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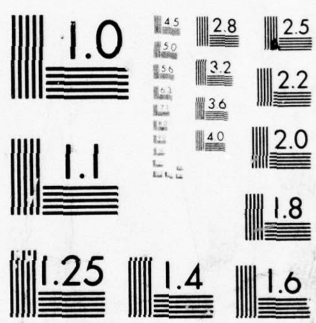

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Final Report

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

Volume III: Integration Module Definition

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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ABBREVIATIONS

A/D — Analog to digital
ADI — Attitude director indicator
AGL — Above ground level
ATCRBS — Air Traffic Control Radar Beacon System
BCD — Binary coded decimal
BDHI — Bearing, distance, heading indicator
BIT — Built-in test
CADC — Central air data computer
CDI — Course indicator
CDU — Control display unit
COTR — Contracting Officer's Technical Representative
CT — Control transformer
D/A — Digital to analog
DDC — Data Device Corporation
D/S — Digital to synchro
DTL — Diode transistor logic
EMI — Electromagnetic interference
E_O — Output voltage
FDI — Flight director indicator
FDS — Flight director system
FDSC — Flight director system steering computer
GPS — Global Positioning System
HSI — Horizontal situation indicator
IM — Integration Module
INS — Inertial Nav. System
I_O — Output current
IOT&E — Initial Operational Test and Evaluation
I_Q — Quiescent current
JPO — Joint Program Office
LSB — Least significant bit
LRU — Line replaceable unit
MSB — Most significant bit
MSL — Mean sea level
NAVAIR — Naval Air Systems Command
NAV/LOC — Navigation/Localizer
NAV/COMM — Navigation/Communications
P_{BD} — Bearing and distance power
P_O — Output power
P_Q — Quiescent power
P_T — Total power
R/D — Resolver-to-digital converter
RMI — Radio magnetic indicator
ROM — Read-only memory
S/D — Synchro to digital
S&H — Sample and hold
S/P — Serial to parallel

TACAN	—	Tactical Air Navigation
TAS	—	True airspeed
TBD	—	To be designated
T^2L	—	Transistor-transistor logic
TR	—	Torque receiver
UE	—	User Equipment
VOR	—	VHF omni-directional range

SUMMARY

One of the primary goals of the GPS User Equipment Set Z integration task was the definition of an Integration Module as an interface device between Set Z and selected indicators or displays aboard the specified test aircraft. Specifically, the performance characteristics and system integration requirements for the IM were defined, and a form, fit, and function specification was written for use by the GPS JPO. The specification for the IM was developed at a "black box" level, with input and output characteristics specified. Detailed circuit design and packaging of the IM were not required by this task. However, to verify the feasibility of an IM and to validate the specification, ARINC Research investigated the circuit design requirements for the IM described in the form, fit, and function specification. In particular, the following tasks were conducted, the results of which can be found in the referenced sections:

a. Determined the avionic systems that the IM could service (Sections 1 and 2).

b. Established the feasibility of the IM based on host vehicle constraints. (Section 2).

c. Defined the design requirements for the IM (Section 3).

d. Determined the impact of the IM on Set Z and the user vehicle (Sections 3.5 and 3.6).

e. Determined any design and system integration problem areas (Sections 3 and 7).

f. Determined what special testing would be required for the IM (Section 5).

g. Prepared a form, fit, and function specification for the IM (Section 6 and Appendix A).

Additionally, other tasks were performed that helped to determine alternate approaches to the design of an IM and substantiate the specification requirements. They included the following:

a. Investigated the detailed circuit design requirements for each function of the IM (Section 3).

b. Determined the power requirements for the IM based on the integration requirements established for the worst-case load (Section 3.3).

c. Performed a budgetary cost analysis for the design investigated (Section 3.4).

d. Identified four alternative approaches to the functional design of the IM (Section 4).

e. Prepared signal characteristics sheets for each IM to aircraft avionics input/output signal for each aircraft (Appendix B).

The results of the above-described tasks produced an IM configuration that is both feasible and flexible for interfacing Set Z with the test aircraft avionics. Based on GPS JPO direction, the IM will interface with those avionic systems and instruments that were previously driven by a TACAN set on the Air Force aircraft, and share those systems on the Navy aircraft with the existing TACAN set. This method of integration minimizes the necessary aircraft modifications. Set Z would then provide the following output signals through the IM to drive primarily HSIs and BDHIs in the fixed-wing aircraft, and BDHIs and CDIs in the helicopter:

a. Bearing to waypoint

b. Distance to waypoint

c. Deviation off desired track

d. To/from flag

e. Warning flags (distance and deviation).

Conversely, Set Z will receive the following signals through the IM from the various aircraft avionic systems:

a. Course set from HSI or CDI

b. Magnetic heading from compass system

c. True airspeed from true airspeed computer

d. Encoded altitude from encoding altimeter.

The IM configuration described herein was designed around the use of solid-state D/S and S/D converter modules that can be purchased off-the-shelf. However, since off-the-shelf modules can be expensive when purchased in small quantities, alternative approaches are worthy of consideration. For example, custom designing the module functions to tailor their requirements to those of the IM can reduce its overall cost.

Of primary importance in the design of an IM is the type and size of load it will drive. Since the IM described in this report is an interface device common to all test aircraft and based on the worst-case type (HC-130H), the output circuit specified is capable of driving high-current synchros. Achieving this capability can result in the IM requiring an average of 98 watts of dc power and 166 watts peak. These large quantities could be reduced by several means, such as reducing the required load or changing the configuration of the IM to decrease its output capabilities.

Four alternate approaches to the IM configuration are currently possible with the IM integrated into the TACAN location. The baseline alternative is that described in detail in this report and as defined by the IM specification (Appendix A). The other alternatives are "spin-offs" of that configuration. The "austere" (A) configuration is a "bare bones" approach capable of being implemented within the Set Z receiver/ processor LRU. The "budget" (B) configuration duplicates the TACAN capability. The "composite" (C) configuration is the IM described in detail in this report. The "deluxe" (D) configuration expands the capability of configuration C to drive other horizontal indicators in addition to vertical indicators. Configuration D requires modification to the aircraft wiring to achieve the desired integration.

The final product of the IM definition study was a form, fit, and function specification for the IM. The specification, prepared in accordance with MIL-STD-490, Type C1a format, was developed following detailed investigation of the most cost-effective means of interfacing Set Z with the test aircraft avionics. Initial guidance for the direction that the integration effort was to follow was received from the GPS JPO, after which close liaison was maintained to ensure compatibility with GPS program requirements.

Conclusions

Based on the results of this study, it is concluded that the Integration Module can be a very effective interface device for integrating Set Z into the specified test aircraft. The IM will allow for a versatile demonstration of the capabilities of the Global Positioning System when flying a navigation mission with the aid of other instrument displays in addition to the Set Z CDU.

Inserting Set Z into the position formerly occupied by a TACAN set is a very convenient integration point. It provides a ready interconnection to most flight director systems and displays. It might be pointed out, however, that driving just horizontal navigation displays is only half the navigation problem. Interfacing Set Z with vertical as well as horizontal navigation displays would provide for a demonstration of the complete GPS navigation situation.

The IM described in detail in this report and whose requirements are specified in the form, fit, and function specification is a simple signal-converting device. It does not perform any data processing functions, but instead relies upon Set Z software to perform these routines. However, it does have the ability to transform Set Z from an isolated and independent navigation system into part of the integrated avionics suite with the capability of displaying a highly accurate navigation solution on the pilot's primary flight instruments in forms with which he is familiar.

The test aircraft do not present any major constraints on the integration approach described in this report. Since each of the test-aircraft avionic systems are similar in the areas in which Set Z would be integrated, a common or composite IM is feasible and can be designed.

The composite configuration of the IM described herein does not present a major impact on the test aircraft. The only functions that require wiring not presently in the aircraft are the true airspeed and encoded altitude signals. All other functions operate through the existing TACAN wiring. The most significant area of IM impact is in the packaging arrangement of the IM. The configuration (C) described in this report requires separate boxes for the converters and drivers.

The converter would be mounted alongside Set Z receiver/processor and the driver behind it, all on a size 1 ATR mount similar to the TACAN system being replaced.

The most versatile configuration, D, would impact the test aircraft by requiring additional wiring harnesses, junction boxes, and control panels, since the vertical navigation functions are inaccessible to the TACAN wiring.

The major impact of the IM will be felt by Set Z, particularly in the following areas:

a. Power supply

b. Input signal software processing

c. Built-in-test software routine

If Set Z is to supply the dc power for the IM, the size of the power supply will have to be increased significantly to accommodate the IM power requirements. This situation can lead to heat dissipation problems in the receiver/processor LRU. The input signals from the IM to Set Z (magnetic heading, course set, and true airspeed) require Set Z to perform software routines not originally specified in the user system segment specification. Built-in-test also requires special software routines. Overall, however, these impacts on Set Z do not appear to be overwhelming, and should be able to be resolved through a joint effort of the Set Z contractor, the GPS JPO, and the IM designer.

Recommendations

Based on the results of the definition study performed on the Integration Module, ARINC Research Corporation recommends that:

a. One of the IM configuration alternatives offered in this report be selected as the desired approach to an effective interface device, preferably configuration D.

b. The exact load (HSIs, BDHIs, etc.) to be driven by the IM be specified in detail.

c. A definite Set Z-to-IM interface digital code structure be identified and defined.

d. The preferred IM mounting location be identified and specified.

e. The source of IM dc power (Set Z or IM) be identified.

f. Further study be performed on the requirements for using and integrating the vertical navigation function.

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1 INTRODUCTION

1.1 SCOPE OF IM DEFINITION EFFORT

This report presents the results of a study and analysis performed by ARINC Research Corporation to define the requirements for an Integration Module that will allow Global Positioning System User Equipment Set Z to interface effectively with avionic systems of the five test aircraft selected for Phase I testing of the GPS.

The broad objectives and accomplishments of the IM study are discussed in this section, tracing the development of the IM from the early investigation to the specification stage. Presented in subsequent sections are the detailed results of the findings, including:

a. IM integration requirements, both electrical and physical, for the five test aircraft (Section 2)

b. A basic design concept for an IM common to the five test aircraft (Section 3)

c. Alternative IM design concepts (Section 4)

d. IM test requirements (Section 5)

e. IM specification requirements (Section 6)

The end product of this study was a prime-item specification for the Integration Module, prepared to MIL-STD-490, which is presented in Appendix A.

1.2 DEVELOPMENT OF IM CONCEPT

One of the primary goals of the GPS Integrated Logistic Support Program is to identify and define the requirements for an Integration Module that will allow GPS UE Set Z to be interfaced effectively with other avionic systems onboard the four specified USAF test aircraft and one Navy test aircraft during GPS Phase I testing. To accomplish this task, contracted to ARINC Research Corporation, it was first necessary to determine the limitations and constraints imposed on such an investigation. These were found to fall into four categories:

a. General limitations and constraints, according to initial guidance provided by the GPS Joint Program Office

b. Constraints due to the different aircraft configurations

c. Constraints imposed by requirements of the UE system specification

d. Known performance limitations of UE Set Z.

These limitations and constraints are listed in Table 1-1. Some were known at the beginning of the IM definition task, others became evident as the study progressed.

After the initial guidelines were established, a survey of tentatively identified GPS test aircraft was conducted to identify those avionic systems that could be driven by Set Z within the framework of the limitations and constraints of Table 1-1 (essentially, TACAN substitution in the most economical manner). Considering the potential of Set Z in a TACAN cavity and the output signals that would be available from it, as determined from discussion with the contractor for Set Z, it was concluded that:

a. The projected output capability of Set Z is sufficiently flexible to interface with practically all of the onboard navigation systems.

b. The flight director system, specifically the horizontal situation indicator, appears to represent the most appropriate candidate for interface because of the commonality of that system and display among the test aircraft.

Based on discussions of these initial findings with the GPS JPO, and further study and analysis of pertinent aircraft and avionics technical orders, it was determined on a preliminary basis that the HSI could provide the broadest range of navigation parameters that could be driven with a minimum amount of aircraft modification or group A parts replacement. Consistent with these findings, and incorporating suggestions from the JPO, the following working guidelines were established:

a. The output of the Set Z integration module will be specified to drive the displays that the TACAN set currently drives on the selected test aircraft.

b. The IM will be developed to drive horizontal type displays only.

Subsequent analysis indicated that the substitution of Set Z for an onboard TACAN set would have both advantages and disadvantages. A distinct advantage of integrating the set into the aircraft avionics suite in the cavity formerly occupied by the TACAN would provide a convenient point of integration, both mechanically and electrically. Mechanically, Set Z is to be designed to be physically identical to the TACAN-XXX. Electrically, interconnecting the set with existing TACAN interface wiring would reduce the number of wiring changes necessary for integrating the equipment into an aircraft, and also provide a feasible selection of signals for the avionic display interface.

The primary disadvantage of substituting Set Z for the TACAN set appeared to be that the number and type of avionics displays that Set Z could drive would be constrained to those presently driven by TACAN interface signals. The alternative to being constrained to TACAN interface signals would be to establish a direct Set Z interface with the various avionic systems and displays. However, the selection of this alternative would require relatively extensive modification of the host aircraft, including the addition of selector panels, relay panels, and junction boxes. Consequently, it appeared that interfacing the avionic systems and displays presently driven by the TACAN and operating within the constraints so imposed represented a choice consistent with the guidelines relative to economical integration.

TABLE 1-1. LIMITATIONS AND CONSTRAINTS IN DEFINITION OF INTEGRATION MODULE (Sheet 1 of 2)

a. General – Initial Guidance by GPS JPO

1) A TACAN set onboard the four Air Force test aircraft (C-141A, HC-130H, KC-135, and HH-53) will be physically replaced by UE Set Z.

2) The pilot's avionic systems will be the primary instrumentation to receive the Set Z interface signals.

3) The navigation parameters displayed will be in a form familiar to the pilot.

4) The integration task will be accomplished in as economical manner as possible with respect to aircraft modifications and overall impact on Group A items.

5) Set Z will receive true airspeed and encoded altitude signals from other avionic systems through the Integration Module.

b. Due to Different Aircraft Configurations

The four fixed-wing aircraft have very similar avionic system configurations in regards to the TACAN installations, and have similar flight director systems that communicate with the TACAN set. However the helicopter avionics system is configured differently in that it does not have a flight director system, per se; however, it does have a TACAN set that communicates with instruments similar to those in the fixed-wing aircraft.

c. Imposed by Requirements of UE System Specification SS-US-101B

1) The IM shall be accommodated within Set Z receiver/processor LRU.

2) Set Z shall provide an input/output capability from the receiver/processor LRU to the IM.

3) The IM shall contain the necessary conversion circuitry, buffers, processor, connectors, etc., to drive other avionic systems.

4) The IM shall not be classified as part of Set Z.

5) The failure or lack of the IM shall not affect the operation of Set Z.

6) Set Z shall be capable of outputting all of the navigation data generated, per para. 3.7.5.9.1 of SS-US-101B, to the IM.

7) The IM shall provide for inputting altimeter data to Set Z.

TABLE 1-1. (Sheet 2 of 2)

d. Imposed by Known Limitation of Set Z 1) Set Z receiver/processor LRU will be contained in a 3/4 ATR short case, thus restricting the size of the IM. 2) Set Z will consume a total of 151 watts. Apparently this figure includes the power supply requirements for the IM.

The choice of the above alternative was supported by the fact that the avionic systems and indicators presently driven by the TACAN and which would be driven by Set Z represent a sufficiently large sample of the displays of the onboard avionics suites to verify the capability of the Set Z to drive any of the other avionics displays.

It remained necessary, however, to consider other integration alternatives for the UE set for two primary reasons:

a. Of the five specified aircraft studied, only two – the C-141A and the HC-130H – are configured with dual TACAN installations. The other three – the KC-135, HH-53 and P-3C – are configured with single TACAN systems. Initial guideline provided by the JPO was that Set Z be installed as a replacement for a TACAN set only in those models of the specified test aircraft possessing dual TACAN configurations.

b. Guidance from the Navy relative to the P-3C aircraft was that the TACAN set was to remain installed and that provision was to be made for Set Z to be switched in and out of the avionics suite at the pilot's option.

For the above reasons, and to ensure that all logical alternatives for integrating the UE set were considered, six alternative configurations were postulated and evaluated within the scope of the requirements and guidelines previously discussed. These integration alternatives can be expressed in general terms as follows:

a. Alternative A – Replace TACAN and drive the horizontal navigation displays formerly driven by that set.

b. Alternative B – Replace TACAN and drive the horizontal navigation displays formerly driven by that set, plus selected other horizontal displays.

c. Alternative C – Retain TACAN in the aircraft but provide a GPS mode to drive the horizontal navigation displays driven by that set.

d. Alternative D – Retain TACAN in the aircraft but provide a GPS mode to drive the horizontal navigation displays driven by that set, plus selected other horizontal displays.

e. Alternative E – Drive selected vertical navigation displays in conjunction with Alternatives B or D.

f. Alternative F – Drive all onboard horizontal and vertical navigation displays in conjunction with Alternatives B or D.

Results of the evaluation of these alternatives are summarized in Table 1-2, in which Alternative A is clearly indicated as being the most consistent with previously established requirements and guidelines, particularly with respect to the C-141A and the HC-130H which contain dual TACAN systems. However, for the KC-135 and the HH-53, Alternative A is a viable option only if the replacement of the single TACAN set is permitted; otherwise Alternative C represents the option most consistent with guidelines. Replacement of the single TACAN set with the UE in the latter two aircraft was recommended, since:

a. The KC-135 and the HH-53 will be dedicated test aircraft operated primarily in the GPS test environment for a limited time period; and

b. The design and fabrication of the number of unique group 'A' items necessary to effect the adoption of Alternative C for each of the two aircraft will not be consistent with guidelines for economical integration.

That is, Alternative A should be adopted for all four of the Air Force aircraft. This recommendation is reflected in the tables of selected avionics equipment presented in Section 2.

In the case of the P-3C, the Navy COTR's direction that the TACAN equipment not be removed indicates that Alternative C is most consistent with guidelines for economical integration.

In Table 1-2 it may be noted that Alternatives E and F, relative to the integration of the UE set with vertical displays, could represent a special case for integration. The IM could be specified and defined to accept output vertical information from Set Z to drive the radar altimeter, glideslope indicator, and the pitch steering bar of the attitude direction indicator. However, the information displayed by means of the GPS would be in a form not immediately comprehensive to the pilot. For example, in the GPS mode the display on the radar altimeter would be more representative of true altitude (MSL) than it would be of the absolute altitude (AGL) that the pilot is accustomed to reading. Similar variations or differences could appear in the other vertical displays mentioned. This could represent a safety-of-flight consideration since terrain elevation is not a GPS parameter. It is recommended that the vertical information from Set Z not be integrated into any of the existing vertical information displays without a separate investigation of the utility of such an integration from an operational standpoint and careful consideration of the safety-of-flight aspects.

TABLE 1-2. COMPARISON OF ALTERNATIVES FOR INTEGRATING UE SET Z INTO TEST AIRCRAFT

Requirements/Guidelines/ Criteria	Alternative					
	A	B	C	D	E**	F***
1. Comprehensive Pilot Display	Same as TACAN	Same as TACAN and other systems	Same as TACAN	Same as TACAN and other systems	Possibly confusing to pilot	Confusing to pilot
2. Potential Output Accuracy/Reliability	Better than TACAN	Better than TACAN and other systems	Better than TACAN	Better than TACAN and other systems	Better than TACAN but not other systems	Better than some but not others, e.g., ILS
*3. Extent of Aircraft Modification (Mechanical, Wiring, etc.)	0-1	1-2	3	3	3	5
*4. Extent of Group 'A' Equipment Modifications	0-1	1-2	2	3-4	4	5
*5. Addition of New Group 'A' Equipment	0-2	1-2	3	3-4	3-4	5
6. Operational Improvement Potential	Outputs not restricted to TACAN limits	Same as A plus more flexibility	Same as A plus leaves TACAN	Same as C plus more flexibility	Provides best mix of displays and flexibility	Requires further analysis of operational requirements
7. Restrictions Imposed by Alternative	Only drive TACAN outputs	Same as A plus 3, 4, & 5 above	Same as A plus location problems	Same as C plus 3, 4, & 5 above	Same as B & D plus 3, 4, & 5 above	Flight safety
8. Tests Set Z Integration Capabilities	Adequate for initial Phase I testing	Slightly better than A	Same as A plus allows for TACAN comparison	Slightly better than C	Provides more flexibility and test comparison	Not recommended for Phase I testing without further study

*Scale Factor: 0 = none, 1 = very minor, 2 = minor, 3 = moderate, 4 = major, 5 = extensive
**B or D plus vertical displays
***B or D plus all vertical and horizontal displays.

2
IM REQUIREMENTS FOR TEST AIRCRAFT

This section discusses the functional integration of UE Set Z into the five test aircraft types through the Integration Module. Presented for each aircraft type are:

a. A narrative description of present navigation systems and instruments with which Set Z will interface.

b. A table listing the interface signals that Set Z will generate to drive these systems and instruments.

c. Functional block diagrams showing the GPS interface signals between Set Z and the systems and instruments.

d. Electrical characteristics of major interface signals between the IM and the avionic systems and instruments. (These signal characteristic sheets appear in Appendix B.)

2.1 IM REQUIREMENTS FOR C-141A

The C-141A is a high-speed, heavy logistic transport aircraft equipped with two independent AN/ARN-21 TACAN sets and two separate flight director systems. The TACAN and flight director systems are identified as No. 1 (pilot's) and No. 2 (copilot's).

Each FDS consists of an attitude director indicator, horizontal situation indicator, flight director computer, and navigation selector panel. Besides providing navigation data to the flight director systems, the TACAN sets provide the same type of data to the bearing, distance, heading indicators (BDHI) on the pilot's, copilot's, and navigator's instrument panels. The pilot or copilot may select either TACAN system through his respective BDHI navigation selector panel. The navigator has two BDHIs dedicated to each of the TACAN systems. The autopilot that normally receives navigation information from the copilot's FDS also receives certain data from the TACAN system directly through the navigation selector panel.

UE Set Z will physically and functionally replace the TACAN No. 1 (pilot's) system during GPS Phase I testing, interfacing with the IM through the same avionic systems and instruments with which the TACAN No. 1 interfaced previously. These interfaces are shown in the functional block diagram of Figure 2-1.

In addition to the normal TACAN interface signals, Set Z will also receive true airspeed and encoded altitude data from the central air data computer. Table 2-1 provides a cross-reference of Set Z interface signals to and from the appropriate avionic system or instrument. The characteristics of each of the pertinent interface signals listed in Table 2-1 are described in detail in Appendix B.

The TACAN coupler presently installed in the aircraft supplies an analog dc signal to the pilot's flight director computer and the AN/ASN-24 navigation computer. The signal to the FDC causes it to be less sensitive to changes in the deviation signal as the aircraft approaches a TACAN ground station, and therefore changes in the position of the ADI bank steering bar become more gradual. The signal to the navigation computer provides that system with an indication of slant range distance to the TACAN ground station that is tuned in to improve the dead reckoning accuracy.

It was determined that the signal to the FDC is not required for GPS navigation since Set Z does not have the same sensitivity problem as TACAN when the aircraft approaches a waypoint. The signal to the navigation computer also is not required since that system is to be replaced with dual inertial navigation systems by the time Set Z is installed. Therefore, these signals do not appear on Figure 2-1 or in Table 2-1.

The operational aspects of Set Z, when installed in the C-141A and integrated with the various avionics, are similar to those of the TACAN replaced. Set Z will not interrupt or change the normal operational procedures of the other avionics onboard the aircraft. A descriptive account of the integration operation of Set Z can be found in the C-141A Flight Manual (T.O. 1C-141A-1, Section 4); the Radio, Communications, and Navigation Systems Technical Manual (T.O. 1C-141A-2-8, Section 11); and the Instruments Technical Manual (T.O. 1C-141A-2-6); with the phrase "TACAN set" read as "Set Z".

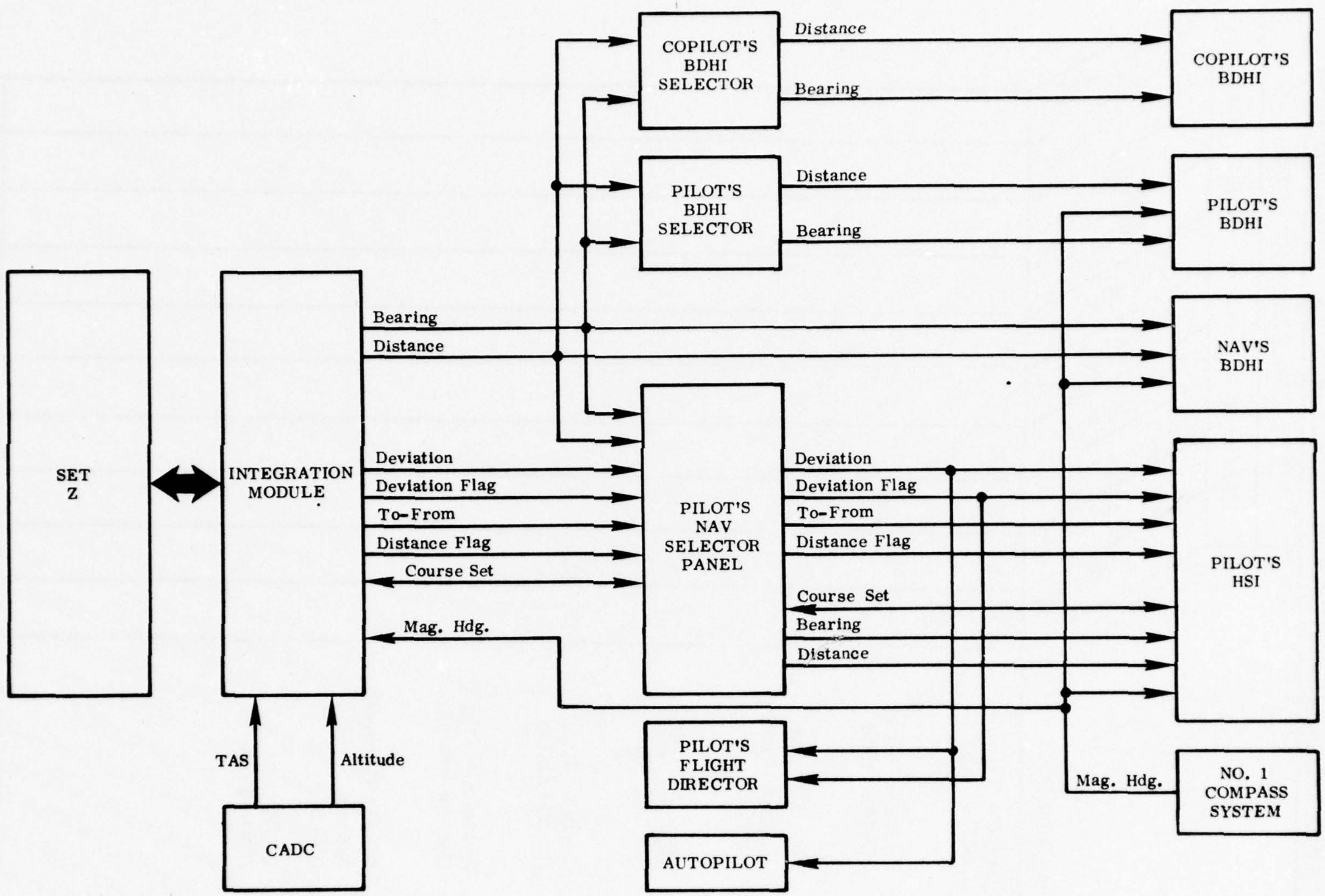


Figure 2-1. Block Diagram, C-141A Interface Signal

TABLE 2-1. AVIONIC/SET Z INTERFACE SIGNALS, C-141A AIRCRAFT

	Set Z Interface Signals									
	IM Output to Displays							Ref. Inputs to IM		
Avionic System	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Course Set	Mag. Heading	True Airspeed	Encoded Altitude
1. Pilot's HSI (AQU-4/A)	X	X	X	X	X	X	X			
2. Pilot's BDHI (ID-798/ARN)	X	X								
3. Pilot's Flight Director Comp. (3K91002)				X	X					
4. Copilot's BDHI (ID-798/ARN)	X	X								
5. Nav's BDHI (ID-798/ARN)	X	X								
6. Automatic Flight Control System				X						
7. Pilot's Compnass System (C-12)								X		
8. CADC (CPU-43/A)									X	X

2.2 IM REQUIREMENTS FOR KC-135A

The KC-135A is a high-speed air refueling aircraft incorporating a single AN/ARN-72 TACAN navigation system and a dual flight director system. Each flight director system consists of an attitude director indicator, horizontal situation indicator, flight director control, roll computer, pitch computer, altitude controller, instrument amplifier, heading slew control, rate-of-turn gyro, and mode control and annunciator.

The independent flight director systems share the one TACAN set to provide the pilot and copilot with displays of airplane attitude, heading, and position based upon TACAN signals when the flight director mode control is in the NAV/LOC position. In addition to providing navigation data to the flight director systems, the TACAN system also provides bearing data to the pilot's, copilot's, and navigator's radio magnetic indicators.

During GPS Phase I testing, UE Set Z will physically and functionally replace the single TACAN set onboard the KC-135A test aircraft. Set Z will then interface with the existing avionics through the IM and provide those signals shown in Figure 2-2.

In addition to providing the normal type of TACAN signals, Set Z will receive a true airspeed signal from the true airspeed computer and encoded altitude from the altitude computer. A cross-reference of the interface signals between the IM and the appropriate avionic system or instrument is provided in Table 2-2, with the characteristics of each of these signals provided in Appendix B.

Replacing the TACAN set with Set Z in the KC-135A will not modify the normal operation of the existing avionic systems and instruments. For a comprehensive description of the operation of Set Z with the existing equipment, the KC-135A Flight Manual (T.O. 1C-135(R)A-1, Section 4), and Radio, Communication, and Navigation Systems Technical Manual (T.O. 1C-135(R)A-2-11) should be consulted, with the phrase "UE Set Z" substituted for "TACAN set" or "UHF navigation receiver".

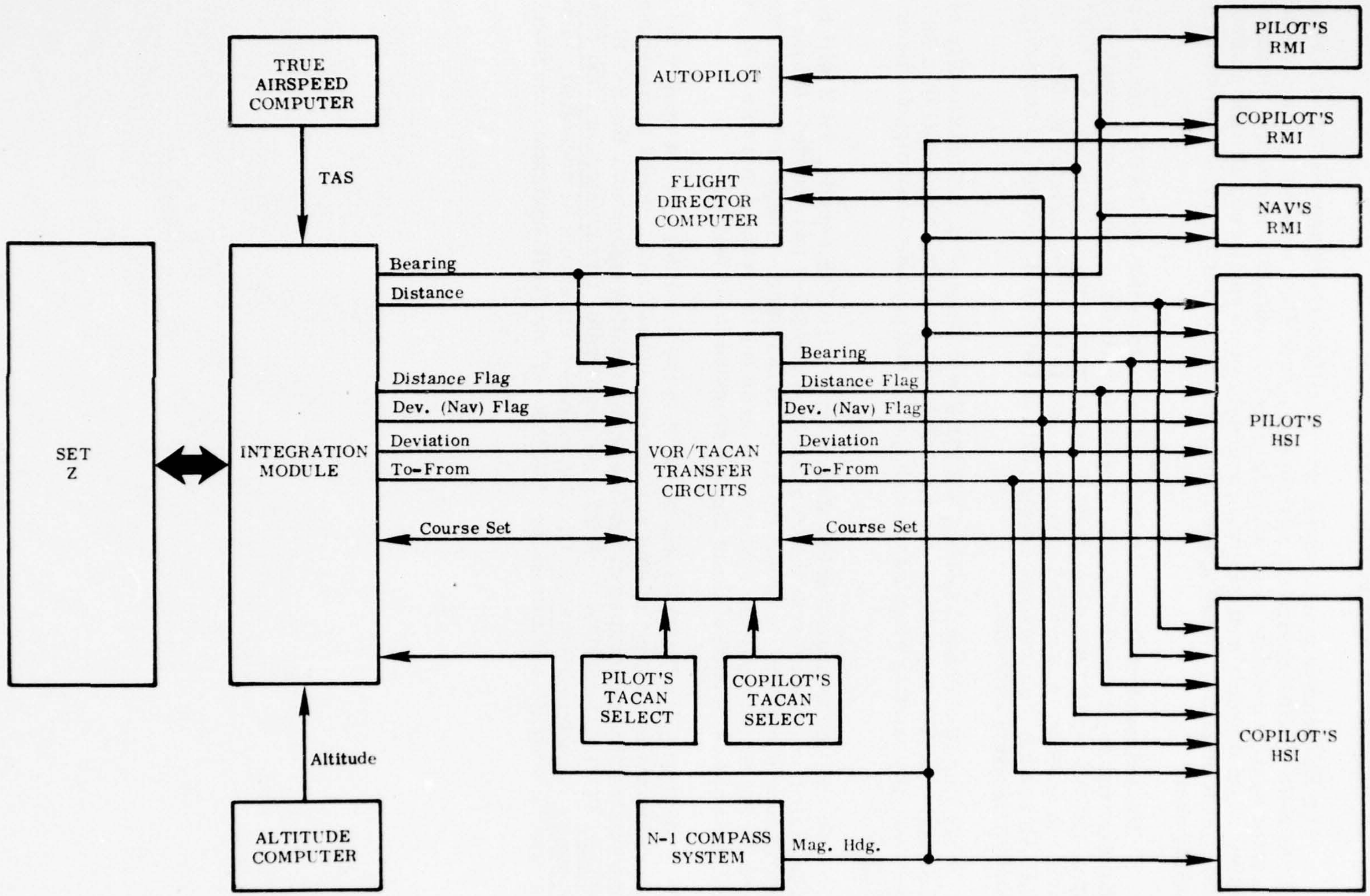


Figure 2-2. Block Diagram, KC-135A Interface Signal

TABLE 2-2. AVIONIC/SET Z INTERFACE SIGNALS, KC-135A AIRCRAFT

	Set Z Interface Signals									
	IM Output to Displays							Ref. Input to IM		
Avionic System	Bearing	Distance	Distance Flag	Deviation	Deviation (Nav) Flag	To-From Ind.	Course Set	Mag. Heading	True Airspeed	Encoded Altitude
1. Pilot's HSI (331A-8H)	X	X	X	X	X	X	X			
2. Pilot's RMI (ID-250/ARN)	X									
3. Copilot's HSI (331A-8H)	X	X	X	X	X	X				
4. Copilot's RMI (ID-250/ARN)	X									
5. Nav's RMI (ID-250/ARN)	X									
6. Flight Director System (ASQ-14(V))				X	X					
7. Autopilot (MC-1)				X						
8. Compass System (N-1)								X		
9. Altitude Comp. (CPU-66/A)										X
10. TAS Computer (Type A-2)									X	

2.3 IM REQUIREMENTS FOR HC-130H

The HC-130H long-range search and recovery aircraft is equipped with two independent AN/ARN-21 TACAN sets and two separate flight director systems. The TACAN sets and flight director systems are identified as No. 1 (pilot's) and No. 2 (copilot's).

Each FDS consists of a flight director computer, an attitude director indicator, a horizontal situation indicator, a rate gyro, an MD-1 gyro, a rate-of-turn sensor, and an instrument selector panel.

The FDSs are interconnected with the two TACAN sets through the mode selector panels such that the pilot or copilot can select either TACAN No. 1 or No. 2. Thus, the No. 1 or pilot's TACAN set is able to provide interface signals to both the No. 1 and No. 2 flight director systems, depending upon the position of the mode control switch.

TACAN range and bearing data are also sent to the pilot's, copilot's, and navigator's BDHIs. However, the BDHIs are dedicated to either the No. 1 or No. 2 TACAN systems, and cannot be switched between the two systems.

The No. 1 TACAN set will be replaced by UE Set Z during the GPS Phase I test period and provide those interface signals as shown in Figure 2-3 to drive the onboard avionic systems and instruments. The Set Z signals will be switchable between the two flight director systems in the same manner as the TACAN signals. This capability adds flexibility to the FDS not present in the other test aircraft by allowing for a cross-comparison with the No. 2 TACAN system.

In addition to the TACAN type signals, Set Z will receive encoded altitude from the AN/AAU-21A encoding altimeter. True airspeed will not be available for use by Set Z since that indication is not in an electrical signal format in the HC-130H.

A cross-reference of the interface signals between Set Z IM and the appropriate avionic systems or instruments is provided in Table 2-3. Characteristics of these signals are listed in Appendix B.

The TACAN coupler presently installed in the aircraft supplies an analog dc signal to the two flight director computers that changes the sensitivity of the deviation signal. This signal causes the FDCs to be less sensitive to changes in the deviation signal as the aircraft approaches a TACAN ground station. Thus, changes in the position of the ADI bank steering bar become more gradual as the aircraft approaches the TACAN station. It was determined that this type of signal is not required when navigating with Set Z, since GPS positioning does not rely on ground station angular radials. Therefore the signal does not appear on Figure 2-3 or in Table 2-3.

The replacement of the No. 1 TACAN set and TACAN coupler in the HC-130H with Set Z and the IM will not alter the normal operation of the existing avionic systems and instruments. The switch position previously labeled "TAC1" will become "GPS" on the pilot's and copilot's mode selector panels. The integrated operation of Set Z with the existing avionics will be the same as that for the TACAN No. 1 set as described in the HC-130H Flight Manual (T.O. 1C-130(H)H-1, Section 4), and the Radio Communications and Navigation Systems Maintenance Manual (T.O. 1C-130(H)H-2-11, Sections 3 and 11).

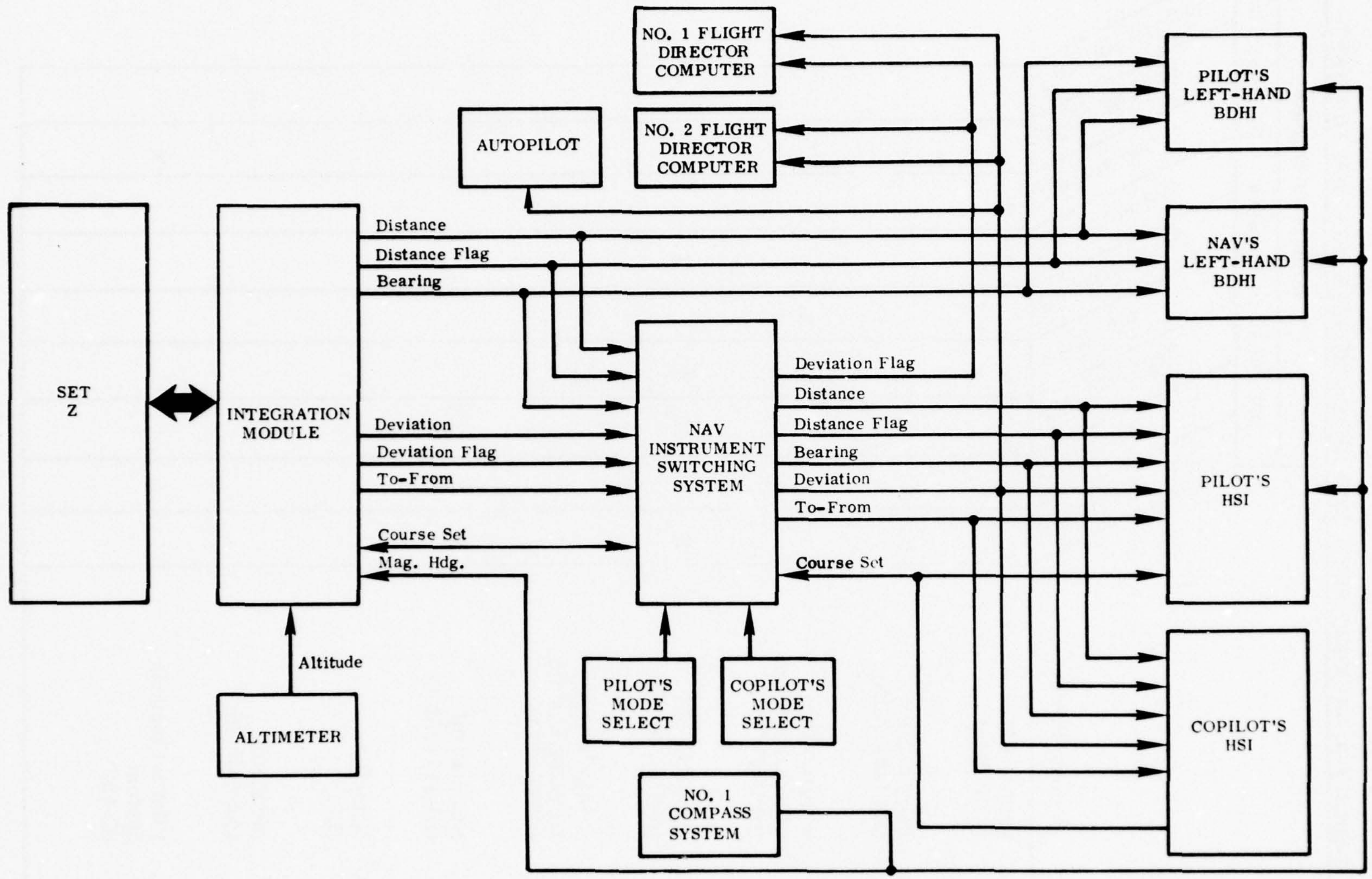


Figure 2-3. Block Diagram, HC-130H Interface Signal

TABLE 2-3. AVIONIC/SET Z INTERFACE SIGNALS, HC-130H AIRCRAFT

Avionic System	Set Z Interface Signals								
	IM Output to Displays							Ref. Input to IM	
	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Course Set	Mag. Heading	Encoded Altitude
1. Pilot's HSI (AQU-2/A)	X	X	X	X		X	X		
2. Pilot's BDHI (ID-1103/ARN)	X	X	X						
3. Pilot's Flight Director System (CPU-65/A)				X	X				
4. Copilot's HSI (AQU-2/A)	X	X	X	X		X			
5. Copilot's Flight Director System (CPU-65/A)				X	X				
6. Nav's BDHI (ID-1103/ARN)	X	X	X						
7. Autopilot (E-4)				X					
8. Altimeter (AAU-21/A)									X
9. Pilot's Compass System (C-12)								X	

2.4 IM REQUIREMENTS FOR HH-53B/C

The HH-53B/C search-and-recovery helicopter is equipped with a single AN/ARN-65 TACAN system that provides bearing and distance data to the pilot's and copilot's BDHIs when the VOR/TACAN selector switch is in the TACAN position. The helicopter does not contain a flight director system such as normally found on fixed-wing aircraft. Instead, the helicopter incorporates other instruments and systems that provide the pilot with information similar to flight director data. Besides driving indicators on the BDHI, the TACAN set also interfaces with the pilot's and copilot's course indicators and the pilot's flight director indicator or hover indicator. The CDIs and FDI primarily provide steering-type displays to the pilot and copilot on cross-pointer indicators that receive deviation and deviation-reliability data from the TACAN system. Where the data are displayed is dependent upon the position of the VOR/TACAN selector switches.

On the helicopter, the copilot has control over the TACAN system while the pilot is responsible for the VOR system. The copilot's VOR/TACAN selector switch is labeled "TACAN MASTER/VOR SLAVE", and the pilot's selector is labeled "VOR MASTER/TACAN SLAVE". During TACAN operation the pilot will receive slaved TACAN data on his instruments if his selector switch is in the "TACAN SLAVE" position.

During GPS Phase I testing, the AN/ARN-65 TACAN set will be physically and functionally replaced with the UE Set Z and IM. Set Z will provide the same interface signals formerly provided by the TACAN set. Selection of the display of GPS signals will be through the use of the two "VOR/TACAN" selector switches, which will be relabeled to "VOR/GPS". Set Z will also receive true airspeed and encoded altitude data from the TAS transmitter and AN/AAU-21A encoding altimeter, respectively. The interface signals between the Set Z IM and the various avionic systems and instruments are shown in Figure 2-4. Table 2-4 provides a cross-reference of these same signals, with the appropriate instruments. The characteristics of the interface signals are listed in Appendix B.

Normal operation of the other avionic systems and instruments will not be changed once Set Z and the IM are installed on the helicopter in place of the present TACAN system. The integrated operation of Set Z with the existing avionics will be the same as for the TACAN system, as described in detail in the HH-53B/C Flight Manual (T.O. 1H-53(H)B-1, Section 4), and Organizational Maintenance Technical Manual (T.O. 1H-53(H)B-2-1, Section 17).

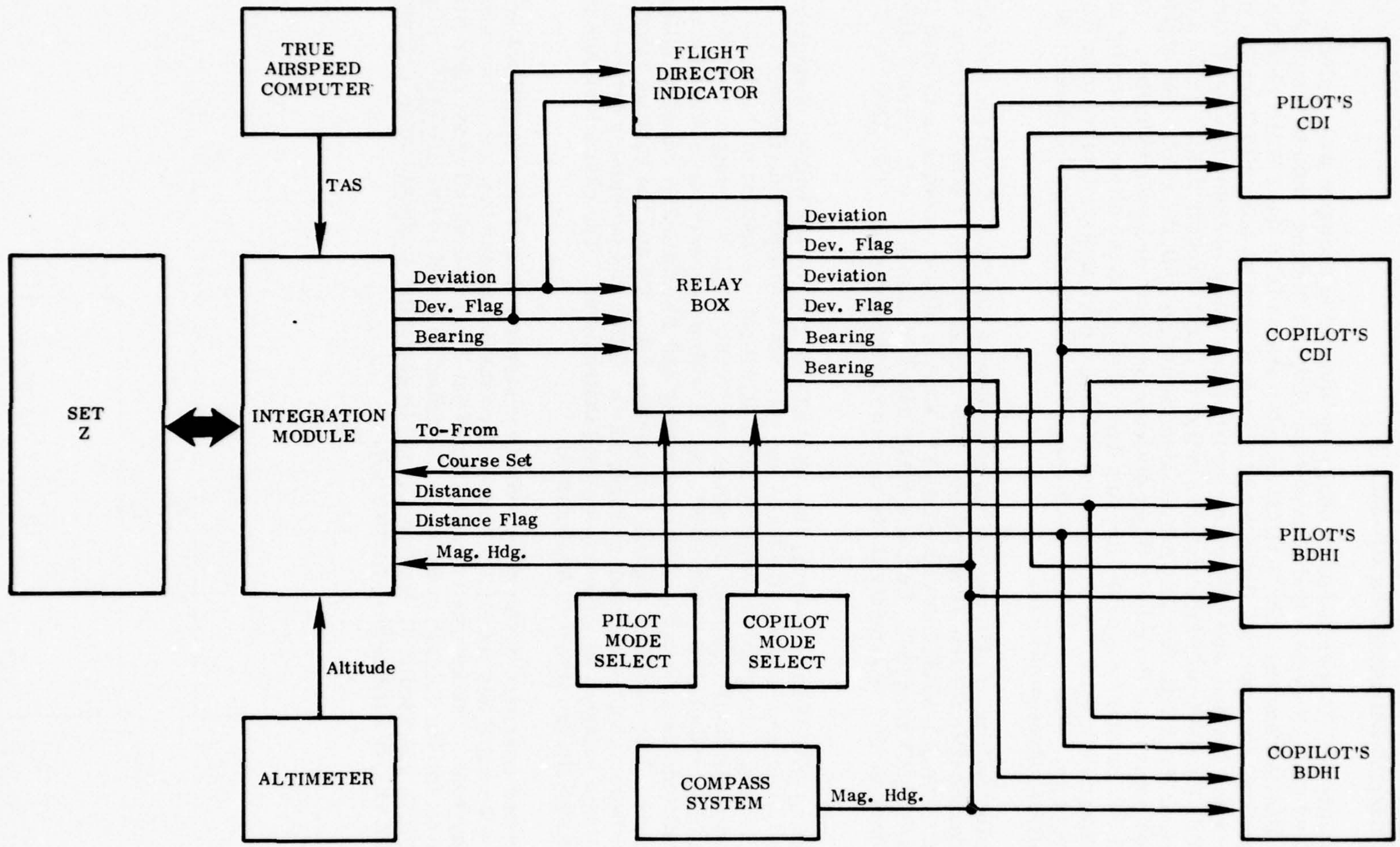


Figure 2-4. Block Diagram, HH-53B/C Interface Signal

TABLE 2-4. AVIONIC/SET Z INTERFACE SIGNALS, HH-53B/C AIRCRAFT

	Set Z Interface Signals									
	IM Output to Displays							Ref. Input to IM		
Avionic System	Bearing	Distance	Distance Flag	Deviation	Deviation Flag	To-From Ind.	Course Set	Mag. Heading	True Airspeed	Encoded Altitude
1. Pilot's BDHI (ID-1103/ARN)	X	X	X							
2. Pilot's CDI (ID-387/ARN)				X	X					
3. Pilot's FDI (353-999-0100)				X	X					
4. Copilot's BDHI (ID-1103/ARN)	X	X	X							
5. Copilot's CDI (ID-387/ARN)				X	X	X	X			
6. Compass System (J-4)								X		
7. True Airspeed Computer (A24950-00-005)									X	
8. Altimeter (AAU-21/A)										X

2.5 IM REQUIREMENTS FOR P-3C

The Navy P-3C four-engine turboprop patrol and antisubmarine warfare aircraft incorporates a single AN/ARN-52(v) TACAN set in its avionics suite. The TACAN set operates in conjunction with the AN/AJN-15 FDS and HSI group to provide crew members with a visual display of navigation data. The FDS consists of two FDIs (similar to ADIs), a flight director system steering computer (FDSC), a signal data converter, and two rate gyroscope transmitters. The FDS receives deviation data from the TACAN system for processing and display on the FDI pitch-and-roll command indicator and warning flag.

The HSI group consists of three HSIs, three HSI control panels, and two navigation advisory light panels. The three HSI indicators are identical and are for the pilot's, copilot's, and NAV/COMM's use. All TACAN navigation data are not equally shared by the three HSIs but depend upon the condition of the control panel switch positions. The pilot's HSI control panel, together with his FDS control unit, permit the pilot to maintain priority control over all manual and automatic modes and submodes of operation. The copilot's HSI control panel permits him to select certain navigation submodes, or to monitor the navigation situation selected by the pilot. Finally, the NAV/COMM's HSI control panel allows the navigator to monitor bearing, distance, and set course as selected by the pilot.

The TACAN set will not be replaced by UE Set Z and IM during GPS Phase I testing, but will share its interface signal responsibility with Set Z through the incorporation of a relay junction box. A switch on the box will allow the pilot to select either TACAN or GPS signals for display on the three HSIs when the HSI control panel is in the TACAN mode. Set Z will also receive true airspeed and encoded altitude data from the TAS computer and AN/AAU-21/A encoding altimeter, respectively.

The functional interface of Set Z with onboard avionics is shown in Figure 2-5. Table 2-5 presents a cross-reference of IM interface signals to the appropriate avionic systems and instruments. Characteristics of these signals are listed in Appendix B.

The normal operation of the avionics system will not be changed by the integration of Set Z into it through the use of a relay junction box. Operation of the system will remain as described in Flight Director System and HSI Group Organizational Maintenance Instructions Technical Manual (NAVAIR 01-75PAC-2-9.1). The only difference is that any reference to "TACAN" would also apply to Set Z when describing interface signals.

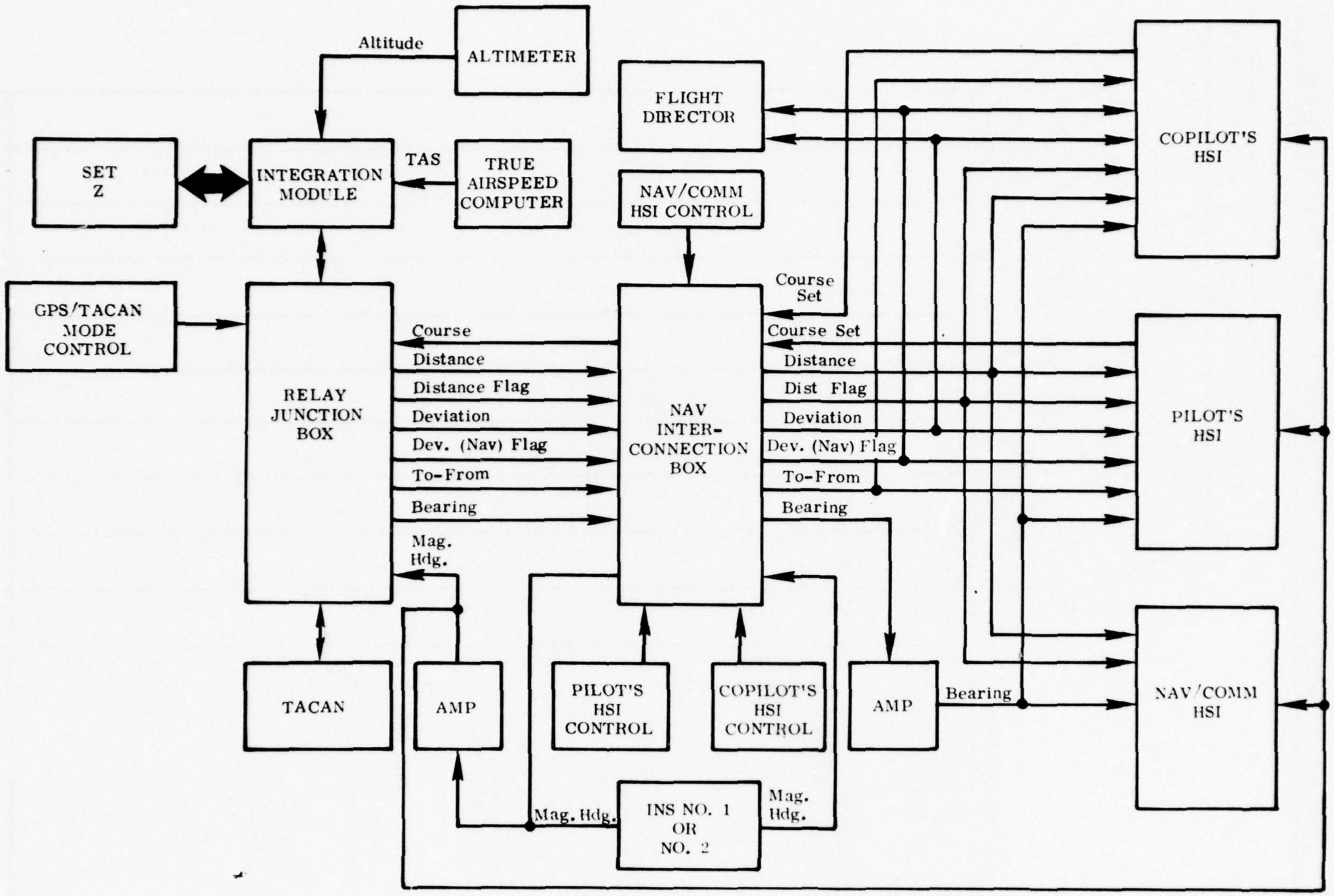


Figure 2-5. Block Diagram, P-3C Interface Signal

TABLE 2-5. AVIONIC/SET Z INTERFACE SIGNALS, P-3C AIRCRAFT

	Set Z Interface Signals									
	IM Output to Displays							Ref. Input to IM		
Avionic System	Bearing	Distance	Distance Flag	Deviation	Deviation (Nav) Flag	To-From Ind.	Course Set	Mag. Heading	True Airspeed	Encoded Altitude
1. Pilot's HSI (ID-1540/A)	X	X	X	X	X	X	X			
2. Copilot's HSI (ID-1540/A)	X	X	X	X	X	X	X			
3. Nav's HSI (ID-1540/A)	X	X	X							
4. Flight Director Computer (AN/AJN-15)				X	X					
5. Inertial Nav System (AN/ASN-84)								X		
6. True Airspeed Computer (CPK-28/A24G-9)									X	
7. Altimeter (AAU-21/A)										X

2.6 OPERATIONAL CONSIDERATIONS

A study of Set Z integration requirements for the test aircraft, together with a cross-comparison of the aircraft configurations, indicated a similar definition of the Integration Module for each aircraft. This single or composite definition is reflected in the IM specification (Appendix A), with further clarification provided in this section.

On the basis of the constraints discussed in Section 1, particularly that of cost-effectiveness, the IM has been specified to provide only horizontal-type navigation data to the host vehicle avionics. The primary instrument that will receive this information is the horizontal situation indicator. The HSI is one of the pilot's two primary flight instruments, the other being the attitude director indicator. These two instruments are usually mounted directly in front of the pilot and copilot where they can quickly view and assess the aircraft's attitude and heading. The Set Z control display unit, on the other hand, will be mounted on the center console – i.e., out of direct line of sight – in most of the test aircraft. By coupling Set Z through the IM to the flight director instruments (HSI and ADI) as shown in Figure 2-6, the pilot will be able to receive primary navigation data, such as waypoint distance and bearing, in his direct line of sight. The data will also be displayed in a pictorial form with which he is already familiar.

Unlike the HSI, the Set Z control display unit does not present the complete navigation situation in one visual display. The pilot has to continually operate the function pushbuttons on the CDU to get the same information continuously available on the HSI. The HSI presentation provides the pilot with the aircraft's heading, the desired course to the next waypoint, the bearing of that waypoint relative to the aircraft's heading, the aircraft distance to the left or right of the desired course, the distance to the next waypoint, and the direction of the desired course in relation to the next waypoint. There are also warning flags to indicate when unreliable data are being received by the HSI.

Figure 2-6 is representative of a typical Set Z integration into one of the fixed-wing test vehicles. The HH-53B/C helicopter installation is similar to that shown, except that the HSI and ADI are replaced with a CDI and FDI that provide similar displays. The figure shows those signals converted by the IM for display on the ADI, HSI, and BDHI. Also shown are those signals that are processed and/or converted by the IM for use by Set Z.

BDHI is also useful for displaying a horizontal navigation situation; however it is not as versatile as an HSI. During a GPS navigation exercise, the BDHI will provide a display of aircraft heading from the compass system, the bearing to the next waypoint on one of the bearing pointers, and the distance to the next waypoint. The BDHI does not provide course information, as does the HSI. The BDHI can be used as a backup instrument for the HSI or as an alternate display of navigation data from another system.

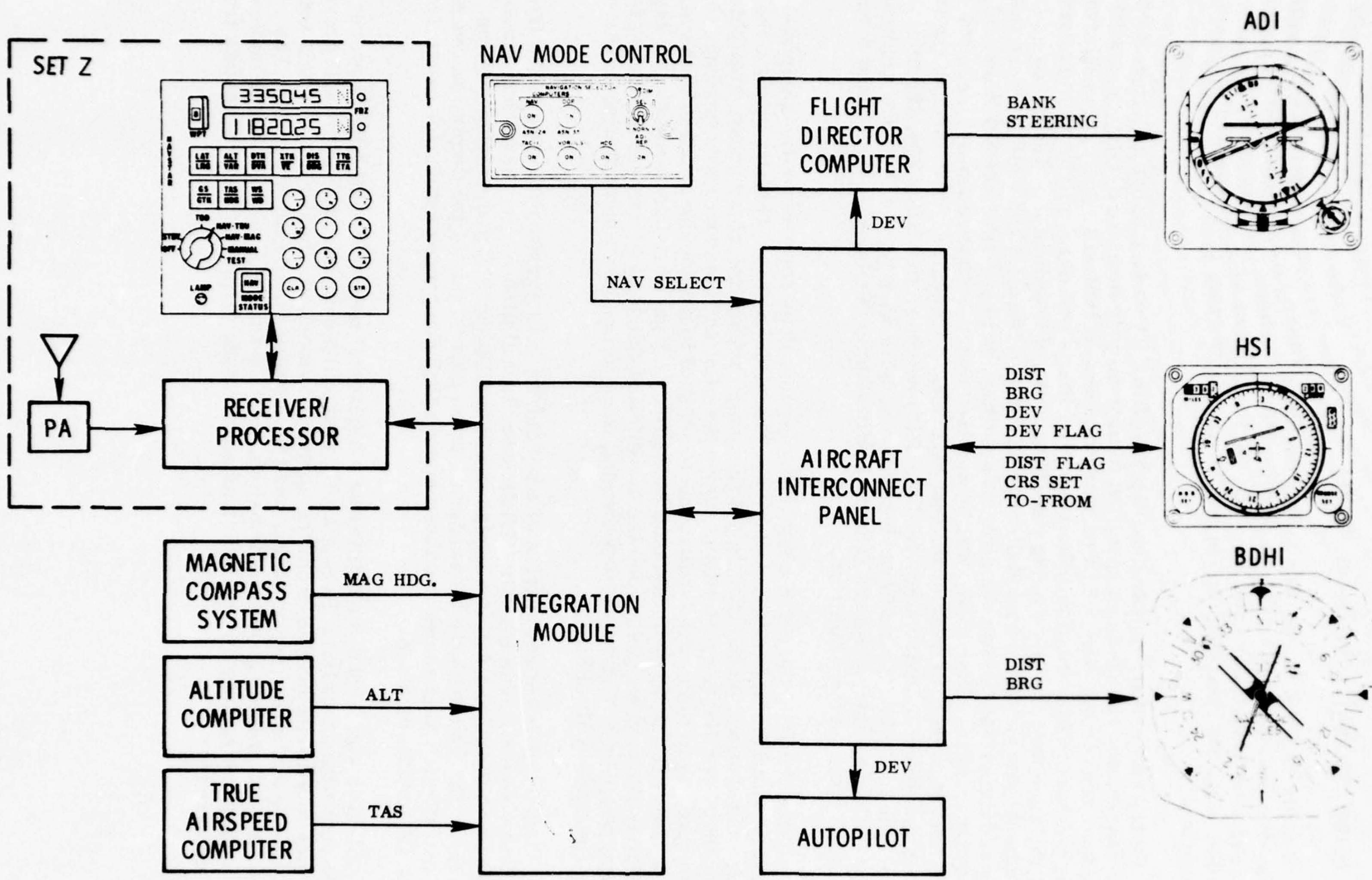


Figure 2-6. Typical Set Z Aircraft Integration

3
INTEGRATION MODULE DESIGN CONCEPT

This section provides details of the design concept study performed on the Set Z Integration Module. The object of this study was to define the IM beyond the system level by investigating the actual detail circuit design requirements for a typical IM configuration. Pertinent areas investigated included:

a. Feasibility and method of implementing each signal type referenced in the IM specification (see Section 3.1)

b. A marketing survey of the availability, size, cost, and power requirements of digital-to-synchro and synchro-to-digital converters (Section 3.2)

c. IM power requirements (Section 3.3)

d. Cost considerations (Section 3.4)

e. IM size and packaging requirements (Section 3.5)

f. Set Z impact areas (Section 3.6)

3.1 *IM CIRCUIT DESIGN CONCEPTS*

The IM must be designed to allow Set Z to interface effectively and economically with existing onboard aircraft avionics, particularly those instruments and systems that presently interface with the TACAN system. With this basic requirement in mind, the detailed design requirements for each of the following signals were studied:

a. Bearing

b. Distance

c. True airspeed

d. Magnetic heading

e. Altitude

f. Course set

g. Distance flag

h. To-from

i. Deviation flag

j. Deviation

The following paragraphs present the fundamental requirements for each signal, the signal coding, and circuit design considerations. The aircraft found to present the worst-case condition for the majority of the signals listed was the HC-130H. Therefore, most of the design considerations are based on an IM for this particular aircraft.

One area that could not be thoroughly investigated was the Set Z-to-IM interface. Detailed descriptions of the interface signals do not now exist since the contractor for Set Z has not undertaken detailed design of that set. Therefore, to perform a detailed design analysis of the IM, it was necessary to make basic assumptions on the type and format of these interface signals, as will be brought out in the following discussion.

3.1.1 Bearing Signal

3.1.1.1 Requirements

The IM must convert Set Z digital aircraft bearing data into an analog signal capable of driving the synchros described in Table 3-1. The output of a three-wire synchro signal is provided from the IM for the bearing interface signal. The bearing signal will then be sent to an aircraft junction box and divided into the required number of signal lines to drive the various aircraft instruments.

The IM must be capable of providing the power necessary to drive the worst-case combination of synchro loads. As can be seen in Table 3-1, the HC-130H aircraft requires the largest output load – its two HSI and two BDHI indicators require a total average output current of 602 mA. The peak current could be approximately three times this value, according to one manufacturing source (ILC Data Device Corp.). Because of the high output level, power amplification must be applied to the output of the D/S converter. Only two amplifiers are necessary because of the Y-connection configuration of the synchro receiver stator winding. Supplying the high level energy to two of the three input lines and directly connecting the third lead to ground (the common connection) is just as effective as using three power boosters, according to one manufacturing source.*

It should be noted that, while the above scheme will work with the test aircraft of this study, it may not be compatible with other aircraft types due to grounding problems. Three amplifiers may be required for those aircraft.

The selection of proper power amplifiers for this application can pose a problem. These amplifiers are required to drive large parallel inductive loads that consist of a combination of both control transformers (CTs) and torque receivers (TRs). It is highly desirable to isolate these two different outputs from each other because of possible feedthrough problems that could cause instability in the driving amplifiers and CTs. This is not possible in the IM since only one set of bearing synchro leads is available at the IM interface, and more than one set of bearing leads would require an aircraft rewiring effort. A market survey (see Section 3.2) has shown that amplifiers presently on the market could be marginal in this application, and a custom-designed unit may be necessary.

*ILC Data Device Corporation

TABLE 3-1. INDICATORS DRIVEN BY GPS BEARING SIGNAL

Aircraft	Ind. Type	Synchro Type	Synchro Mfr, P/N	Input Current, (mA)*	Qty	Total Current, (mA)*
HC-130H	HSI AQU-2/A	CT	Bendix AY 500-5	21	2	42
	BDHI ID-1103/ ARN	TR	26V-11TR4C	280	2	560
C-141A	HSI AQU-4/A	CT	Bendix AY 500-5	21	1	21
	BDHI ID-798/ ARN		McGraw-Edison	62	3	186
KC-135A	HSI 331A-8G	CT	McGraw-Edison 4277-01-05	30	2	60
	RMI ID-250/ ARN	TR	Bendix AY 203-S-2-B	120	3	360
P-3C	HSI ID-1540A	CT	Bendix AY 500-5	21	3	63
HH-53B/C	BDHI ID-1103/ ARN	TR	26V-11TR4C	280	2	560

*Average current is given; peak is 3 times that value.

To decrease the possibility of amplifier instability and power requirements, individual synchro loads could be tuned. Load tuning, a method of reducing the high-output drive current required, is accomplished by resonating the highly inductive synchro input with capacitors. Three capacitors of the proper value are connected across the output in a delta configuration. Different capacitance valves would be required for each aircraft type, and tuning would probably be required for each aircraft installation for optimum bearing accuracy.

3.1.1.2 Input Coding

The bearing signal will have the following characteristics:

a. Range: 0 to 360°

b. Resolution: 0.1°

c. Accuracy: ±0.5°

To obtain a resolution of 0.1°, a minimum of 12 bits of digital information must be utilized in the D/S conversion, derived as follows:

$360° / 2^n = 0.1°$

$2^n = 3600$

Since $2^{11} = 2048$ and $2^{12} = 4096$,

$n = 12$ bits, minimum

The marketing survey discussed in Section 3.2 revealed that most D/S module manufacturers utilize a natural binary coding of angular information. It would therefore be cost effective to use this coding as the digital bearing input signal from Set Z. This information would take the following form for a 12-bit input code:

MSB	1	180°
	2	90°
	3	45°
	4	22.5°
	5	11.25°
	6	5.625°
	7	2.813°
	8	1.406°
	9	0.7031°
	10	0.3516°
	11	0.1758°
LSB	12	0.08799°

Example: 011010010000 = 90° + 45° + 11.25° + 1.406° = 147.66°

The above code appears as presented in the documentation of D/S module manufacturers. For transmission between Set Z and IM it may be desirable to make bit one the least significant bit (LSB) rather than most significant bit (MSB). This format is presently being used with TACAN-XXX and new AQU-11/A HSI. See Section 3.1.11 for further coding details.

Care must be taken in development of Set Z software that digital data never be allowed to change 180° in one step since this could cause a false synchro null, thus placing the bearing pointer 180° from its desired location.

3.1.1.3 Bearing Circuit Design

Figure 3-1 shows a possible circuit configuration for the bearing signal. A serial-to-parallel converter is utilized at the input to translate serial natural binary data into parallel data. If Set Z information is provided in parallel, this converter would not be required. It should be noted that the input signal levels have not yet been determined; level translation circuits may become necessary if the input signal and circuit device types are not compatible.

A shift register will hold the input data until Set Z indicates that the information is complete and ready for transfer. At this time the 12-bit word (minimum number of bits) is shifted into a D/S converter. The converter utilizes a 26 Vac, 400 Hz reference signal and converts the digital angular information into an analog synchro drive output. System accuracy requirements (±0.5) must be met by the converter. Two power amplifiers at the output complete the circuit, with the third output grounded. Care must be taken in grounding that output to ensure that the ground return current does not flow through any of the low-level analog circuit ground paths. See Section 3.1.1.1 for further details on grounding.

3.1.2 Distance Signal

3.1.2.1 Requirements

The IM must convert digital aircraft distance information from Set Z into three sets of analog signals capable of driving the units, tens, and hundreds distance synchros on the indicators described in Table 3-2. One set of three synchro leads is provided for each of the units, tens, and hundreds synchros. These signals are sent to a junction box where they are divided into the number of signals required for each aircraft type to drive the various onboard avionics requiring distance information.

As in the case of bearing information, the IM must be capable of providing the power necessary to drive the worst-case combination of synchro loads. As can be seen in Table 3-2, the HC-130H aircraft requires the largest output load. Its two HSI and two BDHI indicators require a total average output current of 760 mA for each of three outputs.

Further information on the output requirements was provided in Section 3.1.1 relative to the bearing signal. That information is also applicable to distance and will not be repeated here.

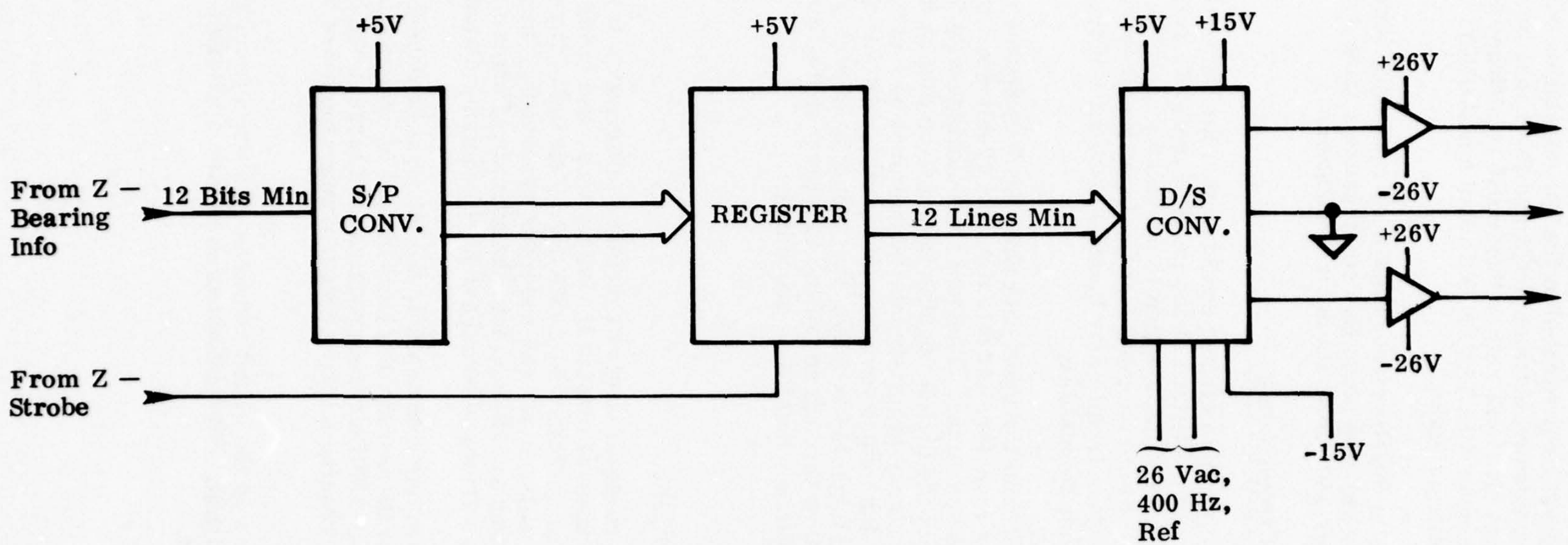


Figure 3-1. Bearing Conversion Circuit

TABLE 3-2. INDICATORS DRIVEN BY GPS DISTANCE SIGNAL

Aircraft	Ind. Type	Synchro Type	Synchro Mfr. P/N	Input Current, (mA)*	Qty	Total Current, (mA)*
HC-130H	HSI AQU-2/A	TR	Clifton CRC-B-A-1	100	2	200
	BDHI ID-1103/ ARN	TR	26V-11TR4C	280	2	560
C-141A	HSI AQU-4/A	TR	Clifton CRC-8-A-1	100	1	100
	BDHI ID-798/ ARN	TR	--	33	3	99
KC-135A	HSI 331A-8H	TR	Clifton CRH-8-A-1L411	~100	2	~200
P-3C	HSI ID-1540A	TR	Clifton CRC-8-A-1	100	3	300
HH-53B/C	BDHI ID-1103/ ARN	TR	26V-11TR4C	280	2	560

*Average current is given; peak is 3 times that value.

Note: Three synchros required; units, tens, and hundreds.

3.1.2.2 Input Coding

The units interface signal will have the following characteristics:

a. Range: 0 to 9 (0° to 360°)

b. Resolution: 0.1 (3.6°)

c. Accuracy: ±0.2 (±7.2°)

d. Scale factor: 36° = 1 numeral

To obtain a resolution of 3.6°, the digital signal provided for the units synchro must contain a minimum of seven bits, as derived by the method shown in Section 3.1.1.2.

The tens and hundreds interface signals will have the following characteristics:

a. Range: 0 to 9 (0° to 360°)

b. Resolution: 1.0 (36°)

c. Accuracy: ±0.2 (±7.2°)

d. Scale factor: 36° = 1 numeral

To obtain a resolution of 36°, the digital signal provided for tens and hundreds must contain a minimum of four bits each, as derived by the previously illustrated method.

The natural binary angular code utilized for bearing information (see Section 3.1.1.2) should also be utilized for distance data. This code would provide units, tens, and hundreds information in a 16-bit digital distance word. The first seven bits of the word would contain units information. This would be followed with two sets of four bits each for tens and hundreds information. If a 16-bit word is used, the extra bit may be utilized for synchronization. This scheme is illustrated below:

MSB	1	
↓		Units
LSB	7	
MSB	8	
↓		Tens
LSB	11	
MSB	12	
↓		Hundreds
LSB	15	

The scale factor conversions (36° = 1 numeral) would be performed by Set Z software. Section 3.1.11 provides further discussion on coding.

3.1.2.3 Circuit Design Considerations

Figure 3-2 shows a possible circuit configuration for the distance signal conversion. As with the bearing signal, a serial-to-parallel converter is utilized to convert serial natural binary data into parallel data. A 16-bit serial input word will be converted into a 16-line parallel output.

Three shift registers will be utilized, one holding seven bits for the units converter and the other two holding four bits each for the tens and hundreds converter. A data-ready line and strobe will control system timing to ensure proper data transfer and conversion.

Three D/S converters are required, each having a minimum accuracy of ±7.2°. One converter must utilize a minimum of seven bits, the other two converters a minimum of four bits each.

Two power amplifiers are required for each converter, and the third output is grounded. As discussed for the bearing signal (Section 3.1.1), care must be taken to ensure proper grounding.

3.1.3 True Airspeed Signal

3.1.3.1 Requirements

The IM must convert analog TAS information from a central air data computer or true-airspeed computer synchro transmitter into a digital signal. The digital TAS signal will be supplied to Set Z, and must be converted from synchro format to digital format by an S/D converter.

3.1.3.2 Output

The TAS input signal to the IM for the C-141A aircraft will have the following characteristics:

a. Range (worst case): 100 to 650 knots

b. Resolution: 1 knot

c. Accuracy: ±4 knots

To obtain a resolution of one knot, S/D conversion must utilize a minimum of 10 bits (see derivation method, Section 3.1.1.2).

As previously stated, natural binary angular coding is utilized by the majority of manufacturers of S/D converters. It would therefore be cost effective to use this coding for the TAS digital signal sent to Set Z.

A scale factor of 36° of synchro rotation per 100 knots is utilized for all aircraft except the HH-53B/C helicopter, for which the scale factor has not been determined.

Electrical zero – the system TAS indicated by the TAS synchro when it is at its zero position – is different in several aircraft. The TAS information must be adjusted so that Set Z can perform its required computations for all aircraft. This

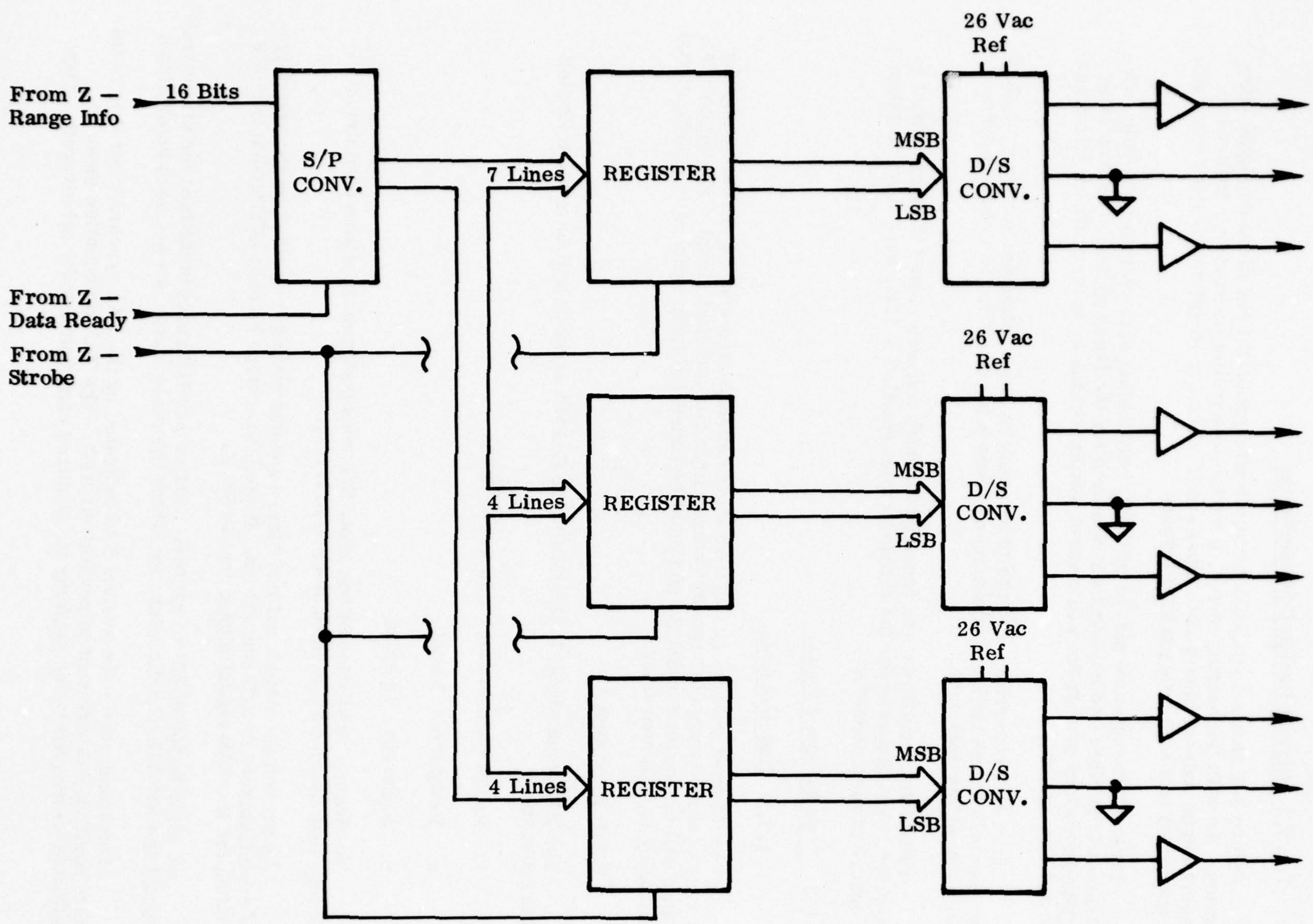


Figure 3-2. Range Data Circuit

means that the scale factor must be changed for the helicopter, and electrical zero set properly on all aircraft. These adjustments are to be handled (per COTR direction) by the IM hardware. Table 3-3 provides an example of the adjustments required.

3.1.3.3 Circuit Considerations

Figure 3-3 shows a possible circuit configuration for TAS conversion. The three-line synchro information is fed into an S/D converter (10-bit minimum). A process inhibit signal from Set Z will hold data in the S/D converter until the set is ready to receive the data. While processing is taking place, a converter-busy signal is sent to Set Z for synchronizing purposes. At the proper time, parallel data from the S/D converter is sent to a buffer register where it is held until a strobe signal from Set Z allows it to be transmitted from the IM to Set Z.

As Figure 3-3 indicates, the digital data is sent from the IM in parallel to Set Z. The most desirable data format, serial or parallel, to Set Z cannot be determined at this time since the set's input/output format structure has not yet been decided upon by the manufacturer. If a serial format is more desirable, then a parallel-to-serial converter must be added to the output circuit in the IM.

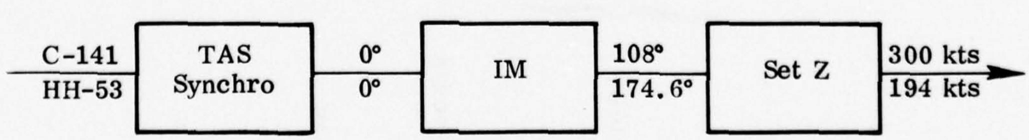
No adjustment circuitry has been shown on this schematic. A prescaled counter can be used for the setting of electrical zero constants, and a read-only memory (ROM) for the required scale factor change.

Output IM logic levels must also be made compatible with the Set Z input circuits.

TABLE 3-3. TAS COMPUTATION ADJUSTMENTS FOR GPS

Aircraft	Synchro System Electrical Zero (degrees/knots)	Scale Factor (degrees/knot)	Set Z Software Scaling	TAS (knots)	IM Output (degrees)
C-141	0/300	36/100	0° = 0 knots	300	108 (0100110011)
HH-53B/C	0/194	90/100*	0° = 0 knots	194	174.6 (0111110001)

System Operation:



*Assumed

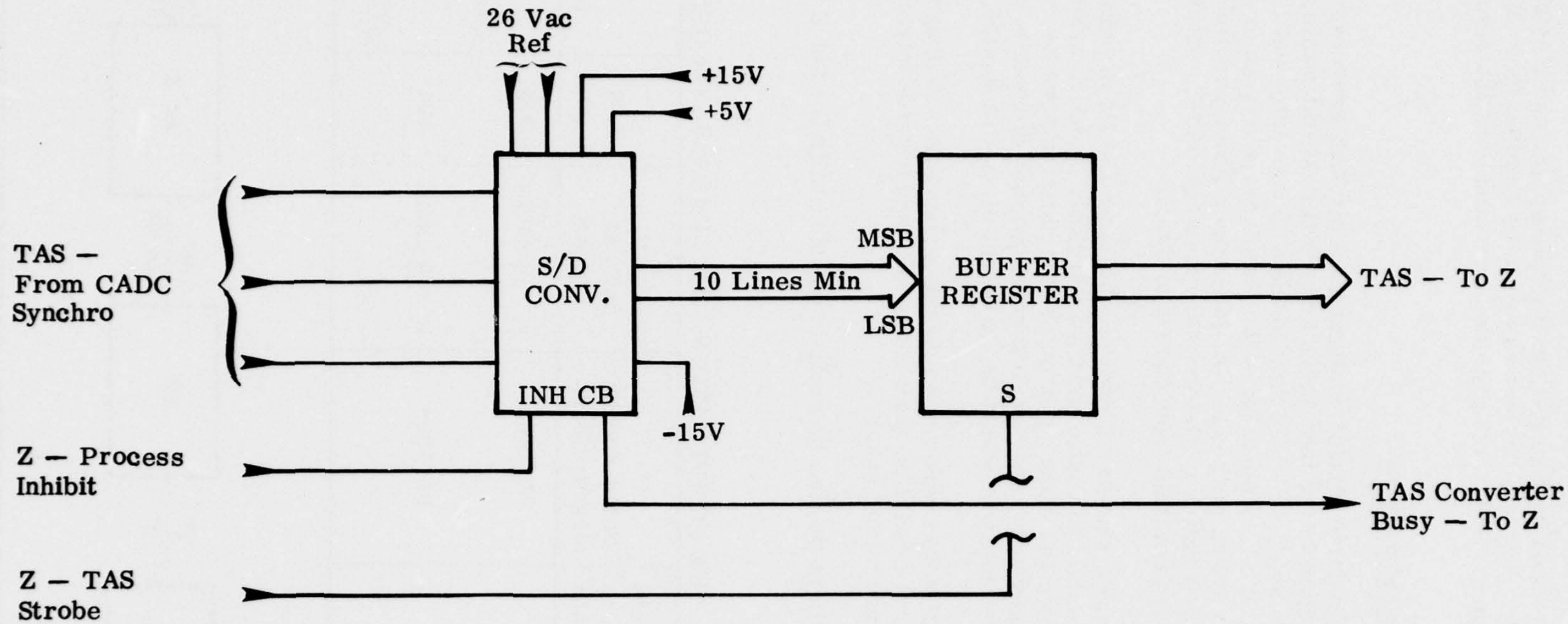


Figure 3-3. True Airspeed (TAS) Data Circuit

3.1.4 Magnetic Heading

3.1.4.1 Requirements

The IM must convert analog magnetic heading information from the magnetic compass synchro transmitter into a digital signal. The digital magnetic heading signal will then be supplied to Set Z.

3.1.4.2 Output

The magnetic heading interface signal will have the following characteristics:

a. Range: 0° to 360°

b. Resolution: 0.1°

c. Accuracy: ±0.5°

To obtain a resolution of 0.1°, the S/D conversion must utilize a minimum of 12 bits (see Section 3.1.1.2).

As with TAS information, binary angular coding will be used. There is no scale factor problem for magnetic heading since the analog and digital signal are both in degrees.

3.1.4.3 Circuit Design Considerations

Figure 3-4 shows a possible circuit configuration for magnetic heading. The circuit used for magnetic heading will be basically the same as for TAS (see Section 3.1.3.3).

3.1.5 Altitude Signal

3.1.5.1 Requirements

The IM must transfer encoded altitude data from the test aircraft's altitude encoding device such as a CADC or encoding altimeter.

3.1.5.2 Output Coding

The encoded altitude information received by the IM will contain 10 bits of digital data, encoded to conform with the U.S. National Standard for the Air Traffic Control Radar Beacon System (ATCRBS).

The altitude signal will have the following characteristics:

a. Range: -1000 to +60,000 feet

b. Resolution: 100 feet

c. Accuracy: ±100 feet

d. Scale factor: 10 bits

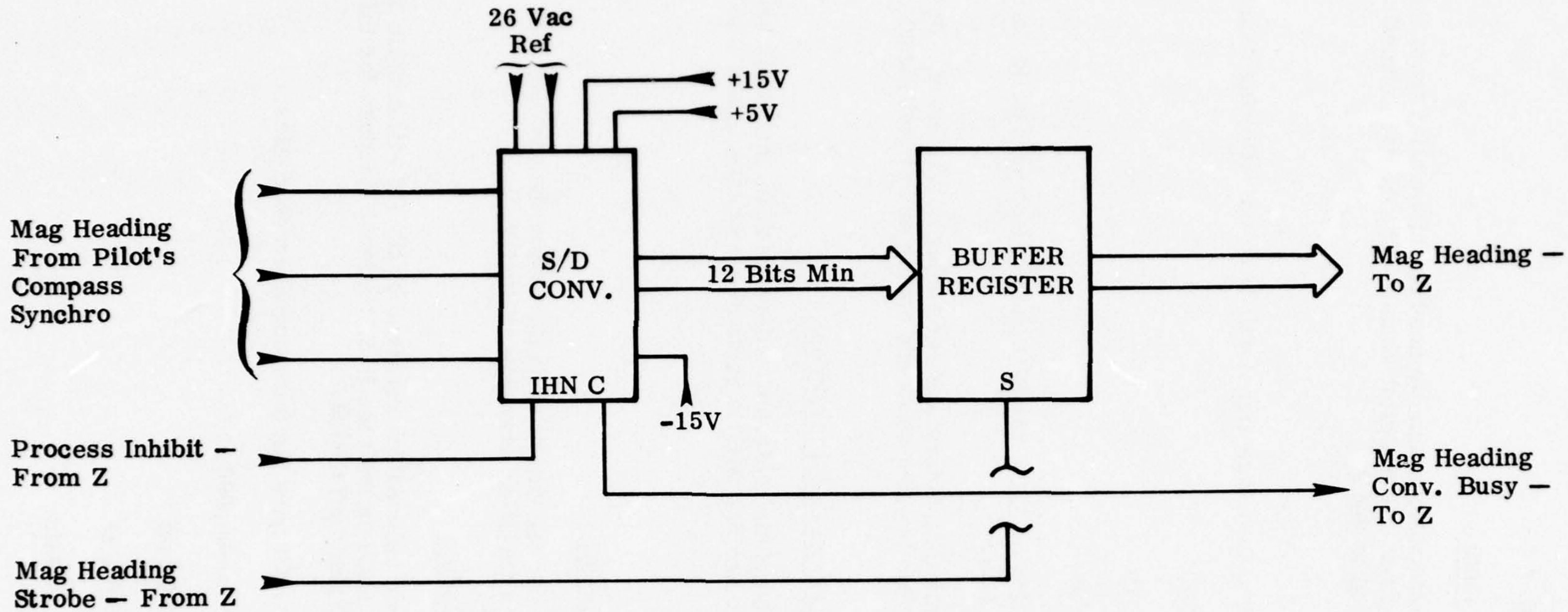


Figure 3-4. Magnetic Heading Data Circuit

3.1.5.3 Circuit Design Considerations

Figure 3-5 shows a possible circuit configuration for encoded altitude. The circuit is a buffer register that receives the encoded altitude in parallel form, then buffers the signal and holds the information until a strobe signal is received from Set Z.

This design cannot be finalized until the internal structure of Set Z is determined. Some factors that must be considered in a final design are:

a. Parallel or serial input to Set Z

b. Signal voltage levels

c. Whether the IM should change coding structure before the signal is sent to Set Z

d. Protection of IFF input in case of IM failure.

3.1.6 Course Set Signal

3.1.6.1 Requirements

The IM must convert analog course data from the pilot's HSI course set resolver into a digital signal. The digital course set signal will be supplied to Set Z where it will be used for deviation and to-from calculations.

3.1.6.2 Output Coding

The course set signal will have the following characteristics:

a. Range: 0° to 360° (sine and cosine)

b. Resolution: 0.1°

c. Accuracy: ±0.5°

To obtain a resolution of 0.1°, the resolver-to-digital converter (R/D) must utilize a minimum of 12 bits (see Section 3.1.1.2).

As with all the other conversions previously described, natural binary angular coding will be utilized. No scale factor problems should be encountered since the analog and digital signal are both in degrees and do not vary from aircraft to aircraft.

3.1.6.3 Circuit Design Considerations

Figure 3-6 shows a possible circuit configuration for course set conversion. This circuit will be basically the same as for TAS (ref. Section 3.1.3.3), the only difference being that an R/D rather than an S/D converter is used.

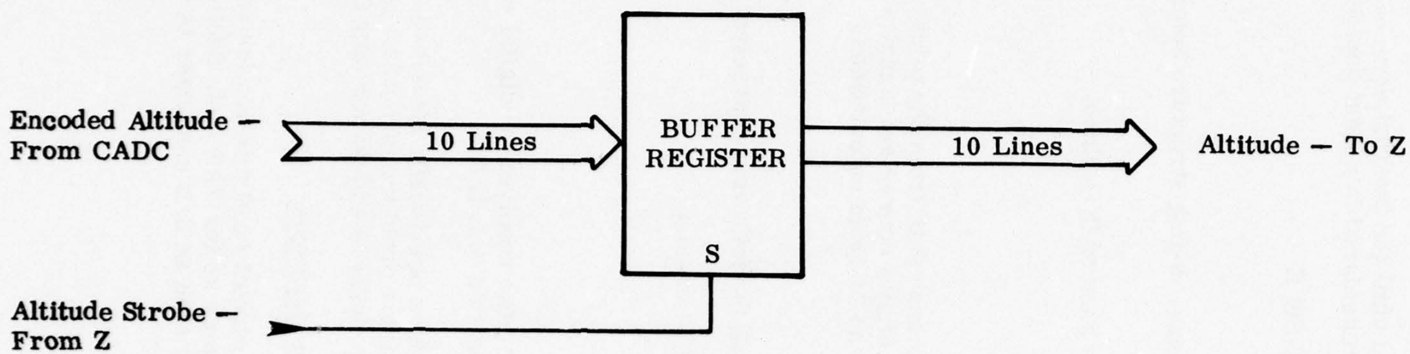


Figure 3-5. Altitude Data Circuit

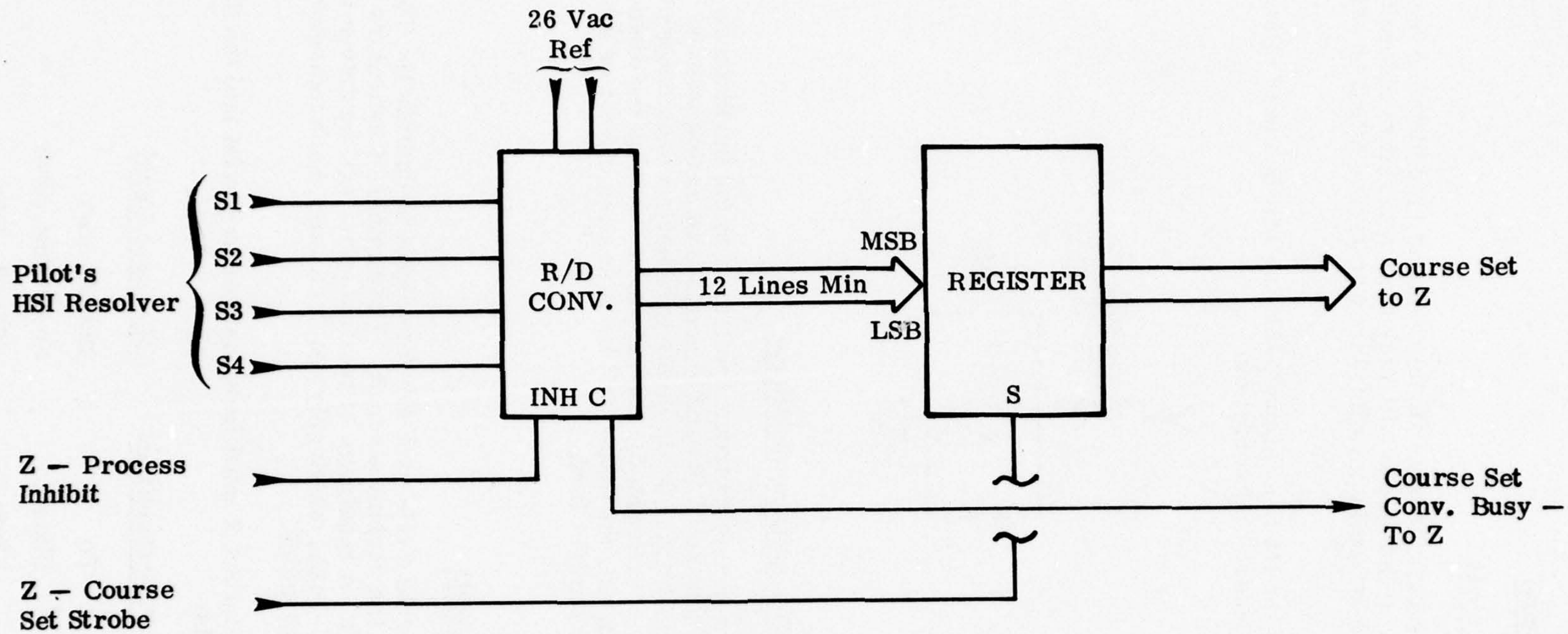


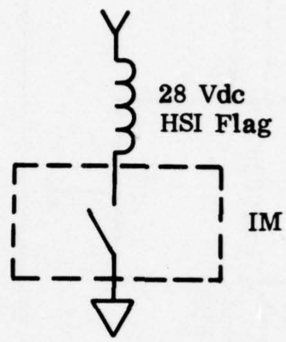
Figure 3-6. Course Set Data Circuit

3.1.7 Distance Flag Signal

3.1.7.1 Requirements

The IM must generate a discrete signal to operate the distance flag on various indicators. The number of indicators will vary from aircraft to aircraft. A maximum of four indicators will be driven in parallel; this worst-case situation will be on the HC-130H aircraft.

When the output of the IM is at ground, the flag will be out of view. The following diagram shows the required IM operation.



3.1.7.2 Circuit Design Considerations

Figure 3-7 shows a possible circuit configuration for the distance flag signal. A discrete logic signal from Set Z is used to activate an analog switch. When the input signal is at the proper level (logic levels have not yet been determined), the output will be grounded, completing the HSI circuit and driving the distance flag out of view. When not grounded, the output will be in an open circuit or a high impedance state, and will not allow current flow.

3.1.8 To-From Signal

3.1.8.1 Requirements

The IM must generate a tri-level discrete signal to operate the To-From indicator on the HSIs in the various aircraft. The number of indicators will vary from aircraft to aircraft. A maximum of two indicators will be driven in parallel on all aircraft except the C-141A, which only requires one. Each indicator will present a load resistance of 200Ω ± 25%.

A digital signal from Set Z must be translated by the IM into the following discrete output signal levels:

Flag Condition	IM Output Signal
To	225 uA, max
Blank	No current (Gnd)
From	-225 uA, max

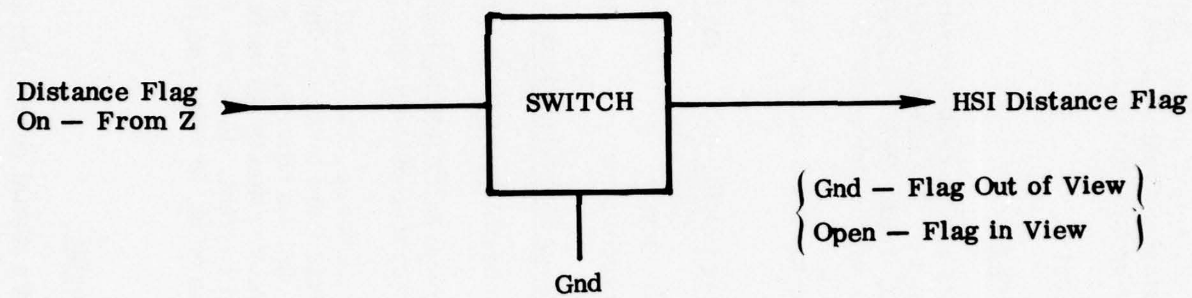


Figure 3-7. Distance Flag Circuit

3.1.8.2 Circuit Design Considerations

Figure 3-8 shows a possible circuit configuration for the To-From flag signal. Digital information from Set Z will be decoded by the logic circuit. For purposes of this design, it has been assumed that two parallel bits of information will be provided.

At the proper time, the output of the logic circuit will turn on one of the three output circuits. Two constant current sources will provide the output with a current of the proper level for one or two loads, and a switch will place the output at ground.

3.1.9 Deviation Flag Signal

3.1.9.1 Requirements

The IM must generate two discrete signals to operate the deviation flag signal on various aircraft equipment. The number of flag circuits will vary among the five aircraft types. For the KC-135A, P-3C, and HH-53B/C aircraft, a maximum of three parallel 1000Ω loads will be driven by the output.

A digital signal from the Set Z must be translated by the IM into the following discrete output signals:

Flag Condition	IM Output Signal
In view	No current
Out of view	245 uA

3.1.9.2 Circuit Design Considerations

Figure 3-9 shows a possible circuit configuration for the deviation flag signal.

Digital information from Set Z will be furnished to an OR gate and used to turn on or off an output current source of the proper level.

For the purpose of this design, two parallel bits of information are being provided by Set Z. One discrete logic level will indicate that the course setting on the pilot's HSI is not correct, and the other signal will indicate that the computed deviation (cross-track error) information is not valid. Either of these signals will result in the output signal of zero current. If neither of these signals is true, the output will be a constant 245 uA in order to drive the flag out of view.

3.1.10 Deviation Signal

3.1.10.1 Requirements

The IM must convert a digital course deviation signal from Set Z into an analog output signal indicating the distance in nautical miles that the aircraft is displaced to left or right of the desired track. A maximum of five parallel 1000Ω loads will be driven by the output, a worst case condition occurring on the HC-130H aircraft.

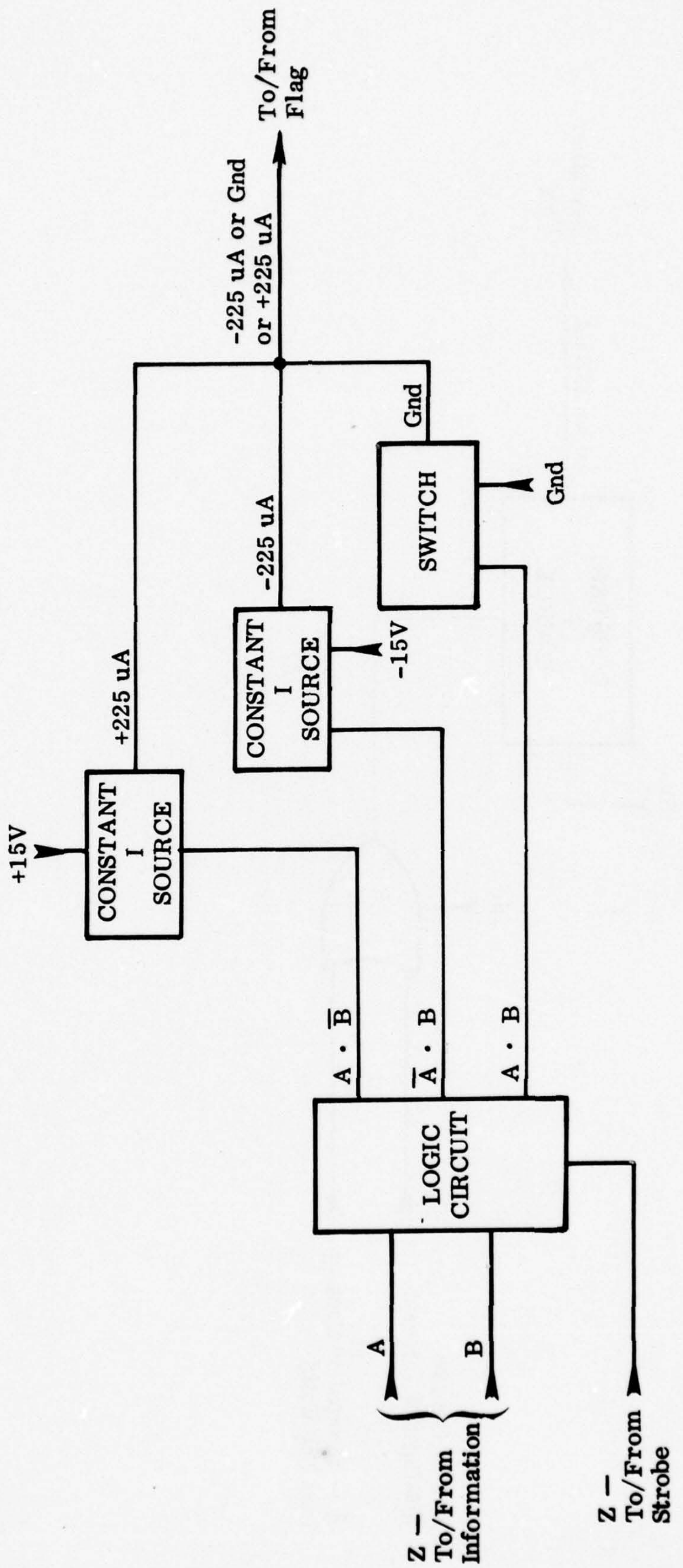


Figure 3-8. To-From Flag Circuit

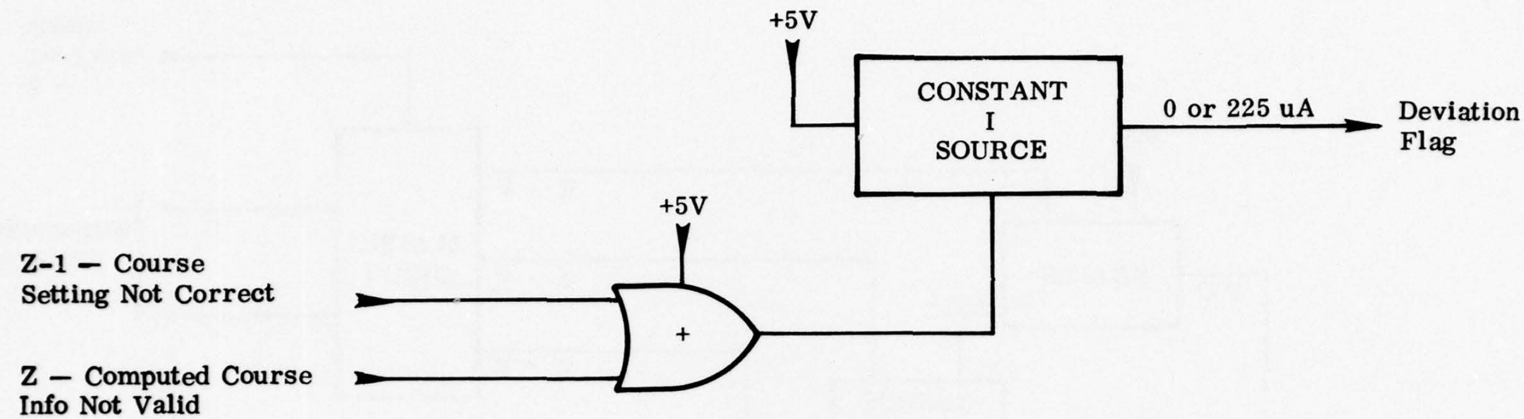


Figure 3-9. Deviation Flag Information

3.1.10.2 Output Coding

The deviation output signal from the IM will have the following characteristics:

a. Range: 0 to ±150 uA

b. Resolution: ±3 uA

c. Accuracy: ±10 uA

To obtain a resolution of 3 uA, the digital information from Set Z must contain a minimum of six bits (see Section 3.1.1.2).

Another bit containing polarity information would also be required. Therefore a total of seven bits is needed to form the complete deviation data word.

The aircraft's flight phase will determine the deviation sensitivity. The full scale deflection of 150 uA will indicate the total deviations as shown below:

a. Enroute = ±6 nm

b. Terminal = ±1.0 nm

c. Approach = ±0.1 nm

Changes in sensitivity are controlled by the pilot's operation of Set Z control display unit. Sensitivity conversion can be handled by the Set Z software or by a scale factor change in the IM. For the IM to make this change, a minimum of two bits of Set Z-generated logic signals, indicating the proper scale factor, would be required. For purposes of this report, it has been assumed that the Set Z software will handle the change in sensitivity.

No particular input code has yet been determined, but binary or BCD appear the most likely choice.

3.1.10.3 Design

Figure 3-10 shows a possible circuit configuration for the deviation signal. Digital information from Set Z (seven parallel input lines are assumed) is processed by a D/A converter into an analog signal of the proper scale and polarity. The analog signal is then converted into a constant current of the proper magnitude to drive the deviation interface circuits in the aircraft avionics system.

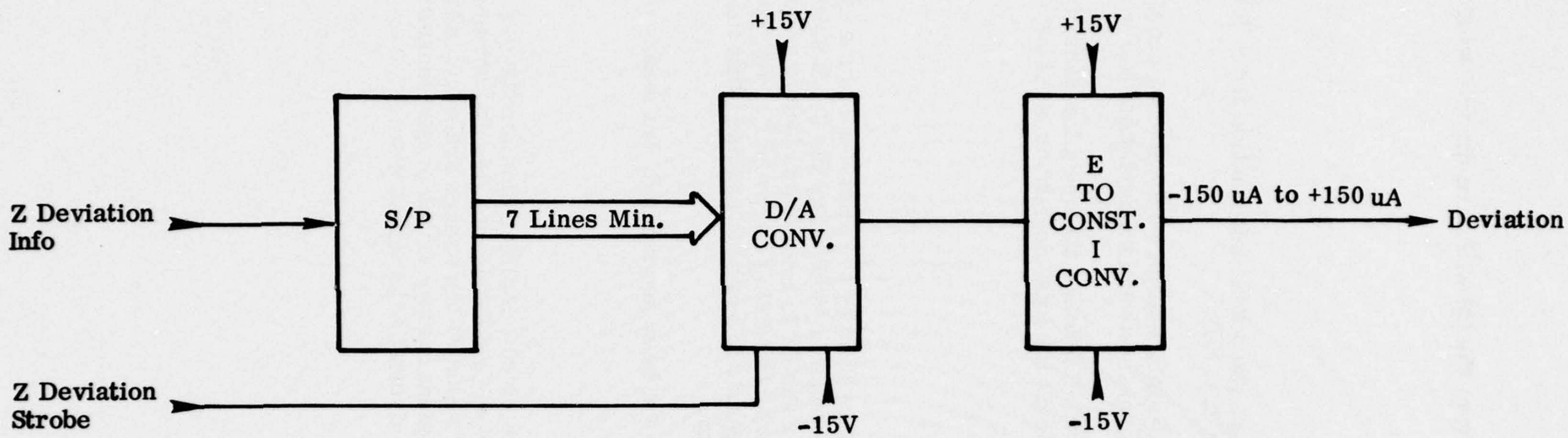


Figure 3-10. Deviation Circuit

3.1.11 Digital Word Structure and Multiplexing

One of the primary purposes of the IM, as presently conceived, is to provide the circuitry required for the Set Z digital output to drive existing TACAN synchro-type displays. If, at some future time, displays are incorporated that accept digital information directly, an IM may not be required if Set Z output coding is now chosen judiciously.

A digital-type display presently under development is the AQU-11/A horizontal situation indicator. This HSI will accept a 32-bit serial word, and all information to the indicator will be time multiplexed over a two-wire system. The distance and bearing word formats utilized by the AQU-11 are shown in Figure 3-11.

Besides the word formats described above, voltage levels, bit rates, clocking methods, and other parameters, as described in ARINC Specification 419, Digital Data System Compendium, must be properly chosen before compatibility can be achieved.

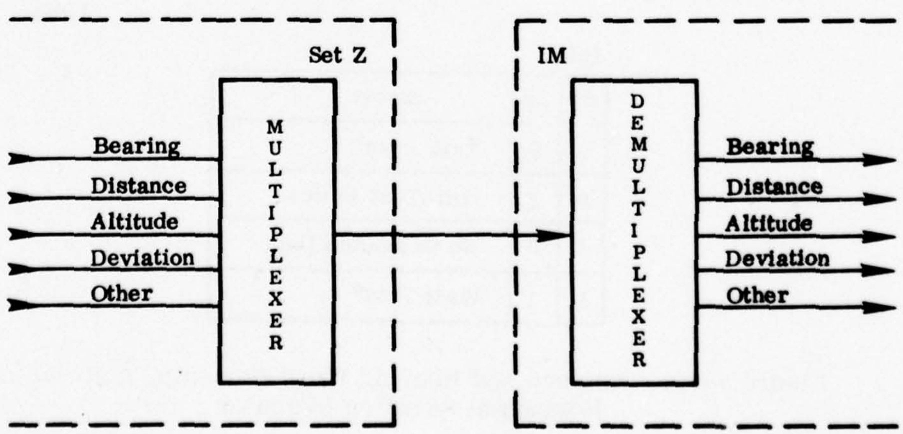
The preliminary specification for the AQU-11 does not specify a Specification 419 code, but such a code has been generated in this study by reviewing the specification and making some basic assumptions. Because of the assumptions, the code does not necessarily represent the final code required, but is presented here to provide the reader with some knowledge of what a Set Z code may entail. The possible 419 code is:

ABB-BBX/CBCC/FBCB/BCCC

Coding details are provided in ARINC Specification 419.

It should be noted that there is a difference in the word formats described in this section and that described in earlier sections of 3.1. The reason is that, to utilize the structure described in this section, a basic design decision must have already been made — namely, that a time-multiplexed serial word will be utilized in transmitting data from Set Z to the IM.

Time division multiplexing is a method of combining the signals of several lines and transmitting them over one line on a time shared basis, as illustrated below.



a. Distance Format

32-31	30-29	28 - 25	24 - 21	20 - 17	16 - 13	12 - 9	8 - 1	Bit No.
Status	100's	10's	1's	1/10's	1/100's	Pad	Label	

Example:

257.86 nm	0010	0101	0111	1000	0110	000	10001001
	2	5	7	8	6	—	Distance Label

Bit

32	31	Status
0	0	Valid Data (+)
0	1	Self-Test Failure
1	0	No Computed Data
1	1	(-)

b. Bearing Format

32 - 29	28 - 25	24 - 21	20 - 18 17	16 - 13	12 - 9	8 - 1
Parity Status 180.0000 90.0000	45.0000 22.5000 11.2500 5.6250	2.8125 1.4062 0.7031 0.3516	0.1757 0.0878 0.0439 Pad	→	→	Label →

Example:

251.7187°	0010	1100	1100	0000	0000	0000	01001001
							Bearing Label

Bit

31	30	Status
0	0	East <180°
0	1	Self-Test Failure
1	0	No Computed Data
1	1	West >180°

Figure 3-11. Distance and Bearing Word Formats, AQU-11/A Horizontal Situation Indicator

A multiplexer is a device for combining signals, and a demultiplexer is one used that separates them. Multiplexing may be utilized not only for the Set Z-to-IM interface, but as a method of combining signals within the IM. Thus it could be used to reduce the number of S/D and D/S converters required. Figure 3-12 shows one multiplexing scheme that could be utilized by the IM.

While multiplexing can be used to reduce the number of converters required, the cost of the additional circuitry needed for multiplexing must be considered. Obviously, as the number of converters saved is increased, multiplexing becomes more attractive. The maximum permissible multiplexer error and conversion rate must also be considered.

TACAN-XXX, another navigation device under development, utilizes a 32-bit coding. Specific details on this device were not available at this writing since the device is undergoing source selection.

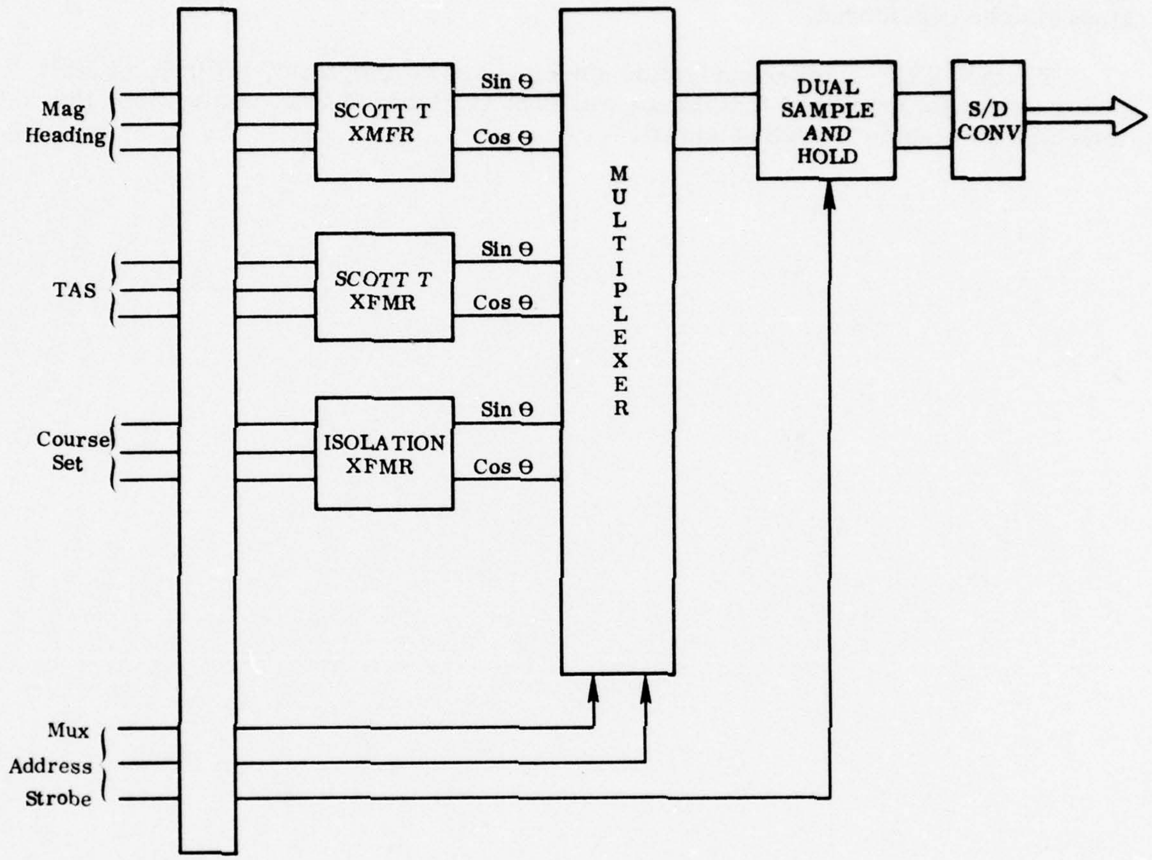


Figure 3-12. Multiplexing of IM Synchro Inputs

3.2 MARKET SURVEY

A limited market survey was made to determine the availability, size, cost and power requirements of D/S and S/D converters that could be purchased off the shelf.

The following companies were contacted by ARINC Research regarding D/S, S/D, D/A, and A/D modules:

Company	Person Contacted
Analog Devices, Inc. Norwood, Mass.	E. Cordovin
Data Device Corporation Bohemia, L.I.	B. Wille
North Atlantic Industries Plainview, N.Y.	H. Nelson
Transmagnetics, Inc. Farmingdale, N.Y.	G. Comeau

Of the companies surveyed, Data Device Corporation (DDC) was found to have the greatest amount of printed information on the subject device types.

In addition to its converter modules, DDC manufactures three different types of power amplifier that can be used "off the shelf". One of these devices, the D-42, can meet (although marginally) all current requirements for the Integration module. No definitive data were obtained from the other manufacturers on their power amplifiers.

The following price and size information is for DDC-manufactured devices, and will be used in subsequent cost and size discussions for the IM.

a. DDC type EDSC and EDRC converters (D/S)

Size: 3.125" x 2.625" x 0.82"

Unit Cost: $610

b. DDC type ESDC and ERDC converters (S/D)

Size: 3.125" x 2.625" x 0.82"

Unit Cost: $725

c. DDC type D-42 synchro driver (amplifier)

Size: 2.4" x 2.8" x 0.71"

Unit Cost: $150

3.3 IM MAJOR COMPONENT POWER REQUIREMENTS

The following analysis was performed to obtain the approximate power requirements for implementing the design described in this study.

3.3.1 Distance and Bearing

3.3.1.1 Output Current

Worst case is for the HC-130H aircraft.

a.	Bearing outputs =	2 HSI CT @ 21 mA ea	=	42 mA
		2 BDHI TR @ 280 mA ea	=	560 mA
				602 mA
b.	Distance outputs =	2 HSI TR @ 100 mA ea	=	200 mA
	(1 of 3)	2 BDHI TR @ 280 mA ea	=	560 mA
				760 mA

c. $I_O(avg) = 602\text{ mA} + 3(760\text{ mA}) = 2.88A$

d. $I_O(peak) = (2.88A)(3) = 8.65A$

3.3.1.2 Device Current Requirements

a. Four D/S converters (assumed values for DDC-type EDSC)

+15V: (50 mA/ea)(4) = 200 mA
-15V: (50 mA/ea)(4) = 200 mA
+5V: (50 mA/ea)(4) = 200 mA

b. Eight D-42 amplifiers (quiescent currents, I_Q; increased power dissipation with load increase has been neglected)

+26V: (100 mA/ea)(8) = 800 mA
-26V: (100 mA/ea)(8) = 800 mA

c. Seven miscellaneous digital devices

4 @ +5V:	(10 mA/ea)(4) =	40 mA
2 @ +5V:	(30 mA/ea)(2) =	60 mA
1 @ +5V:	100 mA/ea =	100 mA
	+5V =	200 mA

3.3.1.3 Total Bearing and Distance Power

Bearing and distance power requirements for the IM are calculated as follows:

$$P_{BD(+5V)} = (0.4A)(5V) = 2W$$

$$P_{BD(+15V)} = (0.2A)(15V) = 3W$$

$$P_{BD(-15V)} = (0.2A)(15V) = 3W$$

For the $\pm26V$ sources, P_{BD} is found by:

$$P_{BD} = P_Q + P_O \tag{3-1}$$

where P_Q is the quiescent power and P_O the output power, found respectively (equations 3-2 and 3-3) as follows:

$$P_Q = E_{26} I_Q \tag{3-2}$$

From Section 3.3.1.2b, I_Q = 800 mA or 0.8A, yielding

$$P_Q = (26V)(0.8A) = 20.8W$$

$$P_O = E_O I_O (0.5) \tag{3-3}$$

E_O has one of the standard values for synchro drives, 11.8V; and, from Section 3.3.1.1, $I_O(avg)$ = 2.88A and $I_O(peak)$ = 8.65A. The value 0.5 represents a 50% duty cycle, since each supply must provide output current for half the output sine wave. Thus,

$$P_O(avg) = (2.88A)(11.8V)(0.5) = 17W$$

yielding, from equation 3-1,

$$P_{BD}(avg) = 20.8W + 17W = \underline{37.8W}$$ for each of the $\pm26V$ sources

Similarly,

$$P_O(peak) = (8.65A)(11.8V)(0.5) = 51W$$

$$P_{BD}(peak) = 20.8W + 51W = \underline{71.8W}$$ for each of the $\pm26V$ sources

3.3.2 Other Devices

The following calculations take into consideration the current for the circuitry required to provide the remaining interface signals:

a. Three S/D converters (assumed for DDC-type EDSC)

+15V: (75 mA/ea)(3) = 225 mA
-15V: (50 mA/ea)(3) = 150 mA
+5V: (400 mA/ea)(3) = 1200 mA

b. One D/A converter (assumed for DDC-type SDAC)

+15V: 25 mA
-15V: 30 mA
+5V: 15 mA

c. Ten miscellaneous digital devices (assumed)

+5V: (35 mA/ea)(10) = 350 mA

d. I_{Total}

+15V: 250 mA
-15V: 180 mA
+5V: 1565 mA

3.3.3 Total IM Power Requirement

The total power (P_T) requirement for the IM is that needed to provide the +5V, +15V, -15V, +26V, and -26V sources:

$$P_{+5V} = (1.965A)(5V) = 9.8W, \quad (I_T = I_{BD} + I_{other\ devices})$$

$$P_{+15V} = (0.45A)(15V) = 6.8W$$

$$P_{-15V} = (0.38A)(15V) = 5.7W$$

$$P_{+26V}(avg) = P_{-26V}(avg) = 37.8W$$

$$P_{+26V}(peak) = P_{+26V}(peak) = 71.8W$$

yielding

$$P_T(avg) = 9.8W + 6.8W + 5.7W + 37.8W + 37.8W = \underline{97.9W}$$

$$P_T(peak) = 9.8W + 6.8W + 5.7W + 71.8W + 71.8W = \underline{166W}$$

3.3.4 Conclusions

The majority of the power used in the IM is for driving aircraft indicators with bearing and distance information. Since the IM will be common to all aircraft in this study, it must be able to meet the power requirements of the worst case situation – in this case, presented by the HC-130H aircraft.

3.4 MAJOR COMPONENT COSTS FOR IM

Table 3-4 itemizes the approximate cost (in small quantities) of the major components required to implement the design considerations described in this study. Pricing data for the S/D and D/S converters and the power amplifiers were obtained from Data Devices Corporation. All other prices are approximate, and were obtained from engineering catalogs.

TABLE 3-4. COST OF MAJOR COMPONENTS OF IM

Component	Qty Per IM	Unit Cost ($)	Total Cost ($)
D/S Converter (DDC type ESDC-L-1)	4	610	2440
S/D Converter (DDC type ESDC-L-1)	3	725	2175
Amplifier (DD type D-41)	8	150	1200
D/A Converter	1	270	270
S/P Converter	3	20	60
Buffer Register	8	8	64
Misc. Dig. Ckts.	6	1	6
TOTAL			$6215

3.5 IM SIZE REQUIREMENTS

The packaging size requirements for the IM are based on many considerations other than the actual circuit design itself. Following are some of the packaging-size factors that remain to be resolved:

a. Actual versus specified available space and mounting location

b. Thermal conditions

c. Use of off-the-shelf converter modules vs. custom-designed circuits

d. Actual versus specified load requirements

e. Exact input interface-signal conditioning required of the IM

f. Required input/output connectors

g. Mounting proximity to Set Z and load

h. Power requirements (internal versus external)

i. Environmental conditions

j. Maintainability

It would be difficult at this time to specify an exact size for the IM without having resolved all or most of these areas of concern. However, based on the design concepts thus far advanced in this study, it appears desirable to package the IM separately and mount it external to Set Z. A safe estimate at this time is that the IM will not be any larger than the present 161B-1 TACAN coupler, which measures 10-1/16" L x 5" W x 6-1/8" H, even though the IM is a much more versatile piece of group A equipment.

3.6 IMPACT OF IM ON SET Z DESIGN

The IM must interface with and receive power, timing, and synchronization signals from Set Z. These factors will impact on the design of both Set Z and the IM, as discussed in the following paragraphs.

3.6.1 *Power Requirements*

Set Z will be required to furnish the IM, as a minimum, the input dc power determined in Section 3.3 and restated below:

+15 Vdc = 6.8W
-15 Vdc = 5.7W
+5 Vdc = 9.8W
+26 Vdc = 37.8W (avg), 71.8W (peak)
-26 Vdc = 37.8W (avg), 71.8W (peak)

These input levels dictate a power supply capable of supplying, as a minimum:

P_T(avg) = 97.9W

P_T(peak) = 166W

3.6.2 Set Z to IM Interface

The Set Z to IM interface signals are summarized in Table 3-5, which outlines the specific type, format, and signal level requirements assumed in this report. Sections 3.1.1 through 3.1.11 described these signals and alternatives in detail; Table 3-5 references the appropriate discussion.

As has been discussed, many decisions regarding interfacing must be made before the final design of the IM can be undertaken. These decisions are generally concerned with:

a. Parallel or serial formats

b. Digital coding formats

c. Signal voltage levels

d. Software or hardware changes for aircraft variations

To make these decisions, IM designers must work closely with the manufacturers of Set Z and with Air Force personnel to ensure that the most cost effective and technically sound approach is undertaken. That approach might necessitate that some IM design concept other than that described in this section be adopted. Possible alternative concepts are discussed in the next section.

TABLE 3-5. REQUIRED SET Z-TO-IM INTERFACE SIGNALS (Sheet 1 of 2)

Signal	Type	Format	Signal Level	Reference Section
A. IM INPUTS FROM SET Z				
Bearing Info.	Digital Word	Serial, 12 bit min., natural binary angle	T^2L or DTL (TBD)	3.1.1.2 & 3.1.1.3
Bearing Strobe	Discrete	1 bit		3.1.1.2 & 3.1.1.3
Distance Info.	3 Digital Words	Serial, 16 bits, natural binary angle		3.1.2.2 & 3.1.2.3
Distance Strobe	Discrete	1 bit		3.1.2.2 & 3.1.2.3
TAS Process Inhibit	Discrete			3.1.3.3
TAS Strobe	Discrete			3.1.3.3
Magnetic Head Process Inhibit	Discrete			3.1.4.3
Magnetic Head Strobe	Discrete			3.1.4.3
Altitude Strobe	Discrete			3.1.5.3
Distance Flag On	Discrete			3.1.7.2
Course Set Process Inhibit	Discrete			3.1.6.3
Course Set Strobe	Discrete			3.1.6.3
Course Setting Not Correct	Discrete			3.1.9.2
Course Setting Not Valid	Discrete	1 bit		3.1.9.2
Deviation Info.	Digital Word	Serial, 7 bits, binary or BCD		3.1.10.2
Deviation Strobe	Discrete	1 bit	T^2L or DTL (TBD)	3.1.10.2

TABLE 3-5. (Sheet 2 of 2)

Signal	Type	Format	Signal Level	Reference Section
A. IM INPUTS FROM SET Z (Cont)				
To-From Info.	Digital Word	Parallel, 2 bits, binary	T^2L or DTL (TBD)	3.1.8.2
To-From Strobe	Discrete	1 bit	↓	3.1.8.2
B. SET Z INPUTS FROM IM				
TAS	Digital Word	Parallel, 10 bit min., natural binary angular	↓	3.1.3.2* & 3.1.3.3
TAS Converter Busy	Discrete	1 bit		3.1.3.3
Magnetic Head	Digital Word	Parallel, 12 bit min., natural binary angular		3.1.4.2 & 3.1.4.3
Magnetic Head Converter Busy	Discrete	1 bit		3.1.4.3
Altitude	Digital Word	Parallel, 10 bits, U.S. Standard ATCRBS		3.1.5.2 & 3.1.5.3
Course Set	Digital Word	Parallel, 12 bits, min., natural binary angular	↓	3.1.6.2 & 3.1.6.3
Course Set Converter Busy	Discrete	1 bit	T^2L or DTL (TBD)	3.1.6.3

*The need for a scale factor change is discussed in Section 3.1.3.2.

4
ALTERNATE IM CONFIGURATIONS

In addition to the IM conceptual design described in Section 3, several other configurations could provide an effective interface between Set Z and the host vehicle avionics. Table 4-1 presents a comparison of four possible configurations, each taking into account the following considerations:

a. IM cost

b. Integration costs

c. Set Z constraints on IM

d. IM impact on Set Z

e. Host vehicle constraints on IM

f. IM impact on host vehicle

g. Integration feasibility and desirability

h. All other constraints and limitations listed in Table 1-1.

Limiting the costs involved for the integration task, including the cost of the IM, is considered one of the primary objectives of this study. Therefore the various configurations in Table 4-1 are listed in order of cost (and complexity), with Configuration A being the most economical and Configuration D the most costly. The Function column lists the input and output signals that could be feasibly interfaced with Set Z and host vehicle. The functions output to the host vehicle are listed first (1-16), followed by the functions input to Set Z (17-20). Configuration C is that IM design discussed in detail in this report. Configuration A and B are variations of C that provide less capability. Configuration D extends the capabilities of Configuration C to interface as many Set Z navigation functions with the host vehicle as is reasonably possible without making the IM a digital data processor.

An important consideration that directly affects the complexity of each configuration is the load factor, which represents the quantity and types of load devices (HSIs, BDHIs, etc.) that each particular IM configuration is expected to drive. Therefore, in addition to the four different configurations presented in Table 4-1, variations within these configurations depend upon the load factor.

Each configuration is discussed in the following paragraphs.

TABLE 4-1. IM CONFIGURATION COMPARISONS

Function	Configurations			
	A Austere	B Budget	C Composite	D Deluxe
a. OUTPUT TO HOST VEHICLE				
1. Bearing	Yes (Low Accuracy, 2.5°)	Yes (Low Accuracy, 2.5°)	Yes (High Accuracy, 0.5°)	Yes (High Accuracy, 0.5°)
2. Distance, Units	No	Yes	Yes	Yes
3. Distance, Tens	No	Yes	Yes	Yes
4. Distance, Hundreds	No	Yes (0-1)	Yes (0-9)	Yes (0-9)
5. Distance Flag	No	Yes	Yes	Yes
6. Deviation Course (Plus Bank Steering)	Yes	Yes	Yes	Yes
7. Deviation Flag	Yes	Yes	Yes	Yes
8. To-From	Yes	Yes	Yes	Yes
9. Vertical Deviation (Plus Pitch Steering)	No	No	No	Yes
10. Vertical Dev. Flag	No	No	No	Yes
11. Desired Track	No	No	No	Yes
12. Track Angle Error (Ground Track)	No	No	No	Yes
13. True Heading	No	No	No	Yes
14. Altitude	No	No	No	Yes
15. Mag/True Warning	No	No	Yes	Yes
16. Degraded Mode Warn.	No	No	Yes	Yes
b. INPUT TO SET Z				
17. Course Set	No	Yes	Yes	No
18. Magnetic Heading	No	Yes	Yes	Yes
19. True Airspeed	No	No	Yes	Yes
20. Altitude	No	No	Yes	Yes

4.1 CONFIGURATION A

Configuration A presents a "bare-bones" approach to the interface task. Only two primary navigation functions are output from Set Z to the IM for display on the host vehicle avionics – bearing and deviation (or cross-track) error. The two functions would provide the pilot with a rudimentary display of the navigation situation on his primary flight instruments. Unfortunately these instruments require considerable manual updating of heading and desired course to coordinate their displays with the output signals. Without a magnetic heading input from the compass system, Set Z does not have an accurate reference for the bearing pointer relative to the compass card on the HSIs and BDHIs. The same situation is true for the deviation function; without an input of the course arrow position, Set Z cannot compare its desired track with the course arrow position. Therefore the deviation bar displacement could be meaningless without constant manual updating of the course arrow position on the HSI.

Configuration A is the most economical of the four considered in this discussion, requiring only one D/S channel (bearing) and only one D/A channel (deviation). However, it does not duplicate the previous TACAN type displays, and does not provide a representative presentation of the avionic integration possibilities of Set Z.

4.2 CONFIGURATION B

Configuration B provides for duplication of the present TACAN functions. This configuration would allow Set Z to provide exactly the same types of outputs and receive the same types of inputs as the TACAN set it replaces.

To reduce the complexity of the Configuration B circuitry, certain functions have been limited in accuracy and range. The bearing circuit specifies a low accuracy conversion figure (±2.5°), and the hundreds digit of the distance display requires only a 36° rotation (0 or 1) instead of the full 360° (0 to 9) of the counter. This configuration will also relieve the pilot of constant manual update of aircraft heading. It will also provide a warning flag indication that his course arrow has not been correctly positioned to the desired track of Set Z.

This particular configuration is a compromise between Configurations A and C (which will be discussed in Section 4.3). Configuration B is not as economical as A and not quite as costly as C. Three D/S channels (bearing, units distance, and tens distance), one D/A channel (deviation), and two S/D channels (course set and magnetic heading) are required to perform the conversions that will duplicate the majority of the TACAN functions. The remaining functions are primarily flag displays that require simple discrete circuits.

4.3 CONFIGURATION C

Configuration C is the IM design described in this report and on which the Set Z integration is presently based. This configuration provides the greatest number of feasible interface choices without requiring much modification to existing wiring of the host vehicle.

In addition to providing the typical TACAN functions, Configuration C allows for inputting true airspeed and encoded altitude into Set Z. Also provided are outputs of magnetic/true heading and degraded mode warnings to operate the appropriate annunciators. The bearing conversion has been upgraded to a high accuracy output ($\leq \pm 0.5°$), and the hundreds digit of the distance display is specified as a full 360° rotation of the counter.

Configuration C is the most costly of the three "cost effective" configurations (A, B, and C), i.e., those directed toward least-possible modification of the host vehicle. This configuration requires four D/S channels (bearing and units/tens/hundreds distance), one D/A channel (deviation), and three S/D channels (course set, magnetic heading, and true airspeed) to perform the basic conversions. In addition to duplicating the TACAN functions, it allows for Set Z operation in a degraded mode with an alternate source of altitude information, and relieves the pilot of the manual operation of entering altitude or true airspeed on the CDU.

4.4 CONFIGURATION D

Configuration D attempts to incorporate every Set Z function that could be feasibly interfaced into the existing avionics of the host vehicles. This configuration allows for an extensive demonstration of the Set Z capability to interface with other avionic systems. It provides both horizontal and vertical navigation functions, thus having the ability to provide both TACAN and ILS type functions to the appropriate instruments.

The vertical deviation data will be displayed on the glideslope indicator on the ADI or HSI, and on the pitch steering bar on the ADI. There is also an option to display GPS altitude on a servoed altimeter. Several of the manual functions on the HSI have been replaced with functions driven by Set Z, including desired track and ground track. Set Z, through the IM, would drive the course arrow to display desired track and heading marker to display ground track. The option to drive the HSI compass card with true heading data would also be provided.

Configuration D would be an expensive integration effort for both the IM design and installation task. Extensive modifications to the existing aircraft wiring would be required, together with special relay junction boxes and control panels. The IM would have eight D/S channels (bearing, units distance, tens distance, hundreds distance, desired track, ground track, true heading, and altitude), two D/A channels (course deviation and vertical deviation), and two S/D channels (magnetic heading and true airspeed). By incorporating Configuration D into the various host vehicles, the true versatility of Set Z can be clearly demonstrated.

4.5 LOAD FACTOR

An item having considerable impact on the cost, size, and power requirements of the IM is the quantity of similar loads the IM must drive. The loads in question are the synchro impedances, such as bearing and distance. The IM has been specified to drive the same number of loads as does the TACAN set it replaces, which include a combination of HSIs and BDHIs. From an analysis of the current required to drive the bearing and distance synchros in these instruments, the BDHI has been found to require the largest amount of power. To supply this power, special high-power solid state amplifiers are required in the output circuits of the digital-to-synchro converters. These amplifiers require additional space (thermal cooling) and unconventional dc voltages (±26 Vdc), and are costly.

The TACAN sets also require some method of boosting their output capacity. This is usually accomplished with an electromechanical type amplifier that utilizes large transmitting synchros to increase the drive capability of the bearing and distance signals. Special couplers, such as the Collins 161B-1, are used in conjunction with the TACAN sets to provide this capability.

By limiting the bearing and distance loads to HSIs in the fixed wing aircraft, the cost, power consumption, and size of these circuits in the IM can be reduced. Duplicating the same bearing and distance information on a BDHI does not appear to be necessary except in the event of a failure in the HSI, in which case the copilot's HSI can be relied upon for lateral navigation guidance.

5
IM TEST REQUIREMENTS

Test requirements for the UE Set Z Integration Module include those for built-in testing, qualification testing, and integration testing, as will be discussed in this section.

5.1 BUILT-IN TEST CAPABILITY

The IM requires some sort of built-in-test feature to verify that it is operating correctly. There are various ways of implementing such a feature, including continuous self-test, Set Z BIT, and manual BIT.

Continuous self-test would be an automatic and continuous read-back and analysis of the IM output data by the Set Z software. To accomplish this type of BIT, the IM would require dual channels for each analog output signal, as illustrated in Figure 5-1. One channel would route the original data, converted from digital to analog form by a D/A converter, to an end device. The other channel would loop the output back through an A/D converter for conversion back to its original digital format. This format would then be compared in Set Z processor with the original data sent (A' and A, respectively, in Figure 5-1). If the two match within a given tolerance, the IM is operating correctly. If they do not match within the given tolerance, there is an error in the IM and Set Z would flash an error signal.

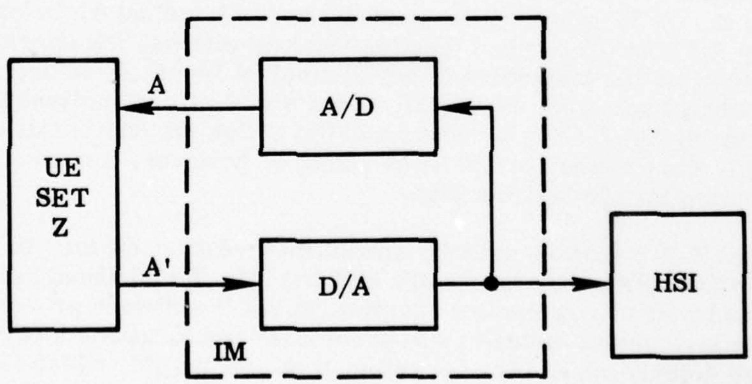


Figure 5-1. Continuous Self-Test Scheme

The continuous self-test method of BIT is expensive to implement because it requires two channels for every conversion, and thus increases the size and power requirements of the IM. The improvement in the assurance of reliable output data realized by this method is questionable due to the amount of additional circuitry required and associated cost.

Set Z BIT for the IM is a cost-effective means of assuring the operator that the IM is functioning correctly. This method of BIT would be an extension of the test feature already planned for Set Z itself. When the mode control is placed in the TEST position, appropriate signals will be sent to the IM to drive the various avionic instruments. Following is an example of what the instruments should show in the TEST mode:

	Function	Display
a.	Bearing	Bearing pointers deflect to 180°
b.	Distance	Distance counters display 000
c.	Deviation	1 dot to the left of center
d.	To-From	Indicates "To"
e.	Flags	In view for 3 seconds, out of view for 20 seconds, then in view permanently
f.	Warning Annunciators	Lit

Care would have to be taken during inflight actuation of the test function since the autopilot and flight director computer are also driven with the same signals. A method to decouple these devices would have to be incorporated along with the BIT. The flags should be dropped first to decouple autopilot to preclude inadvertent autopilot operation with the test signals.

To further enhance the Set Z BIT feature for the IM, manual interrogation of the different signals described above could be incorporated into the Set Z software when the set is in the TEST mode. Instead of the various indicators being placed automatically by Set Z to prescribed locations and conditions, the operator would be allowed to position the indicators to any number of locations he deems necessary to verify the correct operation of the IM. This would be accomplished by entering suitable codes on the Set Z CDU keyboard and observing the end result on the appropriate instruments. This method of BIT does require, however, a more complicated Set Z software routine for the test function.

The Set Z BIT feature without manual intervention appears to be the most desirable method of incorporating BIT into the IM. No additional circuitry is needed in the IM, and only a very modest increase in Set Z software processing. By driving the different instrument indicators to predetermined locations and conditions the operator can quickly assess the operating status of the IM, which is all that is really required for an effective yet economical BIT capability for that module.

5.2 IM QUALIFICATION TESTS

Qualification tests performed on the IM will consist of those tests referenced in Section 4 of the Integration Module product function specification. They include:

a. Functional performance tests

b. Environmental tests

c. Power characteristic tests

d. Electromagnetic radiation tests

e. Reliability tests

f. Maintainability demonstration

g. Operational tests

The object of these tests is to verify the performance requirements specified in Section 3 of the specification. This objective will be met after the test data have been analyzed and it is determined that the IM meets the criteria of the test procedures.

To expedite qualification testing, the IM could be tested concurrently with Set Z. This can readily be done since many of the tests required for the IM are similar to those to be performed on Set Z, particularly the time-consuming environmental tests. Operational or integration testing dictates that the IM be tested along with Set Z, as will be discussed in the next section.

5.3 INTEGRATION TESTS

The integration or operational tests specified in the IM product function specification (Appendix A) are system level tests used to determine the integrated capabilities of the IM in the typical operational environment. These tests are performed after the IM has been installed in the host vehicle and interconnected with Set Z and host vehicle avionics. Specified interface requirements will then be verified as Set Z is being used to perform a GPS navigation mission.

The integration tests will be designed to demonstrate the functional and physical compatibility of the IM with the user equipment and host vehicle. The tests will be divided into three different categories:

a. Installation tests

b. Functional checkout and calibration

c. Safety tests

The installation tests will verify the physical integration of the IM into the host vehicle. They will include mechanical fit checks, power load budgeting, proper grounding techniques, and where practical, continuity and impedance matching checks.

The functional checkout and calibration tests will verify that the IM operates in accordance with the performance requirements of the functional specification when installed in its operational configuration. These tests will include checkout and calibration of the IM when integrated with the host vehicle avionics, proper functional interface operation when operating with Set Z, and maintainability. Maintainability tests will include a demonstration of the built-in test requirements for the IM.

Safety tests will be performed to verify that the IM, when interfaced with the host vehicle avionics, does not compromise the integrity of any aircraft system and cause a safety hazard. In addition to investigating possible EMI problems, the test will also determine the human engineering aspects of the various instrument displays and their relationship to navigation/flight safety. This includes the failure and degraded navigation modes of Set Z and IM.

The integration tests described above should not be considered special tests. The former tests would normally be performed by the integration contractor to ensure proper integration of the user equipment into the aircraft. Integration tests will vary somewhat among the test aircraft installations, primarily due to the different operational flight modes for each aircraft. These modes are usually selected through the use of a flight director mode control or a similar device located at both the pilot's and copilot's position. In some aircraft these controls are cross-coupled so that a number of different navigation mode selections are possible. Careful consideration of the various combinations of modes will have to be taken into account when developing the integration test procedures. Inadvertently overlooking a particular combination could produce a safety hazard during the test mission.

5.4 MASTER TEST PLAN CHANGES

Changes to the GPS Master Test Plan to incorporate the test requirements for the IM do not appear necessary at this time because of the all-encompassing nature of that plan. The plan does not cover areas as detailed as the description of the test requirements for a piece of Group A equipment, such as the IM.

Certain sections in the Master Test Plan, however, do take into consideration the system level user equipment test requirements after the equipment has been installed in the host vehicle. Paragraph 3.3.2 in Section V of that plan provides a description of the overall objectives of integration tests, which have to include the IM by inference since that is the device that allows Set Z to be compatible with the host vehicle avionics. The IOT&E test objectives in paragraph 3.4.1e of Section VII also take into consideration the testing of the IM on a system level.

Future changes to the Master Test Plan that would add detail to it should include a description of IM test requirements and test schedules. A separate paragraph in Section V would be suitable for incorporating these items.

6
IM SPECIFICATION REQUIREMENTS

6.1 SPECIFICATION CONSIDERATIONS

The ultimate objective of the integration Module Definition study was the development of a comprehensive specification describing its "design to" requirements. Such a specification could follow the format of either an ARINC Characteristic or MIL-STD-490. Following a study of the attributes of both types of specification, it was decided that the MIL-STD-490 format would be used, primarily because:

a. MIL-STD-490 was created to standardize the preparation of military specifications for use by all Department of Defense activities and industry. Accordingly, there is greater familiarity and acceptance of the MIL-STD-490 format than the ARINC Characteristic.

b. The formats presented in MIL-STD-490 are in the form of guidance, thereby permitting sufficient flexibility to allow the specification form to be tailored to meet the intended objectives of any specification. With a change in emphasis on some elements, the MIL-STD-490 Type C1a specification is very similar to an ARINC Characteristic.

c. The operating environment of a piece of military equipment is more severe than that to which airline equipment is normally exposed. Therefore a more comprehensive test program must be specified to qualify the military equipment. Referencing other detailed military test specifications conveniently provides the necessary level of testing to ensure that the equipment is qualified. An ARINC Characteristic does not provide an in-depth specification of test requirements.

d. The specifications developed for UE Set Z follow the MIL-STD-490 format and reference the requirements of other detail military specifications. Since the IM is expected to operate in the same environment and under the same conditions, then the same requirements specified for the Set Z should also apply to the IM when applicable.

Based on these primary considerations, the IM specification was developed in accordance with the format requirements of MIL-STD-490. However, some of the outstanding qualities of an ARINC specification or characteristic were also incorporated where applicable, primarily in providing the detailed descriptions of the various interface signals. The IM specification appears in Appendix A.

6.2 THE IM SPECIFICATION

The Integration Module specification follows the format of a Type C1a specification as described in MIL-STD-490. A Type C1a specification is a prime item product function specification that provides the "form, fit and function" of a prime item. This specification describes the interface and performance requirements of the IM for the intended use during Phase I of the GPS program.

In order to ensure system commonality between the IM and Set Z, the same military specification requirements imposed on Set Z were also imposed on the IM, if applicable. Since the IM is to operate in conjunction with Set Z in the same environment, the environmental requirements for the IM are identical to those for Set Z. The IM has been specified to meet both the single and the combined stress tests required for Set Z. Because of the current status of Set Z, certain parameters could not be listed in detail at this time. Therefore the phrase "To Be Determined" (TBD) was used instead. As the correct information becomes available, it should be substituted for the "TBD" entries.

APPENDIX A

PRIME ITEM PRODUCT FUNCTION SPECIFICATION FOR INTEGRATION MODULE

Specification No. __________

Code Ident ______________

1 June 1975

PRIME ITEM PRODUCT FUNCTION SPECIFICATION FOR THE INTEGRATION MODULE OF THE GLOBAL POSITIONING SYSTEM USER EQUIPMENT SET Z

DRAFT

Engineering working document issued for preliminary planning purposes only. All or any part of this document is subject to change without notice.

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1. SCOPE. This specification establishes the interface, performance, design, and test requirements for the User Equipment Set Z Integration Module for the Global Positioning System.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

Federal	None
Military	
MIL-E-5400P	Electronic Equipment, Airborne, General Specification for, 2 July 1973
MIL-P-009024H	Packaging, Handling and Transportability in Systems/ Equipment Acquisition, 15 October 1973
MIL-P-11268H	Parts, Materials, and Processes Used in Electronic Equipments, 28 February 1973
MIL-Q-9858A	Quality Program Requirements, 16 December 1963
Other Government Activity	
CID-US-103	Specification for GPS Z Receiver and Data Processor (TBD)

STANDARDS

Federal	None
Military	
MIL-STD-130D	Identification Marking of U.S. Military Property, Change 3, 5 March 1971
MIL-STD-454D	Standard General Requirements for Electronic Equipment, 31 August 1973
MIL-STD-461A	Electromagnetic Interference Characteristics, Requirements for Equipment, 1 August 1968; Change 6, 3 July 1973
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-471	Maintainability Demonstration, 31 July 1967; Change 3, 9 February 1971

MIL-STD-704A	Electric Power, Aircraft, Characteristics and Utilization of, 9 August 1966; Notices 1-3, 11 April 1973
MIL-STD-756	Reliability Predictions, 15 May 1963
MIL-STD-794D	Parts and Equipment, Procedures for Packaging and Packing; Change 1, 25 May 1973
MIL-STD-810B	Environmental Test Methods, 15 June 1967; Change 4, 21 September 1970
MIL-STD-831	Test Reports, Preparation of, 28 August 1963
MIL-STD-891B	Contractor Parts Control and Standardization Program, 1 April 1974
National	U.S. National Standard for Common System Component Characteristics for the IFF Mark X (SIF)/Air Traffic Control Radar Beacon Systems SIF/ATCRBS, 27 December 1963

DRAWINGS None

OTHER PUBLICATIONS

Manuals None

Regulations None

Handbooks

MIL-HDBK-217B Reliability Stress and Failure Rate Data for Electromagnetic Equipment, 20 September 1974

Bulletins None

Notebooks RADC Reliability Notebook, Volume I, November 1968; Volume II, September 1967

FARADA Data

2.2 Non-Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS None

STANDARDS None

DRAWINGS None

OTHER PUBLICATIONS None

3. REQUIREMENTS

3.1 Item Definition. The Integration Module (IM) for User Equipment Set Z of the Global Positioning System (GPS) shall be an interface device that converts navigation interface signals to the proper format for transmission and/or reception between the Set Z and other avionic systems/instruments onboard the test aircraft (host vehicle) during Phase I GPS testing. The IM shall primarily interface with the same type of avionic equipment with which an airborne TACAN set would normally interface. The IM shall be part of the Set Z system and shall be classified as a Group A equipment component.

3.1.1 Item Diagrams. The general functional interface between the IM, Set Z, and host vehicle shall be as shown in Figure 1.

3.1.1.1 Functional Block Diagram. The functional block diagram for the IM shall be as shown in Figures 2 and 3.

3.1.2 Interface Definition. The interfaces required to ensure that the IM is compatible with Set Z and the host vehicle shall consist of both the functional and physical interfaces described herein.

3.1.2.1 Functional Interfaces. The functional interfaces shall be composed of the input and output interface signals required between Set Z and IM, and the host vehicle and IM.

3.1.2.1.1 Inputs. Input signals shall be those signals received by the IM from the UE Set Z and from the host vehicle avionics.

3.1.2.1.1.1 Set Z to Integration Module. The input signals to the integration module from UE Set Z shall be the interface signals described in specification CID-US-103 for the Set Z receiver and data processor. The characteristics for these signals shall be as listed in Table I. UE Set Z shall also supply the IM with the required power as specified in 3.2.7 of this specification.

3.1.2.1.1.2 Host Vehicle to Integration Module. The input signals to the integration module from the host vehicle avionic systems shall be the interface signals with characteristics listed in Table I and functionally described below.

a. Course Set. The course set signal shall provide a reference to Set Z indicating the manual rotation of the course set control. This reference shall be used by Set Z to determine the location of the course arrow (desired track) on the HSI, and the displacement distance of the deviation bar (cross-track error) from the desired track.

b. Magnetic Heading. The magnetic heading signal shall be received from the aircraft compass system to provide a heading reference to Set Z. The host vehicle instruments to be driven by the IM primarily use magnetic north as a reference.

c. True Airspeed. The true airspeed signal, when available in electrical format, shall be sent to Set Z for use in navigation calculations.

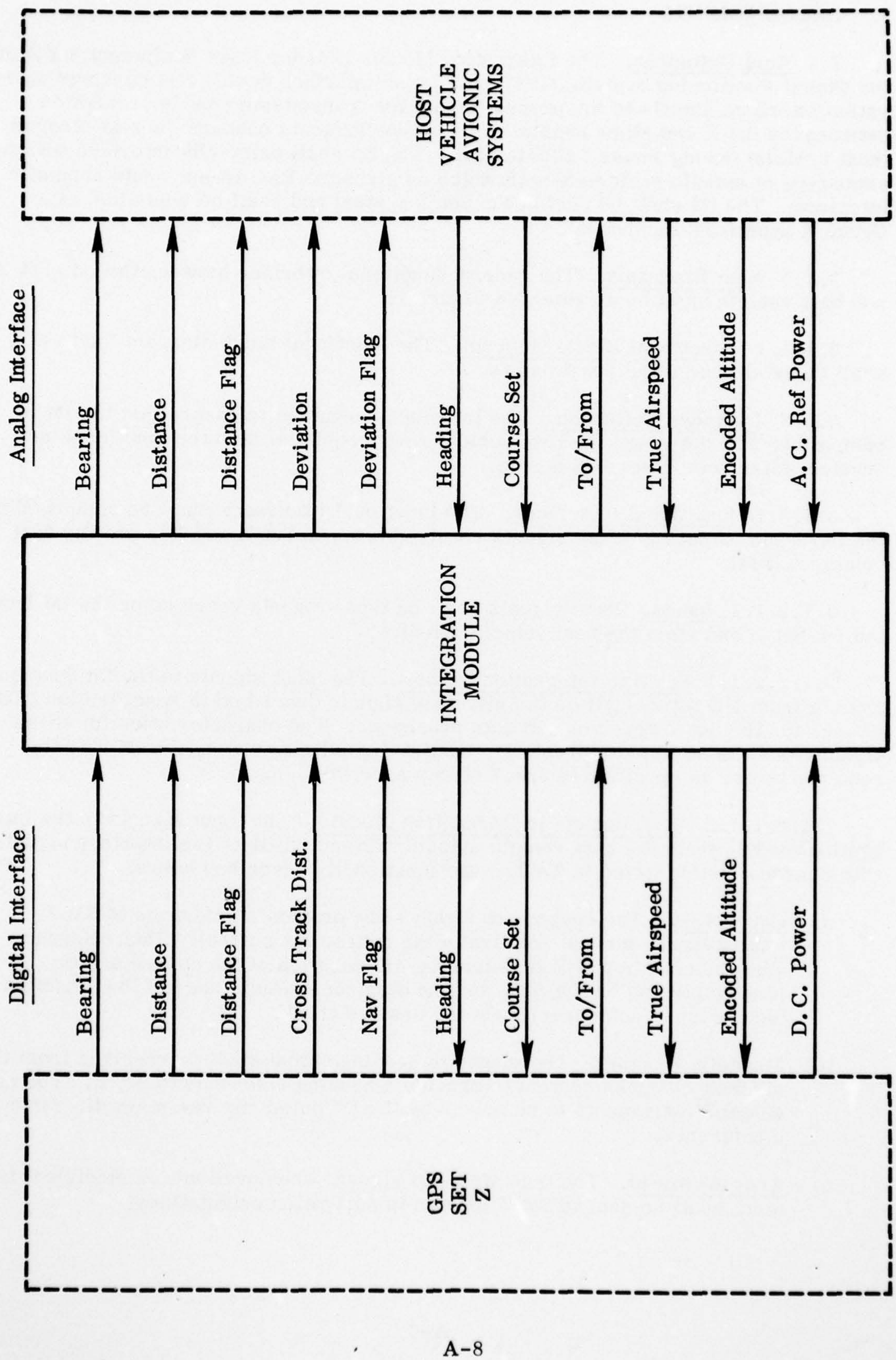

Figure 1. Functional Interface Block Diagram

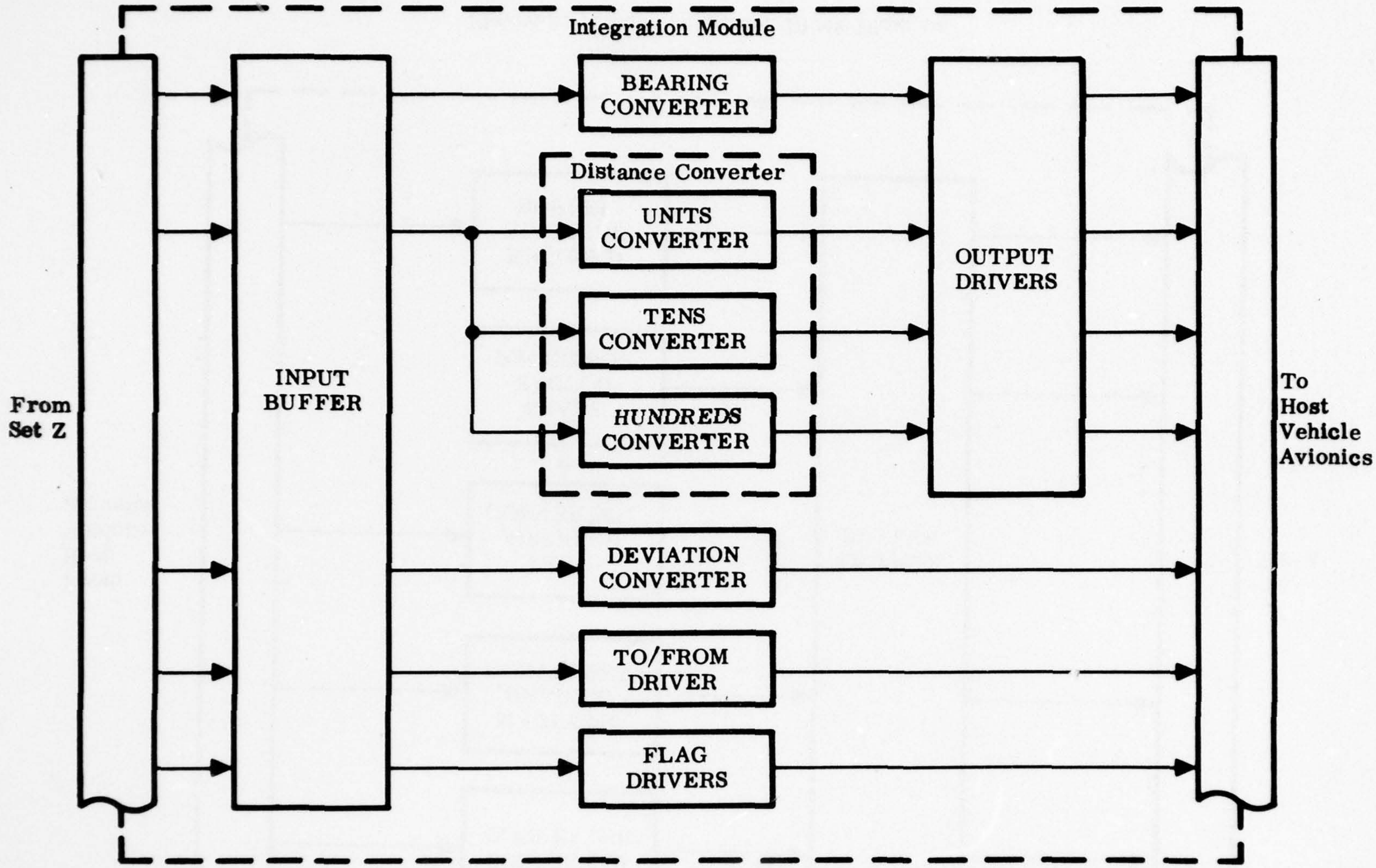

Figure 2. Output Conversion Block Diagram

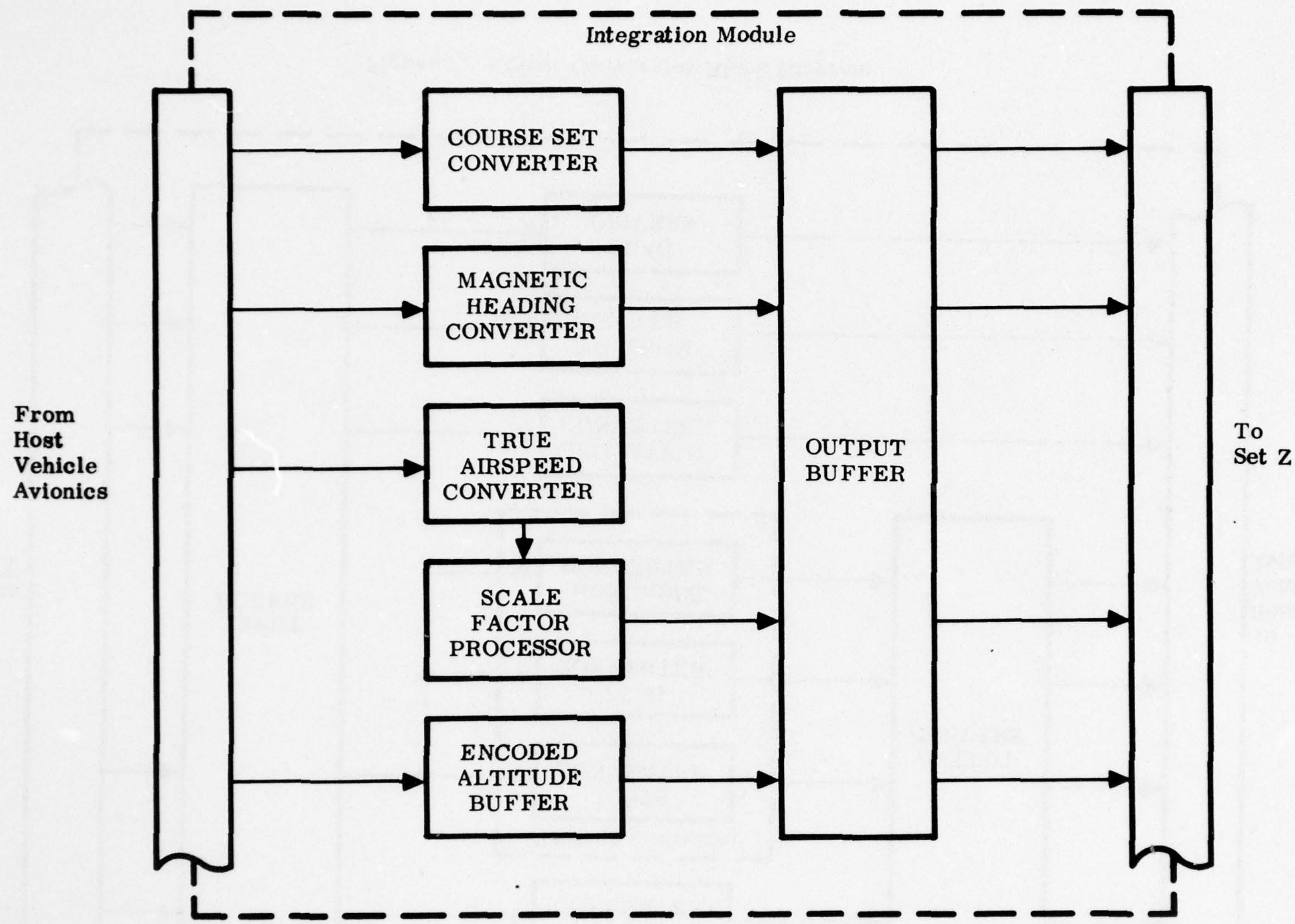

Figure 3. Input Conversion Block Diagram

TABLE I. GPS INTERFACE SIGNALS – INPUT

Specification Paragraph	Function	From	To	Type	Range	Resolution	Accuracy	Index Reference	Positive Direct Sense	Scale Factor	Source Device
3.1.2.1.1.1	Set Z to Integration Module										
a.	Bearing	Z	IM	Digital	0° to 359.9°	0.1°	TBD	Aircraft Heading	To Increasing Values	TBD	TBD
b.	Distance	Z	IM	Digital	0 to 999.99 nm	0.01 nm	TBD	XXX nm	To Decreasing Values	TBD	TBD
c.	Cross-Track Error (Deviation)	Z	IM	Digital	0 to 99.99 nm	0.01 nm	TBD	0 nm	Toward Rt. Wing	TBD	TBD
d.	XTK Enroute	Z	IM	Digital	On-Off	—	—	—	—	TBD	TBD
e.	XTK Terminal	Z	IM	Digital	On-Off	—	—	—	—	TBD	TBD
f.	XTK Approach	Z	IM	Digital	On-Off	—	—	—	—	TBD	TBD
g.	Distance Flag	Z	IM	Digital	On-Off	—	—	Distance Reliable	—	TBD	TBD
h.	Deviation Flag	Z	IM	Digital	On-Off	—	—	XTK Reliable	—	TBD	TBD
i.	To/From	Z	IM	Digital	To-From	—	—	Selected Waypoint	—	TBD	TBD
j.	Mag/True Mode	Z	IM	Digital	Mag-True	—	—	—	—	TBD	TBD
k.	Degradation	Z	IM	Digital	On-Off	—	—	—	—	TBD	TBD
3.1.2.1.1.2	Host Vehicle to Integration Module										
a.	Course Set	HV	IM	Analog	0° to 359.9°	0.1°	±0.5°	Mag. North	Rt. Hand Increments	1° = 1°	Resolver
b.	Magnetic Heading	HV	IM	Analog	0° to 359.9°	0.1°	±0.5°	Mag. North	Nose Right	1° = 1°	3-Wire Synchro
c.	True Airspeed	HV	IM	Analog	50 to 700 kt	±4 kt	±4 kt	0 knots	To Increasing Values	1° = TBD nm	3-Wire Synchro
d.	Encoded Altitude	HV	IM	Digital	-1,000 to 60,000 ft	100 ft	±100 ft	0 feet	Up-Perpendicular to Horizontal Earth Plane	10-bit Gillham Code	Shaft Angle Encoder

LEGEND: HV = Host vehicle, IM = Integration module, TBD = To be determined, XTK = Cross-track, Z = User Equipment Set Z

AD-A051 768 ARINC RESEARCH CORP ANNAPOLIS MD F/G 17/7
DEFINITION OF REQUIREMENTS FOR INTEGRATING USER EQUIPMENT SET Z--ETC(U)
JUN 75 K J BRAMAN, J E NICHOLSON, G R O'BRYAN F09603-75-A-3001

UNCLASSIFIED 1263-01-3-1415 NL

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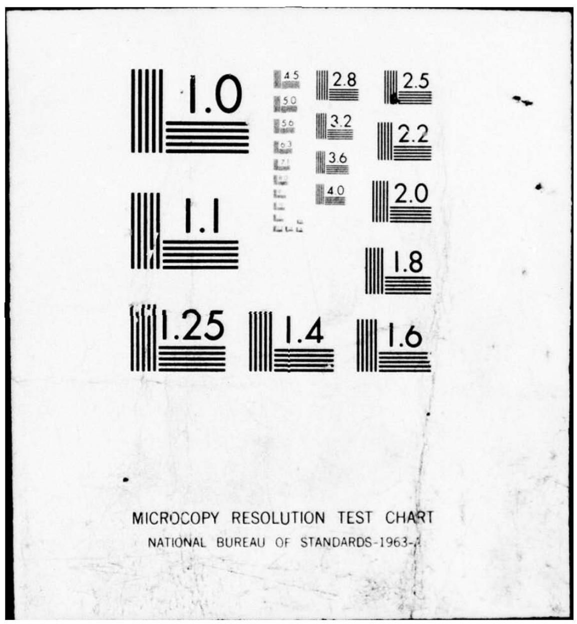

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-

d. Encoded Altitude. The encoded altitude signal from the altitude encoding avionic equipment shall provide pressure altitude information to Set Z for use during degraded modes of operation. The altitude signal will always be referenced to 29.92 in. Hg, and encoded per the U.S. National Standard for SIF/ATCRBS (Gillham Code).

3.1.2.1.2 Outputs. Output signals shall be those signals sent from the IM to Set Z and the host vehicle avionics, respectively.

3.1.2.1.2.1 Integration Module to Set Z. The output signals from IM to Set Z shall be the interface signals with the characteristics listed in Table II and as functionally described in 3.1.2.1.1.2. The IM shall condition these signals as described in 3.2.1 for use by Set Z.

3.1.2.1.2.2 Integration Module to Host Vehicle. The output signals from the IM to the host vehicle avionics shall consist of the interface signals functionally described below and with the characteristics listed in Table II.

a. Bearing. The bearing signal shall provide the aircraft bearing to the next waypoint for display on instrument bearing pointers.

b. Distance. The distance signal shall provide the aircraft distance to the next waypoint for display in various instrument distance windows.

c. Distance Flag. The distance flag signal shall provide a warning that the distance data computed by Set Z is unreliable.

d. Deviation (Cross-Track Error). The deviation signal shall provide an indication of aircraft displacement from the desired track in nautical miles.

e. Deviation Flag. The deviation flag signal shall provide a warning that the deviation data computed by Set Z is unreliable.

f. To/From. The to/from signal shall provide an indication of whether or not the aircraft has passed the selected waypoint.

g. True/Mag Mode. The true/mag mode signal shall provide an indication of whether Set Z is in the magnetic heading or true heading mode of operation.

h. Degraded Mode. The degraded mode signal shall provide an indication of whether Set Z has entered a mode of limited navigation capability.

3.1.2.2 Physical Interfaces. The physical interfaces for the IM shall be those interfaces required to physically integrate the IM into Set Z and the host vehicle.

3.1.2.2.1 Integration Module to Set Z. The IM shall be physically separated from the Set Z receiver/processor line replaceable unit (LRU), but on a common mount with the receiver/processor. Due to size constraints and/or heat dissipation problems, it shall be permissible to divide the IM into two separate units. One unit shall contain all the conversion circuitry while the other unit shall contain all of the heat-producing power drive circuitry.

TABLE II. GPS INTERFACE SIGNALS – OUTPUT

Specification Paragraph	Function	From	To	Type	Range	Resolution	Accuracy	Index Reference	Positive Direct Sense	Scale Factor	Load Device (Parallel Quant.)
3.1.2.1.2.1	Integration Module to Set Z										
a.	Course Set	IM	Z	Digital	0° to 359.9°	0.1°	±0.5°	Mag. North = 0°	Rt. Hand Increment	1° = 1°	TBD
b.	Magnetic Heading	IM	Z	Digital	0° to 359.9°	0.1°	±0.5°	Mag. North = 0°	Nose Right	1° = 1°	TBD
c.	True Airspeed	IM	Z	Digital	50 to 700 kt	1.0	±4.0°	0 knots	To Increasing Values	A/C dep.	TBD
d.	Encoded Altitude	IM	Z	Digital	-1,000 to 60,000 ft	100 ft	±100 ft	-1,000 ft	Up-Perpendicular to Earth Plane	10 bits ICAO Code	TBD
3.1.2.1.2.2	Integration Module to Host Vehicle										
a.	Bearing	IM	HV	Analog	0° to 359.9°	0.1°	±0.5°	Mag. North	To Increasing Values	1° = 1°	3-Wire Synchro (5)
b.	Distance, Units	IM	HV	Analog	0° to 359.9°	0.1 num	0.2 num	X nm	To Decreasing Values	36° = 1 num	3-Wire Synchro (5)
b.	Distance, Tens	IM	HV	Analog	0° to 359.9°	1 num	0.2 num	XX nm	To Decreasing Values	36° = 1 num	3-Wire Synchro (5)
b.	Distance, Hundreds	IM	HV	Analog	0° to 359.9°	1 num	0.2 num	XXX nm	To Decreasing Values	36° = 1 num	3-Wire Synchro (5)
c.	Distance Flag	IM	HV	Discrete	On-Off	—	—	Distance Reliable	—	28 Vdc = Off	Shutter Mech. (4)
d.	Deviation, Enroute	IM	HV	Analog, dc	0 to ±6 nm	±790 ft	±2,600 ft	0 nm	Toward Rt. Wing	150 uA = 20 nm	1,000Ω dc Meter Move (5)
d.	Deviation, Terminal	IM	HV	Analog, dc	0 to ±1 nm	±130 ft	±200 ft	0 nm	Toward Rt. Wing	150 uA = 5 nm	1,000Ω dc Meter Move (5)
d.	Deviation, Approach	IM	HV	Analog, dc	0 to ±600 ft	±13 ft	±40 ft	0 nm	Toward Rt. Wing	150 uA = 1.25 nm	1,000Ω dc Meter Move (5)
e.	Deviation Flag	IM	HV	Discrete	On-Off	—	—	Deviation Reliable	—	245 uA = Off	1,000Ω dc Meter Move (3)
f.	To/From	IM	HV	Discrete	To-From	—	—	Selected Waypoint	Decreasing Distance	+225 uA = To -225 uA = From	200Ω ± 25% dc Meter Move (2)
g.	True/Mag. Mode	IM	HV	Discrete	On-Off	—	—	—	—	True = On	28 Vdc Annunciator (2)
h.	Degraded Mode	IM	HV	Discrete	On-Off	—	—	—	—	Degrade = On	28 Vdc Annunciator (2)

LEGEND: HV = Host vehicle, IM = Integration module, TBD = To be determined, Z = User Equipment Set Z

3.1.2.2.2 Integration Module to Host Vehicle. There shall not be a direct physical interface between the IM and the host vehicle. The IM shall interface with the host vehicle through the receiver/processor mount that contains all of the necessary interface connectors.

3.1.3 Major Components List. The IM shall contain the following major components:

a. IM converter

b. IM driver

3.1.4 Government-Furnished Property List. (Not applicable.)

3.2 Characteristics

3.2.1 Performance. The IM shall meet the performance characteristics specified herein when tested in accordance with the Quality Assurance Provisions set forth in Section 4 of this specification.

3.2.1.1 General Performance Characteristics. The IM shall provide an effective signal conditioning interface between the Set Z and host vehicle avionics. The IM shall be capable of converting those interface signals listed in Table I into the signals listed in Table II, and of driving the worst case parallel loads as derived from Table III without significantly contributing to the existing system error.

3.2.1.2 Specific Performance Characteristics. The IM shall meet the following specific performance characteristics.

3.2.1.2.1 Bearing Conversion. The IM shall convert a digital bearing signal to an analog synchro signal for display on such instruments as shown in Table III with an accuracy of better than ±0.5 degree when the IM is loaded with an impedance equivalent to the worst-case parallel instrument bearing circuit load from Table III.

3.2.1.2.1.1 Conversion Rate. The bearing conversion circuit shall maintain an accurate conversion with bearing turn rates of up to 25 degrees per second.

3.2.1.2.1.2 Degraded Performance. Upon loss of a valid digital bearing signal, Set Z shall provide a degraded-mode signal to the IM for operating a warning annunciator.

3.2.1.2.2 Distance Conversion. The IM shall convert a digital distance signal to three analog synchro signals representing the units, tens, and hundreds digits of the distance measurement. The synchro output signal shall be displayed on those instruments as shown in Table III with an accuracy of better than ±0.2 numerals when the IM is loaded with an impedance equivalent to the worst case parallel instrument distance circuit load from Table III.

3.2.1.2.2.1 Conversion Rate. The distance conversion circuit shall maintain a conversion rate of up to 1 nautical mile per second.

TABLE III. PARALLEL LOAD REQUIREMENTS FOR INTEGRATION MODULE OUTPUTS

Signal	Host Vehicle Instruments				
	C-141A	KC-135A	HC-130H	HH-53B/C	P-3C
1. Bearing	1-HSI (AQU-4/A) 3-BDHI (ID-798/ARN)	2-HSI (331A-8H) 3-RMI (ID-250/ARN)	2-HSI (AQU-2/A) 2-BDHI (ID-1103/ARN)	2-BDHI (ID-1103/ARN)	3-HSI (ID-1540/A)
2. Distance	1-HSI (AQU-4/A) 3-BDHI (ID-798/ARN)	2-HSI (331A-8H)	2-HSI (AQU-4/A) 2-BDHI (ID-1103/ARN)	2-BDHI (ID-1103/ARN)	3-HSI (ID-1540/A)
3. Distance Flag	1-HSI (AQU-4/A)	2-HSI (331A-8H)	2-HSI (AQU-2/A) 2-BDHI (ID-1103/ARN)	2-BDHI (ID-1103/ARN)	3-HSI (ID-1540/A)
4. Deviation	1-HSI (AQU-4/A) 1-Flight Dir (3K91002) 1-Autopilot	2-HSI (331A-8H) 1-Flight Dir (ASQ-141(V)) 1-Autopilot (MC-1)	2-HSI (AQU-2/A) 2-Flight Dir (CPU-65/A) 1-Autopilot (E-4)	2-CDI (ID-387/ARN) 1-FDI (353-999-0100)	2-HSI (ID-1540/A) 1-Flight Dir (AN/AJN-15)
5. Deviation Flag	1-HSI (AQU-4/A) 1-Flight Dir (3K91002)	2-HSI (331A-8H) 1-Flight Dir (ASQ-141(V))	2-Flight Dir (CPU-65/A)	2-CDI (ID-387/ARN) 1-FDI (353-999-0100)	2-HSI (ID-1540/A) 1-Flight Dir (AN/AJN-15)
6. To/From	1-HSI (AQU-4/A)	2-HSI (331A-8H)	2-HSI (AQU-2/A)	2-CDI (ID-387/ARN)	2-HSI (ID-1540/A)
7. Course Set	1-HSI (AQU-4/A)	1-HSI (331A-8H)	1-HSI (AQU-2/A)	1-CDI (ID-387/ARN)	1-HSI (ID-1540/A)

LEGEND: BDHI = Bearing, distance, heading indicator, CDI = Course indicator, FDI = Flight director indicator, HSI = Horizontal situation indicator, RMI = Radio magnetic indication

3.2.1.2.2.2 Degraded Performance. Upon loss of a valid digital distance signal, Set Z shall output a signal to indicate that the distance data are unreliable. This signal shall be capable of driving the distance flag alarm circuit on those instruments shown in Table III after conditioning by the IM.

3.2.1.2.3 Deviation (Cross-Track Error). The IM shall convert a digital cross-track error signal to an analog signal for display on those instruments listed in Table III. The signal shall be dependent upon the chosen sensitivity scale factor from Set Z.

3.2.1.2.3.1 Sensitivity. Three levels of sensitivity shall be associated with the deviation signal. The different levels will depend upon the scale factor selected on the Set Z control/display unit. They shall include the following, with full-scale deflections either side of the course centerline shown:

a. Enroute = ±6 nm

b. Terminal = ±1 nm

c. Approach = ±0.1 nm

3.2.1.2.3.2 Degraded Performance. Upon loss of a reliable deviation signal or an incorrect course set angle, Set Z shall output a signal to indicate that the course deviation data are unreliable. This signal shall be capable of driving the deviation flag circuit on those instruments shown in Table III after conditioning by the IM.

3.2.1.2.4 To/From Indication. The IM shall convert the to/from digital signal to the correct level for driving the to-from flag on those instruments shown in Table III.

3.2.1.2.5 Course-Set Conversion. The IM shall convert the manually selected course-set analog signal from an HSI to a digital signal for use by Set Z with an accuracy of ±0.5 degree.

3.2.1.2.5.1 Conversion Rate. The course-set conversion circuit shall maintain an accurate conversion with changes to the course-set control of up to 10 degrees per second.

3.2.1.2.6 Heading Conversion. The IM shall convert analog magnetic heading data from a compass system to a digital signal for use by Set Z with an accuracy of ±0.5 degree.

3.2.1.2.6.1 Conversion Rate. The magnetic heading conversion circuit shall maintain an accurate conversion with changes to magnetic heading of up to 25 degrees per second.

3.2.1.2.7 True Airspeed Conversion. The IM shall convert an analog true airspeed signal to digital format for use by Set Z with an accuracy of better than ±4 knots.

3.2.1.2.7.1 Conversion Rate. The true airspeed conversion circuit shall maintain a conversion rate with changes in true airspeed of up to 100 knots/minute.

3.2.1.2.8 Encoded Altitude. The IM shall process the digital encoded altitude signal for use by Set Z. The encoded altitude signal code shall be the same Gillham code referenced in the U.S. National Standard for Common System Component Characteristics.

3.2.2 Physical Characteristics

3.2.2.1 Weight. The weight of the IM shall not exceed 4.6 kilograms (10 lb).

3.2.2.2 Form Factor. The IM shall not displace a volume of more than $0.005 m^3$ ($300 in.^3$).

3.2.2.3 Durability. The IM shall be designed to withstand airborne operations and maintenance.

3.2.2.4 Health and Safety. Any health or safety hazards to personnel shall be eliminated from the design of the IM.

3.2.3 Reliability. Reliability predictions shall be performed using the methods contained in MIL-STD-756 and MIL-HDBK-217. Failure rate data for parts not covered by MIL-HDBK-217, RADC Reliability Notebook, Volume II, or FARADA, shall be validated by statistical analyses of data from other sources.

3.2.3.1 Mean-Time Between Failures (MTBF). The MTBF of the IM shall be no less than 1000 hours under field service conditions.

3.2.3.2 Failure. Any failure of the IM shall not cause a degradation in the performance of Set Z or any other host vehicle avionics equipment. That also includes the disconnection of the IM from Set Z.

3.2.4 Maintainability. The minimum maintainability requirements for the IM shall be as specified herein.

3.2.4.1 Organizational Level. The organizational level of maintenance shall be that maintenance performed on the host vehicle.

3.2.4.1.1 Maximum Corrective Maintenance Downtime ($M_{max}Ct$). The $M_{max}Ct$ to isolate, remove, and replace a faulty IM by level 3 skilled personnel in a fully accessible Set Z shall be no greater than five minutes.

3.2.4.2 Intermediate Level. The intermediate level of maintenance shall be that maintenance performed off the host vehicle.

3.2.4.2.1 Maximum Corrective Maintenance Downtime ($M_{max}C_t$). The $M_{max}C_t$ to isolate and replace a faulty module or printed circuit card in the IM shall be no greater than 20 minutes for level 5 skilled personnel.

3.2.4.3 Depot Level. The IM shall be designed for depot level repair using automatic test equipment to the maximum extent possible.

3.2.4.3.1 Maximum Corrective Maintenance Downtime ($M_{max}C_t$). The $M_{max}C_t$ at the depot level shall be no greater than 30 minutes.

3.2.4.4 Maintenance Complexity. The IM shall make maximum use of interchangeable and removable modules or printed circuit cards that require no field adjustment after initial installation. Maximum use shall be made of existing manual and automatic test equipment.

3.2.4.4.1 Test Points. The IM shall incorporate a sufficient number of accessible test points to minimize the fault isolation procedure.

3.2.4.4.2 Calibration and Adjustment. The IM shall incorporate a minimum number of adjustment controls for calibration purposes.

3.2.4.5 Service and Access. The design of the IM shall ensure quick and easy access to elements requiring service. Use of special tools for repair and adjustment shall be kept to a minimum.

3.2.5 Environmental Conditions. The IM shall be capable of operating without mechanical or electrical damage or degradation in performance under any combination of the environmental conditions specified herein.

3.2.5.1 Temperature. The operational temperature range shall be -40° to +55°C, and the nonoperational temperature range shall be -62° to +85°C.

3.2.5.2 Altitude. The operational altitude range shall be from sea level to +50,000 feet.

3.2.5.3 Humidity. The operational humidity range shall be in accordance with 3.2.24.4 of MIL-E-5400.

3.2.5.4 Vibration. The IM, when normally mounted, shall be capable of withstanding the following sinusoidal and random vibration limits.

3.2.5.4.1 Sinusoidal Vibration. Resistance to sinusoidal vibration shall be in accordance with MIL-E-5400, Figure 2, curve IVA.

3.2.5.4.2 Random Vibration. Resistance to random vibration shall be in accordance with MIL-STD-810, test method 514, Figure 514.1-4, test level AJ.

3.2.5.5 Shock. Resistance to shock shall be in accordance with 3.2.24.6 of MIL-E-5400.

3.2.5.6 Sand and Dust. Resistance to the effects of sand and dust shall be in accordance with 3.2.24.7 of MIL-E-5400.

3.2.5.7 Fungus. Resistance to the effects of fungus shall be in accordance with 3.2.24.8 of MIL-E-5400.

3.2.5.8 Salt Atmosphere. Resistance to the effects of salt atmosphere shall be in accordance with 3.2.24.9 of MIL-E-5400.

3.2.5.9 Explosive Conditions. Resistance to the effects of explosive conditions shall be in accordance with 3.2.24.10 of MIL-E-5400.

3.2.5.10 Heat Dissipation and Cooling. The IM shall be designed for free convection cooling without the need for integral thermal environment protection and control devices. Surrounding ambient air shall be considered adequate for cooling purposes.

3.2.6 Transportability. The IM shall meet the transportability packaging and storage requirements of MIL-STD-794.

3.2.7 Electrical Power. The IM shall be a dc-powered device; ac power shall be used for synchro converter reference purposes only. The dc power shall be supplied to the IM from the power supply of Set Z. Total dc power consumption of the IM shall be no greater than 175 watts during periods of peak demand.

3.2.7.1 Voltage Levels. The IM shall operate without degradation to performance when supplied with the following voltages:

a. +15 Vdc ±1%, ripple = 50 mV

b. -15 Vdc ±1%, ripple = 50 mV

c. +5 Vdc ±1%, ripple = 50 mV

d. +28 Vdc ±1%, ripple = 50 mV

e. -28 Vdc ±1%, ripple = 50 mV

f. 26 Vac, 400 Hz, aircraft bus power

3.2.7.2 Power Source Characteristics. The IM shall operate without damage when Set Z is exposed to the power conditions specified in MIL-STD-704A, Figure 3 (limits 1 and 4); Figure 9 (limits 1 and 4); and Figure 17. The IM shall not experience a degradation in performance when Set Z is exposed to the conditions of MIL-STD-704A, Figure 3 (limits 2 and 3); Figure 9 (limits 2 and 3); and Figure 17.

3.3 Design and Construction. The IM shall be designed in accordance with MIL-E-5400, Class 1 equipment requirements and as specified herein.

3.3.1 Materials, Processes, and Parts. Materials, processes, and parts shall be in accordance with MIL-STD-891.

3.3.1.1 Microelectronic Modular Assemblies. Microelectronic modular assemblies shall be in accordance with MIL-P-11268.

3.3.1.2 Standard and Nonstandard Parts and Materials. Standard MS, AN, and MIL parts shall be used wherever practical and shall be identified by standard part numbers. When nonstandard parts and materials are used, the requirements for Category II contracts, as specified in MIL-E-5400, shall be enforced.

3.3.2 Electromagnetic Radiation. The IM shall meet the electromagnetic interference characteristic requirements of MIL-STD-461, Class A1 equipment, methods CE02, CE04, RE02, RS02, and RS03.

3.3.3 Identification and Marking. Nameplates and product markings shall be in accordance with MIL-STD-130.

3.3.4 Workmanship. Workmanship shall be in accordance with MIL-STD-454, requirement 9.

3.3.5 Interchangeability. Interchangeability shall be in accordance with MIL-STD-454, requirement 7.

3.3.6 Safety. Personnel safety shall be in accordance with MIL-STD-454, requirement 1.

3.3.7 Human Performance/Human Engineering. Human performance/human engineering shall be in accordance with MIL-STD-454, requirement 62.

3.4 Major Component Characteristics. The IM shall be functionally and physically separated into an IM converter and an IM driver.

3.4.1 IM Converter. The IM converter shall consist of those circuits that perform the input buffering, digital-to-analog conversion, analog-to-digital conversion, and any other special low-level signal conditioning required to interface Set Z to the host vehicle avionics.

3.4.1.1 Output Conversion Circuits. The IM converter shall contain all of the necessary buffering and conversion circuits, as shown in Figure 2, to provide the signal conditioning of the Set Z digital output signals that shall drive those instruments referenced in Table III.

3.4.1.2 Input Conversion Circuits. The IM converter shall contain all of the necessary buffering and conversion circuits, as shown in Figure 3, to provide signal conditioning of the host vehicle avionics input signals that will be used by the Set Z.

3.4.2 IM Driver. The IM driver shall consist of all the necessary circuits required to buffer the output signals of the output conversion circuits, as shown in Figure 2, to drive the parallel loads of the host vehicle avionics.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. A quality assurance program shall be conducted to verify that the design and performance of the integration module meets, as a minimum, the requirements specified in Section 3. The program shall use the four verification methods described in 4.2.1 to verify compliance with the requirements of this specification.

4.1.1 Responsibility for Quality Assurance. Unless otherwise specified in the contract, the contractor shall be responsible for the performance of all quality assurance requirements set forth herein. The contractor may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to witness or perform any of the verifications set forth in this specification when such verifications are deemed necessary to assure deliverable contract end items conform to the requirements of this specification.

4.2 Quality Conformance Verifications. Four methods of verifying the requirements of Section 3 shall be implemented in the quality assurance program as applicable. These methods shall be defined as:

a. Inspection. A method of verification of physical characteristics without the use of special laboratory type equipment, procedures, items, and services to determine conformance with the specified requirements.

b. Analysis. A method of verification involving study, calculation, and modeling to verify the specified requirements.

c. Demonstration. A method of verification denoting the qualitative evaluation of the properties and parameters of items (or components thereof) by means that do not necessarily require the use of laboratory equipment, procedures, items, or services to verify conformance with the specified requirements.

d. Tests. A method of verification denoting the qualitative and quantitative evaluation of the properties and parameters of items (or components thereof) by technical means requiring the use of laboratory type equipment, procedures, items, and services to verify conformance with specified requirements.

4.2.1 Verification Cross Reference Index. A verification cross-reference index is provided in Table IV. Table IV cross-references each paragraph in Section 3 of this specification to an applicable verification method; and, where a test is specified, to a test verification paragraph.

4.2.2 Verification Procedures. Detailed step-by-step procedures shall be prepared for all tests and demonstrations, and submitted to the procuring activity for approval 90 days prior to conducting the tests and demonstrations. Inspections shall not require detailed procedures. Instead, an outline of the inspections to be performed and the method used to perform them shall be prepared and submitted to the procuring activity prior to performing the inspections. Analyses shall not require detailed procedures, but each analysis shall be formally submitted to the procuring activity in report form. The procuring activity reserves the right to require additional verification to determine compliance with the requirements of the specification.

4.2.3 Accept-Reject Criteria. The accept-reject criteria for each step, as applicable, of the test procedures shall be specified at the time the procedures are submitted for approval.

4.2.4 Rejection and Retest. If the equipment does not meet the acceptance criteria specified in the test procedure, the procuring activity may reject the equipment wholly or in part. The rejected equipment may be reworked to correct the defects and submitted for retest.

4.2.5 Combined Testing. Maximum use shall be made of test resources so as to expedite the quality assurance program. Whenever feasible, tests and demonstrations may be combined with one another and with other tests and demonstrations.

TABLE IV. VERIFICATION CROSS REFERENCE INDEX (Sheet 1 of 3)

Section 3 Requirement Reference	Verification Method NA	1	2	3	4	Section 4 Verification Requirement
3.1 Item Definition		X				4.2.7.1
3.1.1 Item Diagrams		X				4.2.7.1
3.1.1.1 Functional Block Diagrams		X				4.2.7.1
3.1.2 Interface Definition	X					
3.1.2.1 Functional Interfaces	X					
3.1.2.1.1 Inputs				X	X	4.2.7.8
3.1.2.1.1.1 Set Z to Integration Module				X	X	4.2.7.8
3.1.2.1.1.2 Host Vehicle to Integration Module				X	X	4.2.7.8
3.1.2.1.2 Outputs				X	X	4.2.7.8
3.1.2.1.2.1 Host Vehicle to Integration Module				X	X	4.2.7.8
3.1.2.1.2.2 Integration Module to Host Vehicle				X	X	4.2.7.8
3.1.2.2 Physical Interfaces	X					
3.1.2.2.1 Integration Module to Set Z		X				4.2.7.1
3.1.2.2.2 Integration Module to Host Vehicle		X				4.2.7.1
3.1.3 Major Component List		X				4.2.7.1
3.2 Characteristics	X					
3.2.1 Performance	X					
3.2.1.1 General Performance Requirements				X	X	4.2.7.8
3.2.1.2 Specific Performance Requirements				X	X	4.2.7.2
3.2.1.2.1 Bearing Conversion				X	X	4.2.7.2
3.2.1.2.1.1 Conversion Rate				X	X	4.2.7.2
3.2.1.2.1.2 Degraded Performance				X	X	4.2.7.2
3.2.1.2.2 Distance Conversion				X	X	4.2.7.2
3.2.1.2.2.1 Conversion Rate				X	X	4.2.7.2
3.2.1.2.2.2 Degraded Performance				X	X	4.2.7.2
3.2.1.2.3 Course Deviation (Cross-Track Error)				X	X	4.2.7.2
3.2.1.2.3.1 Sensitivity				X	X	4.2.7.2
3.2.1.2.3.2 Degraded Performance				X	X	4.2.7.2
3.2.1.2.4 To/From Indication				X	X	4.2.7.2

LEGEND: NA = Not Applicable, 1 = Inspection, 2 = Analysis, 3 = Demonstration, 4 = Test

TABLE IV. (Sheet 2 of 3)

Section 3 Requirement Reference	Verification Method					Section 4 Verification Requirement
	NA	1	2	3	4	
3.2.1.2.5 Course-Set Conversion				X	X	4.2.7.2
3.2.1.2.5.1 Conversion Rate				X	X	4.2.7.2
3.2.1.2.6 Heading Conversion				X	X	4.2.7.2
3.2.1.2.6.1 Conversion Rate				X	X	4.2.7.2
3.2.1.2.7 True Airspeed Conversion				X	X	4.2.7.2
3.2.1.2.7.1 Conversion Rate				X	X	4.2.7.2
3.2.1.2.8 Encoded Altitude				X	X	4.2.7.2
3.2.2 Physical Characteristics	X					
3.2.2.1 Weight		X				4.2.7.1
3.2.2.2 Form Factor		X				4.2.7.1
3.2.2.3 Durability		X				4.2.7.1
3.2.2.4 Health and Safety		X				4.2.7.1
3.2.3 Reliability			X	X	X	4.2.7.6
3.2.3.1 Mean Time Between Failures (MTBF)			X	X	X	4.2.7.6
3.2.3.2 Failure				X	X	4.2.7.6
3.2.4 Maintainability			X	X		4.2.7.7
3.2.4.1 Organizational Level	X					
3.2.4.1.1 Maximum Corrective Maintenance Downtime				X		4.2.7.7
3.2.4.2 Intermediate Level	X					
3.2.4.2.1 Maximum Corrective Maintenance Downtime				X		4.2.7.7
3.2.4.3 Depot Level	X					
3.2.4.3.1 Maximum Corrective Maintenance Downtime				X		4.2.7.7
3.2.4.4 Maintenance Complexity				X		4.2.7.7
3.2.4.4.1 Test Points				X		4.2.7.7
3.2.4.4.2 Calibration and Adjustment				X		4.2.7.7
3.2.4.5 Service and Access				X		4.2.7.7
3.2.5 Environmental Conditions				X	X	4.2.7.4

LEGEND: NA = Not Applicable, 1 = Inspection, 2 = Analysis, 3 = Demonstration, 4 = Test

TABLE IV. (Sheet 3 of 3)

Section 3 Requirement Reference	Verification Method					Section 4 Verification Requirement
	NA	1	2	3	4	
3.2.5.1 Temperature				X	X	4.2.7.4
3.2.5.2 Altitude				X	X	4.2.7.4
3.2.5.3 Humidity				X	X	4.2.7.4
3.2.5.4 Vibration				X	X	4.2.7.4
3.2.5.4.1 *Sinusoidal Vibration*				X	X	4.2.7.4
3.2.5.4.2 Random Vibration				X	X	4.2.7.4
3.2.5.5 Shock				X	X	4.2.7.4
3.2.5.6 Sand and Dust				X		4.2.7.4
3.2.5.7 Fungus				X		4.2.7.4
3.2.5.8 Salt Atmosphere				X		4.2.7.4
3.2.5.9 Explosive Conditions				X		4.2.7.4
3.2.5.10 Heat Dissipation and Cooling				X		4.2.7.4
3.2.6 Transportability		X				4.2.7.1
3.2.7 Electrical Power				X	X	4.2.7.2
3.2.7.1 Voltage Levels				X	X	4.2.7.2
3.2.7.2 Power Source Characteristics				X	X	4.2.7.4
3.3 Design and Construction		X				4.2.7.1
3.3.1 Materials, Processes, and Parts		X				4.2.7.1
3.3.1.1 Microelectronic Modular Assemblies		X				4.2.7.1
3.3.1.2 Standard and Nonstandard Parts and Materials		X				4.2.7.1
3.3.2 Electromagnetic Radiation				X	X	4.2.7.5
3.3.3 Identification and Marking		X				4.2.7.1
3.3.4 Workmanship		X				4.2.7.1
3.3.5 Interchangeability		X				4.2.7.1
3.3.6 Safety		X				4.2.7.1
3.3.7 *Human Performance/Human Engineering*		X				
3.4 Major Component Characteristics	X					4.2.7.1
3.4.1 IM Converter				X	X	4.2.7
3.4.2 IM Driver				X	X	4.2.7

LEGEND: NA = Not Applicable, 1 = Inspection, 2 = Analysis, 3 = Demonstration, 4 = Test

4.2.6 Test Conditions. Unless specified otherwise, the IM shall be tested under the following conditions:

a. Ambient temperature: $25° \pm 10°C$

b. Altitude: Nominal ground level

c. Relative humidity: Less than 95%

d. Vibration and shock: None

e. Pressure: Atmospheric, 28 to 32 in. Hg

f. Electrical power: Nominal supply voltages

g. Output loads: Output loads shall be as follows:

(1) The bearing signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 1 on Table III.

(2) The distance signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 2 of Table III.

(3) The distance flag alarm signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 3 of Table III.

(4) The deviation signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 4 of Table III.

(5) The deviation warning flag signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 5 of Table III.

(6) The to/from signal shall be connected to a load equivalent to the worst-case parallel load conditions shown on line 6 of Table III.

(7) Any other output signal not specifically identified shall be tested to the equivalent of three loads connected in parallel.

h. Substitute loads: Substitute loads for (1) through (6) specified above shall not be allowed unless specifically approved by the procuring activity.

4.2.7 Verification Requirements. The following verification requirements shall be performed to verify that the IM conforms to the requirements of Section 3.

4.2.7.1 Item Examination. The IM shall be inspected to verify that its design, construction, materials, markings, workmanship, and mechanical measurements comply with the requirements of this specification.

4.2.7.2 Performance Verification. The following tests shall be implemented to verify the performance requirements of this specification.

4.2.7.2.1 Functional Performance Tests. The IM shall be functionally tested to verify that the performance requirements of 3.2.1 have been met under the specified test conditions.

4.2.7.3 Environmental Tests. Environmental tests on the IM shall be performed in two phases: a single stress test and combined stress tests. Environmental tests on the IM shall be performed concurrently with the Set Z environmental tests.

4.2.7.3.1 Single Stress Tests. The IM shall be subjected to the single stress tests and levels as shown in Figure 4. The voltage level tests apply to the input to the Set Z power supply.

4.2.7.3.2 Combined Stress Tests. The IM shall be subjected to the combined stress tests and levels as shown in Figure 5. The voltage level tests apply to the input to Set Z power supply.

4.2.7.3.3 Fungus Test. The IM shall be tested for the effects of fungus growth while nonoperating in accordance with MIL-STD-810, method 508, procedure I.

4.2.7.3.4 Sand and Dust Test. The IM shall be tested for the effects of sand and dust while nonoperating in accordance with MIL-STD-810, method 510, procedure I.

4.2.7.3.5 Salt Atmosphere Test. The IM shall be tested for the effects of salt atmosphere while nonoperating in accordance with MIL-STD-810, method 509, procedure I.

4.2.7.3.6 Explosive Condition. The IM shall be tested for the effects of explosive conditions while nonoperating in accordance with MIL-STD-810, method 511, procedure I.

4.2.7.4 Power Characteristic Tests. Selected functional tests of 4.2.7.2.1 shall be conducted with the maximum and then the minimum power supply voltages of 3.2.7.1 applied to the IM. During the maximum voltage test, heat dissipation measurements shall be made. All other power characteristic tests shall be performed during the single and combined stress tests as shown in Figures 4 and 5.

4.2.7.5 Electromagnetic Radiation Tests. The IM shall be tested to determine electromagnetic compatibility in accordance with MIL-STD-462, test methods CE02, CE04, RE02, RS02, and RS03.

4.2.7.6 Reliability Test. IM reliability shall be tested concurrent with the combined stress test specified in 4.2.7.3.2 with a repetition in that test for a total of 2,500 hours.

4.2.7.7 Maintainability Demonstration. Maintainability demonstration shall be performed in accordance with MIL-STD-471, test method 1.

4.2.7.8 Operation Verification. The IM shall be tested at the system level when interconnected to Set Z and each host vehicle. This test shall demonstrate that the IM meets the functional and physical interface requirements as specified herein.

4.2.8 Test Reports. Test reports shall be prepared in accordance with the requirements of MIL-STD-831.

5. PREPARATION FOR DELIVERY

5.1 General. Preservation, packaging, and packing shall be in accordance with the requirements of MIL-STD-794.

6. NOTES

6.1 Intended Use. The integration module is intended for use with the GPS Set Z in the following aircraft:

a. C-141A

b. KC-135A

c. HC-130H

d. HH-53B/C

e. P-3C

6.2 Definitions. The following definitions apply to the terms used in this specification:

a. Host vehicle. Any one of the aircraft in which the integration module will be installed.

b. Group A equipment component. Necessary interconnecting and interfacing components and equipment for the installation of the UE Set Z into the host vehicle.

c. UE Set Z. One of three configurations of very accurate navigation receivers for Phase I of the GPS program.

d. Numerals. Divisions on distance counters.

e. Abbreviations:

HV	–	Host vehicle
IFF	–	Identification, friend or foe
IM	–	Integration module
LRU	–	Line replaceable unit
($M_{max}C_t$)	–	Maximum corrective maintenance downtime
MTBF	–	Mean time between failures
SIF	–	Selective identification feature
TACAN	–	Tactical Air Navigation

NOTES:

1. All tolerances per MIL-STD-810B unless otherwise specified.

2. Unless otherwise stated, all time periods given represent minimum time allowed for test.

3. Unless otherwise plotted, environmental parameters are at ambient test laboratory levels.

4. Resonance Search: Logarithmic sweep of vibration 5-2000-5 Hz, 1g 0-peak sinusoidal.

5. Resonance Dwell: Procedure and schedule according to MIL-STD-810B, Method 514, Procedure I, Part 2. Vibration levels according to MIL-E-5400, Figure 2, Curve IVA.

6. Vibration Cycling: Procedure and schedule according to MIL-STD-810B, Method 514, Procedure I, Part 3. Vibration levels according to MIL-E-5400, Figure 2, Curve IVA.

7. Random Vibration: Continuous broadband random vibration according to MIL-STD-810B, Method 514, Figure 514-4, Test Level AJ, and Table 514-II.

8. The UE will be mounted on its normal vibration isolators, if any, during vibration tests. Different vibration conditions may be separated in time to accommodate functional testing, laboratory setup, or inspection of results, as necessary.

9. Air flow in chamber TBD.

10. MIL-STD-704A, Paragraph 5.1.3.6.

    MIL-STD-704A, Paragraph 5.1.4: Normal operation Class "B"; operate without damage, Figure 3, Limits 1 and 4; operate without degradation, Figure 3, Limits 2 and 3.

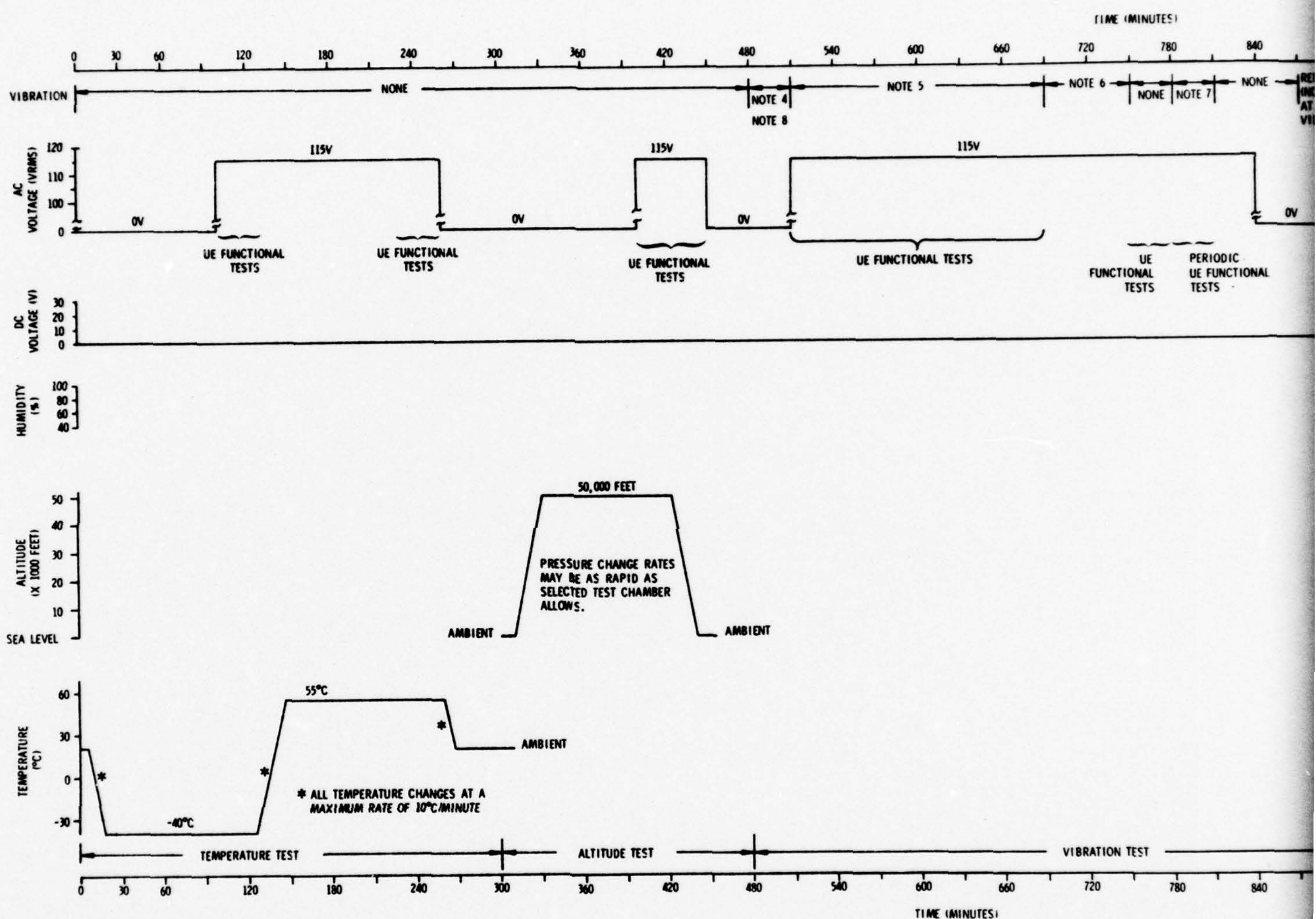
11. MIL-STD-704A, Paragraph 5.1.3.6.

12. MIL-STD-704A, Paragraph 5.2.2.

    MIL-STD-704A, Paragraph 5.2.3: Normal operation Class "B"; operate without damage, Figures 9 and 17, Limits 1 and 4; operate without degradation, Figures 9 and 17, Limits 2 and 3.

13. MIL-STD-704A, Paragraph 5.2.2.

Figure 4. Set Z and IM Single Stress Test
(Sheet 1 of 2)



TIME (MINUTES)
0 30 60 120 180 240 300 360 420 480 540 600 660 720 780 840
VIBRATION
NONE
NOTE 4
NOTE 8
NOTE 5
NOTE 6
NONE
NOTE 7
NONE
AC VOLTAGE (VRMS)
120 110 100 0
0V
115V
UE FUNCTIONAL TESTS
UE FUNCTIONAL TESTS
0V
115V
UE FUNCTIONAL TESTS
0V
115V
UE FUNCTIONAL TESTS
UE FUNCTIONAL TESTS
PERIODIC UE FUNCTIONAL TESTS
0V
DC VOLTAGE (V)
30 20 10 0
HUMIDITY (%)
100 80 60 40
ALTITUDE (X 1000 FEET)
50 40 30 20 10 SEA LEVEL
50,000 FEET
PRESSURE CHANGE RATES MAY BE AS RAPID AS SELECTED TEST CHAMBER ALLOWS.
AMBIENT
AMBIENT
TEMPERATURE (°C)
60 30 0 -30
55°C
-40°C
AMBIENT
* ALL TEMPERATURE CHANGES AT A MAXIMUM RATE OF 10°C/MINUTE
TEMPERATURE TEST
ALTITUDE TEST
VIBRATION TEST
0 30 60 120 180 240 300 360 420 480 540 600 660 720 780 840
TIME (MINUTES)

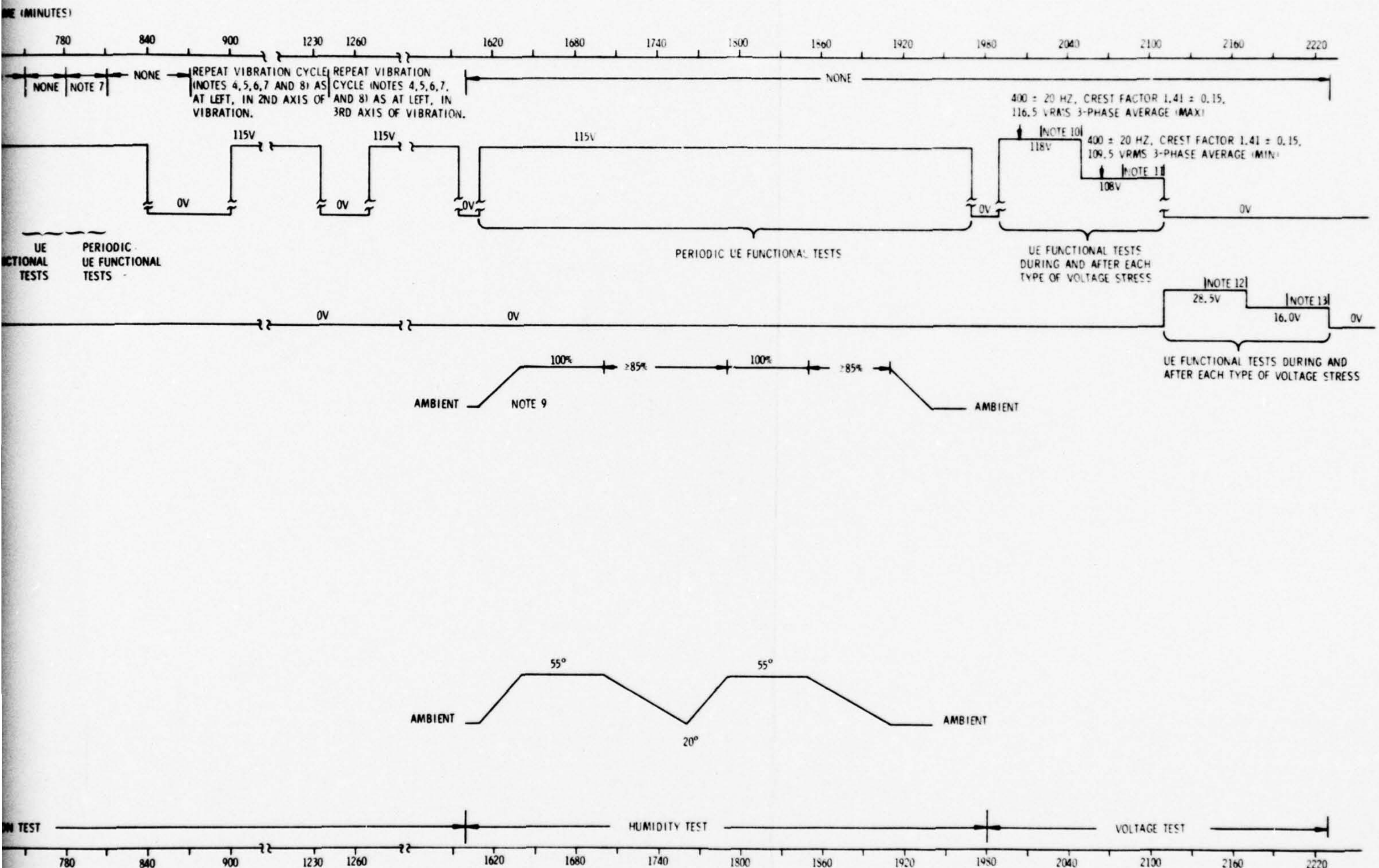


FIGURE 4. SET Z & IM SINGLE STRESS TEST (SHEET 2 OF 2)

NOTES·

1. Unless otherwise stated, all tolerances are per MIL-STD-810B.

2. Phase IV same as Phase III with vibration on different axis.

3. Unless otherwise stated, all time periods given represent the minimum time allowed for test.

4. Vibration Level: MIL-STD-810B, Method 514, Figure 514-4, Test Level AJ

5. Vibration Level: MIL-STD-810B, Method 514, Figure 514-4, Test Level AH

6. Vibration Level: MIL-E-5400, Figure 2, Curve IVA.
   Procedure: MIL-STD-810B, Method 514, Procedure I, Part 2

7. MIL-STD-704A, Paragraph 5.1.3.6.

   MIL-STD-704A, Paragraph 5.1.4: Normal operation Class "B"; operate without damage, Figure 3, Limits 1 and 4; operate without degradation, Figure 3, Limits 2 and 3.

8. MIL-STD-704A, Paragraph 5.1.3.6.

9. MIL-STD-704A, Paragraph 5.2.2.

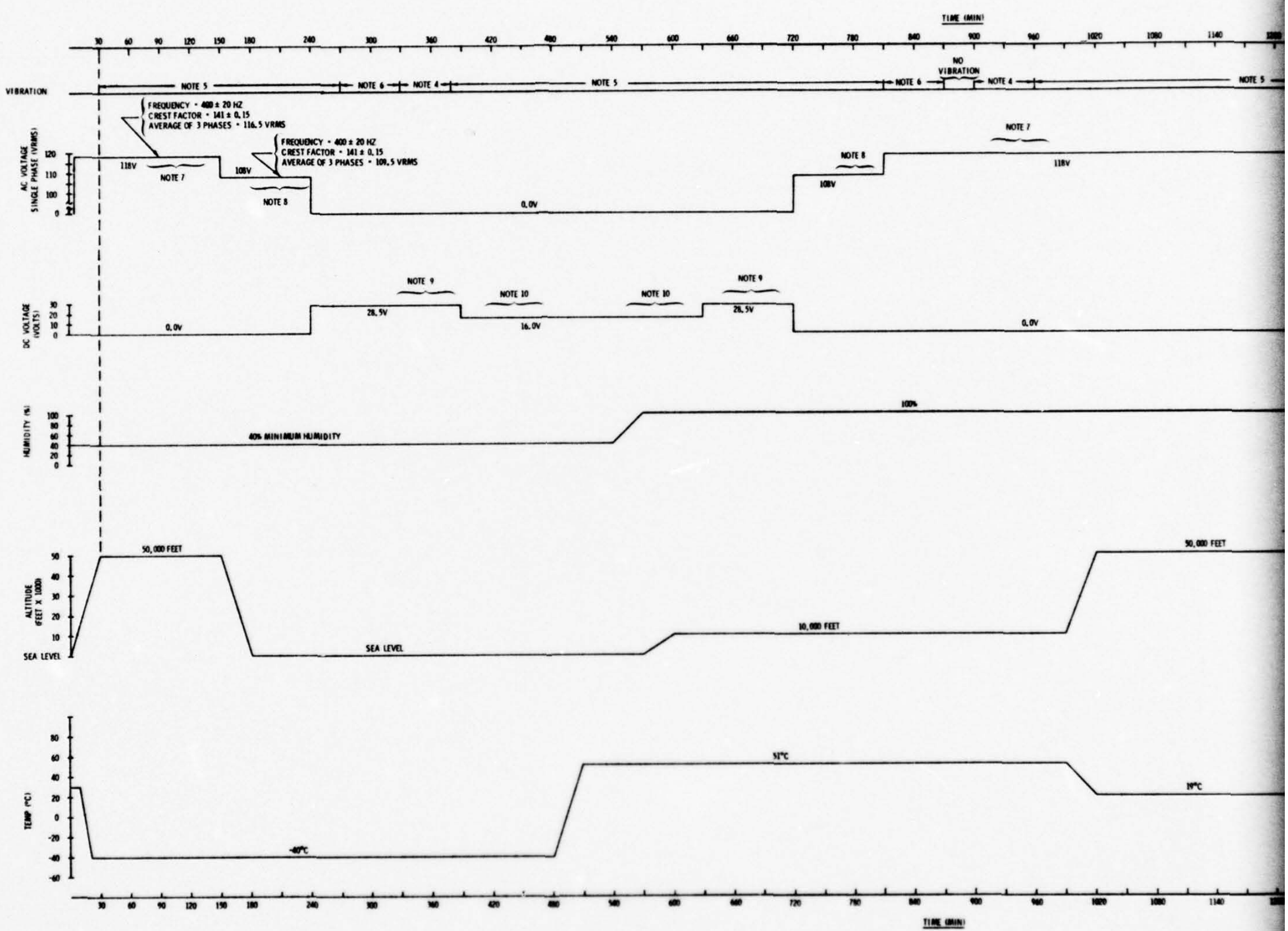
   MIL-STD-704A, Paragraph 5.2.3: Normal operation Class "B"; operate without damage, Figures 9 and 17, Limits 1 and 4; operate without degradation, Figures 9 and 17, Limits 2 and 3.

10. MIL-STD-704A, Paragraph 5.2.2.

11. Airflow in chamber TBD.

12. Vibration on different axis from Phases 1 and 2.

Figure 5. Set Z and IM Combined Stress Tests
(Sheet 1 of 2)



TIME (MIN)
30 60 90 120 150 180 240 300 360 420 480 540 600 660 720 780 840 900 960 1020 1080 1140
VIBRATION
NOTE 5
NOTE 6
NOTE 4
NOTE 5
NOTE 6
NO VIBRATION
NOTE 4
NOTE 5
FREQUENCY = 400 ± 20 HZ
CREST FACTOR = 141 ± 0.15
AVERAGE OF 3 PHASES = 116.5 VRMS
FREQUENCY = 400 ± 20 HZ
CREST FACTOR = 141 ± 0.15
AVERAGE OF 3 PHASES = 109.5 VRMS
AC VOLTAGE SINGLE PHASE (VRMS)
120
110
100
0
118V
NOTE 7
108V
NOTE 8
0.0V
NOTE 8
108V
NOTE 7
118V
DC VOLTAGE (VOLTS)
0.0V
NOTE 9
28.5V
NOTE 10
16.0V
NOTE 10
NOTE 9
28.5V
0.0V
HUMIDITY (%)
40% MINIMUM HUMIDITY
100%
ALTITUDE (FEET X 1000)
50
40
30
20
10
SEA LEVEL
50,000 FEET
SEA LEVEL
10,000 FEET
50,000 FEET
TEMP (°C)
80
60
40
20
0
-20
-40
-60
-40°C
51°C
19°C
TIME (MIN)

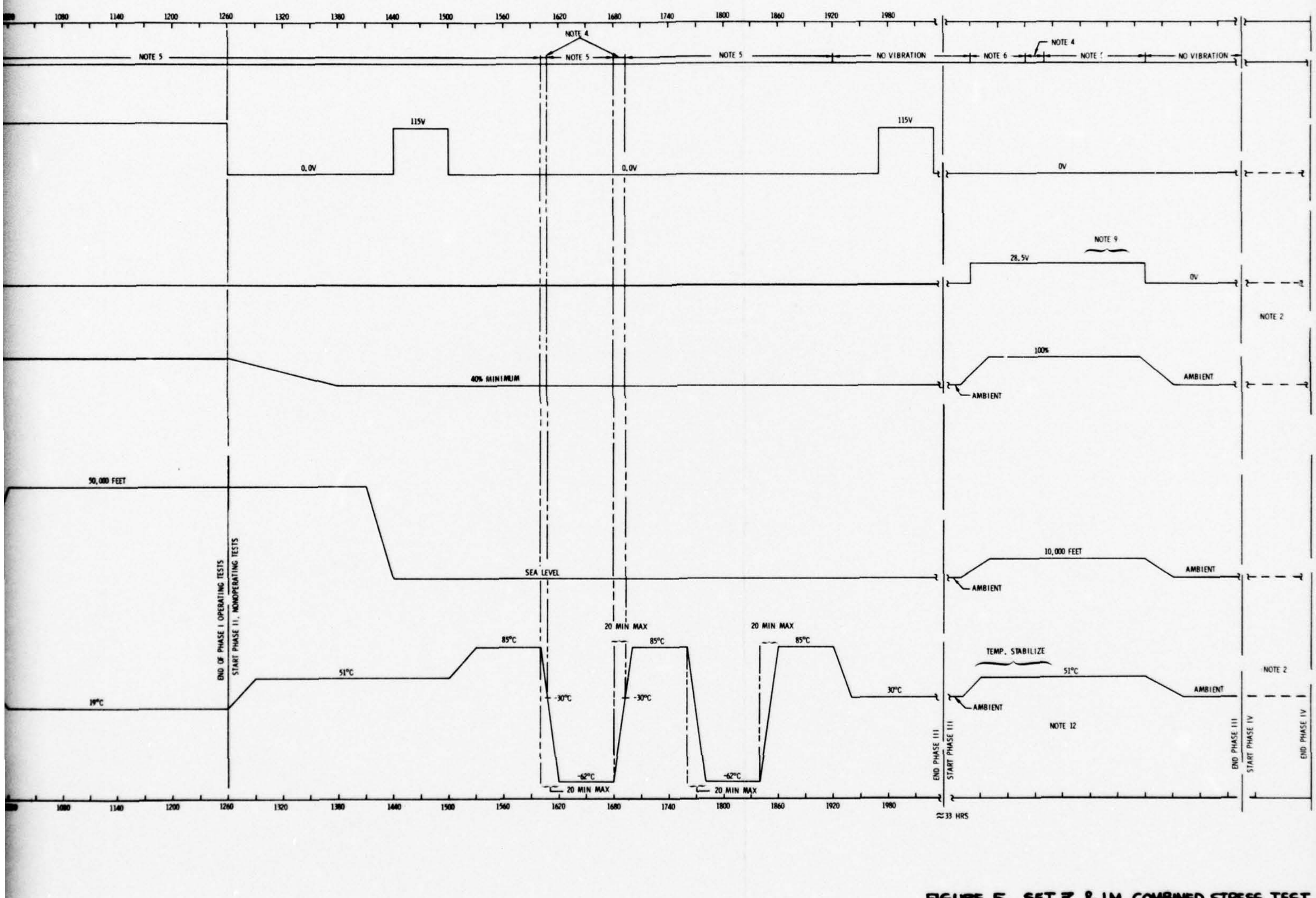


FIGURE 5. SET II & IM COMBINED STRESS TEST
(SHEET 2 of 2)

APPENDIX B

INTERFACE SIGNAL CHARACTERISTICS

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Bearing	Analog, Synchro	O	Integration Module	Pilot's HSI & BDHI Copilot's BDHI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to the bearing pointer* to display relative bearing of the aircraft's present position to selected waypoint. The relative bearing is the difference, in degrees, between the lubber line and the bearing pointer as read from the compass card.

*Note: No. 1 pointer on all BDHI's

SIGNAL CHARACTERISTICS

RANGE: 0° to 360°

RESOLUTION: 0.1°

ACCURACY: $\pm 0.5^{\circ}$

INDEX REFERENCE: Aircraft Heading

POSITIVE DIRECTION SENSE: Increasing Bearing

SCALE FACTOR: $1^{\circ} = 1^{\circ}$

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-4/A), 3-Wire Synchro, EP AY500-5 or equal
2) Pilot's BDHI (ID-798/ARN), 3-Wire Synchro
3) Copilot's BDHI (ID-798/ARN), 3-Wire Synchro
4) Navigator's BDHI (ID-798/ARN), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted, shielded triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -

J174A-M (X)
N (Y)
P (Z)

A/C: C-141A	CODE: BRG-1	REF: AQU-4/A, MIL-I-27848A ID-798/ARN, MIL-I-25992A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, units	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's BDHI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the units digit in the range window. Displays aircraft present position distance to selected waypoint in 1nm increments (0.5nm indexed). Driven independently of other digits, but read in conjunction with them in order to provide the least significant digit.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 0.1 (3.6^o)

ACCURACY: ± 0.2 ($\pm 7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-4/A), 3-Wire Synchro, Clifton CRC-8-A-1 or equal.
2) Pilot's BDHI (ID-798/ARN), 3-Wire Synchro,
3) Copilot's BDHI (ID-798/ARN), 3-Wire Synchro,
4) Navigator's BDHI (ID-798/ARN), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -
J174A-F (Y)
G (X)

NOTE: 'Z' is tied to ground

A/C: C-141A	CODE: DIST-1	REF: AQU-4/A, MIL-I-27848A ID-798/ARN, MIL-I-25992A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, tens	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's BDHI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the tens digit in the range window. Displays aircraft present position distance to selected waypoint in 10nm increments. Driven independently of other distance digits but read in conjunction with them.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ± 0.2 ($\pm 7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-4/A), 3-Wire Synchro, Clifton CRC-8-A-1 or equal
2) Pilot's BDHI (ID-798/ARN), 3-Wire Synchro,
3) Copilot's BDHI (ID-798/ARN), 3-Wire Synchro
4) Navigator's BDHI (ID-798/ARN), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD
INTERFACE CONN (Existing Junction Box) -
J174A-H (X)
J (Y)

NOTE: 'Z' tied to ground

A/C: C-141A	CODE: DIST-2	REF: AQU-4/A, MIL-I-27848A ID-798/ARN, MIL-I-25992A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, hundreds	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's BDHI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the hundreds digit in the range window. Displays aircraft present position distance to the selected waypoint in 100nm increments. Driven independently of the other distance digits, but read in conjunction with them in order to provide the most significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ± 0.2 ($\pm 7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-4/A), 3-Wire Synchro, Clifton CRC-8-A-1 or equal
2) Pilot's BDHI (ID-798/ARN), 3-Wire Synchro,
3) Copilot's BDHI (ID-798/ARN), 3-Wire Synchro,
4) Navigator's BDHI (ID-798/ARN), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD
INTERFACE CONN (Existing Junction Box) -
J174A-K (X)
-L (Y)

NOTE: 'Z' tied to ground

A/C: C-141A	CODE: DIST-3	REF: AQU-4/A, MIL-I-27848A ID-798/ARN, MIL-I-25992A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation	Analog, d.c.	0	Integration Module	Pilot's HSI Pilot's Flt. Dir Auto pilot

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal that indicates the distance in nautical miles that the aircraft is displaced to the left or right of the desired track. When the deviation exceeds the range equivalent to full scale deflection, the output should not be less than full scale current, nor should it be permitted to exceed 500 microamps under any conditions likely to be encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: 0 to ± 150 Microamperes

RESOLUTION: ± 3 Microamperes

ACCURACY: ± 10 Microamperes

SCALE FACTOR: 75 Microamperes = 1 dot

150 Microamperes = 2 dots

SENSITIVITY: (full scale)

Enroute = ± 6.0 nm

Terminal = ± 1.0 nm

Approach = ± 0.1 nm

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-4/A); meter movement, 1000 ohms ± 3 %
2) Pilot's Flight Director Computer (3K91002)
3) Automatic Flight Control System

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO. : Twisted, shielded pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -

J174A-D (+ & Right)
E (- & Left)

A/C: C-141A	CODE: DEV-1	REF: AQU-4/A, MIL-I-27848A 3K91002, TBD	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	O/I	FROM	TO
Distance Flag	Discrete	O	Integration Module	Pilot's HSI

<u>FUNCTIONAL DESCRIPTION</u>

Provides a discrete signal to operate the distance warning flag. The flag is normally out of view when the range indicator is operating and the range data is valid. The flag covers the range indicator when the distance information is not valid or the device supplying the distance data is not operating.

<u>SIGNAL CHARACTERISTICS</u>

RANGE: 28 vdc ground applied = out-of-view
28 vdc ground not applied = in-view

<u>ELECTRICAL CHARACTERISTICS</u>

LOAD: 1) Pilot's HSI (AQU-4/A) Meter movement (28VDC)

<u>MOUNT INTERCONNECTION DATA</u>

WIRE TYPE & NO.: Single conductor

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) - J174A-A

A/C: C-141A	CODE: DIF-1	REF: AQU-4/A, MIL-I-27848A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation (NAV) Flag	Discrete	0	Integration Module	Pilot's HSI Pilot's Flt. Dir.

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate the deviation warning flag or circuit when the deviation data is unreliable or a malfunction has occurred in the course deviation circuitry.

SIGNAL CHARACTERISTICS

RANGE: in-view <180μa

out-of-view = 245μa

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (AQU-4/A), Suppressed zero meter movement, 1000 ohms 3% resistance

2) Flight director

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -
J174A-C (+)
-B (-)

A/C: C-141A	CODE: DEF-1	REF:	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
To-From	Analog, d.c.	0	Integration Module	Pilot's HSI

FUNCTIONAL DESCRIPTION

Provides a d.c. analog signal to drive the TO-FROM indicator. Indicator displays direction aircraft (present position) is flying in relation to the selected waypoint. If the aircraft is flying toward the waypoint and has not intercepted a reference line perpendicular to the aircraft track and through the waypoint, the indication will be TO. Once past the waypoint reference line the indication will be FROM, unless the next waypoint has been selected.

SIGNAL CHARACTERISTICS

RANGE: TO = +225 μa MAX
BLANK = no signal
FROM = -225 μa MAX

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (AQU-4/A), Meter movement, 200 ohms ±15% resistance

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) - J174A-V (+)
-W (-)

A/C: C-141A	CODE: TFI-1	REF: AQU-4/A, MIL-I-27848A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Course Set	Analog, Resolver	I	Pilot's HSI	Integration Module

FUNCTIONAL DESCRIPTION

Provides an electrical reference signal of the desired track manually selected by the COURSE SET control on the HSI. Signal provides a position reference of the course arrow for positioning the course deviation indicator to the left or right of the desired course. Also provides reference for placing the To-From indicator. Desired track manually selected must match the desired course displayed on the CDU or deviation flag will be displayed.

SIGNAL CHARACTERISTICS

RANGE: 0^o to 360^o

RESOLUTION: 0.1^o

ACCURACY: $\pm 0.5^o$

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Right Hand Increments

SCALE FACTOR: $1^o=1^o$

ELECTRICAL CHARACTERISITCS

SOURCE: 1) Pilot's HSI (AQU-41A); resolver type EP AY221-5-B or equivalent

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two shielded pairs and one Triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -

J174A-X(D) -b(A)
-Y(E) -c(B)
-Z(F) -d(C)
-a(G)

A/C: C-141A	CODE: RES-1	REF: AQU-41A, MIL-I-27848A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Magnetic Heading	Analog, synchro	I	Pilot's Compass System	Integration Module

FUNCTIONAL DESCRIPTION

Provides angular reference signal of aircraft heading relative to magnetic north. May be used to position bearing pointers and desired track (course arrow) relative to compass card position.

SIGNAL CHARACTERISTICS

RANGE: 0^{0} to 360^{0}

RESOLUTION: 0.1^{0}

ACCURACY: $\pm 0.5\%$

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: $1^{0} = 1^{0}$

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Pilot's Compass System (C-12);
3-wire synchro, type
EP AY201S-77-T or equivalent

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Shielded Triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing Junction Box) -
J174A-R(Z)
-S(Y)
-T(X)

A/C: C-141A	Code: MGH-1	REF: C-12, T.O.5N1-2-15-2	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
True Airspeed	Analog, Synchro	I	No.1 CADC	Integration Module

FUNCTIONAL DESCRIPTION

Provides a value for aircraft true airspeed in angular analog signal format.

SIGNAL CHARACTERISTICS

RANGE: 100 to 650 knots

RESOLUTION: 1 knot

ACCURACY: ± 4 knots

INDEX REFERENCE: 0 knots

POSITIVE DIRECTION SENSE: To increasing values

SCALE FACTOR: 36^0 = 100 knots

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Central Air Data Computer (CPU-43/A); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted, shielded Triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (NAV Junction Box) -
TB 6 H-402(X)
-403(Y)
-404(Z)

A/C: C-141A	CODE: TAS-1	REF: CPU-43/A, MIL-C-38037A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Encoded Altitude	Digital	I	No.1 CADC	Integration Module

FUNCTIONAL DESCRIPTION

Provides an input of pressure altitude in digital format for use by the system when operating with less than full navigation capability. The encoded altitude data will at all times be referenced to 29.92 in Hg. The digital code for altitutde is in accordance with both the ICAO Annex 10 SSR System SARPS and the U.S. National Standard for the ATCRBS.

SIGNAL CHARACTERISTICS

RANGE: -1000 to 60,000 feet

RESOLUTION: 100 feet

ACCURACY: ± 100 feet

INDEX REFERENCE: 0 feet

POSITIVE DIRECTION SENSE: Up-perpendicular to horizontal earth plane

SCALE FACTOR: 10 bits

ELECTRICAL CHARACTERISTICS

SOURCE: 1) No.1 Central Air Data Computer (CPU-43/A); shaft angle encoder.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Ten single shielded conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (CADC) - Tie into bottom plug
P410A-18(A1) -22(B2) -26(C4)
-19(A2) -23(B4) -27(D4)
-20(A4) -24(C1)
-21(B1) -25(C2)

A/C: C-141A	CODE: ALT-1	REF: CPU-43/A, MIL-C-38037A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Bearing	Analog, Synchro	0	Integration Module	Pilot's HSI & RMI Copilot's HSI & RMI Navigator's RMI

FUNCTIONAL DESCRIPTION

Provides angular information to the bearing pointer* to display relative bearing of the aircraft's present position to selected waypoint. The relative bearing is the difference, in degrees, between the lubber line and the bearing pointer as read from the compass card.

*Note: No. 1 pointer on all HSI's and RMI's

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: $\pm 0.5^{o}$

INDEX REFERENCE: Aircraft Heading

POSITIVE DIRECTION SENSE: Increasing Bearing

SCALE FACTOR: $1^{o} = 1^{o}$

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (331A-8H), 3-Wire Synchro
2) Copilot's HSI (331A-8H), 3-Wire Synchro
3) Pilot's RMI (ID-250/ARN), 3-Wire Synchro
4) Copilot's RMI (ID-250/ARN), 3-Wire Synchro
5) NAV's RMI (ID-250/ARN), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) - RD6905(BP) -32 (X)
-31 (Y)
-30 (Z)

Note: 'Z' tied to ground

A/C: KC-135A	CODE: BRG-1	REF: 331A-8H, T.O. 12R5-4-93-12 ID-250/ARN, MIL-C-5824A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, units	Analog, Synchro	O	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the units digit in the range window. Displays aircraft present position distance to selected waypoint in 1 nm increments (0.5nm indexed). Driven independently of other digits, but read in conjunction with them in order to provide the least significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^{o} to 360^{o})

RESOLUTION: 0.1 (3.6^{o})

ACCURACY: ± 0.2 ($\pm 7.2^{o}$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^{o} = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (331A-8H), 3-Wire Synchro,

2) Copilot's HSI (331A-8H), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) -
RD6905(BP) -2 (X)
-3 (Y)

Note: 'Z' tied to ground

A/C: KC-135A	CODE: DIST-2	REF: 331A-8H, T.O. 12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, tens	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the tens digit in the range window. Displays aircraft present position distance to selected waypoint in 10nm increments. Driven independently of other distance digits but read in conjunction with them.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ± 0.2 ($\pm 7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (331A-8H), 3-Wire Synchro,

2) Copilot's HSI (331A-8A), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) -
RD6905(BP) -4 (X)
-5 (Y)

Note: 'Z' tied to ground

A/C: KC-135A	CODE: DIST-2	REF: 331A-8H, T.O. 12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, hundreds	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the hundreds digit in the range window. Displays aircraft present position distance to the selected waypoint in 100nm increments. Driven independently of the other distance digits, but read in conjunction with them in order to provide the most significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ±0.2 (±7.2^o)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing value (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (331A-8H), 3-Wire Synchro,

2) Copilot's HSI (331A-8H), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) - RD6905(BP) -6 (X)
-7 (Y)

NOTE: 'Z' tied to ground

A/C: KC-135A	CODE: DIST-3	REF: 331A-8H, T.O. 12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation	Analog, d.c.	0	Integration Module	Pilot's HSI, Copilot's HSI, Flt Dir System, Autopilot

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal that indicates the distance in nautical miles that the aircraft is displaced to the left or right of the desired track. When the deviation exceeds the range equivalent to full scale deflection, the output should not be less than full scale current, nor should it be permitted to exceed 500 microamps under any conditions likely to be encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: 0 to ± 150 microamperes

RESOLUTION: ± 3 microamperes

ACCURACY: ± 10 microamperes

SCALE FACTOR: 75 microamperes=1 dot
150 microamperes=2 dots

SENSITIVITY: (full scale)
Enroute = ±6.0 nm
Terminal = ±1.0 nm
Approach = ±0.1 nm

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (331A-8H); meter movement, 1000 ohms ± 3%.
2) Copilot's HSI (331A-8H); meter movement, 1000 ohms ± 3%
3) Flight Director Computer (ASQ-141)
4) Autopilot (MC-1)

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted, shielded pair

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) -
RD6905(BP)-40(+ & R)
-48(- & L)

Note: Pin 48 is common for TO-FROM also.

A/C: KC-135A	CODE: DEV-1	REF: 331A-8H, T.O.12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance Flag	Discrete	0	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate the distance warning flag. The flag is normally out of view when the range indicator is operating and the range data is valid. The flag covers the range indicator when the distance information is not valid or the device supplying the distance data is not operating.

SIGNAL CHARACTERISTICS

RANGE: 28 Vdc ground applied = out-of-view

28 Vdc ground not applied = in-view

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (331A-8H), Meter movement

2) Copilot's HSI (331A-8H), Meter movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG & 20 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - RD238-J(+)
-P(-)

A/C: KC-135A	CODE: DIF-1	REF: 331A-8H, T.O. 12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation (NAV) Flag	Discrete	0	Integration Module	Relay

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate a relay that provides the necessary current through closed contacts to operate the course deviation warning flag. The flag indicates when the course deviation data is unreliable.

SIGNAL CHARACTERISTICS

RANGE: Open or 28 Vdc ground

SCALE FACTOR: Flag in-view = open
Flag out-of-view = 28 VDC ground

ELECTRICAL CHARACTERISTICS

LOAD: 1) Relay (RR6812); relay coil.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Single conductor

WIRE SIZE: No. 20 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Relay) - RR6812-X1(+)

A/C: KC-135A	CODE: DEF-2	REF: Relay, T.O.1C-135(R)A-2-12-2,dwg.RN3.2610	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
To-From	Analog, d.c.	0	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides a d.c. analog signal to drive the TO-FROM indicator. Indicator displays direction aircraft (present position) is flying in relation to the selected waypoint. If the aircraft is flying toward the waypoint and has not intercepted a reference line perpendicular to the aircraft track and through the waypoint, the indication will be TO. Once past the waypoint reference line the indication will be FROM, unless the next waypoint has been selected.

SIGNAL CHARACTERISTICS

RANGE: TO = +225 μa MAX

BLANK = no signal

FROM = -225 μa MAX

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (331A-8H), Meter movement, 200 ohms resistance

2) Copilot's HSI (331A-8H), Meter movement, 200 ohms resistance

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) -
RD6905(BP)-56(+)
-48(RTN)

A/C: KC-135A	CODE: TFI-1	REF: 331A-8H, T.O. 12R5-4-93-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Course Set	Analog, resolver	I	Pilot's HSI	Integration module

FUNCTIONAL DESCRIPTION

Provides an electrical reference signal of the desired track manually selected by the COURSE SET control on the HSI. Signal provides a position reference of the course arrow for positioning the course deviation indicator to the left or right of the desired course. Also provides reference for placing the TO-FROM indicator. Desired track manually selected must match the desired course displayed on the CDU, or the deviation flag will be displayed.

SIGNAL CHARACTERISTICS

RANGE: 0^o to 360^o

RESOLUTION: 0.1^o

ACCURACY: $\pm 0.5^o$

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Right Hand Increments

SCALE FACTOR: $1^o = 1^o$

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Pilot's HSI (331A-8H); resolver Clifton TSH11F08A049 or equivalent.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Seven single shielded conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN, TACAN Coupler - } RD 6905(BP)-33(F) -34(E) -35(D) -36(G) -38(C) -41(A) -42(B)

A/C: KC-135A	CODE: RES-1	REF: 331A-8H, T.O.12R5-4-93-12	Sheet 1 of 1

SIGNAL NAME	TYPE	I/O	FROM	TO
Magnetic Heading	Analog, synchro	I	N-1 Compass System	Integration Module

FUNCTIONAL DESCRIPTION

Provides angular reference signal of aircraft heading relative to magnetic north. May be used to position bearing pointers and desired track (course arrow) relative to compass card position.

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: $\pm$ 0.5%

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: $1^{o} = 1^{o}$

ELECTRICAL CHARACTERISTICS

SOURCE: N-1 Compass System Amplifier (ME-1A); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Three single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN Coupler) -
RD6905(BP)-12(X)
-13(Y)
-47(Z)

A/C: KC-135A	CODE: MGH-1	REF: ME-1A, MIL-A-25088B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
True Airspeed	Analog, Synchro	I	True Airspeed Computer	Integration Module

FUNCTIONAL DESCRIPTION

Provides a value for aircraft true airspeed in angular analog signal format.

SIGNAL CHARACTERISTICS

RANGE: 150 to 650 knots

RESOLUTION: 2 knots

ACCURACY: $\pm$ 4 knots

INDEX REFERENCE: 0 knots

POSITIVE DIRECTION SENSE: To increasing values

SCALE FACTOR: 36^{o} = 100 knots

ELECTRICAL CHARACTERISTICS

SOURCE: 1) True Airspeed Computer (Type A-2); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Three single conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - Tie into TAS Computer
RD122-C(X)
-D(Y)
-E(Z)

A/C: KC-135A	CODE: TAS-1	REF: Type A-2, MIL-C-5191B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Encoded Altitude	Digital	I	Altitude Computer	Integration Module

FUNCTIONAL DESCRIPTION

Provides an input of pressure altitude in digital format for use by the system when operating with less than full navigation capability. The encoded altitude data will at all times be referenced to 29.92 in Hg. The digital code for altitude is in accordance with both the ICAO Annex 10 SSR System SARPS and the U.S. National Standard for the ATCRBS.

SIGNAL CHARACTERISTICS

RANGE: -1000 to 62,750 feet

RESOLUTION: 100 feet

ACCURACY: ± 100 feet

INDEX REFERENCE: 0 feet

POSITIVE DIRECTION SENSE: Up-perpendicular to horizontal earth plane

SCALE FACTOR: 10 bits

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Altitude Computer (CPU-66/A-1); Shaft angle encoder.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Ten single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - Tie into Altitude Computer -
RD3393-6(A1) -10(B2) -14(C4)
-7(A2) -11(B4) - 5(D4)
-8(A4) -12(C1)
-9(B1) -13(C2)

A/C: KC-135A	CODE: ALT-1	REF: CPU-66/A-1,MIL-C-38240/1C	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Bearing	Analog, Synchro	0	Integration Module	Pilot's HSI and BDHI Copilot's HSI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to the bearing pointer* to display relative bearing of the aircraft's present position to selected waypoint. The relative bearing is the difference, in degrees, between the lubber line and the bearing pointer as read from the compass card.

*Note: No. 2 pointer on all BDHI's

SIGNAL CHARACTERISTICS

RANGE: 0^0 to 360^0

RESOLUTION: 0.1^0

ACCURACY: $\pm 0.5^0$

INDEX REFERENCE: Aircraft Heading

POSITIVE DIRECTION SENSE: Increasing Bearing

SCALE FACTOR: $1^0 = 1^0$

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
2) Copilot's HSI (AQU-2/A) 3-Wire Synchro, EP AY500-5 or equal.
3) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C
4) Navigator's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO: Twisted Triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
J102-32 (X)
31 (Y)
30 (Z)

A/C: HC-130H	CODE: BRG-1	REF: AQU-2/A, MIL-H-26689B ID-1103/ARN, MIL-I-38357B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, units	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's HSI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the units digit in the range window. Displays aircraft present position distance to selected waypoint in 1nm increments (0.5nm indexed). Driven independently of other digits, but read in conjunction with them in order to provide the least significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 0.1 (3.6^o)

ACCURACY: ±0.2 ($\pm 7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
2) Copilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
3) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.
4) Navigator's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO: Two Conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - J102-2(X)
-3(Y)

Note: 'Z' tied to ground

A/C: HC-130H	CODE: DIST-1	REF: AQU-2/A, MIL-I-26689B ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, tens	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's HSI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the tens digit in the range window. Displays aircraft present position distance to selected waypoint in 10nm increments. Driven independently of other distance digits but read in conjunction with them.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ±0.2 (±7.2^o)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
2) Copilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
3) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.
4) Navigator's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two Conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
J102-4(X)
-5(Y)

Note: 'Z' tied to ground

A/C: HC-130H	CODE: DIST-2	REF: AQU-2/A, MIL-I-26689B ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, hundreds	Analog, Synchro	0	Integration Module	Pilot's HSI & BDHI Copilot's HSI Navigator's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the hundreds digit in the range window. Displays aircraft present position distance to selected waypoint in 100nm increments. Driven independently of the other distance digits, but read in conjunction with them in order to provide the most significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ±0.2 (±7.2^o)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
2) Copilot's HSI (AQU-2/A), 3-Wire Synchro, EP AY500-5 or equal.
3) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.
4) Navigator's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal:

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two Conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - J102-6(X)
-7(Y)

A/C: HC-130H	CODE: DIST-3	REF: AQU-2/A, MIL-I-26689B ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation	Analog, d.c.	O	Integration Module	Pilot's HSI, Copilot's HSI, Pilot's Flt Dir, Copilot's Flt Dir, and Autopilot

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal that indicates the distance in nautical miles that the aircraft is displaced to the left or right of the desired track. When the deviation exceeds the range equivalent to full scale deflection, the output should not be less than full scale current, nor should it be permitted to exceed 500 microamps under any conditions likely to be encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: 0 to ± 150 Microamperes

RESOLUTION: ± 3 Microamperes

ACCURACY: ± 10 Microamperes

SCALE FACTOR: 75 Microamperes = 1 dot
150 Microamperes = 2 dots

SENSITIVITY: (full scale)
Enroute = ± 6.0 nm
Terminal = ± 1.0 nm
Approach = ± 0.1 nm

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A); meter momement, 1000 ohms ±3%
2) Copilot's HSI (AQU-2/A); meter movement, 1000 ohms ±3%
3) Pilot's Flight Director Computer (CPU-65/A), 1000 ohms ±3%
4) Copilot's Flight Director Computer (CPU-65/A), 1000 ohms ±3%
5) Autopilot (E-4)

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two single shielded conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - J102-40(+ & R)
-48(- & L)

NOTE: Pin 48 is common for TO-FROM

A/C: HC-130H	CODE: DEV-1	REF: AQU-2/A, MIL-I-26689B CPU-65/A, MIL-C-38286	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance Flag	Discrete	0	Integration Module	Pilot's HSI & BDHI Copilot's HSI Navigator's LH BDHI

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate the distance warning flag. The flag is normally out of view when the range indicator is operating and the range data is valid. The flag covers the range indicator when the distance information is not valid or the device supplying the distance data is not operating.

SIGNAL CHARACTERISTICS

RANGE: 28 Vdc ground applied = out-of-view

28 Vdc ground not applied = in-view

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (AQU-2/A), Meter Movement
2) Copilot's HSI (AQU-2/A), Meter Movement
3) Pilot's BDHI (ID-1103/ARN), Meter Movement
4) Navigator's BDHI (ID-1103/ARN), Meter Movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (TACAN J-Box) - TB500C-50(+)
-49(-)

A/C: HC-130H	CODE: DIF-1	REF: AQU-2/A, MIL-I-26689A ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation (NAV) Flag	Discrete	0	Integration Module	Pilot's Flight Director Copilot's Flight Director

FUNCTIONAL DESCRIPTION

Provides a discrete signal (28VDC gnd) to operate a relay that passes the low level (+ side) signal to the flight director computer. The signal indicates that the course deviation data is unreliable.

SIGNAL CHARACTERISTICS

RANGE: Open or 28 Vdc ground

SCALE FACTOR: Flag in-view = open
Flag out-of-view = 28 Vdc ground

ELECTRICAL CHARACTERISTICS

LOAD: 1) Relay (R83RM); relay coil

2) Flight Director Computer (CPU-65/A); 1000 ohms ±3%

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two single conductors

WIRE SIZE: No.20 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - P347RA-H(+)
-L(-)

A/C: HC-130H	CODE: DEF-1&2	REF: Relay, T.O.1C-130(H)H-2-11, Fig. 3-17 CPU-65/A, MIL-C-38286	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
To-From	Analog, d.c.	0	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides a d.c. analog signal to drive the TO-FROM indicator. Indicator displays direction aircraft (present position) is flying in relation to the selected waypoint. If the aircraft is flying toward the waypoint and has not intercepted a reference line perpendicular to the aircraft track and through the waypoint, the indication will be TO. Once past the waypoint reference line the indication will be FROM, unless the next way point has been selected.

SIGNAL CHARACTERISTICS

RANGE: TO = +225 μa MAX.

BLANK = no signal

FROM= -225 μa MAX.

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's HSI (AQU-2/A), Meter Movement, 200 ±50 ohms resistance

2) Copilot's HSI (AQU-2/A), Meter Movement, 200 ±50 ohms resistance

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two Conductor Shielded

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - J102-56(+)
-48(RTN)

A/C: HC-130H	CODE: TFI-1	REF: AQU-2/A, MIL-I-26689B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Course Set	Analog, resolver	I	Pilot's HSI	Integration Module

FUNCTIONAL DESCRIPTION

Provides an electrical reference signal of the desired track manually selected by the COURSE SET control on the HSI. Signal provides a position reference of the course arrow for positioning the course deviation indicator to the left or right of the desired course. Also provides reference for placing the TO-FROM indicator. Desired track manually selected must match the desired course displayed on *the CDU, or deviation flag will be displayed.*

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: $\pm$ 0.5%

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: 1^{o} - 1^{o}

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Pilot's HSI (AQU-2/A); resolver type EP AY221-5-B or equivalent

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two shielded pairs and three single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -

J102-33(F)	-38(C)
-34(E)	-39(B)
-35(D)	-37(A)
-36(G)	

A/C: HC-130H	CODE: RES-1	REF: AQU-2/A, MIL-I-26689B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Magnetic Heading	Analog, synchro	I	No.1 Compass System	Integration Module

FUNCTIONAL DESCRIPTION

Provides angular reference signal of aircraft heading relative to magnetic north. May be used to position bearing pointers and desired track (course arrow) relative to compass card position.

SIGNAL CHARACTERISTICS

RANGE: 0° to 360°

RESOLUTION: 0.1°

ACCURACY: $\pm$ 0.5%

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: 1° - 1°

ELECTRICAL CHARACTERISTICS

SOURCE: 1) No.1 Compass System (C-12); 3-wire synchro, type EP AY201S-77-T or equivalent

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted triplet

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
J102-12(X)
-13(Y)
-47(Z)

A/C: HC-130H	CODE: MHG-1	REF: C-12, T.O.5N1-2-15-2	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Encoded Altitude	Digital	I	Altimeter-Encoder	Integration Module

FUNCTIONAL DESCRIPTION

Provides an input of pressure altitude in digital format for use by the system when operating with less than full navigation capability. The encoded altitude data will at all times be referenced to 29.92 Hg. The digital code for altitude is in accordance with both the ICAO Annex 10 SSR System SARPS and the U.S. National Standard for the ATCRBS.

SIGNAL CHARACTERISTICS

RANGE: -1000 to 38,000 feet

RESOLUTION: 100 feet

ACCURACY: ± 100 feet

INDEX REFERENCE: 0 feet

POSITIVE DIRECTION SENSE: Up-perpendicular to horizontal earth plane

SCALE FACTOR: 10 bit

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Altimeter-encoder (AAU-21A); shaft angle encoder

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Ten single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD

INTERFACE CONN (Altimeter Conn) -

P982-K(A1)	-E(B4)
-J(A2)	-D(C1)
-H(A4)	-C(C2)
-G(B1)	-B(C4)
-F(B2)	-L(D4)

A/C: HC-130H	CODE: ALT-1	REF: AAU-21/A, MIL-A-81403	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Bearing	Analog, Synchro	0	Integration Module	Pilot's BDHI Copilot's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to the No. 2 bearing pointer to display relative bearing of the aircraft's present position to selected waypoint. The relative bearing is the difference, in degrees, between the lubber line and the bearing pointer as read from the compass card.

SIGNAL CHARACTERISTICS

RANGE: 0^{0} to 360^{0}

RESOLUTION: 0.1^{0}

ACCURACY: $\pm 0.5^{0}$

INDEX REFERENCE: Aircraft Heading

POSITIVE DIRECTION SENSE: Increasing Bearing

SCALE FACTOR: $1^{0} = 1^{0}$

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C

2) Copilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Shielded pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-V(X)
-U(Y)

Note: 'Z' tied to 'Z' of magnetic heading

A/C: HH-53B/C	CODE: BRG-1	REF: ID-1103/ARN, MIL-I-38357B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, units	Analog, Synchro	0	Integration Module	Pilot's BDHI Copilot's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the units digit in the range window. Displays aircraft present position distance to selected waypoint in 1nm increments (0.5nm indexed). Driven independently of other digits, but read in conjunction with them in order to provide the least significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^{o} to 360^{o})

RESOLUTION: 0.1 (3.6^{o})

ACCURACY: ±0.2 (±7.2^{o})

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^{o} = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.
2) Copilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - P106R-R(X)
-P(Y)

Note: 'Z' tied to ground

A/C: HH-53B/C	CODE: DIST-1	REF: ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, tens	Analog, Synchro	0	Integration Module	Pilot's BDHI Copilot's BDHI

<u>FUNCTIONAL DESCRIPTION</u>

Provides angular information to rotate the tens digit in the range window. Displays aircraft present position distance to selected waypoint in 10nm increments. Driven independently of other distance digits but read in conjunction with them.

<u>SIGNAL CHARACTERISTICS</u>

RANGE: 0 to 9 (0^0 to 360^0)

RESOLUTION: 1.0 (36^0)

ACCURACY: $\pm$0.2 ($\pm 7.2^0$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^0 = 1 numeral

<u>ELECTRICAL CHARACTERISTICS</u>

LOAD: 1) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

2) Copilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

<u>MOUNT INTERCONNECTION DATA</u>

WIRE TYPE & NO.: Twisted pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-N(X)
-M(Y)

Note: 'Z' tied to ground

A/C: HH-53B/C	CODE: DIST-2	REF: 1102/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, hundreds	Analog, Synchro	0	Integration Module	Pilot's BDHI Copilot's BDHI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the hundreds digit in the range window. Displays aircraft present position distance to selected waypoint in 100nm increments. Driven independently of the other distance digits, but read in conjunction with them in order to provide the most significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 1.0 (36^o)

ACCURACY: ±0.2 (±7.2^o)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

2) Copilot's BDHI (ID-1103/ARN), 3-Wire Synchro, 26V-11TR4C or equal.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - P106R-L(X)
-K(Y)

Note: 'Z' tied to ground

A/C: HH-53B/C	CODE: DIST-3	REF: ID-1103/ARN, MIL-I-38357A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation	Analog,d.c.	O	Integration Module	Pilot's CDI & FDI Copilot's CDI

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal that indicates the distance in nautical miles that the aircraft is displaced to the left or right of the desired track. When the deviation exceeds the range equivalent to full scale deflection, the output should not be less than full scale current, nor should it be permitted to exceed 500 microamps under any conditions likely to be encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: 0 to ± 150 Microamperes

RESOLUTION: ± 3 Microamperes

ACCURACY: ± 10 Microamperes

SCALE FACTOR: 75 Microamperes = 1 dot
150 Microamperes = 2 dots

SENSITIVITY: (full scale)

- Enroute = ±6.0 nm
- Terminal = ±1.0 nm
- Approach = ±0.1 nm

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's CDI (ID-387); meter movement, 1000 ohms ±3%
2) Copilot's CDI (ID-387); meter movement, 1000 ohms ±3%
3) Pilot's FDI (353-999-0100); meter movement, 1000 ohms ±2%

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted, shielded pair

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - P106R-h(-&L)
-i(+&R)

A/C: HH-53B/C	CODE: DEV-1	REF: ID-387, MIL-I-9229 353-999-0100, T.O.5F8-5-10-3	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance Flag	Discrete	0	Integration Module	Pilot's BDHI Copilot's BDHI

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate the distance warning flag. The flag is normally out of view when the range indicator is operating and the range data is valid. The flag covers the range indicator when the distance information is not valid or the device supplying the distance data is not operating.

SIGNAL CHARACTERISTICS

RANGE: 28 Vdc ground applied = out-of-view

28 Vdc ground not applied = in-view

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's BDHI (ID-1103/ARN), Meter Movement
2) Copilot's BDHI (ID-1103/ARN), Meter Movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two Conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-J(-)
-S(+)

A/C: HH-53B/C	CODE: DIF-1	REF: ID-1103/ARN, MIL-I-3857A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation (NAV) Flag	Analog, d.c.	0	Integration Module	Copilot's CDI Pilot's CDI & FDI

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal to operate the deviation warning flag when the course deviation data is unreliable or a malfunction has occurred in the course deviation circuitry. The signal shall be linear and shall not exceed 500 microamperes under any conditions encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: In-view $< 180\ \mu A$

Fully-out-of-view = $245\ \mu A$

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's CDI (ID-387/ARN); suppressed zero mechanism, 1000 ohms $\pm 3\%$
2) Copilot's CDI (ID-387/ARN); suppressed zero mechanism, 1000 ohms $\pm 3\%$
3) Pilot's FDI (353-999-0100); suppressed zero mechanism, 1000 ohms $\pm 2\%$

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) - P106R-j(+)
-k(-)

A/C: HH-53B/C	CODE: DEF-1	REF: ID-387/ARN, MIL-I-9229 FDI, 5F8-5-10-3	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
TO-FROM	Analog, d.c.	0	Integration Module	Pilot's CDI Copilot's CDI

FUNCTIONAL DESCRIPTION

Provides a d.c. analog signal to drive the TO-FROM indicator. Indicator displays direction aircraft (present position) is flying in relation to the selected waypoint. If the aircraft is flying toward the waypoint and has not intercepted a reference line perpendicular to the aircraft track and through the waypoint, the indication will be TO. Once past the waypoint reference line the indication will be FROM, unless the next waypoint has been selected.

SIGNAL CHARACTERISTICS

RANGE: TO = +250 μA max

BLANK = no signal

FROM = -250 μA max

ELECTRICAL CHARACTERISTICS

LOAD: 1) Pilot's CDI (ID-387/ARN), Meter Movement

2) Copilot's CDI (ID-387/ARN), Meter Movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-f(+)
-g(-)

A/C: HH-53B/C	CODE: TFI-1	REF: ID-387/ARN, MIL-I-9229	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Course Set	Analog, resolver	I	Copilot's CDI	Integration Module

FUNCTIONAL DESCRIPTION

Provides an electrical reference signal of the desired track manually selected by the COURSE SET control on the HSI. Signal provides a position reference of the course arrow for positioning the course deviation indicator to the left or right of the desired course. Also provides reference for placing the TO-FROM indicator. Desired track manually selected should match the desired course displayed on the CDU.

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: ± 0.5%

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: $1^{o} - 1^{o}$

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Copilot's CDI (ID-387/ARN); resolver type EP AY221S-5-B1 or equivalent

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two twisted shielded pairs and one single shielded conductor

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-W(C)-e(B)
-b(E)
-c(G)
-d(A)

NOTE: 'D' & 'F' leads connected to ground

A/C: HH-53B/C	CODE: RES-1	REF: ID-387/ARN, MIL-I-9229	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Magnetic Heading	Analog, synchro	I	J-4 Compass System	Integration Module

FUNCTIONAL DESCRIPTION

Provides angular reference signal of aircraft heading relative to magnetic north. May be used to position bearing pointers and desired track (course arrow) relative to compass card position.

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: $\pm$ 0.5%

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: 1^{o} - 1^{o}

ELECTRICAL CHARACTERISTICS

SOURCE: 1) J-4 Compass System Amplifier (ME-1A); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Three single shielded conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN (Existing TACAN Conn) -
P106R-X(Z)
-Y(Y)
-Z(X)

A/C: HH-53B/C	CODE: MGH-1	REF: ME-1A, MIL-A-25088B	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
True Airspeed	Analog, synchro	I	True Airspeed Transmitter	Integration Module

FUNCTIONAL DESCRIPTION

Provides a value for aircraft true airspeed in angular analog signal format.

SIGNAL CHARACTERISTICS

RANGE: -30 to 170 knots

RESOLUTION: 2 knots

ACCURACY: ± 4 knots

INDEX REFERENCE: 0 knots

POSITIVE DIRECTION SENSE: To increasing values

SCALE FACTOR: (TBD)

ELECTRICAL CHARACTERISTICS

SOURCE: 1) True Airspeed Transducer (P/N A24950-00-005); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted triad

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - Tie into TAS Transducer -
P64R-C(X)
-E(Y)
-D(Z)

A/C: HH-53B/C	CODE: TAS-1	REF: A24950-00-005, T.O.5P4-2-26-3	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Encoded Altitude	Digital	I	Altimeter-Encoder	Integration Module

FUNCTIONAL DESCRIPTION

Provides an input of pressure altitude in digital format for use by the system when operating with less than full navigation capability. The encoded altitude data will at all times be referenced to 29.92 in Hg. The digital code for altitude is in accordance with both the ICAO Annex 10 SSR System SARPS and the U.S. National Standard for the ATCRBS.

SIGNAL CHARACTERISTICS

RANGE: -1000 to 38,000 feet

RESOLUTION: 100 feet

ACCURACY: ±100 feet

INDEX REFERENCE: 0 feet

POSITIVE DIRECTION SENSE: Up-perpendicular to horizontal earth plane

SCALE FACTOR: 10 bits

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Altimeter-Encoder (AAU-21/A); shaft angle encoder

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Ten single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - Tie into Altimeter Conn -

P202-K(A1)	-F(B2)	-B(C4)
-J(A2)	-E(B4)	-L(D4)
-H(A4)	-D(C1)	
-G(B1)	-C(C2)	

A/C: HH-53 B/C	CODE: ALT-1	REF: AAU-21/A, MIL-A-81403	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Bearing	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI Navigator's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to the bearing pointer to display relative bearing of the aircraft's present position to selected waypoint. The relative bearing is the difference, in degrees, between the lubber line and the bearing pointer as read from the compass card.

SIGNAL CHARACTERISTICS

RANGE: 0^o to 360^o

RESOLUTION: 0.1^o

ACCURACY: $\pm 0.5^o$

INDEX REFERENCE: Aircraft Heading

POSITIVE DIRECTION SENSE: Increasing Bearing

SCALE FACTOR: $1^o = 1^o$

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), 3-Wire Synchro
2) Copilot's HSI (ID-1540/A), 3-Wire Synchro
3) Navigator's HSI (ID-1540/A), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted Shielded Pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: BRG-1	REF: ID-1540/A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, units	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI Navigator's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the units digit in the range window. Displays aircraft present position distance to selected waypoint in 1nm increments (0.5nm indexed). Driven independently of other digits, but read in conjunction with them in order to provide the least significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^o to 360^o)

RESOLUTION: 0.1 (3.6^o)

ACCURACY: ±0.2 ($\pm7.2^o$)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^o = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), 3-Wire Synchro
2) Copilot's HSI (ID-1540/A), 3-Wire Synchro
3) Navigator's HSI (ID-1540/A), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted Shielded Pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box; Pin Assignments TBD

A/C: P-3C	CODE: DIST-1	REF: ID-1540/A,	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, tens	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI Navigator's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the tens digit in the range window. Displays aircraft present position distance to selected waypoint in 10nm increments. Driven independently of other distance digits but read in conjunction with them.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^0 to 360^0)

RESOLUTION: 1.0 (36^0)

ACCURACY: ±0.2 (±7.2^0)

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^0 = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), 3-Wire Synchro
2) Copilot's HSI (ID-1540/A). 3-Wire Synchro
3) Navigator's HSI (ID-1540/A), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted Shielded Pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: DIST-2	REF: ID-1540/A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance, hundreds	Analog, Synchro	0	Integration Module	Pilot's HSI Copilot's HSI Navigator's HSI

FUNCTIONAL DESCRIPTION

Provides angular information to rotate the hundreds digit in the range window. Displays aircraft present position distance to selected waypoint in 100nm increments. Driven independently of the other distance digits, but read in conjunction with them in order to provide the most significant digit for the distance value.

SIGNAL CHARACTERISTICS

RANGE: 0 to 9 (0^{0} to 360^{0})

RESOLUTION: 1.0 (36^{0})

ACCURACY: ±0.2 (7.2^{0})

INDEX REFERENCE: 0

POSITIVE DIRECTION SENSE: To decreasing values (distance to go)

SCALE FACTOR: 36^{0} = 1 numeral

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), 3-Wire Synchro
2) Copilot's HSI (ID-1540/A), 3-Wire Synchro
3) Navigator's HSI (ID-1540/A), 3-Wire Synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted Shielded Pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: DIST-3	REF: ID-1540/A,	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation	Analog, d.c.	O	Integration Module	Pilot's HSI, Copilot's HSI, Flight Director Computer

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal that indicates the distance in nautical miles that the aircraft is displaced to the left or right of the desired track. When the deviation exceeds the range equivalent to full scale deflection, the output should not be less than full scale current, nor should it be permitted to exceed 500 microamps under any conditions likely to be encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: 0 to ± 150 Microamperes

RESOLUTION: ± 3 Microamperes

ACCURACY: ± 10 Microamperes

SCALE FACTOR: 75 Microamperes = 1 dot
150 Microamperes = 2 dots

SENSITIVITY: (full scale)
Enroute = ± 6.0 nm
Terminal = ± 1.0 nm
Approach = ± 0.1 nm

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A); meter movement 1000 ohms ± 3%
2) Copilot's HSI (ID-1540/A); meter movement 1000 ohms ± 3%
3) Flight Director Computer (CP-928/AJN-15)

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: One single conductor and one shielded conductor

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:
IM CONN's - TBD
INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: DEV-1	REF: ID-1540/A, MIL-I-2366A CP-928/AJN-15, NAVAIR 01-75PAC-2-5.11	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Distance Flag	Discrete	O	Integration Module	Pilot's HSI Copilot's HSI Navigator's HSI

FUNCTIONAL DESCRIPTION

Provides a discrete signal to operate the distance warning flag. The flag is normally out of view when the range indicator is operating and the range data is valid. The flag covers the range indicator when the distance information is not valid or the device supplying the distance data is not operating.

SIGNAL CHARACTERISTICS

RANGE: 28 Vdc ground applied = out-of-view
28 Vdc ground not applied = in-view

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), Meter Movement
2) Copilot's HSI (ID-1540/A), Meter Movement
3) Navigator's HSI (ID-1540/A), Meter Movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: DIF-1	REF: ID-1540/A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Deviation (NAV) Flag	Anaolg, d.c.	0	Integration Module	Pilot's HSI, Copilot's HSI, Flight Director Computer

FUNCTIONAL DESCRIPTION

Provides a variable d.c. signal to operate the deviation warning flag when the course deviation data is unreliable or a malfunction has occurred in the course deviation circuitry. The signal shall be linear, and shall not exceed 500 microamperes under any conditions encountered in normal service.

SIGNAL CHARACTERISTICS

RANGE: In-view <180 μA

Fully-out-of-view = 245 μA

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI(ID-1540/A); suppressed zero mechanism, 1000 ohms $\pm$ 3%
2) Copilot's HSI(ID-1540/A); suppressed zero mechanism, 1000 ohms $\pm$ 3%
3) Flight Director Steering Computer (CP-928/AJN-15)

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: DEF-1	REF: ID-1540/A, MIL-I-23366A CP-928/AJN-15, NAVAIR 01-75PAC-2.5.11	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
To-From	Analog, d.c.	O	Integration Module	Pilot's HSI Copilot's HSI

FUNCTIONAL DESCRIPTION

Provides a d.c. analog signal to drive the TO-FROM indicator. Indicator displays direction aircraft (present position) is flying in relation to the selected waypoint. If the aircraft is flying toward the waypoint and has not intercepted a reference line perpendicular to the aircraft track and through the waypoint, the indication will be TO. Once past the waypoint reference line the indication will be FROM, unless the next waypoint has been selected.

SIGNAL CHARACTERISTICS

RANGE: TO = +225 μA Max

BLANK = no signal

FROM = -225 μA Max

ELECTRICAL CHARACTERISTICS

LOAD:
1) Pilot's HSI (ID-1540/A), Meter Movement
2) Copilot's HSI (ID-1540/A), Meter Movement

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two Shielded Conductors

WIRE SIZE: 22

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE TFI-1	REF: ID-1540/A	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Course Set	Analog, resolver	I	Pilot's HSI or Copilot's HSI	Integration Module

FUNCTIONAL DESCRIPTION

Provides an electrical reference signal of the desired track manually selected by the COURSE SET control on the HSI. Signal provides a position reference of the course arrow for positioning the course deviation indicator to the left or right of the desired course. Also provides reference for placing the TO-FROM indicator. Desired track manually selected must match the desired course displayed on the CDU, or deviation flag will be displayed.

SIGNAL CHARACTERISTICS

RANGE: 0° to 360°

RESOLUTION: 0.1°

ACCURACY: $\pm 0.5^{\circ}$

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Right Hand Increments

SCALE FACTOR: $1^{\circ} = 1^{\circ}$

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Pilot's HSI (ID-1540/A); resolver type EP AY-211-5-B or equivalent
2) Copilot's HSI (ID-1540/A); resolver type EP AY-211-5-B or equivalent.

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Two twisted shielded pairs

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: RES-1	REF: ID-1540/A, MIL-I-23366	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Magnetic Heading	Analog, Synchro	I	INS System No.1 or 2	Integration Module

FUNCTIONAL DESCRIPTION

Provides angular reference signal of aircraft heading relative to magnetic north. May be used to position bearing pointers and desired track (course arrow) relative to compass card position.

SIGNAL CHARACTERISTICS

RANGE: 0^{o} to 360^{o}

RESOLUTION: 0.1^{o}

ACCURACY: $\pm 0.5\%$

INDEX REFERENCE: Magnetic North

POSITIVE DIRECTION SENSE: Nose Right

SCALE FACTOR: $1^{o} = 1^{o}$

ELECTRICAL CHARACTERISTICS

SOURCE: 1) INS System Electronic Control Amplifier (AM-4923/A); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted shielded pair

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TACAN/GPS Relay Box Pin Assignments TBD

A/C: P-3C	CODE: MGH-1	REF: AM-4923/A, 16-35AM4923-1	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
True Airspeed	Analog, Synchro	I	True Airspeed Computer	Integration Module

FUNCTIONAL DESCRIPTION

Provides a value for aircraft true airspeed in angular analog signal format

SIGNAL CHARACTERISTICS

RANGE: 70-450 knots

RESOLUTION: 2 knots

ACCURACY: ± 4 knots

INDEX REFERENCE: 0 knots

POSITIVE DIRECTION SENSE: To increasing values

SCALE FACTOR: 36^{o} = 100 knots

ELECTRICAL CHARACTERISTICS

SOURCE: 1) True Airspeed Computer (CPR-28/A24G-9); 3-wire synchro

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Twisted, shielded triad

WIRE SIZE: No. 22 AWG

PIN ASSIGNMENT:

IM CONN's - TBD

INTERFACE CONN - TB403-A4(X)
-A5(Y)
-A6(Z)

A/C: P-3C	CODE: TAS-1	REF: CPR-28/A24G-9, NAVAIR 01-75PAC-2-12	Sheet 1 of 1

INTERFACE SIGNAL CHARACTERISTICS

SIGNAL NAME	TYPE	I/O	FROM	TO
Encoded Altitude	Digital	I	Altimeter-encoder	Integration Module

FUNCTIONAL DESCRIPTION

Provides an input of pressure altitude in digital format for use by the system when operating with less than full navigation capability. The encoded altitude data will at all times be referenced to 29.92 in Hg. The digital code for altitude is in accordance with both the ICAO Annex 10 SSR System SARPS and the U.S. National Standard for the ATCRBS.

SIGNAL CHARACTERISTICS

RANGE: -1000 to 38,000 feet

RESOLUTION: 100 feet

ACCURACY: ± 100 feet

INDEX REFERENCE: 0 feet

POSITIVE DIRECTION SENSE: Up-perpendicular to horizontal earth plane

SCALE FACTOR: 10 bit

ELECTRICAL CHARACTERISTICS

SOURCE: 1) Altimeter-Encoder (AAU-21/A); shaft angle encoder

MOUNT INTERCONNECTION DATA

WIRE TYPE & NO.: Ten single conductors

WIRE SIZE: No.22 AWG

PIN ASSIGNMENT

IM CONN's - TBD

INTERFACE CONN - RH2D11 (Unused Plug)

K(A1)	G(B1)	D(C1)	L(D4)
J(A2)	F(B2)	C(C2)	
H(A4)	E(B4)	B(C4)	

A/C: P-3C	CODE: ALT-1	REF: AAU-21/A, MIL-A-81403	Sheet 1 of 1

APPENDIX C

CROSS-TRACK DEVIATION - RATIONALE AND MECHANIZATION

C.1 INTRODUCTION

This appendix presents a rationale and method for the mechanization of a cross-track deviation warning signal as an output from GPS UE Set Z to avionics indicators aboard the GPS Phase I test aircraft. The material presented here is responsive to a request from the COTR in January 1975 to investigate the subject of coordinating the manual operation of the course set control knob and the course deviation bar on the HSI* when that instrument is being driven by Set Z input signals. This investigation was considered necessary since:

a. The manual course set control input signal to Set Z was not originally specified in the GPS User Equipment Specification SS-US-101-B.

b. The output of a course deviation warning signal from Set Z to the HSI could impact the Set Z software by requiring one or more routines not originally anticipated in the software design.

C.2 SUMMARY

This investigation has indicated that a rationale and sufficient basis exist for mechanically coordinating the manual course set control function with the course deviation display on the HSI, and outputting a warning signal if deviation data are not reliable. If this coordination is not achieved, it is conceivable that the aircrews of the GPS Phase I test aircraft may be exposed to unreliable cross-track deviation information by way of the HSI. Similarly, unless the opportunity for the display of unreliable cross-track deviation data is minimized, the test aircrews will be required to monitor the HSI closely and perform cross-checks with the Set Z CDU in order to ascertain the validity of the course deviation display.

Both the possibility of displaying unreliable information to the aircrew and the necessity for aircrew monitoring and cross-check of the HSI should be considered as detrimental to the GPS test program, having the potential of unduly influencing the results of the tests. It is therefore recommended that, as a minimum form of mechanization:

a. The analog course set control signal from the HSI, representing desired aircraft course, be input to Set Z in digital format; and

b. Methods be developed to compare the input of a above with the desired course to GPS waypoints, as input to the Set Z CDU; and actuate the course deviation flag on the HSI when the difference between the two courses exceeds a predetermined tolerance.

*The HSI is installed on four of the five designated test aircraft. The HH-53B/C uses a BDHI and a CDI which utilize the same types of displays and controls as the HSI. Consequently this discussion applies to all five test aircraft.

Section C.4 describes three alternative means of accomplishing this mechanization, from the minimum recommended approach discussed above to more highly automated methods.

C.3 STATEMENT OF PROBLEM

The problem approached during this investigation is discussed below in terms of its origin, nature, and potential impact on GPS testing.

C.3.1 Origin of the Problem

As stated elsewhere in this report (Section 1.2), a primary purpose of the Integration Module is to allow Set Z to drive selected avionics displays such as the HSI with the same type of output signals normally provided by a TACAN set. To a great extent, this can be accomplished by the IM design concepts discussed in this report. However, there are some operational and functional differences in the HSI when operating in the GPS mode. Table C-1 summarizes the similarities and differences between a TACAN-originated HSI display and one originating in Set Z in its currently specified design configuration.

TABLE C-1. SIMILARITIES AND DIFFERENCES, TACAN VS. GPS ORIGINATED HSI DISPLAY

HSI Display	Navigation System	
	TACAN	GPS
A. Bearing	Magnetic bearing to TACAN station relative to aircraft heading	Magnetic bearing to preselected GPS waypoint relative to aircraft heading
B. Distance	Slant range from aircraft to selected TACAN station	Ground range from aircraft nadir (present position) to selected GPS waypoint
C. Course Deviation	Angular displacement of aircraft track from selected TACAN radial (course)	Aircraft position displacement in nautical miles (cross-track error) from GPS desired course to selected GPS waypoint
D. Deviation Alarm Flag	Indicates that TACAN course deviation data unreliable	Not available without mechanization
E. To-From	Direction to or from selected TACAN station along desired aircraft course	Direction to or away from selected GPS waypoint along desired aircraft course

As may be noted in Table C-1, the differences in the GPS-originated HSI and those of the TACAN-originated displays of bearing, distance, and to-from (items A, B, and E of Table C-1) are slight, and can be readily accommodated by the test aircrew. Similarly, differences in the course deviation (item C, Table C-1), although based on different HSI input parameters (i.e., angular vs. lateral displacement, degrees off course vs. NMI cross-track error), are also relatively small and should cause little concern to the aircrew. However, the absence of the deviation alarm flag (item D, Table C-1) in the GPS mode is more significant and thus forms the basis for the problem investigated. The absence of a course deviation alarm flag could result in an HSI display of unreliable cross-track error and the aircrew's inadvertent application of these data to his navigation problem. This situation will require monitoring and attention by the aircrew, which is not typical of normal TACAN operation. This condition occurs when navigating in the GPS mode since the course (cross-track) deviation signal is independent of the rotation of the course set control knob; i.e., these functions are not coordinated.

C.3.2 Impact on GPS Testing

The primary purpose of the IM in GPS Phase I testing is to enable navigation presentations on other avionics displays in conjunction with the display of the Set Z CDU. It therefore appears that the requirements for continuous or periodic monitoring of the HSI control settings, and the opportunity for the display of unreliable cross-track deviation data that exist without the mechanization necessary to coordinate the course deviation displays, could be detrimental to the conduct of the tests and thus unduly influence the results.

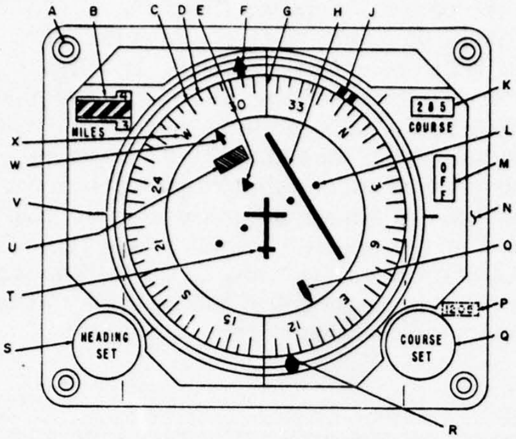
C.4 TECHNICAL DISCUSSION

This section briefly discusses a typical HSI and its basic functions, TACAN and GPS navigation procedures, and a technical approach for coordinating the course (cross-track) deviation warning signal and the course set control function when operating in the GPS mode. To facilitate this discussion, Figure C-1 provides an illustration of a typical HSI and a brief description of each of its indicator functions; Table C-2 defines the navigation terms used.

C.4.1 Basic HSI Description

The HSI is usually one of two instruments associated with an airplane flight director system, the other being the attitude director indicator. The HSI receives navigation information directly from other avionic systems, such as TACAN, through a switching matrix in a junction box. Some of the same information is also sent to the flight director computer for processing and formatting, which in turn drives the ADI with the appropriate steering signals. In addition to receiving navigation signals electrically from other avionic systems, the HSI can also receive manual-input navigation information through two front-panel controls, the heading-set and course-set knobs.

A typical HSI, as shown in Figure C-1, represents the horizontal navigation situation. Its primary displays are heading, bearing, distance, course deviation, and to-from information. A stationary aircraft symbol (T) and lubber line (G) are fixed to the glass face of the instrument. "T" represents the aircraft as viewed from above. Navigation information relative to the aircraft's present position is displayed by indicating devices arranged around the aircraft symbol. The aircraft's magnetic heading,



A	MOUNTING HOLE	N	CASE FLANGE
B	DIGITAL DISTANCE DISPLAY	O	RECIPROCAL COURSE INDEX
C	10° INCREMENTAL MARKS	P	ELAPSED TIME INDICATOR
D	5° INCREMENTAL MARKS	Q	COURSE SET KNOB
E	TO-FROM ARROW	R	RECIPROCAL BEARING MARKER
F	BEARING POINTER	S	HEADING SET KNOBS
G	LUBBER LINE	T	AIRPLANE SYMBOL
H	COURSE DEVIATION BAR	U	DEVIATION BAR ALARM FLAG
J	HEADING MARKER	V	FIXED MARKER
K	DIGITAL COURSE DISPLAY	W	COURSE ARROW
L	COURSE DEVIATION DOTS	X	CARDINAL MARKINGS
M	POWER OFF FLAG		

Compass card (C&D). The compass card usually displays aircraft magnetic heading as read on the card under the lubber line. Heading information is supplied to the HSI from a compass system. The compass card can also display true heading for aircraft equipped to provide such information (e.g., the P-3C). The card rotates as the aircraft heading changes.

Heading marker (J). The heading marker displays the selected heading as manually set-in by the rotation of the heading set control (S). Once the heading marker has been set to the desired heading, it rotates with the compass card. The difference in the position of the heading marker with respect to the lubber line is the amount and direction of heading error. When the airplane is in the autopilot mode, heading error signals are sent to the autopilot.

Bearing pointer (F). The bearing pointer rotates around the outer edge of the compass card and indicates the magnetic bearing of a navigation aid, such as a TACAN radio station, from the aircraft. The relative bearing of the navigation aid from the aircraft is the angular difference, in degrees, between the lubber line and bearing pointer.

Distance display (B). The distance display provides a digital readout of range to a navigation aid from the aircraft's present position. A range of up to 1,999 nautical miles can be displayed on most HSIs, but is usually limited to 199 nm by a TACAN system. When range data are not available or are unreliable, the range warning flag (as displayed) will cover the distance display.

Course arrow (W). The course arrow can be manually positioned with the course set (Q) control to a selected navigation course. When the flight director mode control is in a radio navigation mode, the course arrow is fixed to the compass card and rotates with it as aircraft heading changes. If the mode control is in the heading mode, the course arrow is usually slaved to the aircraft magnetic heading and always points to the lubber line at the top of the indicator, even if aircraft heading changes. The course display (K) provides a convenient digital readout of the course arrow position relative to the compass card.

Course deviation bar (H). The course deviation bar, which is the center portion of the course arrow, displays the aircraft deviation to the right or left of the desired course. The amount of deviation is referenced to the four course-deviation dots (L) that represent the course deviation scale. During TACAN navigation the dots represent degrees off course, while during GPS navigation they will represent nautical miles off course (or cross-track deviation). The sensitivity of the scale can be changed during GPS navigation depending upon the aircraft flight mode, i.e., enroute, approach, or terminal.

To-from arrow (E). The to-from arrow indicates the direction of the flight toward or away from a navigation aid. When that arrow points in the same direction as the course arrow, the selected course is to the NAV aid.

Deviation bar alarm flag (U). When in view during TACAN operation the deviation bar alarm flag indicates that the course deviation data are unreliable. The deviation bar alarm flag will not be available in the GPS mode unless the mechanization described in this document is accomplished.

Figure C-1. Typical HSI Layout

TABLE C-2. COMMON AIR NAVIGATION TERMS PERTINENT TO THIS DISCUSSION

(Reference: AFM-51-40, Vol. I)

Navigation Term	Definition
Bearing	The horizontal angle at a given point, measured clockwise from a specific reference datum to a second point. The direction of one point relative to another as measured from a specific datum.
Bearing, magnetic	The horizontal angle of a given point, measured from magnetic north clockwise to the great circle through the object or body and the given point.
Bearing, relative	The horizontal angle at the aircraft, measured clockwise from the true heading of the aircraft to the great circle containing the aircraft and the object or body.
Bearing, true	The horizontal angle at a given point, measured from true north clockwise to the great circle passing through the point and the object or body.
Course	Direction of the intended path of an aircraft over the earth.
Course deviation	Distance in nautical miles or degrees that an aircraft is off course.
Cross-track deviation	Same as above, except that distance is expressed in nautical miles.
Drift	The *rate* of lateral displacement of an aircraft, usually expressed in degrees.
Drift angle	The angle between true heading and true course (track), expressed as degrees right or left according to the direction the aircraft has drifted.
Heading	The angular direction of the longitudinal axis of an aircraft, measured clockwise from a reference point.
Heading, compass	The reading taken directly from a compass.
Heading, magnetic	The heading of an aircraft with reference to magnetic north.
Heading, true	The heading of an aircraft with reference to true north.
Lubber line	A reference mark representing the longitudinal axis of an aircraft.
Slant Range	Measurement of range along the line of sight.
Track	The actual path of an aircraft over the surface of the earth or its graphic representation: also called "track made good".

its heading relative to a preselected heading, and its position relative to a selected navigational course, can be determined by comparing the positions of the indicating devices relative to the aircraft symbol.

The aircraft symbol and lubber line always represent the aircraft heading. Also incorporated in the HSI are warning flags to indicate unreliable distance and/or deviation data, or a primary power failure.

One of the key displays on the HSI and central to the present discussion is course deviation. That parameter is displayed on a course deviation bar (ref. H, Figure C-1).

C.4.2 Course Deviation – TACAN Operation

During TACAN operation, four features of the HSI combine to enable and present a graphic display of course deviation. These features, referenced to Figure C-1, are the course arrow (W), the reciprocal course index (O), the course deviation bar (H), and the course set control (Q). As may be concluded from Figure C-1, when the course arrow, its reciprocal index, and the deviation bar are aligned, an arrow is formed (head, W; shaft, H; tail, O) pointing to the selected course. The lateral displacement of the shaft of the arrow, i.e., the course deviation bar, represents aircraft excursions from the selected course and indicates which direction the pilot must steer to intercept and hold the selected course and thus align the three indicators.

The manual course set control knob is used for course selection. Rotation of the control changes simultaneously the position of the three indicators (course arrow, reciprocal index, and deviation bar). However, right or left displacment of the deviation bar will still be apparent unless the aircraft is exactly on the selected course at the time the manual change is made.

C.4.3 Course Deviation Display – GPS Mode

To fly a course using an HSI driven by GPS Set Z, and without mechanized coordination of the course deviation display and manual course set control, the procedure would be as follows:

a. Read the course to the selected GPS waypoint from the Set Z CDU.

b. Rotate the course set control until the arrow points to the selected course on the compass card. The digital course display (ref. K, Figure C-1) will slew to display the selected course; the reciprocal course index will move to correspond to the reciprocal of the course arrow; and the alignment of the course deviation bar will change to correspond to the position of the course arrow and the reciprocal index. Any displacement of the aircraft to the left or right of the selected course will be shown by the position of the course deviation bar relative to the course arrow and reciprocal index.

c. Ensure that the course as read out on the CDU and as set on the HSI coincide.

Navigation to the selected waypoint can then proceed in a manner similar to that using TACAN, ie., the course deviation bar will display right and left displacement as it is computed by Set Z. Aligning the course deviation bar, the course arrow and its reciprocal will hold the aircraft on the selected course until the GPS waypoint is passed, at which time the procedure described above must be repeated to achieve the next course.

Without mechanized coordination of the course set display and the manual course set control, it is essential that the aircrew ensure that the course to the GPS waypoint as read from the Set Z CDU, and the course arrow setting on the HSI, precisely agree each time the control is used. If this is not done, the cross-track deviation bar driven by Set Z will continue to indicate cross-track error. However, the indicator will not be reliable and, unlike normal TACAN operation, no flag will set to warn that the deviation data as displayed on the HSI are unreliable.

C.4.4 Technical Approaches to Mechanization

Three alternative approaches to the mechanization of a coordinated manual course set and course deviation warning display can be considered. These approaches, which vary in complexity, potential cost and utility, are:

a. Alternative A – Input the manual course set control function into Set Z as a reference signal and perform a software comparison of the selected GPS course with the course as set on the HSI. Set the HSI deviation flag if courses do not agree.

b. Alternative B – Eliminate the requirement for manual manipulation of the course set control knob. This can be accomplished by automatically driving the HSI course arrow to the course entered through the Set Z CDU, using a signal from Set Z through the IM to the HSI course command resolver.

c. Alternative C – Drive the course arrow automatically to the desired course as in b, above, and also allow manual inputs through the course set control to input a desired course to Set Z. This approach would eliminate the need to enter a desired course into Set Z through the CDU keyboard.

The above alternatives should be considered in terms of 1) implementation cost and 2) the impact on the design of Set Z, the test aircraft, and the IM. Table C-3 presents a comparison of the three approaches to mechanization discussed above. The comparative factors are evaluated on a scale of 0 (maximum cost or impact) to 4 (minimum cost or impact).

The estimation of implemention costs used in the rating include those costs associated with installation modifications and additions to test aircraft, and additional IM circuitry.

The impact on Set Z for all three of the alternatives is primarily in the software area. The test-aircraft impact takes into consideration modifications to existing wiring, the addition of relay junction boxes, and control panels; it does not include removing a TACAN set and using the existing TACAN wiring. The impact on the IM includes the addition of circuitry to perform a new function, and the increased power supply requirements to take care of this additional circuitry.

Obviously, a value assigned to the operational desirability of each of the approaches to mechanization could change the ratings in Table C-3 considerably.

TABLE C-3. COMPARISON OF CROSS-TRACK MECHANIZATION APPROACHES

Consideration	Rating for Indicated Approach*		
	A	B	C
1. Estimated implementation cost	3	1	0
2. Impact on Set Z	1	3	2
3. Impact on test aircraft	3	1	1
4. Impact on IM	2	2	1
Average Rating	2.25	1.75	1.33

*0 = maximum, 4 = minimum cost or impact

However, operational desirability is too subjective to be evaluated in this document, and can vary widely among users. Intuitively, it would seem that the most desirable approach would be the one that most reduces the aircrew's workload. However, the cost of achieving the highest level of automation may not be justifiable in terms of the difference in workload between approaches A and C.

C.5 CONCLUSIONS AND RECOMMENDATIONS

C.5.1 Conclusions

As a result of this investigation it is concluded that:

a. A rationale and sufficient basis exists for mechanically coordinating the course set control function with the course deviation display on the HSI, and outputting a warning signal when deviation data are unreliable.

b. Several approaches to mechanizing the required HSI coordination are feasible. These approaches vary in complexity, cost, and potential utility. However, all approaches will impact on the Set Z design to approximately the same degree.

c. Operational utility and desirability versus cost will influence the selection of an approach to mechanizing the HSI cross-track deviation functions.

C.5.2 Recommendations

It is recommended that:

a. The manual course set control and course deviation display features of the HSI be coordinated through one of the approaches to mechanization discussed in this report. Alternative A should be considered as the minimum level of mechanization.

b. The approach to mechanization selected be further studied from a standpoint of cost and impact versus operational utility and desirability before a final decision among the three alternatives is made.

APPENDIX D

COURSE DEVIATION SENSITIVITY

D.1 INTRODUCTION

This appendix presents a rationale for the selection of a set of course deviation sensitivity figures to be used by GPS Set Z when operating in the enroute, terminal, and approach modes. This document is responsive to an April 1975 directive from the COTR that ARINC Research recommend sensitivity figures useful in establishing the cross-track error sensitivity function for Set Z. The need for this information became apparent at a design review meeting of the COTR and Set Z prime contractor on April 1975. At this meeting, attended by ARINC Research, it was concluded that the design sensitivity figures proposed by the Set Z contractor were not consistent with the inherent accuracy capabilities of Set Z. As a result, ARINC Research was tasked by the COTR to recommend more appropriate figures.

D.2 SUMMARY

This investigation, while yielding a set of full-scale course deviation figures for Set Z, also established that various factors might make it desirable to modify these figures at some future date. Thus, while a valid set of course deviation figures is important to the design of Set Z, they need and should not be considered fixed – they can be changed, without affecting the Set Z design, simply by modifying software. Consequently, at this time in the GPS program ARINC Research recommends the following full-scale course deviation sensitivity figures for the three basic modes of GPS navigation:

a. Enroute: ±6 nm

b. Terminal: ±1 nm

c. Approach: ±600 ft

An expanded range of figures that might provide a smoother transition between sensitivity figures during mode changes is discussed in Section D.4.2, and it might be desirable to modify the sensitivity figures to that range at some later date.

D.3 BACKGROUND

This section presents background information necessary to the development of the conclusions of this appendix. Common navigation terms used in this discussion are defined in Table C-2, Appendix C.

D.3.1 General

Set Z calculates the desired true course between two waypoints based on latitude and longitude indications of the waypoints entered into the CDU. Set Z also continuously computes the aircraft's present position. Normally the pilot flies the aircraft along the desired true course between two waypoints. If the aircraft should fly off of the desired course, Set Z calculates the distance perpendicular to the desired course based on present position data. This information is displayed on the Set Z CDU as cross-track error. The maximum cross-track error that can be displayed on the CDU is 99.99 nm to the left or right of the desired course.

Set Z will also output the cross-track error signal as course deviation to various instrument systems in the IOT&E test aircraft through the Integration Module. An instrument such as the HSI will receive this information and display it on the course deviation indicator (center portion of the course arrow). The course deviation indicator is a meter movement and not a digital readout; therefore it is limited in the accuracy with which it can display deviation information. To overcome this limitation, the Set Z contractor has proposed to include three different scale-factor selections on the Set Z CDU. These selections are enroute, terminal, and approach, corresponding to the aircraft navigation phase. Changing the scale factors increases or decreases the sensitivity of the meter movement appropriately for each phase of navigation.

The course deviation indicator moves across the HSI face to the left or right of the center of the aircraft symbol. The amount of movement is measured on a scale represented by two dots equally spaced on either side of the aircraft symbol. The course arrow is manually set to the desired course as read from the HSI compass card. If the aircraft is centered on the desired course, the deviation indicator will be centered on the course arrow. If the aircraft is to the left or right of the desired course, the deviation indicator will displace the appropriate distance to the left or right of the course arrow center line.

During navigation with a TACAN set, the course deviation indicator indicates deviation from a TACAN station radial in terms of an angular value. Full scale deflection under these conditions would normally be represented as $\pm 10°$. There is only one level of deviation sensitivity for TACAN navigation. With computer oriented navigation systems, such as INS and GPS, deviation is measured in terms of distance (nautical miles) from the desired course. Since these systems are far more accurate than TACAN, cross-track error can be measured to a finer degree. Therefore, while flying enroute a relatively coarse value of sensitivity is sufficient, but as the aircraft approaches a waypoint or destination the deviation indicator should become more sensitive to the distance off the desired course.

D.3.2 Statement of Problem

The problem approached in this investigation was that of selecting course deviation sensitivity figures that would permit the inherent accuracy of Set Z to be realized for approach and landing, and at the same time consider some of the human factors and similar requirements for navigation displays.

The specified position accuracy of Set Z is 45 meters (150 feet). Although it would appear that navigation data of this order of accuracy provided to an HSI would allow highly accurate landing approaches, the instrument itself does not possess the resolution required to display information of such accuracy. Also, it may seem that a single sensitivity figure based on a combination of best Set Z accuracy and best HSI resolution would suffice for all phases of a flight. However, during the enroute and terminal phases of a flight the course deviation bar on the HSI would register every minor excursion from the course line. During any unit of time, the probability is high that enroute course excursions would exceed the minimum sensitivity figure established for a landing approach. Thus, with a single sensitivity figure, the course deviation bar on the HSI would be in constant rapid motion and from a human engineering standpoint, fail to provide meaningful navigation information. Based on the considerations above, the problem became one of establishing some criteria for sensitivity figures that would:

a. Make maximum use of the inherent positional accuracy of Set Z

b. Address human engineering factors with respect to avionic displays

c. Consider the resolution of the instruments upon which the information is displayed.

Based on these criteria, it appears desirable to specify at least three levels of course deviation sensitivity – enroute, terminal and approach.

D.4 TECHNICAL DISCUSSION

D.4.1 Approaches to Solution of Problem

To arrive at a set of course-deviation sensitivity figures, it was first necessary to investigate and analyze the figures specified for other types of navigation systems. The appropriate ARINC characteristics on similar navigation systems were reviewed. Characteristic 582-2 for the Mark 2 Air Transport Area Navigation System contained the information most applicable to GPS. Paragraph 4.3.2.6 of that characteristic includes a commentary from the Area Navigation Subcommittee of Air Transport Association's Air Traffic Control committee on ranges for course deviation sensitivity. That committee recommended that the sensitivities for an area navigation system be selected from the following full-scale ranges for the flight modes indicated:

a. Enroute = 2 to 6 nm

b. Terminal = 1 to 2 nm

c. Approach = 600 to 3000 ft

These figures appear to be reasonable and generally applicable to GPS. However, since GPS will be more accurate than a Characteristic 582 area navigation system, the lower values for the terminal and approach ranges would be more appropriate.

Consideration must be given to the operational use of each of the three flight modes. During enroute navigation a swing of ±6 nm to either side of the desired track would be a convenient display of the navigation situation without making the indicator overly sensitive to changes in the aircraft's position. If a more accurate assessment of the lateral navigation situation is desired, then one of the other two sensitivities can be selected. The enroute selection also allows enough latitude for the pilot to fly an offset route parallel to the desired track.

A full-scale course deviation sensitivity of ±1 nm is recommended for the terminal flight mode. This figure provides a good transition range between the enroute and approach sensitivities. The pilot can use this sensitivity during the terminal portion of the flight or, if he desires, during the enroute portion to monitor a closer tolerance to the desired track.

The approach sensitivity as suggested in Characteristic 582-2 should range between 600 and 3,000 feet for full-scale deflection. The lower limit of this range is recommended for GPS for several reasons:

a. Since the accuracy goal of Set Z is 150 feet, the ±600 feet figure represents an adequate scale factor to compensate for this accuracy and still maintain tight tolerance to the approach flight path.

b. An important fact to be considered with this figure is the human engineering aspect of reading the course deviation indicator accurately. This indicator on most HSIs is 0.050 inch wide. On a 600-foot scale the indicator width represents almost 10% of the scale or 60 feet. An indicator movement of one width would be the smallest measurement visually discernible on the scale.

c. A sensitivity figure better than 600 feet would cause too much erratic indicator movement during an approach in turbulent weather.

D.4.2 Evaluation of Approaches

The advantage of using the recommended figures is that they represent a usable set of sensitivities that can take advantage of Set Z's accuracy. If, during IOT&E, it is found that they should be improved, the change required is performed in the Set Z software instead of hardware, since course deviation sensitivity is a software controlled function.

The disadvantage to these figures concerns the scale factors selected from the range values. Military pilots might prefer to monitor a greater tolerance from the desired track during the enroute portion of the flight without pegging the course deviation indicator against the full-scale stops. A sensitivity somewhere between 10 to 20 miles might be more desirable.

The scale factor for the terminal mode might also cause some problems in that the transition from the ±1 nm scale to the ±600 feet approach scale could cause the indicator to move out to the full-scale stops and remain there if the aircraft is between 1000 to 600 feet off course and the sensitivity is changed to the approach mode. In other words, the indicator width on the ±1 nm scale represents approximately 600 feet, and a movement of one indicator width would be close to 1200 feet. In this area the pilot would want to choose a better sensitivity to assess his navigation situation closer. However, if he chooses the approach sensitivity figure under these conditions his indicator would be at the stops. Therefore a smoother transition is required between the terminal and approach sensitivity-scale factors. It might be desirable to offer a fourth sensitivity figure to compensate for this disparity.

D.5 CONCLUSIONS AND RECOMMENDATIONS

The requirement for a valid set of course deviation sensitivity figures is important to the design of Set Z. However, since these figures are controlled by software and can be readily changed without modifying hardware, they can be changed at any time without significantly affecting the design of Set Z. Therefore, at this time in the GPS program, ARINC Research recommends the following full scale course deviation sensitivity figures for the three basic modes of GPS navigation:

a. Enroute = ±6 nm

b. Terminal = ±1 nm

c. Approach = ±600 ft

An alternative set of figures that could provide a smoother transition between ranges might be the following:

a. Open = ±20 nm

b. Enroute = ±4 nm

c. Terminal = ±3000 feet

d. Approach = ±600 feet

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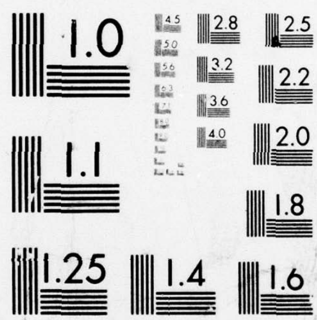

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APPENDIX E

DESIGN CONCEPTS, IM CONFIGURATIONS A AND D

E.1 INTRODUCTION

This paper discusses a design concept for an Austere ("A") and a Deluxe ("D") Integration Module. The description includes input and output coding, multiplexing, ARINC Specification 419, code, size, and cost.

E.2 SUMMARY

As a result of this study, a circuit concept was developed for Configurations A and D. It was determined that internal multiplexing should be utilized with Configuration D to reduce both size and cost. Configuration A does not require multiplexing, and can be placed within Set Z.

A properly selected input and output coding scheme will allow compatibility with other advanced avionics. One possibility, using ARINC Specification 419 code, is ABB-BBX/CBCC/FBCB/BCCC.

E.3 BACKGROUND

As a result of the work done in developing a specification for the Set Z IM, a concept of several different IM configurations was developed. These configuration concepts were presented to the COTR at an IM review meeting. Interest was then expressed that led to providing further information on the A and D configurations. This paper was written to provide more detail on these two configurations.

E.4 TECHNICAL DISCUSSION

E.4.1 Description of Configuration D

Table E-1 lists the input and output signal requirements for Configuration D. The major difference between this IM version and Configuration C (previously described in this volume) is the addition of vertical deviation, desired track, track angle error (ground track), true heading, and altitude signals from Set Z to the host vehicle avionics; and the elimination of a course set signal to Set Z from the host vehicle.

The vertical deviation data will be displayed on the glideslope indicator on the ADI or HSI, and on the pitch steering bar on the ADI. There is also an option to display GPS altitude on a servoed altimeter. Several of the manual functions on the HSI have been replaced with functions driven by Set Z, including desired track and ground track. Set Z, through the IM, would drive the course arrow to display desired track, and the heading marker to display ground track. The option to drive the HSI compass card with true heading data would also be provided.

TABLE E-1. INPUT/OUTPUT SIGNAL REQUIREMENTS FOR CONFIGURATION D

a. INPUTS TO IM FROM SET Z			
Function	Signal Type		Output Load
	Input	Output	
Bearing	Digital word ↓	Synchro drive	Control xfmr & torque receiver (TR)
Distance	↓	Synchro drive	TR (3 sets)
Deviation, course	↓	Current	Meter movement
Deviation, vertical	↓	Current	Meter movement
Desired track	↓	Resolver drive	Resolver
Ground track angle error	↓	Resolver drive	Resolver
True heading	↓	Synchro drive	Control xfmr
Altitude	↓	Synchro drive	Control xfmr
Distance flag	↓	Discrete level	Indicator flag
Course deviation flag	↓	Current	Indicator flag
Vertical deviation flag	↓	Current	Indicator flag
To/From flag	↓	Current	Indicator flag
Degraded mode	↓	Discrete level	Indicator flag
Mag hdg/True hdg Warning	Digital Word	Discrete level	Indicator flag

b. OUTPUTS FROM IM TO SET Z			
Function	Host Vehicle Sensor	Signal Type	
		Input	Output
Magnetic heading	Pilot's compass synchro	Synchro	Digital word
True airspeed	CADC or TAS computer	Synchro	Digital word
Altitude	CADC computer	Digital word	Digital word

All the information described above is presently being generated by Set Z or is available on the host vehicle. Configuration D would therefore not be required to perform any calculations not already performed for Configuration C. It would, however, require the capability of processing the added number of signals.

E.4.1.1 Input/Output Formats and Multiplexing, Configuration D

IM input and output formatting was discussed in various parts of Section 3, particularly Section 3.1.11. No definite formatting conclusions were reached in these sections, but it was determined that:

a. The desirability of multiplexing becomes greater as the number of input and output signals is increased.

b. For future applications it would be highly desirable that the Set Z-to-IM signal be compatible with digital aircraft instrumentation and navigation equipment now in the prototype state (e.g., TACAN XXX and AQU-11).

Configuration D requires a total of 14 input signals from and three output signals to Set Z, compared with eight and four respectively for the C version. Configuration D would require a total of eight D/S converters of various accuracies and resolutions if no internal multiplexing scheme were utilized. This is four more converters than required by Configuration C.

Because of the increased number of input signals and converters, a multiplexing scheme for Configuration D would be desirable. The multiplexing format of the input and output signals should be compatible with the coding presently in use by other advanced navigation equipment. It should be noted that this coding is really a function of Set Z design with which the IM must be compatible.

E.4.1.2 ARINC 419 Code

Section 3.1.11 of this volume presents a possible ARINC Specification 419 code that could be utilized by the Set Z-to-IM interface. (Care must be taken before final system application of this code to ensure full compatibility with desired avionics.) More detail on that code will be provided here, to give a better understanding of possible system design requirements that can be obtained.

The code presented in Section 3.1.11 is:

```
A B B - B B X / C B C C / F B C B / B C C C
a b c - d e f   g h i j   k l m n   o p r s
```

This code is described in detail below. The code characters have been labeled a through s for convenience in describing them.

a. Direction of information flow:

   A = Description of transmitting unit (e.g., signal from Set Z to IM).

b. Word/frame structure:

   B = Individual words consisting of 32 total bits, including data and address/label. For details see Figure 2.1.2.2 of ARINC Specification 419; and Section 3.11 of this volume.

c. Information identifier:

B = Identification is provided by assigning arbitrary label codes to first bits of each data word per Figure 2.1.3.1 of ARINC Specification 419.

d. Language identifier:

B = Provided on the first word bit transmitted. A logic "0" transmitted on this bit signifies that a BCD word follows; a logic "1" signifies that a binary word follows.

e. Sign/status matrix:

B = See Table E-2 for details.

f. Data standards:

X = Not determined yet.

g. Transmission system interconnection:

C = Two wires consisting of one twisted and shielded pair are provided.

TABLE E-2. SIGN/STATUS MATRIX

BCD Designation Matrix		Binary Designation Matrix		
Bit 32	No. 31	Bit 31	No. 30	Designation
0	0	0	0	Plus (+), North, East, Right, To
0	1	0	1	Failure Warning
1	0	1	0	No Computed Data
1	1	1	1	Minus (-), South, West, Left, From

h. Modulation:

B = Tri-level modulation consisting of "HI", "NULL", and "LO" states.

i. Voltage levels:

C = The differential output signals across the specified output terminal (balanced to ground in the transmitter) is $+10 \pm 1$, 0 ± 1, or -10 ± 1 volts for HI, NULL, or LO states respectively for the transmitter.

The input differential (balanced to ground in the receiver) terminals will recognize +10 ± 3, 0 ± 3, or -10 ± 3 volts for HI, NULL, or LO states, respectively. See Figure 2.2.3.3, ARINC Specification 419, for details.

j. Impedance level:

C = Paired output terminals drive a balanced to ground 600 to 12,000 ohm, 1,000 to 30,000 picofarod load. See Figure 2.2.4.3, ARINC Specification 419, for further details.

k. Digital language:

F = BCD or binary as identified per Language Identifier (see character 4, above)

l. Transmission order:

B = LSB is transmitted first.

m. Data bit encoding logic:

C = A HI state after the beginning of the bit interval, returning to a NULL state before the end of the same interval, signifies a logic "one". A LO state after the beginning of a bit interval, returning to a NULL state before the end of the same bit interval, signifies a logic "zero".

n. Error correction/detection:

B = Odd parity provided on last data bit in transmitted word (for binary data only).

o. Bit rate:

B = Bit rate is 11 ± 3.5 kilobits per second.

p. Clocking method:

C = The clocking is provided inherently in the signal data transmission. This is sometimes referred to as "self-clocking data". The identification of the bit interval is related to the initiation of either a HI or LO state from a previous NULL state in bipolar code.

q. Word/frame synchronization:

C = The digital word is synchronized by the existence of a four-bit minimum time gap between periods of word transmission. The beginning of the first transmitted bit following this period signifies the beginning of the new word.

r. Timing tolerance:

C = Identified in ARINC Specification 419, para. 2.4.4.2.

E.4.1.3 Design Concept for Configuration D

Figure E-1 is a schematic diagram of a conceptual design for Configuration D. This design assumes that all signals between the IM and Set Z will be in the form of 32-bit time-multiplexed serial words sent over a two-wire balanced system. These words will contain all the address, data, synchronization, timing, and error detection required to achieve the correct transfer of information.

Two phases of demultiplexing are utilized in this design. The first circuit separates the synchro signals from the flags and deviation signals. The second demultiplexer separates each of the synchro drive signals after they have been processed by a D/S converter. Sample and hold (S&H) circuits are used to hold the synchro output signals during the period that its input signal is not present. This will prevent the synchros from losing their null during the multiplexing cycle.

Timing and synchronizing will be derived from the 32-bit word structure as previously stated. The circuitry required to perform this task is labeled TIMING and DECODE LOGIC. This circuitry will be complex, and success or failure in obtaining proper system operation will rest heavily upon it.

Course and vertical deviation signals are obtained at the output of demultiplexer No. 1 in serial form. They are converted into parallel signals by a S/P converter; into analog signals by a D/A converter; and then into the required current output by a voltage-to-current converter (the S/P converter and voltage-to-current-converter may actually be part of the D/A converter).

The flag signals are processed in a manner very similar to that described in Section 3.1, and will not be discussed in detail here.

Magnetic heading and true airspeed signals are transformer-coupled into a multiplexer. The multiplexer output is held by a dual S&H until the proper timing signals arrive. A S/D converter processes the signal and sends it to a second multiplexer, where it is multiplexed with altitude information, formatted, and sent to Set Z.

This design utilizes multiplexing to greatly reduce the number of D/S converters required within the IM. It should be noted that no detailed study has been made concerning conversion rates and overall accuracy requirements. A study of these factors may indicate the need for more D/S converters. It should also be noted that while multiplexing has reduced the number of D/S converters, it has not and cannot reduce the output power requirements. As discussed in Section 3.1, the output power required is primarily a function of the loads driven, not the driving circuitry.

E.4.1.4 Cost of Configuration D

A detailed cost analysis of Configuration D cannot be made at this time since a more extensive design study is first required. However, it appears that if the proposed multiplexing scheme is successful, the component cost of Configuration D would not be much greater than that of Configuration C. Since no extra D/S converters would be required, only the additional component cost for timing, synchronization, S&H, and flag circuitry is required.

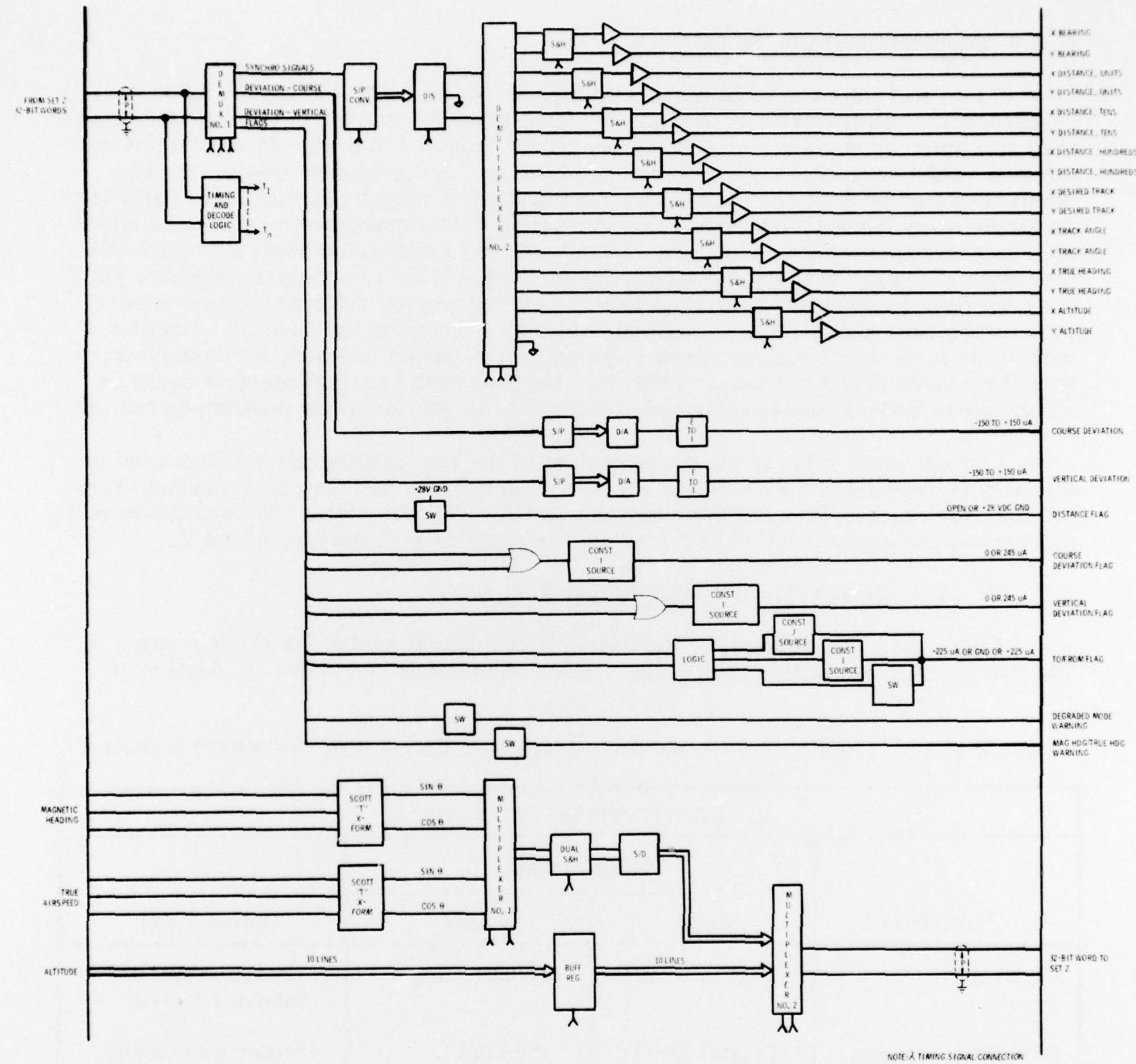

Figure E-1. Schematic Design Concept, Configuration D

E.4.1.5 Size of Configuration D

With multiplexing, the reduction in the number of D/S converters required should allow Configuration D to be packaged in approximately the same size as Configuration C.

E.4.2 Description of Configuration A

Table E-3 lists the input and output signal requirements of Configuration A ("Austere"). Configuration A presents a "bare-bones" approach to the interface task. Only two primary navigation functions are output from Set Z to the IM for display on the host vehicle avionics – bearing and deviation (or cross-track) error. The two functions would provide the pilot with a rudimentary display of the navigation situation on his primary flight instruments. Unfortunately these instruments require considerable manual updating of heading and desired course to coordinate their displays with the output signals. Without a magnetic heading input from the compass system, Set Z does not have an accurate reference for the bearing pointer relative to the compass card on the HSIs and BDHIs. The same situation is true for the deviation function; without an input of the course arrow position, Set Z cannot compare its desired track with the course arrow position. Therefore the deviation bar displacement could be meaningless without constant manual updating of the course arrow position on the HSI.

Configuration A is the most economical of the four configurations discussed in this report, requiring only one D/S channel (bearing) and only one D/A channel (deviation). However, it does not duplicate the TACAN-type displays, and does not provide a representative presentation of the avionic integration possibilities of Set Z.

E.4.2.1 Design Concept for Configuration A

Figure E-2 is a schematic diagram of a conceptual design for Configuration A. The circuitry shown in this figure was discussed in detail in Volume II, Section 3.

TABLE E-3. INPUT/OUTPUT SIGNAL REQUIREMENTS FOR CONFIGURATION A

a. INPUTS TO IM FROM SET Z			
Function	Signal Type: Input	Signal Type: Output	Output Load
Bearing	Digital word	Synchro drive	Control xfmr and torque receiver
Deviation, course	Digital word	Current	Meter movement
Course deviation flag	Digital word	Current	Indicator flag
To/from flag	Digital word	Current	Indicator flag
b. OUTPUTS FROM IM TO SET Z			
None			

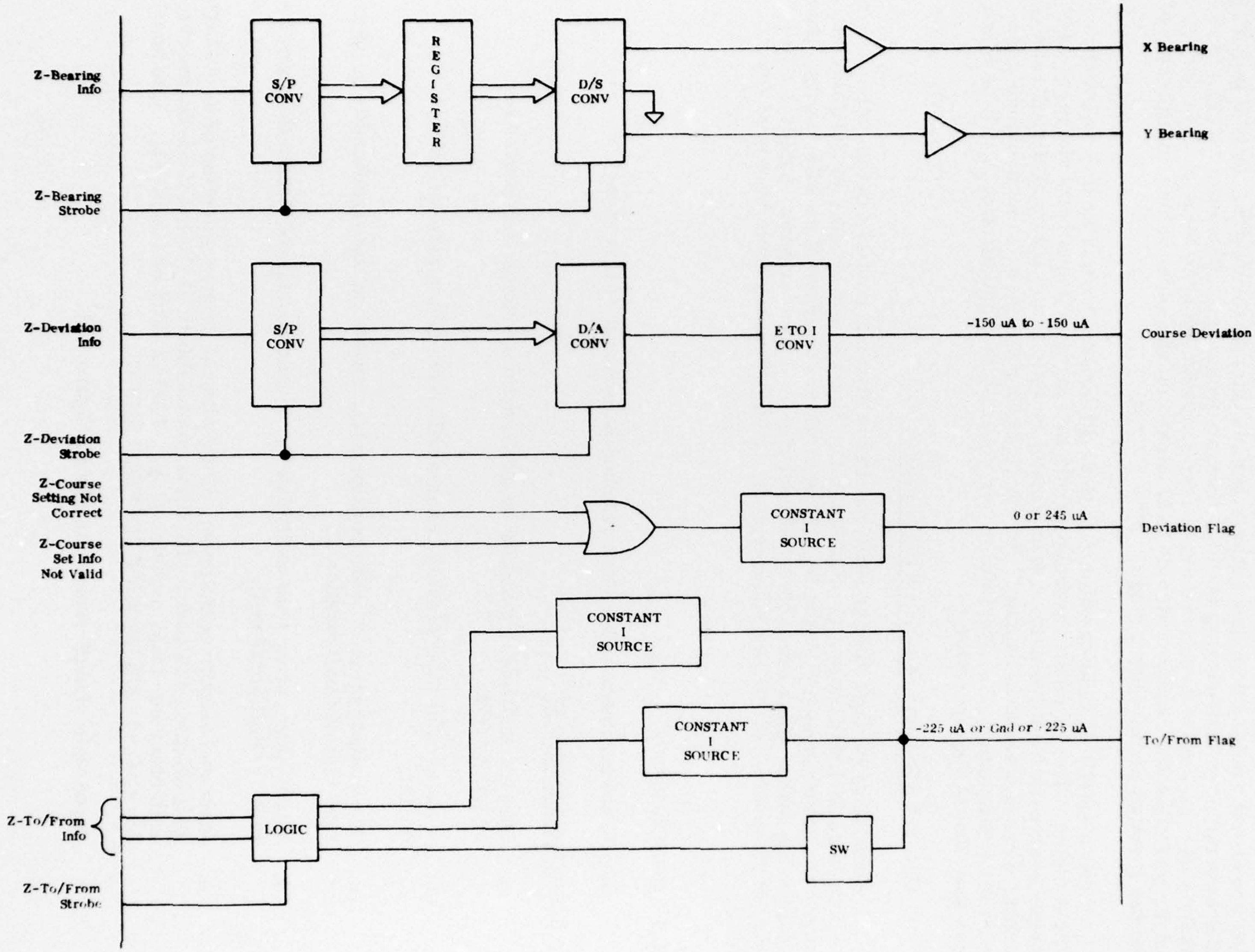

Figure E-2. Schematic Design Concept Configuration A

Configuration A, because of its limited requirements, would be the easiest Integration Module to implement. Multiplexing is not recommended for this configuration because it would add an unnecessary complication to the design. Only if the Set Z interface requires multiplexing would it become necessary. This does not appear likely since the limited requirements of Configuration A should allow it to fit within Set Z, and allow the required signals to be picked up at a point before multiplexing of the Set Z output signals takes place.

The majority of Configuration A power will be used in driving its one synchro output signal. The problems associated with driving both control transformers and torque receivers from the same output without isolation, and with output load requirements, were discussed in Section 3 for Configuration C; these same problems also exist for Configuration A. The total power required by Configuration A will be much less than that of Configuration C.

E.4.2.2 Cost and Size of Configuration A

Because of its lack of complexity, both the size and cost of Configuration A would be considerably less than for Configuration C. Since it is presently planned that Set Z supply the power required by the IM, the savings in power possible with Configuration A would make added space available within Set Z (i.e., smaller power supply). With this added space, and its own smaller size, Configuration A could be placed within Set Z.

E.5 CONCLUSIONS

The following conclusions were reached as a result of this study.

E.5.1 Configuration D

a. Internal multiplexing should be utilized for reducing D/S converter requirements.

b. A successful multiplexing scheme will reduce both size and component costs.

c. The component cost, with multiplexing, should not be significantly greater than that of Configuration C.

d. The package size, with multiplexing, should be approximately the same as that of Configuration C.

e. Input and output multiplexing, along with the proper selection of an ARINC Specification 419 code, will allow compatibility of the Set Z-to-IM interface with other advanced avionics (e.g., TACAN XXX and AQU-11). One possible code is ABB-BBX/CBCC/FBCB/BCCC.

f. A possible circuit concept is shown Figure E-1.

E.5.2 Configuration A

a. Could be placed within Set Z.

b. Interfacing should not be a problem if it is physically located within Set Z.

c. Will be the least costly of all IM configurations.

d. No multiplexing is recommended.

e. A possible circuit concept is shown in Figure E-2.