAN No. 2 antenna location should be satisfactory from an RF pattern standpoint. Pattern blanking should only occur in a very narrow section aft, caused by the vertical stabilizer, and should not be significant. Set Z is not scheduled for testing on the inverted range, and thus no bottom-mounted antenna will be required.

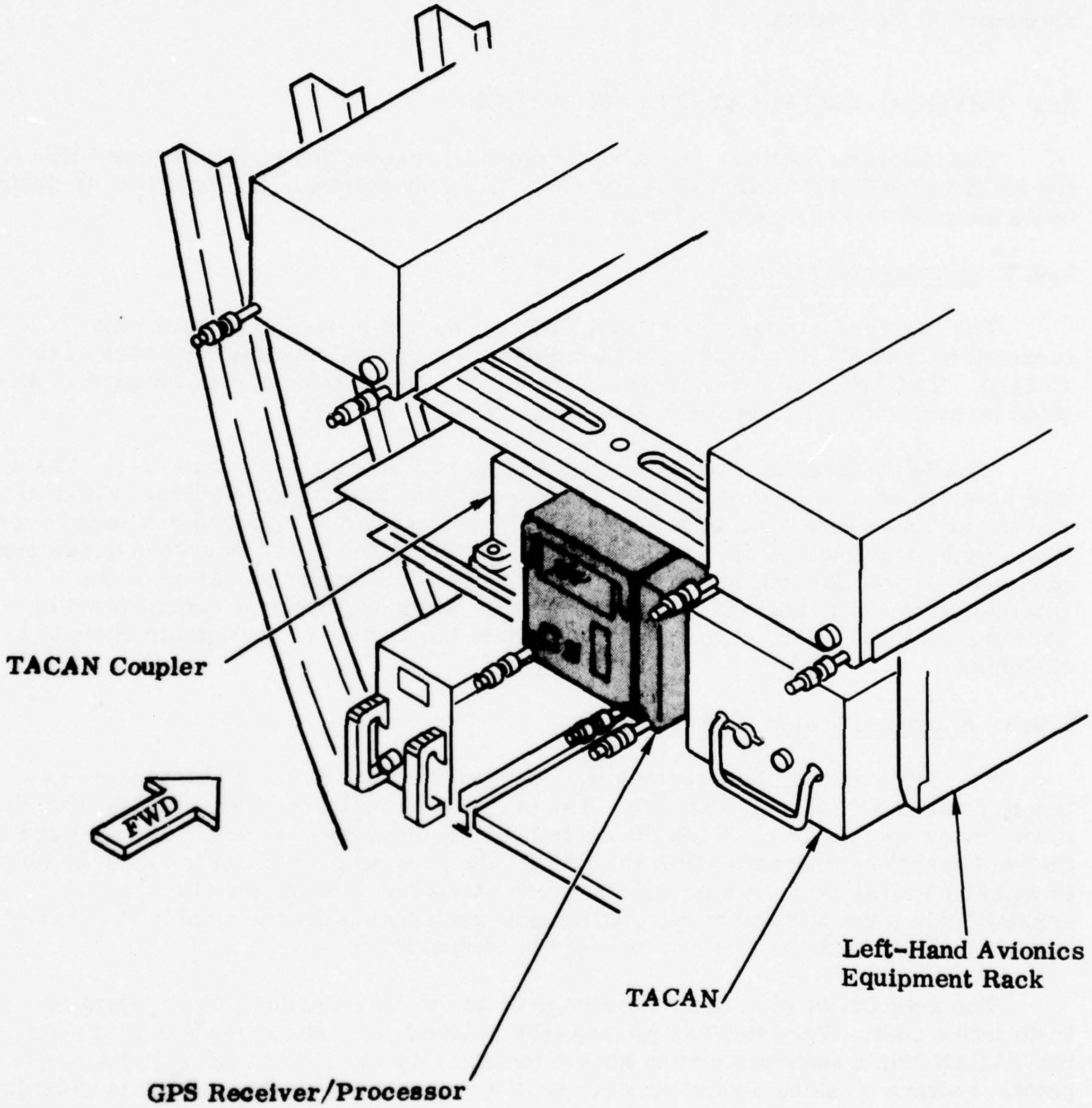


Figure 2-1. GPS UE Set Z Receiver/Processor Installation, C-141A Aircraft

2.2.3 Control/Display Unit

The control/display unit of Set Z will be mounted on the lower side of the cockpit center console, as shown in Figure 2-2, for C-141A aircraft of the present avionics configuration. The CDU will probably stay in the same relative location in aircraft modified under terms of the proposed INS change discussed in Section 2.1.2. The addition of INS control panels and selectors will require removal of one or more controls in the GPS test aircraft. ADF No. 1 and the interphone cord storage panels are suggested candidates for displacement; see Figure 2-3.

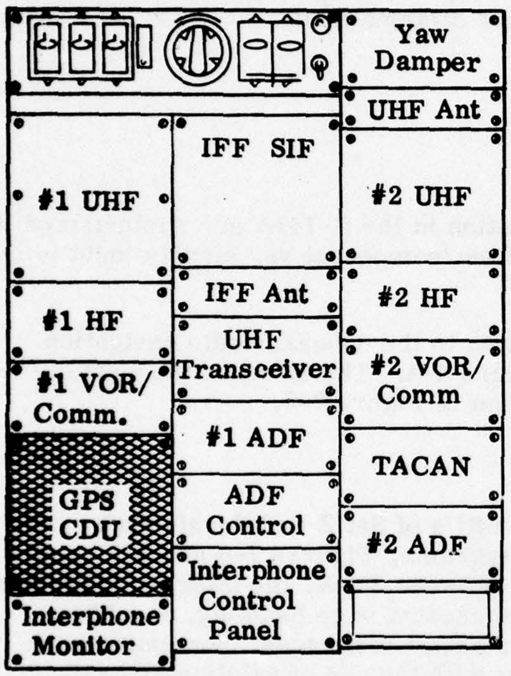


Figure 2-2. C-141A Center Console Layout

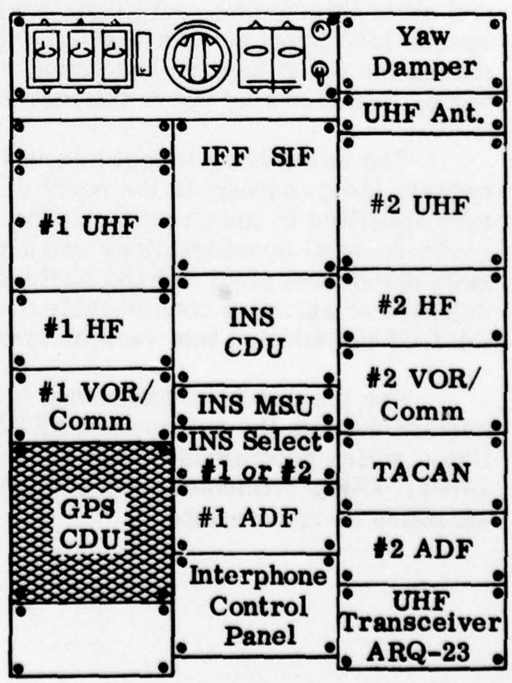


Figure 2-3. C-141A INS Modification, Center Console Layout

The CDU location is based upon JPO direction that the CDU be located at the pilot's station. The CDU must be accessible by the pilot for manual data input and control as well as for visual data readout.

2.2.4 Integration Module

The Integration Module is installed in the receiver/processor mounting, as shown in Figure 1-1. The installation permits independent operation of Set Z, removes power elements (synchro drivers) from the basic LRU for better thermal performance, and enables use of a standardized LRU design in the C-141 aircraft. Cooling of the IM unit (120 watts power consumption) will be by ambient avionics bay air; ducting of cooling air directly to the IM is not contemplated.

2.3 ELECTRONIC INTERFACES

2.3.1 Functional Interfaces

Electronic interfaces for the Set Z installation in the C-141A are summarized in Table 2-2. The table is a matrix of avionic system/component vs. signals input to or output from Set Z.

The relationship of the Set Z test installation to the onboard radio navigation system is shown in the interface diagram of Figure 2-4. The effect of the possible INS modification is shown in the interface diagram of Figure 2-5.

2.3.2 Wiring and Connectors

The cabling and interconnections between LRUs of Set Z and the aircraft systems are shown in the cabling and interwiring diagrams, Figures 2-6 and 2-7 respectively. Pin connections and assignments between Set Z, the Integration Module, and other interfacing, onboard avionics take into account wire bundling, shielding, spares locations, and mateability with existing aircraft harnesses. Reassignments during the Set Z design phase must be consistent with the use of existing aircraft wiring harnesses in any of the test installations, as shown in the cabling diagrams.

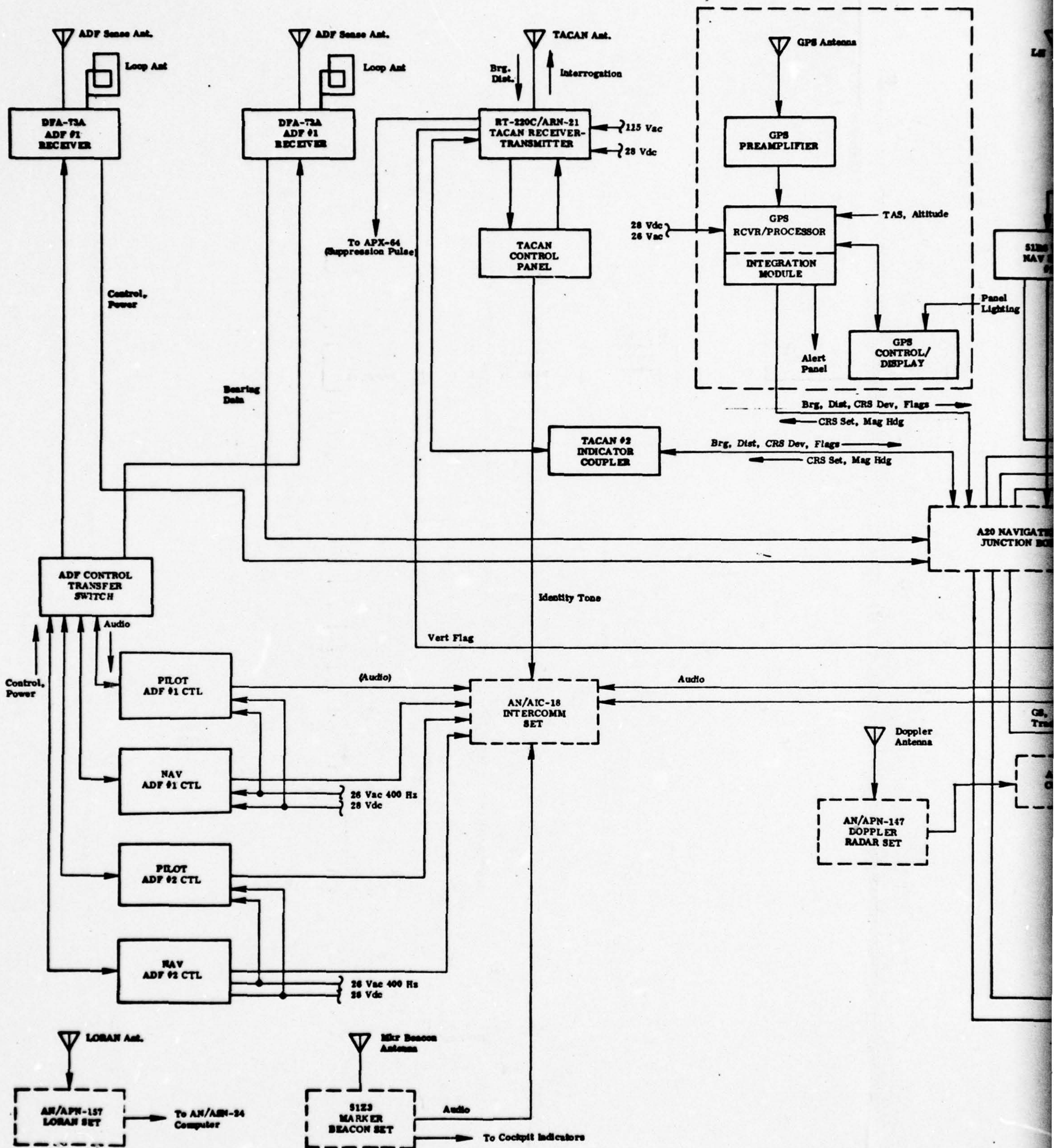
The interwiring layout was influenced by the requirement that Set Z continue to operate independently in the event of a failure of the IM. The selection of the connectors specified in the Group A listing (see Section 2.4) was based on functional and environmental considerations and a requirement to mate to the TACAN harness (at the rack disconnect plug) and the altitude-source harness. Mount connectors were selected to permit a considerable number of spare contacts, thus ensuring flexibility for GPS installation into various dissimilar vehicles without hardware modification.

For the receiver/processor unit and Integration Module, the selection of connectors follows the guidance of ARINC Specification 404A, used by commercial airlines, which recommends the use of plug-in DPX or similar connectors on equipment LRUs. Other connectors were selected from MIL-C-83723 and MIL-C-39012 varieties as appropriate.

TABLE 2-2. ELECTRONIC INTERFACE SIGNALS, C-141A AIRCRAFT

Avionic System/ Component	Set Z Interface Signals: Set Z Output to Systems/Displays									Set Z Interface Signals: Inputs to Set Z							
	Digital Navigation Data	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Degraded Mode	Course Set	A/C Power, 115 Vac, 400 Hz	A/C Power, 28 Vdc	Synchro Ref., 26 Vac, 400 Hz, ØA	Altitude	True Airspeed	Panel Lighting*	Digital Control Data	Magnetic Heading
1. Set Z CDU	X															X	
2. Pilot's HSI (AQU-4/A)		X	X	X	X	X	X		X								
3. Pilot's BDHI (ID-798/ARN)		X	X														
4. Pilot's Flight Director Comp. (3K91002)					X	X											
5. Copilot's BDHI (ID-798/ARN)		X	X														
6. Nav's BDHI (ID-798/ARN)		X	X														
7. Automatic Flight Control System					X												
8. Pilot's Compass System (C-12)																	X
9. Alert Panel								X									
10. Aircraft AC Nav Bus No. 1										X							
11. 26 Vac Isolated Avionics Bus												X					
12. Main DC Avionics Bus No. 1											X						
13. Dual CADCs													X	X			
14. Pilot's Instrument Lighting System															X		

*Direct to GPS CDU


ADF Sense Ant.
Loop Ant
DFA-73A
ADF #1
RECEIVER
ADF Sense Ant.
Loop Ant
DFA-73A
ADF #1
RECEIVER
TACAN Ant.
Brg.
Dist.
Interrogation
RT-220C/ARN-21
TACAN RECEIVER-
TRANSMITTER
115 Vac
28 Vdc
To APX-64
(Suppression Pulse)
TACAN
CONTROL
PANEL
GPS Antenna
GPS
PREAMPLIFIER
GPS
RCVR/PROCESSOR
INTEGRATION
MODULE
28 Vdc
26 Vac
TAS, Altitude
Panel
Lighting
Alert
Panel
GPS
CONTROL/
DISPLAY
Control,
Power
Bearing
Data
Brg, Dist, CRS Dev, Flags
CRS Set, Mag Hdg
TACAN #2
INDICATOR
COUPLER
Brg, Dist, CRS Dev, Flags
CRS Set, Mag Hdg
A20 NAVIGAT
JUNCTION BO
ADF CONTROL
TRANSFER
SWITCH
Identity Tone
Audio
Vert Flag
Control,
Power
PILOT
ADF #1 CTL
(Audio)
Audio
AN/AIC-18
INTERCOMM
SET
NAV
ADF #1 CTL
26 Vac 400 Hz
28 Vdc
Doppler
Antenna
AN/APN-147
DOPPLER
RADAR SET
PILOT
ADF #2 CTL
NAV
ADF #2 CTL
26 Vac 400 Hz
28 Vdc
LORAN Ant.
AN/APN-157
LORAN SET
To AN/ASN-24
Computer
Mkr Beacon
Antenna
51Z3
MARKER
BEACON SET
Audio
To Cockpit Indicators

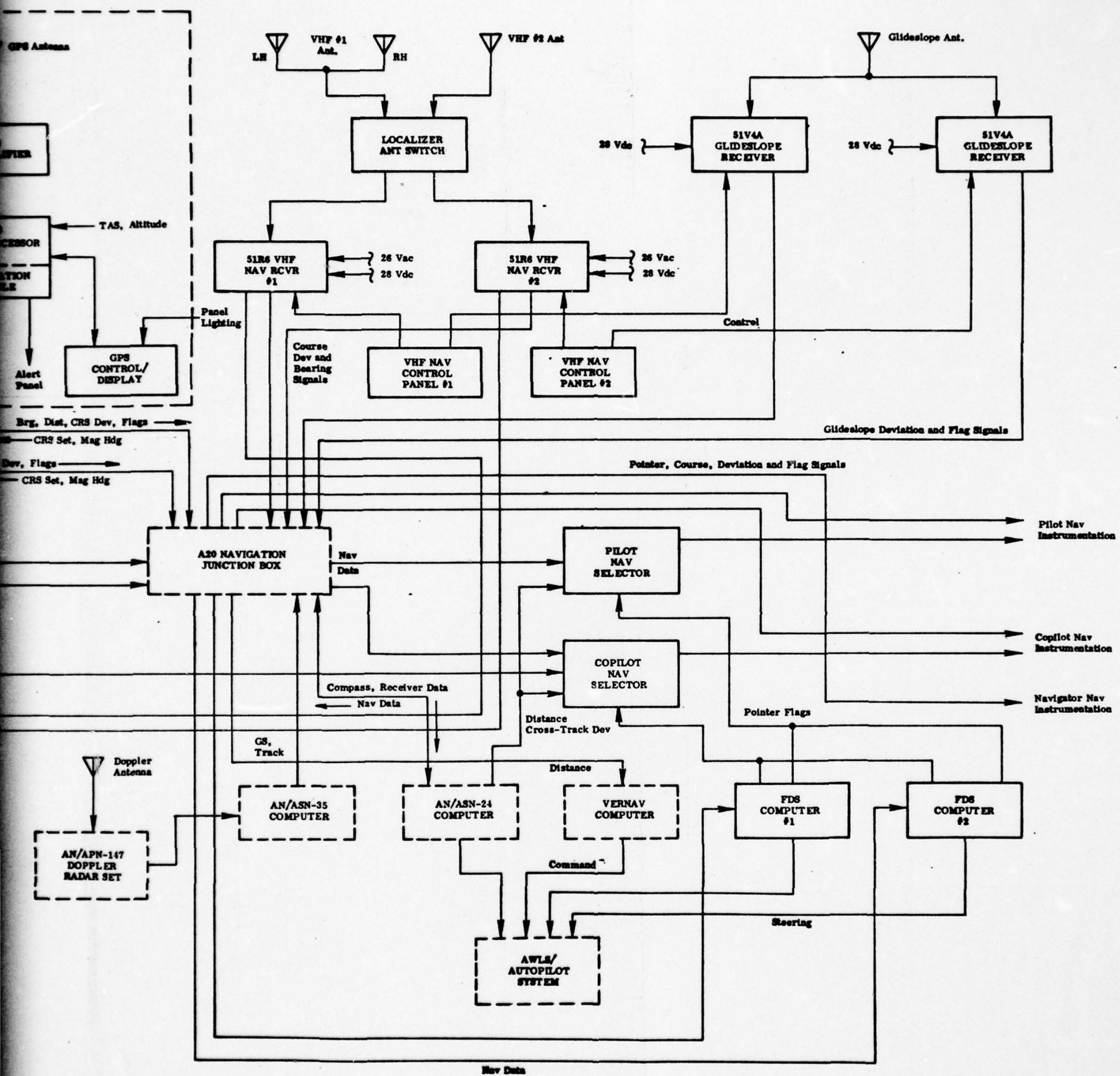
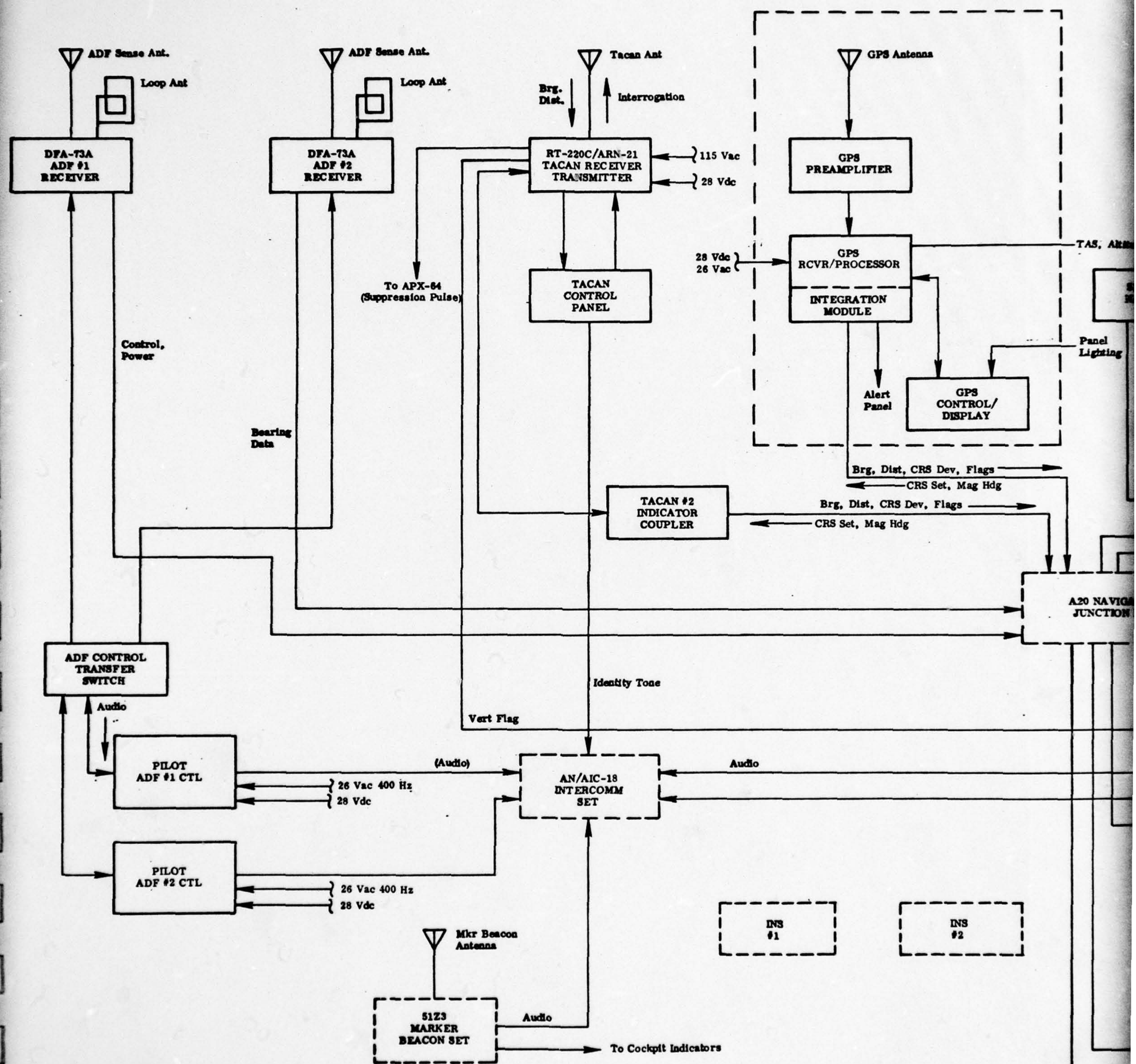


Figure 2-4. C-141A Radio Navigation System Interface Diagram, GPS Test Installation


ADF Sense Ant.
Loop Ant
DFA-73A ADF #1 RECEIVER
ADF Sense Ant.
Loop Ant
DFA-73A ADF #2 RECEIVER
Tacan Ant
Brg. Dist.
Interrogation
RT-220C/ARN-21 TACAN RECEIVER TRANSMITTER
115 Vac
28 Vdc
GPS Antenna
GPS PREAMPLIFIER
28 Vdc
26 Vac
GPS RCVR/PROCESSOR
INTEGRATION MODULE
TAS, Alt
Panel Lighting
To APX-64 (Suppression Pulse)
TACAN CONTROL PANEL
Control, Power
Alert Panel
GPS CONTROL/ DISPLAY
Bearing Data
Brg, Dist, CRS Dev, Flags
CRS Set, Mag Hdg
TACAN #2 INDICATOR COUPLER
Brg, Dist, CRS Dev, Flags
CRS Set, Mag Hdg
A20 NAVIG JUNCTION
ADF CONTROL TRANSFER SWITCH
Identity Tone
Audio
Vert Flag
PILOT ADF #1 CTL
(Audio)
26 Vac 400 Hz
28 Vdc
AN/AIC-18 INTERCOMM SET
Audio
PILOT ADF #2 CTL
26 Vac 400 Hz
28 Vdc
INS #1
INS #2
Mkr Beacon Antenna
51Z3 MARKER BEACON SET
Audio
To Cockpit Indicators

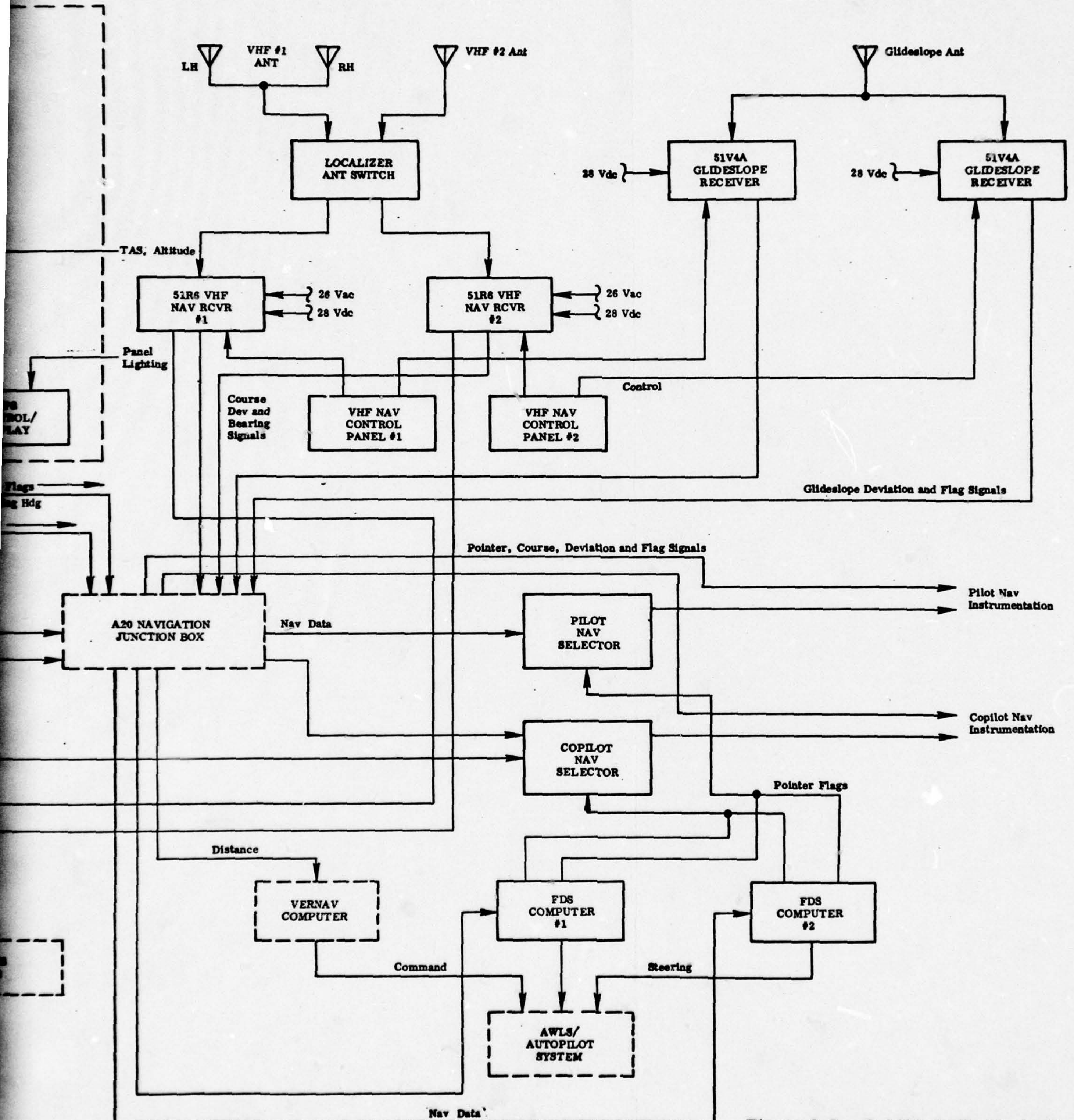


Figure 2-5. C-141A Radio Navigation System Interface Diagram (INS Modification), GPS Test Installation

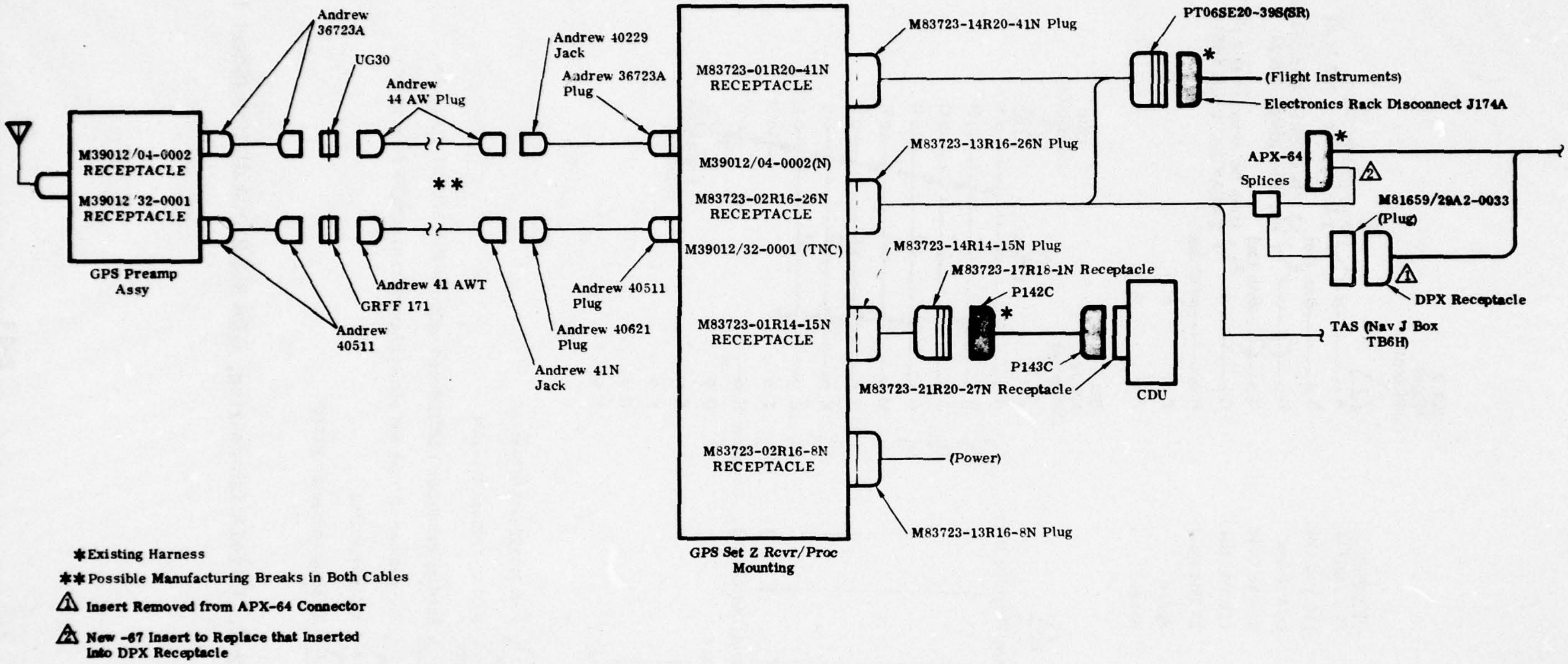
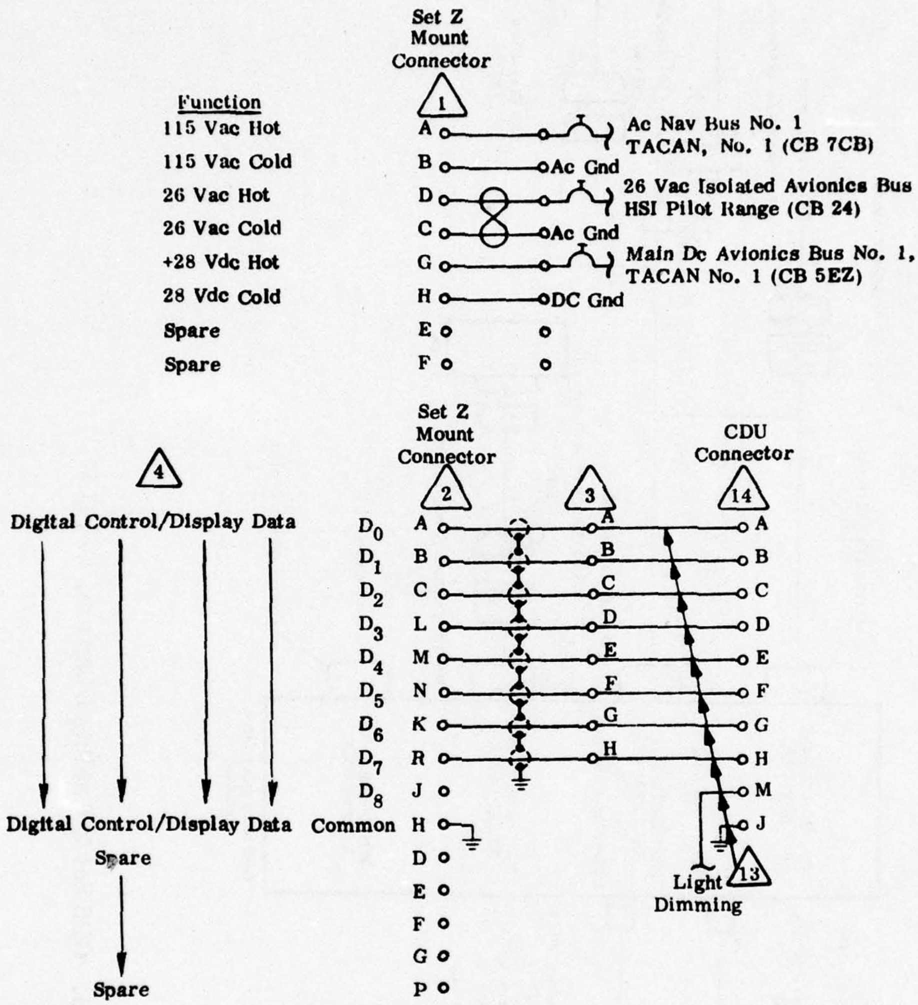


Figure 2-6. GPS Set Z Cabling Diagram, C-141A



1 P/N M83723-13R16-8N

2 P/N M83723-14R14-15N

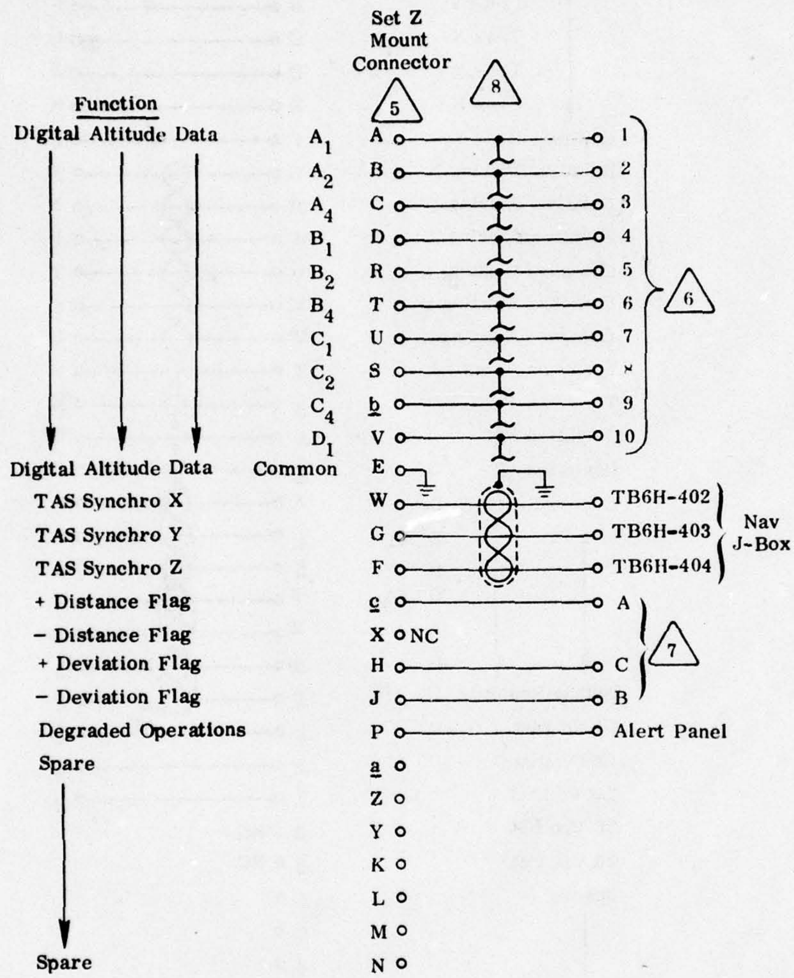
3 Existing connector P142C mated with new P/N M83723-17R18-1N

4 The number of lines and signal characteristics to be determined

13 Existing wiring

14 Existing connector P134C

Figure 2-7. C-141A Interwiring, GPS Set Z Installation (Sheet 1 of 4)



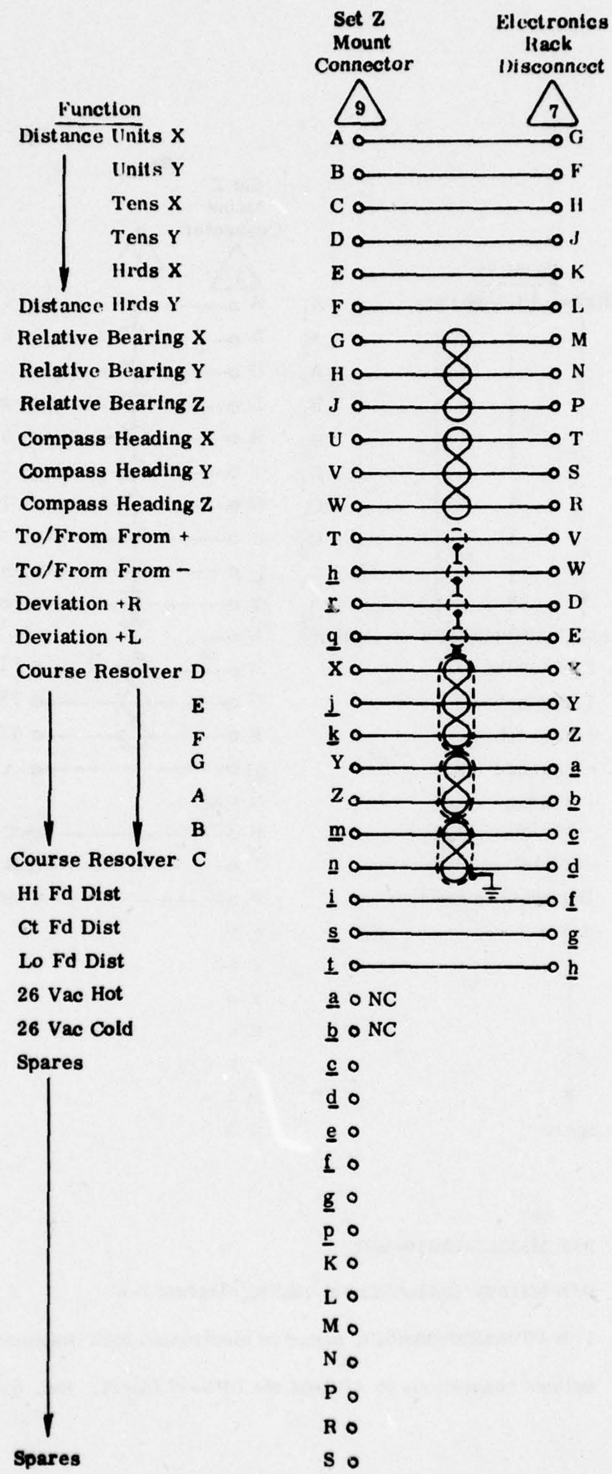
5 P/N M83723-13R16-26N

6 P/N M81659/29A2-0033 ref cabling diagram 2-6

7 P/N PT06SE20-39S(SR), mated to electronics rack disconnect, J174A

8 Spliced connections to APX-64 via DPX-67 insert. Ref. cabling diagram, Figure 2-6

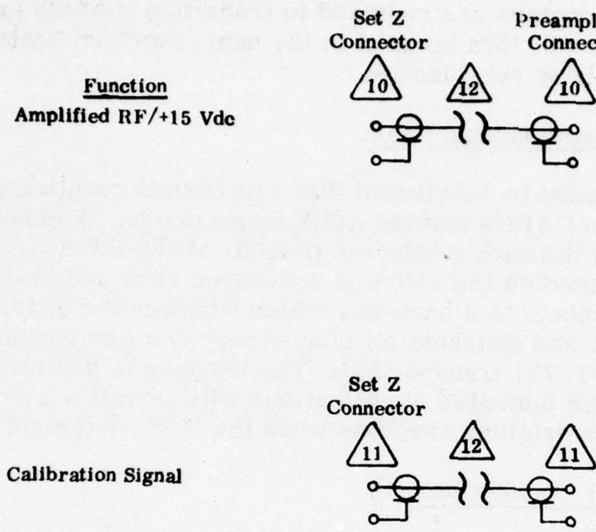
Figure 2-7. (Sheet 2 of 4)



7 P/N PT06SE20-39S(SR), mated to electronics rack disconnect, J174A

9 P/N M83723-14R20-41N

Figure 2-7. (Sheet 3 of 4)



10 P/N 36723A (Andrew)

11 P/N 40511 (Andrew)

12 Intermediate connectors and bulkhead adapters

Figure 2-7. (Sheet 4 of 4)

2.3.2.1 Coaxial Cable

Installation of a foam-filled semiflexible cable presents a special problem in a retrofit installation due to cable rigidity. A connector-transition to a flexible service loop is expected at the access area to the underdeck avionics rack to the left of the crew ladder. Bulkhead adapters are required to transition through the pressure hull, and flexible service loops will then be used in the unpressurized center wing area to connect to to the preamplifier receptacles.

2.3.2.2 Altitude Input Connections

A special harness must be fabricated that will permit coupling into the altitude data lines between the two CADCs and the AIMS transponder. The bottom insert (plug B) is removed from the rack connector (P410A) at the RT-731( )/APX-64(V) receiver/transmitter located on the avionics underdeck rack and inserted into a new DPX plug. This plug connects to a harness, which supplies the altitude signal to the Set Z receiver/processor and connects all plug wiring to a new 67S insert in the P410A connector at the RT-731 transponder. The harness is depicted in the cabling diagram, Figure 2-6. The indicated modifications will permit easy conversion of aircraft wiring back to its original condition when the GPS equipment is removed.

2.3.2.3 TAS Input Connections

New wiring will connect to the true airspeed synchro lines between the CADCs and the TAS indicator (ASN-24) at the navigation junction box. A harness (shielded-wire triplet) will be connected to studs 402, 403 and 404 of TB6H in the junction box and will supply the TAS signal to the Set Z receiver/processor. The harness is depicted in the cabling diagram, Figure 2-6. The use of this new interconnecting harness will keep the existing aircraft wiring intact and permit quick conversion of the aircraft to its original configuration.

2.4 GROUP A ITEM REQUIREMENTS

The Group A items required to effect integration and installation in the C-141A are shown in Table 2-3.

TABLE 2-3. GROUP A INSTALLATION ITEMS FOR UE SET Z ON C-141A AIRCRAFT (Sheet 1 of 4)

Item	Qty	Remarks
a. Receiver/Processor Mounting	1	
Connector, M24308/2-4	1	
Connector, DPX, M81659/31A2-0042	1	
Connector, DPX, M81659/31A2-0034	1	

TABLE 2-3. (Sheet 2 of 4)

Item	Qty	Remarks
a. Receiver/Processor Mounting (Cont)		
Connector, M83723-02R16-8N	1	
Connector, M83723-01R20-41N	1	
Connector, M83723-02R16-26N	1	
Connector, M83723-01R14-15N	1	
Vibration mount, Lord 150PHL8	4	
Holddown, Type C Hollingsead-Pryor	3	
b. Control/Display	–	Use TACAN No. 1 control panel harness and connector
c. Antenna/Preamplifier Mounting	1	Structural configuration to be designed by installer
Doubler	TBD	
Gasket	↓	
Screws	↓	
Brackets, mounting	TBD	
d. Integration Module Converter	1	
e. Integration Module Driver	1	
f. Aircraft Wiring		
Connector, PT06SE20-39S(SR) (plug)	1	Mates with electronics rack disconnect J174A
Connector, M83723-13R16-8N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R20-41N (plug)	1	Mates with GPS mounting receptacle

TABLE 2-3. (Sheet 3 of 4)

Item	Qty	Remarks
f. Aircraft Wiring (Cont)		
Connector, M83723-13R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R14-15N (plug)	1	Mates with GPS mounting receptacle
Connector, DPX (receptacle, without insert)	1	Assembled with existing insert, mates with new DPX
Connector, DPX, M81659/29A2-0033 (plug)	1	Mates with DPX receptacle at RT-731( )/APX-64
Connector, M83723-17R18-1N (receptacle)	1	Mates with P142C plug
Connector, N, Andrew 41N	1	Mates with service loop plug
Connector, N, Andrew 44AW	2	Mates with service loop jack; bulkhead adapter
Connector TNC, Andrew 40511	3	Mates with TNC female on receiver; preamplifier jack; bulkhead adapter
Connector, N, Andrew 36723A	3	Mates with N female on GPS receiver; preamplifier jack; bulkhead adapter
Connector, N, Andrew 40621	1	Mates with calibration line jack
Connector, N, Andrew 40229	1	Mates with signal input line plug
Connector, TNC, Andrew 41AWT	1	Mates with bulkhead adapter
Adapter, bulkhead, N, UG30/U	1	Couples RF signal line through pressure bulkhead to preamplifier RF coaxial cable
Adapter, bulkhead, TNC, GRFF No. 171	1	Couples calibration line through pressure bulkhead to preamplifier calibration coaxial cable
Cable, coaxial, Andrew FHJ4-50B		Signal line

TABLE 2-3. (Sheet 4 of 4)

Item	Qty	Remarks
f. Aircraft Wiring (Cont)		
Cable, coaxial, Andrew FHJ1-50		Calibration line
Cable, coaxial, Andrew FSJ1-50		Service loop; preamplifier connection
Cable, coaxial, Andrew FSJ4-50		Service loop; preamplifier connection
Wire and cable		Various types as required
Insert, DPX 67S	1	
Splices, wire	10	
Decals, assorted	–	
Panel and bracket	1	Support for DPX connector on jumper harness at AN/APX-64 transponder

2.5 EQUIPMENT ENVIRONMENTS

Environmental requirements for Set Z installation in the C-141A are derived by combining a history of exposure to various conditions with the natural environmental characteristics and the aircraft-induced or -controlled environmental characteristics. The result is a comprehensive environmental envelope for the C-141A test activities. The exposure history, natural environment, and aircraft environment are described below, followed by a summary of the total environmental envelope.

2.5.1 Exposure Time History

Figure 2-8 shows a time history of exposure of Set Z to the environmental factors to be encountered during testing in the C-141A at Yuma Proving grounds. It has been assumed that the host test aircraft will be dedicated full time to the tests and will be stationed at Kirtland AFB, Albuquerque, N.M. The aircraft will depart from and return to that base for each day of flight testing.

The sequence of events and duration of each shown in Figure 2-8 are intended to be representative of the test operations to be conducted. While it is realized that any given test exercise may deviate from the sequence shown, it is felt that the events shown in the figure are sufficient to expose Set Z to all of the environmental extremes to be encountered. For example, since the time of day of satellite visibility will vary, and since the aircraft could be left on the ground at any time of day or night, relatively long on-the-ground events have been specified to last 24 hours. This, when combined with annual temperature data for Albuquerque, will result in exposure to both overnight low temperatures of winter months and daytime high temperatures of summer months, thereby defining the natural temperature exposure extremes.

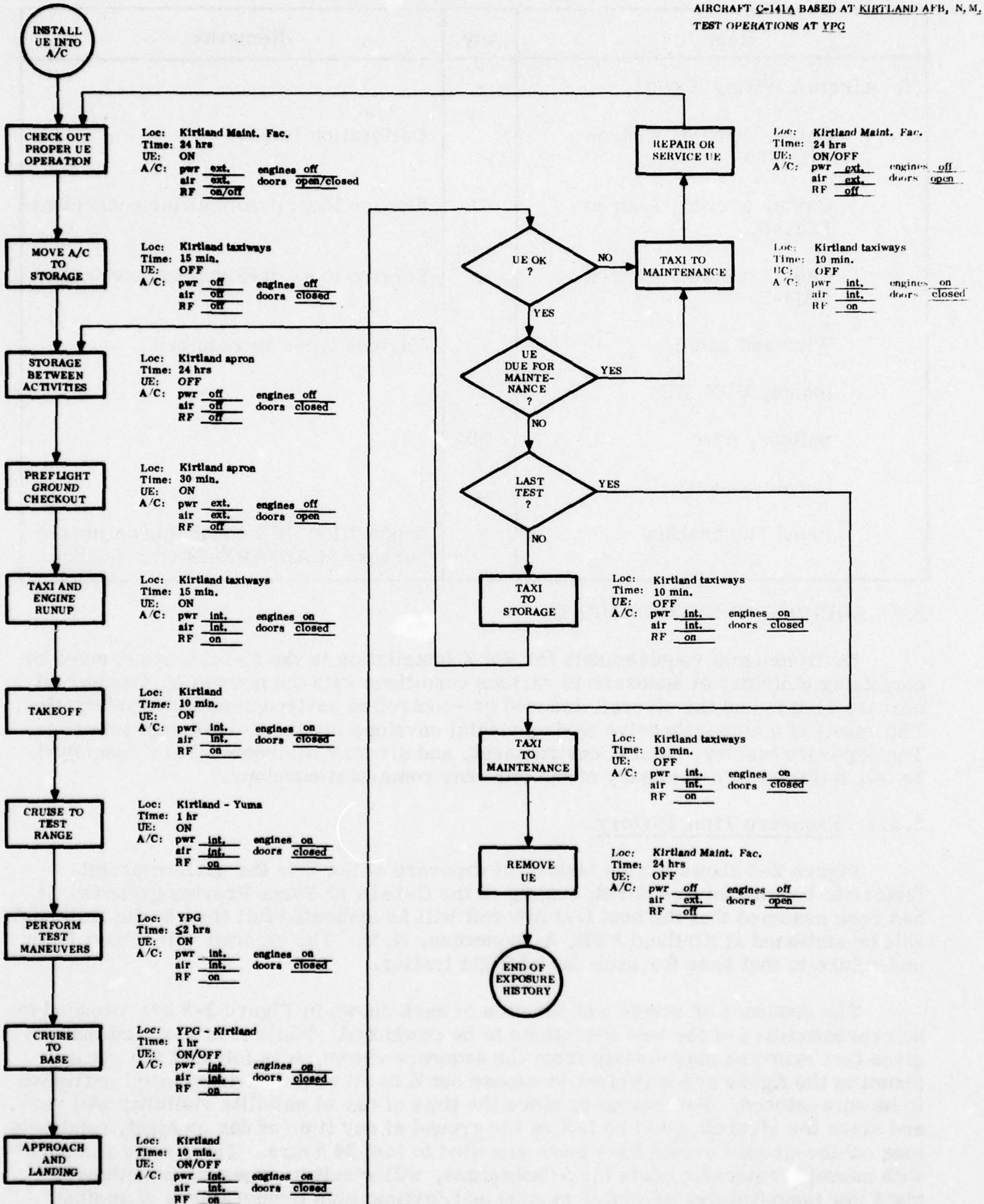


Figure 2-8. Exposure Time History, C-141A Aircraft

2.5.2 Natural Environment

Table 2-4 summarizes the ground level climate in Albuquerque on a monthly and annual basis. The data were obtained from U.S. Weather Bureau records. The C-141A at Kirtland could be exposed to any of these conditions, and the resultant environmental exposure of Set Z would be as discussed in the following paragraphs.

TABLE 2-4. ALBUQUERQUE CLIMATE SUMMARY

Month	Temperature (° F)				Humidity (%)			
	Avg Max	Avg Min	Max Ever	Min Ever	0500 Hours	1100 Hours	1700 Hours	2300 Hours
Jan	46.9	23.5	69	-17	66	48	36	57
Feb	52.6	27.4	75	1	62	43	32	51
Mar	59.2	32.3	85	9	54	32	24	41
Apr	70.1	41.4	89	22	45	25	18	33
May	79.9	50.7	94	28	44	23	16	31
Jun	89.5	59.7	102	42	45	24	18	32
Jul	92.2	65.2	104	54	61	36	28	49
Aug	89.7	63.4	99	52	65	39	30	52
Sep	83.4	56.7	94	37	58	40	30	52
Oct	71.7	44.7	87	25	58	37	29	47
Nov	57.1	31.8	73	12	64	43	35	54
Dec	47.5	24.9	68	4	69	51	43	60

Month	Normal Mean Precipitation (in.)	Normal Mean Wind Speed (mph)
Jan	0.30	7.9
Feb	0.39	8.8
Mar	0.47	10.0
Apr	0.48	10.9
May	0.53	10.5
Jun	0.50	9.9
Jul	1.39	9.1
Aug	1.34	8.1
Sep	0.77	8.5
Oct	0.79	8.3
Nov	0.29	7.7
Dec	0.52	7.6
Annual	7.77	8.9

Note: Data interval: average monthly maximum temperatures, and average monthly precipitation, 1941-1970; temperature extremes, 1959-1973; humidity readings over 13-year period; winds over 34-year period. U.S. Dept. of Commerce, Local Climatological Data, Albuquerque, New Mexico, 1973.

2.5.2.1 Temperature

As shown in Table 2-4, the coldest temperature recorded at Albuquerque is -27°C (-17°F). Set Z could be exposed to this temperature level if the aircraft were left outside overnight. Set Z would be nonoperating under these conditions.

The highest temperatured indicated for Albuquerque is 40°C (104°F). Inside a closed large aircraft parked in the sun, temperatures would be likely to reach 63°C (145°F). Thus the Set Z receiver/processor, CDU, and IM could be exposed to these temperature levels in a nonoperating condition. The external antenna and the preamplifier mounted adjacent to the top fuselage skin could reach temperatures somewhat higher than this due to direct solar heating (estimated at 68°C or 154°F).

For Set Z operation, it is assumed that the aircraft or external cooling system will reduce temperatures in the aircraft to those suitable for the system operating personnel, who would not activate the system until the inside air temperature had cooled to at least 43°C (110°F). The antenna and preamplifier temperatures could remain near 68°C, however, since they are external to the air conditioned area (see Section 2.5.3.3).

For cold-day or nighttime tests, it is assumed that temperatures inside the aircraft will be raised to crew-comfort levels at or shortly after system activation. Startup temperatures could be near the Albuquerque low of -27°C (-17°F).

At a cruising altitude of approximately 30,000 feet, outside air temperatures on the order of -70°C could be expected, according to MIL-STD-210B. The antenna would be directly exposed to this air, and the unheated preamplifier area (see Section 2.5.3.3) could be cooled to nearly this temperature.

2.5.2.2 Humidity

As shown in Table 2-4, the humidity at Albuquerque is typically low or moderate. The antenna will be exposed directly to the occasional rainstorms, and depending on the weather sealing provided for the preamplifier installation, some moisture could collect around that unit. The Set Z receiver/processor, CDU, and IM will not be subjected to direct rainfall, but air of nearly 100% humidity could be drawn into the aircraft under some startup or ground operation conditions.

2.5.2.3 Wind/Dust

Table 2-4 shows typically light winds at Albuquerque, although substantial gusting (monthly recorded maximums of 57 to 90 mph) can occur at any time of year. This condition, coupled with the dryness of the area, will lead to occasional substantial amounts of blowing sand and dust.

Wind over 32 mph is reported by the Weather Bureau for an average of 46 days per year. Therefore, minor abrasive effects from blowing sand can be expected ocassionally at the external antenna location, although the top, flush-mounted antenna installation should minimize this effect. Dust in the areas inside the C-141A fuselage should be of minimal significance to Set Z electronics.

2.5.2.4 Precipitation

Precipitation at Albuquerque averages only 7.77 inches annually, typically less than one-half inch per month. Precipitation will impact only the antenna and preamplifier design and installation. Due to freezing winter temperatures, the antenna weather seal should be designed so as not to trap water that could subsequently freeze and expand to stress the antenna or seal.

2.5.2.5 Atmospheric Pollution

Atmospheric pollution in Albuquerque is not expected to present any severe design problems. Due to the high altitude (~5300 feet) and the generally clear air, ultraviolet radiation levels are relatively high. The air contains no significant amounts of sulfur oxide products, but measurable levels of nitrogen oxides. The highest ozone level recorded near Kirtland was 135 parts per billion (ppb), although records have been kept for only a few years. The summer months have the highest ozone counts, with the federal standard of 80 ppb being exceeded typically 15 to 20 times per month during June and July. Monthly average high ozone counts are shown in the table below.

Month	J	F	M	A	M	J	J	A	S	O	N	D
High ozone count (ppb)	45	50	50	30	60	100	85	60	–	50	55	55

Exposed or unprotected materials, especially rubber and plastic seals and insulation, will have to survive these pollution levels without unacceptable degradation of performance or characteristics.

2.5.3 Aircraft Environment

The following paragraphs summarize the environment onboard the C-141A aircraft during Phase I test operations. The environmental factors discussed are those which result directly from the operation of the aircraft and its associated systems. Where possible, all data are derived at the specific installation locations of Set Z equipment. Data presented here are based upon actual test measurements on the C-141 whenever possible.

2.5.3.1 Mechanical Vibration

Figure 2-9 summarizes the worst case vibration to be experienced at Set Z installation locations during Phase I tests. The figure plots power spectral density (PSD) of vibration as a function of vibration frequency. The data are extracted from flight test results reported in Lockheed Report No. ER-5047-II, dated October 15, 1965. The data plotted represent an envelope of worst case vibration measured in the electronics bay, flight station, and forward fuselage areas. The instrumentation bandwidth used to analyze the flight test data was 7.5 Hz at the 3 dB down points.

In Figure 2-9, the vibration peak at 400 Hz results from a single data point (out of an estimated 500 summarized in the figure) in the referenced source document. This data point, recorded in the forward fuselage area, was at least an order of magnitude higher than all other data points summarized here, and should be

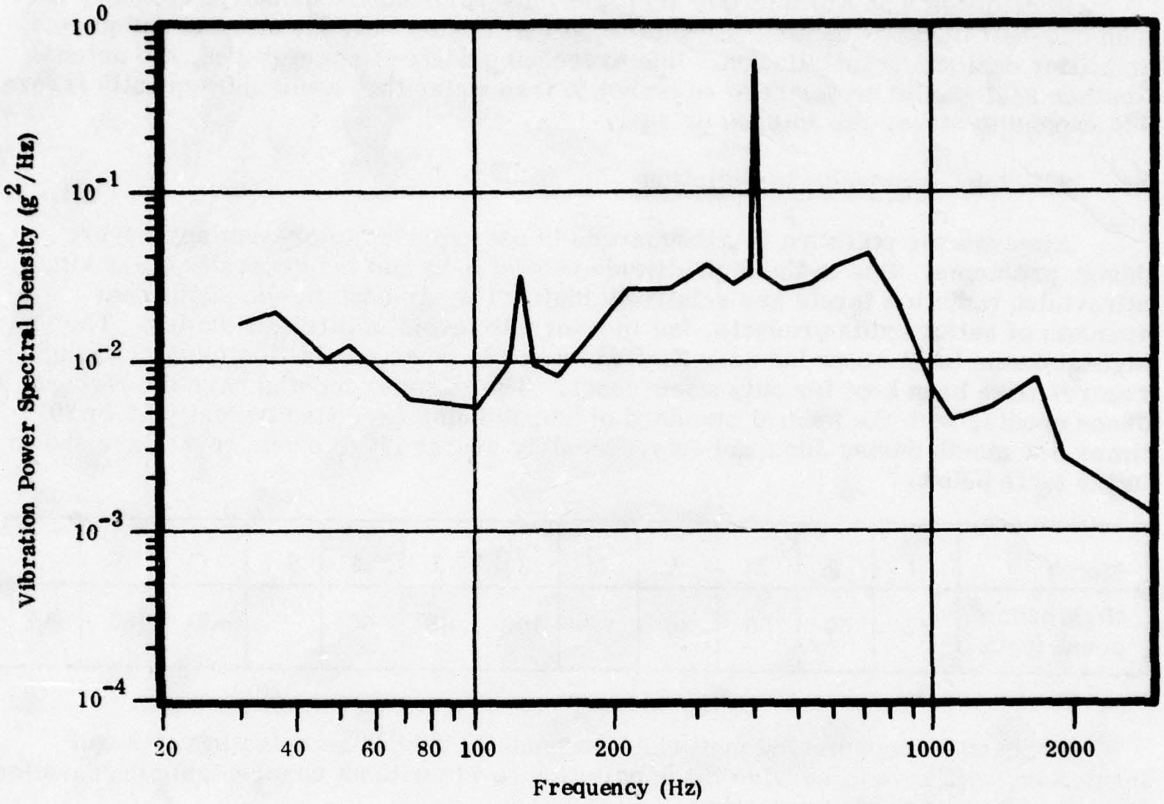


Figure 2-9. Worst Case Vibration Summary, C-141A

considered as an unusual event. In spite of its apparently high level, the data point represents a vibration level of only 2.3g in the 7.5 Hz bandwidth used for data analysis.

Figure 2-10 replots the vibration data in terms of absolute g loading. The data were converted by applying, to the prominent features of the plot of Figure 2-9, the formula

$$g = \sqrt{(g^2/\text{Hz})\,\text{BW}}$$

where BW = 7.5 Hz.

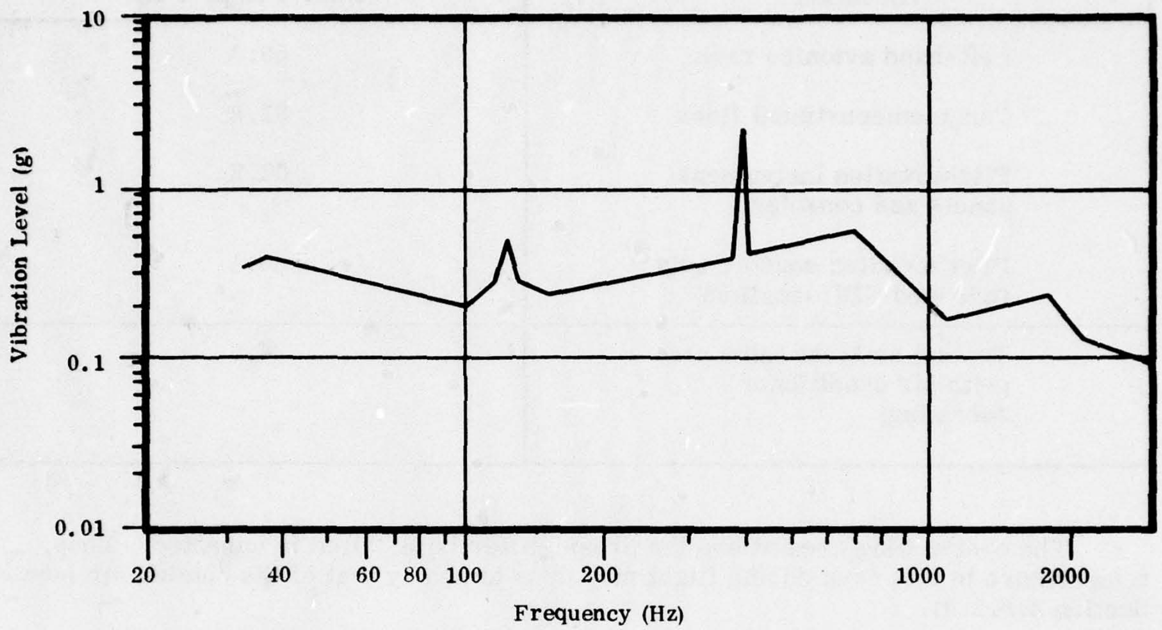


Figure 2-10. Worst Case Vibration, Absolute g-Level, C-141A

2.5.3.2 Acoustic Vibration

No test data were located regarding acoustic pressure levels within the C-141A. However, discussions with cognizant personnel indicated that acoustic levels should be of no design significance. Levels inside the fuselage are well within the tolerance levels of crew and operator personnel, and would not be expected to reach even the +130 dB re 0.0002 ubar level requiring acoustic testing of "delicate equipment" (MIL-STD-810, method 515).

2.5.3.3 Temperature and Humidity

Table 2-5 summarizes the temperature levels recorded on equipment at pertinent locations in the C-141A. These data represent the maximum temperatures given in extensive tables reproduced from an unidentified Lockheed test document obtained from the C-141 System Manager's office at Warner Robins AFB. The temperature recordings were made during ground checkout (air conditioner on, power from APU); aircraft taxi; low level (0 to 5,000 ft) flight with floor heaters off; cruise (>25,000 ft) with floor heaters off; and cruise (>25,000 ft) with floor heaters on. Each of these five test phases lasted one hour.

The maximum temperature of 62.2° C for the flight station instrument area was recorded at the engine rpm indicators, and was unusually high compared to other instrument locations. Generally, temperatures in the instrument area were less than 50° C, with the center console (intended CDU location) exhibiting a maximum temperature of 34.1° C, as shown. The typical cabin air temperature shown in the table is based on data in the C-141A Flight Manual (T.O. 1C-141A-1).

TABLE 2-5. OPERATIONAL TEMPERATURES, C-141A

Location	Max. Temp. (°C)
Left-hand avionics rack	53.5
Cargo compartment floor	31.9
Flight station instrument panels and consoles	62.2
Pilot's center console only (intended CDU location)	34.1
Typical ambient cabin air (with air conditioner operating)	24.0

The center wing area where the preamplifier is installed is unheated. Thus, temperature in this area during flight may drop to nearly that of the outside air (see Section 2.5.2.1).

The humidity in the C-141A is controlled by the air conditioner, which separates excess water from the air. Under normal operating conditions, the water separator removes 70% to 85% of the moisture from the air after it has been cooled to approximately 2°C (35°F) and before it is reheated for circulation through the aircraft.

2.5.3.4 Unit Size and Weight Restrictions

The receiver/processor unit will replace the TACAN No. 1 receiver/transmitter (RT-220C/ARN-21) in the left-hand avionics equipment rack. The dimensions of the space available at this location are 25 cm H x 28 cm W x 54 cm D (10 in. x 11 in. x 21 in.). The weight of the receiver/processor and IM combined will be limited to 27.2 kg in conformance with standard ARINC weight-vs.-size estimates.

No specific size and weight restrictions have been identified for the antenna/preamplifier unit. The anticipated physical characteristics of this unit should not present any installation difficulties at the location of the deactivated top TACAN antenna (FS 741).

The width of the CDU will be limited to the standard instrument faceplate width of 14.6 cm (5.75 in.). The height of the CDU panel will be accommodated by removing the TACAN No. 1 panel and rearranging existing instruments on the center console. The anticipated CDU height of 15.25 cm (6 in.) should be retained as a design specification to avoid increasing the installation problem. The depth of the CDU must be less than 30 cm (11.8 in.), due to space availability in the center console. No weight restriction for the CDU has been identified.

2.5.3.5 Electrical Power

Electrical power for the Set Z power supply will be 115 Vac, 400 Hz obtained from navigation bus No. 1. Panel lighting for the CDU will be from instrument panel power (5 Vac source) available in the cockpit. All power sources will comply with MIL-STD-704A, as required for Set Z.

2.5.3.6 Heat Dissipation

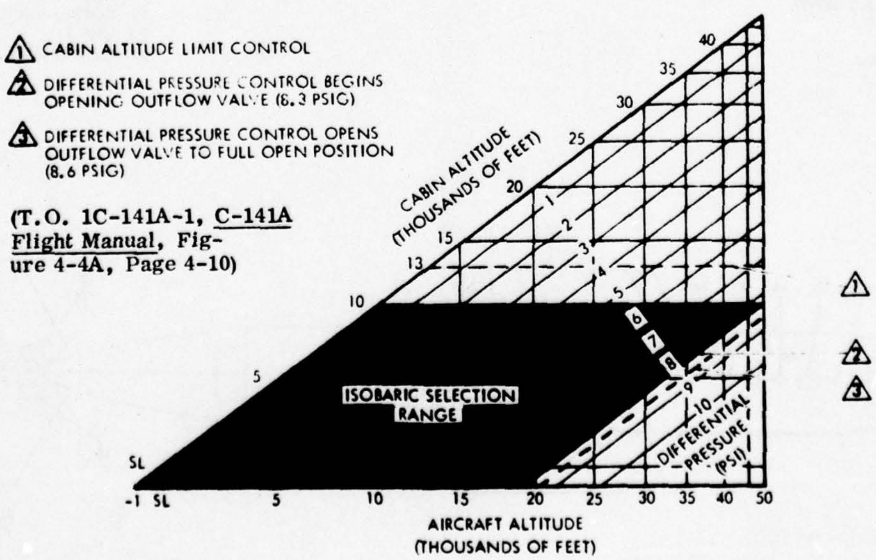
Heat dissipation in the avionics compartment is by means of cabin air circulated through the compartment by fans. One fan circulates air from the flight station into the avionics compartment. During flight, two fans exhaust air from the compartment, but during ground operation only one of these exhaust fans is operated.

Heat dissipation within the center console is by conduction and convection, with no active cooling provided inside the console. Heat is dissipated at the faces of the instruments by the circulating ambient cabin air.

Heat dissipation at the antenna/preamplifier location is by ambient air, which is not conditioned nor actively circulated. Some conductive cooling may exist through the fuselage structure to which the preamplifier is mounted, depending on the mount design.

2.5.3.7 Pressurization

The fuselage of the C-141A is pressurized according to the schedule shown in Figure 2-11. All Set Z units except the antenna/preamplifier will be within this pressurized area. As indicated in the figure, the maximum pressure differential maintained by the automatic pressure relief valve is 8.6 psig (positive). The coaxial cables from the preamplifier to the receiver/processor must be sealed where they penetrate the pressure bulkhead, and must be capable of withstanding this pressure differential.



(T.O. 1C-141A-1, <u>C-141A Flight Manual</u>, Figure 4-4A, Page 4-10)

Figure 2-11. Cabin Pressurization Schedule, C-141A

2.5.4 Electromagnetic Compatibility/Interference (EMC/EMI)

The electromagnetic compatibility of Set Z installations described in the preceding sections has been considered from the standpoint of interference from radiating antennas on the aircraft, interference to or from nearby avionic units, common practice for shielding and wire types, and any historical EMI problems associated with the aircraft. These factors are discussed below.

2.5.4.1 Antenna Locations

Figure 2-12 shows the locations of antennas on the C-141A, including the disabled TACAN No. 2 antenna which will be replaced by the GPS antenna. Table 2-6 summarizes pertinent characteristics of the radiating antennas.

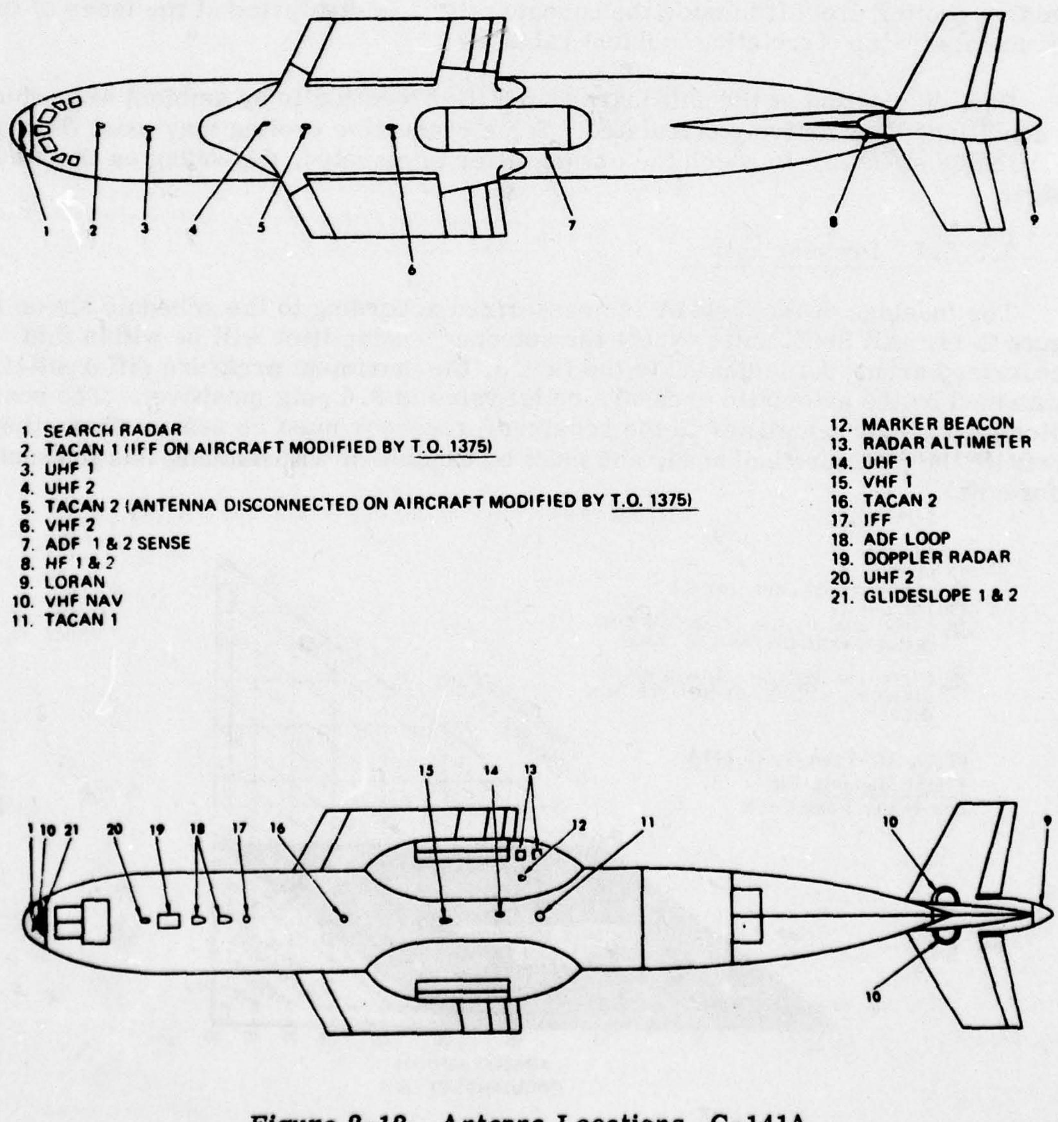


Figure 2-12. Antenna Locations, C-141A

TABLE 2-6. RADIATING ANTENNA SIGNAL CHARACTERISTICS, C-141A

Antenna No. (See Fig. 2-12)	System	Signal Type	Frequency (MHz)	General Antenna Coverage
1	Search Radar (AN/APN-59B)	Pulse	9375	Forward
2	TACAN No. 1 (AN/ARN-21) + IFF (AN/APX-64)	Pulse	1025-1150	Omni upward
3	UHF No. 1 (ARC-50(V) or ARC-90)	AM voice comm	225.0-399.95	Omni upward
4	UHF No. 2 (ARC-50(V) or ARC-90)	AM voice comm	225.0-399.95	Omni upward
6	VHF No. 2 (618M1C or 807A)	AM voice comm	116.0-149.975	Omni upward
8	HF No. 1 and 2 (HF-102)	AM, SSB voice comm	2.0-29.999	Omni
11	TACAN No. 1 (AN/ARN-21)	Pulse	1025-1150	Omni downward
13	Radar Altimeter (AN/APN-150)	FM	4300 ± 50	Downward
14	UHF No. 1 (ARC-50(V) or ARC-90)	AM voice comm	225.0-399.95	Omni downward
15	VHF No. 1 (618M1C or 807A)	AM voice comm	116.0-149.975	Omni downward
17	IFF (AN/APX-64)	Pulse	1090	Omni downward
19	Doppler Radar (AN/APN-147)	CW	8800	Downward
20	UHF No. 2 (ARC-50(V) or ARC-90)	AM voice comm	225.0-399.95	Omni downward

Although no specific mention of historic EMI problems was made by any cognizant personnel, the IFF transmitter which shares the TACAN No. 1 antenna on some aircraft is a possible source of interference. The IFF transmitter has been mentioned as a potential problem on several other aircraft. The AN/APX-64 on the C-141A transmits pulsed signals at 1090 MHz and emits approximately 800 watts (29 dBw) of peak power. The pulsed nature of the signal will tend to spread some spurious noise across a wide spectrum. If the spurious noise generated in the GPS frequency band were approximately 90 dB below the peak IFF output power, and free-space path loss between the two antennas is approximately 60 dB, a noise level of -121 dBW could be created at the GPS antenna during IFF operation. This level is more than 40 dB above the Set Z receiver threshold, and would create an excessive J/S ratio despite the jamming resistance of GPS.

If the IFF does generate sufficient noise to interfere with the GPS set, the problem could be eliminated by including an appropriate emission control plan into the test plans. The IFF could also offer an opportunity to evaluate interference caused by other onboard avionics.

Selection of a different GPS antenna location to reduce this problem would be difficult. Placement of the GPS antenna on the top surface of the T-tail would further separate the two antennas, increasing the path loss by approximately 12 dB. Such a location could further take advantage of the horizontal stabilizer to shield the GPS antenna from IFF emissions. However, this location would greatly increase the RF cable length required between the GPS preamplifier and receiver unless the receiver were also moved to the tail area. This in turn would require lengthy cable runs between the receiver/processor and the CDU and other avionics.

The other radiating antennas onboard the aircraft are not expected to present problems to the GPS antenna. The former all appear either to 1) have RF spectrums well removed from that of the GPS RF, 2) be oriented away from the GPS antenna, 3) be inoperative during GPS tests, or 4) reflect a combination of these.

2.5.4.2 Nearby Avionic Units

Table 2-7 lists the receivers located, along with the Set Z receiver/processor, in the C-141A left-hand avionics equipment rack. The table indicates pertinent receiver characteristics with regard to EMI to or from the Set Z receiver.

At the time of this writing, the Set Z intermediate and local oscillator (LO) frequencies have not been definitely selected. Thus it is not possible to identify any coincidence of IF or LO frequency with any of the receivers in Table 2-7. However, in view of the apparent lack of any historical EMI problems on the C-141, it is not expected that problems will be encountered with the GPS installation.

TABLE 2-7. RECEIVERS NEAR SET Z RECEIVER/PROCESSOR, C-141A AIRCRAFT

Receiver	RF (MHz)	LO (MHz)	IF (MHz)	RF Sensitivity
UHF No. 1 (AN/ARC-90)	225.0-399.95	285.0-459.95	60	3 uV for 10 dB S/N
UHF No. 2 (AN/ARC-90)*	225.0-399.95	285.0-459.95	60	3 uV for 10 dB S/N
TACAN No. 1 (AN/ARN-21)*	962-1024 1151-1213	1025-1150	63	–
UHF Comm (AN/ARC-50(V))*	225.0-399.95	Assume 285.0-459.95	Assume 60	–

*Unit adjacent to Set Z receiver/processor.

Table 2-8 lists the transmitters located in the C-141A left-hand avionics equipment rack along with the Set Z receiver/processor. The table indicates pertinent transmitter characteristics with regard to EMI to the Set Z receiver.

Since the IF and LO frequencies of Set Z have not been selected, the possibility of RF leakage from these transmitters interfering with the Set Z receiver cannot be accurately assessed. Direct RF interference from in-band noise generated by the TACAN No. 1 transmitter is doubtful, in view of the MIL-E-6051 requirement for 60 dB shielding of each of the two units and the frequency difference between them.

TABLE 2-8. TRANSMITTERS NEAR SET Z RECEIVER/PROCESSOR, C-141A AIRCRAFT

Transmitter	RF (MHz)	Modulation	Power (W)
UHF No. 1 (AN/ARC-90)	225.0-399.95	AM	30-75**
UHF No. 2 (AN/ARC-90)*	225.0-399.95	AM	30-75
TACAN No. 1 (AN/ARN-21)*	1025-1150	Pulse	1000 peak, minimum
UHF Comm (AN/ARC-50(V))*	225.0-399.95	AM	30-75

*Unit adjacent to Set Z receiver/processor.
**300-750W out of UHF power amplifier No. 1.

2.5.4.3 Wiring and Cabling

The GPS installation has been specified to take maximum advantage of existing avionics system wiring on the C-141A. Since no known historical problems of EMI have been identified for this wiring, none are anticipated for the GPS installation. The possibility cannot be entirely ruled out, since sufficient data have not been located to estimate accurately the noise levels on the lines.

New cables and wires required for the Set Z installation have been specified in accordance with MIL-W-5088 and best engineering practices. It is anticipated that these measures will be sufficient to preclude EMI problems for the installation.

2.5.4.4 Historical EMI/EMC

No historical EMI/EMC problems have been identified for the C-141A, according to discussions with cognizant personnel.

2.5.5 Environmental Summary, C-141A

Table 2-9 summarizes the environmental exposure of the Set Z to be installed in the C-141A for GPS Phase I testing at Yuma Proving Grounds. The table presents the maximum and minimum operating and nonoperating extremes of each of the environmental parameters discussed in the preceding sections. The environmental envelope represented by the table thus shows the conditions which Set Z and IM may experience and be required to survive during the test program.

The parameter values given in the table apply to all Set Z and IM components unless otherwise noted. The temperature and pressurization specifications for the antenna and preamplifier are listed separately, since their installation exposes them directly to severe natural environments.

TABLE 2-9. TEST ENVIRONMENT SUMMARY, C-141A AIRCRAFT

Environmental Parameter	Range
Temperature	
Operating: CDU, IM, Rcvr/Proc	-27° to +53.5° C
Operating: Antenna/Preamp	-70° to +68° C
Nonoperating: CDU, IM, Rcvr/Proc	-27° to +63° C
Nonoperating: Antenna/Preamp	-70° to +68° C
Humidity	
Operating and nonoperating	≤100% Antenna directly exposed to rain
Vibration	
Operating and nonoperating	≤2.3g, 40-2000 Hz (see Figure 2-10)
Acoustic Pressure	
Operating and nonoperating	<130 dB re 0.0002 ubar
Pressure	
Operating and nonoperating	≤10,000 ft normal
Antenna/Preamp	≤40,000 ft; 8.6 psi across RF cable seal (adapter)
Wind/Dust	
Operating and nonoperating	Some blowing sand/dust at antenna; not severe
Atmospheric Pollution:	
Operating and nonoperating	Slight. Some ultraviolet, ozone, nitrogen oxides
Electrical Power	Per MIL-STD-704A

All of the environmental exposure levels listed in Table 2-9 fall within the service condition limits of SS-US-101B, with the exception of the operating temperature range of the antenna/preamplifier unit. That unit is subjected to operating temperatures below those specified in SS-US-101B (-40° C) when the aircraft is at cruising altitude. The unit can also be subjected to operating temperatures in excess of those specified in SS-US-101B (+55° C) when on the ground in Albuquerque. It is recommended that the GPS JPO consider modifying the SS-US-101B temperature specifications for the antenna and preamplifier to extend the range to those temperatures that may be encountered during the Phase I test program.

2.6 TEST VS. OPERATIONAL CONFIGURATION INTEGRATION REQUIREMENTS

C-141A aircraft in operational use have similar configurations. The test installation of Set Z is essentially the same as may be expected in a Class V modification.

Certain pending changes to the aircraft in the C-141 fleet involve a dual INS installation, in-flight refueling along with a stretched fuselage, a station-keeping modification, a new ILS, new TACAN, satellite communication equipment, and radar proximity warning receiver. Of these changes, only the INS is considered as having potential impact on the Set Z installation. As noted in Section 2.2.3, the INS will cause rearrangement of the cockpit center console to accommodate the system controls, and certain equipments will be displaced. There is a likelihood that the single spare caution panel light may be needed for the INS, in which case the Set Z installation will need an additional light at the instrument panel.

Jumper harnesses used in the test aircraft will be replaced with permanent aircraft wiring. Table 2-10 details the similarities and differences between the Class II (test configuration) and Class V (operational configuration) installations.

TABLE 2-10. COMPARISON OF SET Z TEST AND OPERATIONAL CONFIGURATIONS, C-141A AIRCRAFT

Element	Test Configuration	Operational Configuration
Antenna/Preamplifier Assy	Top of aircraft @ FS 741	Same
Receiver/Processor Unit	LH underdeck avionics equipment rack	Same
Integration Module	LH underdeck avionics equipment rack	Same
Control/Display Unit	LH side of the cockpit center console	Same
Connection to CDU	Jumper harness to TACAN control panel harness plug P142C	TACAN control panel harness via a new connector
Connection to Flight Instruments	Jumper harness to avionics rack discon-nect J-174A	TACAN harness via new connector, added wiring
Altitude Input	Jumper harness to connect between APX-64 and CADCs	Splice or terminal board wiring connections
TAS Input	Wiring to terminal board connections	Same
Degraded Mode Light	Connection to spare lamp in caution panel	Same; new added caution light with INS modification

3
TEST AIRCRAFT INTEGRATION, KC-135A

This section provides detailed information concerning the integration of UE Set Z into the KC-135A aircraft for GPS Phase I testing. The section provides information pertaining to the derivation of requirements; a description of the test installation, cabling and connections, and electronic interfaces; and a summary of Group A items that will be required for installation and interface. All items considered relevant to installation requirements of Set Z into the KC-135A are presented in checklist format in Appendix B.

3.1 INTEGRATION REQUIREMENTS DERIVATION

The integration requirements information contained in this section was derived from a study of technical orders and reports for the KC-135A aircraft (see bibliography, Volume I, Appendix A). Additionally, information and data were collected during trips to the KC-135 System Manager's office at Oklahoma City Air Logistics Center and to the Boeing Company, Wichita, Kansas (see trip and contact list, Volume I, Appendix B).

3.1.1 Physical Installation Requirements

As discussed in Section 1.2, Set Z consists of three LRUs: receiver/processor, antenna/preamplifier, and CDU. The physical configuration of the KC-135A and its associated avionics, the environment onboard the aircraft, the GPS Phase I Test Plan, and direction from the GPS JPO have imposed requirements on the physical installation of these three LRUs. The specific rationale for the installation of each unit will be described along with the installation descriptions presented in the following sections.

3.1.2 Avionics Configuration

Table 3-1 lists the KC-135A avionics relevant to the integration effort. Relevancy is based upon replacement by, interface with, or potential interference to or from Set Z.

During visits to the SM at OCALC, ARINC Research determined that approximately 700 KC-135A aircraft are in the Air Force inventory, and that most of these have the AN/ARN-72 TACAN system installed and the AIMS AN/APX-64 transponder with Mode C altitude reporting incorporated. The cockpit configuration of these aircraft may vary. According to Boeing engineers, about 200 KC-135A aircraft have a control panel located near the copilot's right knee below the side window. A future installation of a satellite communications system will add an antenna to the aircraft top.

The differing configurations may have some impact on the Set Z installation. For test purposes, the described installation should be compatible with these

TABLE 3-1. KC-135A AVIONICS EQUIPMENTS AFFECTED BY SET Z TEST INSTALLATIONS

Item Removed	Item Interfacing	Potential Interference
Rcvr/Trans (RT-636/ARN-72)	Pilot's HSI (331A-8H)	IFF (AN/APX-64)
	Copilot's HSI (331A-8H)	
Mount (MT-2601/ARN-72)	Pilot's RMI (ID-250A)	
Control Panel* (C-3844/ARN-72)	Copilot's RMI (ID-250A)	
	Navigator's RMI (ID-250A)	
Instrumentation Coupler (161B-1)	N-1 Compass	
Top Antenna (AT-741/A)	Dual Flight Director System (AN/ASQ-141(V))	
Switching Relay* (SA-521/A)	115 Vac Gen. No. 1 AC Bus	
	28 Vdc TR Bus No. 2	
	26 Vac (From Amplifier ME-1A)	
	RGA Annunciator Panel	
	TAS Computer (MIL-C-5191B)	
	Transponder (RT-728A/APX-64(V))	
	Altitude Computer (CPU-66/A-14)	
	VOR/TACAN Transfer/Relay (2 ea)	
	TACAN Select Switch/Ind (2 ea)	
	Navigator Light Control Circuit (RT-30-6)	

*Disable or remove

variations. Minor modifications may be necessary with respect to the antenna/preamplifier location if the satellite communications system is also incorporated in the test aircraft or if noise interference is generated by the top IFF antenna.

3.2 PHYSICAL INSTALLATION DESCRIPTION

The following sections describe the physical installation of various LRUs of Set Z in the KC-135A. Each description includes the rationale for selection or design of the installation.

3.2.1 Receiver/Processor

The Set Z receiver/processor will occupy the cavity presently occupied by the AN/ARN-72 TACAN receiver-transmitter unit located on the floor of the electronics compartment. The receiver/processor installation is illustrated in Figure 3-1.

The installation at this location is dictated by available avionics space and by direction from the JPO. This unit will be mounted on vibration isolators along with the Integration Module to protect it from the environment during flight. Cabin air is circulated through the electronics cabinet for equipment cooling. Air is drawn into the cabinet at floor level and is exhausted from the top region of the cabinet. Cooling air will be drawn from the cabinet into the front of the GPS receiver/processor and circulated through the unit by a fan. The hot air is then exhausted through the bottom of the mounting tray. Heat dissipation in the unit (120 watts power consumption) will not necessitate that cooling air be ducted directly to the unit.

3.2.2 Antenna/Preamplifier Assembly

The Set Z antenna will replace the AT-741/A TACAN antenna on top of the aircraft at FS 375 RBL 3.5. The preamplifier unit will extend inside the aircraft, below the antenna. An airtight seal must be provided around the antenna mounting flange. Space inside the fuselage is somewhat restricted at the overhead antenna location, but is adequate to accommodate the assembly. An air conditioning duct passes along the top of the cabin in this vicinity, with about 15 cm between the aircraft skin and the ductwork. It will probably be necessary to remove a section of this duct to facilitate installation.

The antenna location takes advantage of an existing antenna site to minimize GPS installation cost. Since the TACAN and GPS antennas operate at similar frequencies, the subject antenna location should be satisfactory from an RF pattern standpoint. The very high sensitivity of the GPS receiver may make it sensitive to noise. Pattern blanking caused by the vertical stabilizer should occur only in a very narrow section aft, and should be insignificant. Set Z is not scheduled for testing on the inverted range, and thus no bottom-mounted antenna will be required for that installation.

3.2.3 Control/Display Unit (CDU)

The Set Z CDU will be mounted on the navigator's table below and just inboard from the C-1242/APN-59 search radar control in the navigator's vertical instrument panel. The proposed CDU location is shown in Figure 3-1. The navigator's station

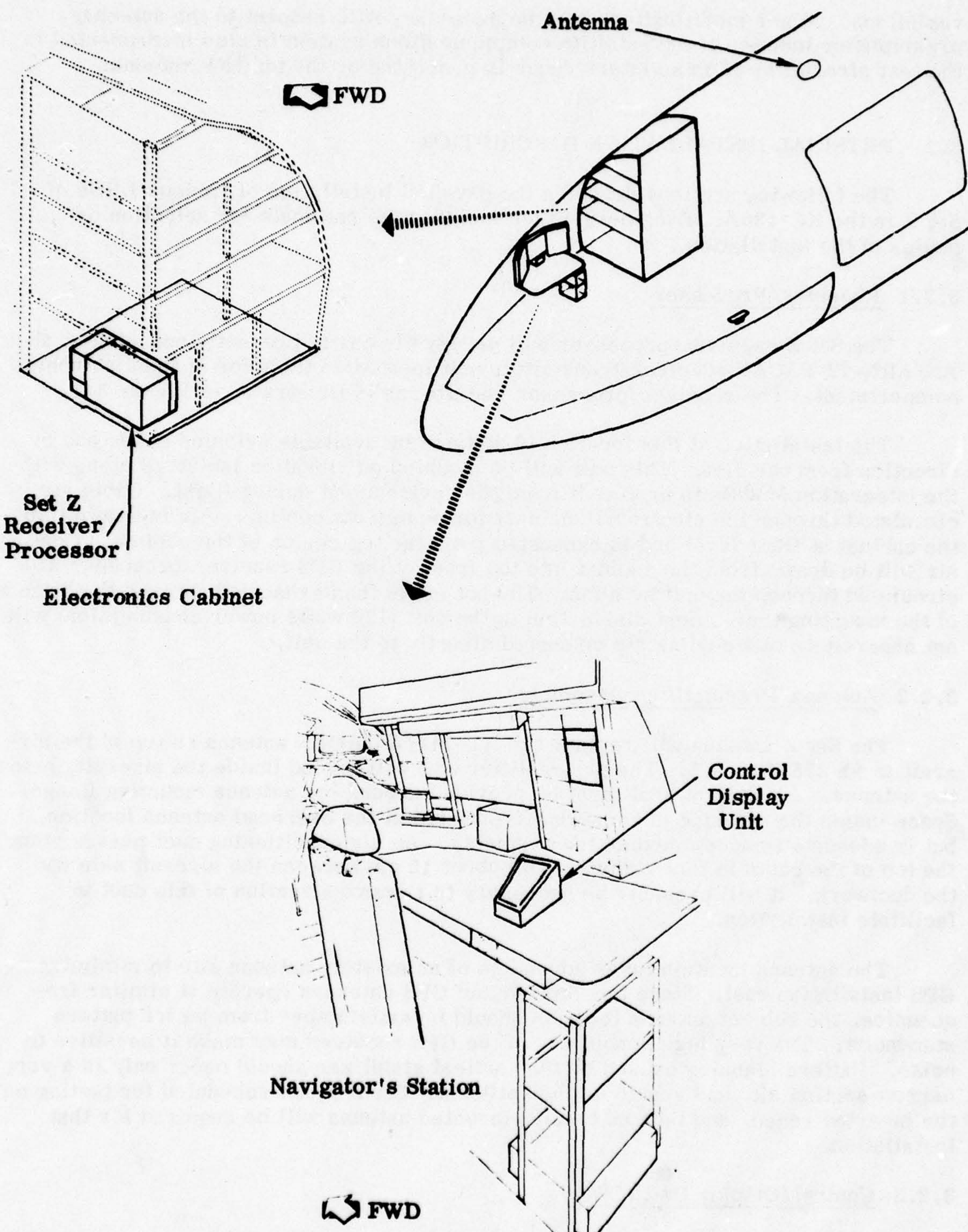


Figure 3-1. GPS Navigation System, KC-135A Test Installation

was selected for the test installation after discussions with OCALC and Boeing engineers and following an inspection of possible cockpit locations in the aircraft itself. The KC-135A, unlike other aircraft in the test series, has no center console arrangement for mounting control panels. Avionics switch panels are arranged overhead or to the left and right of the pilot and copilot, respectively. Available space in the cockpit panels is minimal. Two possible locations were found: one at the copilot's left knee and the other on the side panel forward of and below the right window. The first of these would require relocating a weather radar scope to another cockpit location, not readily identified. The latter would require reshaping of the plastic side panel trim and modification of the fuselage structure. However, Boeing Company engineers advise that the side-panel location has already been utilized for installation of a different control panel in some 200 of the fleet aircraft. The overall difficulty and cost factor of a cockpit installation and its probable location in a region inaccessible to all but the copilot have promoted consideration of the navigator station site. Moreover, the KC-135A is likely to retain an active navigator crew member for the foreseeable future.

3.2.4 Integration Module

The Integration Module is installed in the receiver/processor mounting, as shown in Figure 1-1. The installation permits independent operation of Set Z, removes power elements (synchro drivers) from the basic LRU for better thermal performance, and enables use of a standardized LRU design in the KC-135A aircraft. Cooling of the IM unit (120 watts power consumption) will be by ambient electronics compartment air; ducting of cooling air directly to the IM is not contemplated.

3.3 ELECTRONIC INTERFACES

3.3.1 Functional Interfaces

Electronic interfaces for the Set Z installation in the KC-135A are summarized in Table 3-2. The table is a matrix of avionic system/component vs. signals input to or output from Set Z. The relationship of the Set Z test installation to the onboard radio navigation system is shown in the interface diagram of Figure 3-2.

3.3.2 Wiring and Connectors

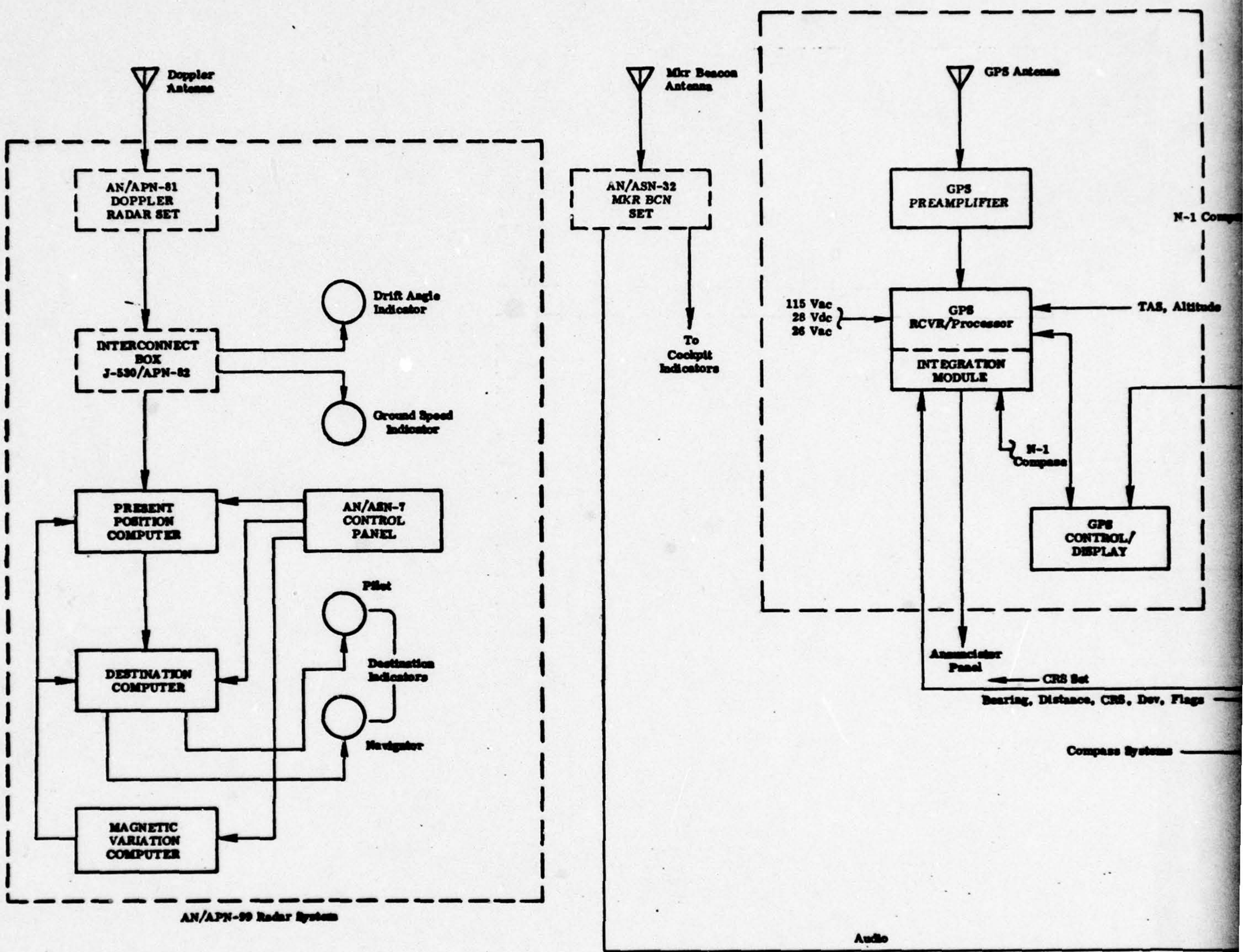
The cabling and interconnections between LRUs of Set Z and the aircraft systems are shown in the cabling and interwiring diagrams, Figures 3-3 and 3-4 respectively. Pin connections and assignments between Set Z, the IM, and other interfacing onboard avionics take into account wire bundling, shielding, spares locations, and mateability with existing aircraft harnesses. Reassignments during Set Z design phase must be consistent with the use of these existing aircraft wiring harnesses in any of the test installations, as shown in the cabling diagrams.

The interwiring layout was influenced by the requirement that Set Z continue to operate independently in the event of a failure in the integration module. The selection of the connectors specified in the Group A listing (see Section 3.4), was based on functional and environmental considerations and a requirement to mate to the TACAN coupler, TAS, and altitude source harnesses. For the receiver/processor unit and IM, the selection of connectors is guided by ARINC Specification 404A, used by commercial airlines, which recommends the use of plug-in DPX or

TABLE 3-2. ELECTRONIC INTERFACE SIGNALS, KC-135A AIRCRAFT

Avionic System/ Component	Set Z Interface Signals: Set Z Output to Systems/Displays									Inputs to Set Z							
	Digital Navigation Data	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Degraded Mode	Course Set	A/C Power, 115 Vac, 400 Hz	A/C Power, 28 Vdc	Synchro Ref. 26 Vac, 400 Hz, ØA	Altitude	True Airspeed	Panel Lighting*	Digital Control Data	Magnetic Heading
1. Set Z CDU	X															X	
2. Pilot's HSI 331A-8H		X	X	X	X	X	X		X								
3. Pilot's RMI ID-250/ARN		X															
4. Copilot's HSI 331A-8H		X	X	X	X	X	X										
5. Copilot's RMI ID-250/ARN		X															
6. Nav's RMI ID-250/ARN		X															
7. Flight Director System ASQ-14(V)					X	X											
8. Autopilot MC-1					X												
9. Compass System N-1												X					X
10. RGA Annunciator Panel								X									
11. Altitude Computer CPU-66/A													X				
12. True Airspeed Computer Type A-2														X			
13. Navigator's Instrument Lighting System 28 Vac															X		
14. AC Distribution Gen No. 1 ØA										X							
15. TR Bus No. 2											X						

*Direct to CDU



Doppler Antenna
AN/APN-81 DOPPLER RADAR SET
Drift Angle Indicator
INTERCONNECT BOX J-530/APN-82
Ground Speed Indicator
PRESENT POSITION COMPUTER
AN/ASN-7 CONTROL PANEL
Pilot
Destination Indicators
DESTINATION COMPUTER
Navigator
MAGNETIC VARIATION COMPUTER
AN/APN-99 Radar System
Mkr Beacon Antenna
AN/ASN-32 MKR BCN SET
To Cockpit Indicators
GPS Antenna
GPS PREAMPLIFIER
N-1 Compa
115 Vac
28 Vdc
26 Vac
GPS RCVR/Processor
INTEGRATION MODULE
TAS, Altitude
N-1 Compass
GPS CONTROL/ DISPLAY
Annunciator Panel
CRS Set
Bearing, Distance, CRS, Dev, Flags
Compass Systems
Audio

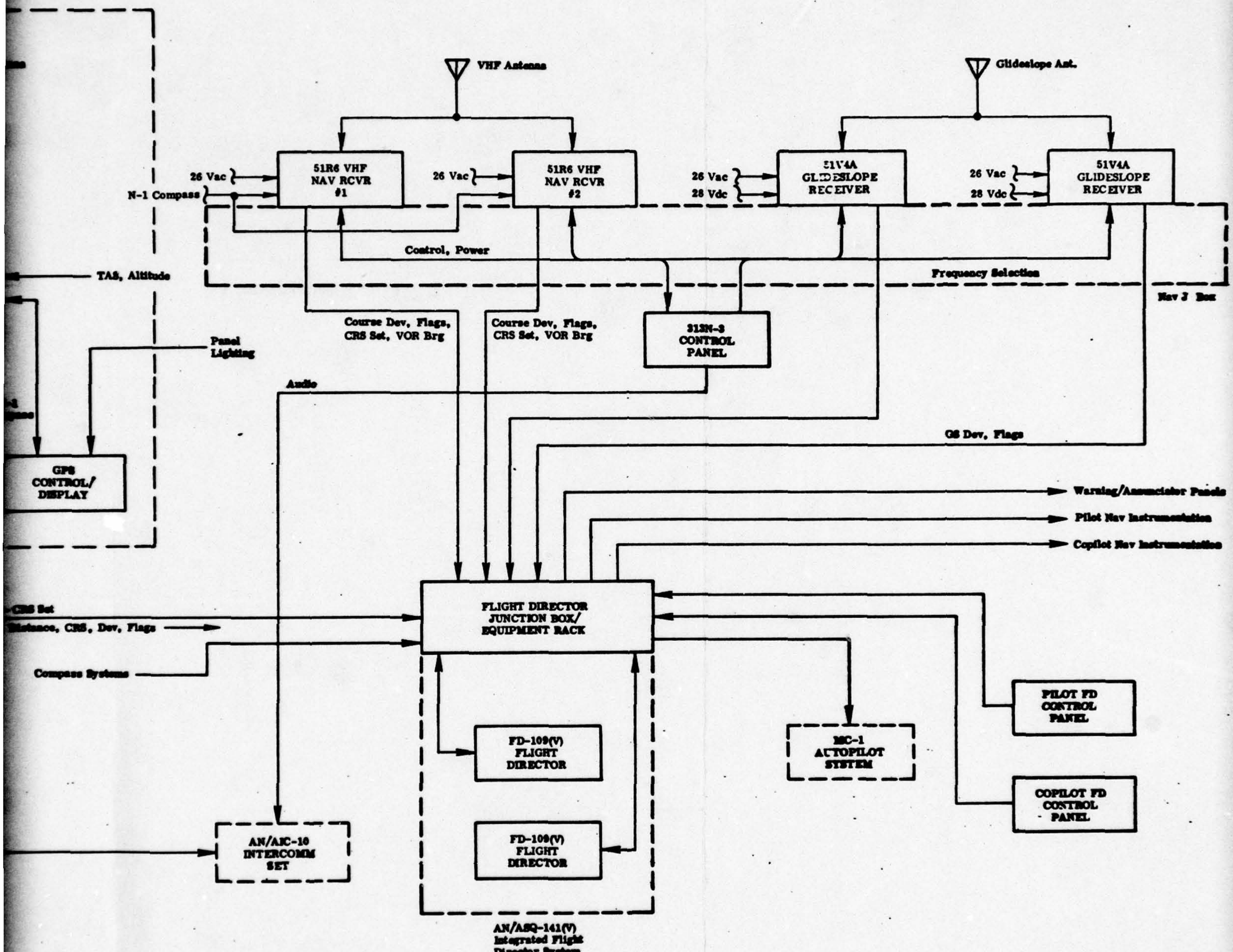


Figure 3-2. KC-135A Radio Navigation System Interface Diagram, GPS Test Installation

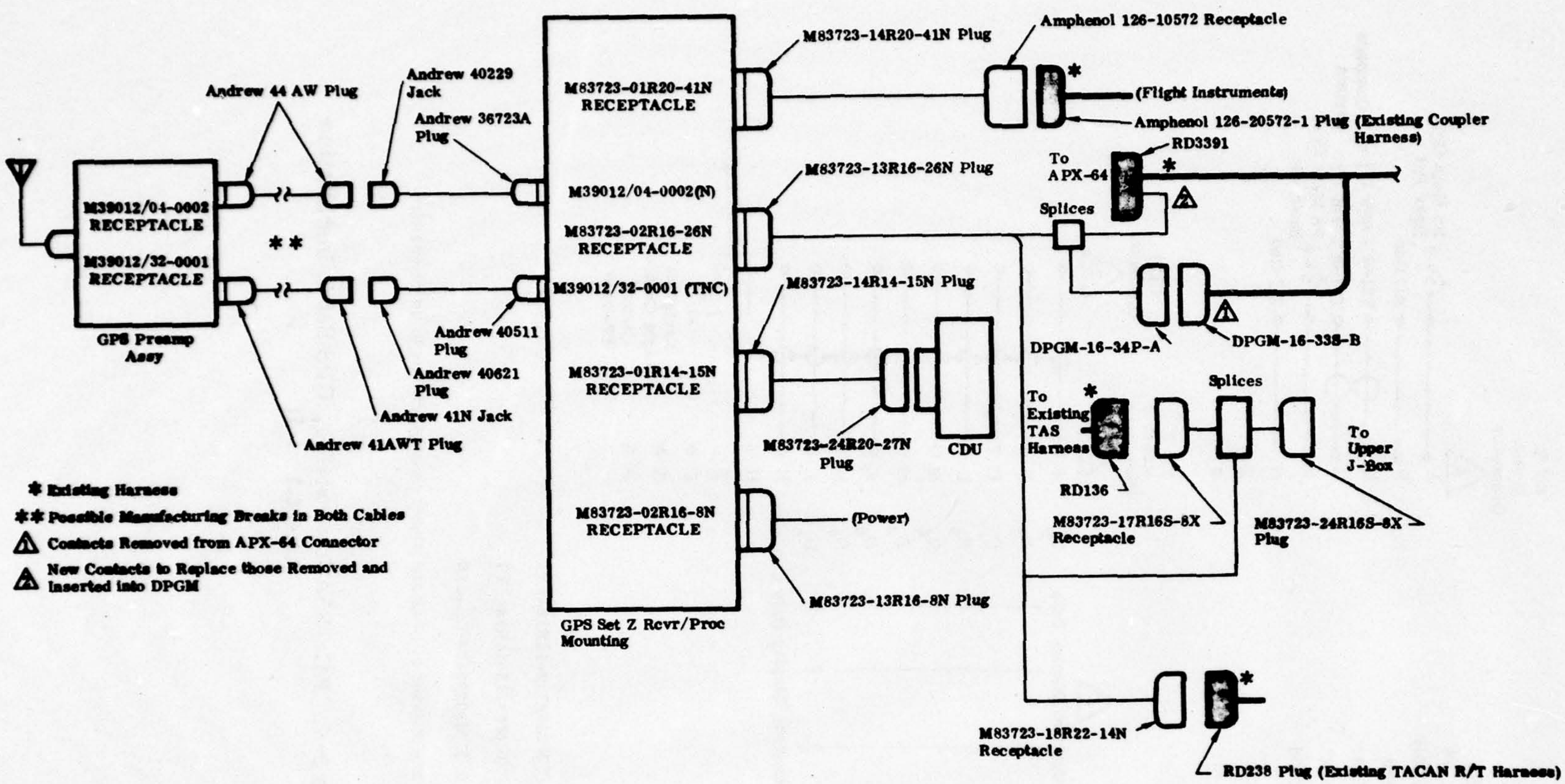


Figure 3-3. KC-135A Cabling Diagram – GPS Test Installation

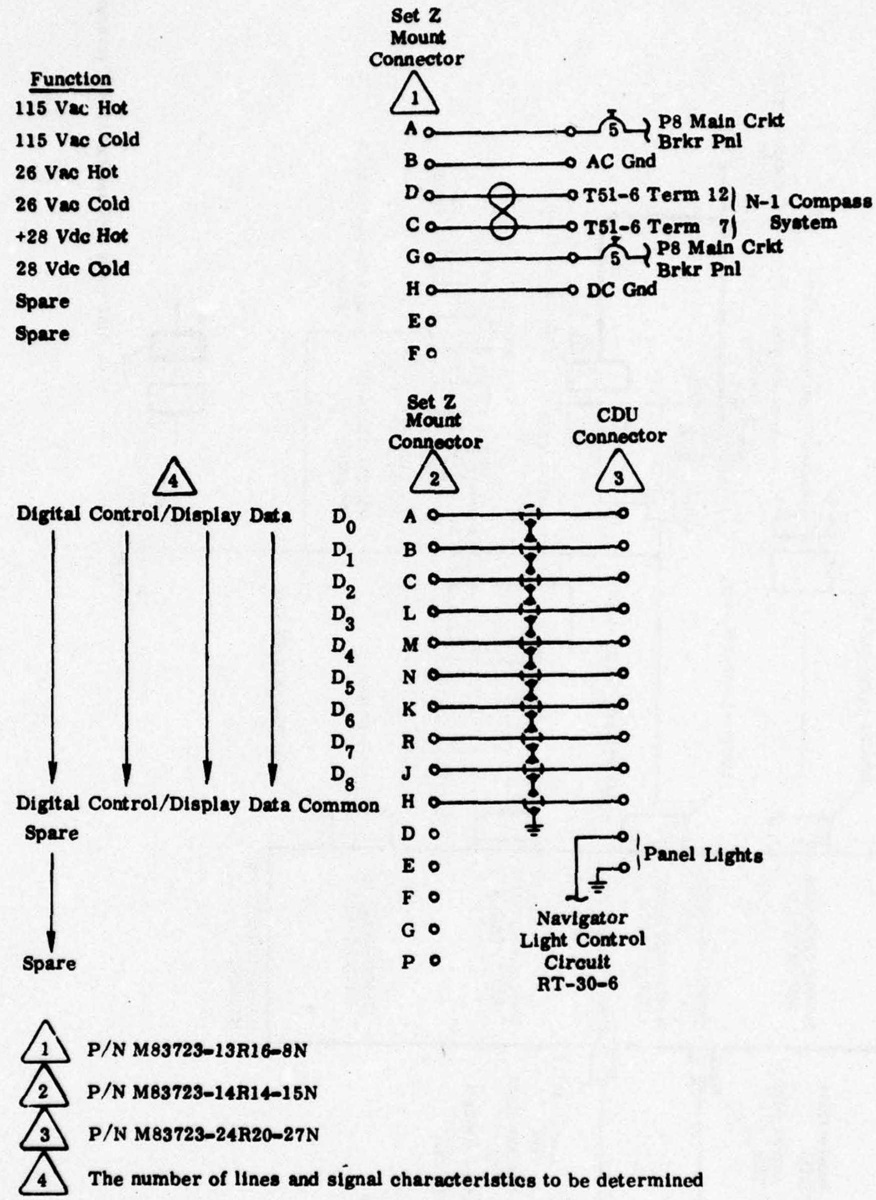
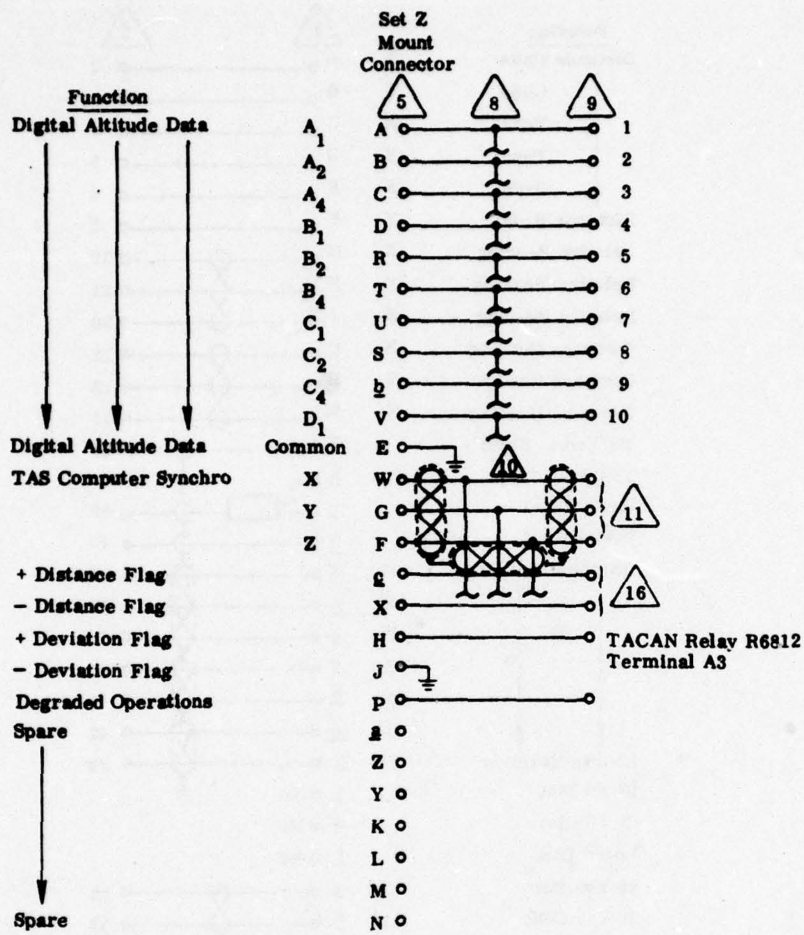


Figure 3-4. KC-135A Interwiring, GPS Set Z Installation (Sheet 1 of 4)



5 P/N M83723-13R16-26N

8 Spliced connections to APX-64, see cabling diagram, Figure 3-3

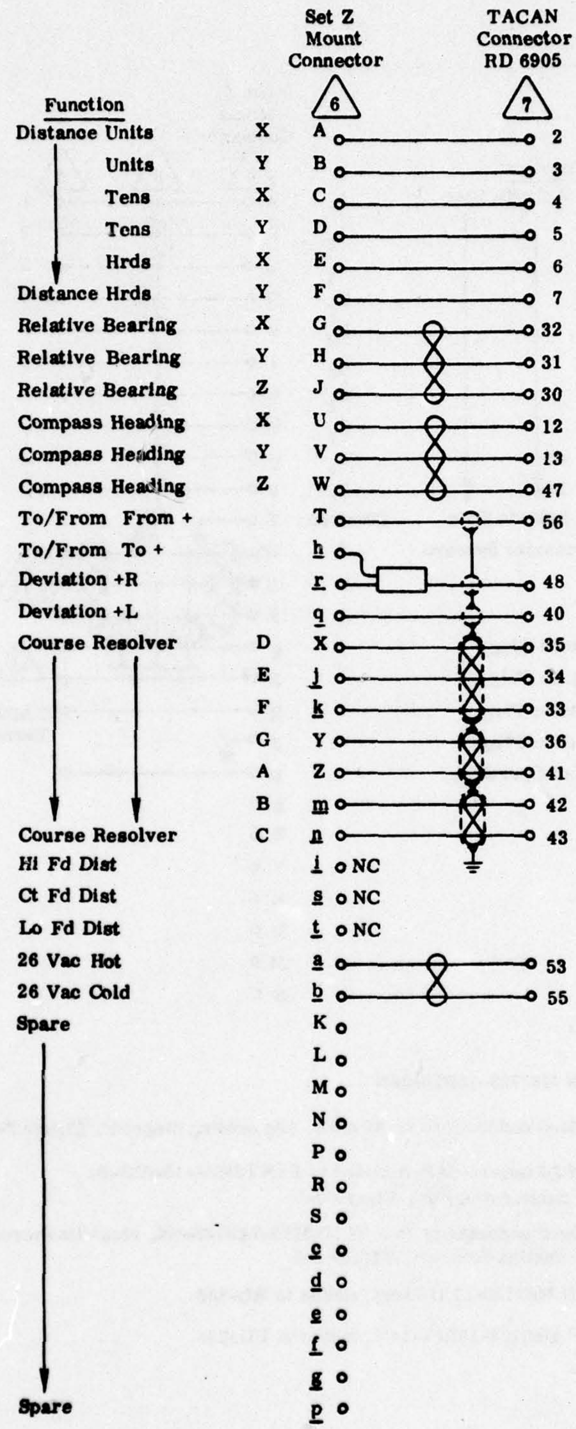
9 P/N DPGM-16-34P-A mated to P/N DPGM-16-33S-B, see cabling diagram, Figure 3-3

10 Spliced connections to P/N M83723-24R16S-8X, plugs into upper J box, see cabling diagram, Figure 3-3

11 P/N M83723-17R16S-8X, mates to RD-136

16 P/N M83723-18R22-14N, mates to RD-238

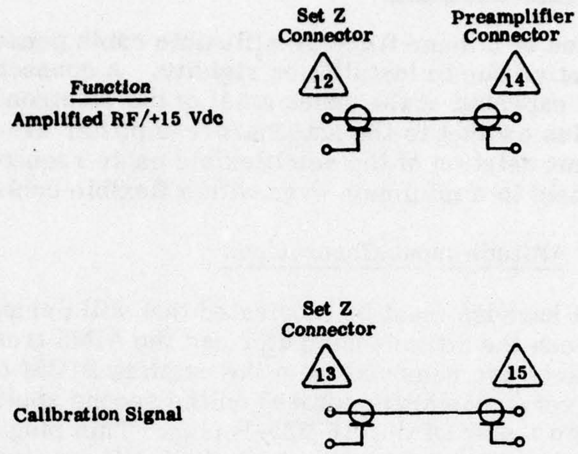
Figure 3-4. (Sheet 2 of 4)



6 P/N M83723-14R20-41N

7 P/N 126-10572 (Amphenol)

Figure 3-4. (Sheet 3 of 4)



12 P/N 36723A (Andrew)
13 P/N 40511 (Andrew)
14 P/N 44AW (Andrew)
15 P/N 41AWT (Andrew)

Figure 3-4. (Sheet 4 of 4)

similar connectors on equipment LRUs. Other connectors were selected from MIL-C-83723 and MIL-C-39012 as appropriate.

3.3.2.1 Coaxial Cable

Installation of a foam-filled semiflexible cable presents a special problem in retrofit installation due to installation rigidity. A connector-transition to a flexible service loop is expected at the upper shelf of the electronics cabinet. The proximity of the electronics cabinet to the antenna/preamplifier assembly in the KC-135A aircraft may permit deletion of the semiflexible cable requirement altogether, since losses can be held to a minimum even with a flexible cable.

3.3.2.2 Altitude Input Connections

A special harness must be fabricated that will permit coupling into the altitude data lines between the altitude computer and the AIMS transponder. The 10 pertinent connector contacts are removed from the existing DPJM connector (RD 3391) at the RT-728A receiver/transmitter located on the second shelf of the electronics cabinet and inserted into a new DPGM-16-33S-B plug. This plug connects to a harness, which supplies the altitude signal to both the Set Z receiver/processor and to 10 new contacts inserted into the vacant positions in the RD 3391 plug. The harness is depicted in the cabling diagram, Figure 3-3. The indicated modifications will permit easy conversion of aircraft wiring back to its original condition when the GPS equipment is removed.

3.3.2.3 TAS Input Connections

A special harness must be fabricated that will permit coupling into the true airspeed synchro lines between the TAS computer and the upper junction box on electronics cabinet shelf No. 1. The existing RD 136 plug will be disconnected from the upper junction box and connected to a new receptacle M83723-17R16S-8X. This receptacle is attached to the new harness which supplies the TAS signal to both the GPS Set Z receiver/processor and to a new plug, M83723-24R16S-8X, for connection to the upper junction box. The harness is depicted on the cabling diagram, Figure 3-3. The use of this new interconnecting harness will keep the existing aircraft wiring intact and permit quick conversion of the aircraft to its original configuration.

3.4 GROUP A ITEM REQUIREMENTS

The Group A items required to effect integration and installation in the KC-135A are shown in Table 3-3.

3.5 EQUIPMENT ENVIRONMENTS

Environmental requirements for the Set Z installation in the KC-135A are derived by combining a history of exposure to various conditions with the natural environmental characteristics and the aircraft-induced or -controlled environmental characteristics. The result is a comprehensive environmental envelope for the KC-135A test activities. The exposure history, natural environment, and aircraft environment are described below, followed by a summary of the total environmental envelope.

TABLE 3-3. GROUP A INSTALLATION ITEMS FOR UE SET Z ON KC-135A AIRCRAFT (Sheet 1 of 3)

Item	Qty	Remarks
a. Receiver/Processor Mounting	1	
Connector, M24308/2-4	1	
Connector, DPX, M81659/31A2-0042	1	
Connector, DPX, M81659/31A2-0034	1	
Connector, M83723-02R16-8N	1	
Connector, M83723-01R20-41N	1	
Connector, M83723-02R16-26N	1	
Connector, M83723-01R14-15N	1	
Vibration mount, Lord 150PHL8	4	
Holddown, Type C, Hollingsead-Pryor	3	
b. Control/Display Mounting	–	
Connector, M87323-21R20-27N	1	
Brackets, mounting	TBD	Structural details to be designed by installer.
c. Antenna/Preamplifier Mounting	1	
Doubler	TBD	Structural details to be designed by installer.
Gasket	↓	
Screws	↓	
Brackets, mounting	TBD	
d. Integration Module Converter	1	

TABLE 3-3. (Sheet 2 of 3)

Item	Qty	Remarks
e. Integration Module Driver	1	
f. Aircraft Wiring		
Connector, Amphenol 126-10572 (receptacle)	1	Mates with TACAN coupler plug, RD6905
Connector, M83723-13R16-8N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R20-41N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-13R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R14-15N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-17R16S-8X (receptacle)	1	Mates with existing RD 136
Connector, M83723-24R16S-8X (plug)	1	Mates with upper junction box receptacle
Connector, DPGM-16-33S-B (plug)	1	Mates with DPGM receptacle on GPS altitude harness
Connector, DPGM-16-34P-A (receptacle)	1	Mates with DPGM plug on altitude harness near APX-64
Connector, M83723-24R20-27N (plug)	1	Mates with CDU receptacle
Connector, M83723-18R22-14N (receptacle)	1	Mates with TACAN R/T plug, RD238
Connector, N, Andrew 41N	1	Mates with service loop plug
Connector, N, Andrew 44AW	2	Mates with service loop jack, pre-amplifier jack
Connector, TNC, Andrew 40511	1	Mates with TNC female on receiver
Connector, N, Andrew 36723A	1	Mates with N female on GPS receiver
Connector, N, Andrew 40621	1	Mates with calibration line jack

TABLE 3-3. (Sheet 3 of 3)

Item	Qty	Remarks
f. Aircraft Wiring (cont)		-
Connector, N, Andrew, 40229	1	Mates with signal input line plug
Connector, TNC, Andrew 41AWT	1	Mates with preamplifier jack
Cable, coaxial, Andrew FHJ4-50B		Signal line
Cable, coaxial, Andrew FHJ1-50		Calibration line
Cable, coaxial, Andrew FSJ1-50		Service loop
Cable, coaxial, Andrew FSJ4-50		Service loop
Wire and cable		Various types as required
Contact, #20 socket P/N 031-0900-001	10	Insert into existing DPJM plug at the APX-64
Splices, wire	13	
Decals, assorted GPS		

3.5.1 Exposure Time History

Figure 3-5 shows a time history of exposure of Set Z to the environmental factors to be encountered during testing in KC-135A at YPG. It has been assumed that the host test aircraft will be dedicated full time to the tests and will be stationed at Kirtland AFB, Albuquerque, N.M. The aircraft will depart from and return to that base for each day of flight testing.

The sequence of events and duration of each shown in Figure 3-5 are intended to be representative of the test operations to be conducted. While it is realized that any given test exercise may deviate from the sequence shown, it is felt that the events in the figure are sufficient to expose Set Z to all of the environmental extremes to be encountered. For example, since the time of day of satellite visibility will vary, and since the aircraft could be left on the ground at any time of day or night, relatively long on-the-ground events have been specified to last 24 hours. This, when combined with annual temperature data for Albuquerque, will result in exposure to both overnight low temperatures of winter months and daytime high temperatures of summer months, thereby defining the natural temperature exposure extremes.

3.5.2 Natural Environment

Table 3-4 summarizes the ground level climate in Albuquerque on a monthly and annual basis. The data were obtained from U.S. Weather Bureau records. The KC-135A at Kirtland could be exposed to any of these conditions, and the resultant environmental exposure of the Set Z equipment would be as discussed in the following paragraphs.

3.5.2.1 Temperature

As shown in Table 3-4, the coldest temperature recorded at Albuquerque was -27°C (-17°F). Nonoperating Set Z units could be exposed to this temperature level if the aircraft were left outside overnight.

The highest temperature on record at Albuquerque is 40°C (104°F). Inside a closed large aircraft parked in the sun, temperatures would be likely to reach 63°C (145°F). Thus the Set Z receiver/processor, CDU, and IM could be exposed to these temperature levels in a nonoperating condition. The external antenna and the preamplifier mounted adjacent to the top fuselage skin could reach temperatures somewhat higher than this due to direct solar heating (estimated at 68°C or 154°F).

For Set Z operation, it is assumed that the aircraft or external cooling system would reduce temperatures in the aircraft to those suitable for the system operating personnel, who would not activate the system until the inside air temperature had cooled to at least 43°C (110°F). The antenna temperature could remain near 68°C, however, since it is partially external to the air conditioned area (see Section 3.5.3.3).

For cold-day or nighttime tests, it is assumed that temperatures inside the aircraft will be raised to crew-comfort levels at or shortly after system activation. Start-up temperatures could be near the Albuquerque low of -27°C (-17°F).

At a cruising altitude of approximately 30,000 feet, outside air temperature on the order of -70°C could be expected according to MIL-STD-210B. The antenna would be directly exposed to the air.

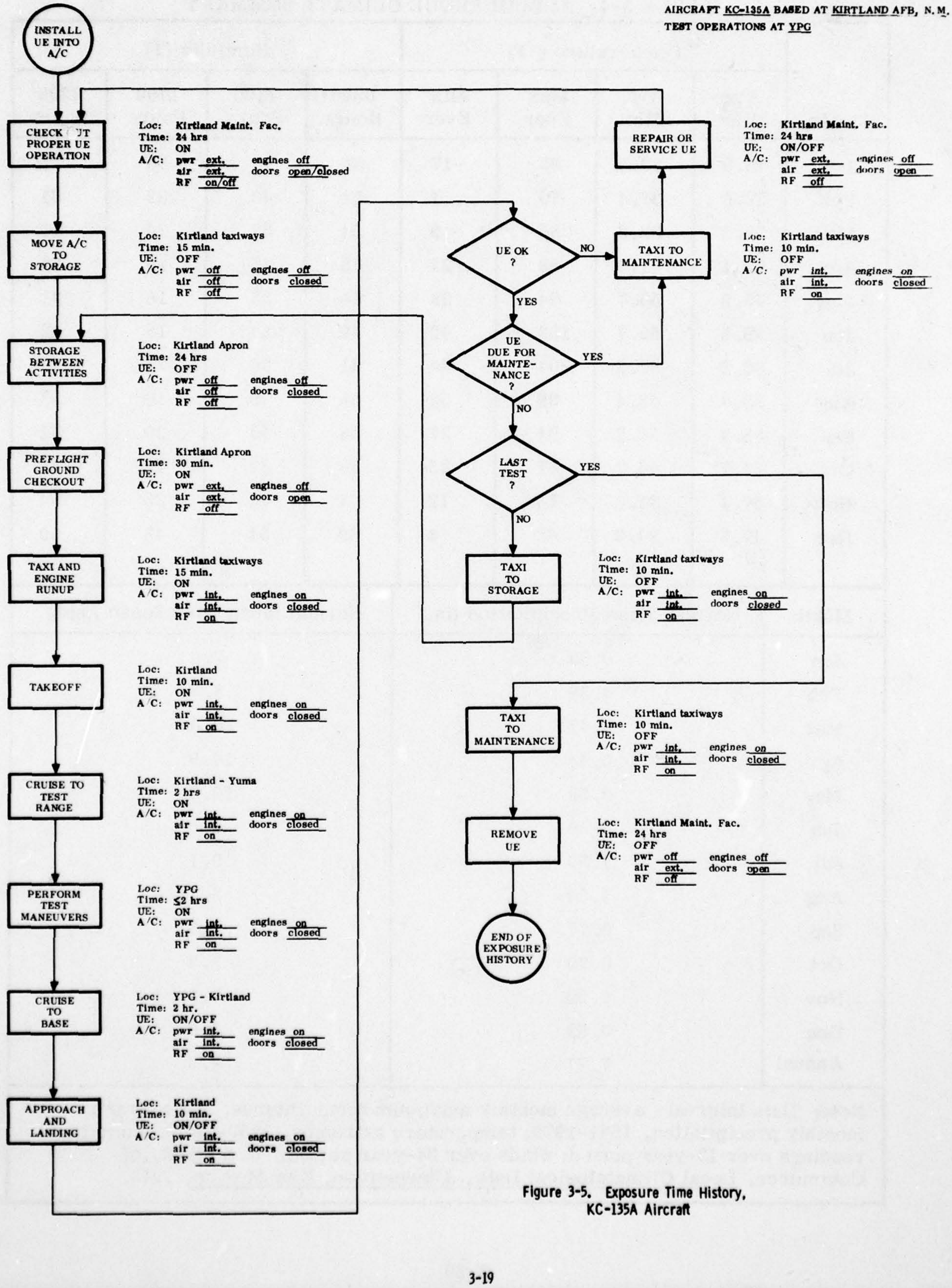


Figure 3-5. Exposure Time History, KC-135A Aircraft

TABLE 3-4. ALBUQUERQUE CLIMATE SUMMARY

Month	Temperature (° F)				Humidity (%)			
	Avg Max	Avg Min	Max Ever	Min Ever	0500 Hours	1100 Hours	1700 Hours	2300 Hours
Jan	46.9	23.5	69	-17	66	48	36	57
Feb	52.6	27.4	75	1	62	43	32	51
Mar	59.2	32.3	85	9	54	32	24	41
Apr	70.1	41.4	89	22	45	25	18	33
May	79.9	50.7	94	28	44	23	16	31
Jun	89.5	59.7	102	42	45	24	18	32
Jul	92.2	65.2	104	54	61	36	28	49
Aug	89.7	63.4	99	52	65	39	30	52
Sep	83.4	56.7	94	37	58	40	30	52
Oct	71.7	44.7	87	25	58	37	29	47
Nov	57.1	31.8	73	12	64	43	35	54
Dec	47.5	24.9	68	4	69	51	43	60

Month	Normal Mean Precipitation (in.)	Normal Mean Wind Speed (mph)
Jan	0.30	7.9
Feb	0.39	8.8
Mar	0.47	10.0
Apr	0.48	10.9
May	0.53	10.5
Jun	0.50	9.9
Jul	1.39	9.1
Aug	1.34	8.1
Sep	0.77	8.5
Oct	0.79	8.3
Nov	0.29	7.7
Dec	0.52	7.6
Annual	7.77	8.9

Note: Data interval: average monthly maximum temperatures, and average monthly precipitation, 1941-1970; temperature extremes, 1959-1973; humidity readings over 13-year period; winds over 34-year period. U.S. Dept. of Commerce, Local Climatological Data, Albuquerque, New Mexico, 1973.

3.5.2.2 Humidity

As shown in Table 3-4, the humidity at Albuquerque is typically low or moderate but will rise to 100% during occasional rain storms. The antenna will be exposed directly to the rain. The Set Z receiver/processor CDU, preamplifier, and IM will not be subjected to direct rainfall, but air of nearly 100% humidity could be drawn into the aircraft under some startup or ground operation conditions.

3.5.2.3 Wind/Dust

The Table 3-4 data indicate typically light winds at Albuquerque, but substantial gusting (monthly recorded maximums of 57-90 mph) can occur at any time of year. This condition, coupled with the dryness of the area, will lead to occasional substantial amounts of blowing sand and dust. Wind over 32 mph is reported by the Weather Bureau for an average of 46 days each year. Therefore, minor abrasive effects from blowing sand can be expected occasionally at the external antenna location, although the top, flush mounted antenna installation should minimize this effect. Dust in the areas inside the KC-135A fuselage should be of minimal significance to Set Z electronics.

3.5.2.4 Precipitation

Precipitation at Albuquerque averages only 7.77 inches per year, typically less than one-half inch per month. Precipitation will impact only the antenna/preamplifier design and installation. Due to freezing winter temperatures, the antenna weather seal should be designed so as not to trap water that could subsequently freeze and expand to stress the antenna or seal.

3.5.2.5 Atmospheric Pollution

Atmospheric pollution in Albuquerque is not expected to present any severe design problems. Due to the high altitude (approximately 5300 feet) and the generally clear air, ultraviolet radiation levels are relatively high. The air contains no significant amounts of sulfur oxide products, but measurable levels of nitrogen oxides. The highest ozone level recorded near Kirtland AFB was 135 parts per billion (ppb) although records have been kept for only a few years. The summer months have the highest ozone counts, with the federal standard of 80 ppb being exceeded typically 15 to 20 times per month during June and July. Monthly average high ozone counts are shown in the table below.

Exposed or unprotected materials, especially rubber and plastic seals and insulation, will have to survive these pollution levels without unacceptable degradation of performance or characteristics.

Month	J	F	M	A	M	J	J	A	S	O	N	D
High ozone count (ppb)	45	50	50	30	60	100	85	60	–	50	55	55

3.5.3 Aircraft Environment

The following paragraphs summarize the environment onboard the KC-135A during Phase I test operation. The environmental factors presented below are those which result directly from the operation of the aircraft and its associated systems. All data are derived at the specific installation locations of Set Z equipment when data resolution permits. Only limited actual test data defining the environment could be located by the manufacturer, Air Force System Manager's office, or other general data sources.

3.5.3.1 Mechanical Vibration

No flight test measurements of vibration levels on the KC-135A could be located. However, the manufacturer (Boeing-Wichita) provided a plot of the sinusoidal vibration design requirements established for electronics to be installed above WL 210 and forward of FS 400 in the KC-135A. This plot is believed to be based upon ground engine runup and flight data, and is presented in Figure 3-6.

3.5.3.2 Acoustic Vibration

No test data were located to define the acoustic environment inside the KC-135A. However, environmental engineers at the manufacturer's plant indicated that there were no special design requirements for internal electronics due to acoustic pressure levels. They estimated that levels were well below 130 dB re 0.0002 ubar at all pertinent locations. In addition, personnel at the Air Force Flight Dynamics Laboratory, WRAFB, Ohio, stated that acoustic vibration inside large aircraft was generally of no concern to electronics design, especially anywhere forward of the engines or propeller plane.

3.5.3.3 Temperature and Humidity

No test data were available to describe the temperature environment at Set Z installation locations in the KC-135A. However, aircraft manufacturer engineers did not feel that the thermal environment would impose any design requirements in excess of the current SS-US-101B specifications.

Due to likelihood of an installation exposing most of the CDU to ambient cabin air, the only Set Z units to be in an enclosed area will be the receiver/processor and IM. Since these will replace the existing TACAN receiver/transmitter, which generates a higher heat load than Set Z and operates satisfactorily under normal conditions, temperature should not be a design or installation problem. (A cautionary note regarding this installation is discussed in Section 3.5.3.6).

Cabin air temperature is controlled automatically and is adjustable by the pilot. Crew comfort will normally dictate a cabin temperature of approximately 20° to 24°C.

The air conditioning system on the KC-135A removes excess moisture from the cabin air before it is circulated through the cabin. The air is cooled to +1.7° (+3°, -1°)C, at which point the water separator removes approximately 85% of the moisture. The air is then reheated to the desired temperature by mixing with a controlled amount of hot air and circulated to the cabin.

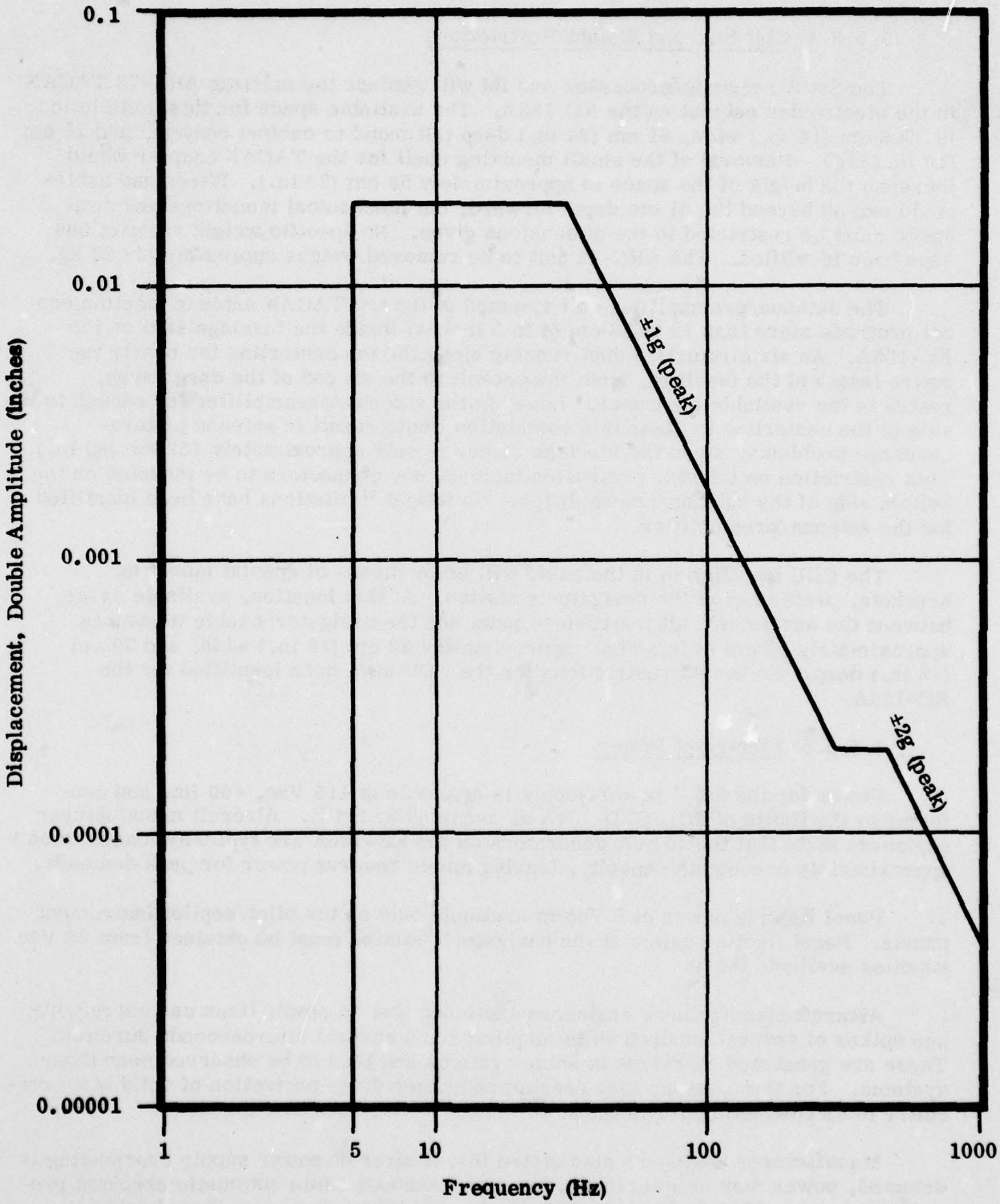


Figure 3-6. Sinusoidal Vibration Design Requirements for Electronics, KC-135A

3.5.3.4 Unit Size and Weight Restrictions

The Set Z receiver/processor and IM will replace the existing ARN-72 TACAN in the electronics cabinet on the KC-135A. The available space for this installation is 35.6 cm (14 in.) wide, 61 cm (24 in.) deep (aft panel to cabinet center), and 25 cm (10 in.) high. Removal of the small mounting shelf for the TACAN coupler would increase the height of the space to approximately 50 cm (20 in.). Wires and cables could extend beyond the 61 cm depth forward, but mechanical mountings and sway space must be restricted to the dimensions given. No specific weight restrictions have been identified. The ARN-72 unit to be removed weighs approximately 27 kg.

The antenna/preamplifier unit mounted at the top TACAN antenna location cannot protrude more than 10 to 13 cm (4 to 5 inches) inside the fuselage skin on the KC-135A. An air circulation duct running along the top centerline for nearly the entire length of the fuselage, from the cockpit to the aft end of the cargo area, restricts the available clearance. Locating the antenna/preamplifier far enough to the side of the centerline to clear this restriction would result in antenna pattern-coverage problems, since the fuselage radius is only approximately 152 cm (60 in.). This restriction on interior protrusion includes any connectors to be mounted on the bottom side of the antenna/preamplifier. No weight limitations have been identified for the antenna/preamplifier.

The CDU installation in the cabin will be by means of special mounting brackets, preferably at the navigator's station. At this location, available space between the navigator's aft instrument panel and the navigator's table measures approximately 20 cm (8 in.) high, approximately 30 cm (12 in.) wide, and 30 cm (12 in.) deep. No weight restrictions for the CDU have been identified for the KC-135A.

3.5.3.5 Electrical Power

Power for the Set Z power supply is available at 115 Vac, 400 Hz, and conforms to the limits of MIL-STD-704A as required by Set Z. Aircraft manufacturer engineers state that the 40 kVA generators on the KC-135A are typically loaded to only approximately one-eighth capacity, leaving ample reserve power for peak demands.

Panel lighting power at 5 Vac is available only on the pilot/copilot instrument panels. Panel lighting power at the navigator's station must be obtained from 28 Vac supplies available there.

Aircraft manufacturer engineers cautioned that dc power lines can carry voltage spikes of several hundred volts amplitude and several microseconds duration. These are generated by relays in some systems and tend to be observed near those systems. For this reason, they recommend zener diode protection of solid state circuitry to be powered by these lines.

Manufacturer engineers also stated that if aircraft power supply overheating is detected, power may be interrupted for 2 to 7 seconds while automatic checkout procedures occur. This is an abnormal service condition, however, and should not occur routinely. Such an interruption of power would cause Set Z to break signal track and lose navigation data, requiring a restart, reinitialization, and reacquisition, and essentially introducing a TTFF delay in the test procedures.

3.5.3.6 Heat Dissipation

Heat dissipation in the avionics cabinet is by means of cabin air drawn into the inboard side of the cabinet through a vent at the end of each shelf. Each avionics shelf is hollow with holes in the top surface, allowing cooling air to travel through each shelf and up around the avionic components. The air is then drawn out of each shelf area at the outboard cabinet side and exhausted down below the cargo floor.

The bottom shelf, actually formed by the floor of the cargo area, is not hollow and the air drawn in the inboard end of this area at the floor level circulates freely through the area. Thus, the Set Z receiver/processor and IM will be in the direct flow of this air as it first enters the bottom shelf area. Engineers of the KC-135A System Manager's office expressed the belief that there would be no heat problems, but warned that the floor-level air intake vent for this bottom shelf was sometimes blocked by carpeting, preventing effective cooling. They also warned that the pressure relief flaps on the aft panel of the cabinet are frequently bent permanently open during maintenance operations, disrupting the proper flow of cooling air.

The CDU and preamplifier units will be cooled by circulating ambient air in the cabin. The space between the antenna mount and the top air conditioning duct is relatively restricted and air flow is probably slight. However, in view of the low power consumption of the preamplifier, no heating problem is anticipated.

3.5.3.7 Pressurization

All Set Z units will be installed within the pressurized fuselage. Pressurization is according to the schedule shown in Figure 3-7. As indicated in the figure, the maximum differential pressure is 9.42 psi, positive. The antenna structure must therefore withstand this pressure differential and must provide a suitable pressure seal with the fuselage.

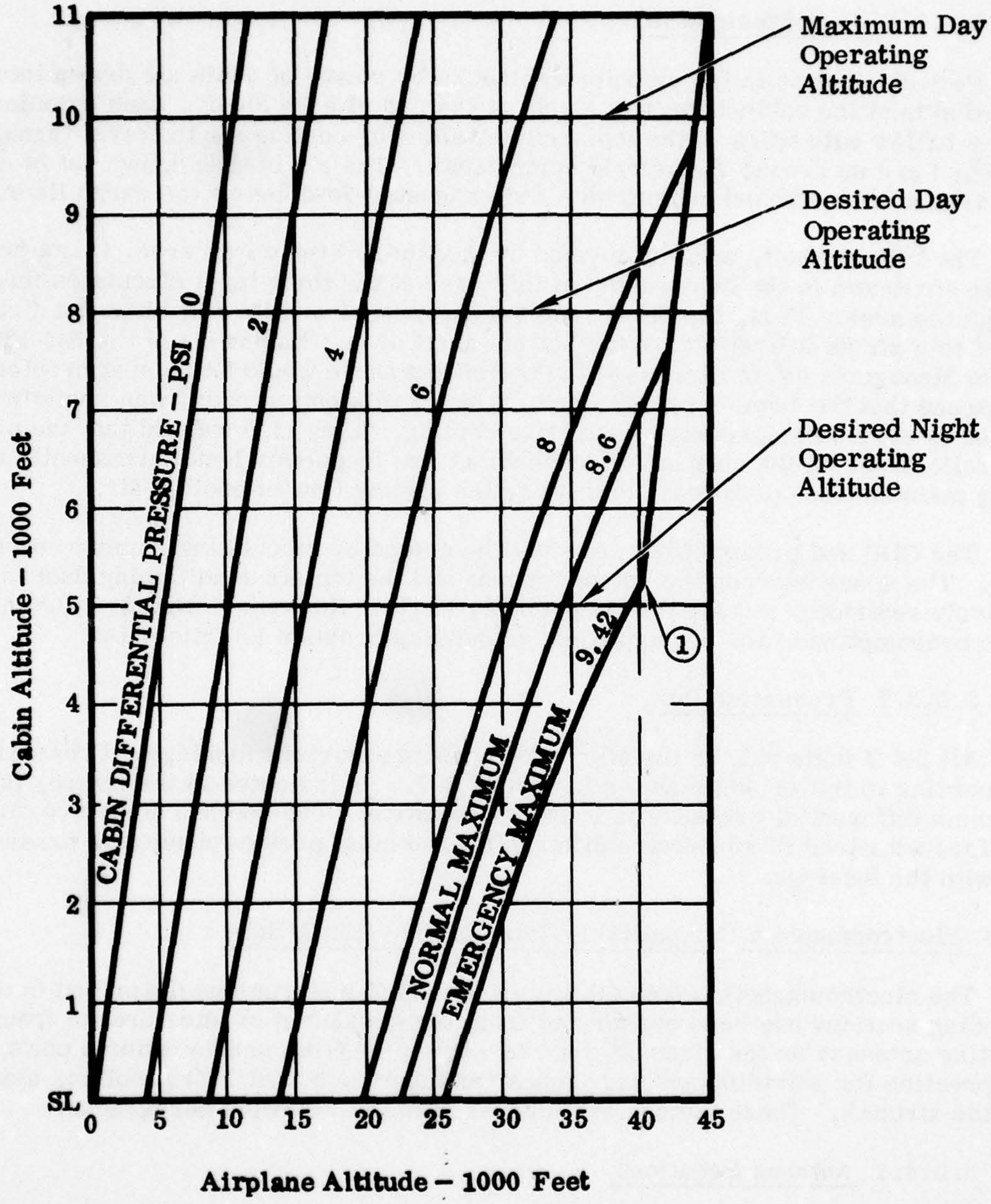
3.5.4 Electromagnetic Compatibility/Interference (EMC/EMI)

The electromagnetic compatibility of the Set Z installations described in the preceding sections has been considered from the standpoint of interference from radiating antennas on the aircraft, interference to or from nearby avionic units, common practice for shielding and wire types, and any historical EMI problems associated with the aircraft. These factors are discussed in the following paragraphs.

3.5.4.1 Antenna Locations

Figure 3-8 shows antenna locations on the KC-135A, including the top TACAN antenna to be replaced by the GPS antenna. Table 3-5 summarizes pertinent characteristics of radiating antennas, the type most likely to cause interference problems.

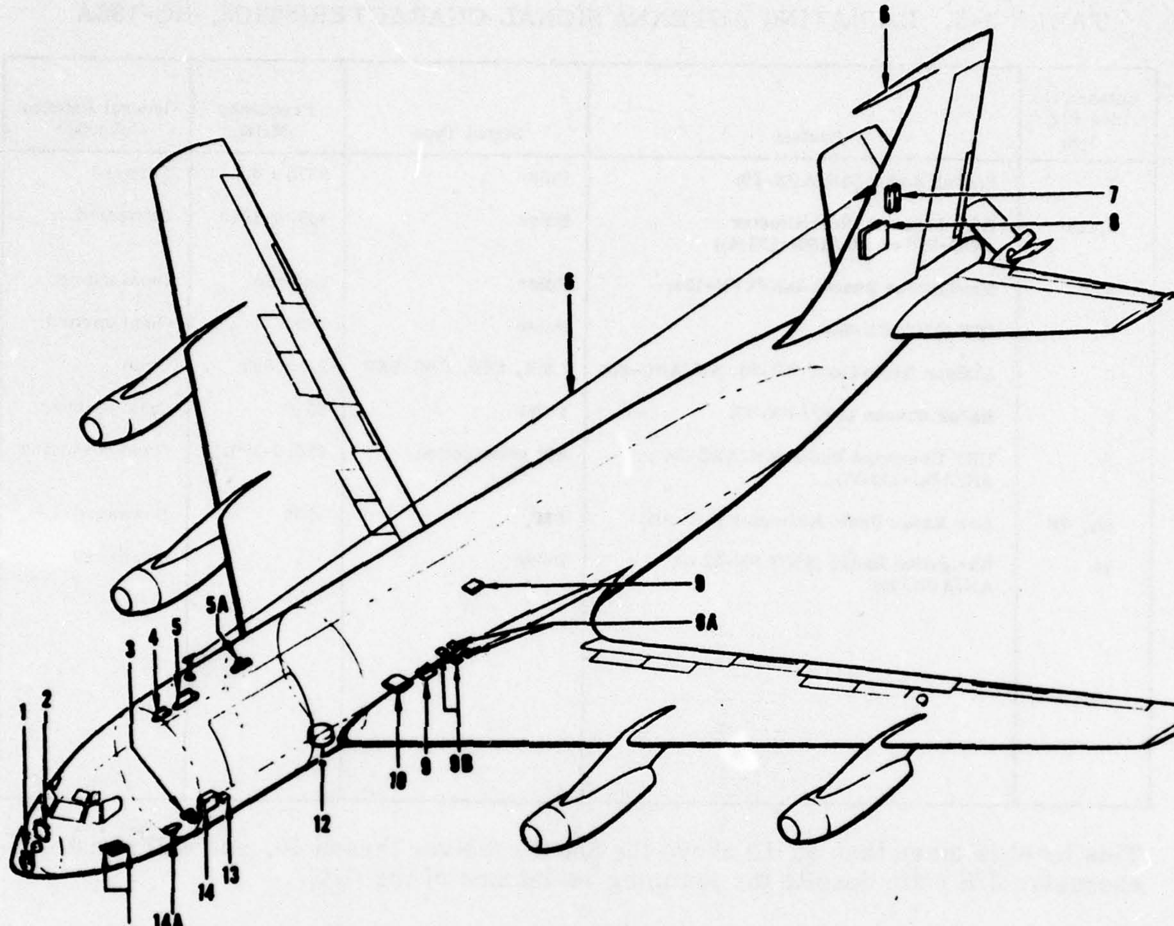
Both aircraft manufacturer and KC-135A System Manager representatives have suggested that the IFF transmitter is a possible source of interference. The AN/APX-64 on the KC-135A transmits pulsed signals at 1090 MHz and emits approximately 800 watts (29 dBW) of peak power. The pulsed nature of the signal will tend to spread some spurious noise across a wide spectrum. If the spurious noise generated in the GPS frequency band were approximately 90 dB below the peak IFF output power, and free-space path loss between the two antennas is approximately 50 dB, a noise level of as high as -111 dBW could be created at the GPS antenna during IFF operation.



(1) Estimated maximum cabin altitude during cruise as limited by engine bleed performance

(T.O. 1C-135(K)A-1, KC-135A Flight Manual, Figure 4-2, page 4-2)

Figure 3-7. Cabin Pressurization Schedule, KC-135A



1 SEARCH RADAR
2 GLIDE SLOPE RECEIVER
3 AFT HIGH RANGE RADIO ALTIMETER
4 TACAN (TOP)
5 RENDEZVOUS BEACON
5A IFF (TOP)
6 LIAISON RADIO (2 PLACES)
7 RADAR BEACON
8 VOR/ILS (VHF-NAV) RADIO
9 UHF COMMAND RADIO (2 PLACES)
9A LOW RANGE RADIO ALTIMETER (AFT)
9B LOW RANGE RADIO ALTIMETER (FORWARD)
10 MARKER BEACON
11 DELETED
12 UHF-ADF
13 TACAN (BOTTOM)
14 RADAR NAVIGATION
14A IFF (BOTTOM)
15 FORWARD HIGH RANGE RADIO ALTIMETER

Figure 3-8. Antenna Locations, Typical, KC-135A

TABLE 3-5. RADIATING ANTENNA SIGNAL CHARACTERISTICS, KC-135A

Antenna No. (See Fig. 3-8)	System	Signal Type	Frequency (MHz)	General Antenna Coverage
1	Search Radar (AN/APN-59)	Pulse	9375 ± 40	Forward
3, 15	High Range Radio Altimeter (SCR-718 or AN/APN-133(A))	Pulse	440 or 1640	Downward
5	Rendezvous Beacon (AN/APN-134)	Pulse	Ku band	Omni upward
5A	IFF (AN/APX-64)	Pulse	1090	Omni upward
6	Liaison Radio (AN/ARC-58, AN/ARC-65)	AME, SSB, CW, FSK	2-29.999	Omni
7	Radar Beacon (AN/APN-69)	Pulse	9310	Omni azimuth
9	UHF Command Radio (AN/ARC-34 or AN/ARC-133(V))	AM voice comm	225.0-399.9	Omni downward
9A, 9B	Low Range Radio Altimeter (AL-101)	FM	4300	Downward
14	Navigation Radar (AN/APN-82 or AN/APN-99)	Pulse		Downward

This level is more than 50 dB above the Set Z receiver threshold, and will create an excessive J/S ratio despite the jamming resistance of the GPS.

If the IFF does generate sufficient noise to interfere with the GPS set, the problem could be eliminated by including an appropriate emission control plan into the test plan. Operation of the IFF during the GPS tests could also offer an opportunity to evaluate interference caused by other onboard avionics.

Selection of a different GPS antenna location to reduce this problem would be difficult. Placement of the GPS antenna on the top of the tail would further separate the two antennas, increasing the path loss by approximately 20 dB. However, the lack of a horizontal surface to act as a ground plane around the GPS antenna could have detrimental effects on the antenna pattern. Additionally, this location would greatly increase the RF cable length required between the GPS preamplifier and receiver unless the receiver were also moved to the tail area. This in turn would require lengthy cable runs between the receiver/processor and the CDU and other avionics.

The other radiating antennas onboard appear to be well removed from the GPS RF, oriented away from the GPS antenna, inoperative during GPS tests, or a combination of these.

3.5.4.2 Nearby Avionics Units

Table 3-6 lists the receivers located in the KC-135A avionics cabinet along with the Set Z receiver/processor. The table indicates pertinent receiver characteristics with regard to EMI to or from the Set Z receiver.

At the time of this writing, the Set Z intermediate and local-oscillator frequencies have not been definitely selected. It is therefore impossible to identify any coincidence of IF or LO frequency with any of the receivers in Table 3-6. In view of the apparent lack of historical EMI problems on the KC-135A, however, it is not expected that any difficulties will be encountered relative to the GPS installation.

Table 3-7 lists the transmitters located in the KC-135A avionics cabinet along with the Set Z receiver/processor. The table indicates pertinent transmitter characteristics with regard to EMI to the Set Z receiver.

TABLE 3-6. RECEIVERS NEAR SET Z RECEIVER/PROCESSOR, KC-135A AIRCRAFT

Receiver	RF (MHz)	LO (MHz)	IF (MHz)	RF Sensitivity
Liaison Radio (AN/ARC-58 or AN/ARC-65)*	2-29.999	Est. 3.8-31.8, 1.5	1.8, 0.3	~1 uV for 19 dB S/N
IFF (AN/APX-64)	1030	1089.5	59.5	-66 to -78 dBm
2 UHF Radios (AN/ARC-34 or AN/ARC-133(V))	225.0-399.9	Assume 285.0-459.95	Assume 60	–

*Unit adjacent to Set Z receiver/processor.

TABLE 3-7. TRANSMITTERS NEAR SET Z RECEIVER/PROCESSOR, KC-135A AIRCRAFT

Transmitter	RF (MHz)	Modulation	Power
Liaison Radio (AN/ARC-58 or AN/ARC-65)*	2-29.999	AME, SSB, CW, FSK	25-1000W, depending on set + mode
IFF (AN/APX-64)	1090	Pulse	~800W peak
2 UHF Radios (AN/ARC-34 or AN/ARC-133(V))	225.0-399.9	AM	Assume 30-75W

*Unit adjacent to Set Z receiver/processor.

Since the IF and LO frequencies of Set Z have not been selected, the possibility of RF leakage from these transmitters interfering with the Set Z receiver cannot be accurately assessed. Direct RF interference from in-band noise generated by the IFF transmitter is doubtful, in view of the MIL-E-6051 requirement for 60 dB shielding of each of the two units and the frequency difference between them.

3.5.4.3 Wiring and Cabling

The GPS installation has been specified to take maximum advantage of existing avionics system wiring on the KC-135A. Since no known historical problems of EMI have been identified for this wiring, none are anticipated for the GPS installation. The possibility cannot be entirely ruled out, since sufficient data have not been located to estimate accurately the noise levels on the lines.

New cables and wires required for the Set Z installation have been specified in accordance with MIL-W-5088 and best engineering practices. It is anticipated that these measures will be sufficient to preclude EMI problems for the installation.

3.5.4.4 Historical EMI/EMC

Discussions with cognizant KC-135A personnel indicated that no historical EMI problems have been identified for that aircraft, other than the possible interference from the IFF as discussed above.

3.5.5 Environmental Summary, KC-135A

Table 3-8 summarizes the environmental exposure of Set Z installed in the KC-135A for GPS Phase I testing at YPG. The table presents the maximum and minimum operating and nonoperating extremes of each of the environmental parameters discussed in the preceding sections. The environmental envelope represented by the table thus shows the conditions which Set Z and the IM may experience and be required to survive during the test program.

The parameter values given in Table 3-8 apply to all Set Z and IM components unless otherwise noted. Some temperature and pressurization specifications for the antenna/preamplifier are listed separately, since this installation exposes them more directly to severe natural environments.

All of the environmental exposure levels listed in Table 3-8 fall within the service condition limits of SS-US-101B, with the exception of the operating temperature range of the antenna unit. That unit is subjected to operating temperatures below those specified in SS-US-101B (-40°C) when the aircraft is at cruising altitude. The antenna can also be subjected to operating temperatures in excess of those specified in SS-US-101B (+55°C) when on the ground in Albuquerque. It is recommended that the GPS JPO consider modifying the SS-US-101B temperature specifications for the antenna to expand the range to that which could be encountered during Phase I testing.

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DEFINITION OF REQUIREMENTS FOR INTEGRATING USER EQUIPMENT SET Z--ETC(U)

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TABLE 3-8. TEST ENVIRONMENT SUMMARY, KC-135A AIRCRAFT

Environmental Parameter	Range
Temperature	
Operating: CDU, IM, Rcvr/Proc, Preamp	-27° to 50°C (est)
Antenna	-70° to 68°C
Nonoperating: CDU, IM, Rcvr/Proc	-27° to 63°C
Antenna	-70° to 68°C
Preamp	-27° to 68°C
Humidity	
Operating and nonoperating	≤100% Antenna directly exposed to rain
Vibration	
Operating and nonoperating	≤±2g peak, 5-1000 Hz (see Figure 3-6)
Acoustic Pressure	
Operating and nonoperating	<130 dB re 0.0002 ubar
Pressure	
Operating and nonoperating	≤8,000 ft normal
Antenna/Preamp	≤~40,000 ft 9.42 psi across antenna
Wind/Dust	
Operating and nonoperating	Some blowing sand/dust at antenna; not severe
Atmospheric Pollution	
Operating and nonoperating	Slight. Some ultraviolet, ozone, nitrogen oxides
Electrical Power	Per MIL-STD-704A. Manufacturer warns of some voltage spikes on dc lines.

3.6 TEST VS. OPERATIONAL CONFIGURATION INTEGRATION REQUIREMENTS

The KC-135A test aircraft installation of Set Z is designed to conform to the probable installation in an operational vehicle to the extent practicable. The antenna/preamplifier location and installation are expected to remain as configured for the GPS IOT&E. Location of the receiver/processor unit and the IM should remain in the electronics cabinet as described. The CDU, on the other hand, may be relocated to the cockpit area of the operational aircraft. If incorporation of the GPS system causes, and is concurrent with, a major revision of the aircraft navigation system, i.e., removal of all navigation equipments which offer the same kind of information, a redesign of the cockpit control pedestal may be appropriate. In that event, the CDU would be moved to the center pedestal area for display to and control by the pilot or copilot.

A new degraded-mode caution light would be installed and permanent aircraft wiring incorporated in lieu of jumper harnesses for altitude and true airspeed inputs. Table 3-9 details the similarities and differences between the Class II (test configuration) and Class V (operational configuration) installations.

TABLE 3-9. COMPARISON OF SET Z TEST AND OPERATIONAL CONFIGURATIONS, KC-135A AIRCRAFT

Element	Test Configuration	Operational Configuration
Antenna/Preamplifier Assy	Top of aircraft @ FS 375	Same
Receiver/Processor Unit	Electronics cabinet, aircraft floor	Same
Integration Module	Electronics cabinet, aircraft floor	Same
Control/Display Unit	Navigator's table	Cockpit, possibly in a redesigned center console (pedestal)
Connection to Flight Instruments	Jumper harness to TACAN coupler plug and TACAN R/T plug	TACAN harness via new connector, added wiring
Altitude Input	Jumper harness to connect between APX-64 and altitude computer	Splice or terminal board wiring connections
TAS Input	Jumper harness to connect between upper J-box and TAS computer	Splice or terminal board wiring connections
Degraded Mode Light	Connection to RGA mode annunciator panel	New added caution light

4
TEST AIRCRAFT INTEGRATION, HC-130H

This section provides detailed information concerning the integration of UE Set Z into the HC-130H test aircraft for GPS Phase I testing. The section contains information pertaining to the derivation of requirements; a description of the test installation, cabling and connections, and electronic interfaces; and a summary of Group A items that will be required for installation and interface. All items considered relevant to installation requirements of Set Z into the HC-130H are presented in a checklist format in Appendix B.

4.1 INTEGRATION REQUIREMENTS DERIVATION

The integration requirements information contained in this section was derived from a study of technical orders and reports for the HC-130H aircraft (see bibliography, Volume I, Appendix A). Additionally, information and data were collected during trips to the HC-130H System Manager's office at Warner-Robbins Air Logistics Center; Lockheed-Georgia Company, Marietta, Ga.; and March AFB, Riverside, California (see trip and contact list, Volume I, Appendix B).

4.1.1 Physical Installation Requirements

As discussed in Section 1.2, Set Z consists of three LRUs: receiver/processor, antenna/preamplifier, and CDU. The physical configuration of the HC-130H and its associated avionics, the environment onboard the aircraft, the GPS Phase I Test Plan, and direction from the GPS JPO have imposed requirements on the physical installation of these three LRUs. The same considerations impact the IM physical installation. The specific rationale for the installation of each unit will be described along with the installation descriptions presented in the following sections.

4.1.2 Avionics Configuration

Table 4-1 lists the HC-130H avionics relevant to the integration effort. Relevancy is based upon replacement by, interface with, or potential interference to or from Set Z.

During visits to the SM at WRALC, ARINC Research determined that there are some 45 major configuration variations in 17 different models of C-130 aircraft, with a total of 673 in the Air Force inventory. C-130 aircraft use the AN/ARN-21 TACAN system. Early aircraft (C-130A, C-130B, and some C-130E models) have only one TACAN set. Later versions, including the HC-130H model proposed for the GPS test effort, have two TACAN sets installed. The early models either have no flight director system or the relatively simple MA-1, with radio magnetic indicators and course indicator flight instruments. The HC-130H has a dual flight director system, utilizing the CPU-65 unit; AQU-2/A horizontal situation indicators for display of TACAN navigation information; and the AN/ARD-17 aerial tracking system, which is characterized by a large, top-located radome.

TABLE 4-1. HC-130H AVIONICS EQUIPMENTS AFFECTED BY SET Z TEST INSTALLATIONS

Item Removed	Item Interfacing	Potential Interference
Rcvr/Trans No. 1 (RT-220C/ARN-21)	Pilot's HSI (AQU-2/A)	IFF (AN/APX-64)
	Copilot's HSI (AQU-2/A)	
Mount No. 1 (MT-928/ARN-21)	Pilot's BDHI (ID-1103/ARN)	
Control No. 1 (C-1763/ARN-21A)	Navigator's BDHI (ID-1103/ARN)	
Indicator Cplr No. 1 (161B-1)	Flight Director Computer (CPU-64/A) (2 ea)	
	Compass No. 1 (C-12)	
Top Antenna No. 1 (AT-741/A), if still installed	115 Vac Essential AC Bus	
	+28 Vdc Essential DC Bus	
	Compass No. 1 26 Vac Transformer	
	Altimeter/Encoder (AAU-21/A)	
	Transponder (RT-728/APX-64)	
	+28 Vdc Panel Lights (TB133A)	

The differing configurations may have some impact on the Set Z installation. For test purposes, the described installation should be compatible with observed variations except for early models. The control panel layout in the cockpit may require rearranging since the center console configuration may be different, even between aircraft in the same model series.

4.2 PHYSICAL INSTALLATION DESCRIPTION

The following sections describe the physical installation of Set Z LRUs in the HC-130H.

4.2.1 Receiver/Processor

The Set Z receiver/processor will occupy the cavity presently occupied by the TACAN No. 1 receiver-transmitter unit (AN/ARN-21) located in the left-hand avionics rack below the cockpit. The receiver/processor installation is illustrated in Figure 4-1.

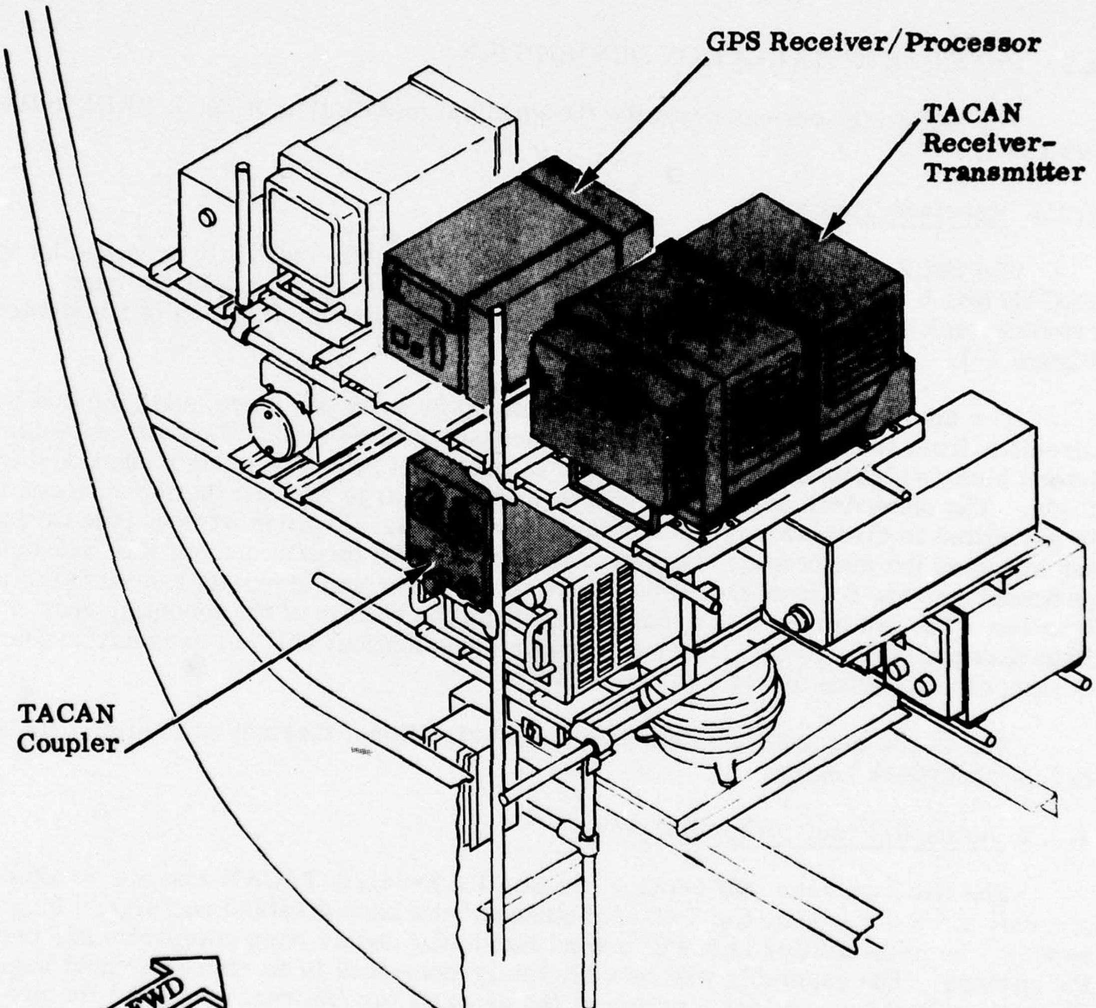
The installation at this location is dictated by avionics space available and by direction from the JPO. The receiver/processor will be mounted on vibration isolators along with the integration module, to protect it from the environment during flight. The underdeck avionics rack is open to the cargo area so that conditioned air is permitted to circulate around the equipment boxes. No compartment fans or ducting are used for electronics cooling. Ambient air will be drawn from the rack compartment into the front of the GPS receiver/processor and circulated through the unit by a fan. The hot air is then exhausted through the bottom of the mounting tray. Heat dissipation in the unit (120 watts power consumption) will not necessitate that cooling air be ducted directly to the unit.

The C-130 aircraft has not experienced significant thermal or cooling problems in this underdeck region.

4.2.2 Antenna/Preamplifier Assembly

The Set Z antenna will replace the No. 1 AT-741/A TACAN antenna on top of the aircraft at FS 517. (The top TACAN antennas have been disabled and are no longer used.) The preamplifier unit will extend inside the center wing compartment, below the antenna. The assembly will be completely contained in an unpressurized region. There is a large access panel on top of the aircraft for external access to the preamplifier compartment, and ample space inside the compartment for the GPS modification. One C-130 configuration has a fuel cell installed in this compartment, but there is sufficient room left over to accommodate the antenna/preamplifier assembly without difficulty.

The antenna location takes advantage of an existing antenna site to minimize GPS installation cost. Since the TACAN and GPS antennas operate at similar frequencies, the subject antenna location should be satisfactory from an RF pattern standpoint. Pattern blanking caused by the AN/ARD-17 antenna may occur in a small sector directly ahead of the aircraft; and also in a very narrow sector aft, caused by the vertical stabilizer. The ARD-17 radome will be transparent to the GPS signals and will not cause shadowing, although some attenuation may be experienced. Set Z is not scheduled for testing on the inverted range, and thus no bottom-mounted antenna will be required for the Set Z installation.



LH Underdeck Rack

Figure 4-1. GPS UE Set Z Receiver Installation, HC-130 Aircraft

4.2.3 Control/Display Unit

The Set Z CDU will be mounted on the upper left hand portion of the cockpit center console, replacing the TACAN No. 1 control panel. A blank panel must be removed and existing communications control panels will have to be rearranged to accommodate the CDU. A possible console configuration is shown in Figure 4-2.

Numerous variations in the control console may exist due to the many aircraft models and system modifications. Several of the possible configurations have been examined with respect to the CDU installation, and no significant impediments to CDU location or installation were found. On some aircraft models it might be necessary to remove another functioning control panel (possibly one of the two radio compass controls) to obtain sufficient room for the CDU. For Class V modifications, however, removal of that panel may not be necessary; see Section 4.6.

4.2.4 Integration Module

The Integration Module is installed in the receiver/processor mounting, as shown in Figure 1-1. The installation permits independent Set Z operation, removes power elements (synchro drivers) from the basic LRU for better thermal performance, and enables use of a standardized LRU design in the HC-130H aircraft. Cooling of the unit (120 watts power consumption) will be by ambient cargo compartment air in the vicinity of the avionics racks; ducting of cooling air directly to the IM is not contemplated.

4.3 ELECTRONIC INTERFACES

4.3.1 Functional Interfaces

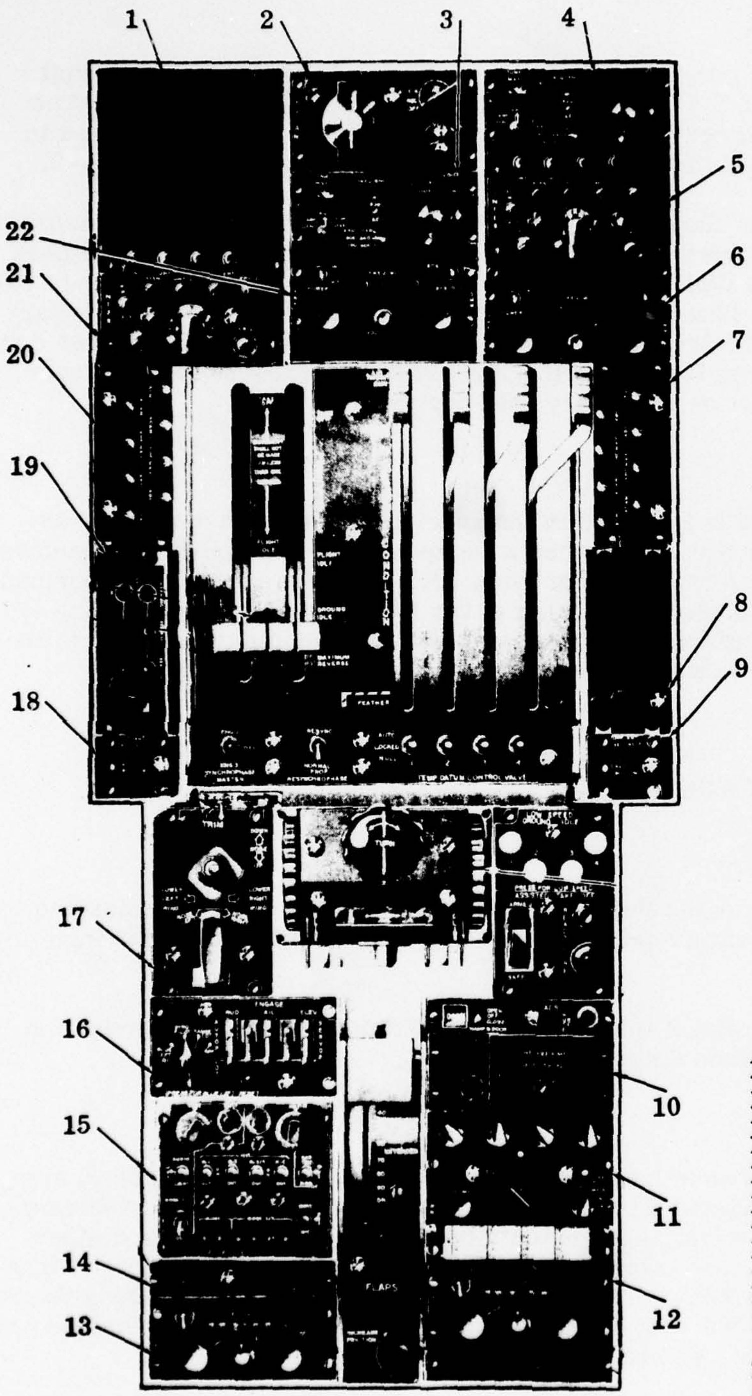
Electronic interfaces for the Set Z installation in HC-130H are summarized in Table 4-2. That table is a matrix of avionic system/component vs. signals input to or output from Set Z.

The relationship of the Set Z test installation to the onboard radio navigation system is shown in the interface diagram, Figure 4-3.

4.3.2 Wiring and Connectors

The cabling and interconnections between LRUs of Set Z and the aircraft systems are shown in the cabling and interwiring diagrams, Figures 4-4 and 4-5 respectively. Pin connections and wiring assignments between Set Z, the IM, and other interfacing onboard avionics take into account wire bundling, shielding, spares locations and mateability with existing aircraft harnesses. Reassignments during the Set Z design phase must be consistent with the use of these existing aircraft wiring harnesses in any of the test installations, as shown in the cabling diagrams.

The interwiring layout was influenced by the requirement that Set Z continue to operate independently in the event of a failure in the IM. The selection of the connectors specified in the Group A listing (see Section 4.4) was based on functional and environmental considerations and a requirement to mate to the TACAN coupler, TACAN control panel, and altitude-source harnesses. For the receiver/processor



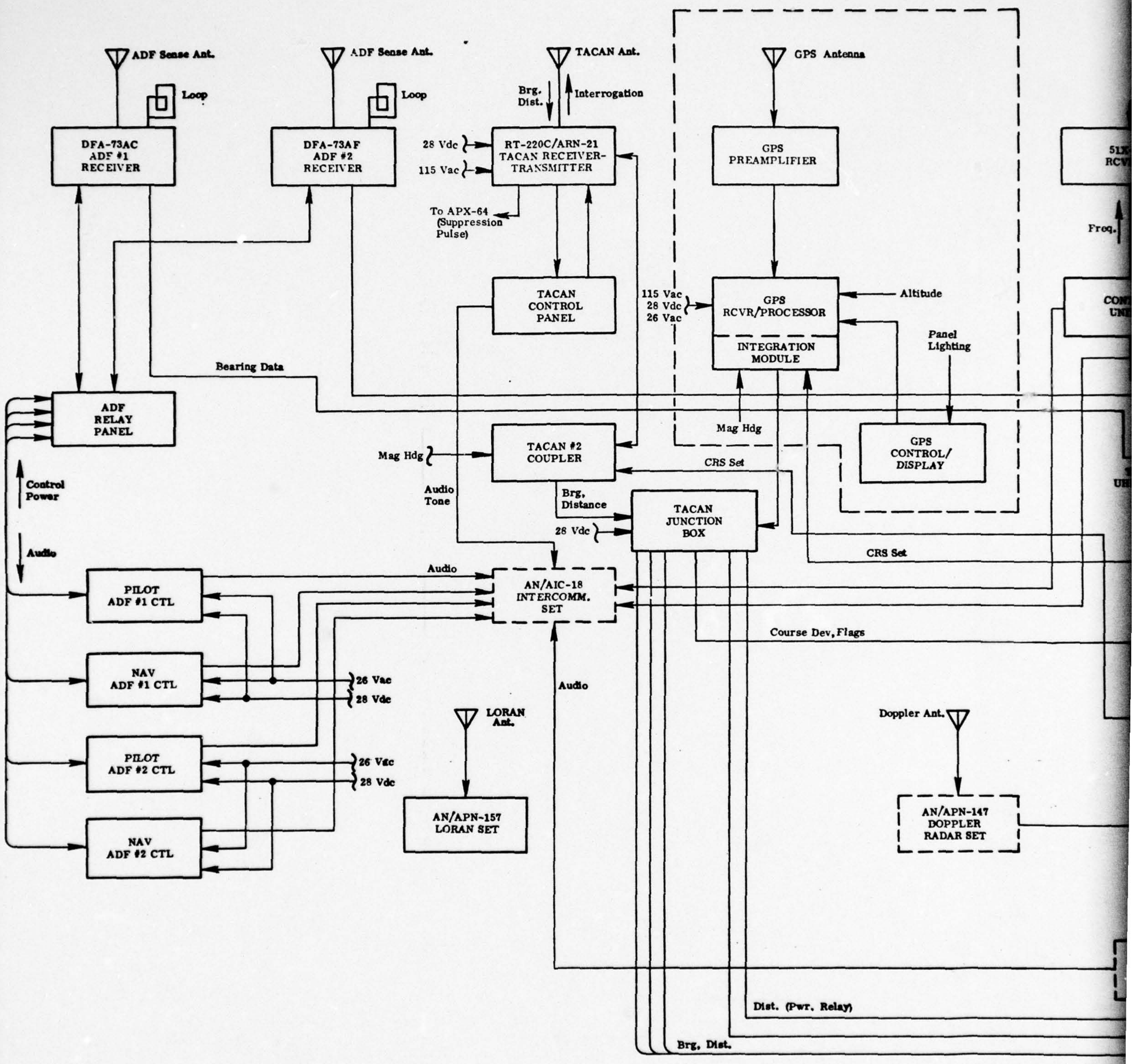
1. GPS CDU
2. TACAN CONT. PANEL
3. ADF #1
4. ADF #2
5. COPILOT'S ICS C/P
6. VHF COMM #2
7. COPILOT'S ICS SW
8. IFF ANT.
9. UHF #2 ANT.
10. UHF #1 PREAMP
11. UHF #1
12. VOR #2
13. VOR #1
14. IFF MONITOR
15. IFF
16. AUTOPILOT
17. TRIM TAB
18. UHF #1 ANT.
19. CPI
20. PILOT'S ICS SW
21. PILOT'S ICS C/P
22. VHF COMM #1

Figure 4-2. HC-130H Center Console with GPS Set Z CDU Test Installation

TABLE 4-2. ELECTRONIC INTERFACE SIGNALS, HC-130H AIRCRAFT

Avionic System/ Component	Set Z Interface Signals: Set Z Output to Systems/Displays: Digital Navigation Data	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.		Course Set	Inputs to Set Z: A/C Power, 115 Vac, 400 Hz	A/C Power, 28 Vdc	Synchro Ref. 26 Vac, 400 Hz, ØA	Altitude	Panel Lighting*	Digital Control Data	Magnetic Heading	
1. Set Z CDU	X														X		
2. Pilot's HSI (AQU-2/A)		X	X	X	X		X		X								
3. Pilot's BDHI (ID-1103/ARN)		X	X	X													
4. Pilot's Flight Director System (CPU-65/A)					X	X											
5. Copilot's HSI (AQU-2/A)		X	X	X	X		X										
6. Copilot's Flight Director System (CPU-65/A)					X	X											
7. Nav's BDHI (ID-1103/ARN)		X	X	X													
8. Autopilot (E-4)					X												
9. Altimeter (AAU-21/A)													X				
10. Pilot's Compass System (C-12)																X	
11. Control Pedestal Lighting System, +28 Vdc														X			
12. Essential AC Bus										X							
13. Essential DC Bus											X						
14. Compass No. 1 Transformer												X					

*Direct to CDU


ADF Sense Ant.
Loop
DFA-73AC
ADF #1
RECEIVER
ADF Sense Ant.
Loop
DFA-73AF
ADF #2
RECEIVER
TACAN Ant.
Brg.
Dist.
Interrogation
28 Vdc
115 Vac
RT-220C/ARN-21
TACAN RECEIVER-
TRANSMITTER
To APX-64
(Suppression
Pulse)
TACAN
CONTROL
PANEL
GPS Antenna
GPS
PREAMPLIFIER
115 Vac
28 Vdc
26 Vac
GPS
RCVR/PROCESSOR
Altitude
INTEGRATION
MODULE
Panel
Lighting
Bearing Data
ADF
RELAY
PANEL
Mag Hdg
GPS
CONTROL/
DISPLAY
Mag Hdg
TACAN #2
COUPLER
CRS Set
Control
Power
Audio
Tone
Brg,
Distance
TACAN
JUNCTION
BOX
28 Vdc
Audio
Audio
CRS Set
PILOT
ADF #1 CTL
AN/AIC-18
INTERCOMM.
SET
NAV
ADF #1 CTL
26 Vac
28 Vdc
Course Dev, Flags
Audio
LORAN
Ant.
Doppler Ant.
PILOT
ADF #2 CTL
26 Vac
28 Vdc
AN/APN-157
LORAN SET
AN/APN-147
DOPPLER
RADAR SET
NAV
ADF #2 CTL
Dist. (Pwr. Relay)
Brg. Dist.
Freq.

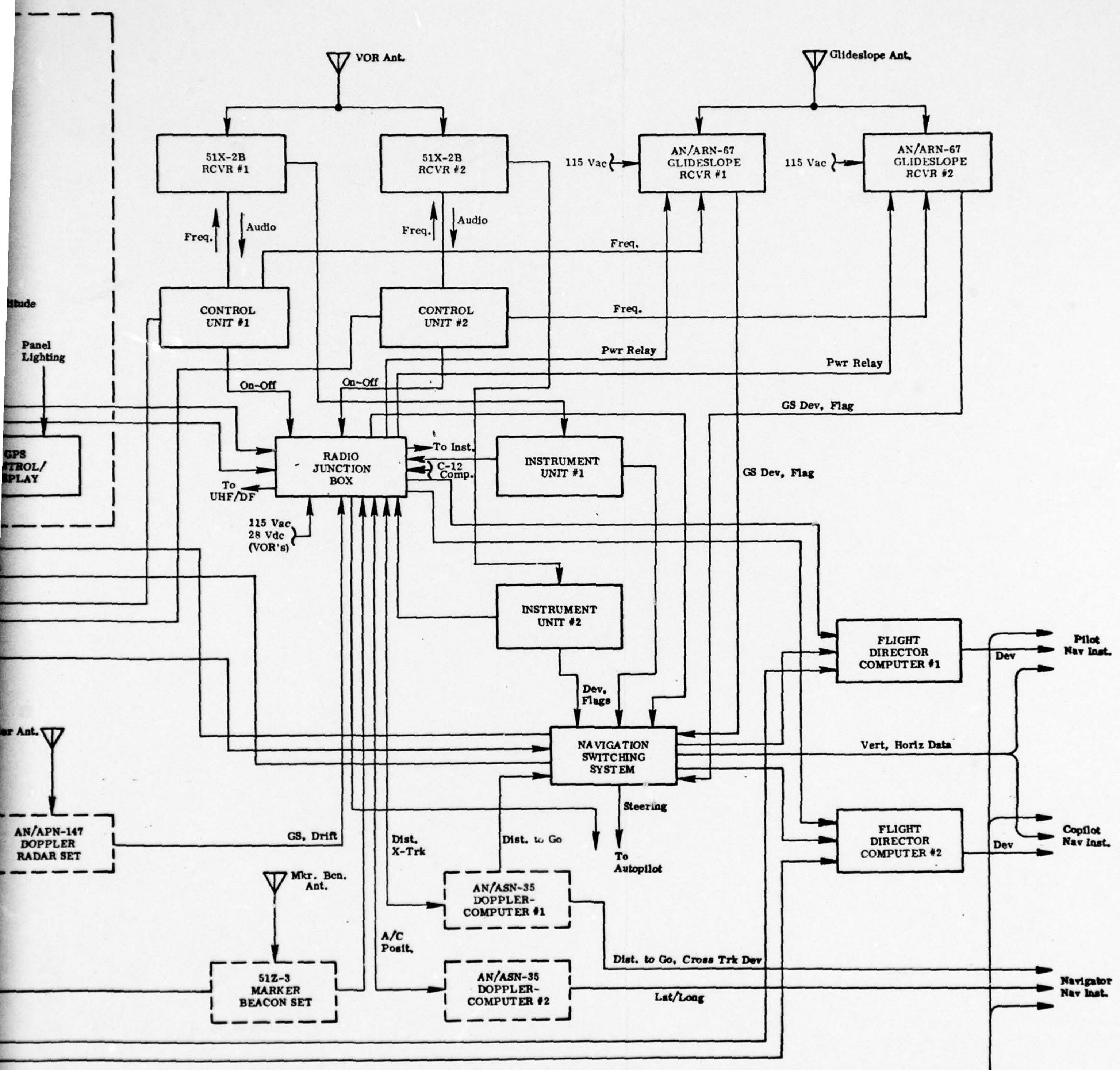


Figure 4-3. HC-130H Radio Navigation System Interface Diagram — GPS Test Installation

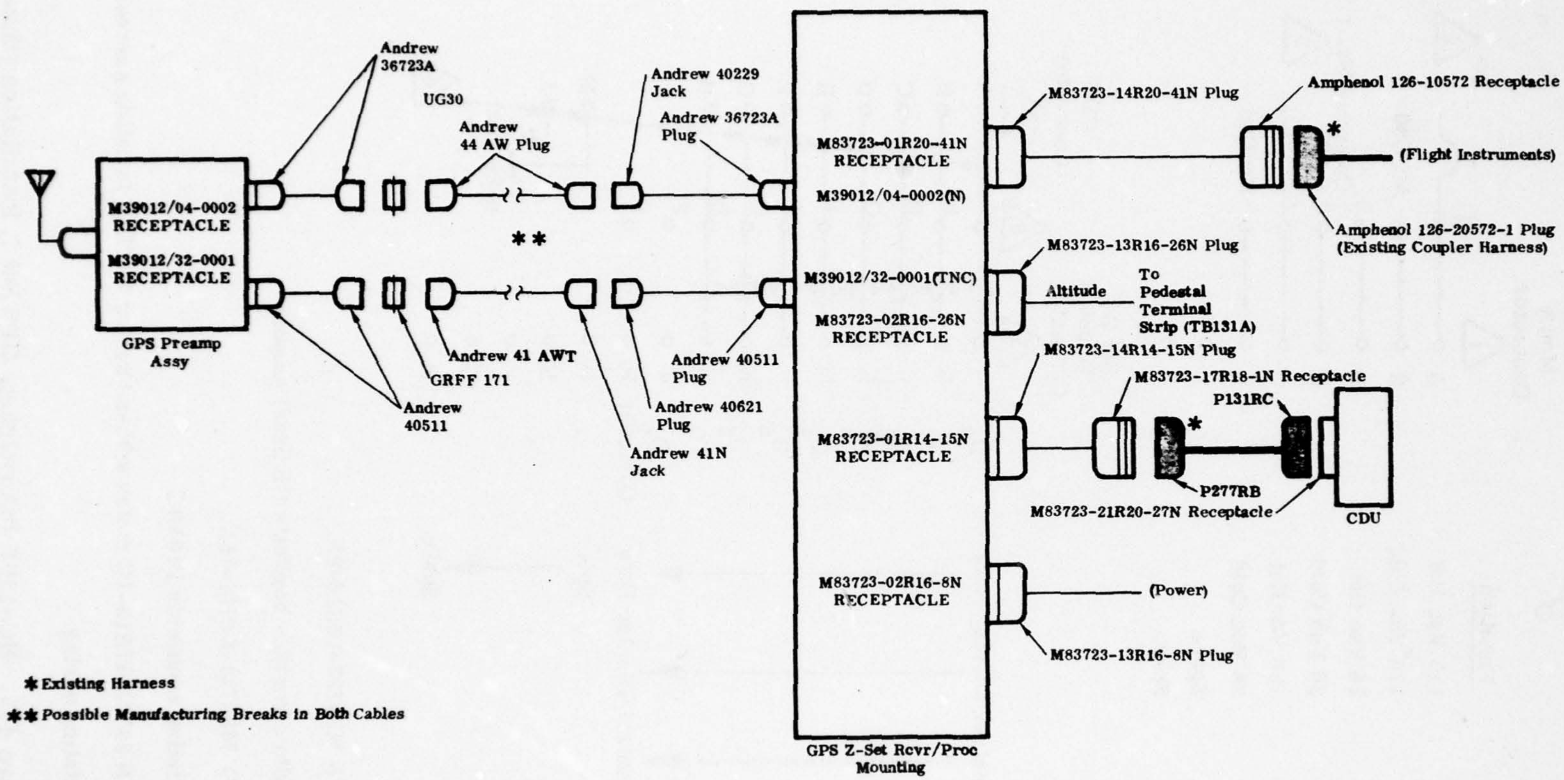
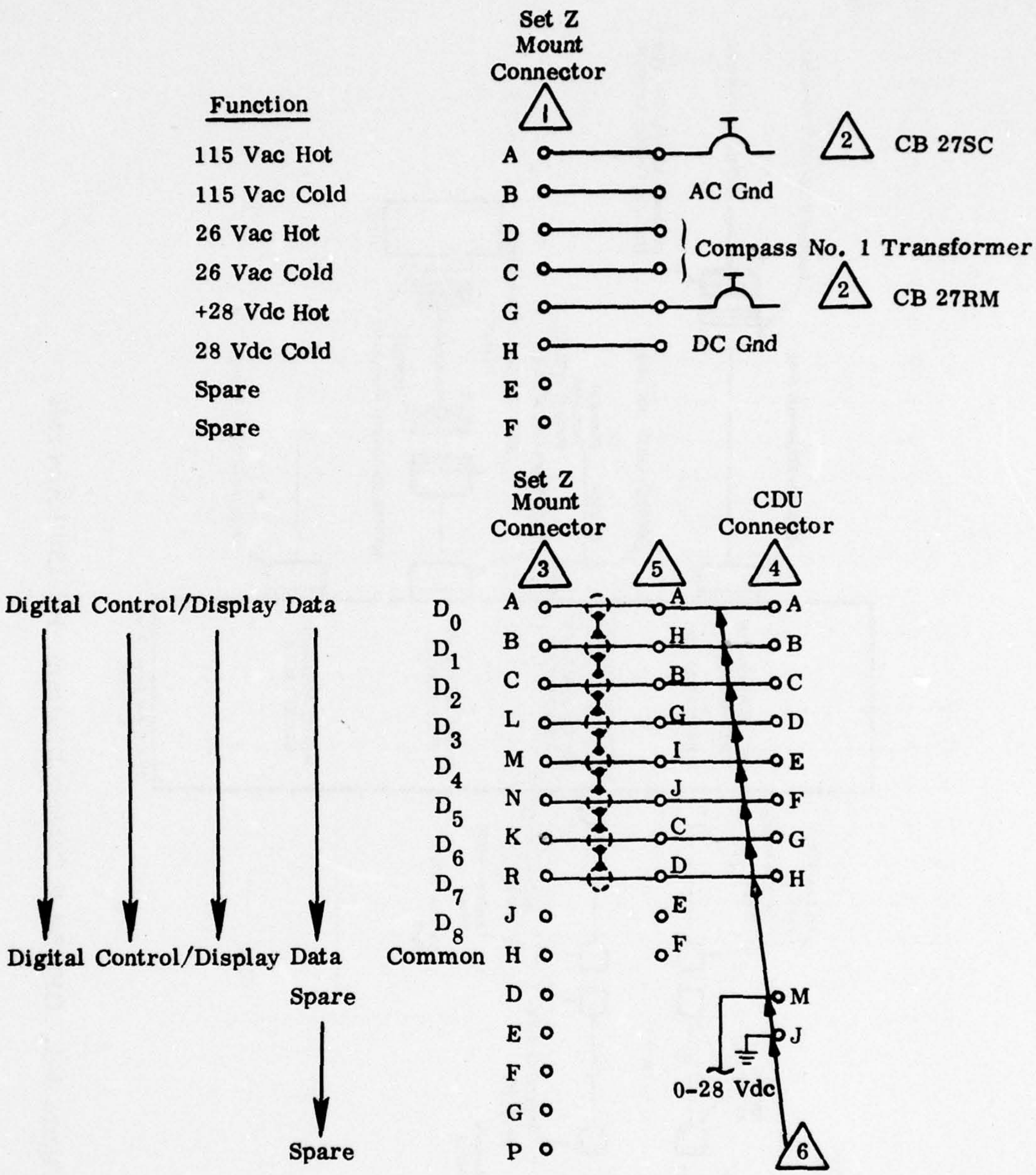
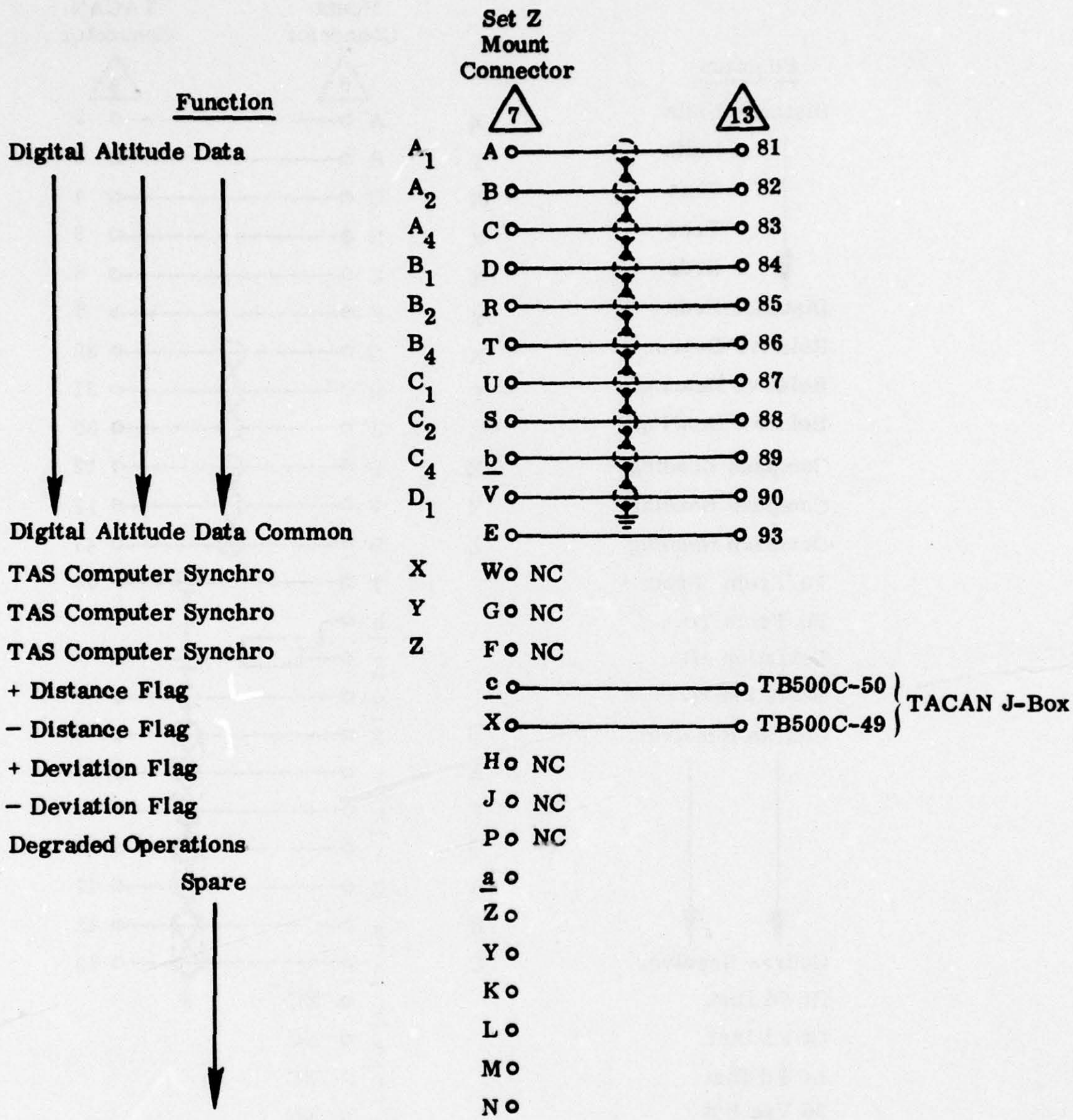


Figure 4-4. GPS Set Z Cabling Diagram, HC-130H Aircraft



1. P/N M83723-13R16-8N
2. Radio circuits - copilot's CB panel (upper)
3. P/N M83723-14R14-15N
4. Existing connector P131RC
5. P/N 83723-17R18-1N mated with connector P277RB (existing harness)
6. Existing wiring

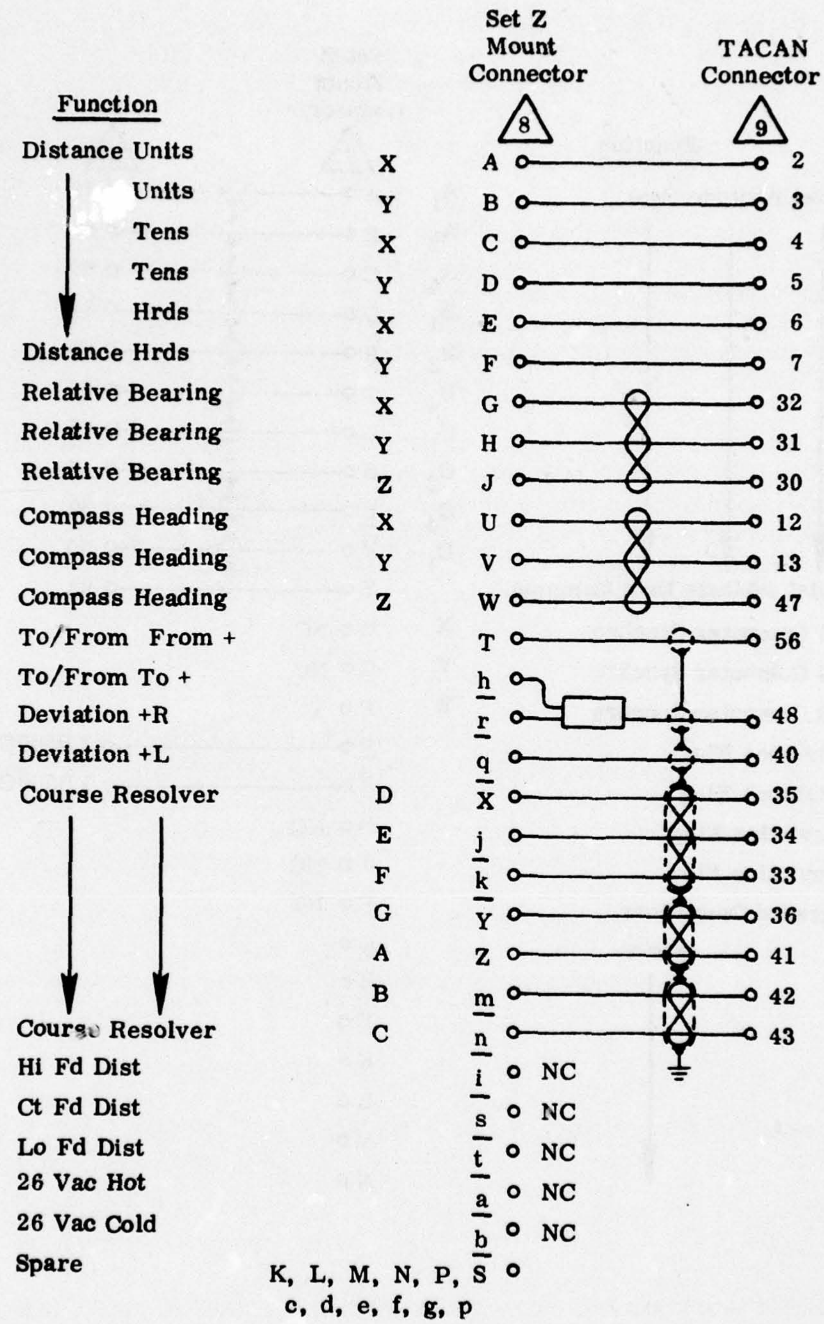
Figure 4-5. HC-130H Interwiring, GPS Set Z Installation (Sheet 1 of 4)



△7 P/N M83723-13R16-26N

△13 Pedestal terminal strip TB131A (forward end)

Figure 4-5. (Sheet 2 of 4)



8 P/N M83723-14R20-41N

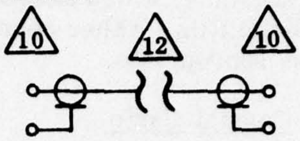
9 P/N 126-10572 (Amphenol), mates with TACAN coupler plug

Figure 4-5. (Sheet 3 of 4)

Function

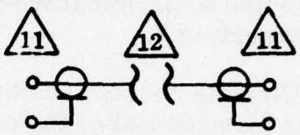
Amplified RF/+15 Vdc

Set Z
Connector



Calibration Signal

Set Z
Connector



△10 P/N 36723A (Andrew)

△11 P/N 40511 (Andrew)

△12 Intermediate connectors and bulkhead adapters

Figure 4-5. (Sheet 4 of 4)

unit and IM, the selection of connectors is guided by ARINC Specification 404A, used by commercial airlines, which recommends the use of plug-in DPX or similar connectors on equipment LRUs. Other connectors were selected from MIL-C-83723 and MIL-C-39012 as appropriate.

4.3.2.1 Coaxial Cable

Installation of semi-flexible cable presents a special problem in any retrofit installation due to cable rigidity and the "clutter" in the cable run path. Bulkhead connectors will be necessary at the forward wall of the center wing compartment to permit transition into the pressurized cabin area. These adapters should be placed to the left of centerline to permit installation without removal of the overhead structure in the cargo compartment.

The semiflexible cables should be attached to the overhead framers at about LBL 48. At the forward end of the cargo compartment, the cables will descend behind the bulkhead then continue forward to the avionics rack structure. Manufacturing breaks in the cables at top and bottom of the cargo compartment forward bulkhead may be expected. Connector-transition to flexible service loops are expected at the right side of the avionics rack, 115 cm above the aircraft deck. Service loop lengths will be limited to about 75 cm.

4.3.2.2 Altitude Input Connections

A special harness must be fabricated that will permit coupling into the altitude data lines between the encoder-altimeter and the AIMS transponder. The harness (11 wires) is connected to a pedestal terminal strip, TB-131A (forward end), studs 81 through 90 and 93. The altitude harness terminates at a 26-pin connector on the Set Z receiver/processor mounting. Wires are individually shielded.

The suggested harness is depicted in the cabling diagram, Figure 4-4. The indicated terminal board connections will permit easy conversion of aircraft wiring back to its original condition when the GPS equipment is removed.

4.4 GROUP A ITEM REQUIREMENTS

The Group A items required to effect Set Z integration and installation in the HC-130 are listed in Table 4-3.

4.5 EQUIPMENT ENVIRONMENTS

Environmental requirements for the Set Z installation in the HC-130H are derived by combining a history of exposure to various conditions with the natural environmental characteristics and the aircraft-induced or -controlled environmental characteristics. The result is a comprehensive environmental envelope for the HC-130H test activities. The exposure history, natural environment, and aircraft environment are described below, followed by a summary of the total environmental envelope.

TABLE 4-3. GROUP A INSTALLATION ITEMS FOR UE SET Z ON HC-130H AIRCRAFT (Sheet 1 of 3)

Item	Qty	Remarks
a. Receiver/Processor Mounting	1	
Connector, M24308/2-4	1	
Connector, DPX, M81659/31A2-0042	1	
Connector, DPX, M81659, 31A2-0034	1	
Connector, M83723-02R16-8N	1	
Connector, M83723-01R20-41N	1	
Connector, M83723-01R16-26N	1	
Connector, M83723-01R14-15N	1	
Vibration mounts, Lord 150PHL8	4	
Holddown, Type C Hollingsead-Pryor	3	
b. Control/Display Mounting	–	Use TACAN No. 1 control panel harness and connector
c. Antenna/Preamplifier Mounting	1	
Doubler	TBD	Structural details to be designed by the installer.
Gasket	↓	
Screws	↓	
Brackets, mounting	TBD	
d. Integration Module Converter	1	
e. Integration Module Driver	1	

TABLE 4-3. (Sheet 2 of 3)

Item	Qty	Remarks
f. Aircraft Wiring		
Connector, Amphenol, 126-10572 (receptacle)	1	Mates with TACAN coupler plug
Connector, M837-13R16-8N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R20-41N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-13R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R14-15N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-17R18-1N (receptacle)	1	Mates with existing P227RB plug - TACAN harness
Connector, N, Andrew 41N	1	Mates with service loop plug
Connector, N, Andrew 44AW	2	Mates with service loop jack; bulkhead adapter
Connector, TNC, Andrew 40511	3	Mates with TNC female on receiver; preamplifier jack; bulkhead adapter
Connector, N, Andrew 36723A	3	Mates with N female on GPS receiver; preamplifier jack; bulkhead adapter
Connector, N, Andrew 40621	1	Mates with calibration line jack
Connector, N, Andrew 40229	1	Mates with signal input line plug
Connector, TNC, Andrew 41AWT	1	Mates with bulkhead adapter
Adaptor, bulkhead, N, UG30/U	1	Couples the RF signal line through the pressure bulkhead to the preamplifier RF coaxial cable
Adaptor, bulkhead, TNC, GRFF No. 171	1	Couples the calibration line through the pressure bulkhead to the preamplifier calibration coaxial cable

TABLE 4-3. (Sheet 3 of 3)

Item	Qty	Remarks
f. Aircraft Wiring (Cont)		
Cable, coaxial, Andrew FHJ4-50B		Signal line
Cable, coaxial, Andrew FHJ1-50		Calibration line
Cable, coaxial, Andrew FSJ1-50		Service loop, preamplifier connection
Cable, coaxial, Andrew FSJ4-50		Service loop, preamplifier connection
Wire and cable		Various types as required
Decals, assorted GPS		

4.5.1 Exposure Time History

Figure 4-6 shows a time history of exposure of Set Z to the environmental factors to be encountered during testing inthe HC-130H at YPG. It has been assumed that the host test aircraft will be dedicated full time to the tests and will be stationed at Kirtland AFB, Albuquerque, N.M. The aircraft will depart from and return to that base for each day of flight testing.

The sequence of events and duration of each shown in Figure 4-6 are intended to be representative of the test operations to be conducted. While it is realized that any given test exercise may deviate from the sequence shown, it is considered that the events shown in the figure are sufficient to expose Set Z to all environmental extremes to be encountered. For example, since the time of day of satellite visibility will vary, and since the aircraft could be left on the ground at any time of day or night, relatively long on-the-ground events have been assumed to last 24 hours. Thus, Set Z will experience at Albuquerque both overnight low temperatures of winter months and daytime high temperatures of summer months, thereby defining the natural temperature exposure extremes.

4.5.2 Natural Environment

Table 4-4 summarizes the ground level climate in Albuquerque on a monthly and annual basis. The data were obtained from U.S. Weather Bureau records. The HC-130H at Kirtland could be exposed to any of these conditions, and the resultant environmental exposure of Set Z equipment would be as discussed in the following paragraphs.

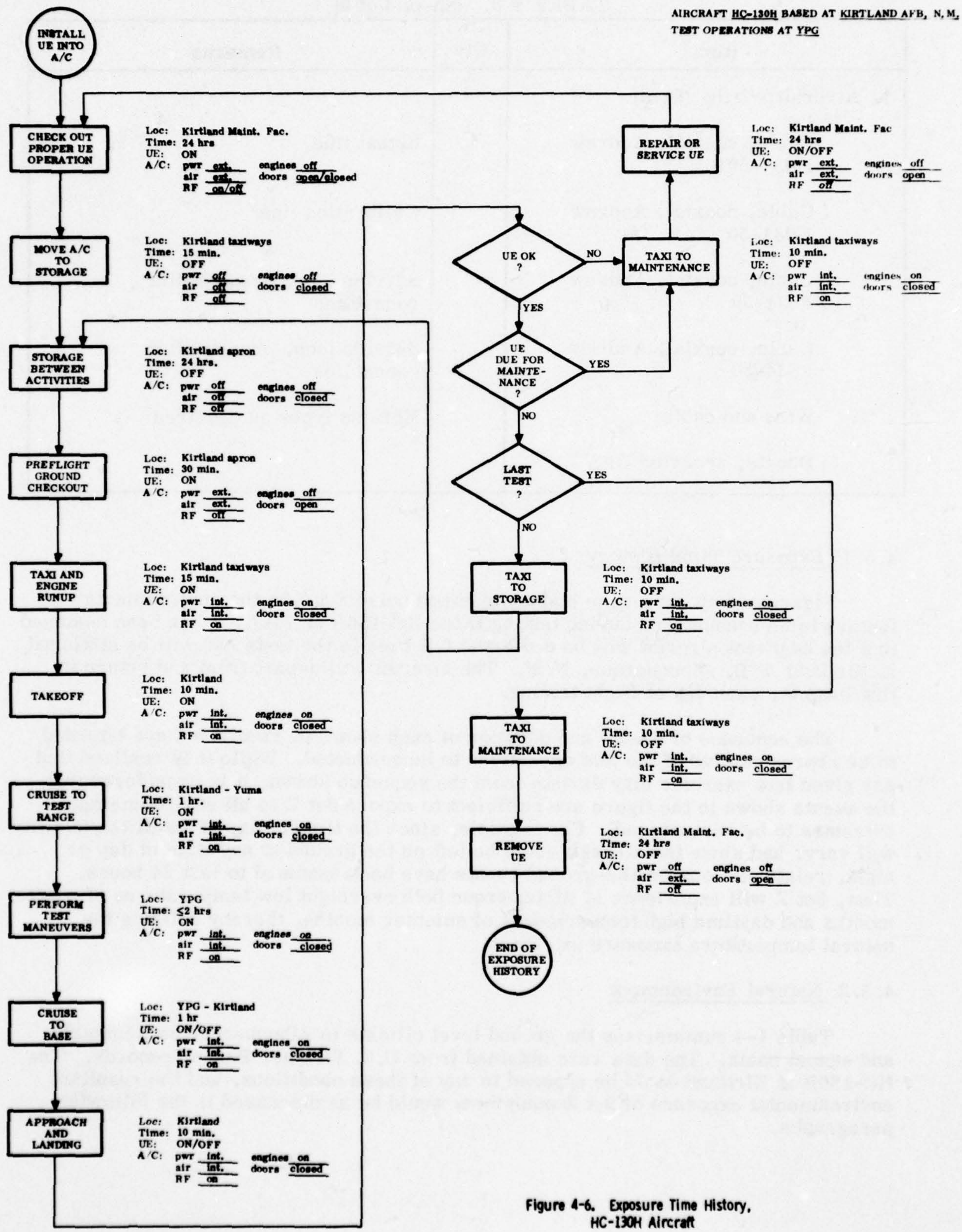


Figure 4-6. Exposure Time History, HC-130H Aircraft

TABLE 4-4. ALBUQUERQUE CLIMATE SUMMARY

Month	Temperature (° F) Avg Max	Avg Min	Max Ever	Min Ever	Humidity (%) 0500 Hours	1100 Hours	1700 Hours	2300 Hours
Jan	46.9	23.5	69	-17	66	48	36	57
Feb	52.6	27.4	75	1	62	43	32	51
Mar	59.2	32.3	85	9	54	32	24	41
Apr	70.1	41.4	89	22	45	25	18	33
May	79.9	50.7	94	28	44	23	16	31
Jun	89.5	59.7	102	42	45	24	18	32
Jul	92.2	65.2	104	54	61	36	28	49
Aug	89.7	63.4	99	52	65	39	30	52
Sep	83.4	56.7	94	37	58	40	30	52
Oct	71.7	44.7	87	25	58	37	29	47
Nov	57.1	31.8	73	12	64	43	35	54
Dec	47.5	24.9	68	4	69	51	43	60

Month	Normal Mean Precipitation (in.)	Normal Mean Wind Speed (mph)
Jan	0.30	7.9
Feb	0.39	8.8
Mar	0.47	10.0
Apr	0.48	10.9
May	0.53	10.5
Jun	0.50	9.9
Jul	1.39	9.1
Aug	1.34	8.1
Sep	0.77	8.5
Oct	0.79	8.3
Nov	0.29	7.7
Dec	0.52	7.6
Annual	7.77	8.9

Note: Data interval: average monthly maximum temperatures, and average monthly precipitation, 1941-1970; temperature extremes, 1959-1973; humidity readings over 13-year period; winds over 34-year period. U.S. Dept. of Commerce, Local Climatological Data, Albuquerque, New Mexico, 1973.

4.5.2.1 Temperature

As shown in Table 4-4, the coldest temperature recorded at Albuquerque is -27°C (-17°F). Any of the Set Z LRUs could be exposed to this temperature level if the aircraft were left outside overnight. Set Z would be nonoperating under these conditions.

The highest temperature shown for Albuquerque is 40°C (104°F). Inside a closed large aircraft parked in the sun, temperatures could reach 63°C (145°F). The Set Z receiver/processor, CDU, and IM could be exposed to these temperature levels in a nonoperating condition. The external antenna and the preamplifier mounted adjacent to the top fuselage skin could experience temperatures even higher due to direct solar heating (estimated 68°C or 154°F).

For Set Z operation, it is assumed that the aircraft or external cooling system would reduce temperatures in the aircraft to those suitable for the system operating personnel, who would not activate the system until the inside air temperature had cooled to at least 43°C (110°F). The antenna and preamplifier could remain near 68°C, however, since they are external to the air conditioned area (see Section 4.5.3.3).

For cold-day or nighttime tests, it is assumed that temperatures inside the aircraft will be raised to crew comfort levels at or shortly after system activation. Start-up temperatures could be near the Albuquerque low of -27°C (-17°F).

At a cruising altitude of 25,000 to 30,000 feet, outside air temperatures in the order of -65°C could be expected, according to MIL-STD-210B. The antenna would be directly exposed to this air, and the unheated preamplifier area (see Section 4.5.3.3) could be cooled to nearly that temperature.

4.5.2.2 Humidity

As indicated by Table 4-4, the humidity at Albuquerque is typically low or moderate. However the antenna will be exposed directly to occasional rainstorms; and depending on the weather sealing provided for the preamplifier installation, some moisture could collect around that unit. The Set Z receiver/processor, CDU, and IM will not be subjected to direct rainfall, but air of nearly 100% humidity could be drawn into the aircraft under some startup or ground operation conditions.

4.5.2.3 Wind/Dust

Winds at Albuquerque are typically light (see Table 4-4), but substantial gusting (monthly record maximums of 57 to 90 mph) can occur at any time of year. This condition, coupled with the dryness of the area, leads to occasional but substantial amounts of blowing sand and dust. Wind over 32 mph is reported by the Weather Bureau on an average of 46 days each year. Minor abrasive effects from blowing sand can be expected occasionally at the external antenna location, although the top, flush-mounted antenna installation should minimize this effect. Dust in the areas inside the HC-130H fuselage should be of minimal significance to the Set Z electronics.

4.5.2.4 Precipitation

Precipitation at Albuquerque averages only 7.77 inches per year, typically less than one-half inch per month. Precipitation will impact only the antenna and preamplifier design and installation. Due to freezing winter temperatures, the antenna weather seal should be designed so as not to trap water that could subsequently freeze and expand to stress the antenna or seal.

4.5.2.5 Atmospheric Pollution

Atmospheric pollution in Albuquerque is not expected to present any severe design problems. Due to the high altitude (approximately 5300 feet) and the generally clear air, ultraviolet radiation levels are relatively high. The air contains no significant amounts of sulfur oxide products, but measurable levels of nitrogen oxides. The highest ozone level recorded near Kirtland AFB is 135 parts per billion, although records have been kept for only a few years. The summer months have the highest ozone counts, with the federal standard of 80 ppb being exceeded typically 15 to 20 times during June and July. Monthly average high ozone counts are shown in the table below.

Month	J	F	M	A	M	J	J	A	S	O	N	D
High ozone count (ppb)	45	50	50	30	60	100	85	60	–	50	55	55

Exposed or unprotected materials, especially rubber and plastic seals and insulation, will have to survive these pollution levels without unacceptable degradation of performance or characteristics.

4.5.3 Aircraft Environment

The following paragraphs summarize the environment onboard the HC-130H during Phase I test operations. All data are derived at the specific installation locations of the Set Z equipment when source data resolution permits. A substantial amount of flight test data for the HC-130 were obtained from Lockheed test reports.

4.5.3.1 Mechanical Vibration

Flight test results reported in Lockheed-Georgia Report No. ER-6707 (see bibliography, Volume I) indicate that the highest overall vibration levels in the 5 to 2500 Hz range are as shown in Table 4-5. The tests also show that vibration peaks occur at propellor blade frequencies (approximately 65 to 72 Hz) and multiples thereof.

TABLE 4-5. PEAK OVERALL VIBRATION LEVELS, HC-130H

Location	Direction	Flight Condition	Overall Vibration (grms)
Pilot's seat rail	Vertical	Power for max endurance at 3,000 ft alt	0.20
Pilot's instrument panel	Lateral	Takeoff power on ground	0.07
Cargo floor, FS 300-780	Vertical	Normal rated power, 20,000 ft alt	0.85
Right-side fuselage, FS 168-583	Radial	Takeoff power on ground	2.90

The same Lockheed report contains a number of vibration power spectral density plots showing the vibration peaks at the propellor blade frequencies and associated harmonics. The largest of these peaks measured forward of FS 300 is 0.9 g^2/Hz, recorded in the radial direction on the fuselage at FS 168, WL 240. Since the analysis instrumentation bandwidth was 10 Hz, this corresponds to a level of 3 g at this peak.

The C-130 System Manager's office provided a plot of the vibration qualification test levels specified for equipment to be mounted in the flight station or electronics area, forward of FS 245, in the HC-130H. This plot is presented here as Figure 4-7, and can be seen to indicate a substantial safety margin over the maximum observed vibration levels. The 10.5g level exceeds the current GPS UE specification (MIL-E-5400, Figure 2, curve IV A), but by only 0.5g; and the plot shown does not require vibration to as high a frequency as the UE specification (500 Hz vs. 2000 Hz).

4.5.3.2 Acoustic Vibration

Little data on acoustic pressure were obtainable for the HC-130H. However, in the general descriptions obtained there were no mentions of excessive noise levels in the flight station or electronics areas. The only locations where noise levels were high enough to merit specific mention are in the cargo area, when the recirculating fan is operating; and in the immediate vicinity of the fuselage skin near FS 280 and 550, where propellor noise in the 37.5-75 Hz octave band was termed "excessive" in the above-referenced Lockheed report. The report also stated that fan noise did not contribute significantly to the noise level in the flight station.

Based upon these reported observations and the general remarks of Air Force Flight Dynamics Laboratory personnel regarding noise in large aircraft, it is concluded that the noise on the HC-130H will not impose any design problems on Set Z equipment.

4.5.3.3 Temperature and Humidity

A flight test report summarizing a temperature survey of a C-130E aircraft provided operating temperatures at anticipated Set Z LRU installation locations. The tests were performed in response to Lockheed-Georgia Engineering Flight Test Request 7205-73-0003, dated October 10, 1973 and were reported in an unnumbered Lockheed document titled C-130 Avionics Equipment Temperature Survey 212E, dated February 12, 1974. Table 4-6 summarizes pertinent results, indicating the maximum temperature measured at each location. The tests included five operating conditions: ground operation with air conditioning on and APU power; taxi; low-level flight (0 to 5000 feet) with cargo floor heaters off; high-level flight (≥25,000 feet) with cargo floor heaters off; and high-level flight (≥25,000 feet) with cargo floor heaters on. Each operating condition was maintained for one hour during the tests.

As shown in the table, the highest temperature reached in the underdeck avionics compartments was 38.3°C, recorded at the Set Z receiver/processor and IM installation location (TACAN receiver/transmitter). A single sensor was located near the aft end of the flight control pedestal, some distance from the intended CDU location, and recorded a maximum temperature of 27.8°C. Other sensors around the instrument panel recorded maximum temperatures of 48.4°C. These readings indicate that the temperatures at Set Z receiver/processor and CDU locations will be well within Set Z operating-temperature specifications.

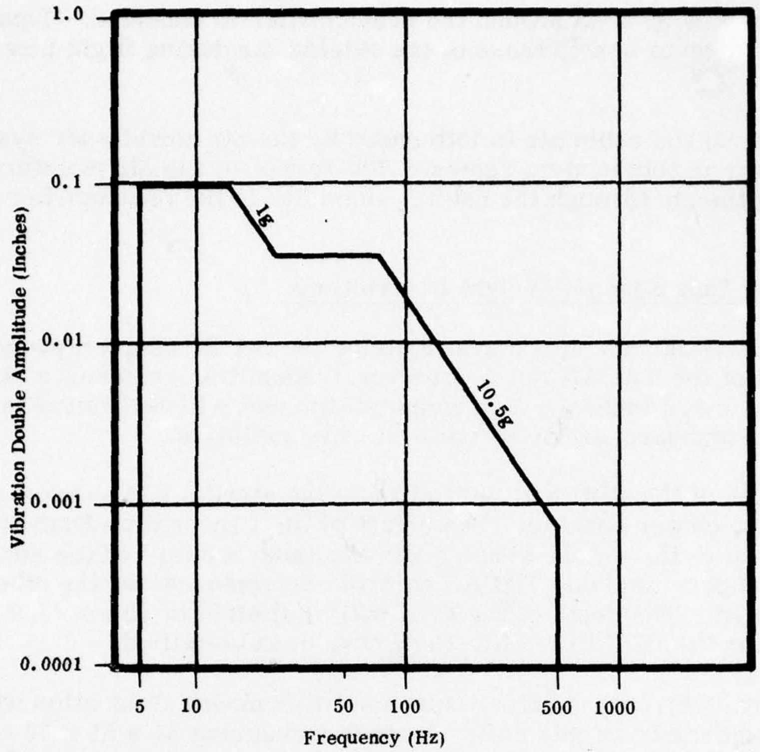


Figure 4-7. Vibration Qualification Test Levels for Electronics, HC-130H

TABLE 4-6. MAXIMUM TEMPERATURES AT SELECTED LOCATIONS, C-130E

Location	Maximum Temperature (°C)
Underdeck electronics racks (all)	38.3
TACAN Nos. 1 and 2 receiver/transmitters and couplers	38.3
Pilot and copilot instrument panels	48.4
Area behind instrument panels	44.7
Instrument case under panel, flight control pedestal	27.8
Typical ambient cabin air (with air conditioner operating)	20

The center wing area around the preamplifier is unheated. Temperatures in this area may drop to nearly those of the outside air during flight (see Section 4.5.3.1).

Humidity of the cabin air is influenced by the air conditioner system. The water separator in this system removes 70% to 85% of the air moisture content prior to circulating the air through the cabin. Humidity in the preamplifier area is uncontrolled.

4.5.3.4 Unit Size and Weight Restrictions

The underdeck rack space available for the Set Z receiver/processor and IM, upon removal of the TACAN No. 1 receiver/transmitter, measures at least 54 x 28 x 25 cm (21 x 11 x 9.8 inches). The weight of the unit will be limited to 27.2 kg in conformance with standard ARINC weight-vs.-size estimates.

The width of the CDU will be limited to the standard 14.6 cm (5.75 in.) to allow mounting in the center console. The height of the CDU will be limited to approximately 20.3 cm (8 in.) by the space made available forward of the engine controls when the blank panel and one TACAN control are removed and the other TACAN control is relocated. The depth of the CDU will be limited to 20 cm (7.9 in.). No weight restrictions for the CDU in the HC-130H have been identified.

Space available at the antenna/preamplifier mounting location will not impose any design constraints on this unit. A space measuring 61 x 51 x 76 cm (24 x 20 x 29.9 in.) is available. No weight restriction for the antenna/preamplifier on the HC-130H has been identified.

4.5.3.5 Electrical Power

Electrical power for the Set Z power supply will be 115 Vac, 400 Hz, obtained from the copilot's (upper) circuit breaker panel using the existing TACAN circuit breakers. A 28 Vdc power source is also available. Panel lighting power for the CDU will be obtained via the existing harness from the 0 to 28 Vdc rheostat. All power sources will comply with MIL-STD-704A, as required for Set Z.

4.5.3.6 Heat Dissipation

Heat dissipation in the receiver/processor/IM location is by ambient cabin air, which is cooled by the aircraft air conditioning unit. The left avionics rack is not enclosed and no special air circulation to it is provided. However, there are no known historical heating problems in this area (see Section 4.5.3.3).

Heat dissipation at the CDU location in the center pedestal is at the face of the unit by means of ambient cabin air, or possibly by conduction through the CDU mounts. No cooling is provided inside the pedestal.

Heat dissipation at the preamplifier location is by means of ambient air in the wing center section and possibly by conduction through the preamplifier mounts. The air in this area is uncirculated and is not conditioned or pressurized. The air will therefore take on extreme high and low temperatures, depending on aircraft location (see Section 4.5.2.1).

4.5.3.7 Pressurization

The fuselage of the HC-130H is pressurized according to the schedule shown in Figure 4-8. All Set Z units except the antenna and preamplifier will be within this pressurized area. Cabin pressure altitude is normally maintained at 8,000 feet or less, with a maximum differential pressure of approximately 7.7 psi allowed by the safety pressure release valve. The RF cables from the preamplifier to the receiver/processor must penetrate the pressure bulkhead and be sealed to maintain this pressure differential.

4.5.4 Electromagnetic Compatibility/Interference (EMC/EMI)

The electromagnetic compatibility of Set Z installations described in the preceding sections has been considered from the standpoint of interference from radiating antennas on the aircraft, interference to or from nearby avionic units, common practices for shielding and wire types, and any historical EMI problems associated with the aircraft. These factors are discussed in the following paragraphs.

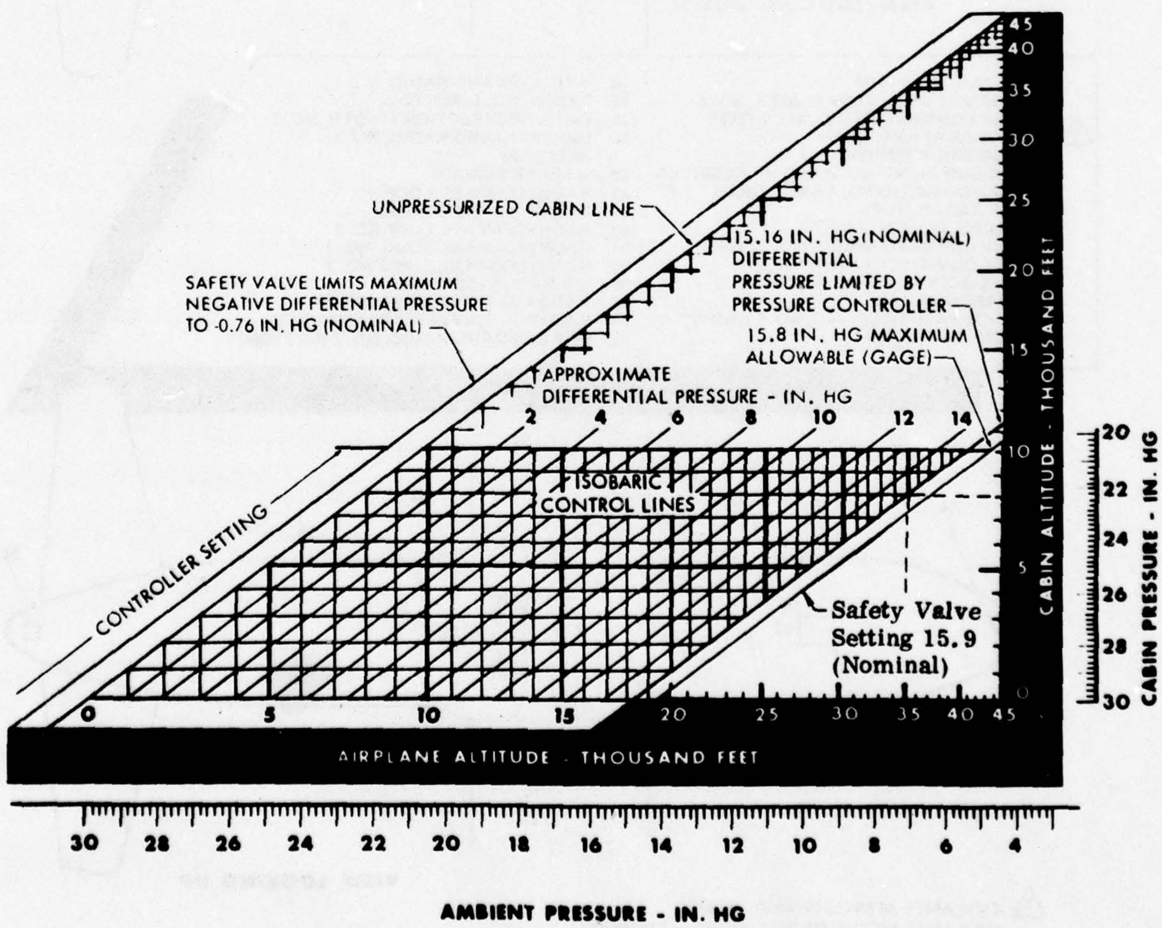


Figure 4-8. Cabin Pressurization Schedule, HC-130H

4.5.4.1 Antenna Locations

Figure 4-9 shows antenna locations on the HC-130H, including the TACAN No. 1 antenna to be replaced by the GPS antenna. Table 4-7 summarizes pertinent characteristics of radiating antennas.

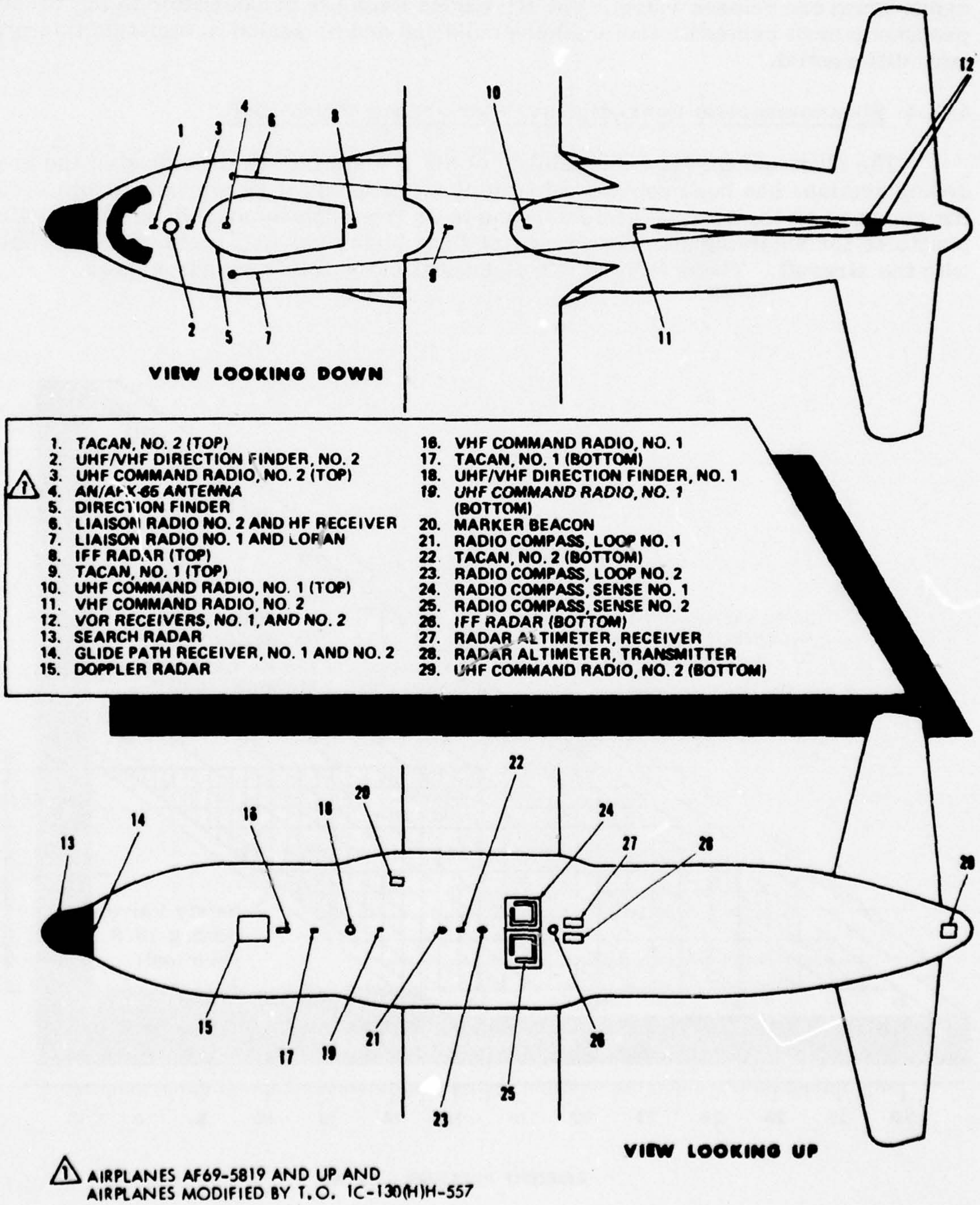


Figure 4-9. Antenna Locations, HC-130H

TABLE 4-7. RADIATING ANTENNA SIGNAL CHARACTERISTICS, HC-130H AIRCRAFT

Antenna No. (See Fig. 4-9)	System	Signal Type	Frequency (MHz)	General Antenna Coverage
1	TACAN No. 2 (AN/ARN-21)	Pulse	1025-1150	Omni upward
3	UHF Command Radio No. 2 (AN/ARC-34C)	Voice comm	225.0-399.95	Omni upward
4	IFF (AN/APX-65)	Pulse	1030	Omni upward
6	Liaison Radio No. 2 (HF-102B)	SSB, AM, and CW	2-29.999	Omni upward
7	Liaison Radio No. 1 (HF-102B)	SSB, AM, and CW	2-29.999	Omni
8	IFF Radar (AN/APX-25, AN/APX-64)	Pulse	1090	Omni upward
10	UHF Command Radio No. 1 (AN/ARC-34C)	Voice comm	225.0-339.95	Omni upward
11	VHF Command Radio No. 2 (VHF-101)	Voice comm	116.0-149.95	Omni upward
13	Search Radar (AN/APN-59D)	Pulse	9375	Forward
15	Doppler Radar (AN/APN-147)	CW	8800	Downward
16	VHF Command Radio No. 1 (VHF-101)	Voice comm	116.0-149.95	Omni downward
19	UHF Command Radio No. 1 (AN/ARC-34C)	Voice comm	225.0-399.95	Omni downward
22	TACAN No. 2 (AN/ARN-21)	Pulse	1025-1150	Omni downward
26	IFF Radar (AN/APX-25, AN/APX-64)	Pulse	1090	Omni downward
28	Radar Altimeter (AN/APN-150)	FM	4300	Downward
29	UHF Command Radio No. 2 (AN/ARC-34C)	Voice comm	225.0-399.95	Omni downward

Although no specific mention of historic EMI problems was made by any cognizant personnel, the IFF transmitters are possible sources of interference. The AN/APX-64 and AN/APX-25 transmit pulsed signals at 1090 MHz and emit approximately 800 to 1000 watts (29 to 30 dBw) of peak power. The AN/APX-65 transmits a minimum of 500 watts (27 dBW) at 1030 MHz. The pulsed nature of the signals will tend to spread some spurious noise across a wide spectrum. If the spurious noise generated in the GPS frequency band were approximately 90 dBw below the peak IFF output power, and free space path loss between the two antennas is approximately 55 dB, a noise level of -115 dBW could be created at the GPS antenna during IFF operation. This level is more than 45 dB above the Set Z receiver threshold, and will create an excessive J/S ratio despite the jamming resistance of GPS.

If the IFF does generate sufficient noise to interfere with Set Z, the problem could be addressed by including an appropriate emission control plan into the test plans. The IFF could also offer an opportunity to evaluate interference caused by other onboard avionics.

Selection of a different GPS antenna location to reduce this problem would be difficult. Placement of the GPS antenna on the top of the tail would further separate the two antennas, increasing the path loss by approximately 15 dB. However, the absence of a horizontal surface to serve as a ground plane around the GPS antenna could have a detrimental effect on the antenna pattern. Also, this location would greatly increase the RF cable length required between the Set Z preamplifier and receiver unless the receiver were also moved to the tail area. This in turn would require lengthy cable runs between the receiver/processor and the CDU and other avionics.

The other radiating antennas onboard the aircraft are expected to present no interference problems to the GPS antenna. The former all appear to either 1) have RF spectrums well removed from that of the GPS RF, 2) be oriented away from the GPS antenna, 3) be inoperative during GPS tests; or a combination of these.

4.5.4.2 Nearby Avionic Units

Table 4-8 lists the receivers located in the HC-130H left-hand underdeck equipment rack along with the Set Z receiver/processor. The table indicates pertinent receiver characteristics with regard to EMI to or from the Set Z receiver.

At the time of this writing, the Set Z intermediate and local-oscillator frequencies have not been definitely selected. It is therefore not possible to identify any coincidence of IF or LO frequency with any of the receivers in Table 4-8. In view of the apparent lack of any historical EMI problems on the HC-130H, however, it is not expected that any difficulties will be encountered with the GPS installation.

Table 4-9. lists the transmitters located in the HC-130H left-hand underdeck equipment rack along with the Set Z receiver/processor. The table indicates pertinent transmitter characteristics with regard to EMI to the Set Z receiver.

Since the Set Z IF and LO frequencies have not been selected, the possibility of RF leakage from these transmitters interfering with the Set Z receiver cannot be accurately assessed. Direct RF interference from in-band noise generated by the TACAN No. 2 transmitter is doubtful, in view of the MIL-E-6051 requirement for 60 dB shielding of each of the two units and the frequency difference between them.

TABLE 4-8. RECEIVERS NEAR SET Z RECEIVER/PROCESSOR, HC-130H AIRCRAFT

Receiver	RF (MHz)	LO (MHz)	IF (MHz)	RF Sensitivity
TACAN No. 2 (AN/ARN-21)*	962-1024, 1151-1213	1025-1150	63	–
*Unit adjacent to Set Z receiver/processor.				

TABLE 4-9. TRANSMITTERS NEAR SET Z RECEIVER/PROCESSOR, HC-130H AIRCRAFT

Transmitter	RF (MHz)	Modulation	Power
TACAN No. 2 (AN/ARN-21)*	1025-1150	Pulse	≥1 kW, peak
*Unit adjacent to Set Z receiver/processor.			

4.5.4.3 Wiring and Cabling

The GPS installation has been specified to take maximum advantage of existing avionics system wiring on the HC-130H. Since no known historical problems of EMI have been identified for this wiring, none are anticipated for the GPS installation. The possibility cannot be entirely ruled out, since sufficient data have not been located to accurately estimate noise levels on the lines.

New cables and wires required for the Set Z installation have been specified in accordance with MIL-W-5088 and best engineering practice. It is anticipated that these measures will be sufficient to preclude EMI problems for the GPS installation.

4.5.4.4 Historical EMI/EMC

No historical EMI problems for the HC-130H were identified during interviews and conversations with cognizant Air Force personnel.

4.5.5 Environment Summary, HC-130H

Table 4-10 summarizes the environmental exposure of Set Z installed in the HC-130H for GPS Phase I testing at YPG. The table presents the maximum and minimum operating and nonoperating extremes of each of the environmental parameters discussed in the preceding sections. The environmental envelope represented by the table thus shows the conditions which Set Z and IM may experience and be required to survive during the test program.

The parameter values shown in Table 4-10 apply to all Set Z and IM components unless otherwise noted. The temperature and pressurization specifications for the antenna and preamplifier are listed separately, since their installation exposes them directly to severe natural environments.

All of the environmental exposure levels shown in Table 4-10 fall within the service condition limits of SS-US-101B, with the exception of the operating temperature range of the antenna/preamplifier unit and high frequency vibration levels. The antenna/preamplifier unit is subjected to operating temperatures below those specified in SS-US-101B (-40°C) when the aircraft is at cruising altitude. The unit can also be subjected to operating temperatures in excess of those specified in SS-US-101B (+55°C) when on the ground in Albuquerque.

It is recommended that the GPS JPO consider extending the SS-US-101B temperature specification for the antenna/preamplifier to include those extremes which may be encountered during Phase I testing. The vibration specification for the HC-130H exceeds the levels of SS-US-101B by only 0.5g, and appears to offer a substantial safety margin over measured vibration levels at the Set Z installation locations. Therefore, it is not recommended that the vibration specification of SS-US-101B be modified to include this slight variation suggested by HC-130H installation specifications.

TABLE 4-10. TEST ENVIRONMENT SUMMARY, HC-130H AIRCRAFT

Environmental Parameter			Range
Temperature			
	Operating:	CDU, IM, Rcvr/Proc	-27° to 48.4°C
		Antenna/Preamp	-65° to 68°C
	Nonoperating:	CDU, IM, Rcvr/Proc	-27° to 63°C
		Antenna/Preamp	-65° to 68°C
Humidity:			
	Operating and nonoperating		≤100% Antenna directly exposed to rain
Vibration			
	Operating and nonoperating		<1g, 5-30 Hz; 10.5g, 75-500 Hz (see Figure 4.7)
Acoustic Pressure			
	Operating and nonoperating		<130 dB re 0.0002 ubar
Pressure			
	Operating and nonoperating		<8,000 ft normal
	Antenna/Preamp		<~30,000 ft 7.7 psi across RF cable seal
Wind/Dust			
	Operating and nonoperating		Some blowing sand/dust at antenna; not severe
Atmospheric Pollution			
	Operating and nonoperating		Slight. Some ultraviolet, ozone, nitrogen oxides
Electrical Power			Per MIL-STD-704A

4.6 TEST VS. OPERATIONAL CONFIGURATION INTEGRATION REQUIREMENTS

The installation approach for Set Z in the HC-130H test aircraft is designed to conform to the extent practicable to the installation method in operational aircraft. All elements of Set Z are expected to remain in essentially the same locations as configured for the Phase I test effort. If AWADS has been incorporated (C-130E aircraft), a large on-top radome has been located at FS 303.65 and the IFF transponder antenna has been moved aft to FS 350.33. Forward blanking of the GPS antenna pattern may be slightly increased but the antenna location should still be satisfactory -- a relocation further aft will only increase vertical tail blanking. The center console may be reconfigured if the operational GPS causes deletion of competing navigation equipments. The CDU, however, can be expected to remain on the forward part of the pedestal.

A new, degraded mode caution light would be installed on the instrument panel and permanent aircraft wiring would replace jumper harnesses to the existing TACAN connectors. A true airspeed computer would have to be installed to provide TAS information to the GPS. Table 4-11 details the similarities/differences between the Class II (test configuration) and Class V (operational configuration) installation.

TABLE 4-11. COMPARISON OF SET Z TEST AND OPERATIONAL CONFIGURATIONS, HC-130H AIRCRAFT

Element	Test Configuration	Operational Configuration
Antenna/Preamplifier Assy	Top of aircraft @ FS 517	Same
Receiver/Processor Unit	LH underdeck avionics rack	Same
Integration Module	LH underdeck avionics rack	Same
Control/Display Unit	LH forward region of cockpit center console	Forward region of cockpit center console
Connection to CDU	Jumper harness to TACAN control panel harness plug	TACAN control panel harness via a new connector
Connection to Flight Instruments	Jumper harness to TACAN coupler plug	TACAN harness via new connector, added wiring
Altitude Input	Harness connection to terminal board between APX-64 and altimeter-encoder	Same
TAS Input	No installation	Added TAS computer, interconnection wiring
Degraded Mode Light	No installation	New added caution light and wiring

5
TEST AIRCRAFT INTEGRATION, HH-53B/C

This section provides detailed information concerning the integration of UE Set Z into the HH-53B/C aircraft for GPS Phase I testing. The section provides information pertaining to the derivation of requirements; a description of the test installation, cabling and connections, and electronic interfaces; and a summary of Group A items that will be required for installation and interface. All items considered relevant to installation requirements of Set Z into the HH-53B/C are presented in checklist format in Appendix B.

5.1 INTEGRATION REQUIREMENTS DERIVATION

The integration requirements information contained in this section was derived from a study of technical orders and reports for the HH-53B/C aircraft (see bibliography, Volume I, Appendix A). Additionally, information and data were collected during trips to the HH-53B/C System Manager's office at Warner Robins Air Logistics Center. Structural deta ıs for the helicopter were obtained during visits to MAW-16 at the Marine Corps Air Station (Helicopters), Santa Ana; and the Naval Air Rework Facility, San Diego. Details concerning a possible major reconfiguration of certain aircraft were obtained from the PAVE LOW III office at Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio (see trip and contact list, Volume I, Appendix B).

5.1.1 Physical Installation Requirements

As discussed in Section 1.2, Set Z consists of three LRUs: receiver/processor, antenna/preamplifier, and CDU. Requirements for and constraints on the physical installation of these LRUs have been imposed by the physical configuration of the HH-53B/C and its associated avionics, the environment onboard the aircraft, the GPS Phase I Test Plan, and direction from the GPS JPO. The same considerations impact the IM physical installation. The rationale for the installation of each unit will be described along with the installation descriptions presented in the following sections.

5.1.2 Avionics Configuration

Table 5-1 lists the HH-53B/C avionics relevant to the integration effort. Relevancy is based upon replacement by, interface with, or potential interference to or from Set Z.

During a visit to the HH-53B/C System Manager's office at WRALC, ARINC Research determined that 41 of these helicopters are in the Air Force inventory, as well as 17 of the SH and CH versions of the aircraft. Most aircraft have the AN/ARN-65 TACAN system and the AIMS AN/APX-64 transponder with mode C altitude reporting incorporated. The cockpit arrangement of electronic panels vary somewhat, since three different configurations of the HH-53B/C are in inventory.

TABLE 5-1. HH-53B/C AVIONICS EQUIPMENTS AFFECTED BY SET Z TEST INSTALLATIONS

Item Removed	Item Interfacing	Potential Interference
Rcvr/Trans (RT-471/ARN-65)	Pilot's CDI (ID-387/ARN)	IFF (AN/APX-64)
Mounting (MT-209/ARN-65)	Copilot's CDI (ID-387/ARN)	
Control (C-1763/ARN-21A)	Pilot's BDHI (ID-1103/ARN)	
Control (C-2275/ARN-59)	Copilot's BDHI (ID-1103/ARN)	
	Pilot's FDI (353-999-0100)	
	J-4 Compass System	
	True Airspeed Computer	
	Transponder (RT-728/APX-64)	
	Altimeter-Encoder (AAU-21/A)	
	115 Vac Primary Radio Bus No. 2	
	28 Vdc Primary Radio Bus No. 2	
	26 Vac Primary Bus No. 2	
	5 Vac Panel Lights	
	Caution Panel	

A possible modification to a number of operational aircraft, termed PAVE LOW III, is currently in development by ASD. This new aircraft version could have substantial impact on Set Z installation, since there is a major revamping of installed avionics.

Integration of the GPS Set Z into the HH-53B/C PAVE LOW III configuration for GPS Phase I testing does not appear to be a reasonable objective. It is questionable whether there is room in the PAVE LOW III cockpit for the GPS CDU. The tentative nature of the PAVE LOW III project, the small number of operational systems planned, and the specialized mission of the system would not seem to support testing of Set Z in a PAVE LOW III compatible installation during the Phase I testing. For an operational installation, the PAVE LOW III configuration would be expected to be considerably different from that of the other HH-53B/C aircraft.

5.2 PHYSICAL INSTALLATION DESCRIPTION

The following sections describe the physical installation of Set Z units in the HH-53B/C. Each installation description includes the rationale for selection or design of that installation.

5.2.1 Receiver/Processor

The Set Z receiver/processor will be mounted in the cavity presently occupied by the AN/ARN-65 TACAN receiver-transmitter unit located on the floor of the right-hand nose avionics compartment. Installation at this location is dictated by available avionics space and by direction of the JPO.

The Set Z receiver/processor installation is illustrated in Figure 5-1. The unit will be mounted on vibration isolators along with its Integration Module for environmental protection during flight. Although the AN/ARN-65 unit is mounted sideways, sufficient space is available for conventional orientation of the GPS receiver/processor except at the extreme forward end of the compartment.

Air conditioning is not supplied to the avionics compartment. Ambient compartment air will be drawn into the front of the GPS receiver/processor and circulated through the unit by a fan. The hot air is then exhausted through the bottom of the mounting tray. Heat dissipated in the receiver/processor, which has a power consumption of 120 watts, is not of a level that will necessitate the ducting of cooling air directly to the unit.

5.2.2 Antenna/Preamplifier Assembly

The Set Z antenna will be mounted on top of the horizontal stabilizer at STA 64, 8 cm in front of the aft beam. The preamplifier unit will extend inside the stabilizer structure below the antenna as shown in Figure 5-2. An antenna installation on the horizontal stabilizer was considered to be mechanically feasible. The location of antenna and preamplifier units on the stabilizer will require detachment of the stabilizer top skin between the main spars, and the addition of necessary doublers and brackets. Void space within the stabilizer is more than sufficient for postulated preamplifier dimensions. One or more access panels must be fabricated and

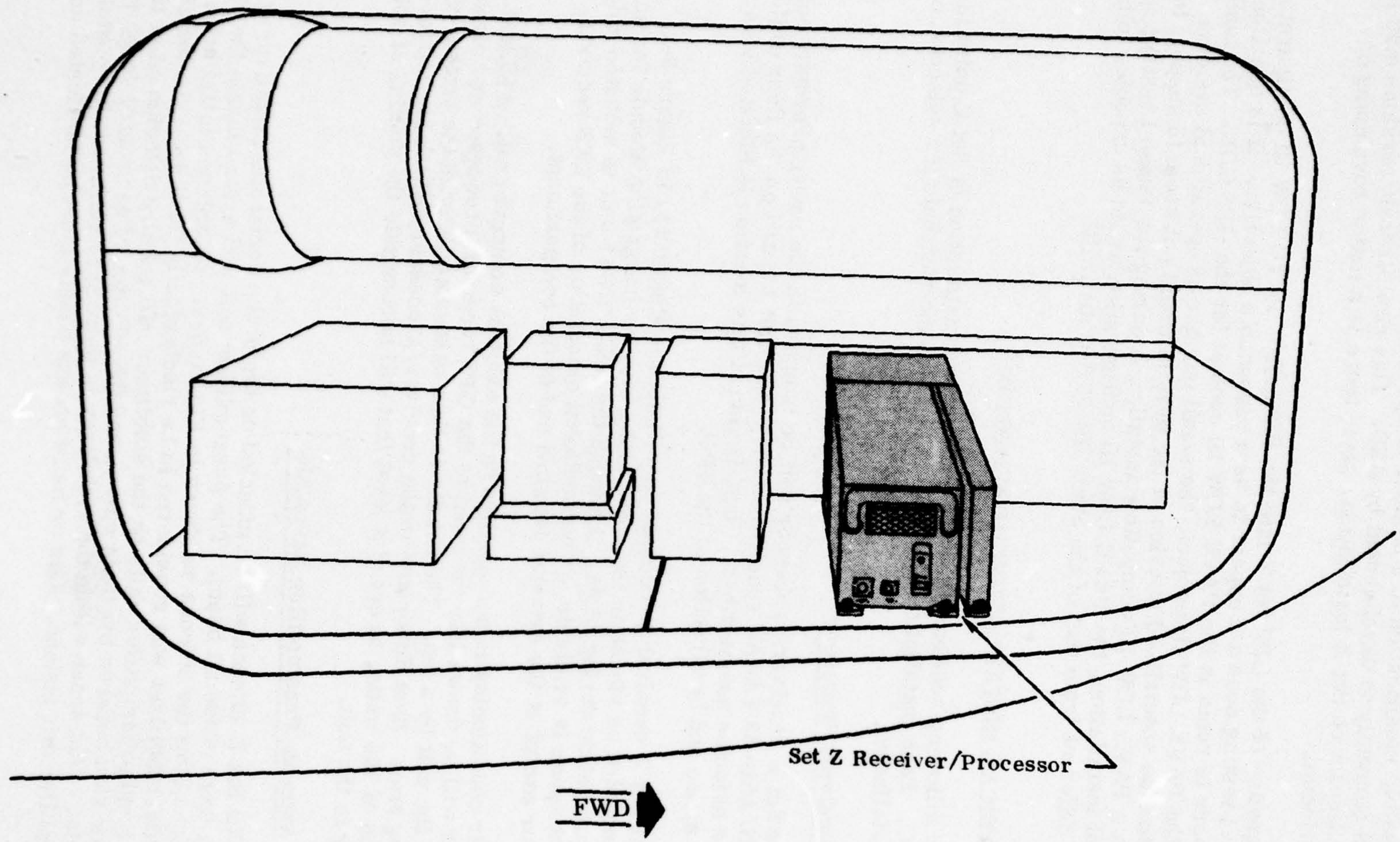


Figure 5-1. Set Z Receiver/Processor Installation, HH-53B/C

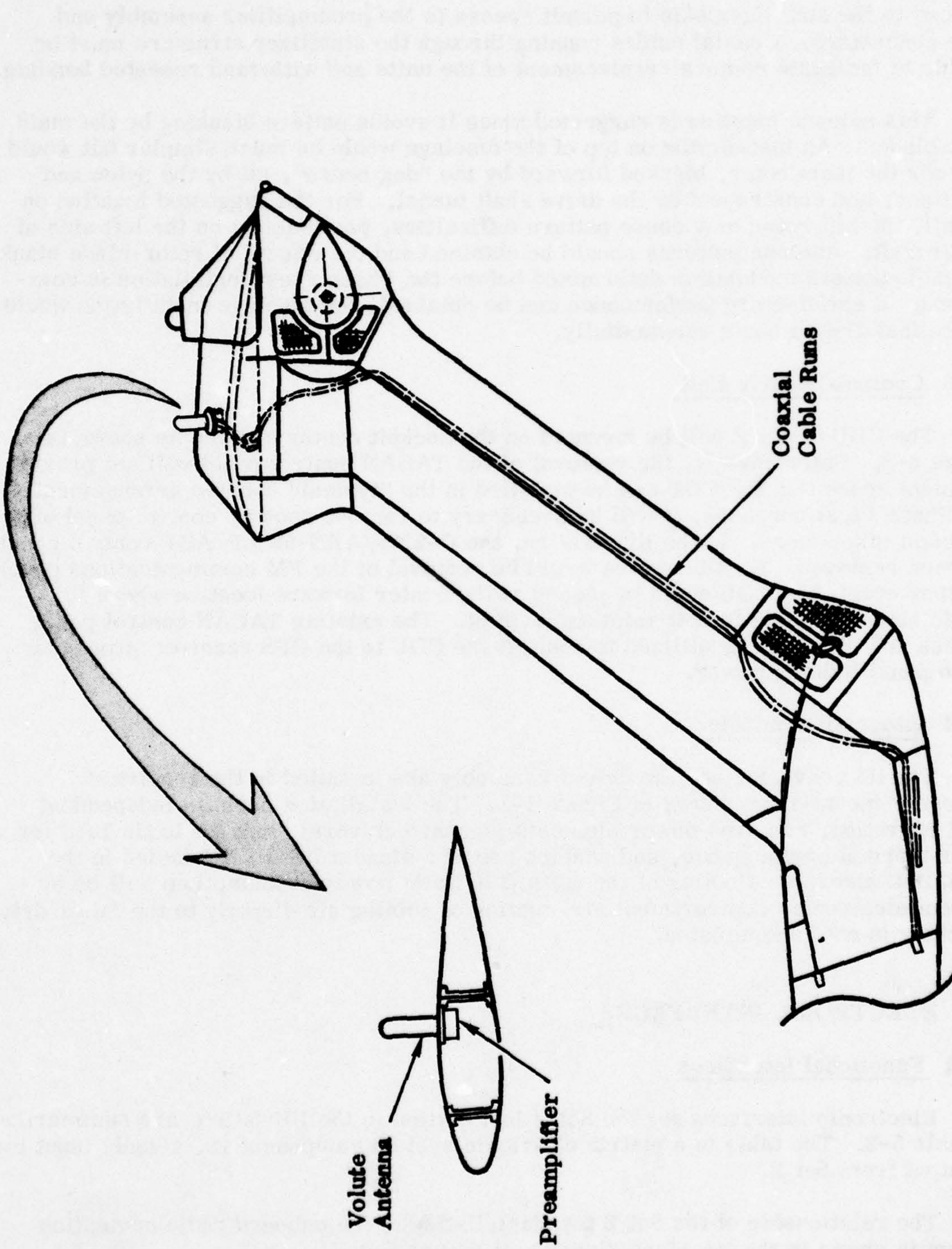


Figure 5-2. Antenna and Cable Installation, HH-53B/C Tail Assembly

attached to the stabilizer skin to permit access to the preamplifier assembly and cable connectors. Coaxial cables running through the stabilizer structure must be flexible to facilitate removal/replacement of the units and withstand repeated bending.

This antenna location is suggested since it avoids pattern blanking by the main rotor blades. An installation on top of the fuselage would be much simpler but would be under the main rotor, blanked forward by the "dog house", aft by the pylon and stabilizer, and constrained by the drive shaft tunnel. For the suggested location on the tail, the tail rotor may cause pattern difficulties, particularly on the left side of the aircraft. Antenna patterns should be obtained and the effects of rotor-blade blanking and multipath modulation determined before the Phase I test installation is commenced. If satisfactory performance can be obtained, the fuselage installation would reduce installation costs substantially.

5.2.3 Control/Display Unit

The CDU of Set Z will be mounted on the cockpit center console as shown in Figure 5-3. Unfortunately, the removal of the TACAN control panel will not provide sufficient space that the CDU can be installed in the "typical" console arrangement. For Phase I test purposes, it will be necessary to remove another control panel of sufficient dimensions. In the illustration, the C-2275/ARN-59 LF/ADF control panel has been removed. An alternative would be removal of the FM communications panel. In either event, the CDU could be placed at the center forward location where it is visible and accessible to both pilot and copilot. The existing TACAN control panel harness and plug may be utilized to connect the CDU to the GPS receiver/processor and to panel lighting power.

5.2.4 Integration Module

The IM converter and the driver assembly are installed in the receiver/processor mounting as shown in Figure 1-1. The installation permits independent Set Z operation, removes power elements (synchro drivers) from the basic LRU for better thermal performance, and enables use of a standardized LRU design in the HH-53B/C aircraft. Cooling of the units (120 watts power consumption) will be by ambient electronics compartment air; ducting of cooling air directly to the IM or driver assembly is not contemplated.

5.3 ELECTRONIC INTERFACES

5.3.1 Functional Interfaces

Electronic interfaces for the Set Z installation in the HH-53B/C are summarized in Table 5-2. The table is a matrix of avionic system component vs. signals input to or output from Set Z.

The relationship of the Set Z test installation to the onboard radio navigation system is shown in the interface diagram of Figure 5-4.

5.3.2 Wiring and Connectors

The cabling and interconnections between LRUs of Set Z and the aircraft systems are shown in the cabling and interwiring diagrams, Figures 5-5 and 5-6 respectively.

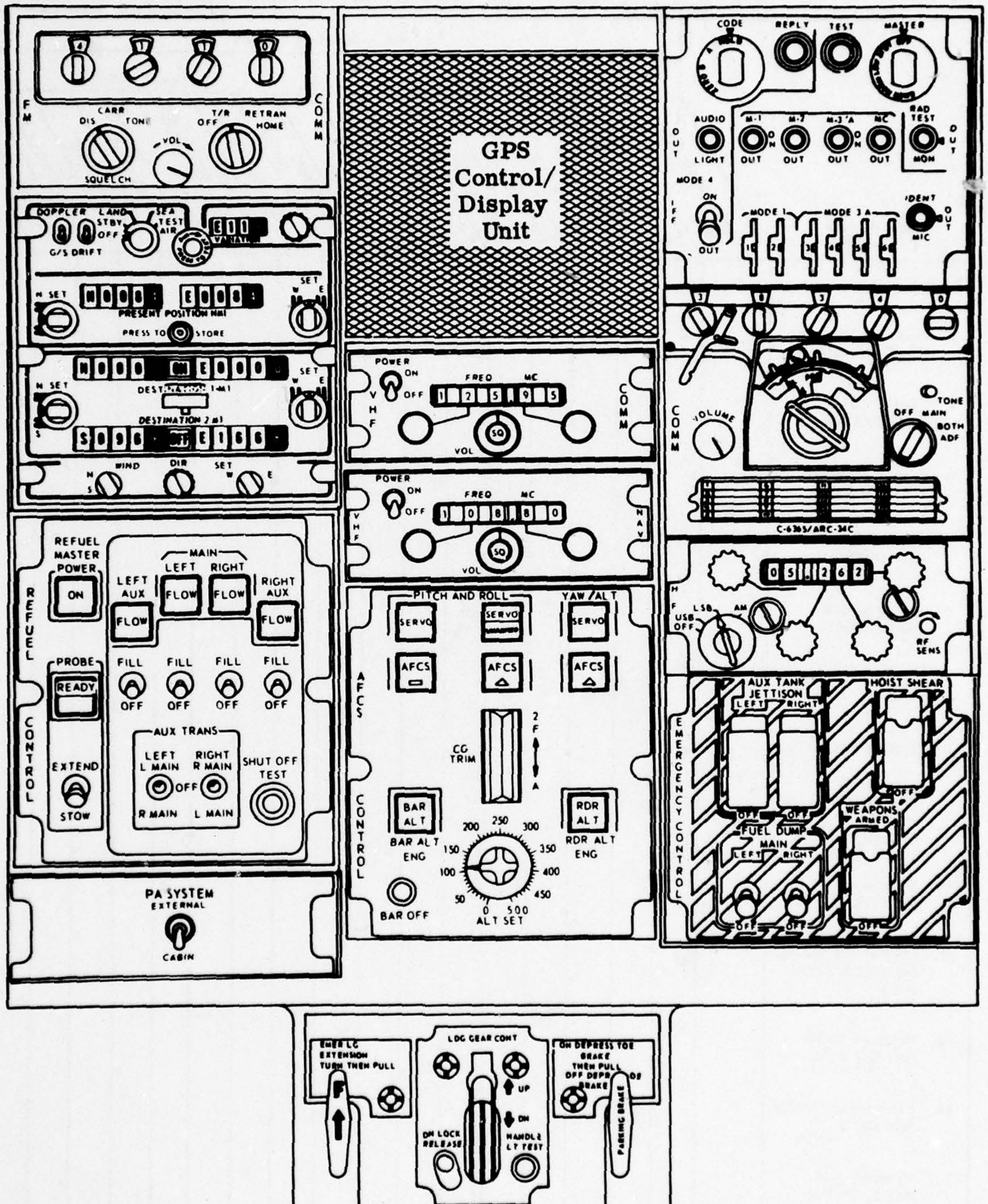
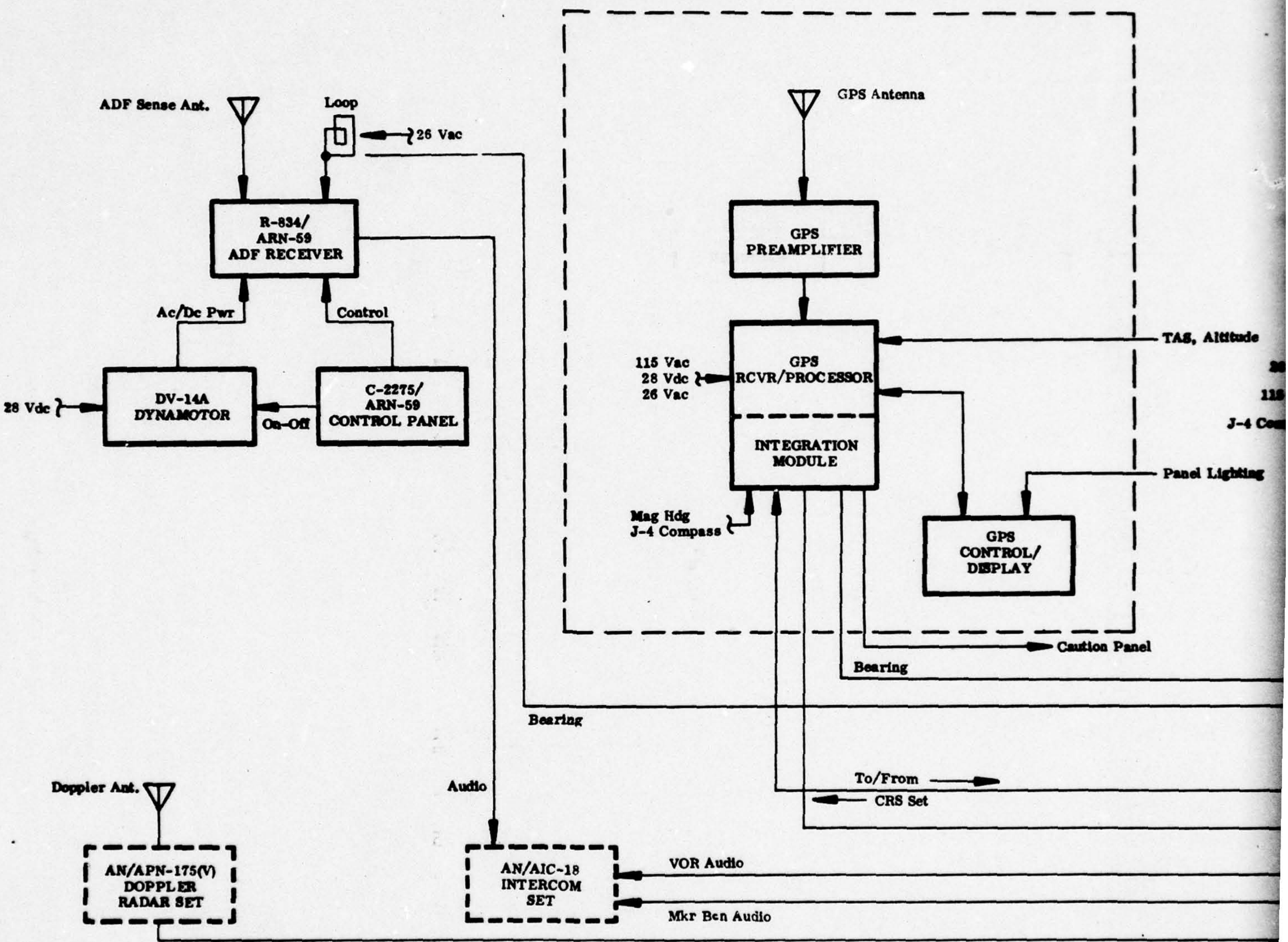


Figure 5-3. HH-53B/C Center Console with GPS Set Z Test Installation

TABLE 5-2. ELECTRONIC INTERFACE SIGNALS, HH-53B/C AIRCRAFT

Avionic System/ Component	Set Z Interface Signals																
	Set Z Output to Systems/Displays									Inputs to Set Z							
	Digital Navigation Data	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Degraded Mode	Course Set	A/C Power, 115 Vac, 400 Hz	A/C Power, 28 Vdc	Synchro Ref., 26 Vac, 400 Hz, ØA	Altitude	True Airspeed	Panel Lighting*	Digital Control Data	Magnetic Heading
1. Set Z CDU	X															X	
2. Pilot's BDHI (ID-1103/ARN)		X	X	X													
3. Pilot's CDI (ID-387/ARN)					X	X											
4. Pilot's FDI (353-999-0100)					X	X											
5. Copilot's BDHI (ID-1103/ARN)		X	X	X													
6. Copilot's CDI (ID-387/ARN)					X	X	X		X								
7. Compass System (J-4)																	X
8. Caution Panel								X									
9. True Airspeed Computer (A24950-30-005)														X			
10. Altimeter (AAU-21/A)													X				
11. Pilot's Instrument Lighting System, 5 Vac															X		
12. Primary Radio Bus No. 2 ØB										X							
13. Primary DC Radio Bus No. 2											X						
14. Primary Bus No. 2, 26 Vac												X					

*Direct to CDU



ADF Sense Ant.
Loop
26 Vac
R-834/
ARN-59
ADF RECEIVER
Ac/Dc Pwr
Control
28 Vdc
DV-14A
DYNAMOTOR
On-Off
C-2275/
ARN-59
CONTROL PANEL
GPS Antenna
GPS
PREAMPLIFIER
115 Vac
28 Vdc
26 Vac
GPS
RCVR/PROCESSOR
INTEGRATION
MODULE
TAS, Altitude
Panel Lighting
Mag Hdg
J-4 Compass
GPS
CONTROL/
DISPLAY
Caution Panel
Bearing
Bearing
To/From
CRS Set
Doppler Ant.
Audio
AN/APN-175(V)
DOPPLER
RADAR SET
AN/AIC-18
INTERCOM
SET
VOR Audio
Mkr Bcn Audio

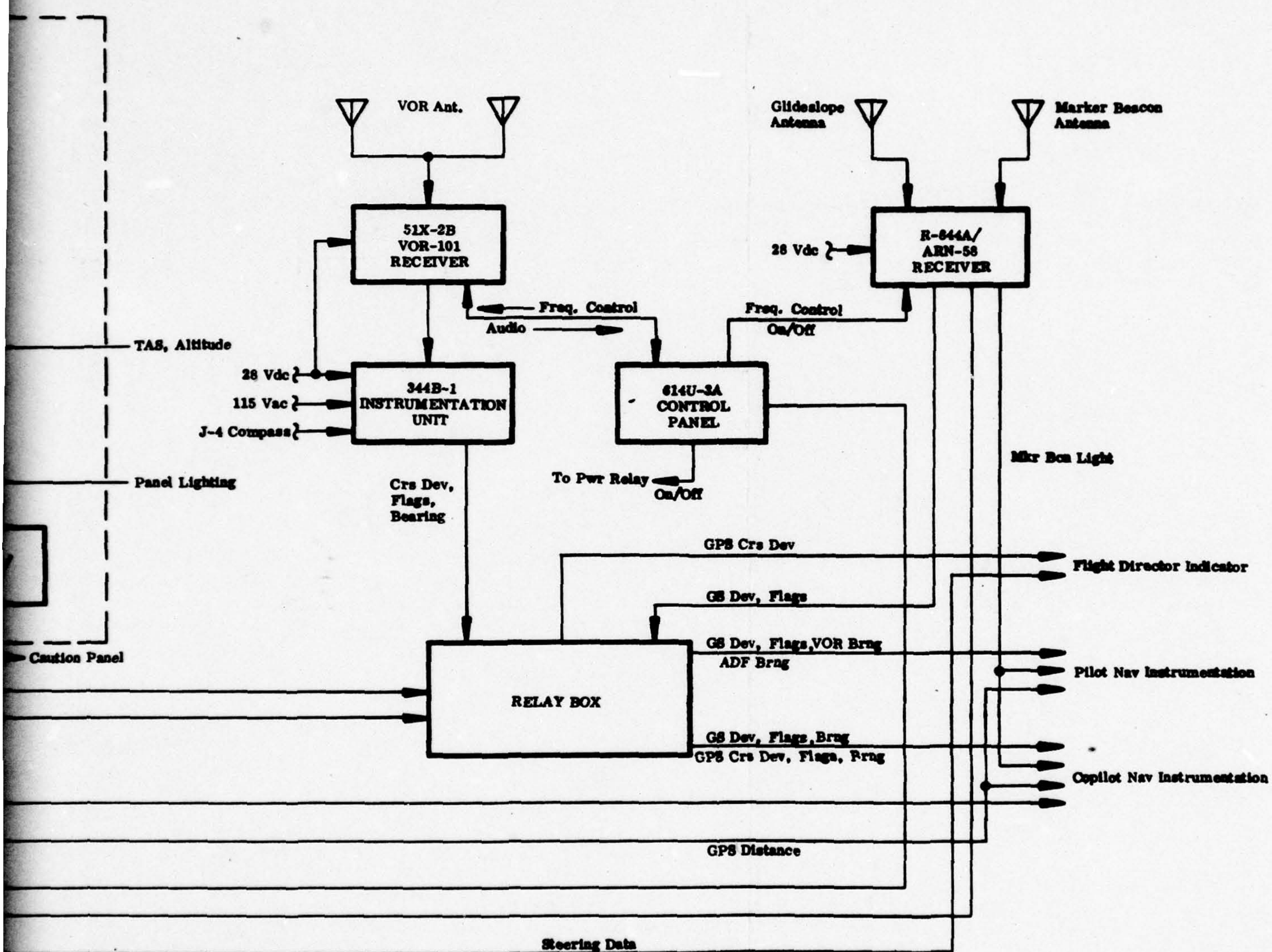


Figure 5-4. HH-53B/C Radio Navigation System Interface Diagram — GPS Test Installation

2

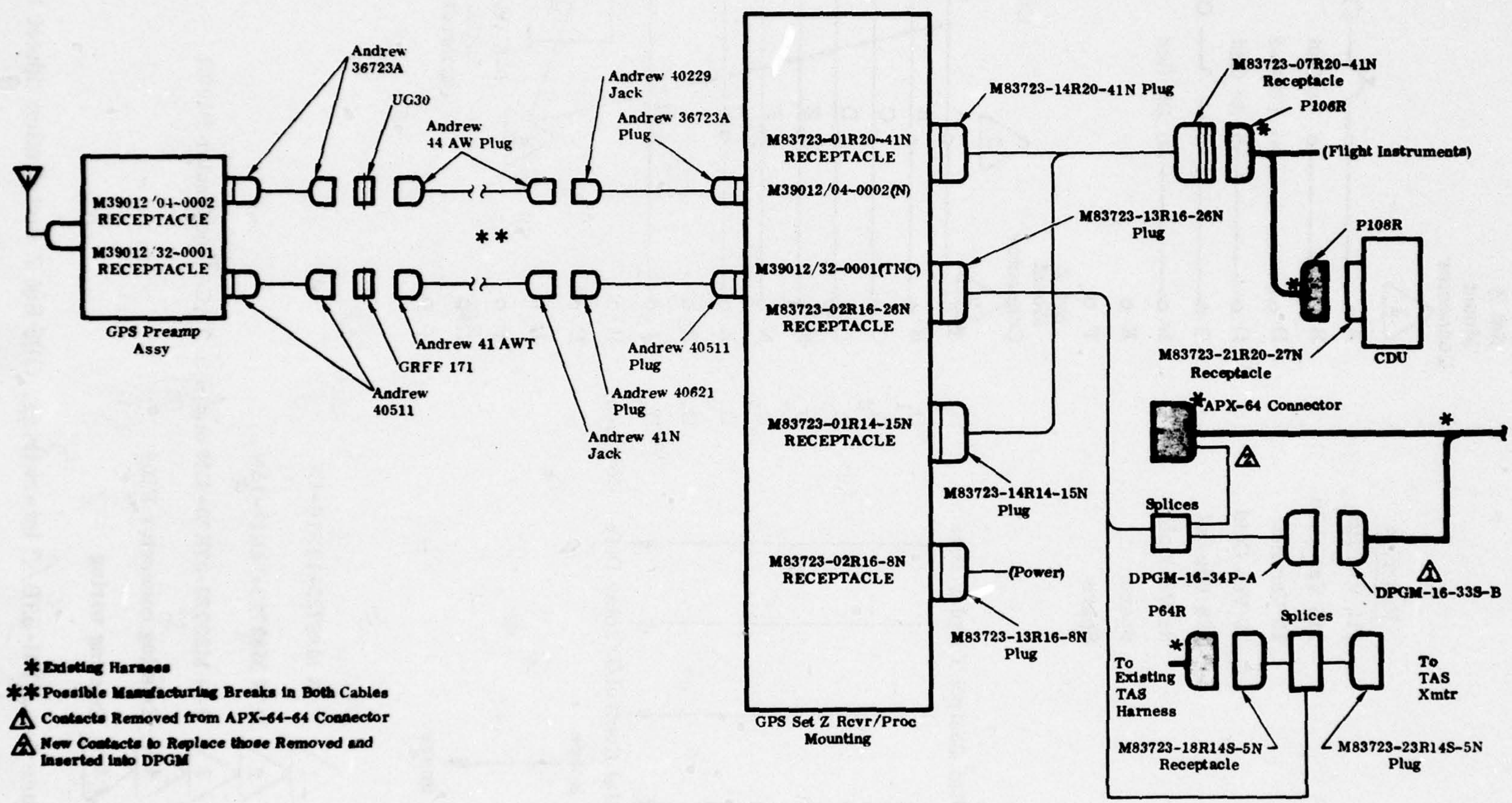
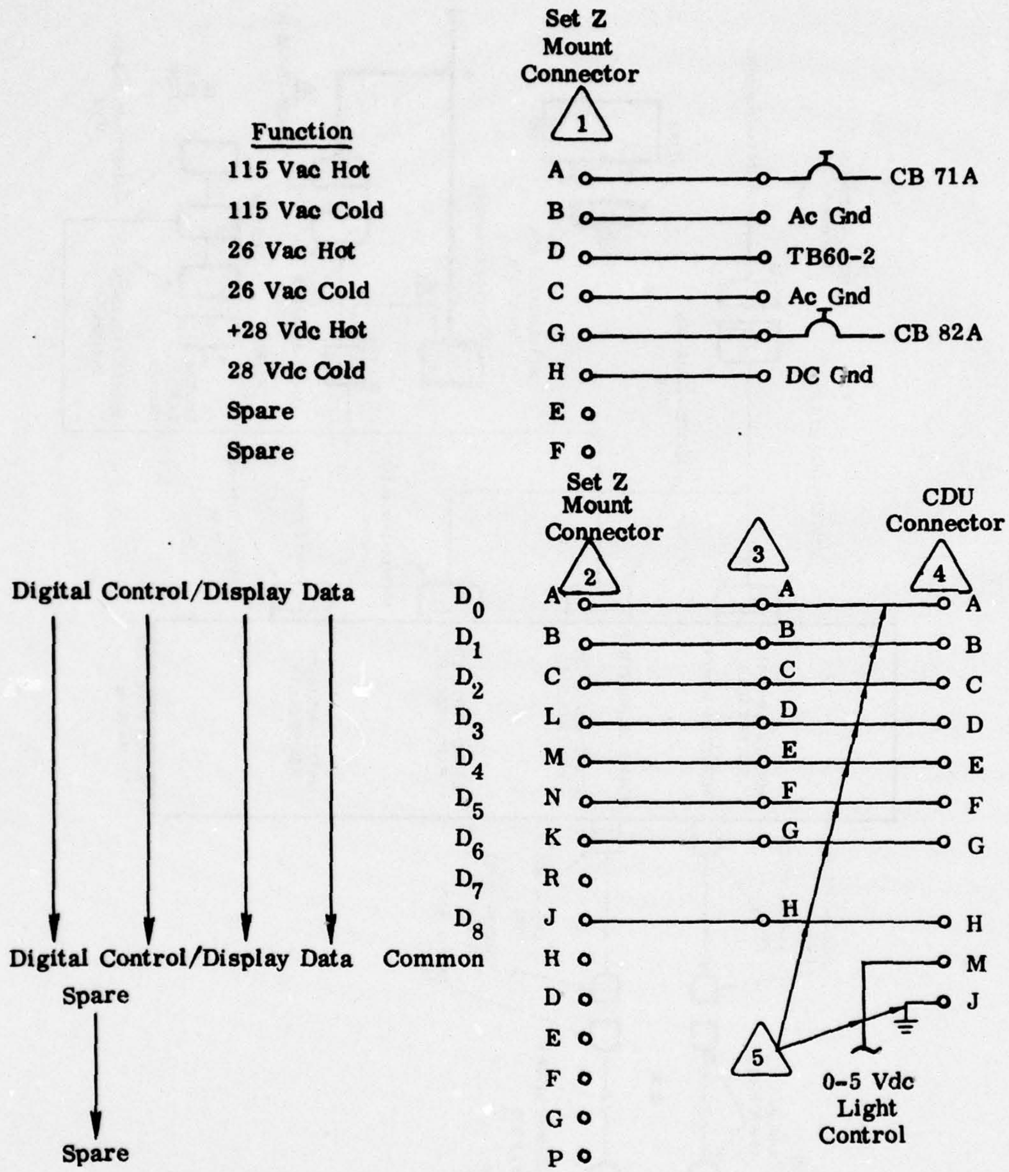


Figure 5-5. GPS Set Z Cabling Diagram, HH-53B/C Aircraft



1 P/N M83723-13R16-8N

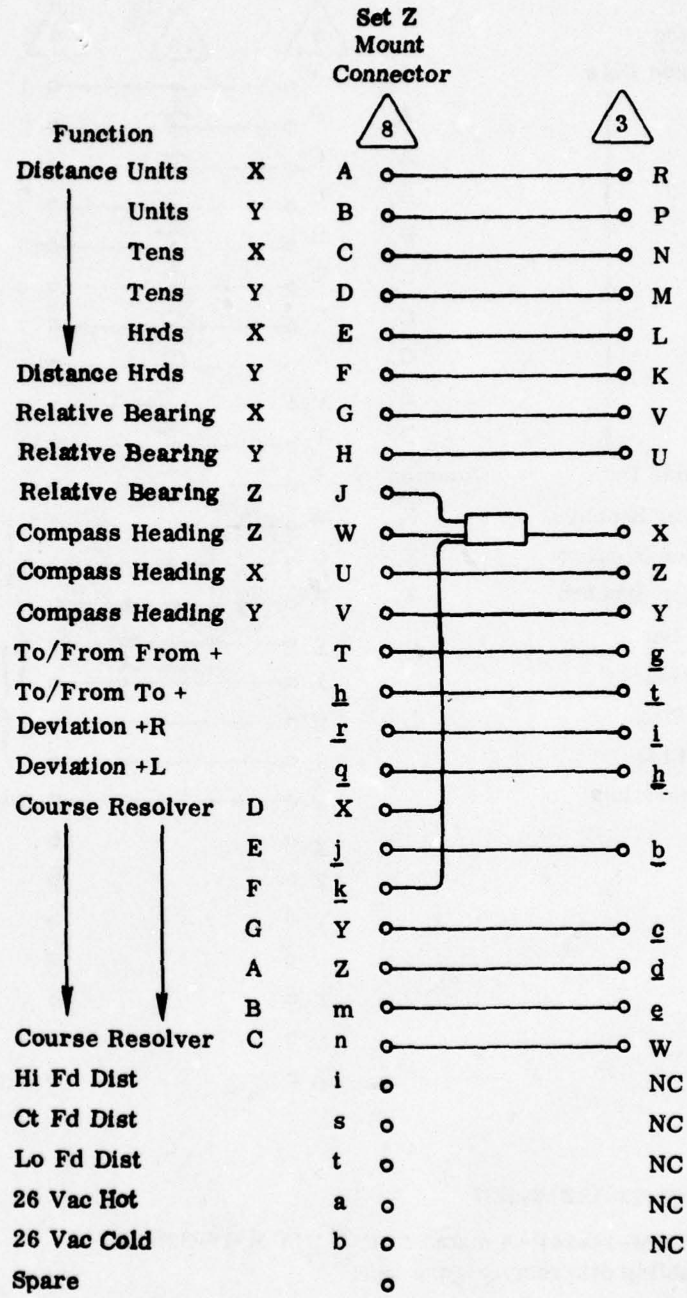
2 P/N M83723-14R14-15N

3 P/N M83723-07R20-41N mated to TACAN connector P106R

4 Existing connector P108

5 Existing wiring

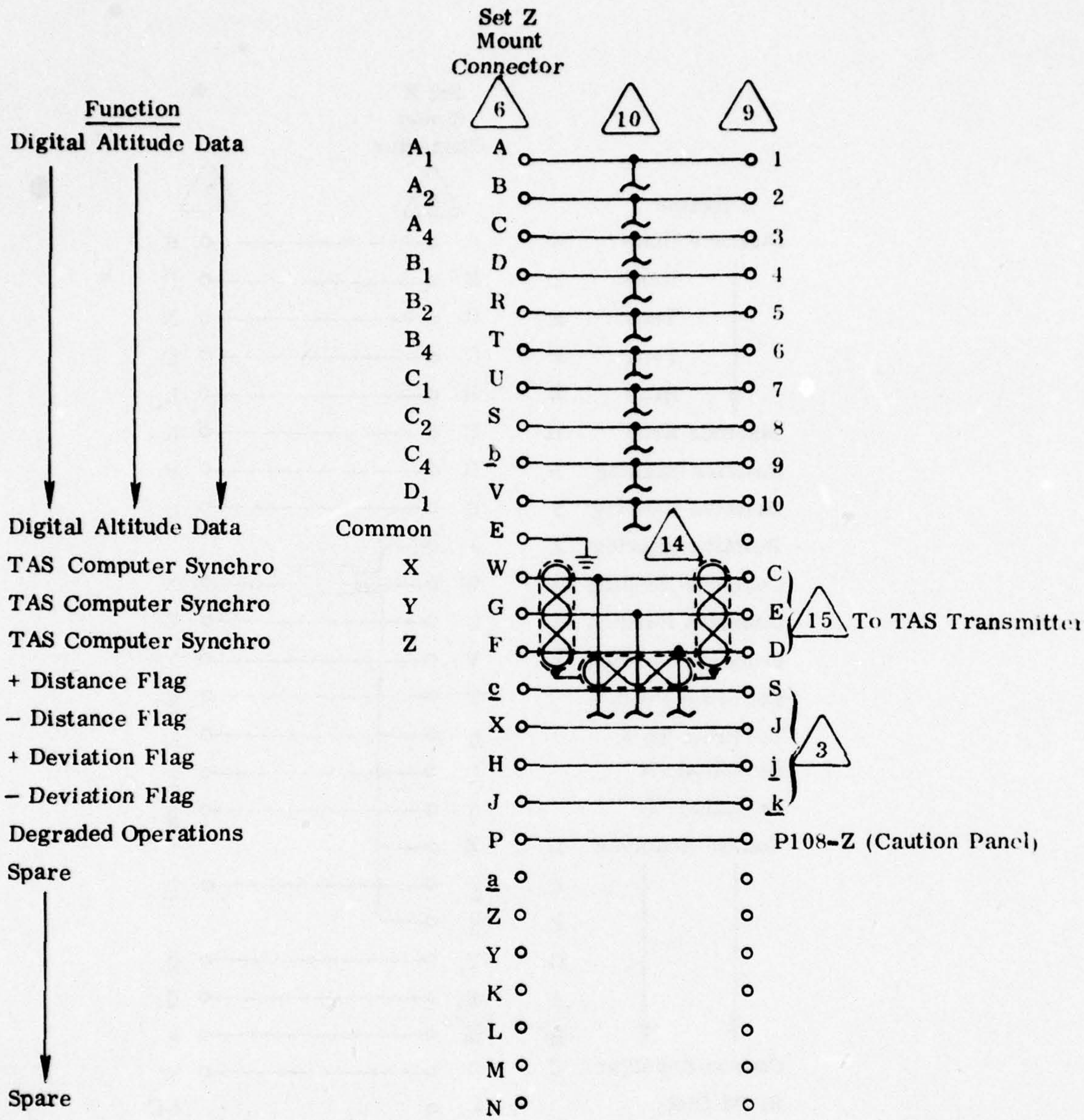
Figure 5-6. HH-53B/C Interwiring, GPS Set Z Installation (Sheet 1 of 4)



3 P/N M83723-07R20-41N mated to TACAN connector P106R

8 P/N M83723-14R20-41N

Figure 5-6. (Sheet 2 of 4)



6 P/N M83723-13R16-26N

9 P/N DPGM-16-34P-A mated to P/N DPGM-16-33S-B, ref. cabling diagram, Figure 5-5

3 P/N M83723-07R20-41N mates to TACAN connector P106R

10 Spliced connections to APX-64, ref. cabling diagram, Figure 5-5

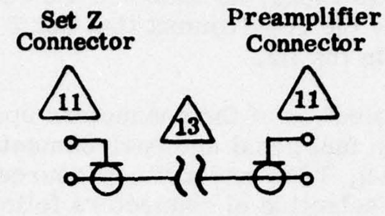
14 Splice connections to P/N M83723-18R14S-5N, mates to existing P64R, ref. cabling diagram, Figure 5-5

15 P/N M83723-23R14S-5N, mates to TAS transmitter receptacle

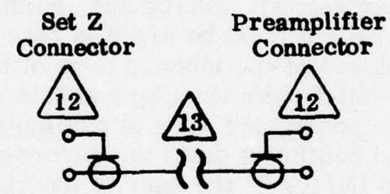
Figure 5-6. (Sheet 3 of 4)

Function

Amplified RF/+15 Vdc



Calibration Signal



(11) **P/N 36723A (Andrew)**

(12) **P/N 40511 (Andrew)**

(13) **Intermediate connectors and bulkhead adapters**

Figure 5-6. (Sheet 4 of 4)

Pin connections and assignments between Set Z, the IM, and other interfacing, onboard avionics take into account wire bundling, shielding, spares locations and mateability with existing aircraft harnesses. Reassignments during the Set Z design phase must be consistent with the use of existing aircraft wiring harnesses in any of the test installations, as shown in the cabling diagrams. The interwiring layout was influenced by the requirement that Set Z continue to operate independently in the event of a failure in the IM.

The selection of the connectors specified in the Group A listing (see Section 5.4) was based on functional and environmental considerations and a requirement to mate to the TACAN, TAS, and altitude-source harnesses. For the receiver/processor unit and IM, the selection of connectors follows the guidance of ARINC Specification 404A, used by commercial airlines, which recommends the use of plug-in DPX or similar connectors on equipment LRUs. Other connectors were selected from MIL-C-83723 and MIL-C-39012 as appropriate.

5.3.2.1 Coaxial Cable

Installation of a foam-filled semiflexible cable presents a difficult problem in the helicopter retrofit installation, particularly through the tail pylon structure. The two coaxial cables must be dressed through the stabilizer structure, and must penetrate a solid web at the inboard edge of the stabilizer. Since the stabilizer is removable, bulkhead connectors at this point will probably be required. An inspection panel at the upper pylon area is available for access. The cable encircles the tail gear box and continues down the underside of the bottom pylon spar. The cables must transition to the top of the spar in the vicinity of PS 66.80 in order to clear the intermediate gear box and the tail skid mount. An access panel in the spar in this region will facilitate cable installation. The cables must then circle below the drive shaft connection and penetrate the aircraft cabin area. A manufacturing break and resulting connectors can be expected at this point. The cables will continue from these connectors, probably without further breaks, to the nose equipment racks.

5.3.2.2 Altitude Input Connections

A special harness must be fabricated to permit coupling into the altitude data lines between the AAU-21/A altimeter-encoder and the AIMS transponder. The 10 pertinent connector contacts are removed from the existing DPJM connector (P-126R) at the RT-728 receiver/transmitter located in the left-side lower electronics compartment and inserted into a new DPGM-16-33S-B plug. This plug connects to a harness, which supplies the altitude signal to the Set Z receiver/processor and also to 10 new contacts inserted into the vacant positions in the P-126R plug.

The harness is depicted in the cabling diagram, Figure 5-5. The indicated modifications will permit easy conversion of aircraft wiring back to its original condition when the GPS equipment is removed.

5.3.2.3 TAS Input Connections

A special harness must be fabricated to permit coupling into the true airspeed synchro lines from the TAS transmitter. The existing P64R plug at the transmitter will be disconnected and connected to a new receptacle, M83723-18R14S-5N. This receptacle is attached to the new harness, which supplies the TAS signal to both Set Z receiver/processor and to a new plug, M83723-23R14S-5N, for connection to the transmitter unit.

The harness is depicted in the cabling diagram, Figure 5-5. The use of this new interconnecting harness will maintain the existing aircraft wiring and permit quick conversion of the aircraft to its original configuration. It should be noted that the TAS transmitter is not installed in HH-53B/C aircraft 73-1647 and the six subsequent configurations.

5.4 GROUP A ITEM REQUIREMENTS

The Group A items required to effect integration and installation in the HH-53B/C are listed in Table 5-3.

TABLE 5-3. GROUP A INSTALLATION ITEMS FOR UE SET Z ON HH-53B/C AIRCRAFT (Sheet 1 of 3)

Item	Qty	Remarks
a. Receiver/Processor Mounting	1	
Connector, M24308/2-4	1	
Connector, DPX, M81659/31A2-0042	1	
Connector, DPX M81659/31A2-0034	1	
Connecotr, M83723-02R16-8N	1	
Connector, M83723-01R20-41N	1	
Connector, M83723-02R16-26N	1	
Connector, M83723-01R14-15N	1	
Vibration mounts, Lord 150PHL8	4	
Holddown, Type C, Hollingsead-Pryor	3	
b. Control/Display	–	Use TACAN control panel harness and connector
c. Antenna/Preamplifier Mounting	1	Structural details to be designed by installer
Double	TBD	
Gasket	TBD	

TABLE 5-3. (Sheet 2 of 3)

Item	Qty	Remarks
c. Antenna/Preamplifier Mounting (cont)		
Screws	TBD	
Brackets, mounting	TBD	
d. Integration Module Converter	1	
e. Integration Module Driver	1	
f. Aircraft Wiring		
Connector, M83723-07R20-41N (receptacle)	1	Mates with TACAN R/T plug
Connector, M83723-13R16-8N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R20-41N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-13R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R14-15N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-18R14S-5N (receptacle)	1	Mates with TAS harness plug P64R
Connector, M83723-23R14S-5N (plug)	1	Mates with TAS transmitter receptacle
Connector, DPGM-16-33S-B (plug)	1	Mates with DPGM receptacle on GPS altitude harness
Connector, DPGM-16-34P-A (receptacle)	1	Mates with DPGM plug on altitude harness near APX-64
Connector, N, Andrew 41N	1	Mates with service loop plug
Connector, N, Andrew 44AW	2	Mates with service loop jack; bulkhead adapter
Connector, TNC, Andrew 40511	3	Mates with TNC female on receiver; preamplifier jack; bulkhead adapter

TABLE 5-3. (Sheet 3 of 3)

Item	Qty	Remarks
f. Aircraft Wiring (Cont)		
Connector, N, Andrew 36723A	3	Mates with N female on GPS receiver; preamplifier jack; bulkhead adapter
Connector, N, Andrew 40621	1	Mates with calibration line jack
Connector, N, Andrew 40229	1	Mates with signal input line plug
Connector, TNC, Andrew 41AWT	1	Mates with bulkhead adapter
		Additional connectors may be required for manufacturing breaks
Adapter, bulkhead, N, UG30/U	1	Couples the RF signal line through the stabilizer bulkhead to the preamplifier RF coaxial cable
Adapter, bulkhead, TNC, GRFF No. 171	1	Couples the calibration line through the stabilizer bulkhead to the preamplifier calibration coaxial cable
Cable, coaxial, Andrew FHJ4-50B		Signal line
Cable, coaxial, Andrew FHJ1-50		Calibration line
Cable, coaxial, Andrew FSJ1-50		Service loop, preamplifier connection
Cable, coaxial, Andrew FSJ4-50		Service loop, preamplifier connection
Wire and cable		Various types as required
Contact, No. 20 socket P/N 031-0900-001	10	Insert into existing DPJM plug at the APX-64
Splices, Wire	13	
Decals, assorted GPS		

5.5 EQUIPMENT ENVIRONMENTS

Environmental requirements for Set Z installation in the HH-53B/C are derived by combining a history of exposure to various conditions with the natural environmental characteristics and the aircraft-induced or -controlled environmental characteristics. The result is a comprehensive environmental envelope for the HH-53B/C test activities. The exposure history, natural environment, and aircraft environment are described below, followed by a summary of the total environmental envelope.

5.5.1 Exposure Time History

Figure 5-7 shows a time history of exposure of Set Z to the environmental factors to be encountered during GPS Phase I testing of Set Z in the HH-53B/C at Yuma Proving Grounds. It has been assumed that the host test aircraft will be dedicated full-time to the tests and will be stationed at YPG. The aircraft will operate from that base for each day of flight testing.

The sequence of events and duration of each shown in Figure 5-7 are intended to be representative of the test operations to be conducted. While it is realized that any given test exercise may deviate from the sequence shown, it is felt that the events shown in the figure are sufficient to expose Set Z to all of the environmental extremes to be encountered. For example, since the time of day of satellite visibility will vary, and since the aircraft could be left on the ground at any time of day or night, relatively long on-the-ground events have been assumed as lasting 24 hours. Thus the overnight low temperatures of winter months and daytime high temperatures of summer months constitute the natural temperature exposure extremes.

5.5.2 Natural Environment

Table 5-4 summarizes Weather Bureau data on the ground level climate in Yuma on a monthly and annual basis. The HH-53B/C at Yuma could be exposed to any of these conditions, and the resultant environmental exposure of the Set Z equipment would be as discussed in the following paragraphs.

5.5.2.1 Temperature

As shown in Table 5-4, the coldest temperature recorded at Yuma is -4° C (25° F). Any of the Set Z LRUs could be exposed to this temperature level if the helicopter were left outside overnight. Set Z would be nonoperating under these conditions.

The highest temperature on record at Yuma is 48° C (118° F). Associated with this air temperature is a soil temperature of 71° C (160° F). Inside a closed helicopter parked in the sun, temperatures would be likely to reach 79° C (175° F). Thus, the Set Z receiver/processor, CDU, and IM could be exposed to these temperature levels in a nonoperating condition. The external antenna and stabilizer mounted preamplifier would not be subjected to the extreme "greenhouse effect" temperatures inside the helicopter, but could reach temperatures comparable to the 71° C soil temperature.

For Set Z operation, it is assumed that the helicopter doors would be opened to allow some cooling of the interior prior to operation. It is assumed that the crew would not activate the equipment until air temperature inside the helicopter had reached that of the outside air (<48°C). Antenna and preamplifier temperatures could remain high, however, since no ventilation is available in the stabilizer and the external antenna will continue to be exposed to direct sun.

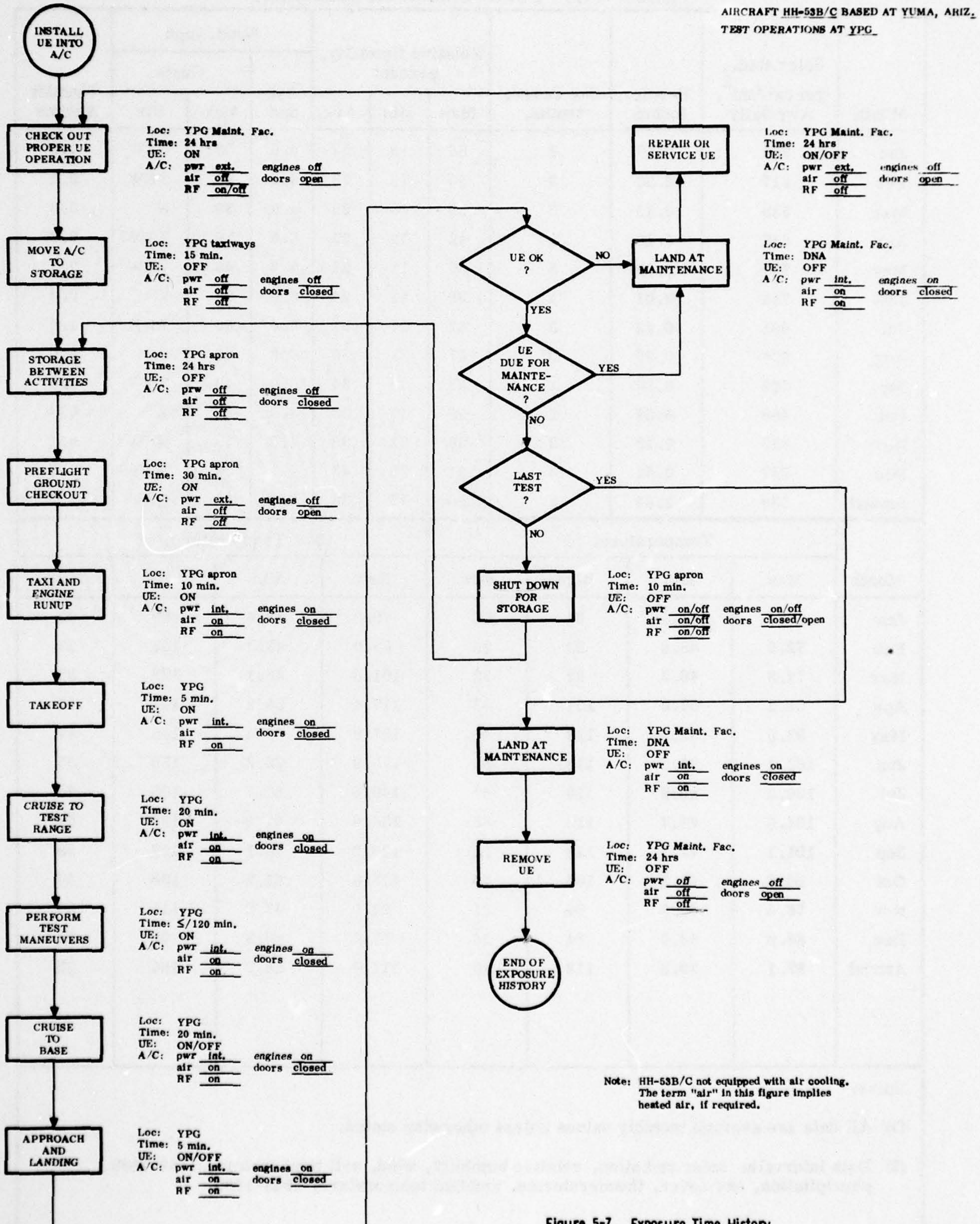


Figure 5-7. Exposure Time History, HH-53B/C Aircraft

TABLE 5-4. YUMA CLIMATE SUMMARY

Month	Solar Rad., gm cal/cm^2, Avg Daily	Precip., inches	Sky Cover, tenths,	Relative Humidity, percent			Wind, mph			Thunder Storms
								Gusts		
				Max	Min	Avg	Avg Spd	Max	Dir	
Jan	323	0.47	4	56	19	37	4.0	38	NNW	0.2
Feb	417	0.33	3	55	19	38	4.7	46	NNW	0.1
Mar	533	0.13	3	50	15	29	4.9	39	N	0.3
Apr	647	0.16	2	42	12	25	5.6	39	WNW	0.2
May	737	0.02	3	39	11	24	5.8	49	WSW	0.3
Jun	754	0.01	1	38	11	24	6.0	54	W	0.4
Jul	691	0.22	3	47	17	31	6.4	60	ENE	1.5
Aug	636	0.50	3	57	21	39	6.2	48	S	4.0
Sep	559	0.30	1	53	18	34	5.0	40	NNW	1.6
Oct	458	0.39	2	50	17	33	3.9	35	W	0.9
Nov	335	0.13	3	56	21	38	4.0	39	NNW	0.1
Dec	287	0.51	3	61	25	43	4.1	36	WNW	0.2
Annual	535	2.64	3	50	17	33	5.1	60	ENE	8.2

Month	Temperature, °F				Soil Temperature, °F			
	Max	Min	High	Low	Max	Min	High	Low
Jan	67.4	41.5	84	25	79.3	38.4	99	22
Feb	72.5	45.8	93	26	88.0	43.3	107	23
Mar	77.3	49.3	93	32	101.8	48.1	128	30
Apr	86.2	57.0	104	43	117.4	56.2	147	42
May	92.5	63.5	113	46	127.9	62.4	146	47
Jun	102.2	72.5	118	54	135.9	72.2	158	55
Jul	106.3	80.2	118	67	140.5	80.7	160	63
Aug	104.6	79.7	116	65	136.8	81.9	157	64
Sep	101.1	73.7	113	55	128.2	73.1	147	55
Oct	90.9	62.2	105	44	113.6	61.2	138	44
Nov	76.4	49.2	94	31	91.9	47.9	115	30
Dec	68.8	43.0	84	26	77.6	40.9	99	26
Annual	87.1	59.8	118	25	111.6	58.9	160	22

Notes:

(1) All data are average monthly values unless otherwise stated.

(2) Data intervals: solar radiation, relative humidity, wind, soil temperature, 1958-1965; precipitation, sky cover, thunderstorms, ambient temperature, 1945-1965.

During test operations, it is assumed that outside air will be circulated through the helicopter on hot days so that ambient temperatures will not exceed those on the outside. On cold days, internal heating is available (see Section 5.5.3.3) in the cockpit area. Outside air temperature at the aircraft altitude limit of 16,000 feet is estimated to be as low as -30° C (-23° F). This estimate is based on the minimum temperature recorded at Yuma and an approximate temperature drop of 1.7° C per 1000 feet of altitude increase. This estimate is warmer than the MIL-STD-210B temperature of approximately -40° C for operations at 16,000 feet. Neither of these temperatures exceeds those given in the SS-US-101B specification for Set Z operating conditions.

5.5.2.2 Humidity

As shown in Table 5-4, the humidity at Yuma is typically low. However, the antenna will be exposed directly to occasional rain and, depending on the weather sealing provided for the preamplifier installation in the horizontal stabilizer, some moisture could collect around that unit. The Set Z receiver/processor, CDU, and IM will not be subjected to direct rainfall, but air of nearly 100% humidity could be present in the helicopter during rain conditions.

5.5.2.3 Wind/Dust

Table 5-4 indicates typically light winds at Yuma, although substantial gusting (35-60 mph) can occur at any time of year. This, coupled with the dryness of the area, will lead to occasional substantial amounts of blowing sand and dust. Abrasive effects from blowing sand can be expected occasionally at the external antenna location. Air leakage into the avionics compartment during wind or takeoff/ground-effect hover conditions could blow dust or sand into the Set Z receiver/processor area.

5.5.2.4 Precipitation

Precipitation at Yuma averages only 2.64 inches annually, typically less than one-half inch per month. Precipitation will directly impact the antenna and preamplifier design and installation. While weather-seal design should protect against accumulation of water which could freeze and induce stresses, this is not expected to be a significant problem at Yuma. During flight through rain, some water could enter the avionics compartment through apertures around the compartment door.

5.5.2.5 Atmospheric Pollution/Corrosion

Atmospheric pollutants or corrosive elements are not expected to present any problems in the Yuma area.

5.5.3 Aircraft Environment

The following paragraphs summarize the environment onboard the HH-53B/C during Phase I test operations. The environmental factors presented are those which result directly from the operation of the aircraft and its associated systems. The environmental levels stated have been derived at the specific Set Z installation locations whenever source data resolution permits.

5.5.3.1 Mechanical Vibration

Vibration data for the HH-53B/C were obtained primarily from Sikorsky Aircraft Report No. SER-65651 (see bibliography, Volume I, Appendix A). The data presented in that report show vibration levels only at the main rotor blade frequency (18 Hz). These levels have been assumed to represent the most severe vibration levels in the aircraft spectrum at most locations. No other vibration data were available.

Vibration levels recorded in the cockpit were less than ±0.3g for indicated airspeeds ranging from zero (hover) to 170 knots at 100% N_R rotor speed, and for main rotor speeds up to 106% N_R at 150 knots IAS. Aircraft floor and overhead vibration levels were less than ±0.5g for the same flight conditions. The greatest vibration levels were recorded during approach to landing, when cockpit levels reached ±0.6g and floor vibration reached ±0.7g.

Sikorsky, through the H-53B/C System Manager's office at WRALC, indicated that peak vibration levels at the tip of the horizontal stabilizer are 10.5g vertical and 6.5g longitudinal at a frequency of 18 Hz. It is assumed that these levels represent a worst-case environment at the antenna/preamplifier installation location.

5.5.3.2 Acoustic Vibration

Limited test data were available regarding acoustic pressure levels on the HH-53B/C. Recordings made near the fuselage skin inside the HH-53B/C during hover conditions showed pressure levels generally below 110 dB re 0.0002 ubar, with a few peaks reaching 120-125 dB. All of these recordings were made above 1 KHz with no lower frequency data presented. The data are presented in Air Force Materials Laboratory Report No. AFML-TR-73-305 (see bibliography, Volume I).

The most severe acoustic environment for the Set Z installation on the HH-53B/C will probably occur externally at the antenna/preamplifier location near the tail rotor. Acoustic pressure measurements on a UH-1C helicopter (Air Force Flight Dynamics Laboratory Report No. AFFDL-TR-73-160) indicated that acoustic levels external to the fuselage were 10-15 dB greater than those inside the aircraft during various flight stages, without gunfire. If this same ratio is true of the HH-53B/C, external acoustic levels of 135 to 140 dB re 0.0002 ubar might be expected at the antenna location, and somewhat lower levels might be present inside the stabilizer skin.

5.5.3.3 Temperature and Humidity

No air cooling or moisture removal systems are provided on the HH-53B/C. Warm air is available at the flight station if desired by the crew for comfort. Therefore, ambient cabin air temperature during equipment operation could be as high as the 48° C (118° F) maximum recorded at Yuma. Minimum temperatures of the ambient air in the cockpit would be no less than -4° C (25° F), but would be more likely to be approximately 20° C during equipment operation because of the warm air available for the crew.

Air circulating through the electronics compartment during flight would enter the compartment at the temperature outside the aircraft. As noted in Section 5.5.2.1, this temperature could range from an estimated -30° C at 16,000 feet on a cold day to

+48° C on the ground in the summer. Since there is no air circulation inside the horizontal stabilizer, preamplifier temperature will be governed by ambient outside air temperature and solar heating (see Section 5.5.2.1). The low power dissipation of the preamplifier is not expected to significantly affect the temperature inside the stabilizer.

Humidity at all equipment installations could approach 100%, depending on weather conditions, since no humidity control is available on the HH-53B/C.

5.5.3.4 Unit Size and Weight Restrictions

The Set Z receiver/processor and IM will replace the AN/ARN-65 TACAN receiver/transmitter on the lower shelf of the right-hand avionics rack. The available space measures 47 x 24 x 23 cm (18.5 x 9.5 x 9 in.), with additional surrounding space of at least 0.028 m^3 (0.99 ft^3). The weight of the receiver/processor and IM combined will be limited to 27.2 kg in conformance with standard ARINC weight-vs.-size estimates. Minimum weight of GPS equipment is desirable for helicopter weight and center-of-gravity considerations.

The CDU installation on the center console will require a 14.6 cm (5.75 in.) standard width. Depth available behind the panel is estimated to be 20 to 25 cm (7.9 to 9.8 in.). With removal of the ADF control panel, the height of the CDU will be limited to 17.5 cm (7 in.). No weight restrictions have been identified.

No design-limiting size constraints will be imposed on the volute antenna by its installation on the horizontal stabilizer. Available space inside the stabilizer for the preamplifier measures approximately 12 x 12 x 40 cm (4.7 x 4.7 x 15.8 in.). No quantitative weight restrictions have been identified for the antenna/preamplifier assembly, although minimum weight is essential due to long moment arms associated with the tail location.

5.5.3.5 Electrical Power

Prime power is available onboard the HH-53B/C at 115 Vac, 400 Hz and 28 Vdc. The available power complies with MIL-STD-704, as required by Set Z.

5.5.3.6 Heat Dissipation

Cooling of all electronics on the HH-53B/C is by ambient air or conduction through mounting structures. No cooled air is available on the aircraft. Air is not forced through the electronics bay, although outside air does leak into and through the area during flight. In the cockpit area, air is circulated by the ventilation system, and may provide some cooling of the CDU through the front panel. The preamplifier will be cooled only by heat conduction through mounting structures or convection of captured air inside the horizontal stabilizer.

5.5.3.7 Pressurization

The HH-53B/C is unpressurized. All Set Z equipment will be subject to the atmospheric pressure at the aircraft altitude. Maximum density altitude for the aircraft is 16,000 feet.

5.5.4 Electromagnetic Compatibility/Interference (EMC/EMI)

The electromagnetic compatibility of the Set Z installations described in the preceding sections has been considered from the standpoint of interference from radiating antennas on the aircraft, interference to or from nearby avionic units, common practices for electrical shielding and wire types, and any historical EMI problems associated with the aircraft.

5.5.4.1 Antenna Locations

Figure 5-8 shows the locations of antennas on the HH-53B/C. Table 5-5 summarizes pertinent characteristics of the radiating antennas.

The IFF antenna, a potential source of EMI on other aircraft, is located on the bottom of the HH-53B/C and is shielded from the GPS antenna by both the fuselage and the horizontal stabilizer. No high power emitting antennas having an RF close to the GPS receiver frequency are located on the top of the aircraft, and no RF EMI is anticipated.

The other radiating antennas onboard the aircraft are expected to present no interference problems to the GPS antenna. The former all appear either to 1) have RF spectrums well removed from that of the GPS RF, 2) be oriented away from the GPS antenna, or 3) be inoperative during GPS tests; or a combination of these.

5.5.4.2 Nearby Avionics Units

Table 5-6 lists the receivers located in the HH-53B/C forward electronics compartment along with the Set Z receiver/processor. The table indicates pertinent receiver characteristics with regard to EMI to or from the Set Z receiver.

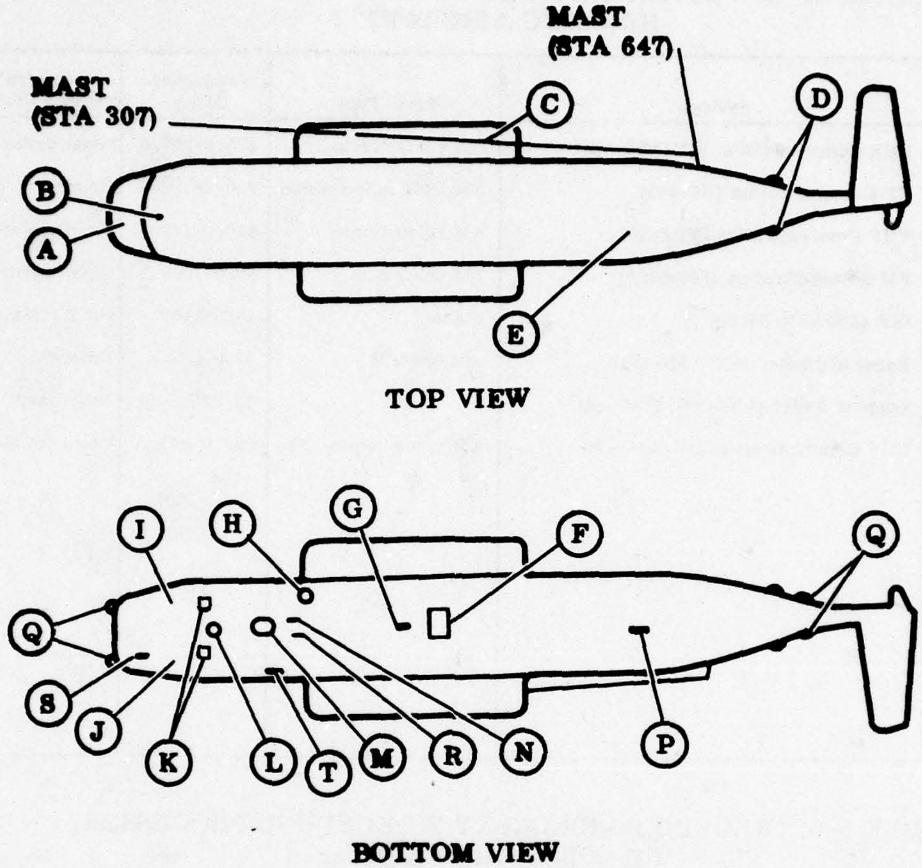
At the time of this writing, the Set Z intermediate and local-oscillator frequencies have not been definitely selected. Therefore it is impossible to identify any coincidence of IF or LO frequency with any of the receivers in Table 5-6. In view of the basic lack of historical EMI problems on the HH-53B/C however, no installation problems are anticipated.

Table 5-7 lists the transmitters located in the HH-53B/C forward electronics compartment along with the Set Z receiver/processor. The table indicates pertinent transmitter characteristics with regard to EMI to the Set Z receiver.

Since the Set Z IF and LO frequencies have not been selected, the possibility of RF leakage from these transmitters interfering with the Set Z receiver cannot be accurately assessed. Direct RF interference from in-band noise generated by the AN/APX-64(V) IFF transmitter is doubtful, in view of the MIL-E-6051 requirement for 60 dB shielding of each of the two units and the frequency difference between them.

5.5.4.3 Wiring and Cabling

The GPS installation has been specified to take maximum advantage of existing avionics wiring on the HH-53B/C. Since no known historical problems of EMI have been identified for this wiring, none are anticipated for the GPS installation. The possibility cannot be entirely ruled out, since sufficient data have not been located to accurately estimate noise levels on the lines.



A. Glideslope
B. UHF Communication (Top)
C. HF Communication
D. VOR/LCL
E. VHF Communication
F. LF ADF Sense
G. LF ADF Loop
H. FM Communication
I. TACAN
J. IFF
K. Radar Altimeter
L. UHF/DF
M. Doppler
N. Marker Beacon
P. UHF Communication (Bottom)
Q. (Undetermined)
R. (Undetermined)
S. (Undetermined)
T. (Undetermined)

Figure 5-8. Antenna Locations, HH-53B/C

TABLE 5-5. RADIATING ANTENNA SIGNAL CHARACTERISTICS, HH-53B/C AIRCRAFT

Antenna No. (See Fig. 5-8)	System	Signal Type	Frequency (MHz)	General Antenna Coverage
B	UHF Communication (AN/ARC-34)	AM voice comm	225.0-399.9	Omni upward
C	HF Communication (HF-103)	AM, SSB voice comm	2.0-29.999	Omni
E	VHF Communication (VHF-101)	AM voice comm	116.0-149.95	Omni upward
H	FM Communication (FM-622A)	FM voice com	30.0-76.0	Omni downward
J	IFF (AN/APX-64(V))	Pulse	1080-1100	Omni downward
K	Radar Altimeter (AN/APN-171(V))	Assume FM	4300 ± 50	Downward
M	Doppler Radar (AN/APN-175(V)-1)		13,325 ± 25	Downward
P	UHF Communication (AN/ARC-34)	AM voice comm	225.0-399.9	Omni downward

TABLE 5-6. RECEIVERS NEAR SET Z RECEIVER/PROCESSOR, HH-53B/C AIRCRAFT

Receiver	RF (MHz)	LO (MHz)	IF (MHz)	RF Sensitivity (dBm)
Radar Altimeter (APN-171(V))*	4300 ± 50	–	–	–
UHF Comm (ARC-34)	225.0-399.9	Assume 285.0-459.95	Assume 60	–
LF ADF (ARN-59)	0.19-1.75	–	–	–
VOR/LCL (VOR-101)	108.0-117.9	–	–	–
IFF (APX-64(V))	1030	1089.5	59.5	-66 to -78
VHF Comm (VHF-101)	116.0-149.95	–	–	–

*Unit adjacent to Set Z receiver/processor.

TABLE 5-7. TRANSMITTERS NEAR SET Z RECEIVER/PROCESSOR, HH-53B/C AIRCRAFT

Transmitter	RF (MHz)	Modulation	Power
Radar Altimeter (APN-171(V))*	4300 ± 50	Assume FM	–
UHF Comm (ARC-34)	225.0-399.9	AM voice comm	Assume 30-75W
IFF (APX-64(V))	1080-1100	Pulse	~80W peak
VHF Comm (VHF-101)	116.0-149.95	AM voice comm	Assume 25-100W
*Unit adjacent to Set Z receiver/processor.			

New cables and wires required for the Set Z installation have been specified in accordance with MIL-W-5088 and best engineering practice. It is anticipated that these measures will be sufficient to preclude EMI problems for the installation, provided that the wires are dressed away from cables and wires of the automatic flight control system.

5.5.4.4 Historical EMI/EMC

During interview and conversations with cognizant personnel regarding the HH-53B/C, the only historical EMI problem identified was that of coupling with the automatic flight control system cables and wires. All cables installed in the helicopter should be dressed away from these cables and wires to avoid any such coupling.

5.5.5 Environmental Summary, HH-53B/C

Table 5-8 summarizes the environmental exposure of Set Z installed in the HH-53B/C for GPS Phase I testing at Yuma Proving Grounds. The table presents the maximum and minimum operating and nonoperating extremes of each of the environmental parameters discussed in the preceding sections. The environmental envelope represented by the table thus shows the conditions which Set Z and IM may experience and be required to survive during the test program.

The parameter values listed in Table 5-8 apply to all Set Z and IM components unless otherwise noted. The temperature, vibration, and acoustic pressure specifications for the antenna and preamplifier are listed separately, since their installation exposes them to more severe environments.

All environmental exposure levels shown in Table 5-8 fall within the service condition limits of SS-US-101B, with the exceptions of the operating temperature range and vibration levels of the antenna/preamplifier unit. That LRU can be subjected to operating temperatures in excess of those specified in SS-US-101B (+55°C) when on the ground at Yuma. The thermal range for the antenna is not expected to present any damage-related problems, since that unit must survive the SS-US-101B nonoperating range of -62°C to +85°C without damage and does not dissipate energy in the operating mode. The exposure of the preamplifier to 71°C while operating is probably of little

TABLE 5-8. TEST ENVIRONMENT SUMMARY, HH-53B/C AIRCRAFT

Environmental Parameter	Range
Temperature	
Operating: CDU, IM, Rcvr/Proc	-30° to 48°C
Operating: Antenna/Preamp	-30° to 71°C
Nonoperating: CDU, IM, Rcvr/Proc	-30° to 79°C
Nonoperating: Antenna/Preamp	-30° to 71°C
Humidity	
Operating and nonoperating	≤100% Antenna directly exposed to rain. Possible rain entering electronics compartment (receiver/processor location)
Vibration	
Operating and nonoperating: CDU, IM, Rcvr/Proc	<1g
Operating and nonoperating: Antenna/Preamp	≤10.5g vert, ≤6.5g longitudinal
Acoustic Pressure	
Operating and nonoperating: CDU, IM, Rcvr/Proc	≤130 dB re 0.0002 ubar
Operating and nonoperating: Antenna/Preamp	≤135-140 dB re 0.0002 ubar (est)
Pressure	
Operating and nonoperating	≤16,000 ft, unpressurized
Wind/Dust	
Operating and nonoperating	Some blowing sand/dust, especially during takeoff or hover. Possible small pebble impact at antenna, due to tail rotor blast.
Atmospheric Pollution	
Operating and nonoperating	Slight. No problems anticipated.
Electrical Power	Per MIL-STD-704A

concern also, relative to damage susceptibility, since its low power dissipation (approximately 1 watt) is unlikely to develop internal stresses not experienced during the required nonoperating exposure to +85°C. In terms of component performance tolerances and other factors, however, this exposure warrants design consideration. It is recommended that the GPS JPO consider expanding the SS-US-101B temperature specification for the antenna/preamplifier to include the levels that may be experienced during Phase I testing.

The vibration specification of 10.5g for the antenna/preamplifier exceeds the SS-US-101B specification, but represents a worst-case horizontal stabilizer vibration recorded at the tip of the stabilizer. It is not recommended that the SS-US-101B vibration specification be modified to accommodate this deviation from the current levels.

5.6 TEST VS. OPERATIONAL CONFIGURATION INTEGRATION REQUIREMENTS

The installation approach for the GPS equipment in the HH-53B/C test aircraft is intended to conform, to the extent practicable, with the probable installation scheme in the operational vehicle. The antenna/preamplifier location and installation are subject, of course, to test results, with relocation a likely prospect depending on GPS performance. Location of the receiver/processor unit and the Integration Module should remain in the right-hand electronics compartment, as described. The CDU should remain centrally located on the cockpit console except that installation in PAVE LOW III aircraft cannot be determined at this time.

Permanent aircraft wiring would be incorporated in lieu of jumper harnesses for altitude and true airspeed inputs. A TAS computer would have to be installed in six aircraft. Table 5-9 details the similarities and differences between the Class II (test configuration) and Class V (operational configuration) installations.

TABLE 5-9. COMPARISON OF SET Z TEST AND OPERATIONAL CONFIGURATIONS, HH-53B/C AIRCRAFT

Element	Test Configuration	Operational Configuration
Antenna/Preamplifier Assy	Top of horizontal stabilizer @ STA 64 in front of aft beam	TBD
Receiver/Processor Unit	RS nose avionics compartment, lower shelf	Same
Integration Module	RS nose avionics compartment, lower shelf	Same
Control/Display Unit	Center forward region of cockpit center console	Same, except PAVE LOW III aircraft TBD
Connection to CDU	Jumper harness to TACAN harness plug	TACAN harness via new connector
Connection to Flight Instruments	Jumper harness (the same one noted above)	TACAN harness via new connector, added wiring
Altitude Input	Jumper harness to connect between APX-64 and altimeter-encoder	Splice or terminal board wiring connections
TAS Input	Jumper harness connection to TAS transmitter connects to both existing harness and the GPS equipment	Splice or terminal board wiring connections
Degraded Mode Light	Connection to caution light panel	Same

6
TEST AIRCRAFT INTEGRATION, P-3C

This section provides detailed information concerning the integration of UE Set Z into the P-3C aircraft for GPS Phase I testing. The section provides information pertaining to the derivation of requirements, a description of the test installation, cabling and connections, electronic interfaces, and a summary of Group A items that will be required for installation and interface. All items considered relevant to installation requirements of Set Z into the P-3C are presented in checklist format in Appendix B.

6.1 INTEGRATION REQUIREMENTS DERIVATION

The integration requirements information contained in this section was derived from a study of technical manuals, handbooks and reports for the P-3C aircraft (see bibliography, Volume I, Appendix A). Additionally, information and data were collected during trips to the aircraft manufacturer, Lockheed-California Company at Burbank, California (see trip and contact list, Volume I, Appendix B).

6.1.1 Physical Installation Requirements

As discussed in Section 1.2, Set Z consists of three LRUs: receiver/processor, antenna/preamplifier, and CDU. Requirements and constraints on the physical installation of these LRUs in P-3C were imposed by the physical configuration of the aircraft and its associated avionics, the "update" modification being implemented into P-3C production, the environment onboard the aircraft, the GPS Phase I Test Plan, and direction from the GPS JPO. The same considerations impact the IM physical installation. The specific rationale for the installation of each unit will be described along with the installation descriptions presented in the following sections.

6.1.2 Avionics Configuration

Table 6-1 lists the P-3C avionics relevant to the integration effort. Relevancy is based upon replacement by, interface with, or potential interference to or from Set Z.

For the Navy aircraft, JPO direction was to retain the TACAN equipment onboard rather than to replace it with Set Z. The installation must utilize existing available space in the avionics compartments, and new aircraft wiring will be needed for all interconnections. Integration with the AN/ARN-52 (or AN/ARN-84) TACAN must be accomplished so that both TACAN and Set Z can drive the navigational flight instruments.

The P-3C aircraft is still in production, with more than 100 aircraft now operational. Three major avionics changes are pending in the P-3C design:

a. Update 1, which deletes the low-light-level television and adds a drum memory, OMEGA, magnetic tape recorder, and DIFAR system

TABLE 6-1. P-3C AVIONICS EQUIPMENTS AFFECTED BY SET Z TEST INSTALLATIONS

Item Removed	Item Interfacing	Potential Interference
Pilot's Camera Control Panel	Pilot's HSI (ID-1540/A)	TACAN (AN/ARN-52(V) or ARN-84)
	Copilot's HSI (ID-1540/A)	
	Nav/Comm HSI (ID-1540/A)	IFF (AN/APX-72)
	TACAN Set (AN/ARN-52(V) or ARN-84)	IFF (AN/APX-76)
	Monitorable Essential AC Bus	
	Monitorable Essential DC Bus	
	Annunciator Panel	
	Copilot's Altimeter (AAU-21/A)	
	Central Repeater Amplifier (AM-4923/A)	
	Flight Director (AN/AJN-15)	
	TAS Computer (CPK-28)	

improvements in the aircraft. This update is effective in 1975 production aircraft.

b. Update 2, which adds a FLIR, sonobuoy reference system, and Harpoon.

c. Update 3, which adds a proposed new acoustic system (Proteus), a new sonar system, and a satellite communications system (FleetSatCom).

The GPS installation in the P-3C should be designed to accommodate Update 1, since that change is firm and is now being produced; and should consider the requirements that may be imposed by Updates 2 and 3 for operational installations.

6.2 PHYSICAL INSTALLATION DESCRIPTION

The following sections describe the physical installation of Set Z LRUs in the P-3C, together with the rationale for the selection or design of each installation approach.

6.2.1 Receiver/Processor

The Set Z receiver/processor will be located in avionics compartment C-1/C-2 on the outboard side of shelf B. The receiver/processor installation is illustrated in Figure 6-1.

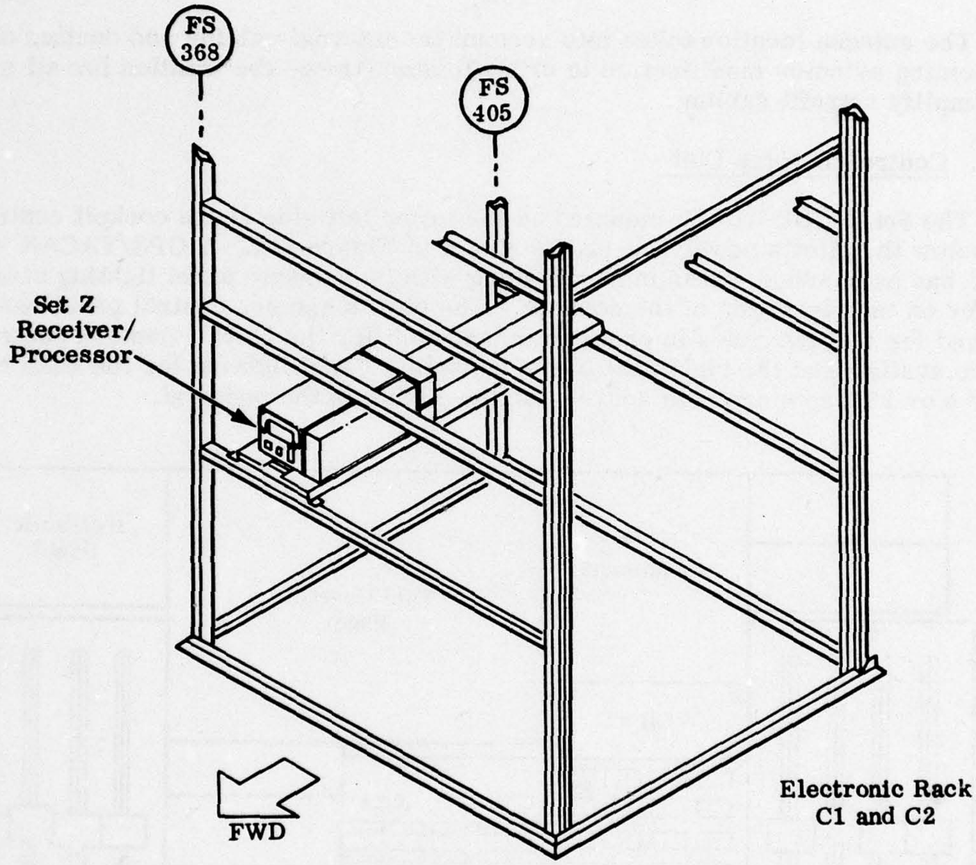


Figure 6-1. P-3C GPS UE Set Z Receiver/Processor Installation

This location is suggested because adequate space is available, and cable runs to interfacing equipments will be short. The receiver/processor unit will be mounted on vibration isolators along with the IM to protect it from the environment during flight. The indicated location is on the right side of the cabin at approximately fuselage station 360. The approximate dimensions of space at the region are 50 x 60 x 35 cm.

Access for equipment removal will be somewhat restricted since it is through the cramped region behind the navigator's chair. The avionics cabinet is cooled by cabin air drawn through the cabinet and exhausted at the cabinet top, aft through a main duct, and overboard. Cooling air will be drawn from the cabinet into the front of the GPS receiver/processor and circulated through the unit by a fan. The hot air is then exhausted through the bottom of the mounting tray. The heat dissipated in the unit, (which has a power consumption of 120 watts) is not of a level that will necessitate the ducting of cooling air directly to the unit.

6.2.2 Antenna/Preamplifier Assembly

The Set Z antenna will be located on top of the aircraft at FS 460. The preamplifier unit will extend inside the aircraft, below the antenna. An airtight seal must be provided around the assembly mounting flange. Space inside the fuselage is adequate to accommodate the assembly without difficulty.

The antenna location takes into account the internal cabling and ducting of a forthcoming avionics modification in order to standardize the location for all aircraft and simplify retrofit cabling.

6.2.3 Control/Display Unit

The Set Z CDU will be mounted on the lower left side of the cockpit center console below the pilot's power levers, as shown in Figure 6-2. A GPS/TACAN selector switch has been added and is mounted along with the console panel lighting circuit breaker on the right side of the console. The pilot's camera control panel has been removed for test purposes in order to make room for the CDU. Camera control will still be available at the right side of the console. Panel lighting for the CDU may be either 5 or 28 Vac since both sources are available in the pedestal.

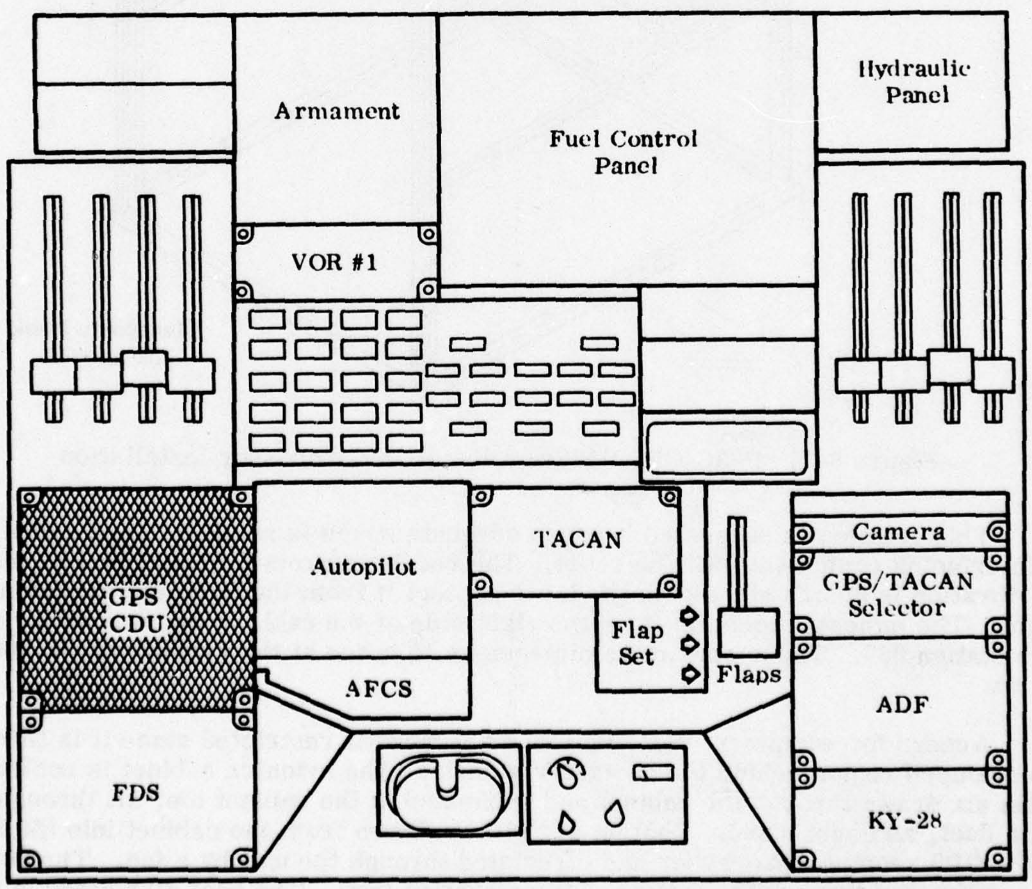


Figure 6-2. P-3C Center Console Layout with Set Z CDU

6.2.4 Integration Module

The Integration Module is installed in the receiver/processor mounting, as shown in Figure 1-1. The installation permits independent Set Z operation, removes power elements (synchro drivers) from the basic LRU for better thermal performance, and enables use of a standardized LRU design in the P-3C aircraft. Cooling of the unit (120 watts power consumption) will be by ambient electronics compartment air; ducting of cooling air directly to the IM is not contemplated.

6.2.5 GPS/TACAN Relay Box

A small relay box (see dimensional sketch, Figure 6-3) will be installed in the C-1/C-2 avionics compartment and connected to both TACAN and Set Z equipments for selectable navigation input to the flight instruments. The box will be designed to accept the two connector plugs normally attached to J1902 and J1905 of the RT-384/ARN-52(V) (or RT-1022/ARN-84(V)). Signal wires that relate to either GPS or TACAN are connected to internal relays, or split within the box. Other connections are wired directly to the output jack as shown in the relay box schematic, Figure 6-4.

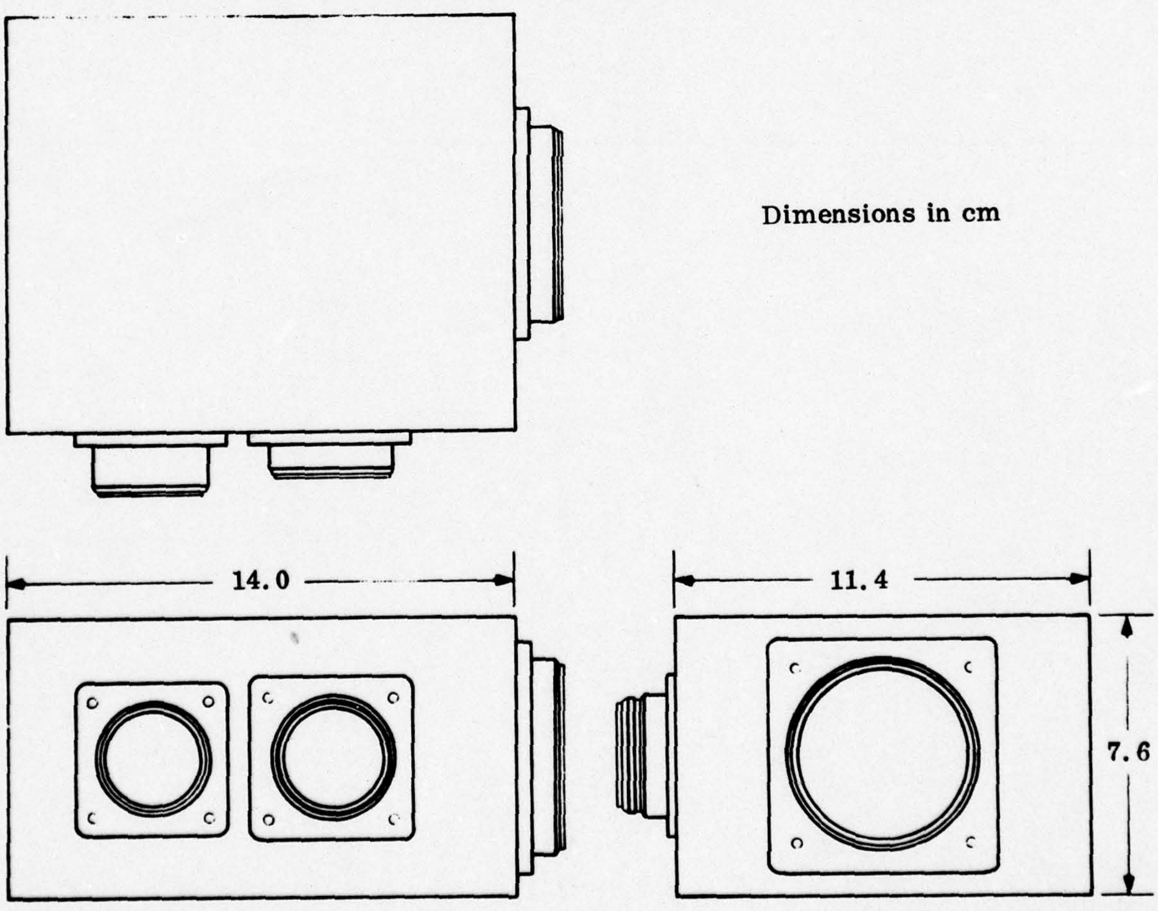
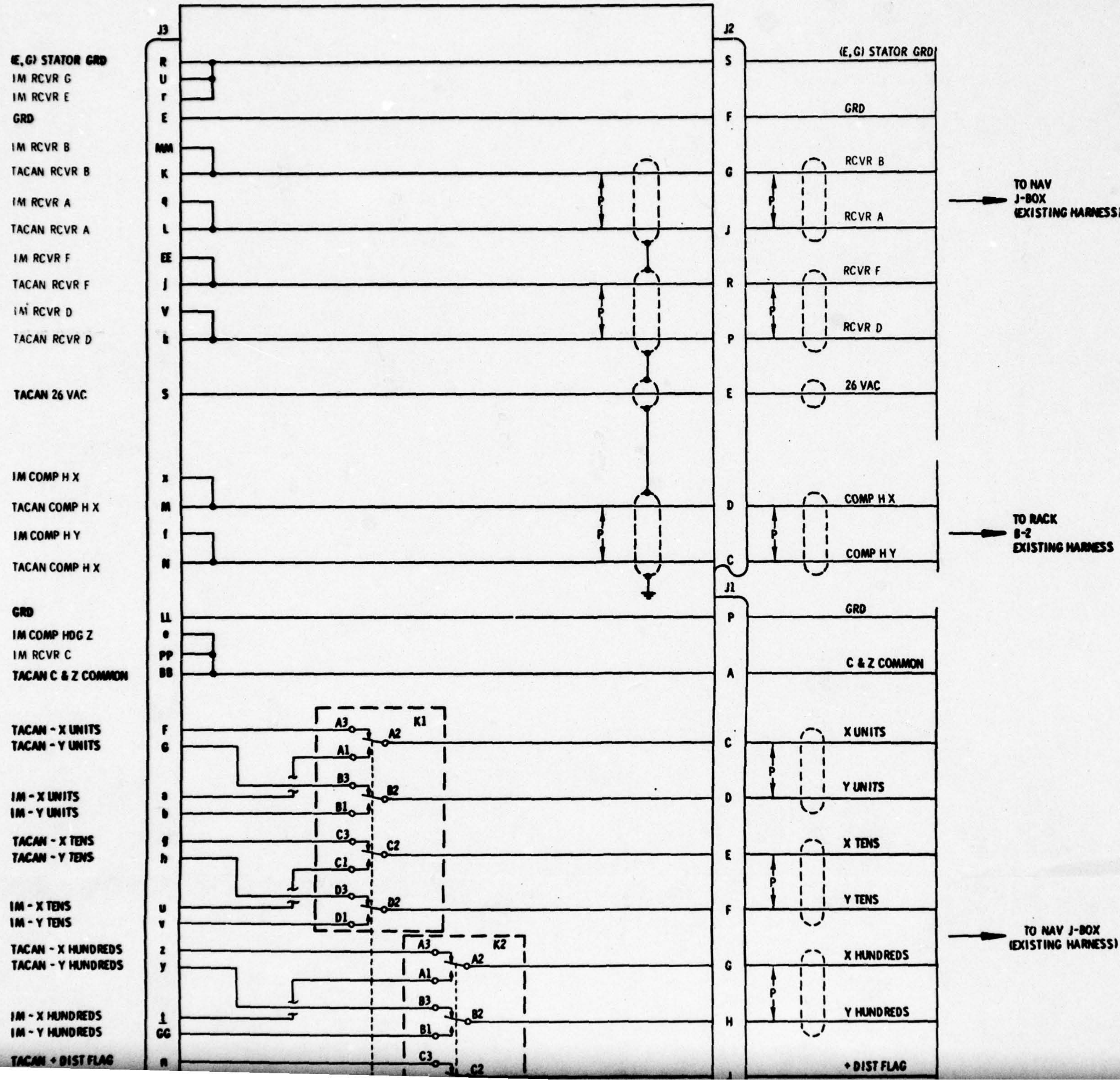


Figure 6-3. GPS/TACAN Relay Box, P-3C Test Installation



J3
J2
J1
(E, G) STATOR GRD
IM RCVR G
IM RCVR E
GRD
IM RCVR B
TACAN RCVR B
IM RCVR A
TACAN RCVR A
IM RCVR F
TACAN RCVR F
IM RCVR D
TACAN RCVR D
TACAN 26 VAC
IM COMP H X
TACAN COMP H X
IM COMP H Y
TACAN COMP H X
GRD
IM COMP HDG Z
IM RCVR C
TACAN C & Z COMMON
TACAN - X UNITS
TACAN - Y UNITS
IM - X UNITS
IM - Y UNITS
TACAN - X TENS
TACAN - Y TENS
IM - X TENS
IM - Y TENS
TACAN - X HUNDREDS
TACAN - Y HUNDREDS
IM - X HUNDREDS
IM - Y HUNDREDS
TACAN + DIST FLAG
K1
K2
(E, G) STATOR GRD
GRD
RCVR B
RCVR A
RCVR F
RCVR D
26 VAC
COMP H X
COMP H Y
GRD
C & Z COMMON
X UNITS
Y UNITS
X TENS
Y TENS
X HUNDREDS
Y HUNDREDS
+ DIST FLAG
TO NAV J-BOX (EXISTING HARNESS)
TO RACK B-2 EXISTING HARNESS
TO NAV J-BOX (EXISTING HARNESS)

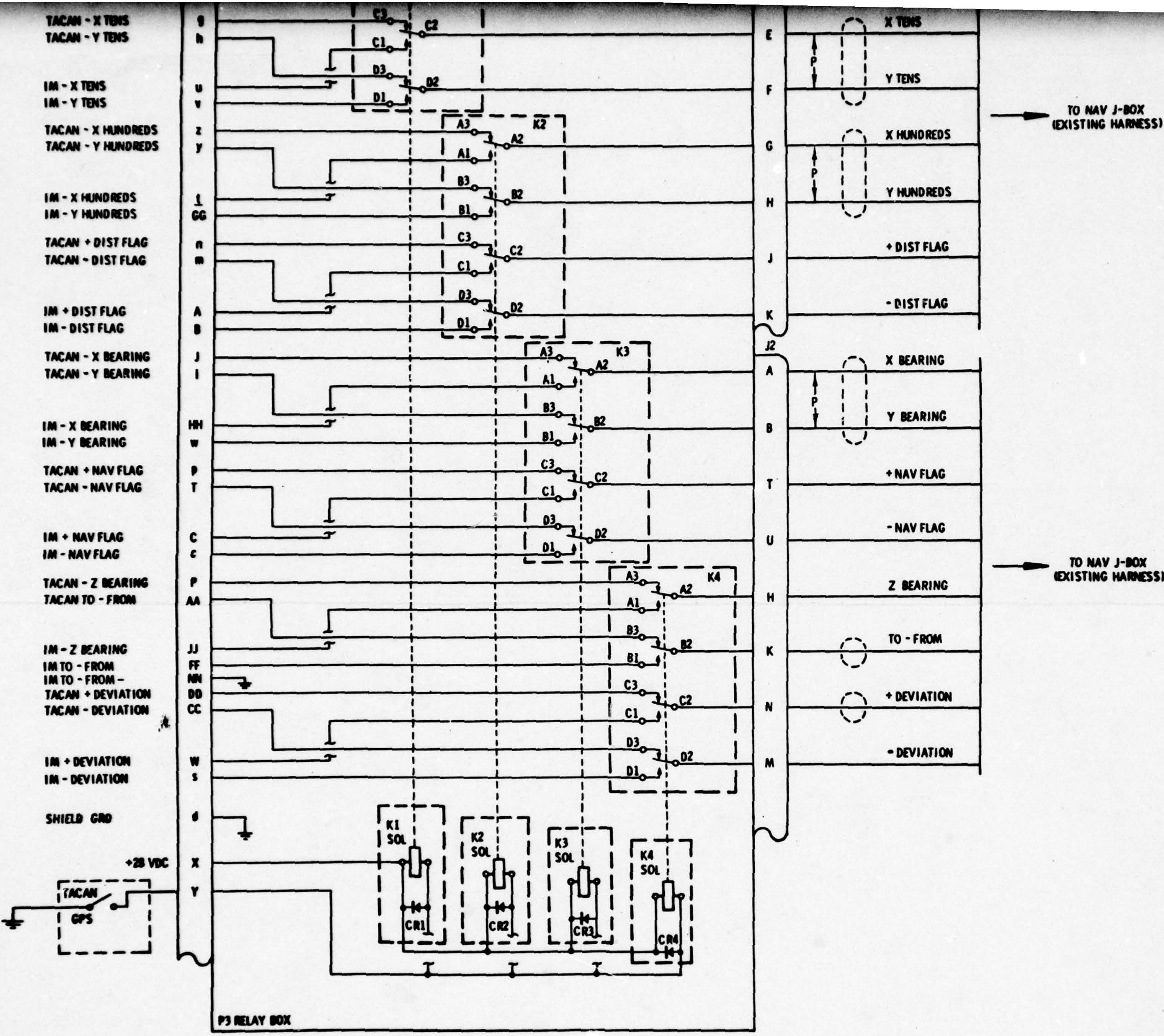


Figure 6-4. Schematic Diagram, P-3C Relay Box

6.3 ELECTRONIC INTERFACES

6.3.1 Functional Interfaces

Electronic interfaces for the P-3C Set Z installation are summarized in Table 6-2. The table is a matrix of avionic system, component vs. signals input to or output from Set Z.

The relationship of the Set Z test installation to the onboard radio navigation system is shown in the interface diagram of Figure 6-5.

6.3.2 Wiring and Connectors

The cabling and interconnections between LRUs of Set Z and the aircraft systems are shown in the cabling and interwiring diagrams, Figures 6-6 and 6-7 respectively. Pin connections and wiring assignments between Set Z, the IM, the relay box, and other interfacing onboard avionics are chosen for spares accessibility but are otherwise arbitrary. Reassignments during the Set Z design phase should be kept to a minimum and should be carefully accomplished to preserve standardization of receiver/processor and Integration Module connections.

The interwiring layout was influenced by the requirement that Set Z continue to operate independently in the event of a failure in the integration module. Selection of the connectors specified in the Group A listing (see Section 6.4) was based on functional and environmental considerations and a requirement for multiservice acceptability. For the receiver/processor unit and IM, the selection of connectors follows the guidance of ARINC Specification 404A, used by commercial airlines, which recommends the use of plug-in DPX or similar connectors on equipment LRUs. Other connectors were selected from MIL-C-83723 and MIL-C-39012 as appropriate.

6.3.2.1 Coaxial Cable

Foam-flex cable runs of less than 5 meters will be required to connect the GPS preamplifier and the receiver/processor. The cables will be displaced to the right for easy retrofit with existing wiring at approximately RBL 10.0, and will terminate near the forward edge of cabinet C-1. Service loops of flexible coaxial cable will be required to transit the forward cabinet area to the front of the receiver/processor unit on shelf B.

6.3.2.2 Altitude Input Connections

A special harness must be fabricated that will permit coupling into the altitude data lines from the copilot's AAU-21/A altimeter encoder. The harness will connect to plug RH2D11 in rack H-2, which is now plugged into (but with wiring open) the aft interconnection box of the No. 1 ASN-84 inertial navigation system. The harness is depicted on the cabling diagram, Figure 6-6.

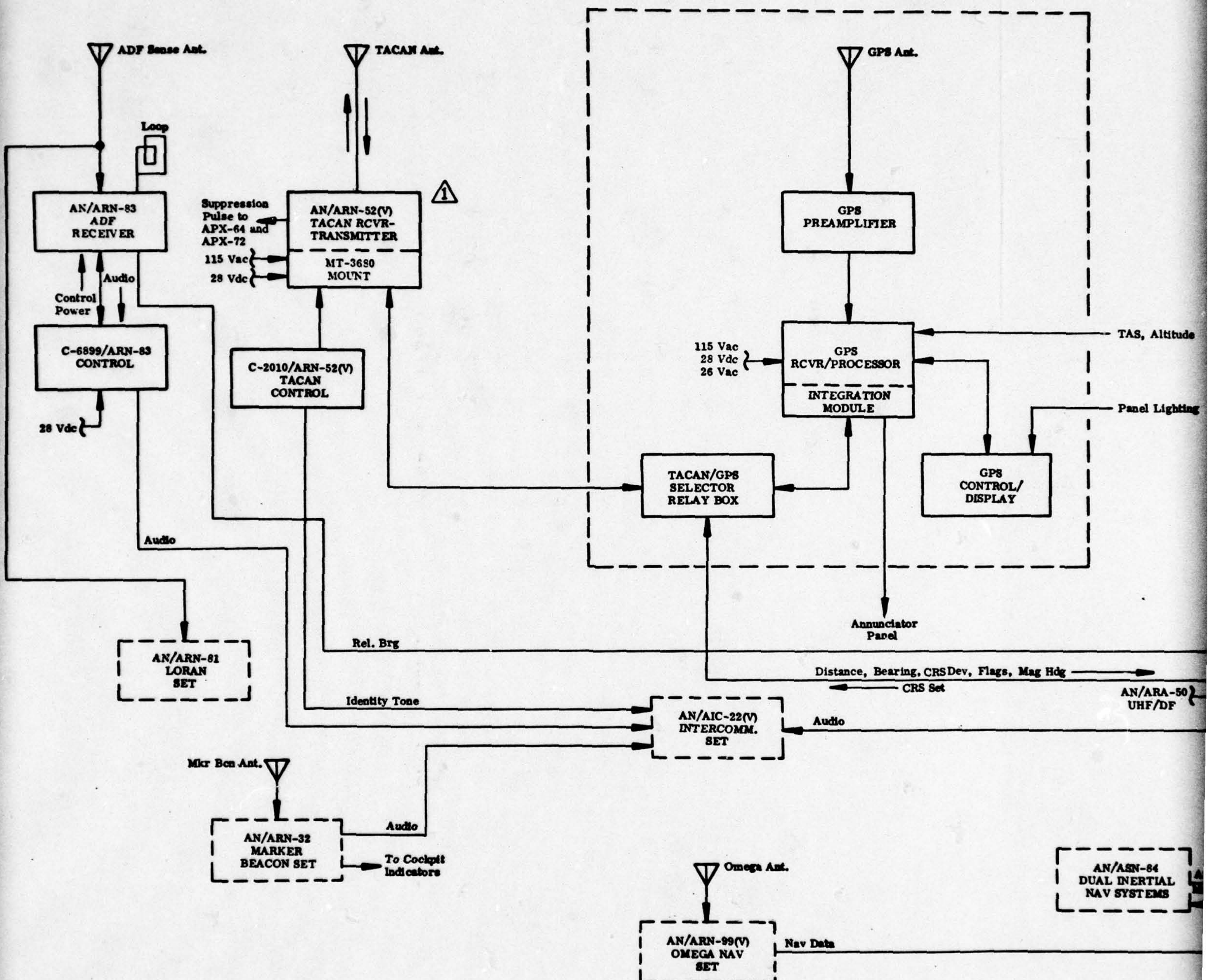
6.3.2.3 TAS Input Connections

A special harness must be fabricated to permit coupling into the true airspeed synchro lines between the true airspeed computer and the navigation interconnection box. Individually shielded wires will be connected to TB403 studs A4, A5, and A6, which are located in compartment C-1. The harness is depicted on the cabling diagram, Figure 6-6.

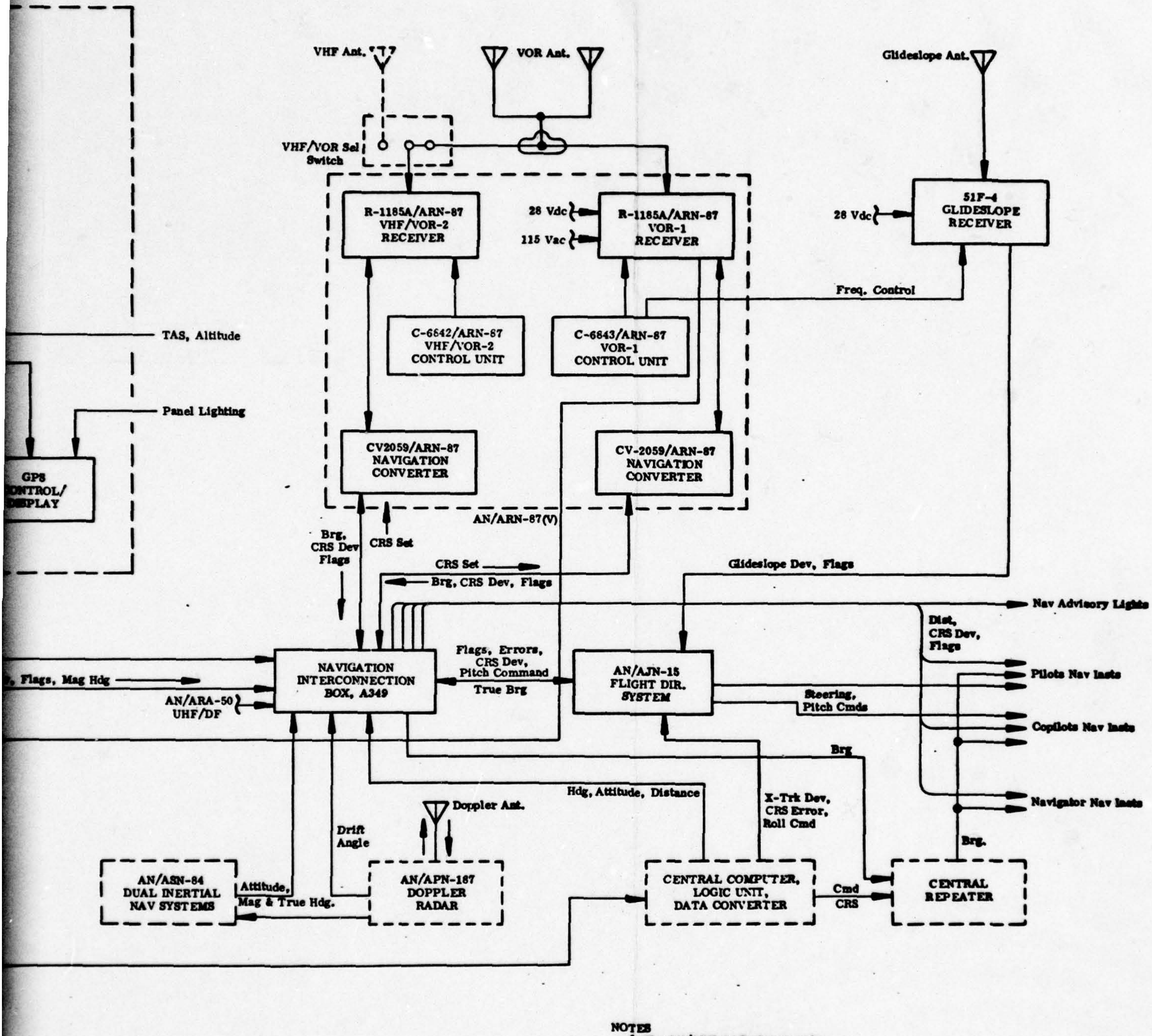
TABLE 6-2. ELECTRONIC INTERFACE SIGNALS, P-3C AIRCRAFT

Avionic System/ Component	Set Z Interface Signals																
	Set Z Output to Systems/Displays									Inputs to Set Z							
	Digital Navigation Data	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Degraded Mode	Course Set	A/C Power, 115 Vac, 400 Hz	A/C Power, 28 Vdc	Synchro Ref., 26 Vac, 400 Hz, ØA	Altitude	True Airspeed	Panel Lighting*	Digital Control Data	Magnetic Heading
1. Set Z CDU	X															X	
2. Pilot's HSI (ID-1540/A)		X	X	X	X	X	X		X								
3. Copilot's HSI (ID-1540/A)		X	X	X	X	X	X		X								
4. Nav's HSI (ID-1540/A)		X	X	X													
5. Flight Director Computer (AN/AJN-15)					X	X											
6. Central Repeater Amp No. 1																	X
7. Annunciator Panel								X									
8. True Airspeed Computer (CPK-28/A24G-9)														X			
9. Altimeter (AAU-21/A)													X				
10. Control Pedestal Lighting System 28 Vac or 5 Vac															X		
11. AC Monitorable Essential Bus										X							
12. DC Monitorable Essential Bus											X						
13. Compartment F-1 Terminal Board												X					

*Direct to CDU



ADF Sense Ant.
Loop
AN/ARN-83
ADF
RECEIVER
Control
Power
Audio
C-6899/ARN-83
CONTROL
28 Vdc
TACAN Ant.
Suppression
Pulse to
APX-64 and
APX-72
115 Vac
28 Vdc
AN/ARN-52(V)
TACAN RCVR-
TRANSMITTER
MT-3680
MOUNT
C-2010/ARN-52(V)
TACAN
CONTROL
GPS Ant.
GPS
PREAMPLIFIER
115 Vac
28 Vdc
26 Vac
GPS
RCVR/PROCESSOR
INTEGRATION
MODULE
TAS, Altitude
Panel Lighting
TACAN/GPS
SELECTOR
RELAY BOX
GPS
CONTROL/
DISPLAY
Audio
AN/ARN-81
LORAN
SET
Annunciator
Panel
Rel. Brg
Distance, Bearing, CRS Dev, Flags, Mag Hdg
CRS Set
AN/ARA-50
UHF/DF
Identity Tone
AN/AIC-22(V)
INTERCOMM.
SET
Audio
Mkr Bcn Ant.
AN/ARN-32
MARKER
BEACON SET
Audio
To Cockpit
Indicators
Omega Ant.
AN/ARN-99(V)
OMEGA NAV
SET
Nav Data
AN/ASN-84
DUAL INERTIAL
NAV SYSTEMS



NOTES
⚠ The AN/ARN-84 System may be Used in Lieu of the AN/ARN-52(V).

Figure 6-5. P-3C Radio Navigation System Interface Diagram – GPS Test Installation

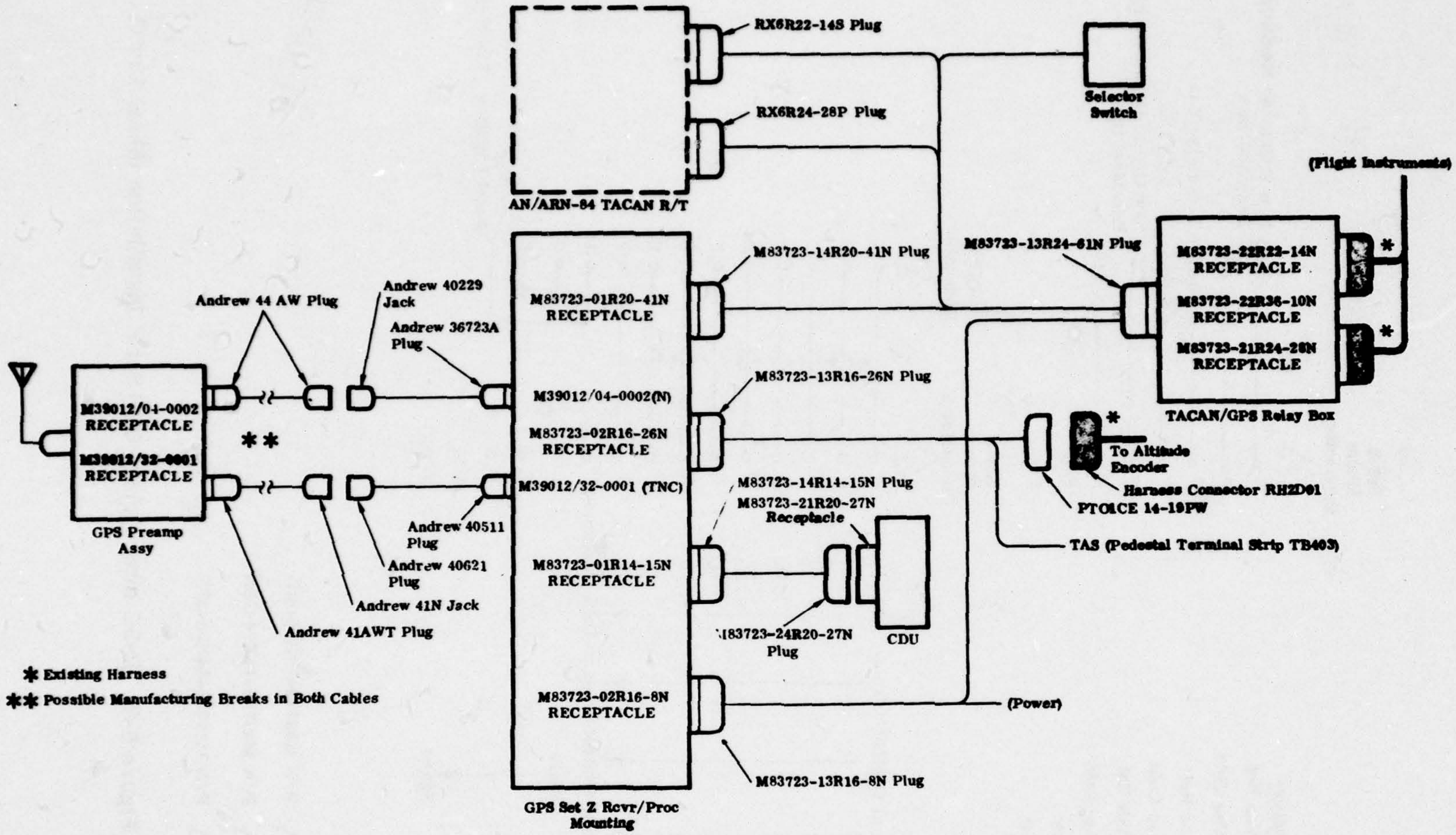


Figure 6-6. GPS Set Z Cabling Diagram, P-3C Aircraft

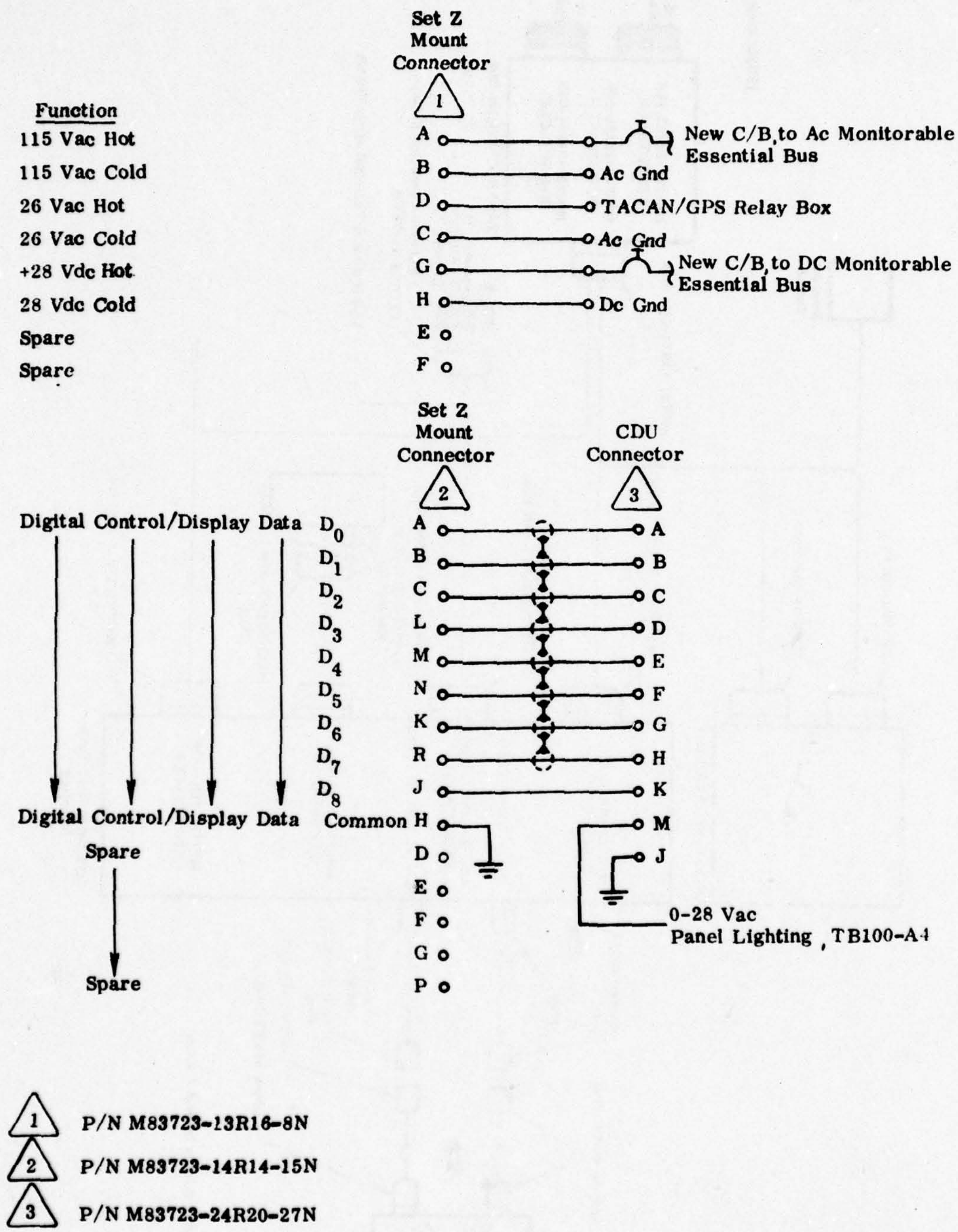
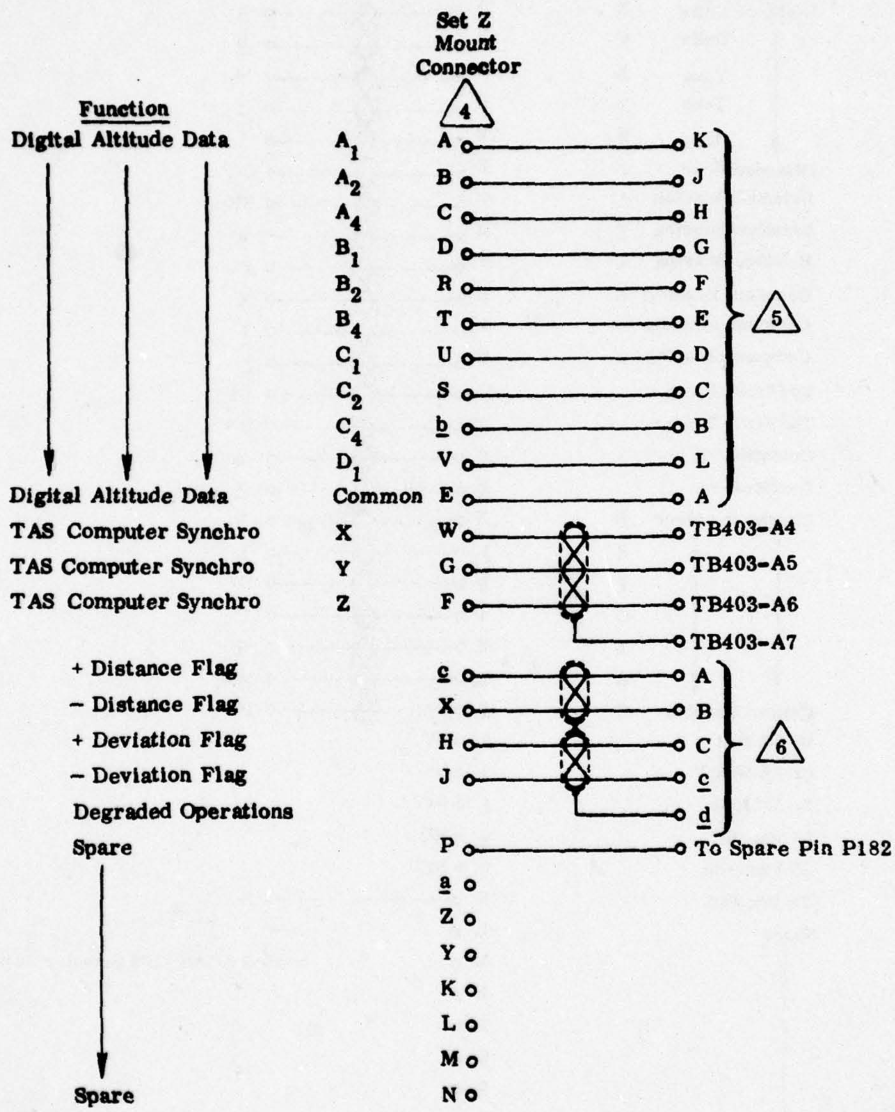


Figure 6-7. P-3C Interwiring, GPS Set Z Installation (Sheet 1 of 6)

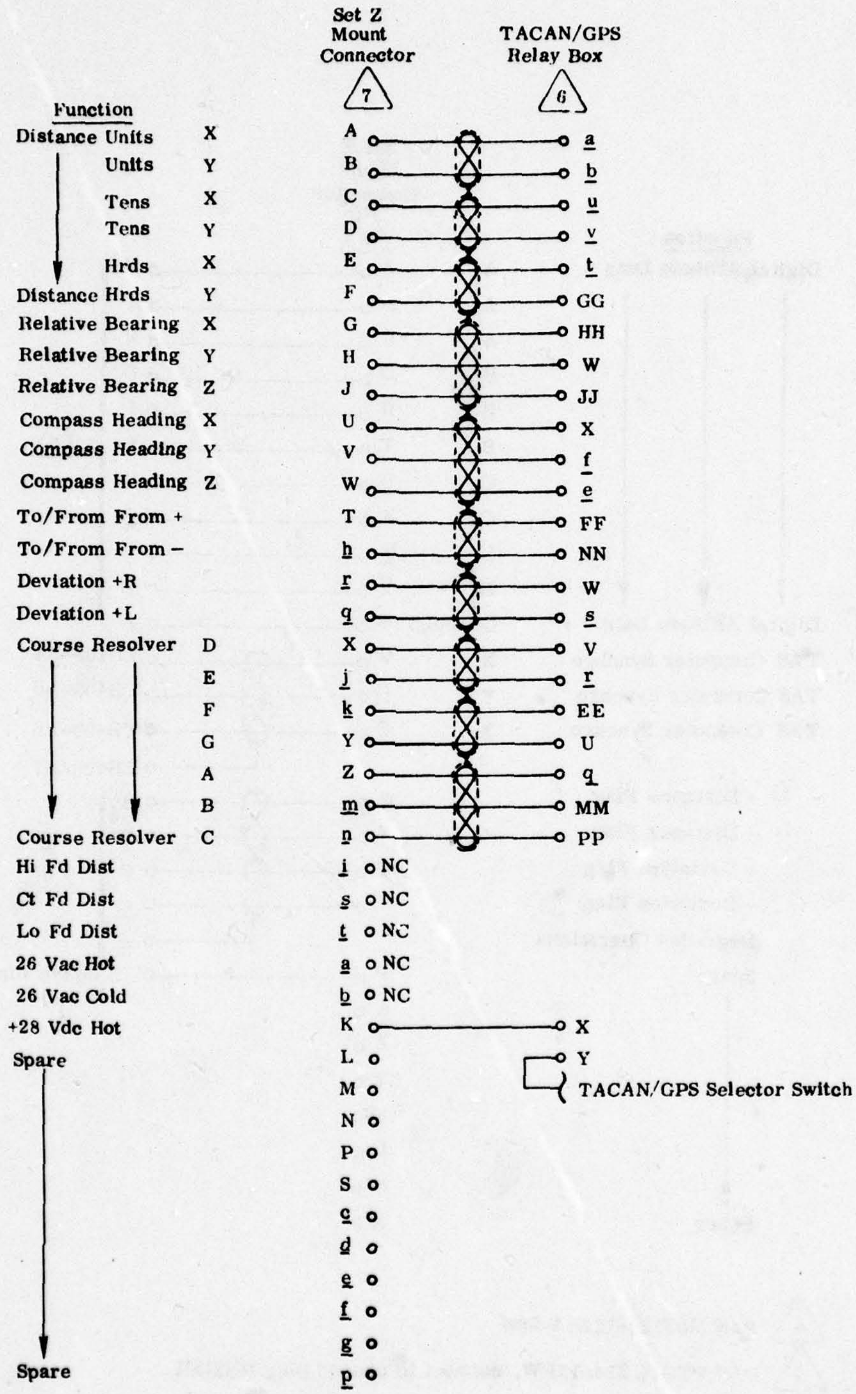


4 P/N M83723-13R16-26N

5 P/N PTO1CE14-19PW, connect to unused plug RH2D01

6 TACAN/GPS relay box connector P/N M83723-13R24-61N

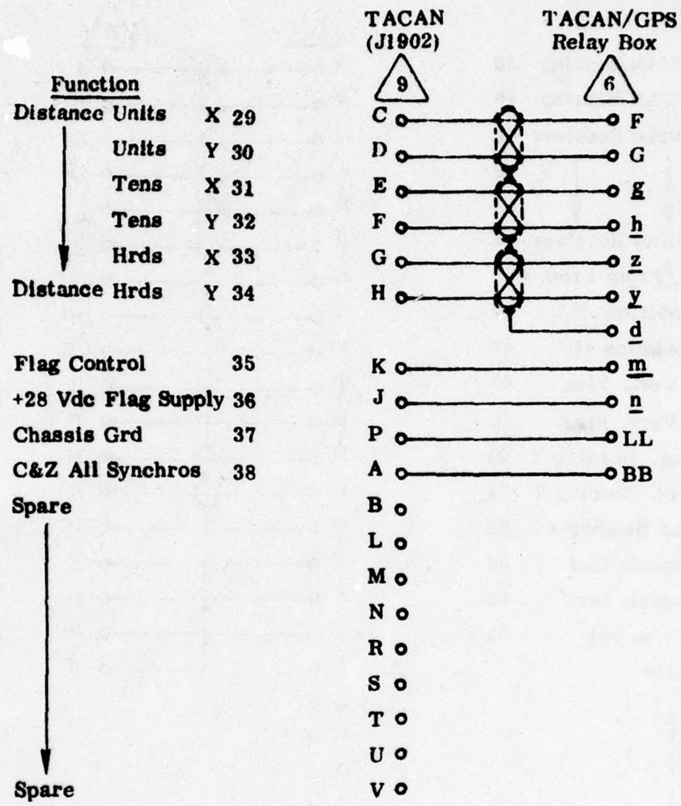
Figure 6-7. (Sheet 2 of 6)



6 TACAN/GPS relay box connector P/N M83723-13R24-61N

7 P/N M83723-14R20-41N

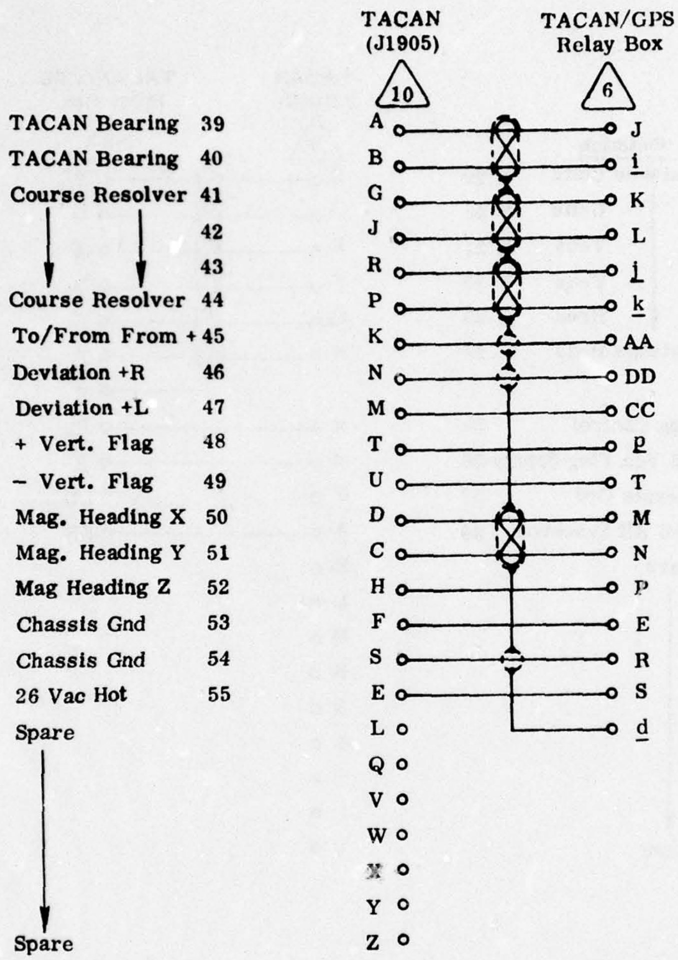
Figure 6-7. (Sheet 3 of 6)



6 P/N M83723-13R24-61N

9 P/N RX6R22-14S, mates with RT-384/ARN-52(V) TACAN receptacle J1902

Figure 6-7. (Sheet 4 of 6)



6 P/N M83723-13R24-61N

10 P/N RX6R24-28P, mates with RT-384/ARN-52(V) TACAN receptacle J1905

Figure 6-7. (Sheet 5 of 6)

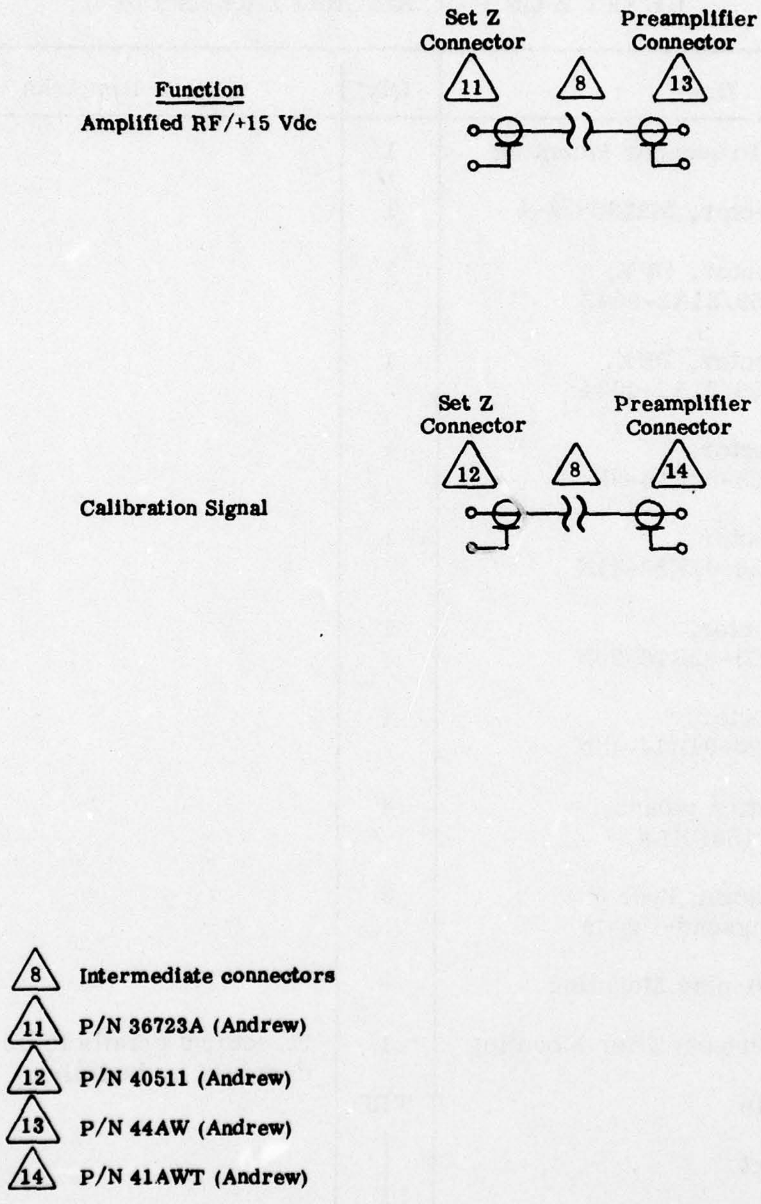


Figure 6-7. (Sheet 6 of 6)

6.4 GROUP A ITEM REQUIREMENTS

The Group A items required to affect integration and installation in the P-3C are shown in Table 6-3.

TABLE 6-3. GROUP A INSTALLATION ITEMS FOR UE SET Z ON P-3C AIRCRAFT (Sheet 1 of 3)

Item	Qty	Remarks
a. Receiver/Processor Mounting	1	
Connector, M24308/2-4	1	
Connector, DPX, M81659/31A2-0042	1	
Connector, DPX, M81659/31A2-0034	1	
Connector, M83723-02R16-8N	1	
Connector, M83723-01R20-41N	1	
Connector, M83723-02R16-26N	1	
Connector, M83723-01R14-15N	1	
Vibration mounts, Lord 150PHL8	4	
Holddown, Type C, Hollingsead-Pryor	3	
b. Control/Display Mounting	–	
c. Antenna/Preamplifier Mounting	1	Structural details to be designed by installer.
Double	TBD	
Gasket	↓	
Screws	↓	
Brackets, mounting	TBD	
d. Integration Module Converter	1	

TABLE 6-3. (Sheet 2 of 3)

Item	Qty	Remarks
e. Integration Module Driver	1	
f. TACAN Relay Box	1	
g. TACAN Selector Panel	1	
h. Aircraft Wiring		
Connector, PT01C314-19PW (receptacle)	1	Mates with plug RH2D01
Connector, M83723-13R16-8N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-13R16-26N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-14R14-15N (plug)	1	Mates with GPS mounting receptacle
Connector, M83723-13R24-61N (plug)	1	Mates with TACAN/GPS relay box receptacle
Connector, RX6R22-14X (plug)	1	Mates with RT-384/ARN-52(V) TACAN receptacle
Connector, RX6R24-28P (plug)	1	Mates with RT-384/ARN-52(V) TACAN receptacle
Connector, M83723-24R20-27N (plug)	1	Mates with CDU receptacle
Connector, N, Andrew 41N	1	Mates with service loop plug
Connector, N, Andrew 44AW	2	Mates with service loop jack; pre-amplifier jack
Connector, TNC, Andrew 40511	1	Mates with TNC female on receiver
Connector, N, Andrew 36723A	1	Mates with N female on GPS receiver
Connector, N, Andrew 40621	1	Mates with calibration line jack
Connector, N, Andrew 40229	1	Mates with signal input line plug
Connector, TNC, Andrew 41AWT	1	Mates with preamplifier jack

TABLE 6-3. (Sheet 3 of 3)

Item	Qty	Remarks
h. Aircraft Wiring (Cont)		
Cable, coaxial, Andrew FHJ4-50B		Signal line
Cable, coaxial, Andrew FHJ1-50		Calibration line
Cable, coaxial, Andrew FSJ1-50		Service loop
Cable, coaxial, Andrew FSJ4-50		Service loop
Wire and cable		Various types as required
Decals, assorted GPS		
Circuit breaker, 115 Vac 5A	1	
Circuit breaker, 28 Vdc 5A	1	

6.5 EQUIPMENT ENVIRONMENTS

Environmental requirements for Set Z installation in the P-3C are derived by combining a history of exposure to various conditions with the natural environmental characteristics and the aircraft-induced or -controlled environmental characteristics. The result is a comprehensive environmental envelope for the P-3C test activities. The exposure history, natural environment, and aircraft environment are described below, followed by a summary of the total environmental envelope.

6.5.1 Exposure Time History

Figure 6-8 shows a time history of exposure of Set Z to the environmental factors to be encountered during the P-3C tests at San Diego and San Clemente Island. It has been assumed that the host test aircraft will be dedicated full time to the tests and will be stationed at Pt. Mugu Naval Air Station, Calif. The aircraft will depart from and return to that base for each day of flight testing.

The sequence and duration of events shown in Figure 6-8 are intended to be representative of the test operations to be conducted. While it is realized that any given test exercise may deviate from the sequence shown, it is felt that the events shown in the figure are sufficient to expose Set Z to all of the environmental extremes to be encountered. For example, since the time of day of satellite visibility will vary, and since the aircraft could be left on the ground at any time of day or night,

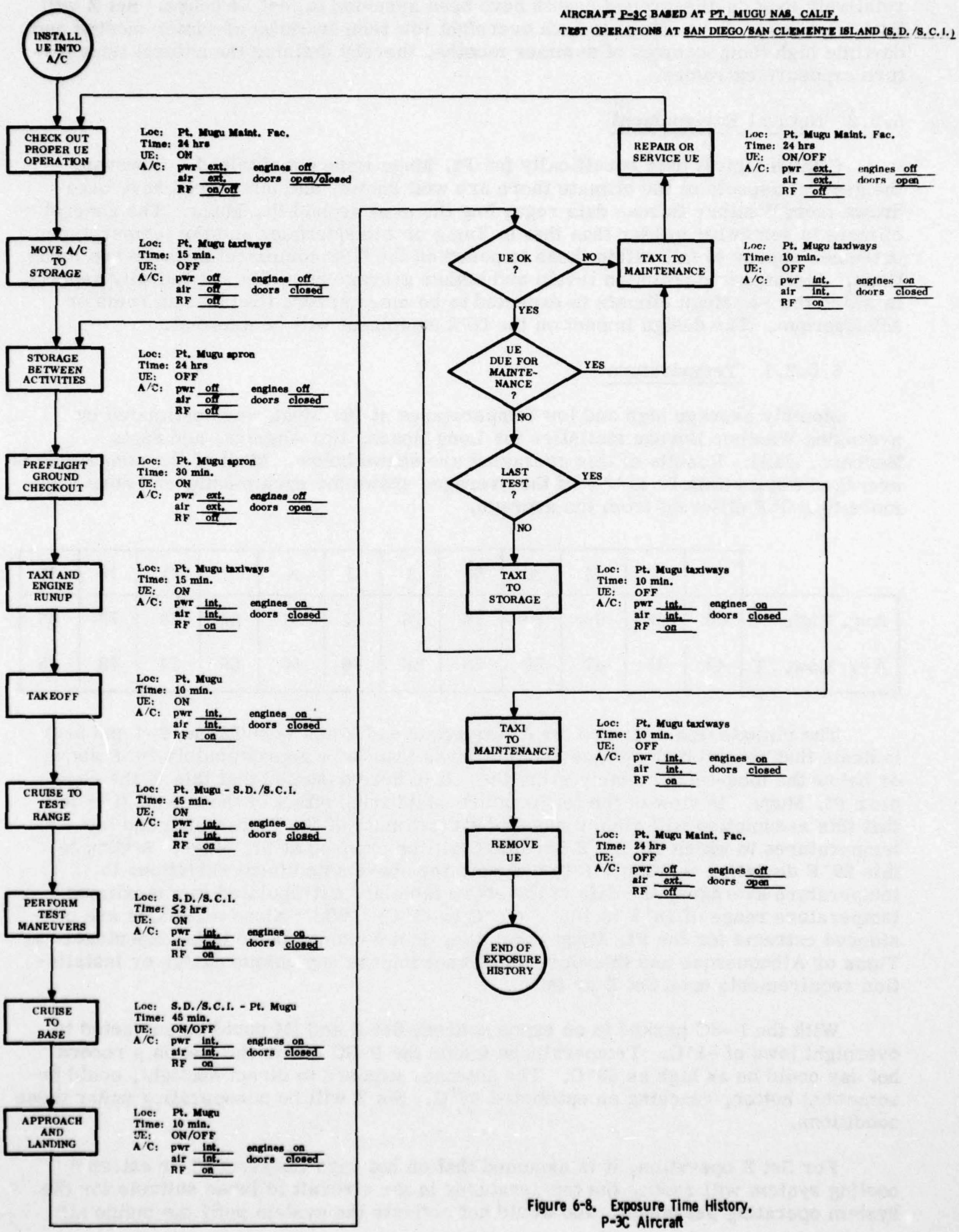


Figure 6-8. Exposure Time History, P-3C Aircraft

relatively long on-the-ground events have been assumed to last 24 hours. Set Z will thus be exposed at Pt. Mugu to both overnight low temperatures of winter months and daytime high temperatures of summer months, thereby defining the natural temperature exposure extremes.

6.5.2 Natural Environment

Climatological data specifically for Pt. Mugu were not obtained. However, the general aspects of the climate there are well known, and inferences have been drawn from Weather Bureau data regarding the area around Pt. Mugu. The general climate is somewhat milder than that in Yuma or Albuquerque, and the temperature extremes appear to fall within those imposed on the GPS equipment at those two locations. Atmospheric pollution levels and higher average humidity are the only aspects in which the Pt. Mugu climate is expected to be more severe than that at Yuma or Albuquerque. The design impact on the GPS equipment will be minimal.

6.5.2.1 Temperature

Monthly average high and low temperatures at Pt. Mugu were estimated by averaging Weather Bureau statistics for Long Beach, Los Angeles, and Santa Barbara, Calif. Results of this averaging are shown below. Most of the temperatures averaged were within 2° to 3° F of the averages shown for each month, and none were more than 5° F different from the average.

	J	F	M	A	M	J	J	A	S	O	N	D
Avg. High, ° F	65	66	68	70	72	76	81	81	80	76	73	68
Avg. Low, ° F	43	45	47	50	53	56	60	60	58	54	48	45

The climate data obtained for Albuquerque and Yuma (see Tables 2-4 and 5-4) indicate that record high and low temperatures tend to be approximately 20° F above or below the long-term monthly averages. It is here assumed that this is the case near Pt. Mugu. In view of the temperature-stabilizing effect of the ocean, it is felt that this assumption will yield a pessimistic estimate of the record high and low temperatures to which the Set Z hardware will be exposed at Pt. Mugu. Adding to this 20° F deviation another 5° F to estimate the above noted local variations in temperature averages, the data in the above table are extrapolated to a maximum temperature range of 18° F to 106° F (-8° C to 41° C). While these estimates are considered extreme for the Pt. Mugu area, they do not exceed those to be experienced at Yuma or Albuquerque and therefore should not impose any unique design or installation requirements upon Set Z or IM.

With the P-3C parked in an exposed area, Set Z and IM could be subjected to overnight lows of -8° C. Temperatures inside the P-3C left in the sun on a record hot day could be as high as 63° C. The antenna, exposed to direct sunlight, could be somewhat hotter, reaching an estimated 68° C. Set Z will be nonoperating under these conditions.

For Set Z operation, it is assumed that on hot days the aircraft or external cooling system will reduce the temperatures in the aircraft to those suitable for the system operating personnel, who would not activate the system until the inside air temperature had cooled to at least that outside the aircraft, a maximum of 41°C. The antenna temperature could remain near 68°C, however, since it is partially external to the air conditioned area (see Section 6.5.3.3).

For cold day or nighttime tests, it is assumed that temperatures inside the aircraft will be raised to crew comfort levels at or shortly after system activation. Startup temperatures could be near the -8°C minimum estimated for Pt. Mugu.

At cruise altitudes of 25,000 to 30,000 feet, outside air temperatures on the order of -65°C could be anticipated according to MIL-STD-210B. The antenna will be exposed directly to these temperatures.

6.5.2.2 Humidity

Average humidity at Pt. Mugu will be generally higher than at Yuma or Albuquerque due to the proximity of the ocean, and the salt content of the humidity will be substantial. Humidities up to 100% will be experienced, and the antenna will be exposed directly to these conditions. Air of nearly 100% humidity could be drawn into the P-3C under some startup or ground operation conditions, to which the CDU, receiver/processor, IM, and preamplifier would be exposed.

6.5.2.3 Wind/Dust

Due to the proximity of the Pacific Ocean coastline, breezes and light winds are common to Pt. Mugu. Some blowing sand and dust can be expected, although such conditions are not known to be severe. Only the antenna will be exposed directly to the sand or dust, and abrasive effects are expected to be minimal, especially in view of the flush-mounted antenna configuration. Sand and dust are not expected to present any design problems for the CDU, receiver/processor, IM, or preamplifier mounted inside the P-3C.

6.5.2.4 Precipitation

Specific precipitation data at Pt. Mugu were not obtained, but annual rainfall is estimated as light to moderate, on the order of 20 inches per year. Only the antenna will be exposed directly to rainfall, and depending upon the weather/pressure seal design the preamplifier could be subject to moisture collection. Due to the possibility of overnight freezing temperatures, the installation should be designed so as to trap no liquid that could freeze and expand to stress the antenna or seals.

6.5.2.5 Atmospheric Pollution

Atmospheric pollution in the area around the Los Angeles basin is known to be substantial during much of the year, although Pt. Mugu is located some distance from the areas of heaviest pollution. Exposed or unprotected materials, especially rubber and plastic seals or insulation, will be subject to the degrading effects of this pollution, typically evidenced as drying, cracking, and loss of resilience. Such materials must be selected or protected to prevent unacceptable degradation of performance or characteristics.

6.5.3 Aircraft Environment

The following paragraphs summarize the environment onboard the P-3C during Phase I test operations. Much of the data are derived from Lockheed-California Company Report No. LR 26378 (see bibliography, Volume I, Appendix A). That report presents electronic equipment design requirements derived from extensive instrumented flight tests of the P-3.

6.5.3.1 Mechanical Vibration

Flight test results reveal that vibration in the electronics racks and consoles on the P-3 does not exceed 0.5g at any frequency. Peak vibrations were generally measured at propeller frequencies and related harmonics (17, 68, and 136 Hz). During aircraft takeoff, landing, and buffeting in flight, 1g vibration at 7 Hz was measured at the nose of the aircraft, and 2g buffeting levels were recorded at the tail where normal cruise vibration levels were 0.2g. Vibration levels as high as 1.1g (at 68 Hz) were recorded on some structures near FS 320. As a result of these measurements, the referenced Lockheed report specifies a vibration design requirement of ±2g, 5 to 500 Hz for electronic equipment to be mounted within the fuselage in any of the electronics racks or consoles. This design requirement exceeds the measured environment in such installations by a safety factor of four and assumes no vibration isolation mounting.

By extending the ±2g requirement to 5 Hz (corresponding to approximately 1.2 inches double amplitude displacement), the design curve encompasses all buffeting type measurements taken on the aircraft. While it is recognized that qualification testing at this level and frequency may not be reasonable with respect to test equipment capabilities (MIL-STD-810B, method 514, calls for sinusoidal double amplitudes of only 0.1 to 0.2 inch at low frequencies), the Lockheed report includes these levels as valid design requirements due to their actual, if transient, occurrence.

6.5.3.2 Acoustic Vibration

The peak overall acoustic vibration level measured inside the aircraft in the 37.5 to 9600 Hz band is 115 dB re 0.0002 ubar, with a peak density of 113 dB per octave (37.5 to 75 Hz). These levels were recorded during takeoff and other conditions not exceeding 5 minutes in duration. During maximum continuous power conditions, peak overall noise level was 110 dB. At normal cruise power, peak overall noise level was 100 dB. None of these levels will impose any design or test requirements on Set Z or IM.

6.5.3.3 Temperature and Humidity

Test data show that ambient temperatures in some equipment racks on the P-3 reach 55°C during normal operating conditions. However, in the C-1/C-2 racks, where the Set Z receiver/processor and IM will be installed, the highest air temperature recorded was 46°C at the air exhaust port of the TACAN receiver/transmitter. The highest temperature in the pilot's instrument panel area was 53°C.

The tests further revealed that if cooling air was lost, temperatures in some equipment compartments could climb to 71°C within a half hour if the equipment continued to operate. However, the compartments are equipped with overheat sensors set to 55°C which provide a warning of an overheat condition. In such an occurrence, electronic equipment could be powered off.

The inside temperature around the antenna/preamplifier unit will be that of the ambient cabin air, regulated to approximately 20° to 24°C for crew comfort.

The Lockheed equipment specification report states that P-3 electronic equipment shall withstand humidities up to 100%, including condensation in and on the equipment.

6.5.3.4 Unit Size and Weight Restrictions

The outboard portion of shelf B in avionics compartment C-1/C-2 on the right side of the cabin offers a space measuring approximately 50.8 x 61 x 35.6 cm (20 x 24 x 14 in.) for the Set Z receiver/processor and IM installation. The weight of the unit will be limited to 27.2 kg in conformance with standard ARINC weight-vs.-size estimates. This weight allows for the inclusion of the IM in a full ATR package space with the Set Z receiver/processor.

The CDU installation on the "Update 1" P-3C center console will limit the width of the CDU to the standard 14.6 cm (5.75 in.). Since the console layout has not yet been designed, no definite CDU height or depth restrictions can be specified. No weight limitations have been identified.

The antenna/preamplifier installation near FS 460 will not impose any size or weight restrictions on the unit design, assuming current size and weight estimates for the unit are reasonable. The unit should not extend more than 10 inches forward of this FS after installation, due to large cable bundles and air conditioning ducts traversing the cabin overhead between FS 400 and FS 450.

6.5.3.5 Electrical Power

The 115 Vac, 400 Hz prime power sources on the P-3C conform to the limits of MIL-STD-704A, as required by Set Z. Panel lighting power for the CDU is available at both 5 and 28 Vac in the center pedestal.

6.5.3.6 Heat Dissipation

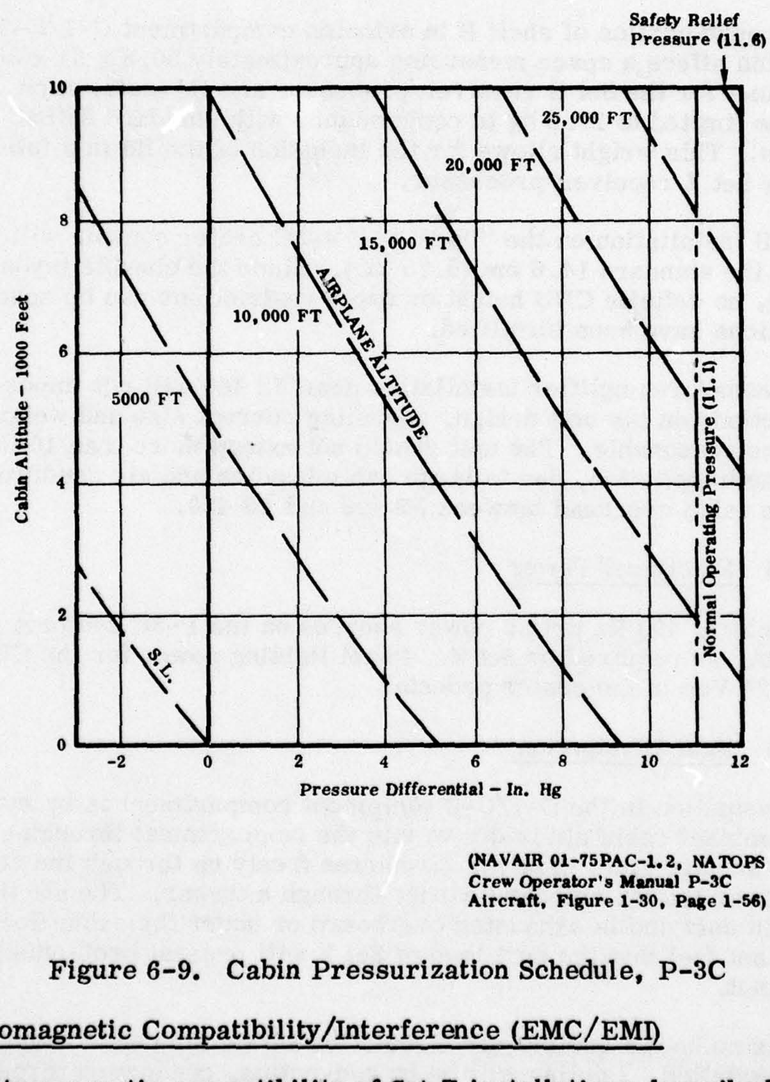
Heat dissipation in the C-1/C-2 equipment compartment is by means of circulating air. Ambient cabin air is drawn into the compartment through a vent at the bottom of the inboard side. The air circulates freely up through the compartment and is drawn out near the top outboard corner through a tusker. The air than travels aft through a main duct and is exhausted overboard or under the cabin floor. Lockheed engineers do not feel that the heat load of Set Z will present problems in the C-1/C-2 cabinet.

There is no known cooling-air circulation within the center console where the CDU will be installed. Cooling will be by convection, conduction through the mounting structure, and ambient cabin air circulating past the CDU faceplate.

The antenna/preamplifier unit will be cooled by circulating ambient cabin air and possibly by heat conduction through the mountings. Due to the small power consumption of the unit, no heat dissipation problems are anticipated.

6.5.3.7 Pressurization

Cabin pressurization is normally maintained according to the schedule shown in Figure 6-9. Under normal flight conditions, the maximum cabin altitude in the P-3C is 11,000 feet. All Set Z units except the antenna will be installed within the pressurized area. The maximum pressure differential allowed by the automatic pressure release valve is 5.5 psig, and the antenna structure and seal must be capable of withstanding this pressure.



(NAVAIR 01-75PAC-1.2, NATOPS Crew Operator's Manual P-3C Aircraft, Figure 1-30, Page 1-56)

Figure 6-9. Cabin Pressurization Schedule, P-3C

6.5.4 Electromagnetic Compatibility/Interference (EMC/EMI)

The electromagnetic compatibility of Set Z installations described in the preceding sections have been considered from the standpoint of interference from radiating antennas on the aircraft, interference to or from nearby avionic units, common practice for shielding and wire types, and any historical EMI problems associated with the aircraft.

6.5.4.1 Antenna Locations

Figure 6-10 shows the locations of antennas on the P-3C. Table 6-4 summarizes pertinent characteristics of the radiating antennas.

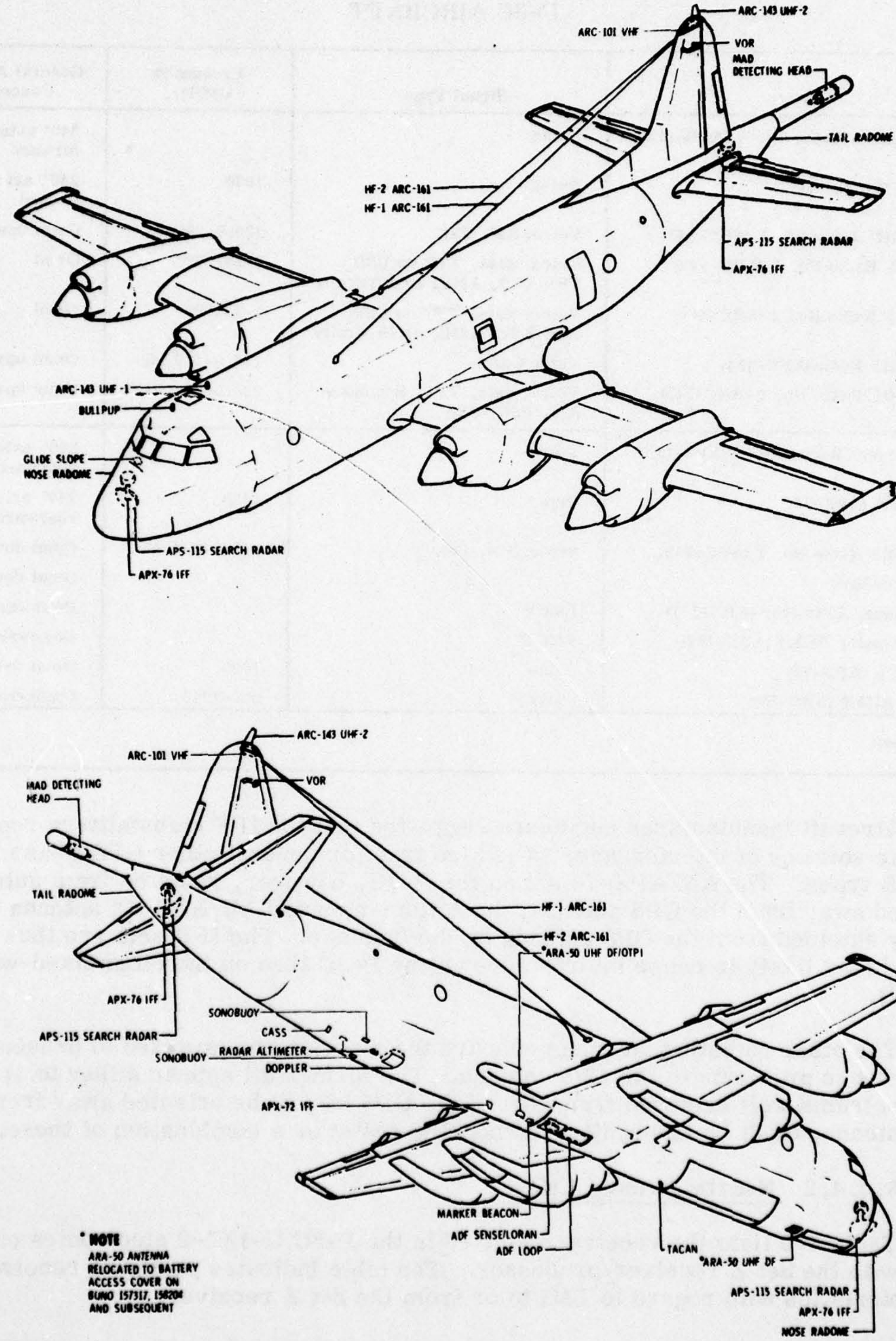


Figure 6-10. Antenna Locations, P-3C

TABLE 6-4. RADIATING ANTENNA SIGNAL CHARACTERISTICS, P-3C AIRCRAFT

	System	Signal Type	Frequency (MHz)	General Antenna Coverage
Top of Aircraft	Search Radar No. 1 (APS-115)	Pulse		240° azimuth forward
	IFF (APX-76)	Pulse	1030	240° azimuth foward
	UHF Radio No. 1 (ARC-143)	Voice; AM, FSK	225.0-399.95	Omni upward
	HF Radio No. 1 (ARC-142)	Voice, data, TTY on USB, USB-LSB, AME, or Diversity	2-29.999	Omni
	HF Radio No. 2 (ARC-142)	Voice, data, TTY on USB, USB-LSB, AME, or Diversity	2-29.999	Omni
	VHF Radio (ARC-101)	Voice Comm	116.0-149.95*	Omni upward
	UHF Radio No. 2 (ARC-143)	Voice, data, TTY, Sonobuoy; AM, FSK, FM	225.0-399.95	Omni upward
Bottom of Aircraft	Search Radar No. 2 (APS-115)	Pulse		240° azimuth rearward
	IFF (APX-76)	Pulse	1030	240° azimuth rearward
	UHF Radio No. 1 (ARC-143)	Voice; AM, FSK	225.0-399.95	Omni downward
	Sonobuoy			Omni downward
	Radar Altimeter (APN-187)	FMCW		Downward
	Doppler Radar (APN-187)	FMCW		Downward
	IFF (APX-72)	Pulse	1090	Omni downward
	TACAN (ARN-52)	Pulse	960-1213	Omni downward

*Assumed

Aircraft manufacturer engineers suggested that the IFF transmitters represent possible sources of interference, as is also true for several other GPS Phase I test-aircraft types. The AN/APX-76 set on the P-3C, however, radiates from antennas oriented away from the GPS antenna; the bottom-mounted AN/APX-72 antenna is largely shielded from the GPS antenna by the fuselage. The IFF sets are thus considered less likely to cause interference on the P-3C than on the other fixed-wing test aircraft.

The other radiating antennas onboard the aircraft are expected to present no interference problems to the GPS antenna. The former all appear either to 1) have RF spectrums well removed from that of the GPS RF, 2) be oriented away from the GPS antenna, or 3) be inoperative during GPS tests; or a combination of these.

6.5.4.2 Nearby Avionic Units

Table 6-5 lists the receivers located in the P-3C C-1/C-2 electronics cabinet along with the Set Z receiver/processor. The table indicates pertinent receiver characteristics with regard to EMI to or from the Set Z receiver.

At the time of this writing, the Set Z intermediate and LO frequencies have not been definitely selected. It is therefore impossible to identify any coincidence of IF or LO frequency with any of the receivers in Table 6-5. In view of the apparent lack of any historical EMI problems on the P-3C, however, it is not expected that any problems will be encountered with the GPS installation.

TABLE 6-5. RECEIVERS NEAR SET Z RECEIVER/PROCESSOR, P-3C AIRCRAFT

Receiver	RF (MHz)	LO (MHz)	IF (MHz)	RF Sensitivity
TACAN (ARN-52, ARN-84)	960-1213	1025-1150	63	-80 to -90 dBm
LORAN (ARN-81)	0.100	–	–	–

Table 6-6 lists the transmitters located in the P-3C C-1/C-2 electronics cabinet along with the Set Z receiver/processor. The table indicates pertinent transmitter characteristics with regard to EMI to the Set Z receiver.

Since the Set Z IF and LO frequencies have not been selected, the possibility of RF leakage from these transmitters interfering with the Set Z receiver cannot be accurately assessed. Direct RF interference from in-band noise generated by the TACAN transmitter is doubtful, in view of the MIL-E-6051 requirement for 60 dB shielding of each of the two units and the frequency difference between them. Aircraft manufacturer engineers did not anticipate any EMI problems for this installation.

TABLE 6-6. TRANSMITTERS NEAR SET Z RECEIVER/PROCESSOR, P-3C AIRCRAFT

Transmitter	RF (MHz)	Modulation	Power
TACAN (ARN-52(V) or ARN-84)	1025-1150	Pulse	1.2-3.0 kW

6.5.4.3 Wiring and Cabling

The GPS installation has been specified to take maximum advantage of existing avionic wiring on the P-3C. Since no known historical problems of EMI have been identified for this wiring, none are anticipated for the GPS installation. The possibility cannot be entirely ruled out, since sufficient data have not been located to accurately estimate noise levels on the lines.

New cables and wires required for the Set Z installation have been specified in accordance with MIL-W-5088 and best engineering practice. It is anticipated that these measures will be sufficient to preclude EMI problems for the installation.

6.5.4.4 Historical EMI/EMC

During discussions with cognizant personnel regarding the P-3C, the only historical EMI problem noted was broadband noise generated by the periodic firing of the high-power strobe light on the top of the aircraft. The noise created by this light's firing circuitry has been sufficient to cause interference on some high-sensitivity communication systems.

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DEFINITION OF REQUIREMENTS FOR INTEGRATING USER EQUIPMENT SET Z--ETC(U)

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6.5.5 Environment Summary, P-3C

Table 6-7 summarizes the environmental exposure of the Set Z installed in the P-3C for GPS Phase I testing at Pt. Mugu and offshore San Diego. The table presents the maximum and minimum operating and nonoperating extremes of each of the environmental parameters discussed in the preceding sections. The environmental envelope represented by the table thus shows the conditions Set Z and IM may experience and be required to survive during the Phase I test program.

TABLE 6-7. TEST ENVIRONMENT SUMMARY, P-3C

Environmental Parameter		Range
Temperature		
Operating:	CDU, IM, Rcvr/Proc	-8° to 46° C
	Antenna	-65° to 68° C
	Preamp	-8° to 41° C
Nonoperating:	CDU, IM, Rcvr/Proc, Preamp	-8° to 63° C
	Antenna	-65° to 68° C
Humidity		
Operating and nonoperating		≤100% Antenna directly exposed to rain
Vibration		
Operating and nonoperating		±2g, 5-500 Hz
Acoustic Pressure		
Operating and nonoperating		≤115 dB re 0.0002 ubar
Pressure		
Operating and nonoperating		≤8,000 ft typical ≤11,000 ft normal max. 5.5 psi across antenna
Wind/Dust		
Operating and nonoperating		Some blowing sand/dust at antenna; not severe
Atmospheric Pollution		
Operating and nonoperating		Moderate. Some deteriorative effects.
Electrical Power		Per MIL-STD-704A

The parameter values shown in Table 6-7 apply to all Set Z and IM components unless otherwise noted. Some temperature and pressurization specifications for the antenna and preamplifier are listed separately, since their installation exposes them more directly to severe natural environments.

All environmental exposure levels shown in Table 6-7 fall within the service condition limits of SS-US-101B, with the exceptions of the operating temperature range of the antenna and the low-frequency vibration levels. The antenna is subjected to operating temperatures below those specified in SS-US-101B (-40° C) when the aircraft is at cruising altitude. It also can be subjected to operating temperatures in excess of those specified in SS-US-101B (+55° C) when on the ground at Pt. Mugu. The thermal range for the antenna is not expected to present any damage problems, since that unit must survive the SS-US-101B nonoperating range of -62°C to +85°C without damage and does not dissipate energy in the operating mode. As explained in Section 6.5.3.1, the ±2g vibration level at low frequencies is a design requirement specified by the aircraft manufacturer, but is not a test requirement.

Based on the above considerations, it is recommended that the GPS JPO consider modifying the SS-US-101B temperature specification for the antenna unit to include the range of temperatures anticipated during Phase I testing. It is further recommended that ±1g to 5 Hz be included as a design goal for the CDU, which is the only Set Z unit installed near a location where this vibration level has been recorded on the P-3C.

6.6 TEST VS. OPERATIONAL CONFIGURATION INTEGRATION REQUIREMENTS

The installation of Set Z in the P-3C test aircraft is designed to conform, to the extent practicable, to the probable installation in the operational vehicle. The antenna/preamplifier location and installation are expected to remain as configured for the Phase I testing. Location of the receiver/processor unit and the integration module should remain in the C-1/C-2 avionics compartment, as described. If incorporation of the GPS system causes, or is concurrent with, a major revision of the aircraft navigation system (i.e., removal of all navigation equipments offering the same kind of information), a redesign of the cockpit control pedestal might be appropriate. The CDU should remain on the console in a convenient location. If the TACAN is deleted, the cockpit selector panel and the TACAN/GPS relay box would be removed and the interconnecting harness modified.

Table 6-8 details the similarities and differences between the test configuration and operational configuration installations.

TABLE 6-8. COMPARISON OF SET Z TEST AND OPERATIONAL CONFIGURATIONS, P-3C AIRCRAFT

Element	Test Configuration	Operational Configuration
Antenna/Preamplifier Assy	Top of aircraft @ FS 460	Same
Receiver/Processor Unit	C-1/C-2 avionics compartment, shelf B outboard	Same
Integration Module	C-1/C-2 avionics compartment, shelf B outboard	Same
Control/Display Unit	Cockpit center console	Same
TACAN/GPS Relay Box	C-1/C-2 avionics compartment	May be deleted
Connection to Flight Instruments	Jumper harness to TACAN/GPS relay box	TACAN harness via new connector, added wiring (if TACAN removed)
Altitude Input	Jumper harness to connect to unused plug at rack H-2	Splice or terminal board wiring connections
TAS Input	Jumper harness to connect to TAS computer at terminal board in compartment C-1	Same
Degraded Mode Light	Connection to annunciator panel	Same

7
COMPOSITE INTEGRATION REQUIREMENTS

Installation guidelines from the GPS JPO, together with the composite data from this study, formed the basis for an integration specification for IOT&E installation of UE Set Z into the test aircraft. This specification, which appears in Appendix A, adheres to the "ARINC characteristic" philosophy of precise form-and-fit information, but is patterned after the military specification format as used by MIL-F-26685. Installation and integration requirements contained in the specification apply generally to all five test aircraft for Phase I testing. Cabling peculiarities for the individual aircraft types are described in cabling and interwiring diagrams contained in the appendix to the specification.

The general use of reference documents as part of the specification requirements has been minimized so that a specification hierarchy will not be created. Where reference to documents pertain to Set Z design or testing, such reference is in a descriptive rather than an obligatory sense.

Products of particular companies are referenced throughout the specification. Where these appear, the noted intent is that an equal item will satisfy the specification requirement.

The accumulated information concerning Set Z installation in the five IOT&E test aircraft is condensed into checklist format in Appendix B.

8
INTEGRATION TEST REQUIREMENTS

Certain special tests should be performed to ensure that the performance of the GPS Set Z will not be compromised because of poor integration into the test aircraft during IOT&E. These tests are identified and discussed below as they pertain both to individual aircraft types and to aircraft installations in general. In addition, the special test requirements of the Integration Module will be discussed. Set Z acceptance and qualification tests are not considered in this integration test category since they are presumed to have been successfully accomplished by the user equipment manufacturer during DT&E.

8.1 SPECIAL TESTING OF INDIVIDUAL AIRCRAFT

The Set Z installation in the five test aircraft will be generally quite similar. In all aircraft but the P-3C, the Set Z receiver/processor replaces a TACAN receiver/transmitter unit. On three aircraft, a TACAN antenna is replaced by the GPS antenna/preamplifier assembly and a TACAN control panel is replaced by the Set Z CDU. Most other variations are not significant insofar as special testing is concerned.

Of special importance is the physical location of the GPS antenna on the HH-53C helicopter. The suggested installation, discussed in Section 5.2.2, locates the antenna/preamplifier assembly on the aircraft horizontal stabilizer. Although offering the least obstructed field of view, this location has significant drawbacks, and performance degradation is still probable. The antenna is positioned out from under the main rotor, but reception may be affected by the proximity of the tail rotor on the left side. In addition, the enclosed stabilizer structure surrounding the preamplifier could create a high temperature environment when the aircraft operates at the southern Arizona test site, particularly during summertime ground operation.

Antenna pattern tests should be made of the HH-53 installation at the Set Z frequency of 1.5 GHz (or equivalent, if scale model tests are performed). Tests should be dynamic, i.e., with both main and tail rotors in motion, and should cover the top hemisphere. It is suggested that tests also be performed with an antenna located on the after fuselage top under the main rotor to see if this less expensive installation site could be used. Tests should be conducted prior to actual Set Z installation for the IOT&E effort.

A special test should be made of the P-3C Set Z installation to ensure that the new GPS/TACAN relay box does not have an adverse affect on flight instrument, TACAN, or GPS operations; and that system switching does not cause prohibitive EMI into other systems. During test-installation checkout, the selector relays should be cycled and any anomalies in the operation of other equipments noted. The operation of all TACAN modes with the relay box in use should be compared to the operation with the box bypassed and noted differences should be investigated for operational impact. Design correction should be undertaken where necessary.

A visual check should be made on the KC-135A to ensure that the floor-level cooling air intake adjacent to the Set Z receiver/processor is not obstructed.

8.2 GENERAL INSTALLATION TESTS

Several installation tests are appropriate to all five host aircraft to be involved in Phase I testing of Set Z. These tests are explicitly covered in the UE integration specification, Section 4.5 (see Appendix A).

8.2.1 Aircraft Wiring

The aircraft wiring, both existing and newly installed, that will be utilized for Set Z interconnections must be tested for proper installation and workmanship. Contacts in the various connectors and wire numbers should be checked against the appropriate wiring diagram, with the wiring then tested for pin-to-pin continuity. Insulation breakdown or inadvertent short circuits in the cables should be tested by applying 1000 Vac between appropriate leads and wires.

8.2.2 Coaxial Cable

The coaxial cable in the Set Z installation must be tested for loss and discontinuities at the Set Z operating frequency. Specified limits are 1.3:1 maximum VSWR at the receiver/processor connector with maximum cable losses of 6 dB (RF cable) or 12 dB (calibration cable). The center conductor of the RF cable, which will carry dc power to the preamplifier, must be checked for dc continuity and isolation from the outer conductor return.

8.2.3 Power Supply Check

With aircraft power applied to Set Z wiring, the appropriate connector contacts in the receiver/processor mounting and CDU connector should be tested to ensure that proper voltage is available. The receiver/processor unit and IM modules should then be installed and power output tested at the GPS preamplifier coaxial cable.

8.2.4 Set Z Operation

The Set Z equipment must be exercised in all modes of operation to ensure that the host vehicle integration has been performed properly and the GPS system is ready for test. This effort should include GPS system self-test, various CDU control and display functions, flight instrument operation, and inputs from external sensors.

Other avionics equipments that have a potential for electronic interference, either to the GPS Set Z or from it, should be exercised simultaneously with the GPS equipment. If interference is observed, the cause should be investigated and the impact on the IOT&E test effort determined. Particular attention must be paid to the operation of avionic units located immediately adjacent to Set Z units. On-the-ground tests of interference noise effects from potential interfering radiating antennas identified in Sections 2 through 6 of this report should be conducted.

8.3 SPECIAL IM TESTS

Special tests involving the IM during the IOT&E period should consist primarily of those tests necessary to demonstrate the effectiveness of the Set Z integration with the host vehicle avionics. These tests concern the operational suitability of the host vehicle avionics when driven by the Set Z interface signals. The tests would be primarily subjective in nature, with host vehicle crew providing their reaction to using the Set Z-driven avionics to solve a navigation problem. The tests should include:

a. Normal operation of Set Z with the host vehicle avionics

b. Degraded-performance operation of Set Z

c. Set Z compatibility during the various switching combinations of the flight director mode control

d. The extent of possible IM electromagnetic interference.

8.3.1 Normal Operation Tests

Set Z should be operated normally to solve a navigation problem, with the host vehicle avionics driven by Set Z used by the flight crew to perform the required steering maneuver. The accuracy of the instrument displays should be compared with the readouts on the Set Z CDU to determine their compatibility. During the tests the crew would observe the usefulness of the signals being displayed on the instruments.

8.3.2 Degraded Performance Operation Test

Degraded performance of Set Z should be simulated to observe the operation of the set with an alternate source of primary navigation data from an external sensor. Such a signal as encoded altitude can then be input into the Set Z navigation calculation to determine the accuracy of the solution of the navigation problem under these conditions. This test would help to establish the validity of using an external sensor as a source for primary navigation data.

8.3.3 Mode Control Tests

All of the test aircraft incorporate mode control panels and switching circuits of varying complexity. By integrating Set Z into the TACAN position, these switching circuits will allow the Set Z signals to be switched into and out of the flight director system and between the various instruments (HSIs and BDHIs). Because of the complexity of some of these switching systems, their operation must be tested when integrated with Set Z interface signals to ensure that the correct signals are being sent to the right avionic suites. Incorrect signal switching could cause an inadvertent flight safety hazard.

8.3.4 IM Electromagnetic Compatibility Test

The IM will have the capability of generating high-level, low-frequency analog signals that might produce unwanted electromagnetic interference in adjacent circuits. Such interference could produce undesired effects in other avionic systems and possibly degrade their performance. Under certain circumstances instability problems

could be encountered in the output synchro drive circuitry. This condition usually results from paralleling dissimilar synchro loads to the same common output. The results of this condition could produce erratic pointer movements in the navigation instruments. Special precautions must be taken during IOT&E to make the aircraft crew aware of these potential problems so that they can record them and take the appropriate action.

APPENDIX A

INTEGRATION SPECIFICATION FOR IOT&E INSTALLATION OF GLOBAL POSITIONING SYSTEM USER EQUIPMENT SET Z

Specification No. ___________

Code Ident ________________

1 June 1975

INTEGRATION SPECIFICATION FOR IOT&E INSTALLATION OF GLOBAL POSITIONING SYSTEM USER EQUIPMENT SET Z

Prepared by

ARINC Research Corporation
1222 E. Normandy Place
Santa Ana, California 92702

1. SCOPE. This specification covers the requirements for aircraft integration and installation of the NAVSTAR Global Positioning System (GPS) User Equipment (UE) Set Z for Initial Operational Test and Evaluation (IOT&E). These requirements support a single Set Z design adaptable to host aircraft by use of the appropriate integration module (IM).

2. APPLICABLE DOCUMENTS

2.1 Government Publications. The following documents form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-C-5015	Connector, Electrical, "AN" Type
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for
MIL-C-5809	Circuit Breaker, Trip-Free, Aircraft, General Specification for
MIL-I-5997	Instruments and Instrument Panels, Aircraft, Installation of
MIL-I-8700	Installation and Test of Electronic Equipment in Aircraft, General Specifications for
MIL-F-25173	Fastener Control Panel, Aircraft Equipment
MIL-E-81512	Encoder, Shaft Position to Digital Contact Type, Altitude Reporting
MIL-C-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-C-81659	Connectors, Electrical, Rectangular, Environment Resistant, Crimp Contacts, General Specification for
MIL-C-83723	Connectors, Electrical, Circular, Environment Resisting, General Specification for

STANDARDS

Military

MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of

MIL-STD-810	Environmental Test Methods
MIL-STD-877	Antenna Subsystem, Airborne, Criteria for Design and Location of
MIL-STD-454	Standard General Requirements for Electronic Equipment

OTHER PUBLICATIONS

USAF T.O. 1-1A-14	Handbook of Installation Practices for Aircraft Electrical and Electronics Wiring (NAVAIR 01-1A-505)
SS-US-101B	System Segment Specification for the User System Segment of the NAVSTAR Global Positioning System, Phase I
CID-US-108	Specification for the GPS Z Set Power Supply Unit
	U.S. National Standards for Common System Component Characteristics for the IFF Mark X (SIF)/ Air Traffic Control Radar Beacon Systems SIF/ATCRBS

2.2 Non-Government Documents. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of request for proposal shall apply.

Aeronautical Radio, Inc. (ARINC)

ARINC Specification No. 404 – Air Transport Equipment Case and Racking

ARINC Report No. 414 – General Guidance for Equipment and Installation Designers

(Application for copies should be addressed to Aeronautical Radio, Inc., 2551 Riva Road, Annapolis, MD 21401.)

3. REQUIREMENTS

3.1 Selection of Specifications and Standards. Specification and standards for necessary commodities and service not specified herein shall be selected in accordance with MIL-STD-143, except as provided in 3.1.1.

3.1.1 Standard Parts. Standard parts (MS, AN, or JAN) shall be used wherever suitable for the purpose intended, and shall be identified on drawings or in other documents by their part numbers. Commercial standard parts may be used in the test installations, when approved by the contracting activity.

3.2 Electronic Requirements

3.2.1 General. The general requirements of MIL-E-5400 shall apply for the entire installation of UE Set Z equipment except as specified herein.

3.2.2 Wire Hookup. External hookup wire shall be in accordance with MIL-W-5088. Where specification requirements vary with the using service, USAF-applicable sections shall govern. Cables shall be securely mounted and be so arranged as to cause negligible strain or stress on the connectors and to minimize noise pickup.

3.2.3 Shielded Cables. The shield of shielded cables or wires shall be bonded and grounded to the metal shell of each connector, except for RF coaxial cables between the Set Z preamplifier and receiver/processor units which shall be grounded at the receiver/processor unit only.

3.2.4 Grounding Practices. Adquate ground shall be provided for all Set Z components. Ground bonding straps shall be provided on the receiver/processor unit and relay panel (if used) in the electronics compartment, and on the control/display unit (CDU) if not hard-mounted in a standard control-panel rack. All surfaces shall be prepared in accordance with USAF T.O. 1-1A-14.

3.2.5 Input Power. The input power to Set Z shall be within the limits of the aircraft electrical characteristics specified in MIL-STD-704. The system utilizes nominal 115 Vac, 400 Hz or 28 Vdc power. Instrument synchro reference voltage of the proper phase (26 Vac, 400 Hz) shall be supplied.

3.2.6 Wire Splices. No splices to existing wiring for unit connection shall be allowed. Splices incorporated into new wiring for Set Z interconnections and jumper harnesses shall be in accordance with MIL-W-5088, para. 3.7.8.

3.3 Installation Design. Set Z shall be installed in the test aircraft so that aircraft rewiring and structural modification efforts are kept to a minimum, consistent with probable production configurations for line replaceable unit (LRU) locations and environments. ARINC Report No. 414 shall be used as the installation design guide. Existing cabling for removed equipment shall be utilized if practicable, provided that the cable harnesses are kept intact so that the displaced equipment can be easily replaced. Set Z shall be so installed that its removal and replacement can easily be accomplished by flight-line maintenance personnel without the need for special tools.

3.3.1 Environment. Set Z shall be so installed that the environmental service conditions for each system component as specified in SS-US-101 will not be exceeded.

3.3.2 System. A typical Set Z shall consist of the following components:

a. Receiver/processor

b. Receiver/processor mounting

c. Control-display unit

d. Antenna/preamplifier assembly

e. Integration module

3.3.2.1 Set Z Receiver/Processor. The Set Z receiver/processor processes the GPS satellite signals and derives aircraft position and velocity in three dimensions, as well as system time. Navigational computations are made relative to inserted waypoints, altitudes, desired track, and speed, and are displayed on the CDU. The receiver/processor also generates calibration and test signals for system use.

3.3.2.2 Control-Display Unit. The CDU provides digital display of GPS navigation data, including position, time, altitude, speed, track, bearing, and enroute deviation. A keyboard permits operator entry of initializing information such as time, waypoints, altitude, desired track, magnetic variation, and wind. System status is also indicated.

3.3.2.3 Preamplifier Assembly. The preamplifier assembly provides a low-gain increase to the received satellite signals to overcome cabling losses in the aircraft installation and retain maximum receiver sensitivity. This unit must be located in close proximity to the GPS antenna and may be incorporated as part of the antenna mount. The preamplifier will also accept calibration signals and power from the Set Z receiver/processor unit.

3.3.2.4 Antenna. The single antenna provides hemispherical coverage on top of the test aircraft for best line-of-sight reception of satellite signals. Configuration will depend on the type of aircraft and will generally be a conformal crossed slot for fixed-wing aircraft types and a volute antenna for helicopters.

3.3.2.5 Integration Module. The integration module converts GPS digital navigation information into signals compatible with aircraft flight instruments. The IM will also process inputs from the aircraft to the Set Z receiver/processor.

3.3.2.6 Interconnection Diagrams. A typical interconnection of the Set Z elements is shown in Figure 1. Specific airplane interwiring diagrams for selected test aircraft are contained in the appendix.

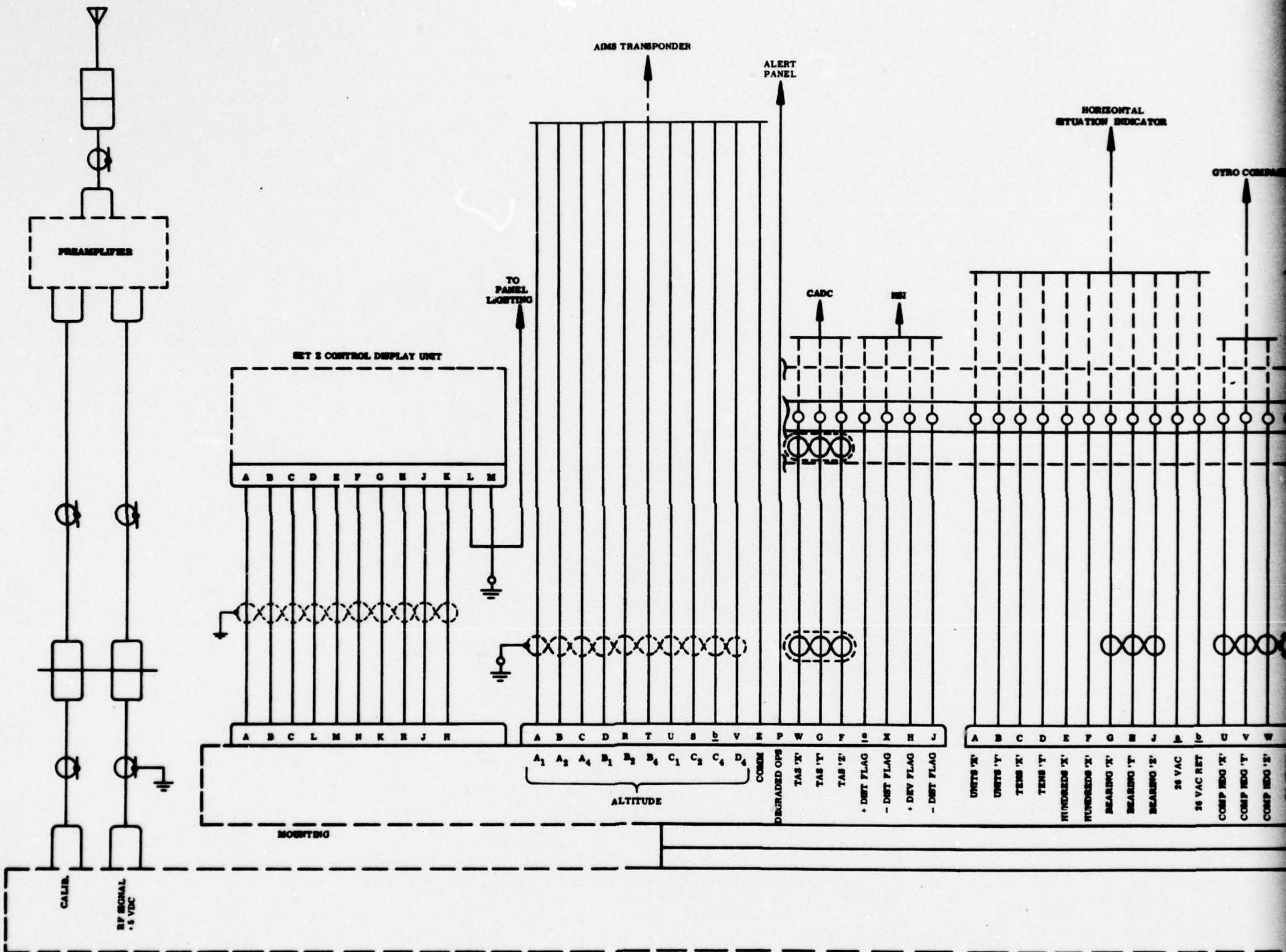
3.3.2.7 Input Signals. The following input signals may be used for operation of Set Z in the test aircraft.

3.3.2.7.1 Course Resolver Input Signal. The resolver input signal, if used, shall be in the form of a seven-wire desired-course output as originated from a horizontal situation indicator (HSI) or course indicator (CDI) course set control, and having the following characteristics. The course set resolver input signal shall be in the form of a sine/cosine angular reference of the manually selected course-arrow position on an HSI. The resolver signal characteristics shall be those for a resolver (Eclipse-Pioneer, Bendix P/N AY-221S-5-B, or equivalent) used as a transmitter. The rotor (R1/R3) winding shall be considered the primary and receive a 26 Vac, 400 Hz reference voltage. The stator (S1/S3, S2/S4) shall be the secondary and provide a 17.2 Vac sine and cosine signal to the Set Z. Rotor windings R2/R4 are short circuited in the GPS integration module.

3.3.2.7.2 True Airspeed Input Signal. The true airspeed input signal, if used, shall be in the form of a transmitter synchro three-wire stator output having 11.8 Vac (rms) line-to-line. Phase rotation shall be S1-S2-S3, with a scale factor of 36 degrees per 100 knots (helicopter scale factor of 180 degrees for 94.3 knots). Range and electrical zero may vary between types of aircraft.

3.3.2.7.3 Altitude Input Signal. The altitude input signal, if used, shall be in the form of a 10-bit, 11-lead digitized output of a shaft encoder as described by MIL-E-81512.

3.3.3 Electrical Interconnections. Set Z shall be capable of operating without the IM, provided that proper aircraft power is supplied to the receiver/processor unit. All necessary input signals can be supplied by keyboard insertion at the CDU,



AIMS TRANSPONDER
ALERT PANEL
HORIZONTAL SITUATION INDICATOR
GYRO COMPA
PREAMPLIFIER
TO PANEL LIGHTING
CADC
HSI
SET 2 CONTROL DISPLAY UNIT
ALTITUDE
COMM
DEGRADED OPS
TAS 'X'
TAS 'Y'
TAS 'Z'
+ DIST FLAG
- DIST FLAG
+ DEV FLAG
- DIST FLAG
UNITS 'X'
UNITS 'Y'
TENS 'X'
TENS 'Y'
HUNDREDS 'X'
HUNDREDS 'X'
BEARING 'X'
BEARING 'Y'
BEARING 'Z'
26 VAC
26 VAC RET
COMP HDG 'X'
COMP HDG 'Y'
COMP HDG 'Z'
MOUNTING
CALIB.
RF SIGNAL +5 VDC

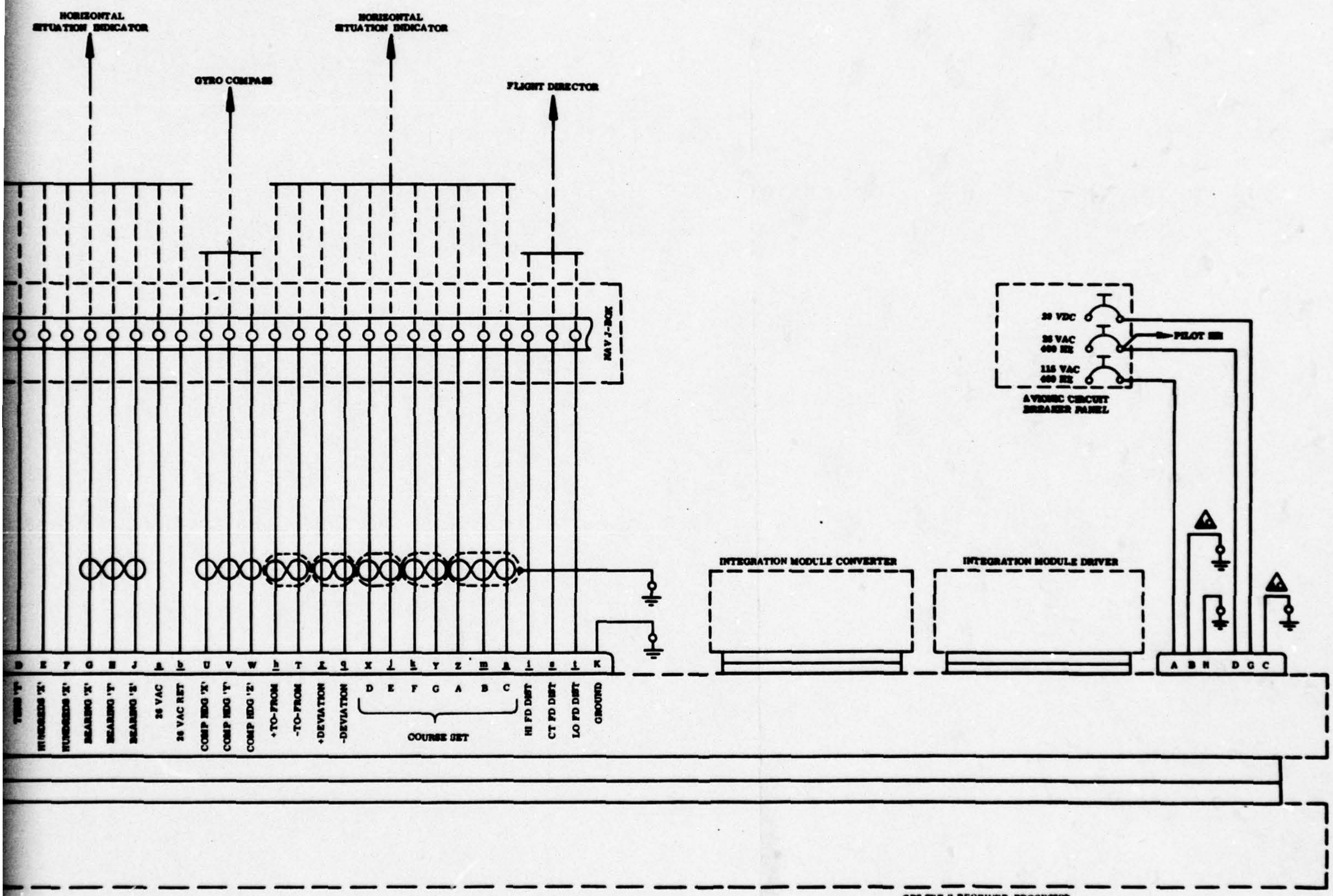


Figure 1. GPS Set Z Installation External Wiring Diagram (Typical)

and navigation information will be read out only on the CDU display. The IM is used to enable navigation data input to the flight instruments. A typical interconnection cabling diagram is shown in Figure 2. Specific airplane cabling diagrams are contained in the Appendix.

3.3.3.1 TACAN Connections. Bearing, deviation, distance, and flag signals are provided by Set Z for display by the flight instruments in a form similar to a normal TACAN output. Direct connection via existing TACAN cabling shall be utilized when practical and feasible. When necessary, jumper harnesses shall be fabricated and installed in accordance with MIL-W-5088 to preclude the necessity of removing or dismantling the existing TACAN harness.

3.3.3.2 Relay/Junction Boxes. Relay/junction boxes shall be incorporated into the installation design only as necessary to permit selection of the desired navigation input to the flight instruments. A relay box and an associated selector switch shall be added to the Set Z installation, when the set is installed, without first removing an existing TACAN set. The relay box shall be designed and located such that existing TACAN harness assemblies can be utilized without modification, and box connectors must be mateable with existing TACAN harness plugs as required. Interwiring and cabling diagrams shall be as shown in the appendix.

3.3.3.3 Alert/Caution Lights. If alert or caution light panels are used in the test aircraft, the Set Z receiver/processor unit may be connected to a panel to advise operators of degraded operation. The alert circuitry in the IM creates a dc path to ground to activate the alert function. The alert panel light shall be connected only where spare light panels are available for this use in the test aircraft.

3.3.3.4 Panel Lighting. The CDU panel lighting must have the flexibility to operate from any of three light power sources (0 to 28V variable dc, 0 to 28V variable ac, or 0 to 5V variable ac), or be adaptable by aircraft type to accommodate the particular lighting voltage of the aircraft. The plastic panel appropriate to the particular aircraft edge panel lighting power source must be specified. In each case, the panel lighting input from the area dimmer shall be connected to the CDU input power contact in accordance with MIL-W-5088. If appropriate to the particular installation, existing TACAN control panel wiring shall be used.

3.4 Mounting. The Set Z shall be mounted in the aircraft in accordance with MIL-I-8700, para. 3.3.4, except as noted below.

3.4.1 Set Z Receiver/Processor Mounting. The Set Z receiver/processor mounting shall consist of a tray designed to accept both the receiver/processor unit and the integration module as plug-in assemblies (see typical outline drawing, Figure 3). The tray shall be secured to the aircraft structure with four platform vibration isolators (Lord 150PHL8 or equivalent) as appropriate for the aircraft vibration environment. The mounting shall be equipped with type C clutched hold-downs and cooling orifices in accordance with ARINC Specification 404. The mounting shall be wired in accordance with MIL-W-5088 to interconnect unit rack-and-panel connectors and the circular connectors on the mounting rear surface. Minor wiring variations may exist between mountings designed for different aircraft types, as depicted in the appendix.

3.4.2 Set Z Control Display Unit. The Set Z control display unit (see Fig. 4) shall be mounted to the console rack or control panel mount using six fasteners appropriate to

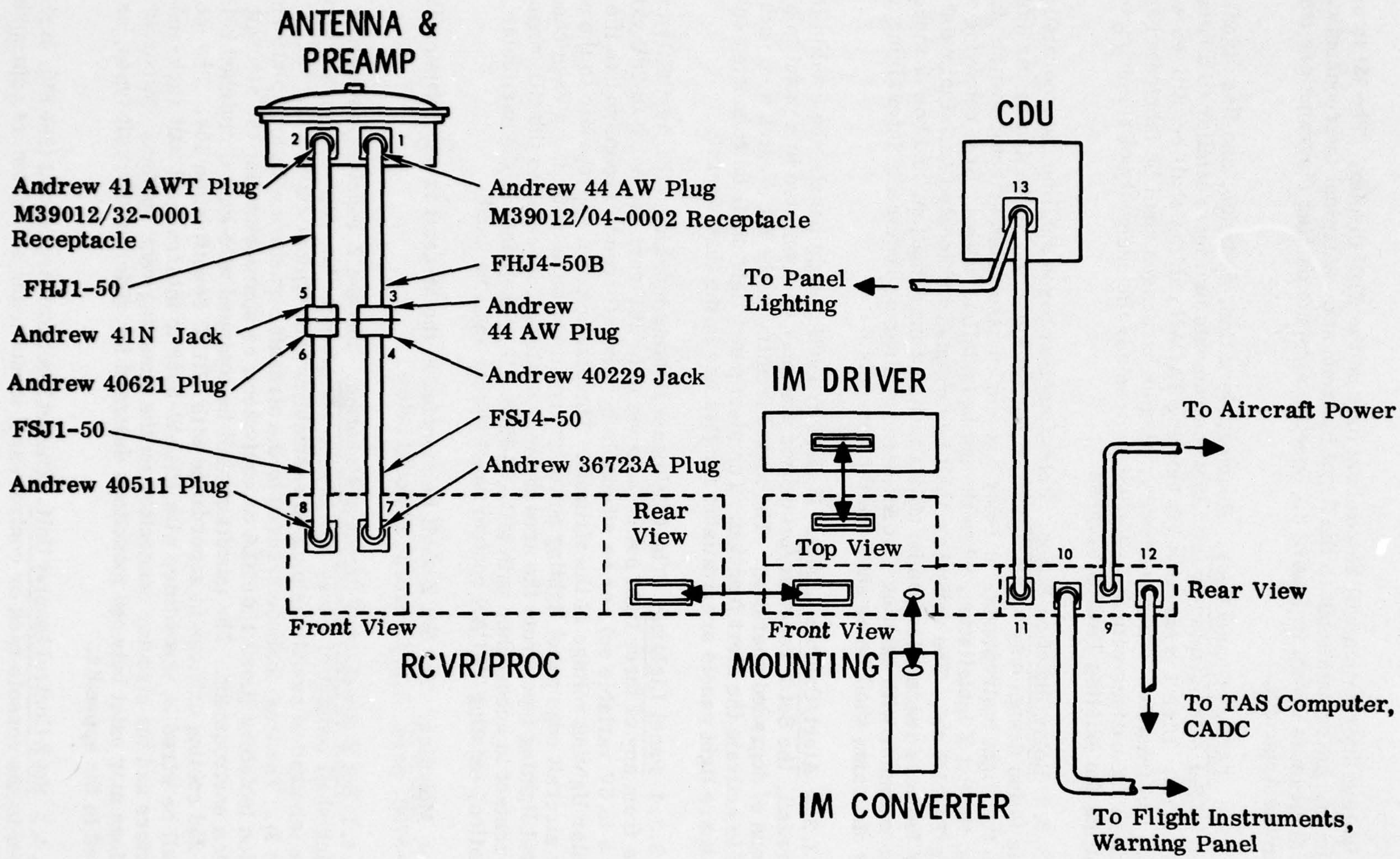
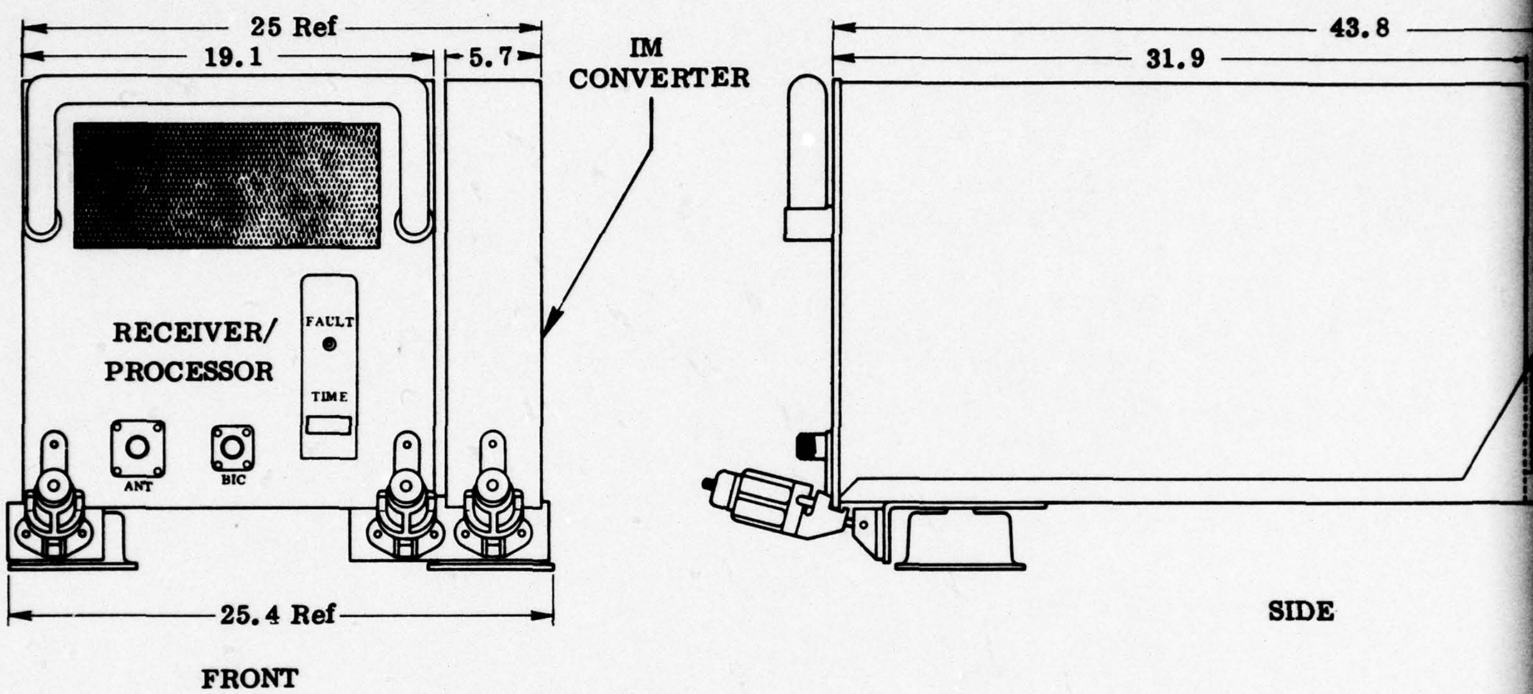


Figure 2. GPS Set Z Cabling Diagram



Dimensions in cm

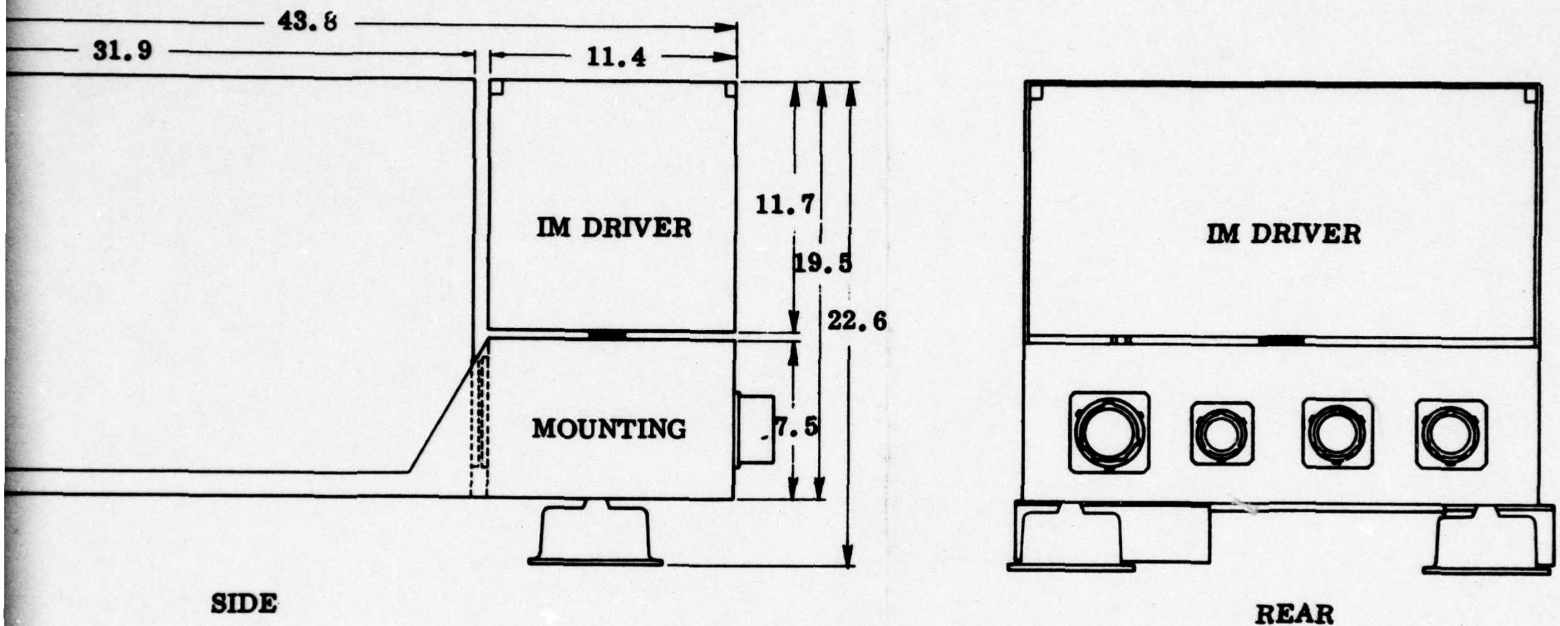
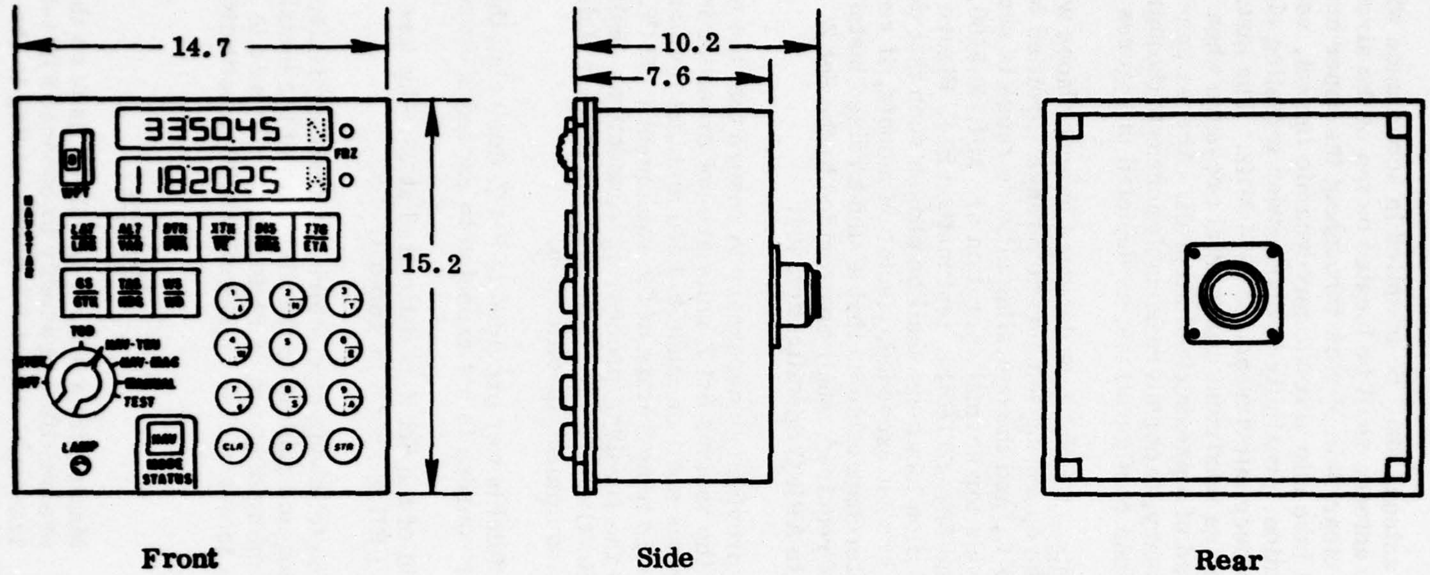


Figure 3. GPS Set Z Receiver/Processor and Mounting



(Dimensions in cm)

Figure 4. Control/Display Unit

the configuration, as described in MIL-F-25173. Isolation mountings and external cooling ducts shall not be used on the control display unit.

3.4.3 GPS Antenna. The GPS antenna shall be installed in accordance with MIL-STD-877, para. 4.2.1.5. The antenna shall be located on top of the aircraft so as to obtain as nearly as possible a clear field of view throughout the upper hemisphere. The selected location shall take into account aerodynamic impact, vehicle structural integrity, ease of installation, proximity to high-power radiating elements, and proximity to sensors which introduce interference at 1575 MHz. The installation shall accommodate and withstand design maximum differential pressure when incorporated in the pressure bulkhead of a pressurized aircraft. Access panels shall be fabricated and installed, as necessary, to permit reasonable access to the unit for servicing. There are two possible antenna configurations, as depicted in Figures 5 and 6.

3.5 Environmental Requirements. UE Set Z is designed in accordance with MIL-E-5400, Class 1. However, the operating temperature range specified in SS-US-101 for Set Z is -40° C to +55° C, and the operating altitude range is sea level to 50,000 feet. Design vibration levels for normal operation are MIL-E-5400, Figure 2, curve IVA (sinusoidal); and MIL-STD-810, test method 514, Figure 514-4, test level AJ (random). Unit installation locations shall be chosen such that design levels for environmental conditions are not exceeded. Isolation mounts, if required, shall be selected to be physically interchangeable so that a standardized installation is maintained. Cooling air ducts, if required, shall be provided to the Set Z receiver mounting in accordance with ARINC Specification 404.

3.6 Cooling. Cooling shall be provided as necessary to ensure that the maximum ambient temperatures specified for the various Set Z units are not exceeded in flight or during ground operation. Provisions shall be made to keep ambient temperatures from exceeding the nonoperating design temperature of the equipment (+85° C). If cooling ducting is routed directly to the receiver/processor, connections shall use mounting orifices per ARINC Specification 404. Air flow shall be at the weight flows and temperatures specified in Set Z equipment specification.

3.7 Power Consumption. The total power provided to Set Z (including the integration module) from aircraft power sources is not expected to exceed 250 watts.

3.8 Weight. The overall weight of the Set Z is estimated at 23.5 kg (excluding cabling). The weight breakdown by LRU is shown in Table 1.

3.9 Electrical Connectors. The following connectors, or their equivalents, will be required to connect aircraft wiring and cabling to the elements of the installed Set Z. Numbers are keyed to the cabling diagram of Figure 2. Reference to specific manufacturers or trade names shall in every case be satisfied with substitution by an equal product.

Connector	Function
1. Andrew 44AW (Type N)	Mates with a MIL-C-39012 (N) jack on the preamplifier assembly to connect FHJ4-50B 1/2-inch coaxial RF cable leading to the Set Z receiver.

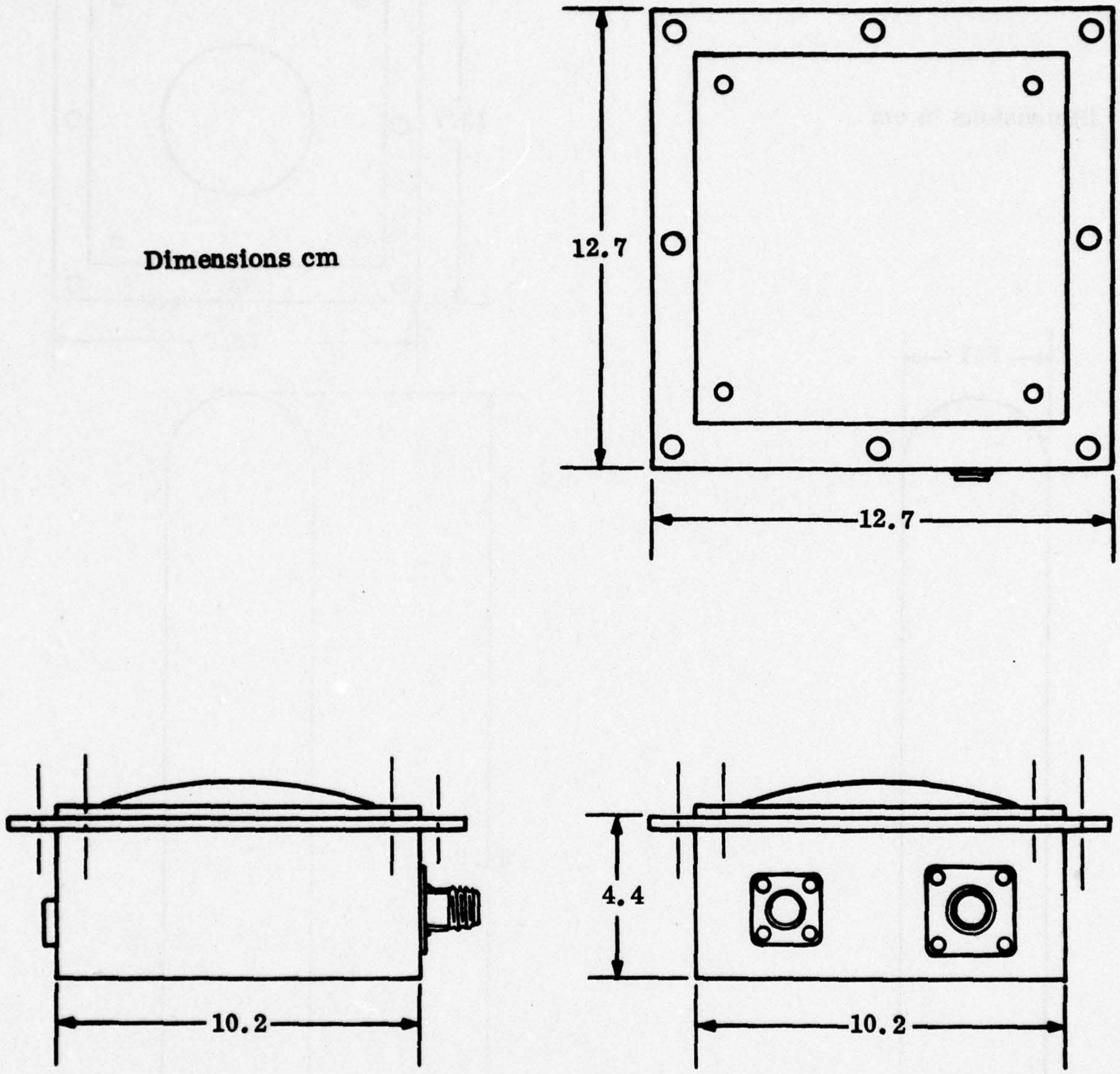


Figure 5. GPS Set Z Conformal Antenna/Preamplifier Assembly

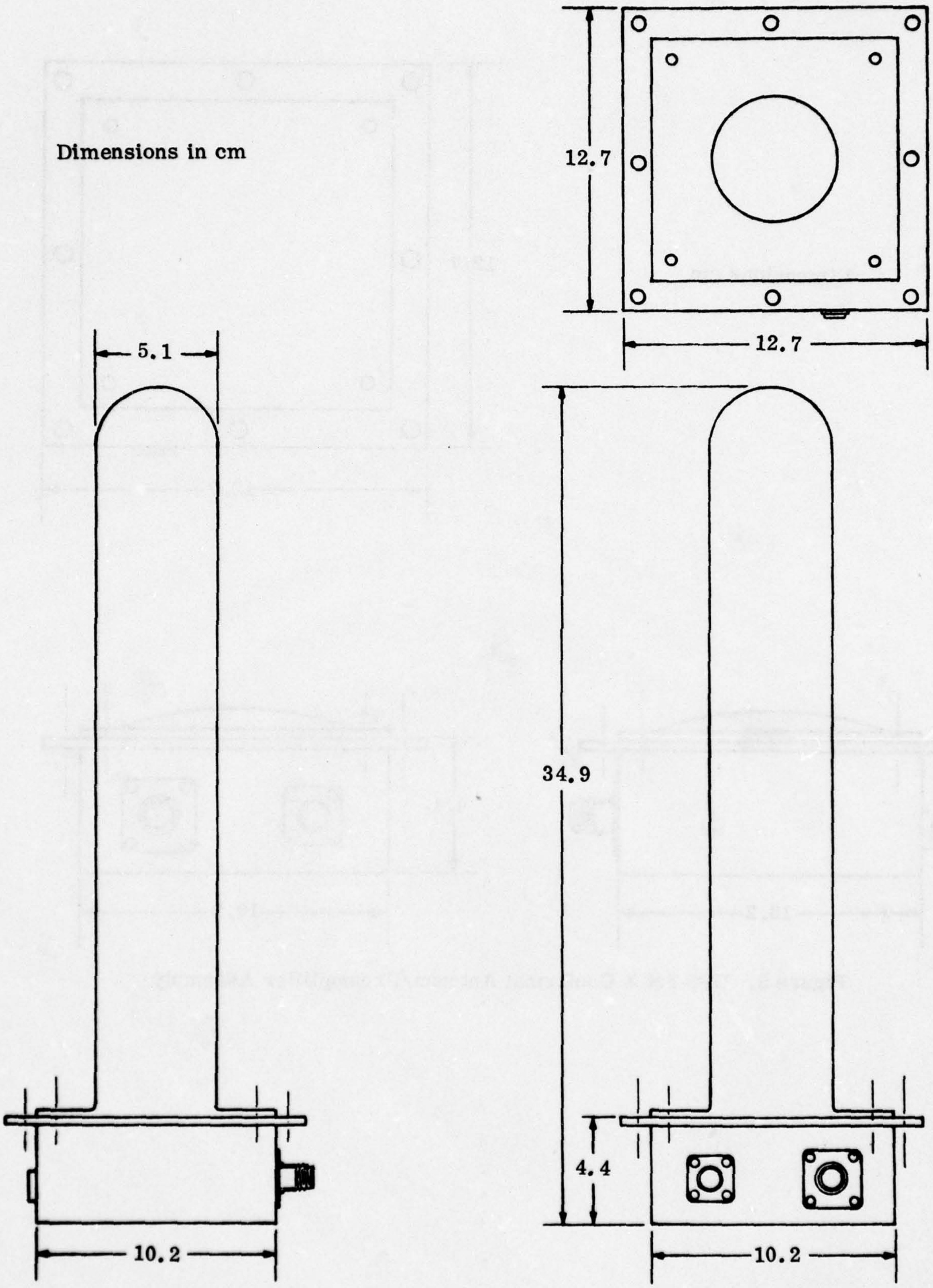


Figure 6. GPS Set Z Volute Antenna/Preamplifier Assembly

Connector	Function
2. Andrew 41AWT (TNC)	Mates with a MIL-C-39012 (TNC) female jack on the preamplifier assembly to connect FHJ1-50 1/4-inch coaxial cable (calibration) leading to the Set Z receiver.
3. Andrew 44AW (Type N)	Mates with an Andrew 40229 jack to connect the RF signal line to a flexible coaxial cable service loop leading to the Set Z receiver.
4. Andrew 40229 (Type N)	Mates with an Andrew 44AW plug to connect a flexible service loop to the rf signal line.
5. Andrew 41N (Type N)	Mates with an Andrew 40621 plug to connect the calibration line to a flexible coaxial cable service loop leading to the Set Z receiver.
6. Andrew 40621	Mates with an Andrew 41N jack to connect a flexible service loop to the calibration line.
7. Andrew 36723A (Type N)	Mates with a MIL-C-39012 (N) female jack on the Set Z receiver front panel to input the amplified RF signal.
8. Andrew 40611 (TNC)	Mates with a MIL-C-39012 (TNC) female jack on the Set Z receiver front panel for calibration signal output.
9. M83723-13R16-8N	Mates with MIL-C-83723 8-pin receptacle on the Set Z receiver mounting to provide aircraft power connections.
10. M83723-14R20-41N	Mates with MIL-C-83723 41-pin receptacle on the Set Z receiver mounting to provide miscellaneous interface signal connections to aircraft instruments and systems.
11. M83723-14R14-15N	Mates with MIL-C-83723 15-pin receptacle on the Set Z receiver mounting to provide interconnections with the Set Z control-display unit.
12. M83723-13R16-26N	Mates with MIL-C-83723 26-pin receptacle on the Set Z receiver mounting to provide signal connections for TAS and altitude inputs.
13. M83723-24R20-27N	Mates with MIL-C-83723 14-pin connector on the Set Z CDU to provide interconnections with the Set Z receiver and connections to panel light power.

Additional connectors may be required, depending on aircraft type, to permit manufacturing breaks and to connect to existing aircraft circuitry. Shown in the appendix are cabling and connector details for the selected test aircraft.

TABLE 1. GPS USER EQUIPMENT SET Z PHYSICAL CHARACTERISTICS

Item	Dimensions (w x l x h, cm)	Weight, kg	Power Consum., W
GPS Receiver/Processor Unit	19.10 x 31.9 x 19.4 (max); 3/4 ATR(S)	13.6	120
Control/Display Unit	14.7 x 10.2 x 15.2	2.27	10
Preamplifier Assembly	10.2 x 10.2 x 3.8	1.09	1
Antenna			
Conformal	12.7 x 12.7 x 5.0	1.36	–
Volute	5.1 dia, 30.5h	2.3	–
Integration Module		2.3	120
Converter	5.7 x 32 x 19.5		
Driver	25 x 11.4 x 11.7		
Receiver/Processor Mounting	25.4 x 43.9 x 7.5	3.0	–

3.10 Workmanship. Set Z shall be installed as specified herein and in accordance with good aircraft installation practices. Particular attention shall be given to wiring, electrical connections and proper location of all components. Set Z fabrication workmanship shall conform to MIL-STD-454, requirement 9.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of Tests. The inspection and testing of Set Z installations shall be classified as acceptance tests.

4.3 Test Conditions

4.3.1 Standard Atmospheric Conditions. Whenever test pressure and temperature are not specified, it shall be understood that the tests are to be conducted at atmospheric pressure (29.92 inches Hg) and room temperature (21°C). When tests conducted at an atmospheric pressure or room temperature differ substantially from the above values, proper allowance shall be made for the difference from the specified condition.

4.3.2 Inspection and Test. Prior to installation, each component shall be inspected for damage incurred during shipment. Set Z shall be functionally tested prior to installation to insure proper operation.

4.4 Acceptance Tests. Acceptance tests shall consist of individual tests.

4.4.1 Individual Tests. Each Set Z installation shall be subjected to the following tests in the order indicated, as described under 4.5:

a. Examination of installation

b. High potential

c. Continuity check

d. Power supply check

e. Coaxial cable condition

f. System self-test

g. CDU operation

h. Panel lighting

i. TAS input

j. Altitude input

k. Flight instrument operation

l. Electronic interference

4.5 Test Methods

4.5.1 Examination of Installation. The installation of Set Z shall be physically inspected to determine compliance with the requirements specified herein.

4.5.2 High Potential. All electrical cables shall be disconnected from all components in Set Z, including the power source. For a period of 5 seconds, a potential of 1,000 Vac at commercial frequency shall be applied between all pairs of related leads and between each lead of the electrical connector of the cable. There shall be no insulation breakdown or short circuit in any cable.

4.5.3 Continuity Check. Each lead in every cable shall be checked for continuity from pin to pin as specified on the wiring diagrams. Except as noted, there shall be no open circuits for any cable.

4.5.4 Power Supply Check. Aircraft power supplied to Set Z shall be checked for compliance with MIL-STD-704 requirements. The electrical cables shall then be reconnected to the Set Z receiver/processor and the power input to the preamplifier and the CDU shall be measured on the applicable pins of the connectors. The voltage shall be within the range specified in CID-US-108.

4.5.5 Coaxial Cable Condition. The coaxial cables between the Set Z receiver/processor and preamplifier shall be checked for discontinuities using reflectometer techniques. The VSWR of cable assemblies, measured at the receiver plug, shall not exceed 1.3:1 in the range of 1.50 to 1.65 GHz when terminated in a 50 ohm load. Loss at 1.5 GHz shall not exceed 6 dB (rf cable) or 12 dB (calibration cable). Following this test, all cables shall be connected to the applicable components.

4.5.6 System Operation

4.5.6.1 System Self-Test. Set Z shall be placed in operation and system self-test shall be exercised. The self-test shall indicate proper operation.

4.5.6.2 CDU Operation. The various functions of the control display unit shall be exercised, including waypoint entry, altitude entry, speed entry, and flight angle entry; and the appropriate display response shall be observed. After entry of all data, each item entered shall be recalled, displayed, and verified.

4.5.6.3 Panel Lighting. Control panel lighting shall be energized and CDU panel lighting verified, including dimmer activation.

4.5.6.4 TAS Input. True airspeed inputs to Set Z shall be verified. With the applicable pitot system pressurized using a CADC input test set (TTU-205 or equivalent), the TAS indication on the CDU shall be compared with the reading of an onboard TAS indicator (if available) operating from the same pitot system. On those aircraft not equipped with TAS indicators, an applicable indicated airspeed instrument shall be used and TAS computed with the measured outside air temperature and local pressure altitude.

4.5.6.5 Altitude Input. The altitude input to Set Z from the altitude encoder shall be verified. With a vacuum applied to the applicable static pressure system using a CADC input test set (TTU-205 or equivalent), the altitude indication on the CDU shall be compared with the pressure altitude indicated on an onboard altimeter operating from the same static pressure system.

4.5.6.6 Flight Instrument Operation. Course and heading inputs to Set Z from the related flight instruments shall be verified. Flight instrument readings of GPS navigation data shall be observed, including waypoint bearing, distance to go, course deviation, to-from indication, and flag display.

4.5.7 Electronic Interference. Exercise all other onboard electronic equipments simultaneously with Set Z to the extent practicable. If interference is observed, either in the operation of Set Z or in other electronic systems where Set Z interference is suspected, the causing system shall be identified and corrective action determined.

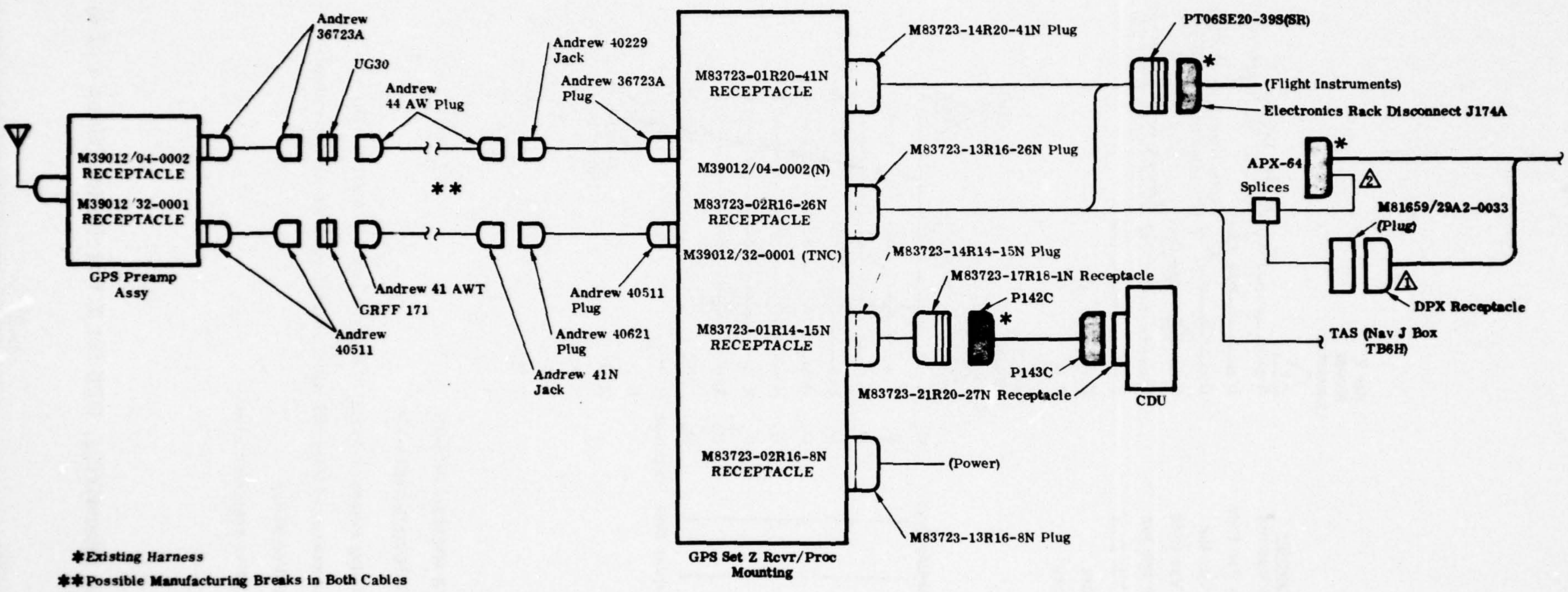
5. PREPARATION FOR DELIVERY

(Not applicable)

Specification No. ____________

APPENDIX

TEST AIRCRAFT WIRING AND CABLING FOR INSTALLATION OF UE SET Z



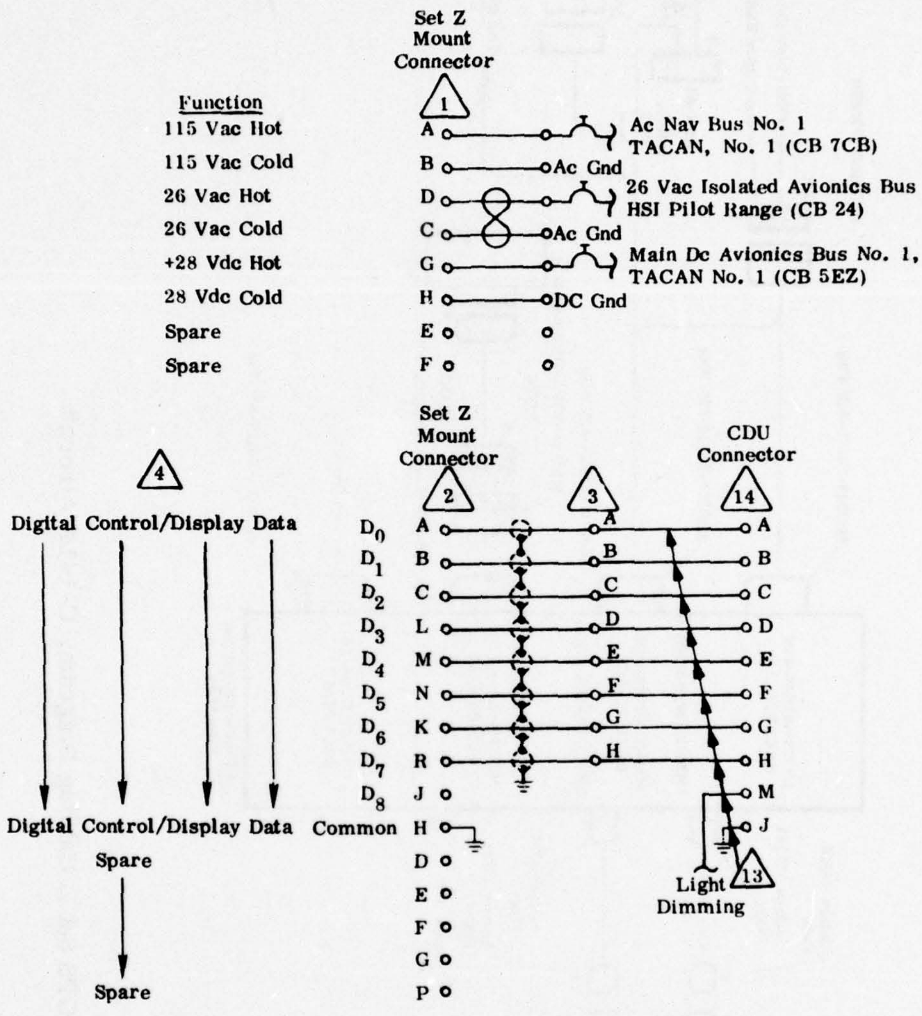
* Existing Harness

** Possible Manufacturing Breaks in Both Cables

⚠1 Insert Removed from APX-64 Connector

⚠2 New -67 Insert to Replace that Inserted into DPX Receptacle

GPS Set Z Cabling Diagram, C-141A Aircraft



1 P/N M83723-13R16-8N

2 P/N M83723-14R14-15N

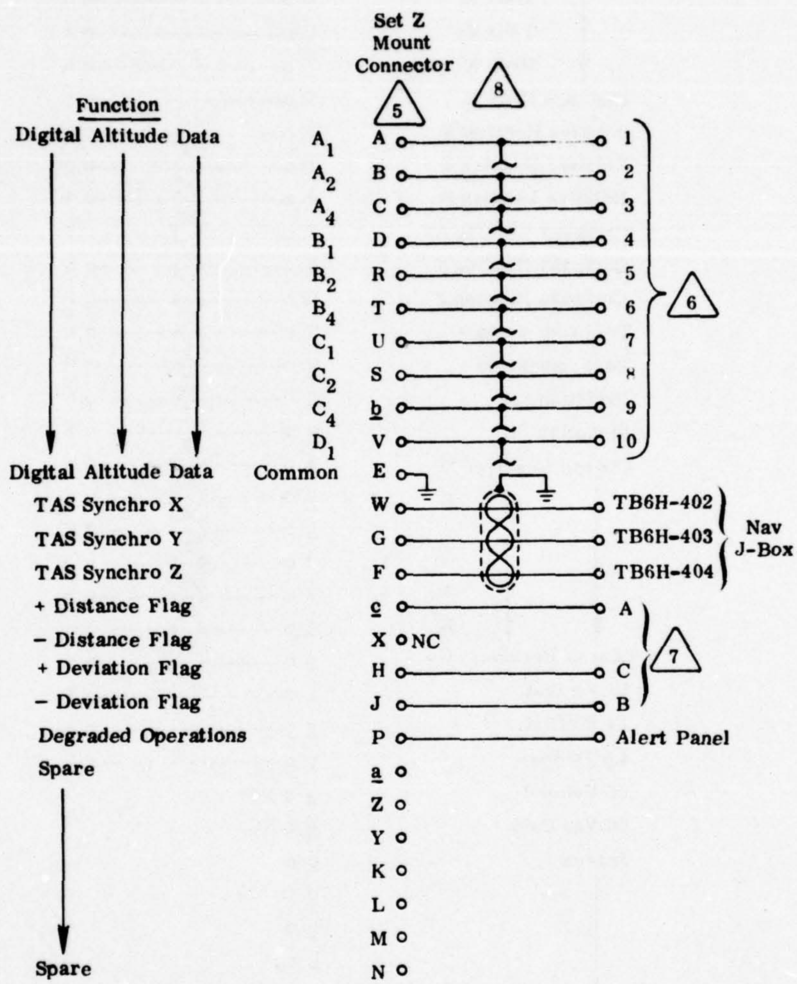
3 Existing connector P142C mated with new P/N M83723-17R18-1N

4 The number of lines and signal characteristics to be determined

13 Existing wiring

14 Existing connector P134C

C-141A Interwiring, GPS Set Z Installation (Sheet 1 of 4)



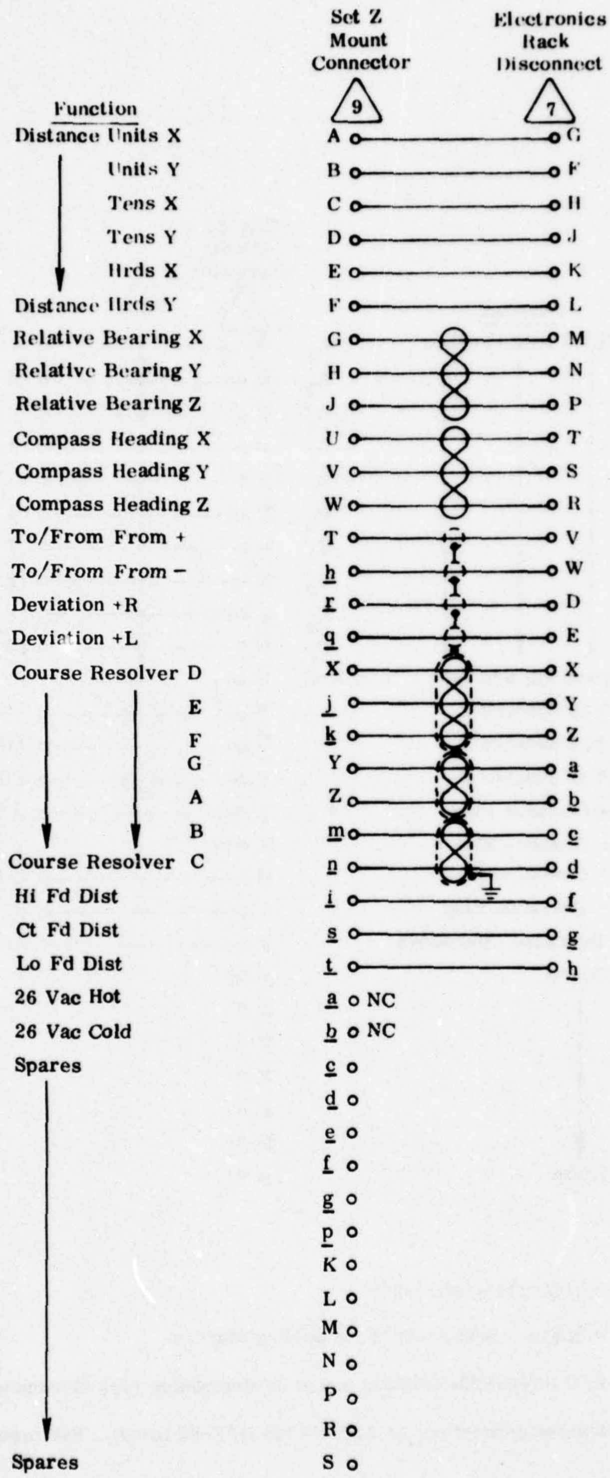
5 P/N M83723-13R16-26N

6 P/N M81659/29A2-0033 ref cabling diagram

7 P/N PT06SE20-39S(SR), mated to electronics rack disconnect, J174A

8 Spliced connections to APX-64 via DPX-67 insert. Ref. cabling diagram

C-141A Interwiring, GPS Set Z Installation (Sheet 2 of 4)



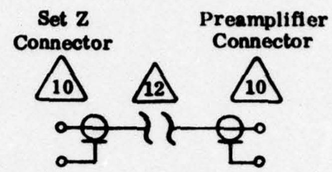
7 P/N PT06SE20-39S(SR), mated to electronics rack disconnect, J174A

9 P/N M83723-14R20-41N

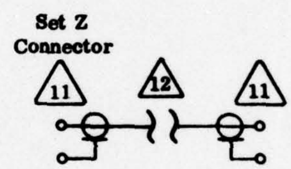
C-141A Interwiring, GPS Set Z Installation (Sheet 3 of 4)

Function

Amplified RF/+15 Vdc



Calibration Signal

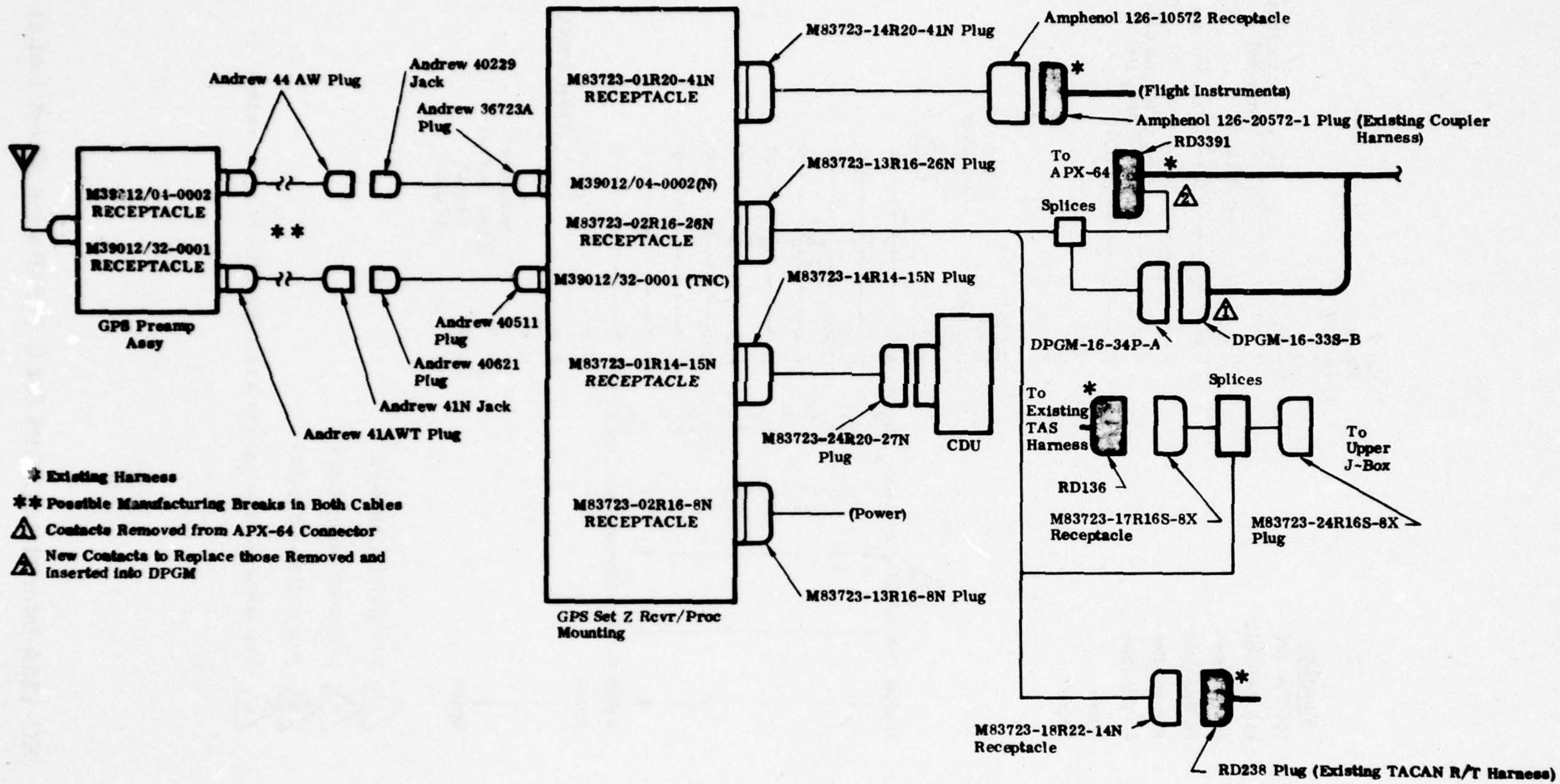


10 P/N 36723A (Andrew)

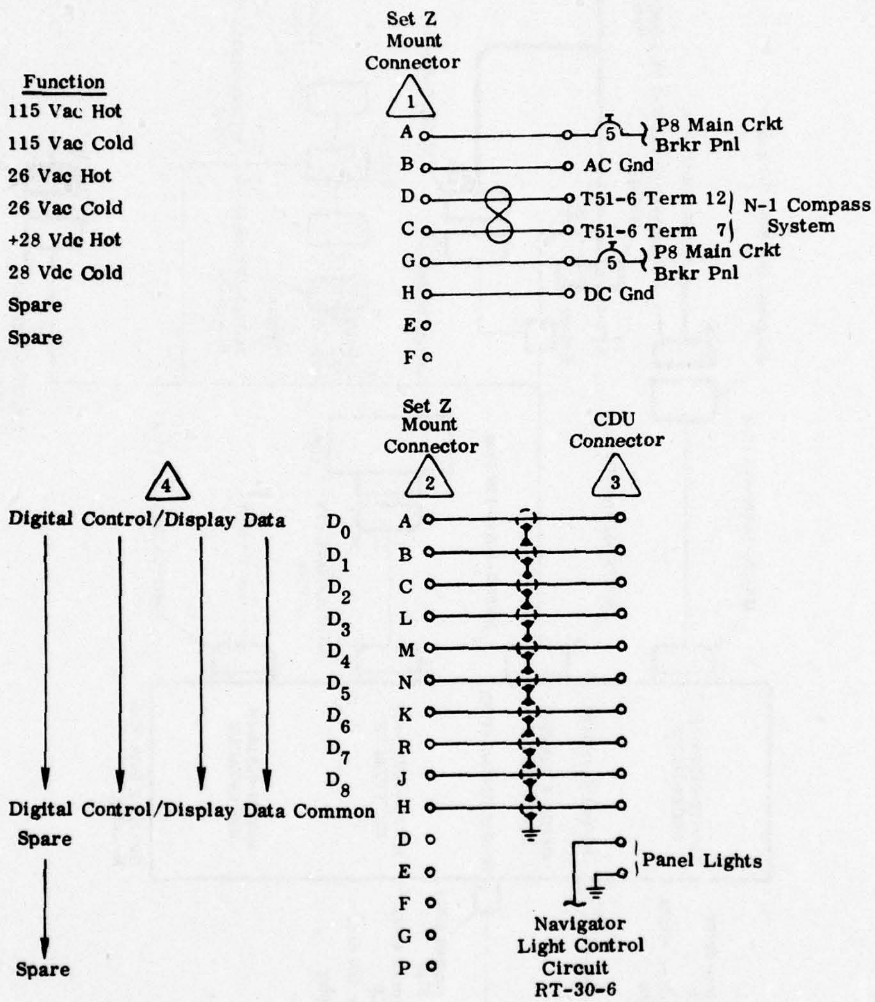
11 P/N 40511 (Andrew)

12 Intermediate connectors and bulkhead adapters

C-141A Interwiring, GPS Set Z Installation (Sheet 4 of 4)



GPS Set Z Cabling Diagram, KC-135A Aircraft



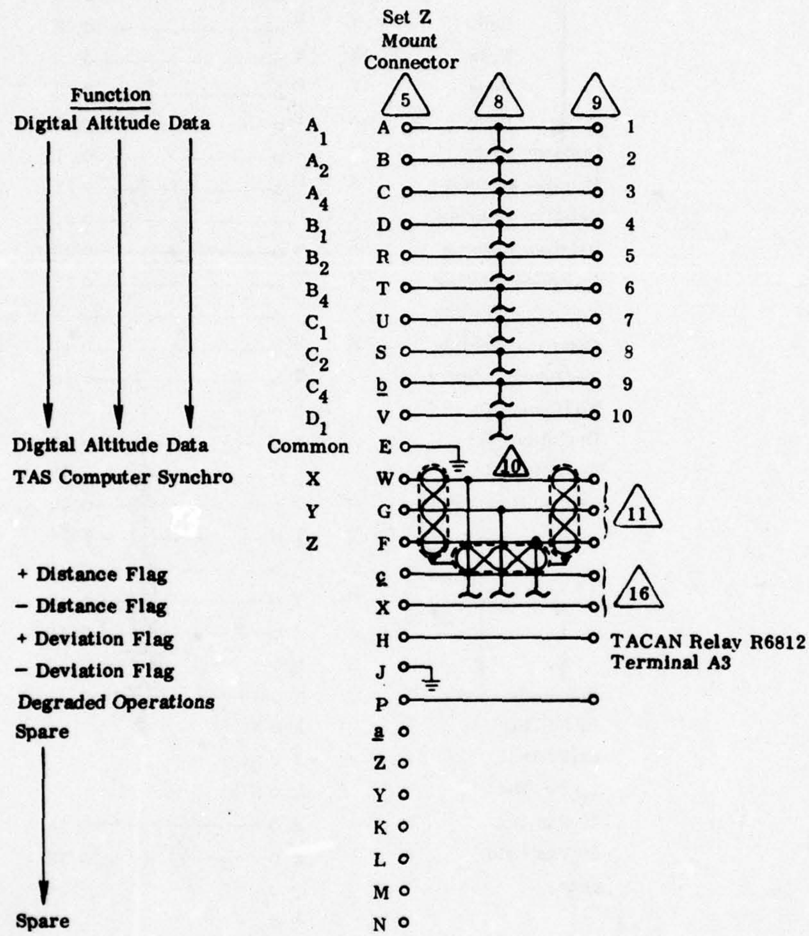
1 P/N M83723-13R16-8N

2 P/N M83723-14R14-15N

3 P/N M83723-24R20-27N

4 The number of lines and signal characteristics to be determined

KC-135A Interwiring, GPS Set Z Installation (Sheet 1 of 4)



5 P/N M83723-13R16-26N

8 Spliced connections to APX-64, see cabling diagram

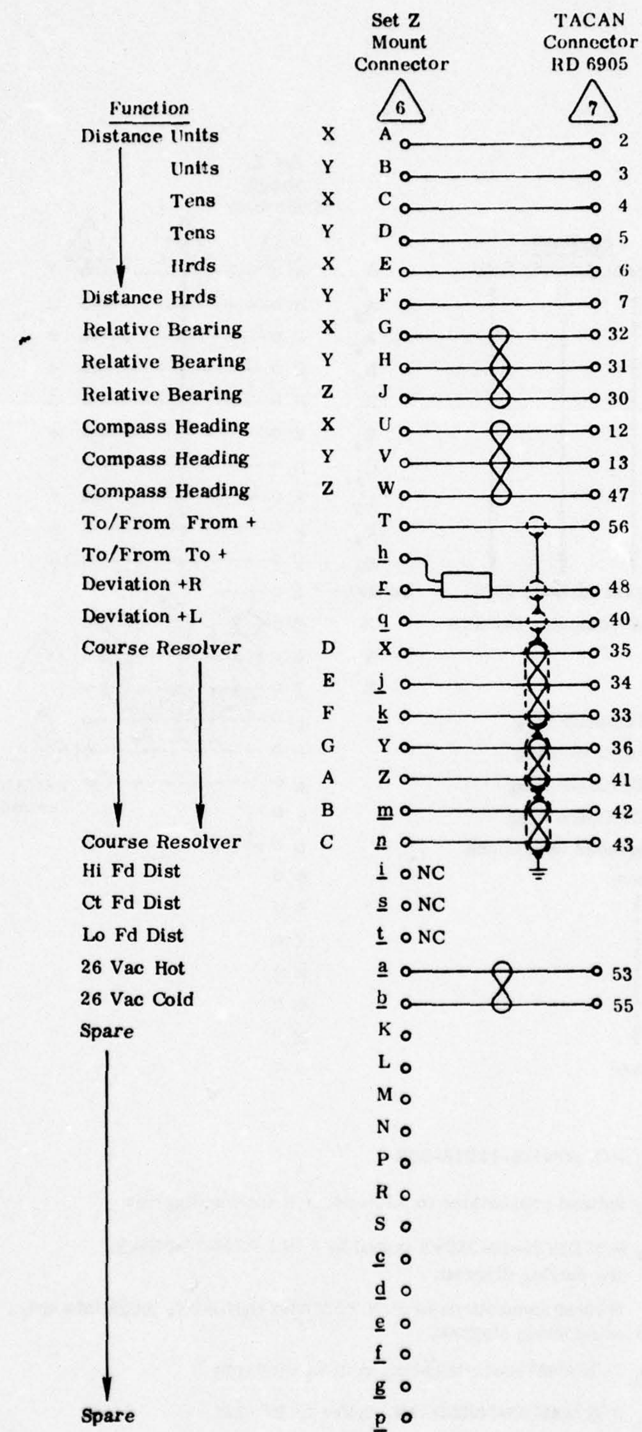
9 P/N DPGM-16-34P-A mated to P/N DPGM-16-33S-B, see cabling diagram

10 Spliced connections to P/N M83723-24R16S-8X, plugs into upper J box, see cabling diagram

11 P/N M83723-17R16S-8X, mates to RD-136

16 P/N M83723-18R22-14N, mates to RD-238

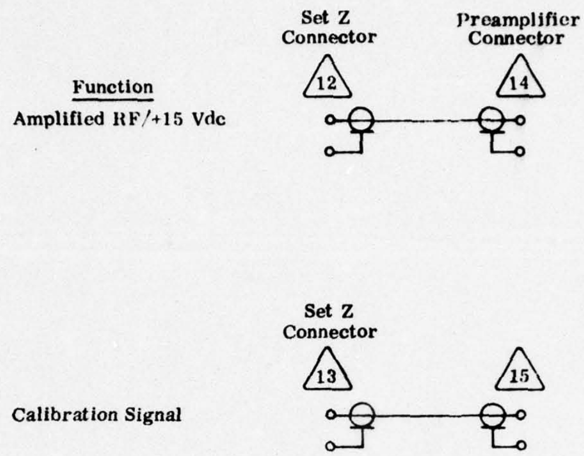
KC-135A Interwiring, GPS Set Z Installation (Sheet 2 of 4)



6 P/N M83723-14R20-41N

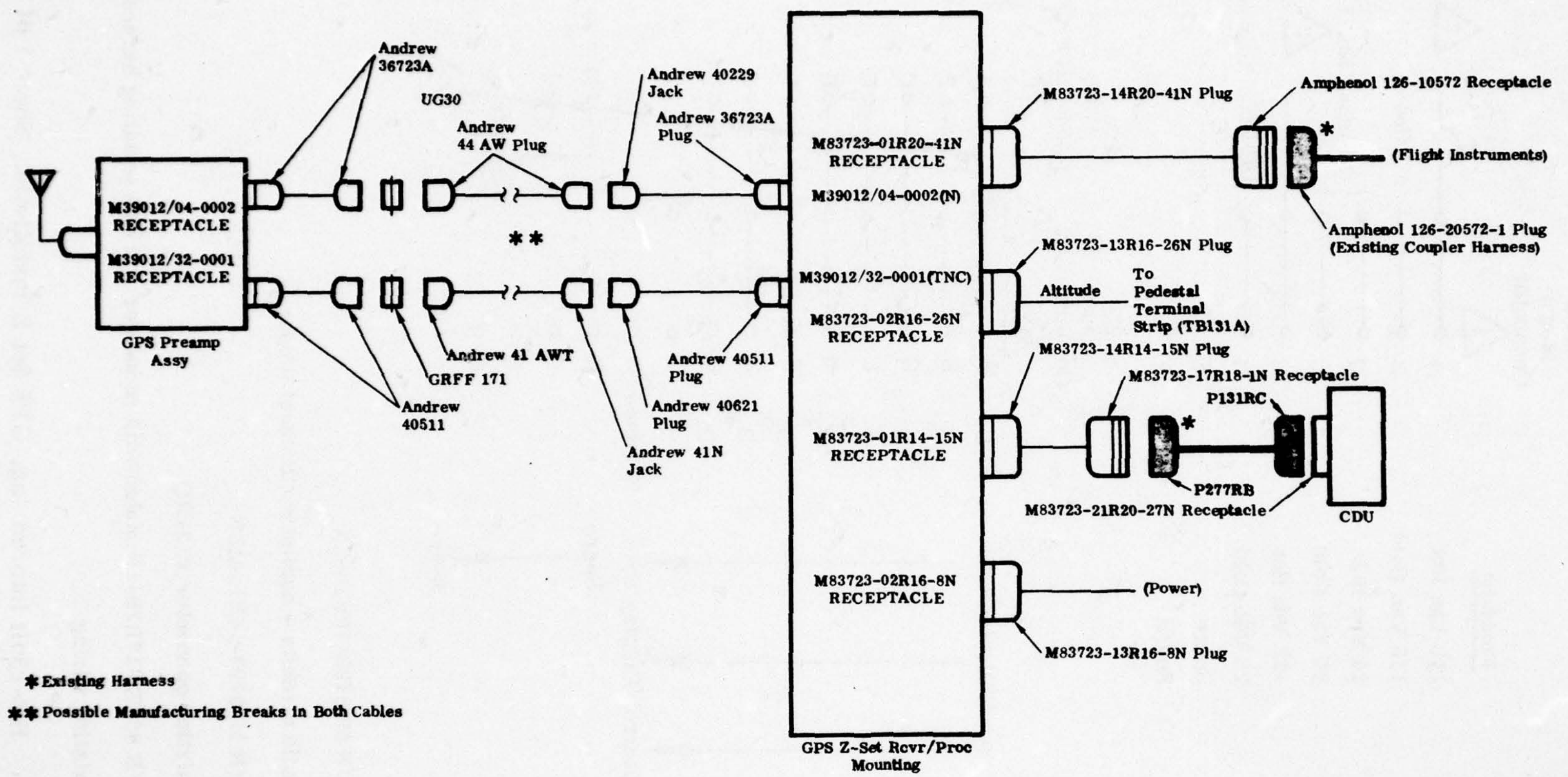
7 P/N 126-10572 (Amphenol)

KC-135A Interwiring, GPS Set Z Installation (Sheet 3 of 4)

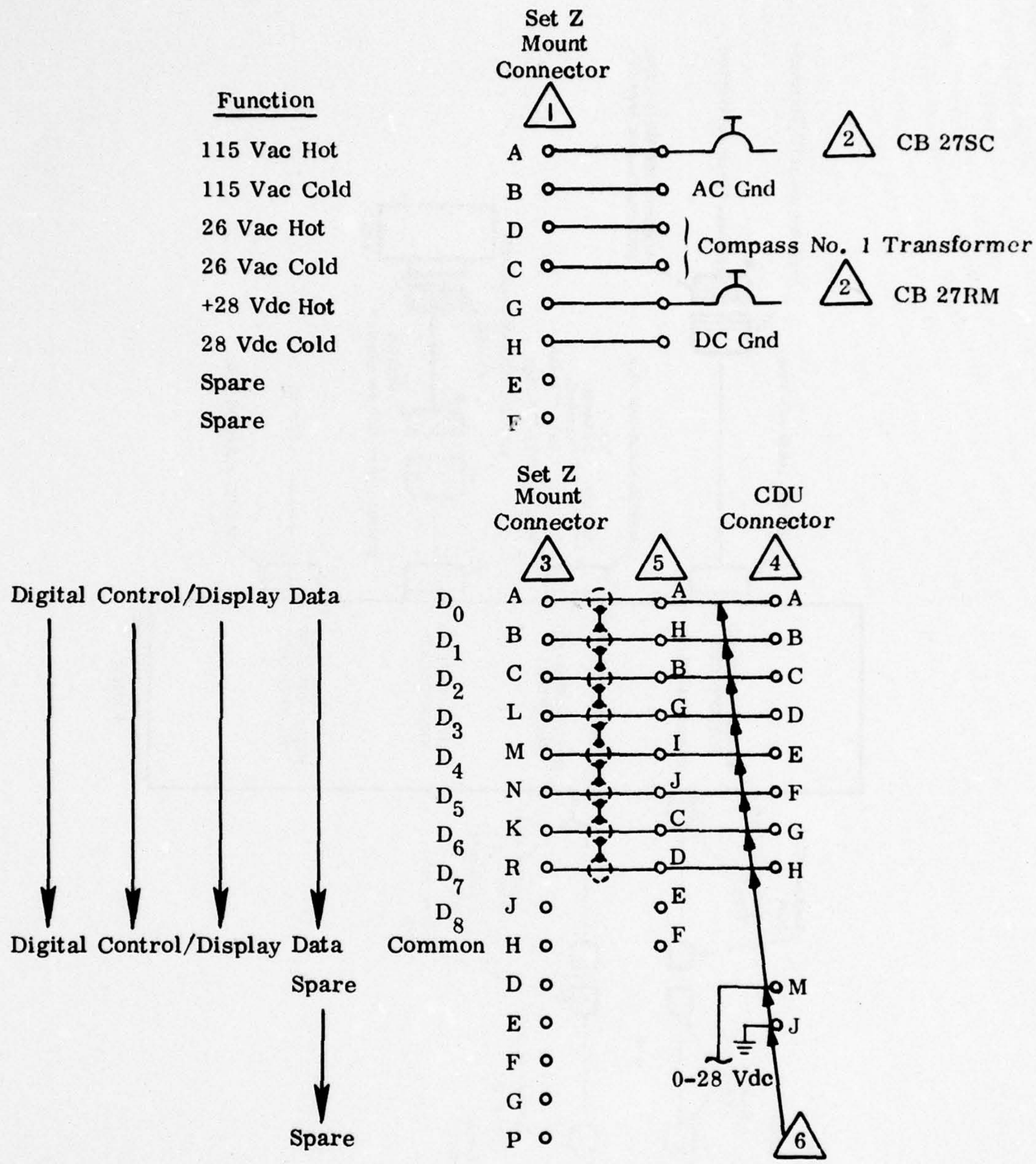


12 P/N 36723A (Andrew)
13 P/N 40511 (Andrew)
14 P/N 44AW (Andrew)
15 P/N 41AWT (Andrew)

KC-135A Interwiring, GPS Set Z Installation (Sheet 4 of 4)



GPS Set Z Cabling Diagram, HC-130H Aircraft



1 P/N M83723-13R16-8N

2 Radio circuits - copilot's CB panel (upper)

3 P/N M83723-14R14-15N

4 Existing connector P131RC

5 P/N 83723-17R18-1N mated with connector P277RB (existing harness)

6 Existing wiring

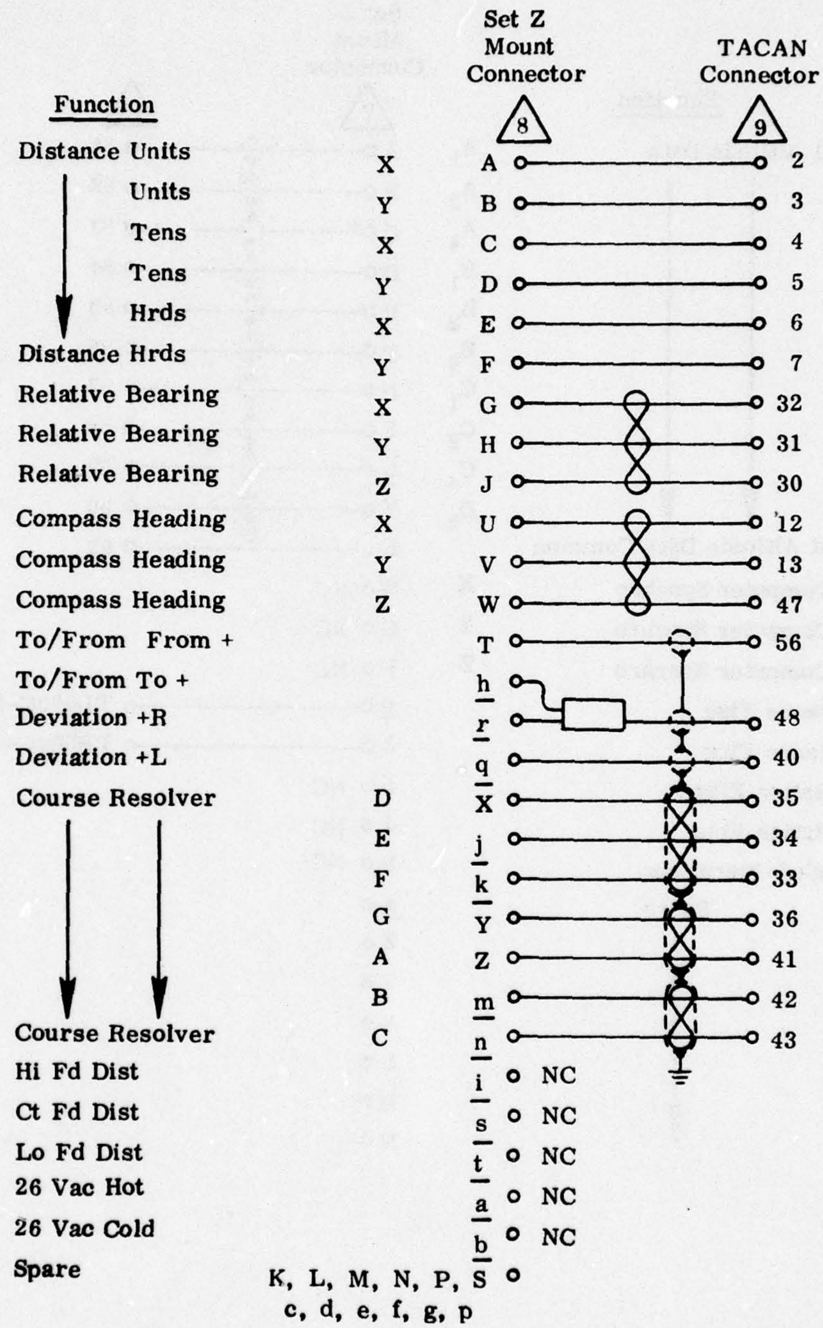
HC-130H Interwiring, GPS Set Z Installation (Sheet 1 of 4)

Function		Set Z Mount Connector (7)	(13)
Digital Altitude Data	A_1	A	81
	A_2	B	82
	A_4	C	83
	B_1	D	84
	B_2	R	85
	B_4	T	86
	C_1	U	87
	C_2	S	88
	C_4	b	89
	D_1	V	90
Digital Altitude Data Common		E	93
TAS Computer Synchro	X	W	NC
TAS Computer Synchro	Y	G	NC
TAS Computer Synchro	Z	F	NC
+ Distance Flag		c	TB500C-50 (TACAN J-Box)
− Distance Flag		X	TB500C-49 (TACAN J-Box)
+ Deviation Flag		H	NC
− Deviation Flag		J	NC
Degraded Operations		P	NC
Spare		a	
		Z	
		Y	
		K	
		L	
		M	
		N	

7. P/N M83723-13R16-26N

13. Pedestal terminal strip TB131A (forward end)

HC-130H Interwiring, GPS Set Z Installation (Sheet 2 of 4)



8 P/N M83723-14R20-41N

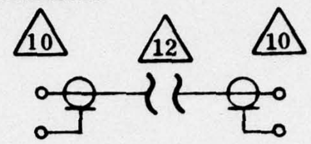
9 P/N 126-10572 (Amphenol), mates with TACAN coupler plug

HC-130H Interwiring, GPS Set Z Installation (Sheet 3 of 4)

Function

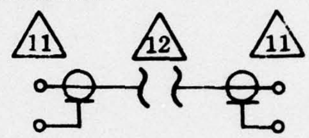
Amplified RF/+15 Vdc

Set Z
Connector



Calibration Signal

Set Z
Connector

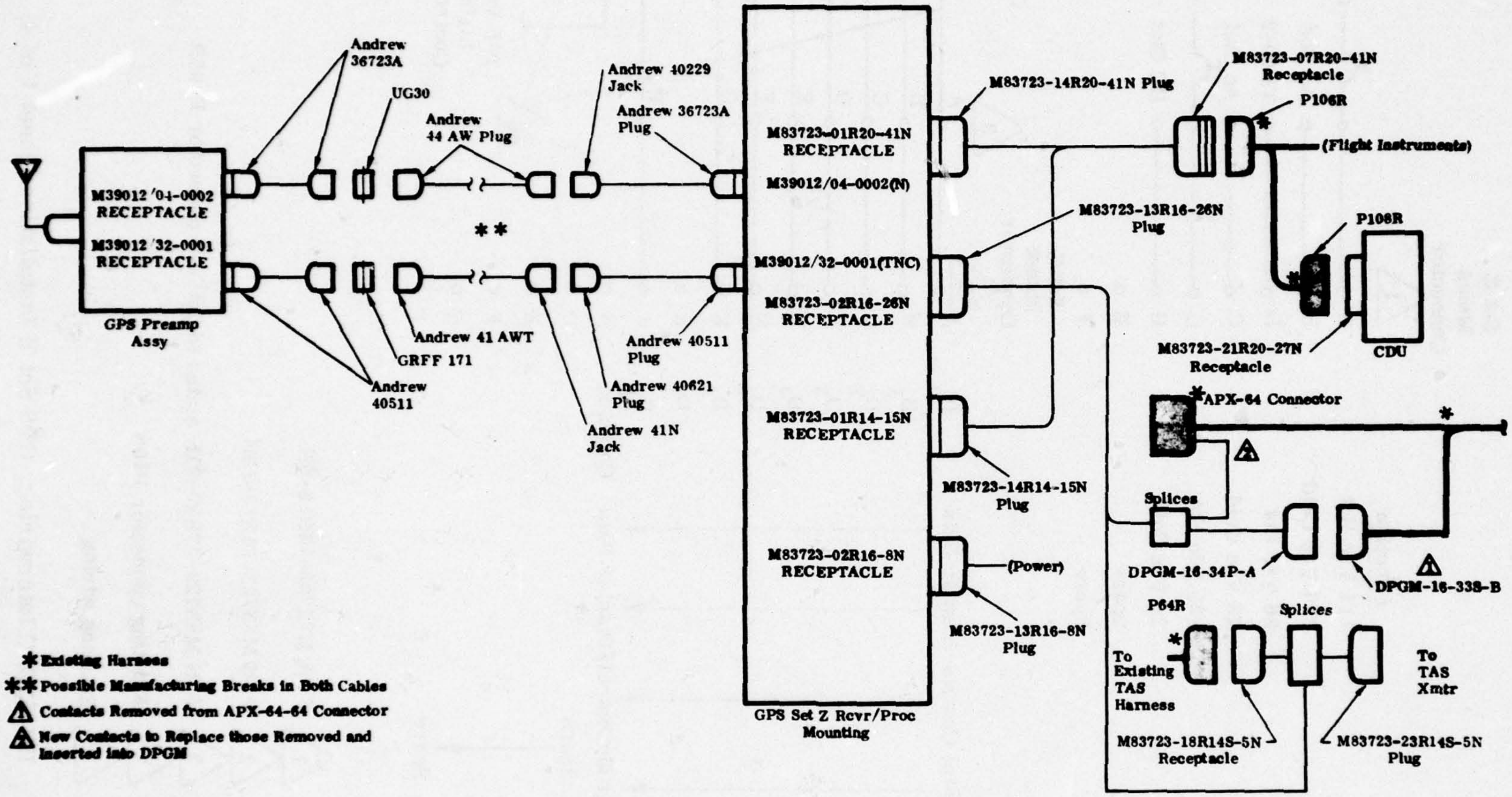


10 P/N 36723A (Andrew)

11 P/N 40511 (Andrew)

12 Intermediate connectors and bulkhead adapters

HC-130H Interwiring, GPS Set Z Installation (Sheet 4 of 4)



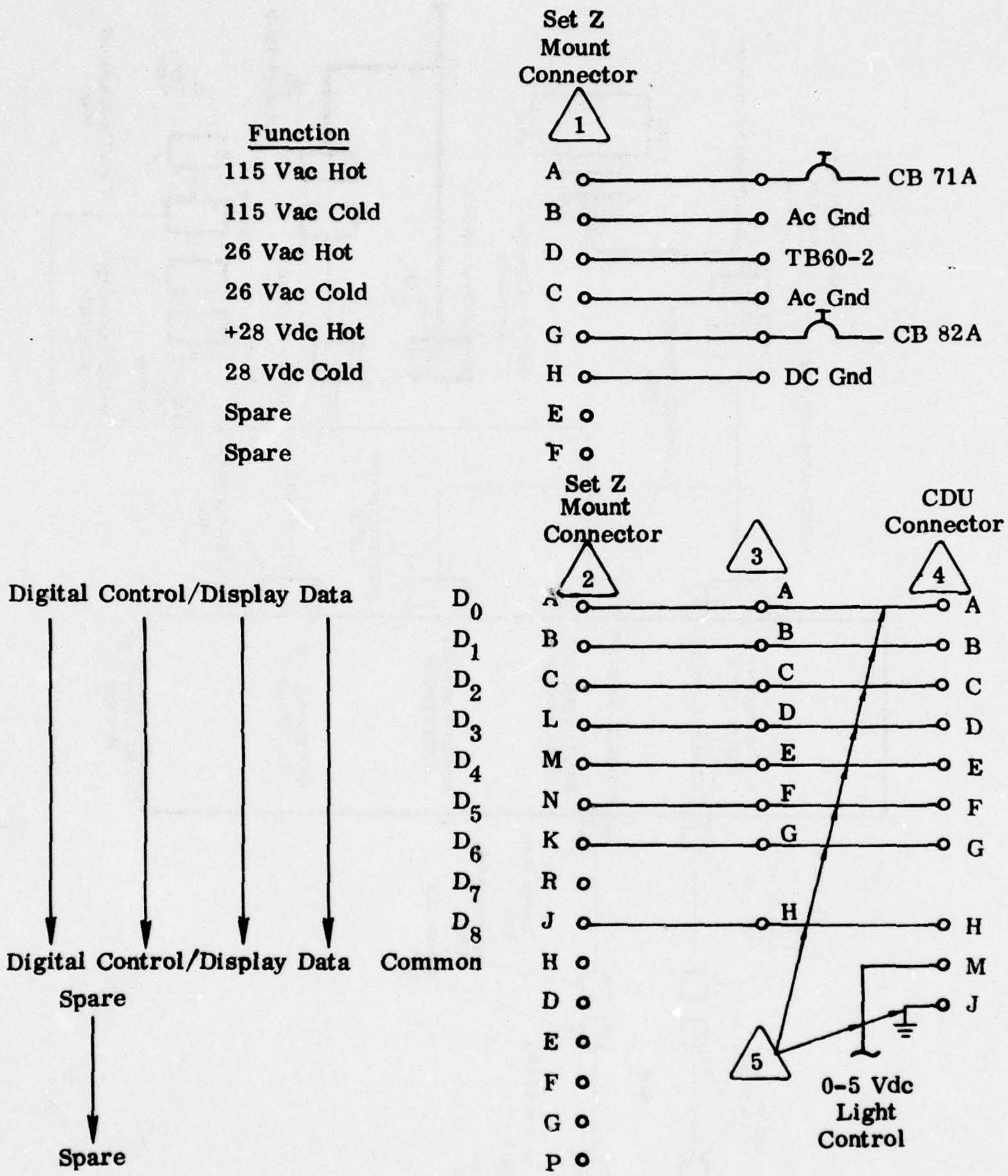
* Existing Harness

** Possible Manufacturing Breaks in Both Cables

(1) Contacts Removed from APX-64-64 Connector

(2) New Contacts to Replace those Removed and Inserted into DPGM

GPS Set Z Cabling Diagram, HH-53B/C Aircraft



1 P/N M83723-13R16-8N

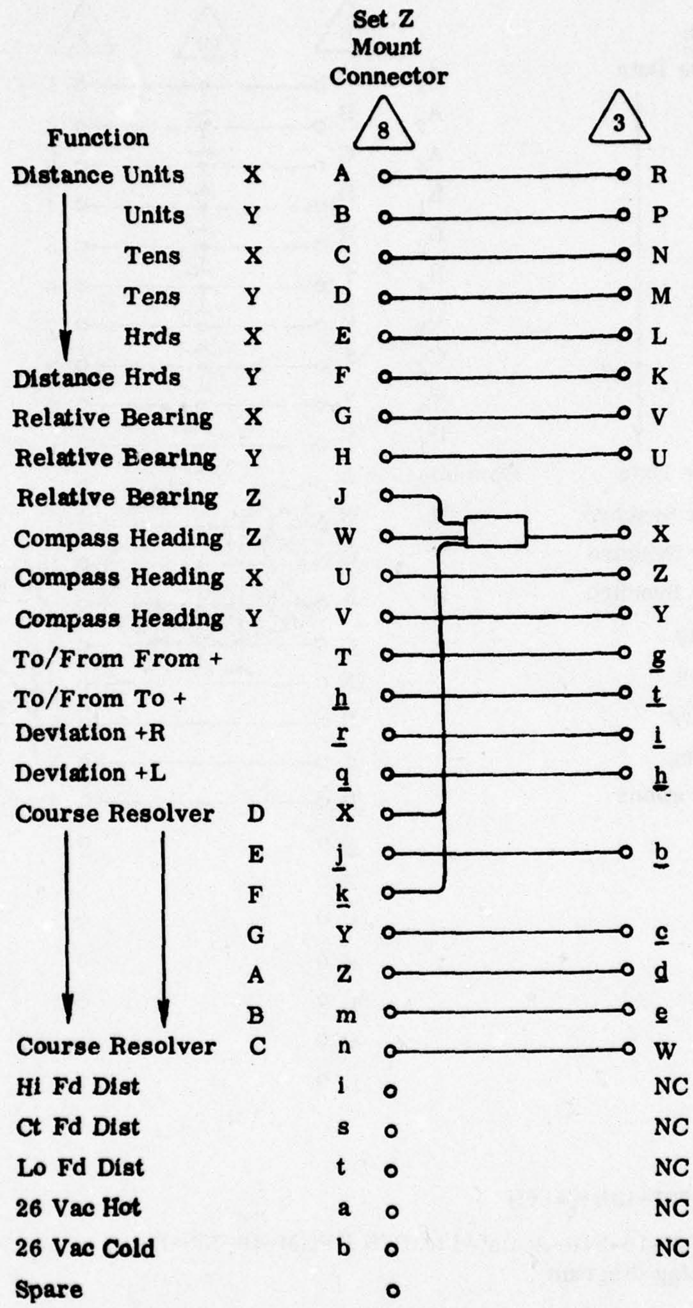
2 P/N M83723-14R14-15N

3 P/N M83723-07R20-41N mated to TACAN connector P106R

4 Existing connector P108

5 Existing wiring

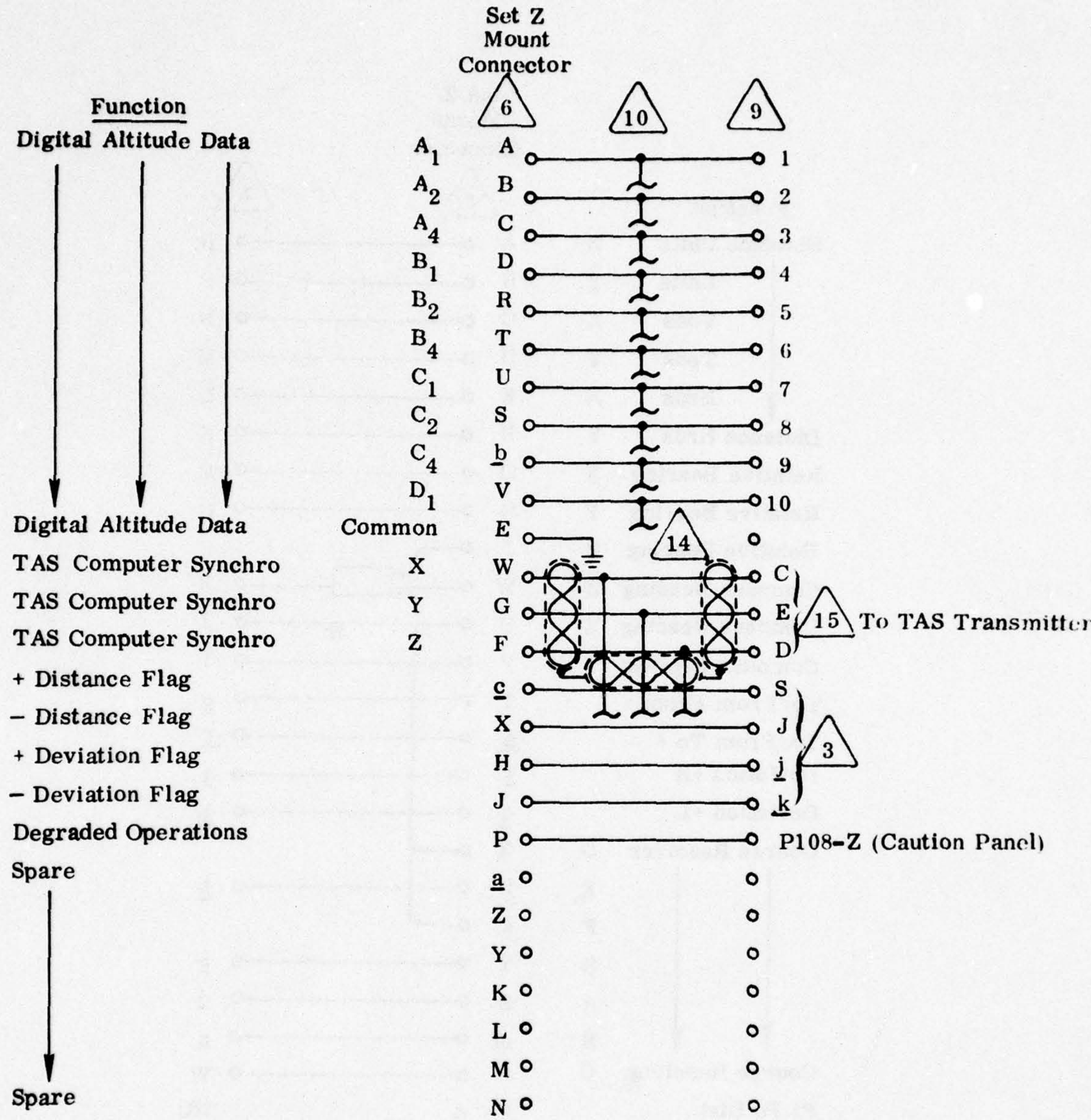
HH-53B/C Interwiring, GPS Set Z Installation (Sheet 1 of 4)



(3) P/N M83723-07R20-41N mated to TACAN connector P106R

(8) P/N M83723-14R20-41N

HH-53B/C Interwiring, GPS Set Z Installation (Sheet 2 of 4)



6 P/N M83723-13R16-26N

9 P/N DPGM-16-34P-A mated to P/N DPGM-16-33S-B, ref. cabling diagram

3 P/N M83723-07R20-41N mates to TACAN connector P106R

10 Spliced connections to APX-64, ref. cabling diagram

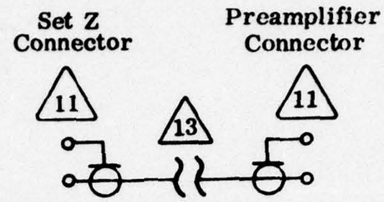
14 Splice connections to P/N M83723-18R14S-5N, mates to existing P64R, ref. cabling diagram

15 P/N M83723-23R14S-5N, mates to TAS transmitter receptacle

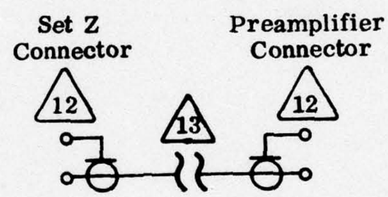
HH-53B/C Interwiring, GPS Set Z Installation (Sheet 3 of 4)

Function

Amplified RF/+15 Vdc



Calibration Signal

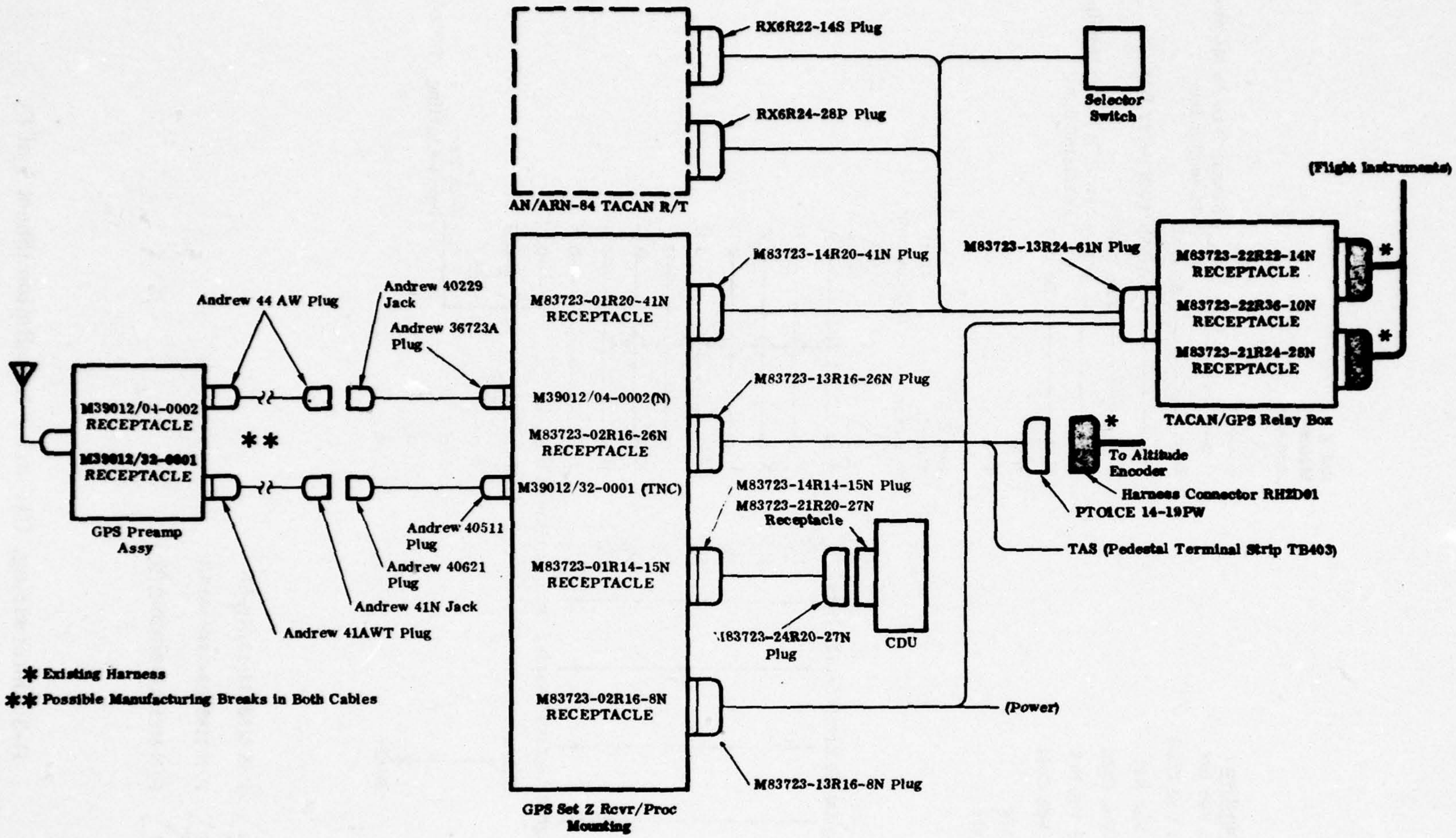


△11 P/N 36723A (Andrew)

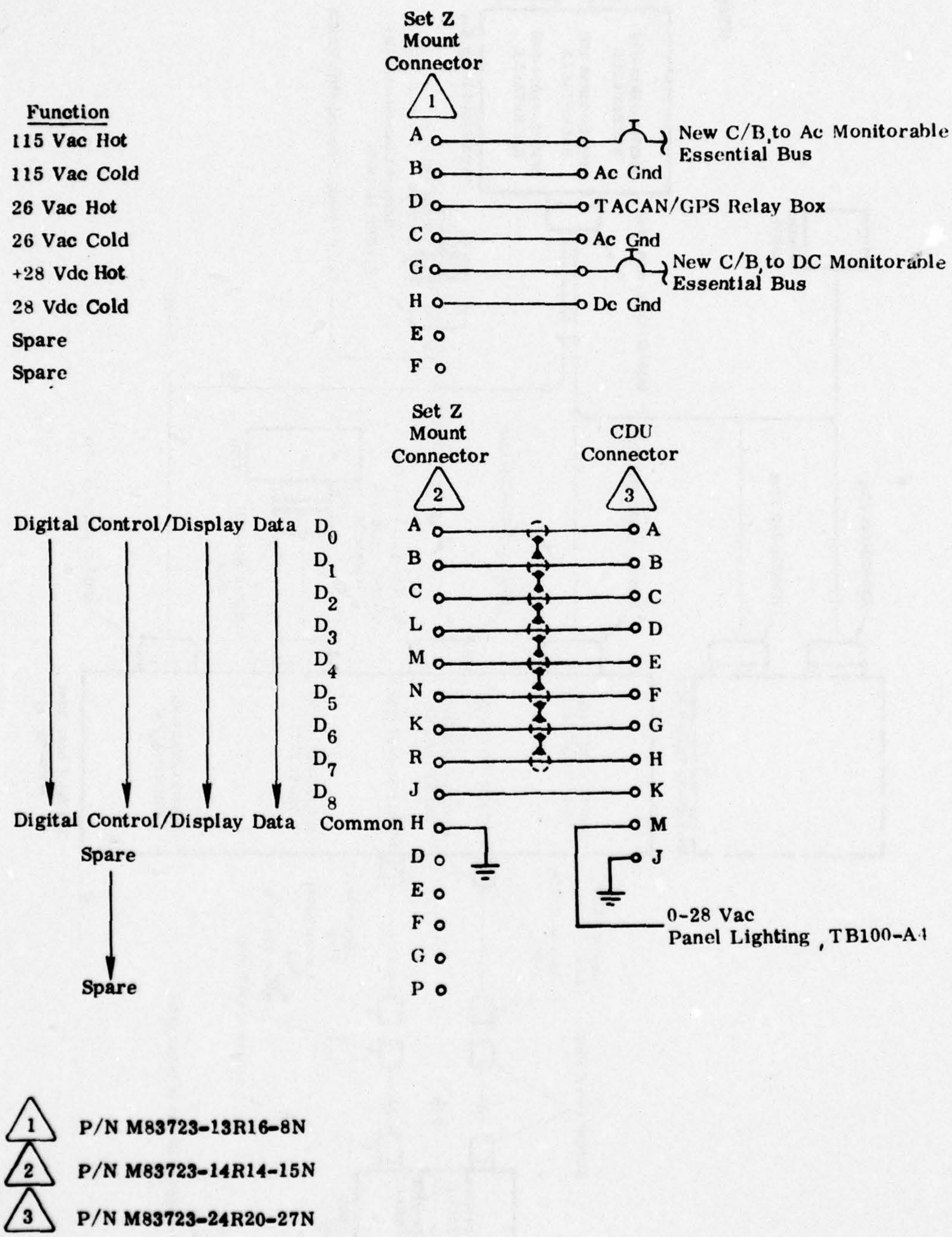
△12 P/N 40511 (Andrew)

△13 Intermediate connectors and bulkhead adapters

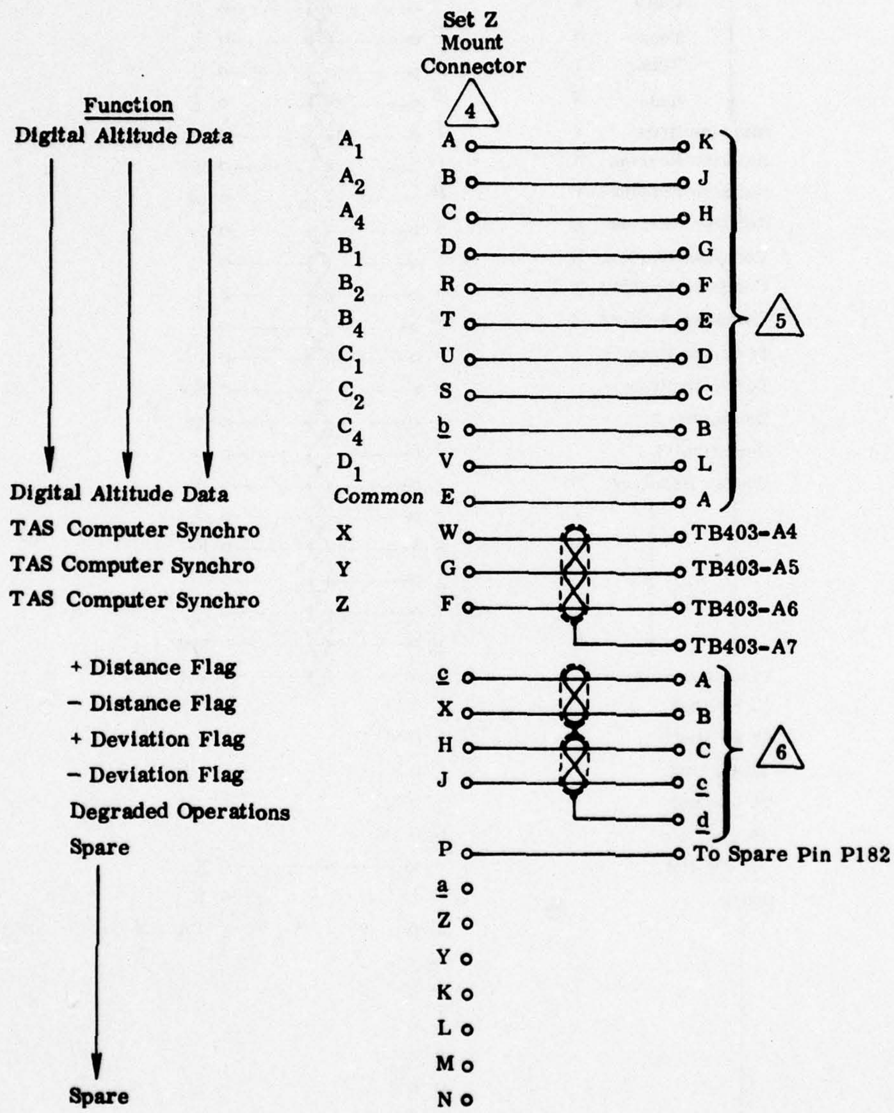
HH-53B/C Interwiring, GPS Set Z Installation (Sheet 4 of 4)



GPS Set Z Cabling Diagram, P-3C Aircraft



P-3C Interwiring, GPS Set Z Installation (Sheet 1 of 6)



4 P/N M83723-13R16-26N

5 P/N PTO1CE14-19PW, connect to unused plug RH2D01

6 *TACAN/GPS relay box connector* P/N M83723-13R24-61N

P-3C Interwiring, GPS Set Z Installation (Sheet 2 of 6)

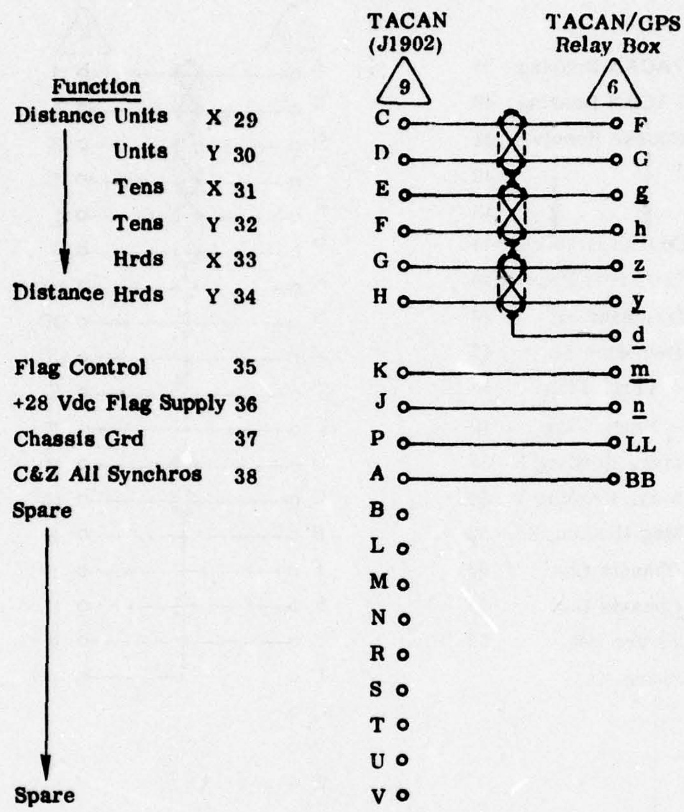
Function		Set Z Mount Connector (7)	TACAN/GPS Relay Box (6)
Distance Units	X	A	a
Units	Y	B	b
Tens	X	C	u
Tens	Y	D	v
Hrds	X	E	t
Distance Hrds	Y	F	GG
Relative Bearing	X	G	HH
Relative Bearing	Y	H	W
Relative Bearing	Z	J	JJ
Compass Heading	X	U	X
Compass Heading	Y	V	f
Compass Heading	Z	W	e
To/From From +		T	FF
To/From From −		h	NN
Deviation +R		r	W
Deviation +L		q	s
Course Resolver	D	X	V
	E	j	r
	F	k	EE
	G	Y	U
	A	Z	q
	B	m	MM
Course Resolver	C	n	PP
Hi Fd Dist		i	NC
Ct Fd Dist		s	NC
Lo Fd Dist		t	NC
26 Vac Hot		a	NC
26 Vac Cold		b	NC
+28 Vdc Hot		K	X
Spare		L	
		M	
		N	
		P	
		S	
		c	
		d	
		e	
		f	
		g	
Spare		p	

Relay box Y — TACAN/GPS Selector Switch

(6) TACAN/GPS relay box connector P/N M83723-13R24-61N

(7) P/N M83723-14R20-41N

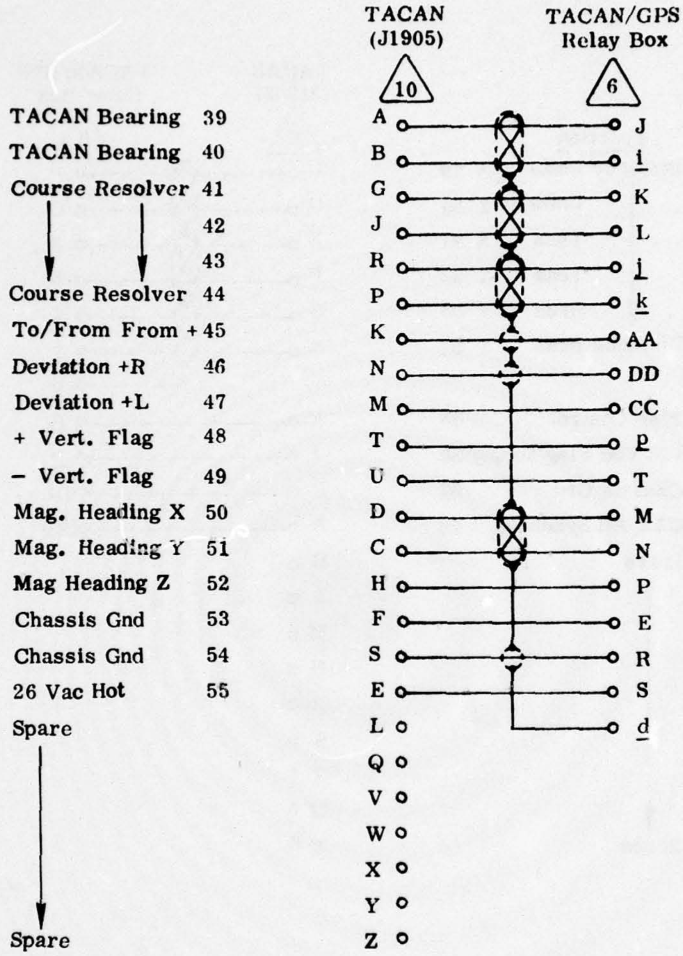
P-3C Interwiring, GPS Set Z Installation (Sheet 3 of 6)



6 P/N M83723-13R24-61N

9 P/N RX6R22-14S, mates with RT-384/ARN-52(V) TACAN receptacle J1902

P-3C Interwiring, GPS Set Z Installation (Sheet 4 of 6)



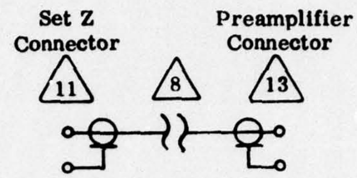
△6 P/N M83723-13R24-61N

△10 P/N RX6R24-28P, mates with RT-384/ARN-52(V) TACAN receptacle J1905

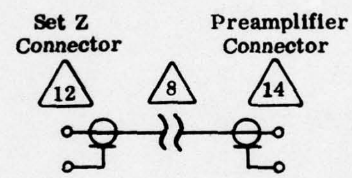
P-3C Interwiring, GPS Set Z Installation (Sheet 5 of 6)

Function

Amplified RF/+15 Vdc



Calibration Signal



8 Intermediate connectors
11 P/N 36723A (Andrew)
12 P/N 40511 (Andrew)
13 P/N 44AW (Andrew)
14 P/N 41AWT (Andrew)

P-3C Interwiring, GPS Set Z Installation (Sheet 6 of 6)

APPENDIX B

GPS SET Z/AIRCRAFT INSTALLATION CHECKLISTS

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST,
AIRCRAFT MODEL C-141A (Sheet 1 of 5)

Parameter	Comment
A. GPS RECEIVER/PROCESSOR INSTALLATION	
1. Location	**The GPS receiver/processor unit, together with the associated Integration Module on common mounting, will replace the TACAN No. 1 (RT-220C/ARN-21) receiver/transmitter unit and mount located in the left-hand avionics equipment rack.**
2. Dimensions of available space	**At least 54 x 28 x 25 cm (replacing RT-220C/ARN-21).**
3. Temperature extremes (in-flight and on ground	**Nonoperating extremes: -27° C to approximately +63° C. Operating extremes estimated at 0° C to 54° C with normal air circulation; startup at -27° C possible, but unlikely.**
4. Altitude extremes	**Electronics cabinet is in pressurized compartment, 0 to 8000 feet during normal flight operations ($\Delta P \leq 8.5$ psi).**
5. Humidity, salt, dust	**Electronics cabinet has same controlled environment as aircraft cabin, so these pollutants should not be a problem.**
6. Vibration/ shock	**<1g, 40-2000 Hz typical; 2.3g maximum anticipated.**
7. Type racks	**Mounting isolators will fasten directly to aircraft equipment rack.**
8. Type connectors	**Set Z receiver/processor and IM connect to the mounting via rack and panel DPX type, and mounting has four MIL-C-83723 circular connectors. RF coaxial connectors are types N and TNC.**
9. Type mounts	**LRUs are individually isolated. GPS unit will use four plateform isolators similar to Lord 150PHL8.**
10. Type latches or hold downs	**Type C clutched hold-downs. Will secure both GPS receiver/processor and IM in the GPS mounting.**
11. Cooling provisions	**Cabin air assisted by an avionics compartment exhaust fan.**
12. Access	**Equipment is accessed through the avionics compartment access door.**
13. Weight/CG restrictions (if any)	**Weigh <27.2 kg in conformance with standard ARINC rack distributions.**

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST,
AIRCRAFT MODEL C-141A (Sheet 2 of 5)

Parameter	Comment
A. (Continued)	
14. Installation problems	No unusual problems anticipated (no historical difficulties noted).
15. EMC/EMI problems	No historical problems.
B. ANTENNA/PREAMPLIFIER INSTALLATION (TOP OF AIRCRAFT)	
1. Location	GPS antenna will replace TACAN No. 2 antenna at FS 741.53.
2. Probable antenna coverage	360 degrees azimuth, 0 to 90 degrees vertical, with a possibility of minor shadowing aft by vertical stabilizer.
3. Distances	Antenna to nearby high power radiation (EMI/EMC): UHF antenna, 236 cm. Antenna to nearby L-band sensor or 1.5 GHz harmonic (EMC/EMI): none in vicinity. Preamplifier to main GPS unit: approximately 1420 cm.
4. Dimensions of available space	No special restrictions.
5. Temperature extremes (in-flight and on ground	Operating and nonoperating: -70° to estimated 68°C (unheated compartment)
6. Altitude extremes	GPS preamplifier will be in unpressurized compartment and will be exposed to altitudes of ≤40,000 ft.
7. Humidity, salt, dust	In an unpressurized compartment, humidity may reach 100%. The enclosed wing center section should keep salt or dust from being a problem.
8. Vibration/ shock	<1g, 40-2000 Hz typical; 2.3g maximum anticipated.
9. Type rack	N/A
10. Type mounts	Hard mount, flange.
11. Cooling provisions	None.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST, AIRCRAFT MODEL C-141A (Sheet 3 of 5)

Parameter	Comment
B. (Continued)	
12. Access	External plate on top of aircraft.
13. Weight/CG restrictions (if any)	No special restrictions.
14. Cable routing, bulkhead penetrations	Coaxial cables between preamplifier and main unit will penetrate into aircraft cabin through pressure bulkhead at forward end of wing center compartment, and will be routed along left side of fuselage overhead to vicinity of entrance door, then down to equipment rack area. Flexible service loops should be used to facilitate cable runs within avionics rack.
15. Installation problems	Penetration of pressure bulkhead by semirigid coaxial cable required.
C. CONTROL UNIT INSTALLATION	
1. Location	Left-hand side of center console.
2. Dimensions of available space	Approximately 15 cm wide, 15 cm high, 30 cm deep
3. Temperature extremes (in-flight, on ground)	Nonoperating extremes: -27° C to approximately 63° C. Operating extremes estimated 0° to 43° C; startup at -27° C possible, but unlikely.
4. Altitude extremes	CDU is located in pressurized cabin: 0 to 8,000 feet during normal flight operations.
5. Vibration/shock	<1g, 40-2000 Hz typical; 2.3g maximum anticipated.
6. Type racks	ARINC-type control rack.
7. Type mounts	Hard mount using standard panel fasteners per MIL-F-25173 to attach the CDU to the center console.
8. Cooling provisions	None.
9. Control access	Control is accessible to pilot and copilot.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST, AIRCRAFT MODEL C-141A (Sheet 4 of 5)

Parameter	Comment
C. (Continued)	
10. Pilot/copilot visibility	CDU will be located in the left-hand portion of center console, visible to pilot and copilot.
11. Weight/CG restrictions (if any)	No special restrictions.
12. EMC/EMI	No anticipated problems.
13. Installation problems	No anticipated problems.
D. OTHER INTERFACES	
1. Autopilot/ flight director	Navigation data from Set Z are routed via A-20 nav junction box. There is no direct input to autopilot.
2. Cockpit instruments	Horizontal navigation data and flag signals are supplied via A-20 nav junction box from Set Z. HSI course select signals are routed to Set Z via A-20 nav junction box.
3. Nav selector panels	Existing TACAN select controls for instrument display will be used, with the GPS navigation data input replacing the TACAN. Relabel TACAN legends "GPS".
4. Nav junction boxes	All interfacing GPS data will be routed via A-20 nav junction box, except altitude inputs from jumper cables inserted in the output harness of the CADC units.
5. Failure warning/ alerts	Navigation and distance flags will be displayed on HSIs. Light on the annunciator panel will be illuminated for degraded-mode operation of GPS.
6. Aircraft power	115 Vac, 400 Hz primary power obtained from the ac nav bus No. 1 via TACAN circuit breaker CB 7CB. 28 Vdc obtained from main dc avionics bus No. 1 via TACAN circuit breaker CB 5 EZ. 26 Vac synchro excitation power obtained from isolated avionics bus via HSI pilot range circuit breaker CB 24.
7. Central GP computer	N/A
8. Wiring and cables	Coaxial cables between preamplifier assembly and receiver will terminate at left hand avionics rack disconnect plugs. Service loops of extra-flexible cable will be used to permit

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST,
AIRCRAFT MODEL C-141A (Sheet 5 of 5)

Parameter	Comment
D. (Continued)	
	easy removal and replacement of receiver. Receiver/processor unit will connect to flight instruments via existing rack disconnect, J174A.
9. Altitude source	Jumper harness containing pickoff splices will be inserted in series with existing altitude signal wires.
10. TAS source	TAS synchro signal will be obtained at TB6H-402, 403, 404 in A-20 nav junction box.
11. Panel lights	Navigator panel lights are powered by variable 0 to 5.4 Vac, controlled by control pedestal light control and routed to CDU via existing wiring and connectors.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST, AIRCRAFT MODEL KC-135A (Sheet 1 of 5)

Parameter	Comment
A. GPS RECEIVER/PROCESSOR INSTALLATION	
1. Location	The GPS receiver/processor unit, together with the associated Integration Module on common mounting, will replace the AN/ARN-72 TACAN R/T unit in electronics cabinet on aircraft floor.
2. Dimensions of available space	At least 54 x 28 x 25 cm (replacing the RT-636/ARN-72).
3. Temperature extremes (in-flight and on ground)	Nonoperating extremes: -27° C to approximately +63° C. Operating extremes estimated 0° C to 50° C with normal air circulation; startup at -27° C possible, but unlikely.
4. Altitude extremes	The electronics cabient is in a pressurized compartment, 0 to 8000 feet during normal flight operations ($\Delta p \leq 9.4$ psi).
5. Humidity, salt, dust	The electronics cabinet has same controlled environment as aircraft cabin, so these pollutants should not be a problem.
6. Vibration/ shock	KC-135 electronics qualification requirements, sinusoidal vibration: 0.02 inches DA, 5-30 Hz; ±1g, 30-300 Hz; 0.0002 inches DA, 300-450 Hz; ±2g, 450-1000 Hz.
7. Type racks	Mounting isolators will fasten directly to aircraft floor.
8. Type connectors	Set Z receiver/processor and Integration Module connect to mounting via rack-and-panel DPX type, and mounting has four MIL-C-83723 circular connectors. RF coaxial connectors are types N and TNC.
9. Type mounts	LRUs are individually isolated. GPS unit will use four plate-form isolators similar to Lord 150PHL8.
10. Type latches or hold-downs	Type C clutched hold-downs. Will secure both GPS receiver/ processor and Integration Module in GPS mounting.
11. Cooling provisions	Cabin air drawn into electronics cabinet at shelf inboard end at floor level and exhausted at shelf outboard end, through a ducting, and below cabin floor. Floor level air intake is subject to blockage by carpeting.
12. Access	Equipment is accessed by removing panel at back of electronics cabinet.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL KC-135A (Sheet 2 of 5)

Parameter	Comment
	A. (Continued)
13. Weight/CG restrictions (if any)	**No unusual restrictions, although weight of unit should not greatly exceed present AN/ARN-72 weight (27 kg).**
14. Installation problems	**No unusual problems anticipated since no historical difficulties noted. Cooling vents should be enlarged to reduce blockage by aircraft carpeting and permit unobstructed cooling air flow.**
15. EMC/EMI problems	**No historical problems.**
	B. ANTENNA/PREAMPLIFIER INSTALLATION (TOP OF AIRCRAFT)
1. Location	**GPS antenna will replace AT-741/A TACAN antenna at FS 375 RBL 3.5 (slightly to right of centerline).**
2. Probable antenna coverage	**Excellent, with a possibility of minor shadowing aft by vertical stabilizer.**
3. Distances	**Antenna to nearby high-power radiation (EMI/EMC): rendezvous beacon antenna at FS 410 (Ku band), 89 cm.** **Antenna to nearby L-band sensor or 1.5 GHz harmonic (EMC/EMI) IFF transponder antenna at FS 465 LBL 3.5: 230 cm.** **Preamplifier to main GPS unit: approx. 280 cm.**
4. Dimensions of available space	**Space between stringers, formers, and skin to internal duct-work is 50 x 40 x ~15 cm, excluding headliner and brackets.**
5. Temperature extremes (in-flight, on ground)	**Nonoperating: antenna, -70° C to 68° C; preamp, -27° C to 68° C** **Operating: antenna, -70° C to 68° C; preamp, -27° C to 50° C**
6. Altitude extremes	**GPS preamplifier will be in pressurized compartment, 0 to 8000 feet during normal flight operations. Antenna must with-stand 9.4 psi differential.**
7. Humidity, salt, dust	**In pressurized compartment, these pollutants should not be problem.**
8. Vibration/ shock	**KC-135A electronics qualification requirements, sinusoidal vibration: 0.02 inches DA, 5-30 Hz; ±1g, 30-300 Hz; 0.002 inches DA, 300-450 Hz; ±2g, 450-1000 Hz.**

GPS SET A/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL KC-135A (Sheet 3 of 5)

Parameter	Comment
	B. (Continued)
9. Type rack	N/A
10. Type mounts	Hard mount, flange. Installation must be sealed for cabin pressurization.
11. Cooling provisions	None, other than ambient cabin air.
12. Access	Somewhat restricted by air conditioning ducting which runs along the cabin overhead.
13. Weight/CG restrictions (if any)	No special restrictions.
14. Cable routing, bulkhead penetrations	Coaxial cables between preamp and main unit will be short and easily installed outside electronics cabinet. Flexible service loops should be used to facilitate cable runs through cabinet structure to floor location.
15. Installation problems	About 15 cm vertical space is limited by air conditioning duct. This ducting may have to be temporarily removed to permit initial installation.
	C. CONTROL UNIT INSTALLATION
1. Location	Navigator's table, right side (near FS 300), below and just inboard from C-1242/APN-59 search radar control in vertical panel.
2. Dimensions of available space	Open table top; no significant restrictions.
3. Temperature extremes (in-flight, on ground)	Nonoperating extremes: -27°C to approximately 63°C. Operating extremes estimated 0°C to 43°C; startup at -27°C possible, but unlikely.
4. Altitude extremes	CDU is located in pressurized cabin; 0 to 8000 feet during normal flight operations.
5. Vibration/shock	KC-135 electronics qualification requirements, sinusoidal vibration: 0.02 inches DA, 5-30 Hz; ±1g, 30-300 Hz; 0.0002 inches DA, 300-450 Hz; ±2g, 450-1000 Hz.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL KC-135A (Sheet 4 of 5)

Parameter	Comment
	C. (Continued)
6. Type racks	Special brackets to fasten CDU securely to the navigator's table at convenient angle for viewing, and permitting clearance for rear connector/wire bundle.
7. Type mounts	Hard mount using standard panel fasteners per MIL-F-25173 to attach CDU to mounting brackets.
8. Cooling provisions	None, other than ambient cabin air.
9. Control access	Location will be most convenient for navigator.
10. Pilot/copilot visibility	CDU will be located at the navigator's station and is not available for pilot/copilot use.
11. Weight/CG restrictions (if any)	No special restrictions.
12. EMC/EMI	No anticipated problems.
13. Installation problems	Location at navigator's station will require a special harness for interconnection to GPS receiver/processor and NavSta panel lighting.
	D. OTHER INTERFACES
1. Autopilot/ flight director	Signal inputs to autopilot and dual flight director system correspond to those supplied by TACAN system. Existing TACAN circuitry via flight director junction box will be used.
2. Cockpit instruments	Two HSIs (331A-8H) and three RMIs (ID-250A) will supply GPS information in terms of distance, bearing, and course data.
3. Nav selector panels	Existing TACAN select controls for instrument display will be used, with GPS navigation data input replacing the TACAN. Relabel TACAN legends "GPS".
4. Nav junction boxes	All interfacing GPS data will be routed via flight director junction box except TAS and altitude inputs from special coupling harnesses at doppler radar and IFF transponder.
5. Failure warning/ alerts	Navigation and distance flags will be displayed on HSIs. Light on RGA annunciator panel will be illuminated for degraded mode operation of GPS.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL KC-135A (Sheet 5 of 5)

Parameter	Comment
D. (Continued)	
6. Aircraft power	115 Vac, 400 Hz primary power and 28 Vdc obtained from P8 main C/B panel using existing TACAN circuit breakers. 26 Vac synchro reference power is obtained from T51-6 terminals 7 and 12 (from ME-1 compass amplifier).
7. Central GP computer	N/A
8. Wiring and cables	Coaxial cables between preamplifier assembly and receiver will terminate at electronics cabinet rack disconnect plugs. Service loops of extra flexible cable will be used to permit easy receiver removal and replacement. Receiver/processor unit will connect to flight instruments via existing TACAN coupler plug RD6905.
9. Altitude source	Jumper harness connects to existing harness (RD3391) and AN/APX-64 transponder in electronics cabinet, second shelf to permit connections to SX806 through SX814, SX816 (10 wires) without splicing into existing aircraft wiring.
10. TAS source	Jumper harness connects to existing harness (RD136) and upper junction box, shelf No. 1, to permit connections to SN573, SN574 and SN575 without splicing into existing aircraft wiring.
11. Panel lights	Navigator panel lights are powered by variable 0 to 28 Vac, controlled by autotransformer with 28 Vac applied to its primary. Power connections are available at RT30-1 through -6, through a new harness to CDU connectior, pin M.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HC-130H (Sheet 1 of 5)

Parameter	Comment
A. GPS RECEIVER/PROCESSOR INSTALLATION	
1. Location	GPS receiver/processor unit, together with associated Integration Module on common mounting, will replace the TACAN No. 1 AN/ARN-21 R/T unit in left avionics rack below cockpit.
2. Dimensions of available space	At least 54 x 28 x 25 cm (replacing the number 1 RT-220C/ ARN-21).
3. Temperature extremes (in-flight and on ground)	Nonoperating extremes: -27° C to approximately +63° C. Operating extremes estimated 0° C to 50° C with normal air circulation; startup at -27° C possible, but unlikely.
4. Altitude extremes	Avionics rack is in pressurized compartment, 0 to 8000 feet feet during normal flight operations.
5. Humidity, salt, dust	Avionics rack has same controlled environment as cargo area, so these pollutants should not be problem.
6. Vibration/ shock	Electronics vibration qualification test requirements: 0.1 inches DA, 5-15 Hz; 1g, 15-25Hz;~0.035 inches DA, 25-75 Hz; 10.5g, 75-500 Hz.
7. Type racks	Mounting isolators will fasten directly to rack structure.
8. Type connectors	Set Z receiver/processor and IM connect to mounting via rack-and-panel DPX type, and mounting has four MIL-C-83723 circular connectors. RF coaxial connectors are types N and TNC.
9. Type mounts	LRUs are individually isolated. GPS unit will use four plate-form isolators similar to Lord 250PHL8.
10. Type latches or hold downs	Type C clutched hold-downs. Will secure both GPS receiver/ processor and IM in GPS mounting.
11. Cooling provisions	Ambient cabin air.
12. Access	Equipment is accessed directly from cargo compartment next to cockpit entrance ladder.
13. Weight CG restrictions (if any)	No unusual restrictions, although weight of unit should not greatly exceed current AN/ARN-21 weight (27 kg).

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HC-130H (Sheet 2 of 5)

Parameter	Comment
A. (Continued)	
14. Installation problems	No unusual problems anticipated (no historical difficulties noted).
15. EMC/EMI problems	No historical problems.
B. ANTENNA/PREAMPLIFIER INSTALLATION (TOP OF AIRCRAFT)	
1. Location	GPS antenna will replace disabled No. 1 AT-741/A TACAN antenna at FS 517.
2. Probable antenna coverage	Possibility of minor shadowing aft by vertical stabilizer and forward by ARD-17 radome.
3. Distances	Antenna to nearby high power radiation (EMI/EMC): IFF transponder antenna at FS 442, 190 cm. Antenna to nearby L-band sensor or 1.5 GHz harmonic (EMC/EMI): same as above. Preamplifier to main GPS unit: approx. 12.7m.
4. Dimensions of available space	Space available is 51 x 51 x 76 cm.
5. Temperature extremes (in-flight, on ground)	Operating and nonoperating: -65° to estimated +68°C (unheated compartment)
6. Altitude extremes	GPS preamplifier will be in unpressurized compartment and will be exposed to altitudes ≤30,000 ft.
7. Humidity, salt, dust	Humidity could reach 100% under some conditions. Salt and dust not expected to be significant problems.
8. Vibration/ shock	No specific data available for this location. Qualification requirements assumed comparable to those stated in A6, above.
9. Type rack	N/A
10. Type mounts	Hard mount, flange
11. Cooling provisions	None

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HC-130H (Sheet 3 of 5)

Parameter	Comment
	B. (Continued)
12. Access	**External plate on top of aircraft.**
13. Weight/CG restrictions (if any)	**No special restrictions.**
14. Cable routing, bulkhead penetration	**Coaxial cables between preamp and main unit will be routed along left side of cargo compartment overhead, then down forward bulkhead to avionics rack area. Flexible service loops should be used to facilitate cable runs through the avionics rack structure to right side of rack. Bulkhead adapters will permit penetration into cargo area from unpressurized center wing compartment where preamplifier assembly is located.**
15. Installation problems	**Penetration of pressure bulkhead by semirigid coaxial cable required.**
	C. CONTROL UNIT INSTALLATION
1. Location	**Forward left section of pedestal.**
2. Dimensions of available space	**15 cm wide, 15 cm high, 20 cm deep**
3. Temperature extremes (in-flight, on ground)	**Nonoperating: -27° C to approximately 63° C. Operating extremes: 0° C to 48.4° C, typical; -27° C startup possible, but unlikely.**
4. Altitude extremes	**CDU is located in pressurized cabin: 0 to 8000 feet during normal flight operations.**
5. Vibration/ shock	**Electronics vibration qualification test requirements: 0.1 inches DA, 5-15 Hz; 1g, 15-25 Hz; ~0.036 inches DA, 25-75 Hz; 10.5g, 75-500 Hz.**
6. Type racks	**ARINC-type control rack.**
7. Type mounts	**Hard mount using standard panel fasteners per MIL-F-25173 to attach CDU to center console.**
8. Cooling provisions	**None**

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HC-130H (Sheet 4 of 5)

Parameter	Comment
C. (Continued)	
9. Control access	Control accessible to pilot and copilot.
10. Pilot/copilot visibility	CDU will be located in the forward left section of the pedestal, visible to pilot and copilot.
11. Weight/CG restrictions (if any)	No special restrictions.
12. EMC/EMI	No anticipated problems.
13. Installation problems	No anticipated problems.
D. OTHER INTERFACES	
1. Autopilot/ flight director	Signal inputs to autopilot and dual flight director system correspond to those supplied by TACAN system. Existing TACAN circuitry via navigator relay panel box will be used.
2. Cockpit instruments	Two HSIs (AQU-2/A) and two BDHIs (ID-1103/ARN) will supply GPS information in terms of distance, bearing, and course data.
3. Nav selector panels	Existing TACAN No. 1 select controls for instrument display will be used with the GPS navigation data input replacing the TACAN No. 1. Relable TACAN No. 1 legends "GPS".
4. Nav junction boxes	All interfacing GPS data will be routed via the TACAN coupler harness except the altitude input and distance flag output.
5. Failure warning/ alerts	Navigation and distance flags will be displayed on the HSIs.
6. Aircraft power	115 Vac, 400 Hz primary power and 28 Vdc obtained from copilot's upper C/B panel using existing TACAN circuit breakers. 26 Vac synchro reference power is obtained from the compass No. 1 transformer.
7. Central GP computer	N/A
8. Wiring and cables	Coaxial cables between preamplifier assembly and receiver will terminate at left avionics rack. Service loops of

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HC-130H (Sheet 5 of 5)

Parameter	Comment
	D. (Continued)
	extra-flexible cable will be used to permit easy receiver removal and replacement. The receiver/processor unit will connect to flight instruments via existing TACAN coupler plug.
9. Altitude source	Jumper harness connects to existing harness at pedestal terminal strip TB131A (forward end) terminals 81 through 90 and 93, with 10 individually shielded and one unshielded wires.
10. TAS source	No TAS source in this aircraft.
11. Panel lights	Navigator panel lights are powered by variable 0 to 28 Vdc controlled by a rheostat. Connection to the CDU is made via existing harness.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HH-53B/C (Sheet 1 of 5)

Parameter	Comment
A. GPS RECEIVER/PROCESSOR INSTALLATION	
1. Location	GPS receiver/processor unit, along with associated Integration Module on common mounting, will replace AN/ARN-65 TACAN unit in right-hand rack, lower shelf.
2. Dimensions of available space	At least 47 x 24 x 23 cm (replacing RT-471/ARN-65), plus additional space of at least 0.028 m^3.
3. Temperature extremes (in-flight and on ground)	Nonoperating extremes: -30° to approximately 79° C; Operating extremes: estimated -30° to 48° C.
4. Altitude extremes	0 to 16,000 ft (unpressurized compartment).
5. Humidity, salt, dust	Compartment not sealed – subject to ambient weather conditions through vents and access ports. Humidity may approach 100%.
6. Vibration/ shock	<1g typical during all flight phases.
7. Type racks	Mounting isolators will fasten directly to lower shelf structure.
8. Type connectors	Set Z receiver/processor and IM connect to the mounting via rack and panel DPX type, and mounting has four MIL-C-83723 circular connectors. RF coaxial connectors are types N and TNC.
9. Type mounts	LRUs are individually isolated. GPS unit will use four plateform isolators similar to Lord 150PHL8.
10. Type latches or hold downs	Type C clutched hold-downs. Will secure both GPS receiver/ processor and IM in GPS mounting.
11. Cooling provisions	None provided.
12. Access	Equipment is accessed by means of external hatch to nose compartment.
13. Weight/CG restrictions (if any)	No unusual restrictions, although weight of unit should be kept to a minimum.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HH-53B/C (Sheet 2 of 5)

Parameter	Comment
A. (Continued)	
14. Installation problems	**Existing AN/ARN-64 unit is odd-shaped, non-ATR box and mount. Set Z must be reoriented in the equipment rack.**
15. EMC/EMI problems	**Avoid coupling with AFCS wires.**
B. ANTENNA/PREAMPLIFIER INSTALLATION (TOP OF AIRCRAFT)	
1. Location	**Antenna to be located on horizontal stabilizer, top surface at FS 851.0, STA 48.0 (approx.) centered between beams and webs. Preamplifier to be located inside the horizontal stabilizer below the antenna.**
2. Probable antenna coverage	**Shadowing will be present from left side due to tail rotor and associated structure.**
3. Distances	**Antenna to nearby high-power radiation (EMI/EMC): N/A** **Antenna to nearby L-band sensor or 1.5 GHz harmonic (EMC/EMI): N/A** **Preamplifier to main GPS unit: approximately 24m.**
4. Dimensions of available space	**Space available is approximately 12 x 12 x 40 cm.**
5. Temperature extremes in-flight and on ground)	**Operating and nonoperating: -30°C to estimated 71°C**
6. Altitude extremes	**0 to 16,000 ft (unpressurized installation)**
7. Humidity, salt, dust	**Confined void will be subject to high humidity due to altitude – temperature variations for normal flight profiles and lack of ventilation. Dust and salt atmosphere are unlikely to create problems.**
8. Vibration/ shock	**≤10.5g at 18 Hz, maximum.**
9. Type rack	**Bracket secured to webs and stringers.**
10. Type mounts	**Hard mount, flange.**

GPS Set Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HH-53B/C (Sheet 3 of 5)

Parameter	Comment
B. (Continued)	
11. Cooling provisions	**None**
12. Access	**No access panels exist in horizontal stabilizer. Unless a panel is fabricated, access to the preamplifier will require structural disassembly of the horizontal stabilizer.**
13. Weight/CG restrictions (if any)	**Long moment arms make minimum weight essential.**
14. Cable routing, bulkhead penetrations	**Coaxial cable must be routed through horizontal stabilizer structure and pylon assembly, then around intermediate gear box and along cabin overhead to right-hand nose electronics compartment.**
15. Installation problems	**Installation requires detachment of horizontal stabilizer skin to incorporate necessary doublers, brackets, and mount preamplifier assembly.**
C. CONTROL UNIT INSTALLATION	
1. Location	**Top center console replacing the TACAN and LF/ADF control panels. The FM-622A radio set control will be relocated to the upper left-corner of console. An alternate configuration would retain ADF and remove FM radio set control.**
2. Dimensions of available space	**Panel depth available is approximately 25 cm.**
3. Temperature extremes (in-flight, on ground)	**Nonoperating extremes: -4° C to approximately 79° C. Operating extremes: -4° C to approximately 48° C.**
4. Altitude extremes	**0 to 16,000 ft (unpressurized installation)**
5. Vibration/shock	**<1g typical, all flight phases.**
6. Type racks	**ARINC-type panel racks.**
7. Type mounts	**Hard mount using standard panel fasteners per MIL-F-25173 to attach the CDU to mounting brackets.**

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HH-53B/C (Sheet 4 of 5)

Parameter	Comment
C. (Continued)	
8. Cooling provisions	None
9. Control access	Location will be accessible by pilot and copilot.
10. Pilot/copilot visibility	Visibility will be available to pilot and copilot.
11. Weight/CG restrictions (if any)	Minimum weight desired.
12. EMC/EMI	No anticipated problems. Avoid coupling with AFCS wires.
13. Installation problems	Installation in cockpit console area requires removal of control panels in addition to C-1763/ARN-21 TACAN control panel.
D. OTHER INTERFACES	
1. Autopilot/ flight director	No GPS interface.
2. Cockpit instruments	Two course indicators (ID-387) and two BDHI instruments (ID-1103) will be driven by Set Z via existing TACAN wiring harness and short adapter harness.
3. Nav selector panels	Existing TACAN select controls for instrument display will be used, with GPS navigation data input replacing the TACAN. Relabel TACAN legends "GPS".
4. Nav junction boxes	Bearing, course deviation, and flag information are routed to navigation instruments via relay box using existing TACAN wirint harness.
5. Failure warning/ alerts	Navigation and distance flags will be displayed on HSIs. Caution panel may be used for GPS failure/degraded mode warning – use pin P of disconnect plug P-108.
6. Aircraft	115 Vac, 400 Hz primary power from TACAN circuit breaker (CB71A) No. 2 primary ac radio bus ØB. 28 Vdc from TACAN circuit breaker (CB82A) No. 2 primary dc radio bus. 26 Vac from TB60-2.
7. Central GP computer	N/A

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL HH-53B/C (Sheet 5 of 5)

Parameter	Comment
	D. (Continued)
8. Wiring and cables	Coaxial cables will have manufacturing breaks (connectors) at inboard edge of horizontal stabilizer and at base of pylon assembly. Service loops of extra-flexible cable will be used at main unit for ease of unit removal and replacement. Set Z will connect to navigating instruments via existing TACAN disconnect plug (P106R).
9. Altitude source	A jumper harness containing pick-off splices will be inserted in series with existing altitude signal wires.
10. TAS source	Jumper harness containing pickoff splices will be inserted in series with existing TAS synchro signal wires.
11. Panel lights	Panel lights are powered by variable 0 to 5 Vac, controlled by upper console light control and connected to the CDU panel by existing wiring and connectors.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL P-3C (Sheet 1 of 5)

Parameter	Comment
A. GPS RECEIVER/PROCESSOR INSTALLATION	
1. Location	GPS receiver/processor unit, along with associated Integration Module on common mounting, will be located on outboard side of shelf B, avionics compartment C-1/C-2 behind navigator's chair.
2. Dimensions of available space	At least 29 x 91 x 35.5 cm. Additional width is available (up to 7 cm) by moving shelf brace.
3. Temperature extremes (in-flight and on ground)	Nonoperating extremes: -8° C to approximately +63° C. Operating extremes estimated 0° C to 46° C with normal air circulation; startup at -8° C possible, but unlikely.
4. Altitude extremes	Electronics cabinet is in pressurized compartment, 0 to 8,000 feet during normal flight operations.
5. Humidity, salt, dust	Electronics cabinet has same controlled environment as aircraft cabin, so these pollutants should not be a problem.
6. Vibration/ shock	±2g, 5-500 Hz qualification design levels. ±0.5g, 5-500 Hz typical.
7. Type racks	Mounting isolators will fasten directly to shelf B in C-1/C-2 avionics compartment.
8. Type connectors	Set Z receiver/processor and IM connect to mounting via rack-and-panel DPX type, and mounting has four MIL-C-83723 circular connectors. RF coaxial connectors are types N and TNC.
9. Type mounts	LRUs are individually isolated. GPS unit will use four plateform isolators similar to Lord 150PHL8.
10. Type latches or hold-downs	Type C clutched hold-downs. Will secure both the GPS receiver/processor and IM in GPS mounting.
11. Cooling provisions	Conditioned air is drawn into avionics compartment where it circulates around installed equipments. Air is exhausted at cabinet top and dumped overboard.
12. Access	Equipment is accessed by removing soft panel on forward side of the compartment behind navigator's chair.
13. Weight/CG restrictions (if any)	No unusual restrictions.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL P-3C (Sheet 2 of 5)

Parameter	Comment
A. (Continued)	
14. Installation problems	Navigator's chair may have to be removed during installation.
15. EMC/EMI problems	Possible noise interference from top-mounted, high-power strobe light.
B. ANTENNA/PREAMPLIFIER INSTALLATION (TOP OF AIRCRAFT)	
1. Location	Antenna to be located on fuselage top, aircraft centerline at approximately FS 460.
2. Probable antenna coverage	Minor shadowing aft by vertical stabilizer and possible interference by propellers near horizon, particularly during aircraft maneuvering.
3. Distances	Cable run from the antenna location to C-1/C-2 compartment will be approximately 5 meters.
4. Dimensions of available space	No significant restrictions are noted either on top of aircraft or inside fuselage.
5. Temperature extremes (in-flight, on ground)	Antenna: -65°C to +68°C, operating and nonoperating; Preamp: -8°C to 63°C, nonoperating; -8°C to 41°C, operating
6. Altitude extremes	GPS preamplifier will be in a pressurized compartment 0 to 8,000 feet during normal flight operations. Antenna must withstand 5.5 psi differential.
7. Humidity, salt, dust	In pressurized compartment, these pollutants should not be a problem.
8. Vibration/ shock	±2g, 5-500 Hz qualification design level; ±0.5g, 5-500 Hz typical.
9. Type rack	N/A
10. Type mounts	Hard mount, flange. Installation must be sealed for cabin pressurization.
11. Cooling provisions	None, other than ambient cabin air.
12. Access	No significant restrictions.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL P-3C (Sheet 3 of 5)

Parameter	Comment
	B. (Continued)
13. Weight/CG restrictions (if any)	No special restrictions.
14. Cable routing, bulkhead penetrations	Semiflexible coaxial cables should be installed along right cabin overhead at RBL 12 to permit unobstructed run. Cables will then bend to right and down to outboard edge of front of compartment C-1.
15. Installation problems	No unusual problems.
	C. CONTROL UNIT INSTALLATION
1. Location	CDU will be located on left side of cockpit center console just behind pilot's power levers.
2. Dimensions of available space	Panel depth available is more than 25 cm.
3. Temperature extremes (in-flight, on ground)	Operating extremes: -8° C to 46° C; Nonoperating extremes: -8° C to 63° C.
4. Altitude extremes	CDU is located in pressurized cockpit; 0 to 8,000 feet during normal flight operations.
5. Vibration/ shock	±2g, 5-500 Hz recommended qualification design level.
6. Type racks	ARINC-type panel racks.
7. Type mounts	Hard mount using standard panel fasteners per MIL-F-25173 to attach CDU to center console.
8. Cooling provisions	None.
9. Control access	Control access to CDU is excellent for pilot or flight engineer. Copilot will have difficulty reaching across console for key-board operation.
10. Pilot/copilot visibility	Visibility will be available to both pilot and copilot.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL P-3C (Sheet 4 of 5)

Parameter	Comment
C. (Continued)	
11. Weight/CG restrictions (if any)	No special restrictions.
12. EMC/EMI	No anticipated problems.
13. Installation problems	Pedestal lighting circuit breaker must be relocated to right side of console and GPS/TACAN selector switch added to that panel area. Pilot's camera control must be removed (copilot's will remain on console).
D. OTHER INTERFACES	
1. Autopilot/ flight director	Steering information will be input to AJN-15 flight director via existing TACAN circuitry. There is no direct GPS interface with autopilot.
2. Cockpit instruments	Pilot and copilot ID-1540/A HSIs and navigator's HSI will be driven by Set Z when GPS is selected in lieu of TACAN for navigation data input.
3. Nav selector panels	GPS/TACAN selector switch will be added to cockpit console to permit selection of either GPS or TACAN navigation data for HSI display.
4. Nav junction boxes	Most navigation data are routed via navigation interconnection box, A349. TACAN and GPS inputs are selected in new relay box installed in C-1/C-2 at ARN-52 location, then routed into the interconnection box via existing TACAN wiring.
5. Failure warning/ alerts	Navigation and distance flags will be displayed on HSIs. On P-3C 158170 and subsequent, an annunciator light spare (9th from bottom) will be connected to warn of GPS degraded-mode operation.
6. Aircraft power	115 Vac, 400 Hz primary power will be obtained from ac monitorable essential bus via new 5-amp circuit breaker; 28 Vdc from the dc monitorable essential bus via new 5-amp circuit breaker; 26 Vac from TACAN source via new GPS/ TACAN relay box.
7. Central GP computer	No direct interface.
8. Central repeater	Bearing information will be input into central repeater via existing TACAN circuitry.

GPS SET Z/AIRCRAFT INSTALLATION CHECKLIST
AIRCRAFT MODEL P-3C (Sheet 5 of 5)

Parameter	Comment
D. (Continued)	
9. TACAN set	GPS receiver/processor will be connected along with the RT-384/ARN-52(V) or RT-1022/ARN-84 to new GPS/TACAN relay box, which permits selection of either TACAN or GPS equipments and connection to existing TACAN wiring.
10. Wiring and cables	Foam-filled coaxial cables are used to connect preamplifier and receiver/processor unit. Service loops of extra-flexible cable will be used at front of C-1/C-2 cabinet for ease of main unit removal and replacement. New wiring will interconnect GPS receiver/processor, TACAN R/T unit, and GPS/TACAN relay box which is connected to the existing TACAN harness via PC2D3 and RC2D4 plugs.
11. Altitude source	Encoded altitude from copilot's AAU-21/A altimeter will be obtained via existing plug RH2D01, in compartment H. Plug RH2D01 is currently attached to No. 1 AN/ASN-84 junction box but receptacle is not wired.
12. TAS source	Synchro TAS signals are obtained from CPK-28 TAS computer at terminal board TB403-A4, -A5, and -A6 located in compartment C-1.
13. Panel lights	Panel lights on CDU are powered by 0-28 Vac controlled by the pedestal lighting switch. Lighting is connected to TB100-A4 in pedestal area. 0-5 Vac is optional from TB100-B5.