Eniv

NASA CR-132930

ADVANCED TRACKING AND DATA RELAY EXPERIMENTS STUDY - Multimode Transponder Experiment Equipment

Magnavox Research Laboratories
2829 Maricopa Street
Torrance, California 90503

15 September 1973

Final Report for Period Sept. 1972 - Sept. 1973

Prepared for

GODDARD SPACE FLIGHT CENTER

Greenbelt, Maryland 20771

(NASA-CR-132930) ADVANCED TRACKING AND DATA RELAY EXPERIMENTS STUDY: MULTIMODE TRANSPONDER EXPERIMENT EQUIPMENT Final Report, Sep. 1972 - Sep. 1973 (Magnavox Research Labs.) ~~29~~ 33 p HC $4.50

N74-16887

Unclas

G3/07 30069

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle ADVANCED TRACKING AND DATA RELAY EXPERIMENTS STUDY - Multimode Transponder Experiment Equipment		5. Report Date 15 September 1973 6. Performing Organization Code
7. Author(s) R. S. Cnossen		8. Performing Organization Report No. R-4741
9. Performing Organization Name and Address The Magnavox Company Magnavox Research Laboratories 2829 Maricopa Street Torrance, CA 90503		10. Work Unit No. 5 11. Contract or Grant No. NAS5-21824
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Type III Final Report 9-72 to 9-73 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Plans and implementation concepts have been developed for a series of experiments utilizing a Multimode Transponder mounted in an aircraft working either through a spacecraft or directly with a ground station which would simulate a TDRSS user working through the TDRSS. The purpose of the experiments would be to determine the best modulation and encoding techniques for combating RFI in discreet bands. The experiments would also determine the feasibility and accuracy of range and range rate measurements with the various modulation and encoding techniques.

This report provides an analysis of the Multimode Transponder and ground support equipment contracted for and determine the additional equipment required to perform the experiments described above.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Experiment, Satellite Transponder, Modulation Evaluation	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	27	

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

MRL TECHNICAL INFORMATION NOTICE

All entries must be completed prior to printing. If a particular block is not applicable, place N/A (not applicable) in the appropriate block.

DISTRIBUTION DATE 21 Sept. 1973

AUTHOR	CONTRIBUTORS	MRL REFERENCE NO. / DOCUMENT DATE
R. S. Cnossen	J. Mackey	R-4741 / 15 September 1973

TITLE ADVANCED TRACKING AND DATA RELAY EXPERIMENTS STUDY - Multimode Transponder Experiment Equipment

SUBJECT/ KEY WORDS

Experiments, Satellite Transponder, Modulation Evaluation

GOVERNMENT CLASS, AND MRL CONTROL NO.	TYPE OF INFORMATION	NO. OF PAGES
Unclassified	Interim Report	27
MAGNAVOX CLASS		NO. OF ILLUST.
Customer Only		16

ABSTRACT/ CONCLUSIONS

Plans and implementation concepts have been developed for a series of experiments utilizing a Multimode Transponder mounted in an aircraft working either through a spacecraft or directly with a ground station which would simulate a TDRSS user working through the TDRSS. The purpose of the experiments would be to determine the best modulation and encoding techniques for combating RFI in discreet bands. The experiments would also determine the feasibility and accuracy of range and range rate measurements with the various modulation and encoding techniques.

This report provides an analysis of the Multimode Transponder and ground support equipment contracted for and determine the additional equipment required to perform the experiments described above.

BY CUTTING OUT THIS RECTANGLE AND FOLDING ON THE CENTER LINE, THE ABOVE INFORMATION CAN BE FITTED INTO A STANDARD CARD FILE.

INFORMATION PREPARED FOR: National Aeronautics and Space Administration

APPROVED BY: PROGRAM MANAGER R. S. Cnossen — R. Cnossen DATE: 21 Sept. 1973

DEPARTMENT MANAGER B. Glazer — B. Glazer DATE: 21 Sept. 1973

70-1002 A (See Reverse Side For Instructions)

PREFACE

This report, dated 15 September 1973, is entitled "Multimode Transponder Experiment Equipment." It is the second of three reports which contain the findings of a program titled "Advanced Tracking and Data Relay Experiments Study." The work was accomplished by the Magnavox Research Laboratories of Torrance, California and complies with the requirements of Contract Number NAS5-21824, Contract Data Item 4.

Plans and implementation concepts have been developed for a series of experiments utilizing a Multimode Transponder mounted in an aircraft working either through a spacecraft or directly with a ground station which would simulate a TDRSS user working through the TDRSS. The purpose of the experiments would be to determine the best modulation and encoding techniques for combating RFI and multipath propagation and to determine the characteristics of VHF and UHF RFI in discreet bands. The experiments would also determine the feasibility and accuracy of range and range rate measurements with the various modulation and encoding techniques.

This report provides an analysis of the Multimode Transponder and its associated ground support equipment contracted for and determines the additional equipment required to perform the experiments described above.

Magnavox wishes to acknowledge the assistance of Pat Mitchell, ATDRE technical officer and Keith Fellerman of the TDRSS program office, G.S.F.C.

This report was prepared by Messrs. R. Cnossen and J. Mackey of MRL.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION III

ATDRE EQUIPMENT

The Multimode Transponder and the Multimode Transmitter and Receiver Units are described in this section along with the support equipment required to perform the experiments detailed in Section II.

Part 1 provides a functional description of both the MMT and MTAR equipments. It includes diagrams of the signal interfaces and includes a description of the MTAR antenna developed for this program. Part 2 details the required test equipment needed to support the test series. Part 3 provides a brief description of the NASA mobile test station which would be used for the flight test series. Finally, part 4 gives a summary of the airborne test beds which were considered during the study.

3.1 MTAR/MMT EQUIPMENT

3.1.1 FUNCTIONAL DESCRIPTION

The section contains a description of the MTAR (ground) and the MMT (airborne) equipment developed for evaluating candidate modulation techniques for TDRSS.

The MTAR equipment consists of four chassis:

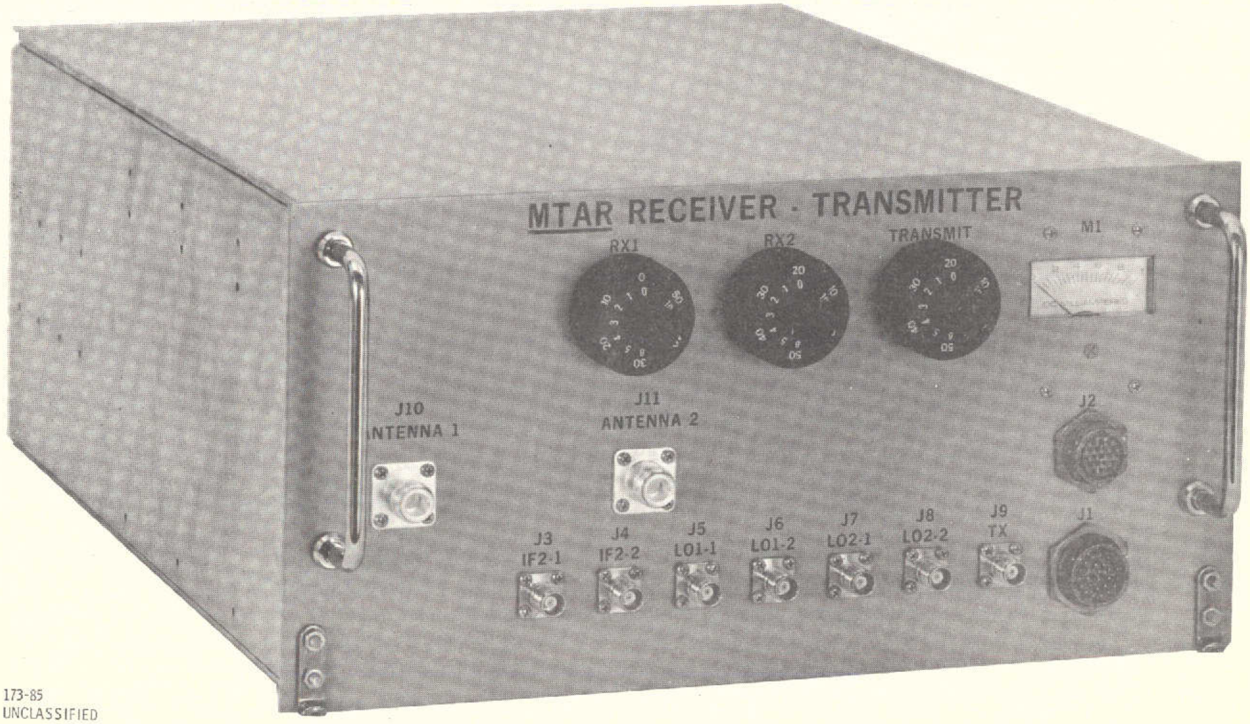
1. The Receiver-Transmitter contains the RF to IF sections for both the receiver and the transmitter. It is shown in figure 3-1.

2. The Signal Processor contains all circuits from IF to baseboard for both the transmitter and receiver. It is shown in figure 3-2.

3. The Power Supply provides all supply potentials to the other three chassis and its appearance is similar to the Signal Processor.

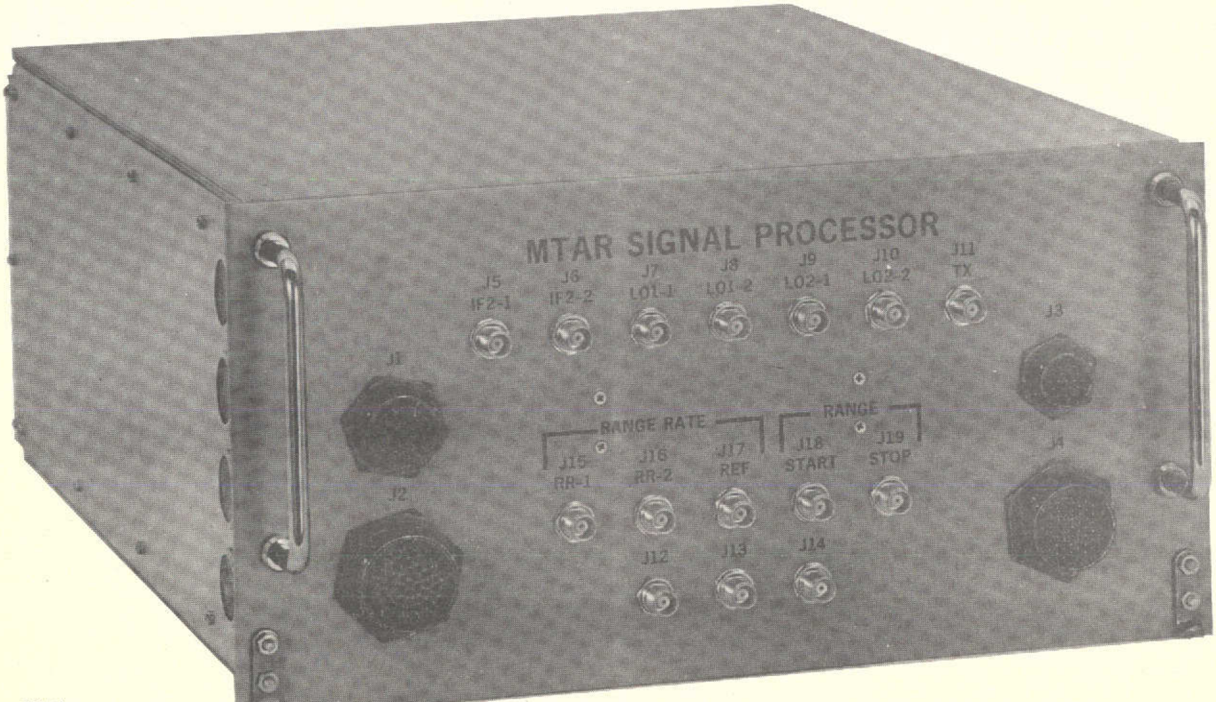
4. The Control/Display Panel houses all mode selection switches and indicates the operational status of the equipment. It is shown in figure 3-3.

The MMT equipment also consists of four chassis which are similar in function and almost identical in appearance to the MTAR equipment. The Control/ Display Panel for the MMT is shown in figure 3-3.



173-85
UNCLASSIFIED

Figure 3-1. MTAR Receiver-Transmitter



173-84
UNCLASSIFIED

Figure 3-2. MTAR Signal Processor

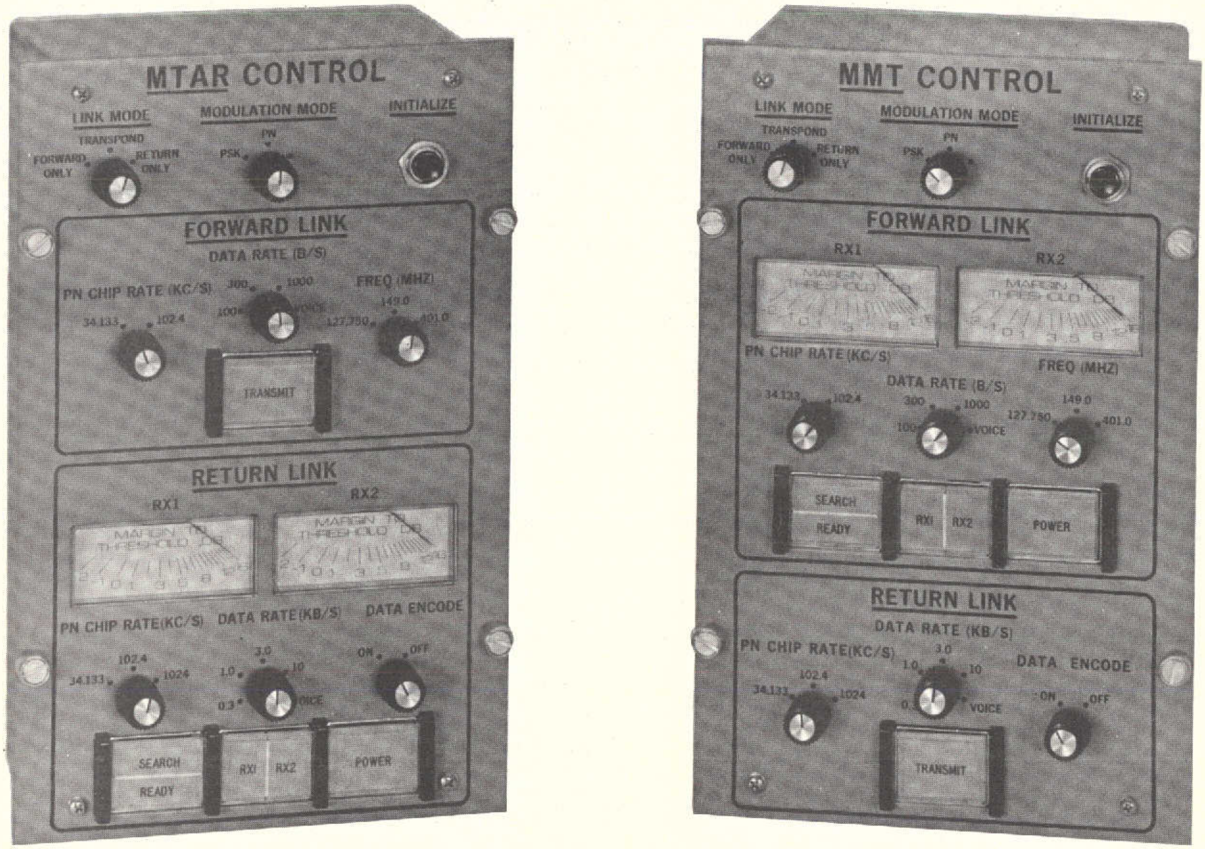


Figure 3-3. MTAR and MMT Control/Display Panels

3.1.1.1 MTAR Equipment

The MTAR consists of a diversity receiver and a transmitter operating through two quadriplexers into two antenna elements. The receiver functional block diagram is shown in figure 3-4. The first mixer converts the 137.0 MHz receive frequency down to 57.0 MHz. The IF amplifiers at 57.0 MHz and 12.0 MHz amplify the received signal.

The third mixer stage serves as a correlator in the pseudonoise mode of operation. The local reference circuitry balance modulates the receiver pseudonoise code with the 10.75 MHz local oscillator signal. When the code on the received signal is in phase with the locally generated code, a narrowband IF signal results. These signals are amplified and drive the phase-lock detectors in each of the two diversity receivers. When the incoming carrier signal is being tracked, each VCO provides a phase coherent drive to a frequency synthesizer which generates the receive local oscillator frequencies.

In the pseudonoise mode the code tracking loop keeps the receiver reference code in phase with the code on the received signal. In each receiver the incoming signal goes to a separate correlator and 1.25 MHz IF amplifier. The local reference provides this correlator with an early-late code from which a tracking error signal is derived. These error signals are combined and filtered in the code track detector and drive a single-clock VCO. Diversity reception requires two receivers because the propagation time difference due to the spatial relationship of the antennas is in the order of a full cycle at the RF carrier frequency. The code-track error signals can be combined to drive a single VCO because the 10 ns time difference in the received signals is insignificant at the code-chip rates used. The code and data-clock synthesizer is driven by the clock VCO and generates the selected chip-rate clock for the receive coder. In the conventional PSK mode the clock VCO and synthesizer are used to recover the received digital data clock.

The in-phase (I) outputs of the phase-lock detectors are combined in the diversity combiner. The telemetry digital data or PDM voice is extracted from the I-combined signal.

The doppler processor in conjunction with the controller searches out the doppler frequency uncertainty to obtain carrier lock. The anticipated doppler frequency error for the TDRS system is much greater than the carrier loop filter bandwidth. The doppler processor employs a technique that searches out the doppler uncertainty much faster than a linear cell-by-cell frequency search. Both the carrier frequency and code-phase uncertainties must be resolved. The controller advanced or retards the code clock phase to obtain pseudonoise code synchronization. The sync-AGC circuitry makes the sync-search decision and generates the AGC signals to control IF amplifier gain.

The MTAR transmitter functions are shown in figure 3-5. The output amplifier drives into a variable attenuator for output power control. The attenuator is connected to the appropirate bandpass filter for the frequency to be transmitted. An RF power divider for each of the bandpass filters provides the outputs to the dual quadriplexer and attenuator arrangement.

A frequency synthesizer driven by a stable crystal-controlled oscillator provides three transmit local-oscillator frequencies and the transmit carrier. One of the three local-oscillator frequencies is selected for mixing with the modulated 67.76 MHz transmit carrier to obtain the desired output frequency.

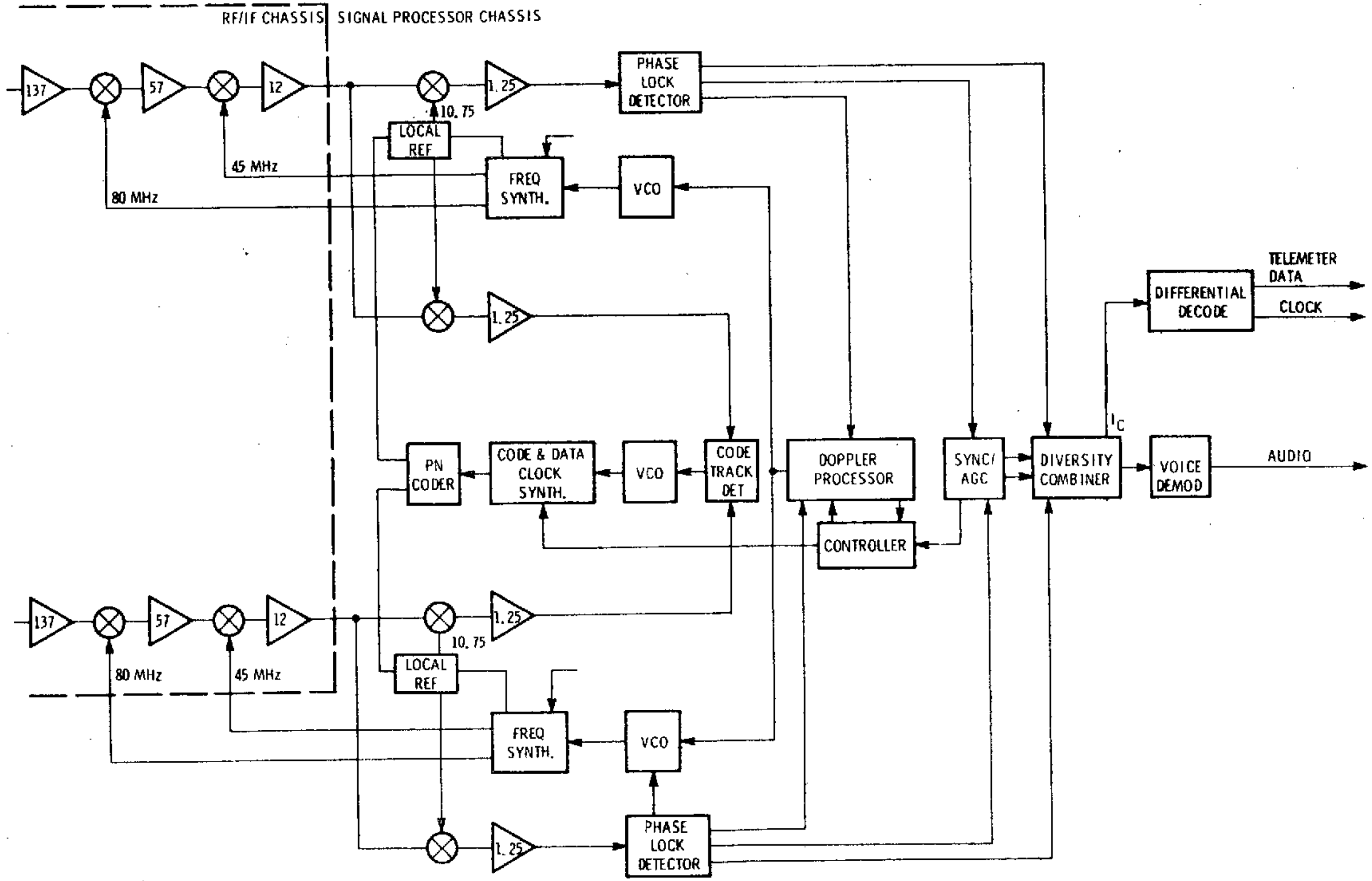


Figure 3-4. MTAR Receiver, Block Diagram

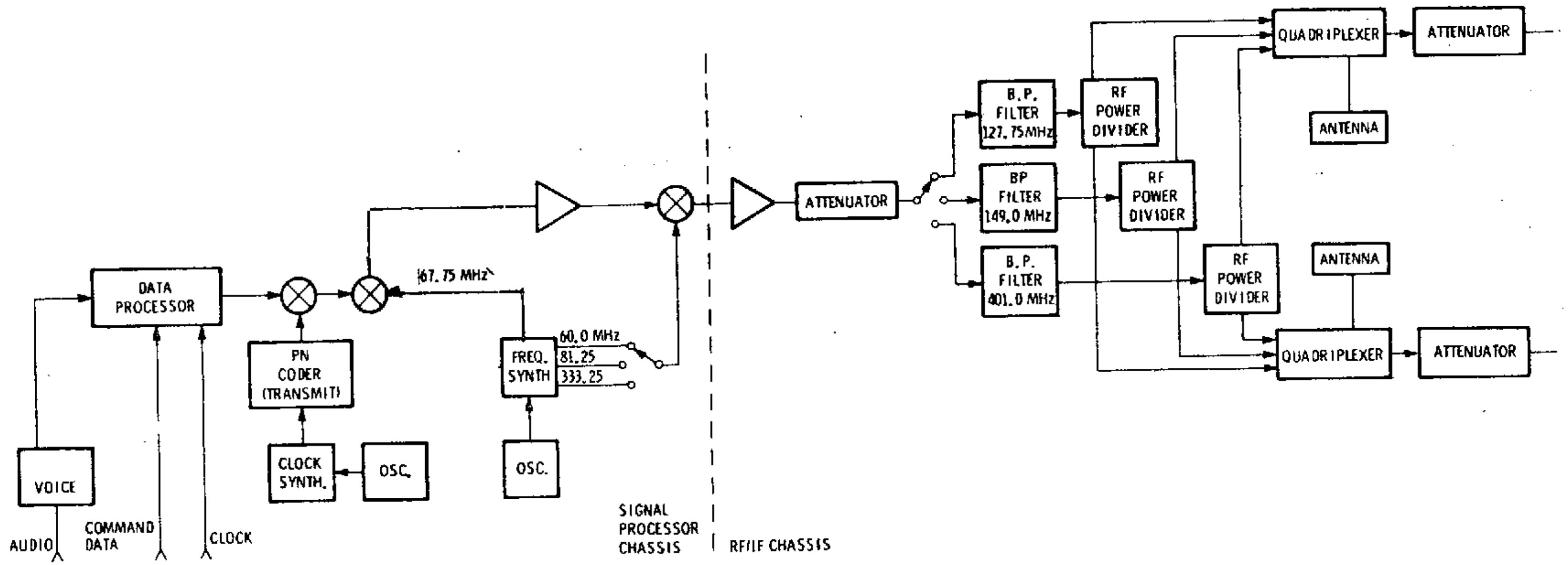


Figure 3-5. MTAR Transmitter, Block Diagram

In the PSK mode digital data or PDM voice is balance modulated on the carrier. In the PN mode the digital data or PDM voice is combined with the pseudo-noise code before being balance modulated with the carrier. The selected code-chip-rate clock is generated by a synthesizer driven by a stable oscillator at 10.24 MHz.

3.1.1.2 MMT Equipment

The MMT functions as a coherent transponder with the transmit carrier frequency synthesized from the receiver VCO tracking the forward link signal. The MTAR transmits to and detects the signal received from the MMT. Control box selection of modulation mode, command and telemetry data rates and pseudonoise chip rates, is provided. Digital data error rates can be measured both with and without convolutional encoding. A voice channel can be selected for both forward and return links. The return link carrier frequency will be 137.0 MHz while one of three frequencies (127.75 MHz, 149.0 MHz or 401.0 MHz) can be selected for the forward link.

The MMT consists of a diversity receiver and a transmitter operating through two quadriplexers into two antenna elements. The receiver functional block diagram is shown in figure 3-6. Selection of the expected receive frequency is made by selecting the appropriate input bandpass preselector and local oscillator frequency to the first mixer. Intermediate-frequency amplifiers at 67.75 MHz and 16.25 MHz amplify the received signal. The third mixer stage serves as a correlator in the pseudonoise mode of operation. The local reference circuitry balance modulates the receiver pseudonoise code with the 15 MHz local oscillator signal. When the code on the received signal is in phase with the locally generated code, a narrowband IF signal results. These signals are amplified and drive the phase-lock detectors in each of the two diversity receivers. When the incoming carrier signal is being tracked, each VCO provides a phase coherent drive to a frequency synthesizer which generates the local oscillator (LO) frequencies and transmit carrier frequency.

In the pseudonoise mode the code tracking loop keeps the receiver reference code in phase with the code on the received signal. In each receiver the incoming signal goes to a separate correlator and 1.25 MHz IF amplifier. The local reference provides this correlator with an early/late code from which a tracking error signal is derived. These error signals are combined and filtered in the code track detector dand drive a single clock VCO. Note that diversity reception requires two receivers because the propagation time difference due to the spatial relationship

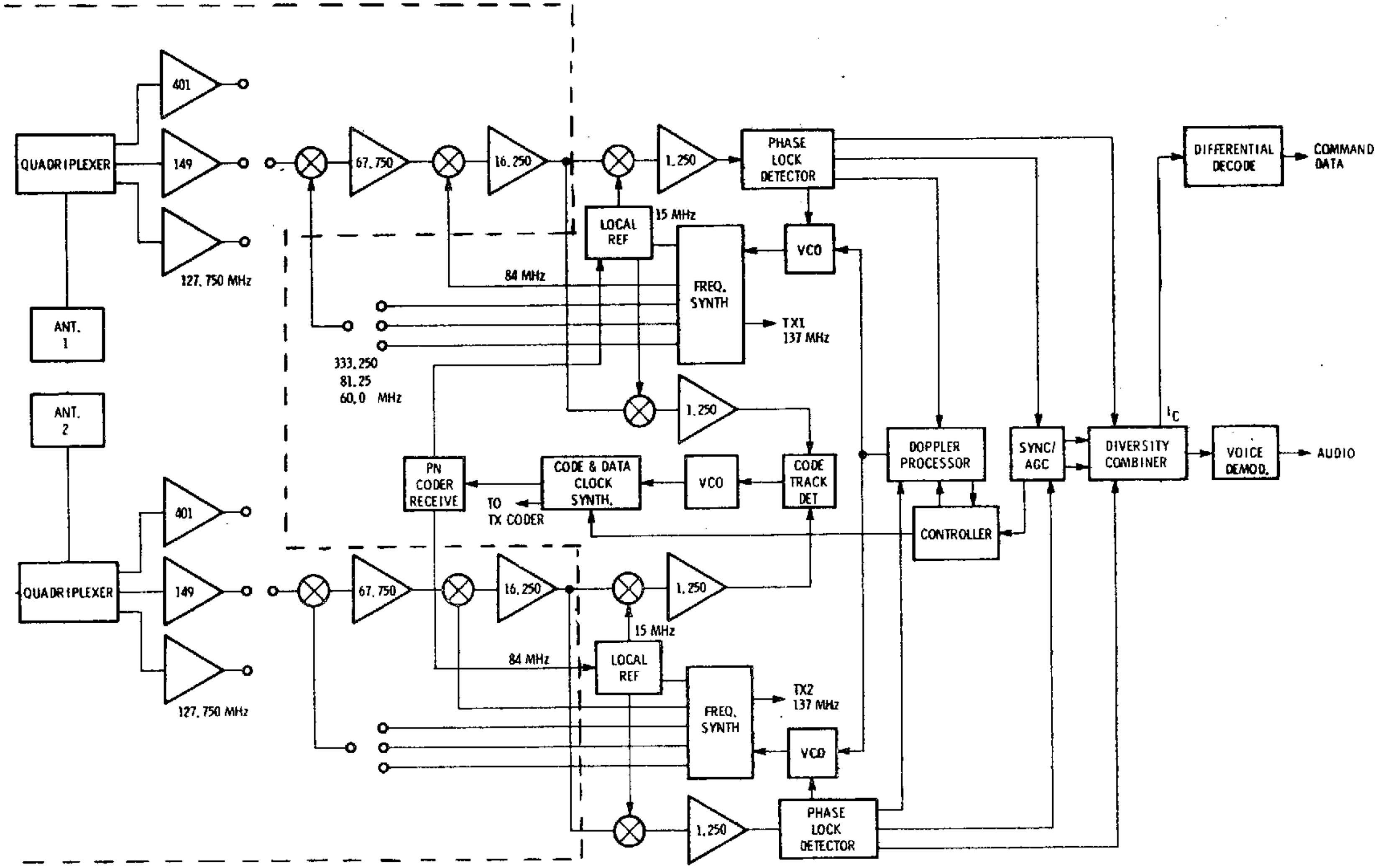


Figure 3-6. MMT Receiver, Block Diagram

of the antennas is in the order of a full cycle at the RF carrier frequency. The code track error signals can be combined to drive a single VCO because the 10 ns time difference in the received signals is insignificant at the code-chip rates used. The code and data clock synthesizer is driven by the clock VCO and generates clocks for the receive and transmit coders. In the PSK mode the clock VCO and synthesizer are used to recover the receive digital data clock.

The in-phase (I) outputs of the phase lock detectors are combined in the diversity combiner. The command digital data or PDM voice is extracted from the I-combined signal.

The Doppler processor in conjunction with the controller searches out the Doppler frequency uncertainty to obtain carrier lock. The anticipated Doppler frequency error for the TDRS system is much greater than the carrier loop filter bandwidth. The doppler processor employs a technique that searches out the doppler uncertainty much faster than a linear cell by cell frequency search. Both the carrier frequency and code phase uncertainties must be resolved. The controller advances or retards the code clock phase to obtain pseudonoise code synchronization. The sync/AGC circuitry makes the sync-search decision and generates the AGC signals to control IF amplifier gain.

The MMT transmitter functions are shown in figure 3-7. The output amplifier drives a power divider to provide outputs to the dual quadriplexer and antenna arrangement. Provision is made to adjust the output power level with a front panel control. The output amplifier is driven by a modulated 137 MHz RF signal. The carrier is selected to be taken from the frequency synthesizer of the diversity receiver phase locked to the strongest received signal.

In the conventional PSK mode the digital data or PDM voice balance modulates a carrier. In the PN mode the digital data/PDM is combined with the pseudonoise code before balance modulating a carrier. The transmit code clock is generated by the code and data clock synthesizer driven by the receive code clock VCO.

The telemetry digital data can be transmitted either with or without convolutional encoding. This feature allows for comparative data error rate tests to be run for evaluating performance improvement with convolutional encoding. A data clock output is provided to clock the external instrument that will generate the telemetry digital data.

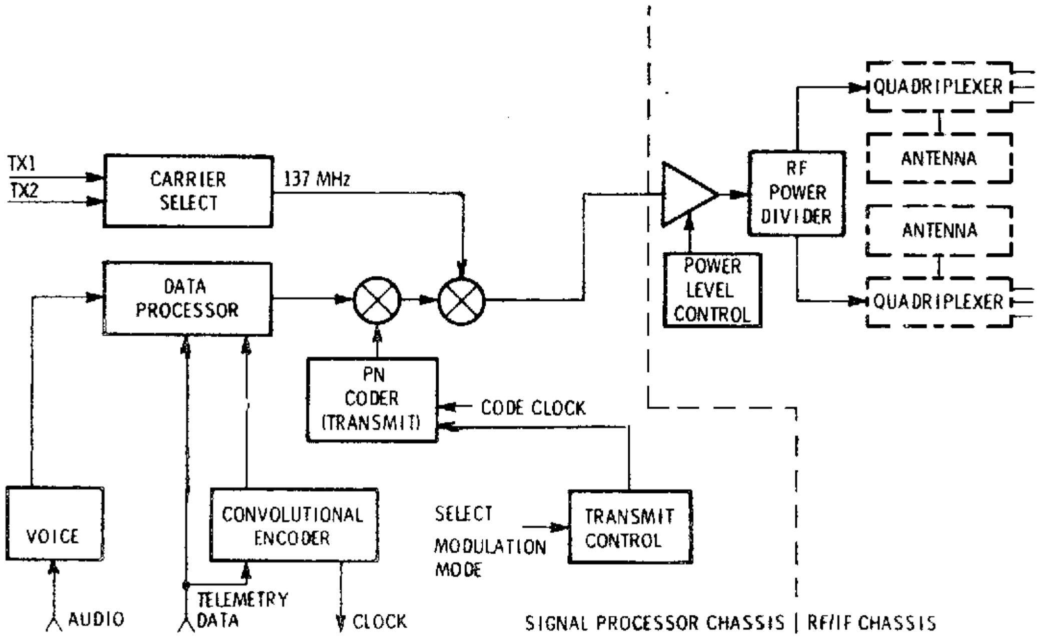


Figure 3-7. MMT Transmitter, Block Diagram

3.2 MTAR ANTENNA

As part of the Multimode Transponder development program, an MTAR antenna was fabricated. This antenna was designed for use on the NASA van during flight testing.

The antenna is a coincident orthogonal trapezoidal log-periodic array. One of the two orthogonal arrays is shown in figure 3-8. The antenna consists of identical orthogonal arrays with dual coaxial outputs. These outputs are in-phase, but provide orthogonal linear polarization. They provide circular polarization when externally combined through an external 90-degree phase shifter as part of the terminal equipment. This antenna is used for simultaneous transmission and reception and requires a quadriplexer and phase shifter as shown in figure 3-9.

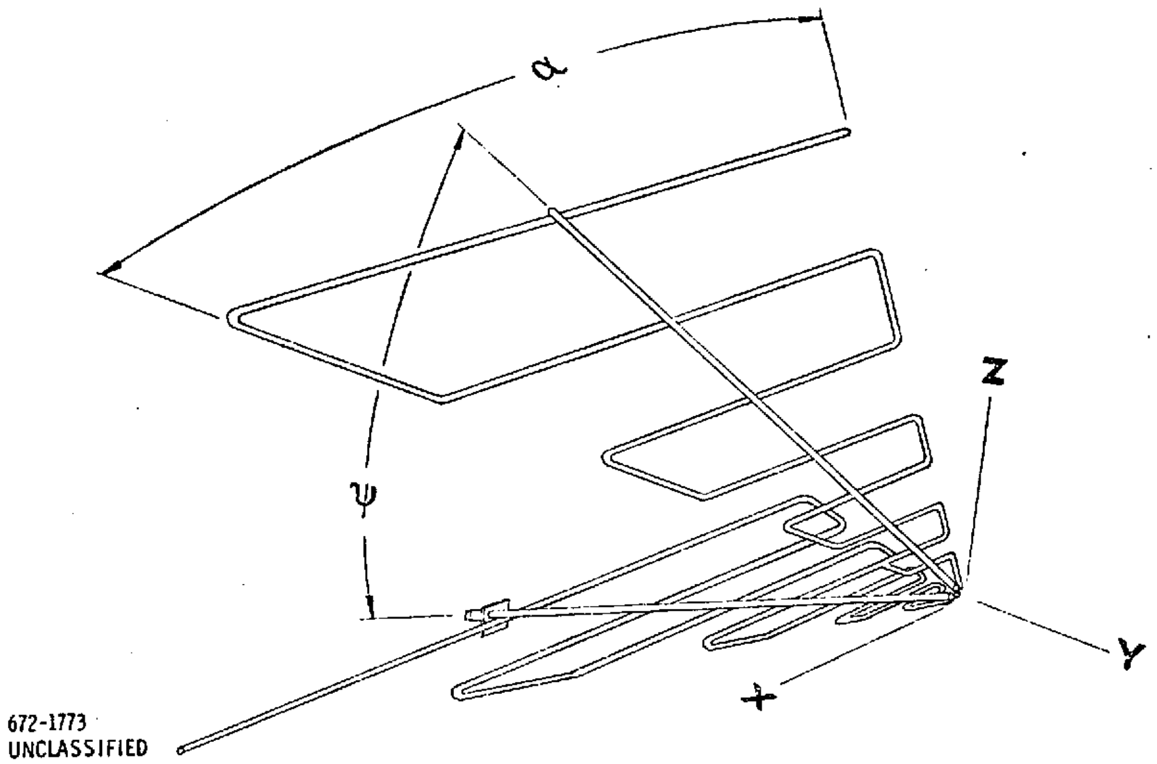


Figure 3-8. Trapezoidal Log-Periodic Antenna Array

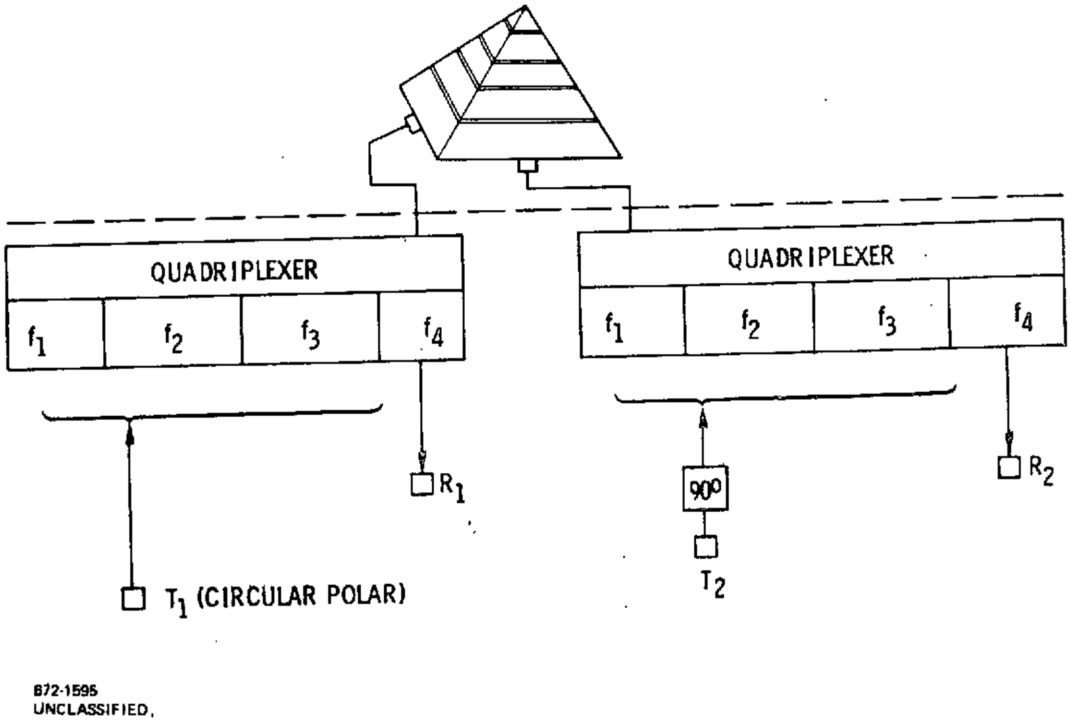


Figure 3-9. Feed Schematic for Orthogonal Log-Periodic Arrays

Each array has the following electrical characteristics:

Frequency range:	126-402 MHz covering four discrete bands; 126-130, 136-138, 148-150, 400-402 MHz
VSWR:	2.0:1 maximum on 50 ohms in each frequency band
Outputs:	Dual 50 ohm coaxial
Pattern:	Unidirectional with each linear array displaying average half-power beamwidths of: E-plane = 65° H-plane = 70°
Front-to-Back ratio:	15 dB average
Gain:	6 dBi, each linear input

3.3 MTAR/MMT INTERFACES

3.3.1 MECHANICAL INTERFACE

The MMT and MTAR equipments were designed to be mounted in a standard rack configuration as shown in figure 3-10. The Power Supply and R-T chassis would hard mount onto shelves in the rack while the Signal Processor would be mounted with isolators to a shelf. The Control/Display panel would mount to a rack panel which also contains the audio jacks and signal monitor plugs. This configuration would be useful for the NASA van and larger airborne testbeds. In an aircraft like the U-2, each chassis would be mounted separately.

3.3.2 LAB TEST INTERFACE

For all laboratory experiments test boxes have been constructed to allow easy access to all status data, data and data clocks, monitor signals and audio signals, A sketch of the MMT/MTAR test interface boxes is shown in figure 3-11.

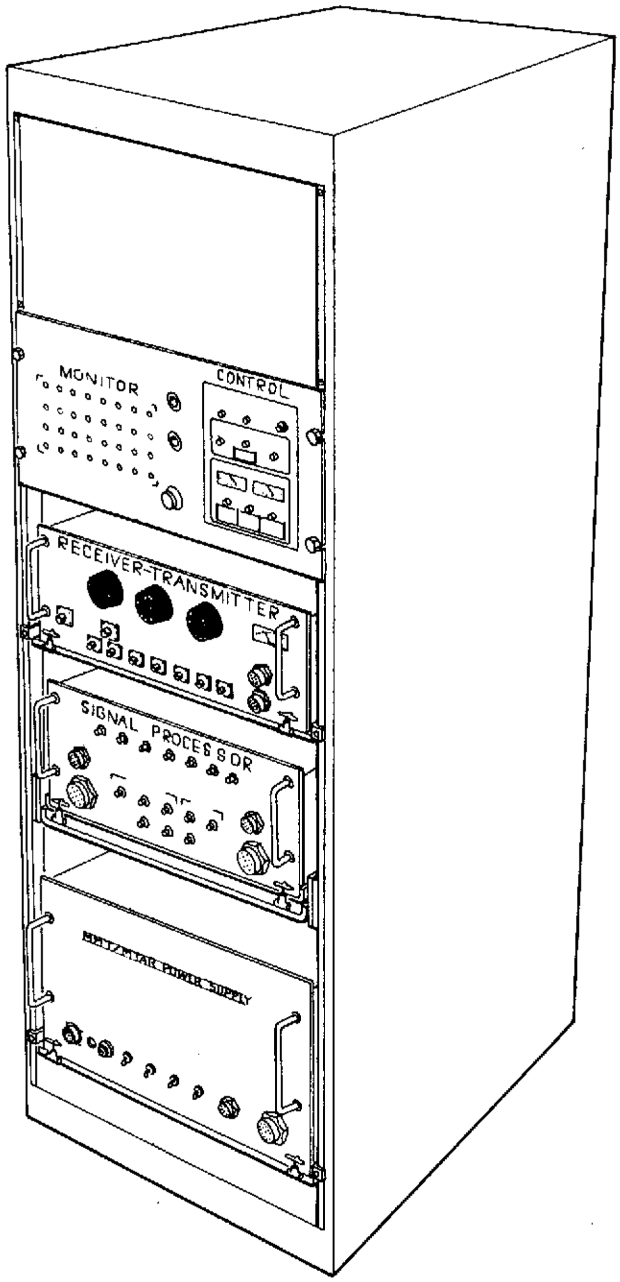
3.3.3 FLIGHT TEST INTERFACE

The method for interfacing and recording test data during flight tests is illustrated for the MTAR and MMT equipment in figures 3-12 and 3-13, respectively. The audio, data, data clocks and status data would be obtained from interface cable (J_1). These are all hard wire lines. The range and range rate signals would come from TNC coax connectors on the MTAR chassis. Data error pulses would come from a BNC connector on the MX-270 chassis. All of these signals would interface with NASA furnished recording equipment.

The audio signals would interface with a tape recorder and player. The accumulation of data error pulses would be counted with an event counter. The range and range rate signals would interface with time interval and frequency counters. All events would be coordinated with a time-of-day counter. All of this data including equipment status data would be stored in a data buffer and multiplexed into a Franklin printer for a permanent record.

3.3.4 MTAR/MMT MONITOR SIGNALS

Table 3-1 presents a list of the monitor signals available from either the MTAR or MMT equipment.



173-82
UNCLASSIFIED

Figure 3-10. Rack Configuration For Both MMT and MTAR Equipments

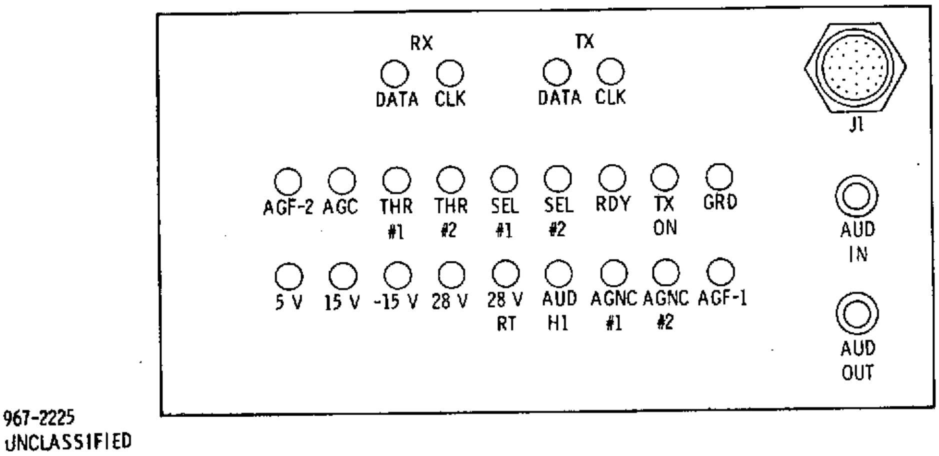


Figure 3-11. MMT/MTAR Lab Test Box Interface

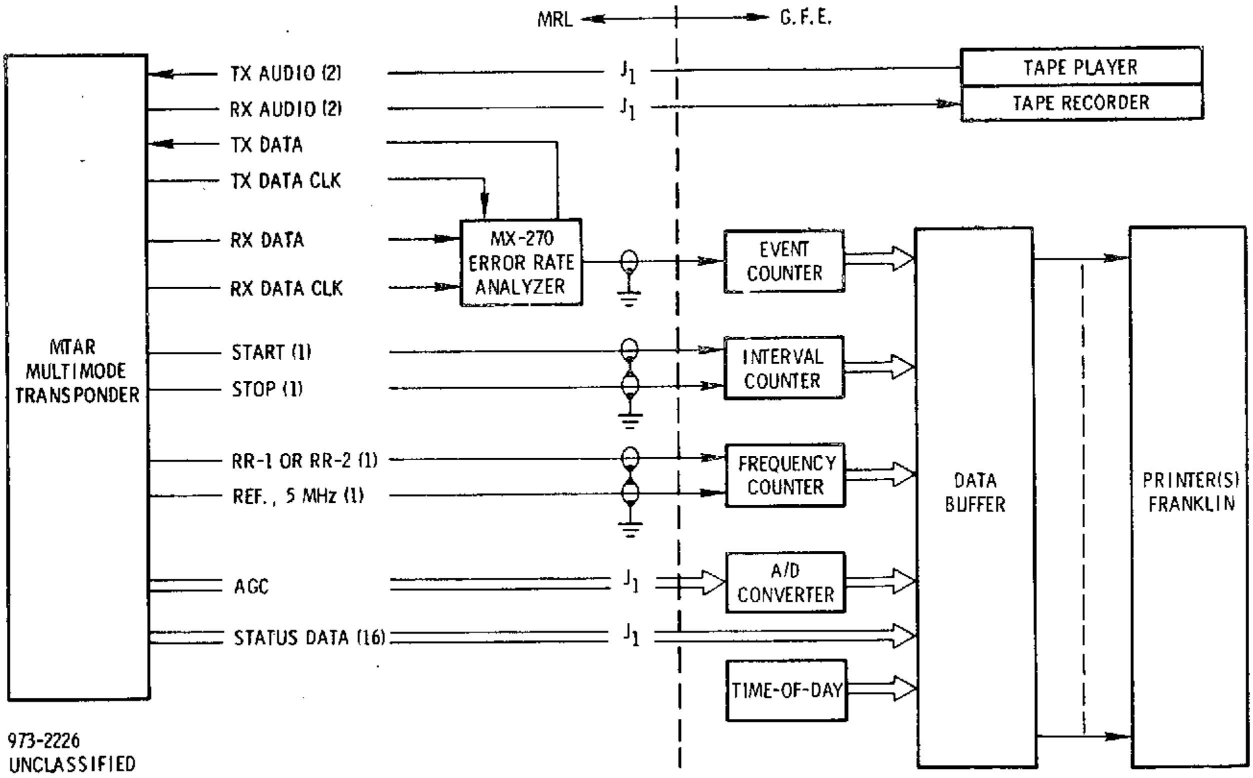


Figure 3-12. MTAR Flight Test Data Interface

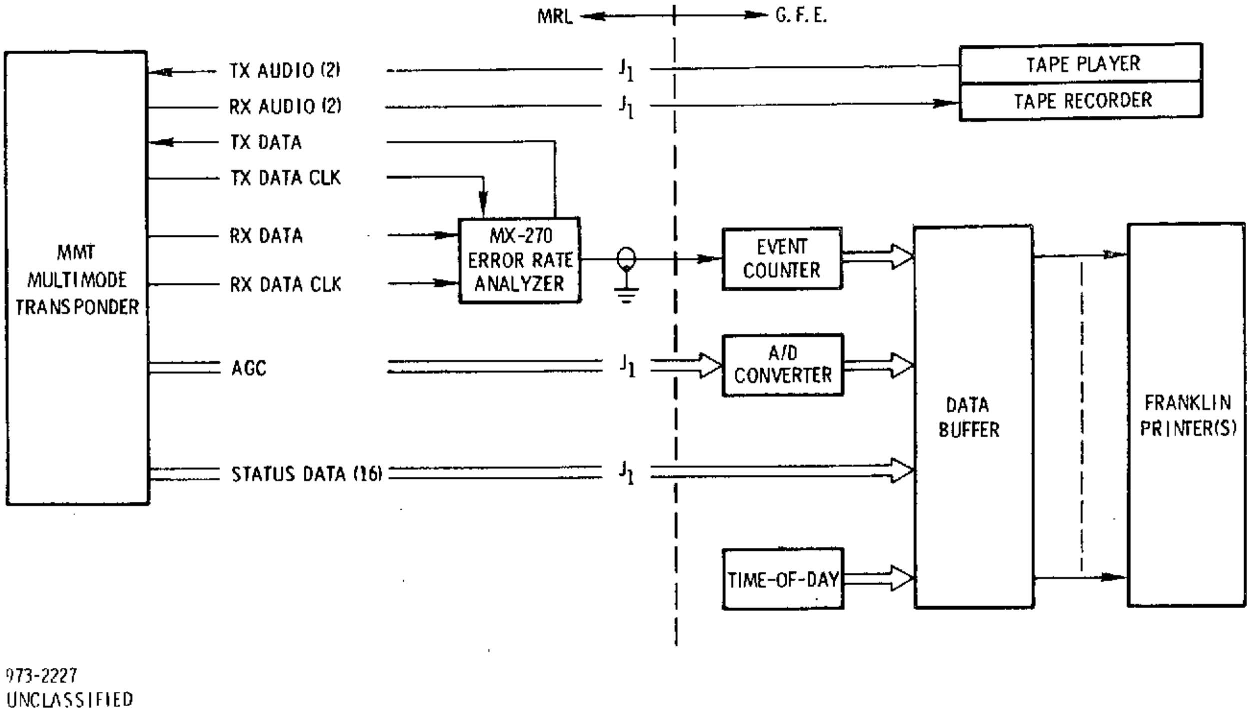


Figure 3-13. MMT Flight Test Data Interface

3.3.5 EXTERNAL INTERFACE SIGNAL SPECIFICATIONS

<u>Antenna Input</u>

Impedence	50Ω Resistive
Level	-90 to -150 dBm
Connector	Type N
Frequency	127.750 to 401 MHz

<u>Prime Power</u>

Voltage	110-120 V, AC, 50-400 Hz
Power	300 Watts Max.
Connector	Std. AC Receptacle

<u>MX-270 Data Error Pulses</u>

Pulse Level	TTL
Pulse Width	1/Data Rate
Connector	BNC. Coaxial
Pulse Rate	0 to 100 pps.

Table 3-1. MTAR/MMT Monitor Signals List

J1	SYMBOL	SIGNAL DESCRIPTION
A	MP5V	+ 5 Volt Power Supply Access
B	MP15V	+15 Volt Power Supply Access
C	M-15V	-15 Volt Power Supply Access
D	MP28V	+28 Volt Power Supply Access
E	MRT28V	+28 Volt Return
F	GDPLATE	Chassis Ground
G	AUDIN1	Transmit Audio Input (Ground) } Configured for
H	AUDIN2	Transmit Audio Input (Signal) } Carbon Mike
J	--	(Impedence: 600Ω, Input: 80 to 1400 mV rms)
K	AUDHI	Received Audio, 6.7 VRMS
L	AUDLO1	Received Audio Output } Balanced Pair,
M	AUDLO2	Received Audio Output } 600Ω, 3 VRMS
N	DATARX	Received Data TTL
P	CLKREC	Received Data Clock TTL
R	TLMTX*	Data to XMTR TTL
S	1XDTCLK*	Data Clock to XMTR TTL
T	AGNC-1	Channel -1 Noncoherent AGC (-0.7 to +15V)
U	AGNC-2	Channel -2 Noncoherent AGC (-0.7 to +15V)
V	AGF-1	Channel -1 Coherent AGC (-0.7 to +15V)
W	AGF-2	Channel -2 Coherent AGC (-0.7 to +15V)
X	AGCMB	Common Coherent AGC (-0.7 to +15V)
Y	THRESH -1	Channel -1 Margin to Threshold (0 to +5V)
Z	THRESH -2	Channel -2 Margin to Threshold (0 to +5V)
a	SEL-1	Channel -1 Selected } Diversity RCVR
b	SEL-2	Channel -2 Selected } Selection TTL
c	READY	Two-Way Link Established TTL
d	TXON	Transmitter ON TTL
e		
f		
g		
h		
j		

*CMDTX and 1XDTCLK for MTAR Equipment.

3.3.6 RANGE AND RANGE RATE SIGNAL SPECIFICATIONS

Start

Connector	TNC Coaxial
Waveform	Pulse
Load	50Ω Resistive
Level	
	0.1 volt true
	0 volt false
Width	1 ms for 1024.0 kcs code
	10 ms for 102.4 kcs code
	30 ms for 34.1 kcs code
Rate	60 ms for fwd link 34 kcs
	rtn link 34 kcs
	40 ms for fwd link 102.4 kcs
	rtn link 102.4 kcs
	120 ms for fwd link 34 kcs
	rtn link 102.4 kcs
	120 ms for fwd link 102.4 kcs
	rtn link 34 kcs

Stop

(Same as above)

Range Rate (RR-1)

Channel	#1
Level	0 dBm ±1 dB
Load	50 Resistive
Frequency	80 MHz Nominal
Waveform	Sinewave, Continuous
Connector	TCN on sig. proc. front panel

Range Rate (RR-2)

Channel	#2
Level	0 dBm ±1 dB
Load	50Ω Resistive
Frequency	80 MHz Nominal
Waveform	Sinewave, Continuous
Connector	TNC on sig. proc. front panel

Reference

Frequency	5 MHz
Level	0 dBm ±1 dB
Load	50Ω Resistive
Waveform	Sinewave
Connector	TNC on sig. proc. front panel

3.4 TDRSS VAN EQUIPMENT

Goddard Space Flight Center has a modile test van which has been identified as a TDRS Test Van. This mobile unit could house the MTAR equipment during air-to-ground testing.

The van is RFI insulated, contains many racks of test equipment, has a self contained power generator and has considerable flexibility for a wide range of experiments. A list of available test equipment in the van has been evaluated and found to be more than adequate for the proposed tests. The only known equipment needed, in addition to the MTAR equipment, MTAR antenna and a MX-270 Bit Error Rate Analyzer, is a data multiplexer and storage unit for interfacing the test data outputs with a Franklin printer. This item would be supplied by NASA.

3.5 CANDIDATE AIRCRAFT EQUIPMENT

A number of aircraft suitable for flight testing were evaluated during this study. They include aircraft which could be furnished by NASA, Flight Systems, Inc, and Rockwell, Int. A capsule summary of these aircraft will be presented in this section.

3.5.1 NASA AIRCRAFT

Four NASA aircraft were identified and found useful for flight testing. They are the (1) C121G Super Constellation, (2) DC-6, (3) Convair 340 and (4) U-2. The first three could provide a suitable airborne testbed for air-to-ground experiments and the fourth would be suitable for use as a high altitude aircraft during air-to-air experiments.

3.5.1.1 C121G Super Constellation

The aircraft types are as follows:

N420NA	C121G	Super Constellation
N421NA	C121G	Super Constellation

Aircraft operating characteristics are summarized in table 3-2. Aircraft interior arrangements and antenna locations are shown in figure 3-14.

The instrumentation section of the aircraft consists of 16 racks containing more than 30 pieces of commercial and special test equipment in addition to the Apollo/LM Simulator System.

Electrical power is supplied to the equipment racks by four 115-vac 60-Hz inverters and six 115-vac, 400-Hz inverters. Ten regulated dc power supplies provide regulated 28-vdc, and each rack is connected to the aircraft 28 vdc bus, 300 amps, max., for unregulated power.

The instrumented aircraft can provide a dynamic tracking target and a data transmission source. The system is capable of receiving signals normally transmitted from the MSFN station to the Apollo CSM/LM spacecraft. System capabilities may be summarized as follows:

- Transmission of voice, telemetry, and television data to the station.
- Reception and demodulation of voice transmission from the station.
- Reception, demodulation, decoding, and verification of station generated digital data.
- Voice transmission in backup mode.
- Voice reception in backup mode.
- Transmission of emergency keyed signals to the station.

Table 3-2. C121G Instrumented Aircraft Operating Characteristics

Max ALT	20,000 feet
Max TAS	250 (11 + 00) (Hrs & Min)
Min TAS	190 (14 + 00) (Hrs & Min)
Recommended	230 (12 + 00) (Hrs & Min)
Optimum ALT	10,000 feet
Max TAS	230 (12 + 00) (Hrs & Min)
Min TAS	165 (16 + 00) (Hrs & Min)
Recommended	200 (14 + 00) (Hrs & Min)
Low ALT	As Required
Max TAS	215 (12 + 15) (Hrs & Min)
Min TAS	145 (20 + 00) (Hrs & Min)
Recommended	185 (16 + 00) (Hrs & Min)

Notes:

Aircraft endurance (hours of fuel to dry tank - shown in parentheses) is based on nominal technical order (flight manual) computations with the following considerations:

a. Two hours reserve fuel NOT included.

b. Normal flight crew of four, an electronics crew of four, and fuel at 5.8 lbs per gallon.

c. Standard day conditions; however other factors, i.e., field elevation, hotter than normal temperatures, turbulent weather, icing conditions, etc., may affect above computations by as much as 20 percent.

d. When mission requirements warrant, the mission time may be increased by unloading excess equipment from the aircraft (fly away kit, life rafts, excess electronic equipment, etc.) and increasing the fuel load.

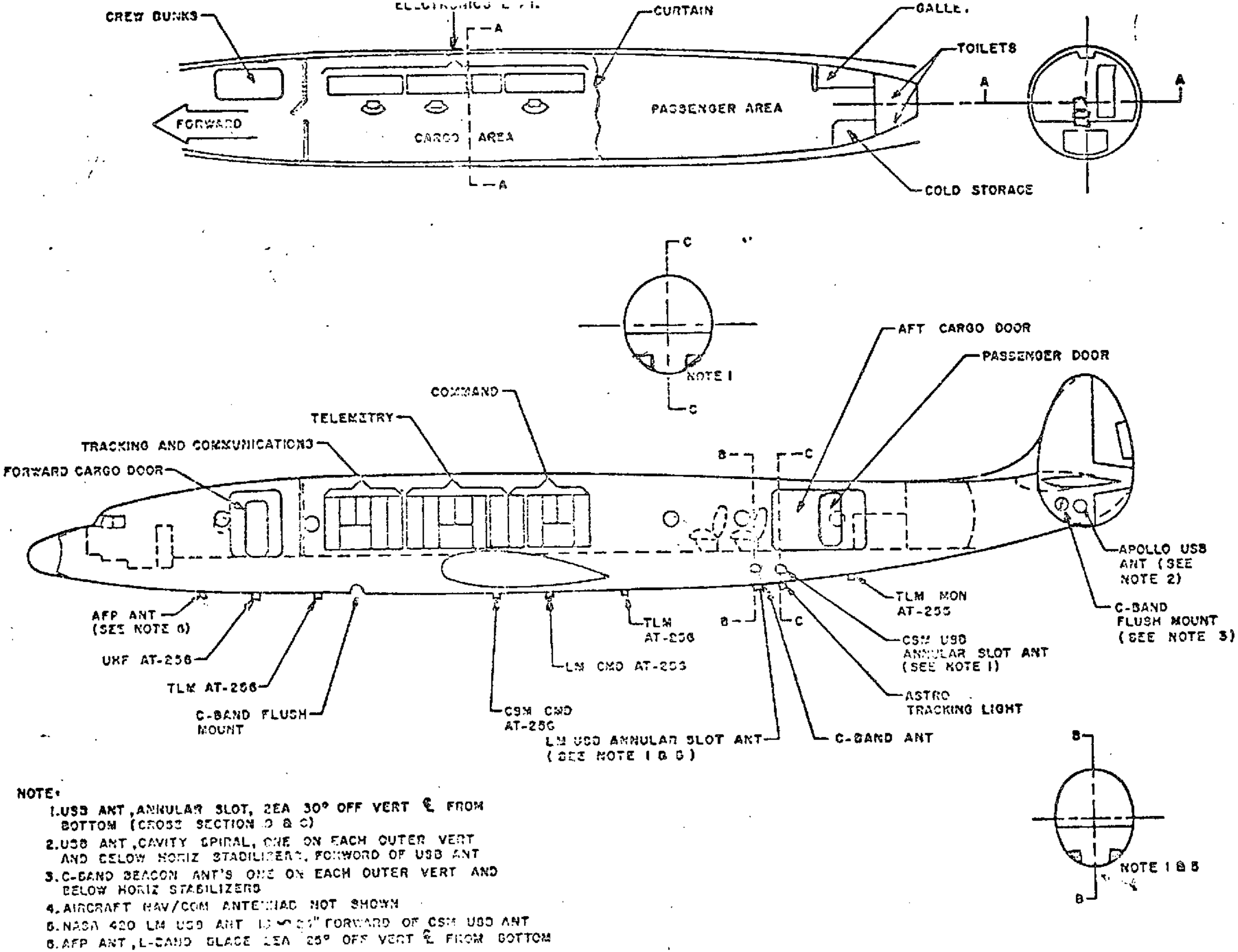


Figure 3-14. C121G Aircraft Interior Arrangements

- Provision of a time reference for all time dependent subsystems.
- Reception and coherent retransmission of ranging signals transmitted by the station.

3.5.1.2 DC-6 Aircraft

NASA has a DC-6 aircraft which would be ideal for flight testing. It's flight performance is on the same order as the C121. Up to 5 racks are available for mounting experimental equipment. It is heavily equipped with conventional test equipment.

3.5.1.3 Convair 340 Aircraft

The Ames Convair 340 flying laboratory is a two-engine, low-wing monoplane with a pressurized cabin. The aircraft is powered by two R-2800 reciprocating engines with thrust reversers. The thrust reversers are for ground use only.

The aircraft is equipped with an all-electric, Sperry A-12 Gyro-Pilot System. A mechanical engaging lever provides connection of the aileron, rudder, and elevator to the autopilot system. Control of the system is exercised from the autopilot controller unit located on the pilot's pedestal.

The aircraft is equipped with one VHF and one UHF transceiver for radio communication.

The aircraft is supplied power for its standard equipment from engine-driven generators, and inverters. Power used for all experimental equipment is supplied from a 14 KW gas turbine power plant located in the aft section of the aircraft.

Access to the aircraft as shown in figure 3-15 is through the main entrance door with integral stairs (door opening: 28" wide x 58" high). Space is available along the left side of the cabin compartment for installation of additional equipment. Seat tracks are installed for easy installation of properly designed equipment racks. All experimental equipment to be placed on board the aircraft must be approved by an Air Safety Board.

The aircraft has no unusual flight characteristics. Stall warning commences approximately 15% above the indicated stall speed. The aircraft is stable under all normal flight conditions. Maximum diving indicated airspeed from 10,000 feet to sea level is 295 knots. Normal cruise in the terminal area is 140 to 160 knots indicated airspeed. Aircraft landing velocity is about 100 knots indicated airspeed.

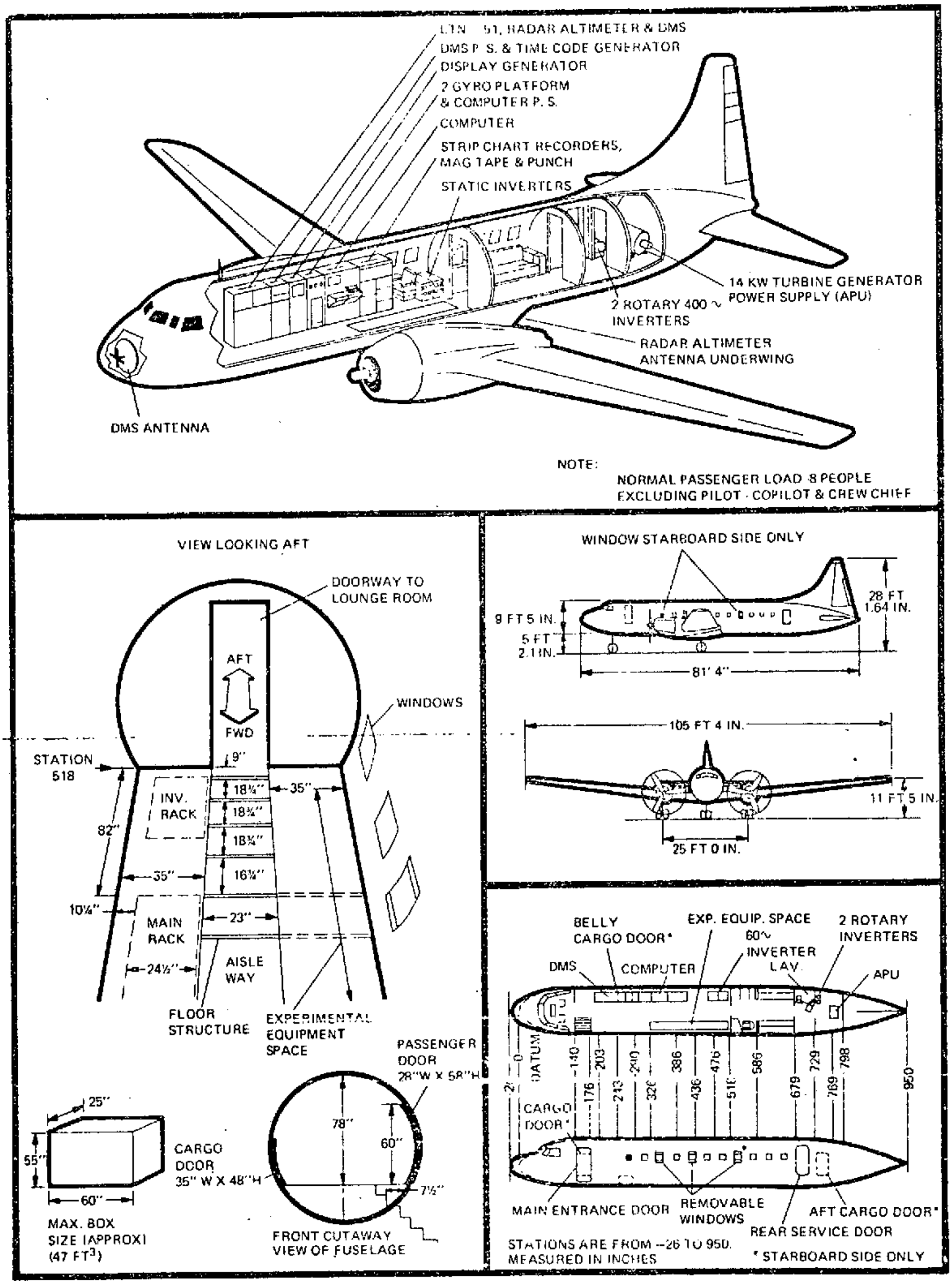


Figure 3-15. Convair 340 Aircraft Interior Arrangements

3.5.1.4 U-2 Aircraft

The U-2 is a NASA owned high altitude aircraft which would be suitable for air-to-air flight experiments. The U-2 is currently making scheduled flights between Ames and Wallop's Island. A piggyback arrangement for a number of experiments and some dedicated flights may be possible. The scheduled missions pass by the vicinity of Edward's Air Force Base where a ground station could be located.

During high altitude flights (65 k feet) the cabin area is pressurized to 30 k feet and temperatures drop to 20^{o}C. This environment appears reasonable for the multimode transponder equipment. It has been verified that there is adequate space and power available to accommodate the MMT equipment. A suitable antenna would have to be installed by Lockheed, subcontractor for all U-2 modifications.

3.5.2 ROCKWELL INTERNATIONAL AIRCRAFT

Rockwell has a Sabreliner (N287NA) which could be used as an airborne testbed. It has been used in the past to perform RFI surveys for NASA (Contract No. NAS5-22009).

This aircraft is suitable for 2-3 hour flights at altitudes of 30,000 feet. The aircraft has adequate space for the MTAR equipment, its associated test equipment and a flight test operator.

The Sabreliner is configured with a 28 volt power and it has inverters that produce 115 volts AC, 60 and 400 Hz. The available aircraft power supply is more than adequate to furnish the requirements for the experiment equipment.

3.5.3 FLIGHT SYSTEMS TEST AIRCRAFT

Flight Systems Test, Inc. could provide a number of suitable aircraft for the flight experiments. After reviewing the requirements for an air-to-ground test series, F. S. T. has reccommended a T-33 aircraft.

All aircraft modification and installation would be provided by F. S. T. A suitable antenna would be furnished for VHF/UHF operations. Operating costs are estimated at $650/hour.

3.6 TEST EQUIPMENT

As a minimum, the test equipment specified in Table 3-3 would be required to perform the experiments listed in the Laboratory Test Plan, Section 2.2.1.

Table 3-3. Lab Test Equipment

Item	Manufacturer	Type No.	Quantity
Counter	Hewlett-Packard	5245L	1
Frequency Converter	Hewlett-Packard	5254B	1
Oscilloscope	Tektronix	547	1
Spectrum Analyzer	Hewlett-Packard	8554L/8552A/141S	1
Power Meter	Hewlett-Packard	435A	1
RF Voltmeter	Boonton	91H-S5	1
Attenuator	Kay		4
Amplifier	Hewlett-Packard	461	2
Signal Generator	Hewlett-Packard	608	2
Double Balanced Mixer	Relcom	M6D	2
Two-Way Power Splitter	-	-	2
50 Ohm Termination			3
Computing Counter	Hewlett-Packard	5360A	1
Interval Plug-In	Hewlett-Packard	5379A	1
Keyboard	Hewlett-Packard	5375A	1
Calibrated 50' Coax Cable			1
Coax Cable		RG-223	A/R
MMT Interface Signal Box	MRL		1
MTAR Interface Signal Box	MRL		1
Bit Error Rate Analyzer	MRL	MX-270B	2

In addition to the items in Table 3-3, there are some major test equipment items which would be required for flight testing. These are summarized in Table 3-4.

Table 3-4. Additional Equipment For Flight Testing

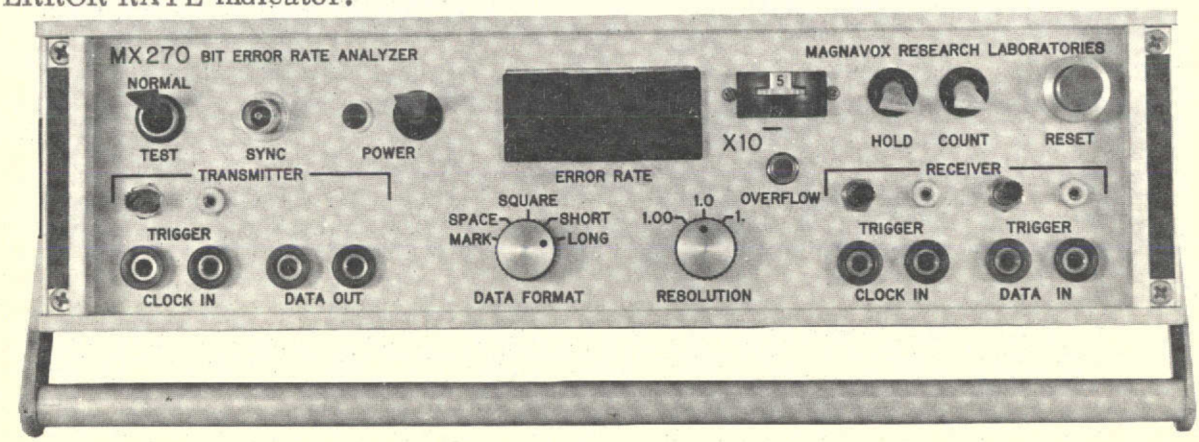
Item	Manufacturer	Type No.	Quantity
Tape Player/Recorder	--	FR1300	2
Printer	Franklin	--	4
Time Code Generator	G. F. E.	--	2
Event Counter	Hewlett-Packard	5245L	2
A/D Converter	--	--	2
Data Multiplexer	--	--	2
UHF Radio	G. F. E.	--	2

3.6.1 MX-270 BIT ERROR RATE ANALYZER

As part of the overall multimode transponder design a data source was provided at both the MMT and MTAR terminals to simulate telemetry and command data sources respectively. A pair of Magnavox MX-270 Bit Error Rate Analyzers were selected for the task. In addition to functioning as data generators, they will provide a method for measuring bit-error rates.

The MX-270 shown in figure 3-16 provides a direct readout of error rate performance for digital communications modems. During operation, test data for the modem channel is clocked out of the MX-270 transmitter section at any rate up to 10 megabits per second. Similarly, the modem clocks data into the MX-270 receiver section. This received sequence is compared bit-by-bit with the generated test sequence and thus the error rate is directly indicated. When a channel is tested on a simplex or full duplex basis, two MX-270's are required.

There are four basic sections in the MX-270: a) transmitter, b) receiver, c) counter, and d) power supply. During operation, a clock pulse received from an external source generates a data pattern selected by the front-panel controls. The modem under test demodulates the data pattern and supplies the demodulated data pattern along with the data clock back into the receiver section of the MX-270. The MX-270 then injection loads a similar data-pattern generator and compares the injection-loaded pattern with the modem demodulated data pattern in a bit-by-bit comparison to generate an error pattern. This error pattern is then counted over a selected number of bits determined by the X10^{-} front-panel control and the RESOLUTION control. The selected sample size error rate is then displayed on the ERROR RATE indicator.



1171-2025
UNCLASSIFIED

Figure 3-16. MX-270 Bit Error Rate Analyzer