AN AIRBORNE TELEMETRY RELAY SYSTEM FOR THE GULF RANGE*

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ABSTRACT

The Airborne Platform Telemetry Relay System (AP/TM) is currently being built for the Gulf Range Instrumentation System. The AP/TM will allow air-to-air missile test and training missions to be conducted beyond the line-of-sight of land-based instrumentation.

The AP/TM is comprised of the following subsystems:

- a Telemetry Data Relay
- a Sea Surveillance Radar and Radar Data Link
- a Drone Control Relay
- a UHF Radio Relay

The Telemetry Data Relay Subsystem will receive telemetry signals from five independent sources and will retransmit them to land based receiving sites. This subsystem contains a 75 square foot, electronically steerable, five beam phased array antenna and uses polarization diversity to eliminate polarization mismatch loss and to improve reception in the presence of multipath propagation.

The AP/TM will also have the capability of relaying four channels of voice communications and drone tracking data and to perform sea surveillance of the mission area. The coordinates of targets detected by the radar will be relayed to the range control center over a high frequency (HF) data link.

In addition to the airborne equipment, the system also includes a ground support instrumentation van which is used for pre- and post-flight checkout and maintenance.

- This project is conducted under contract F08635-84-C-0253 awarded to LTV Aerospace and Defense Company, Sierra Research Division by USAF’s Armament Division, Eglin AFB, Florida.

Key words: Airborne platform, telemetry relay, airborne phased array antenna.

INTRODUCTION

The AP/TM was developed in response to a demand for an airborne platform that could support air-to-air missile firing missions conducted over extended water range areas. The total system consists of two airborne platforms and the ground support instrumentation van. The AP/TM can perform the following functions:

1. Relay TM data from missiles to land based receiving sites (see Figure 1).

2. Conduct radar sea surveillance of planned mission areas and automatically transmit the location and movement of boats to surface instrumentation sites and/or Gulf Range Central Control Sites (see Figure 2).

3. Relay Gulf Range Drone Control Upgrade System (GRDCUS) data/commands, and serve as a ranging station in the GRDCUS airborne tracking station network, which is used to derive time, space, position information (TPSI) on mission participants.

4. Relay UHF voice transmissions.

The equipment that is needed to satisfy the mission requirements can be divided into four major subsystems:

- The Telemetry Relay Subsystem.
- The Sea Surveillance Radar and Radar Data Link Subsystem.
- The Drone Control Relay and Tracking Subsystem (DCRTS).
- The UHF Voice Communications Relay Subsystem.

Most of the equipment in the AP/TM reflects the current state of the art and was selected or designed with reliability and maintainability in mind.

The operation of the system is, to a large extent, automatic and requires little or no operator input in flight. The operating frequencies of the receivers and transmitters are set during the pre-flight checkout. Automatic test equipment is installed in a ground support van which backs up to the cargo door of the aircraft for testing (see Figure 3). This approach allows both airborne platforms to share expensive test equipment and, at the same time, reduces the weight of the aircraft.

THE TM RELAY

The TM relay receives two data streams from each of five independent sources and retransmits the ten signals to land based receiving sites. The performance characteristics of the TM Relay Subsystem are given in Table I, and a block diagram is given in Figure 4.

The S-band receiving antenna is one of the largest electronically steerable phased array antennas to be mounted on an aircraft. The antenna was designed and built by the Georgia Technology Research Institute of Atlanta, Georgia. The main system features of the antenna are listed in Table II. It should be noted that the antenna supports dual orthogonal polarization. This makes polarization diversity reception possible. The benefits of polarization diversity reception are twofold. First, the system can receive linearly polarized signals of any orientation without suffering a 3 dB polarization mismatch loss as does a circularly polarized receiving antenna. Second, polarization diversity reception greatly improves the quality of reception in the presence of multipath distortions. This issue is the subject of another paper which is being presented at this conference [1].

A drawing of the antenna is given in Figure 5 and a diagram of the antenna's RF network is given in Figure 6. A detailed description of the phased array modules may be found in the literature [2].

The Sea Surveillance Radar and Data Link

The AN/APS 128 PC (pulse compression) radar was selected for the sea surveillance mission. The main characteristics of the radar are given in Table III. Preliminary tests indicate that the radar can detect a one square meter target in sea state 3 at a distance of 22 nm.

The detected targets are tagged by the operator by placing a cursor over them. The coordinates of the targets are then transformed by the radar's computer into a distance and bearing from the Range Control Facility (RCF). These coordinates together with data on the position heading and speed of the aircraft are transmitted to the RCF over an HF data link.

A single sideband voice quality channel in the frequency range from 3 MHz to 6 MHz is proposed for the data link. This guarantees communication with a low-flying aircraft over water within the required 200 nm range. The channel will have the capacity to handle the quantity of data to be transmitted.

The selected modem operates at a data rate of 110 bits per second and uses five-fold in band tone diversity and time diversity to minimize errors due to noise bursts, interference and fading. Additional data relay reliability and data quality is achieved by repeating the signal. The data is transmitted in common Digitizer-2 format [3] and the received signal can be fed directly from the demodulator to the RCF's computer.

The Drone Control Relay and Tracking Subsystem

The DCRTS uplinks drone control commands and drone/missile flight termination commands, and downlinks drone/missile flight termination system status data. The subsystem also calculates and/or downlinks TPSI and scoring data. The DCRTS operates, in the GRDCUS network.

The operating frequency of the network is 915 MHz and the system uses time division multiplexing to accommodate multiple users in the Gulf Range. The equipment is being supplied to the systems integrator by the Air Force as government furnished property.

The Voice Communications Relay

The UHF Voice Communications Relay Subsystem provides an uplink and downlink relay capability for up to four UHF channels. A block diagram of the subsystem is given in Figure 7.

The subsystem is composed of four pairs of RT-1146B radios which are coupled to two antennas through two autotune UHF multicouplers. Each pair of radios is wired for automatic two-way simplex operation. The 30 W transmitters provide a coverage of 200 nm with a 20 dB signal-to-noise ratio.

The operation of the relay is totally transparent to the users who use the simplex communication protocol but must operate on two different frequencies.

The Ground Support Van

The Ground Support Van contains all the equipment that is necessary to conduct pre- and post-flight checkout and maintenance of the system. A list of the main equipment items is given in Table IV. The test equipment operates under computer control and all tests are automated. This is particularly desirable in the case of the phased array antenna, where the testing must cover 144 phased array modules with two low noise amplifiers and ten four-bit phase shifters in each module.

The computer also maintains a log of the test results, alerts the operator when the results are out of spec, and prints out test reports on request.

The Aircraft

A modified deHavilland Dash 8 aircraft was selected for the AP/TM because it is large enough to accomodate a 2.5 foot by 30 foot antenna, has adequate payload capacity, and will handle a 30% growth in space and payload. A most important feature is its high wing construction, which offers unobstructed “look down” for the antenna.

The aircraft is capable of flying the required six hour low-high-low-high double mission consisting of two low altitude (500 feet to 5,000 feet) sea surveillance runs and two high altitude (25,000 feet) telemetry runs.

A detailed description of the Dash 8 may be found in Jane’s publications [4].

TABLE I

PERFORMANCE CHARACTERISTICS OF TM RELAY

MISSILE-TO-AP LINK

Operating Frequency	2200 MHz to 2400 MHz (S-band)
Sources	Up to 5 simultaneous dual emitters spatially separated
Source Transmitter Power	2 Watts
Source Antenna Gain	-10 dBi
Missile Antenna Polarization	Linear (Horizontal, Ref. Roll Axis)
AP Antenna Coverage In Azimuth	-60° to +60°
AP Antenna Coverage in Elevation	10°
Signal Bandwidth	3 MHz
Fade Margin	10 dB
S/N Ratio	13 dB
AP Antenna G/T	5.1 dB/K (at +/-60° Scan Angle)

AP-TO-GROUND LINK

Operating Frequency	1435 MHz to 1535 MHz (L-Band)
Number of Channels	10
Effective Radiated Power	42 dBm per Channel
Transmitter Power	46 dBm
AP Antennas	2 stub Antennas with 5 Multiplexed Channels per Antenna

TABLE II

AIRBORNE PHASED ARRAY TM ANTENNA SYSTEM FEATURES

Operating Frequency	2.2 to 2.4 GHz
Number of Channels	5
Polarization	Instantaneous Dual Orthogonal
Scan	Single Dimension Azimuth, +60° to -60°
G/T (Gain-to-Noise Temperature Ratio)	9.1 dB/K (Boresight) 5.1 dB/K (60°)
Dimensions	30 feet long, 2.5 feet high
Weight	2,688 pounds

TABLE III

CHARACTERISTICS OF AN/APS 128 PC RADAR

TRANSMITTER	
Output Device	Traveling Wave Tube
Peak Power	10 KW Nominal, 500 KW Equivalent
Frequency	9.235 GHz to 9.519 GHz Selectable in 16 Steps, 100 MHz Pulse-to-Pulse Frequency Agility
Equivalent Pulse Width	100 ns
PRF	2,000, 1,500, 800, 400 Hz
RECEIVER	Pulse Compression with 3.5 dB Noise Figure
PC Technique	Linear FM with SAW Dispersive and Compression Delay Lines
Processing	CFAR Clutter Rejection, STC, Sweep Integration, Scan-to-Scan Integration

ANTENNA

Type	Flat Plate Slotted Array
Size	60" x 11"
Gain	34 dB min.
Azimuth Beamwidth	1.7°
Elevation Beamwidth	8.0°

TABLE IV

MAJOR TEST EQUIPMENT IN GROUND SUPPORT VAN

Network Analyzer (S-Band)
Telemetry Link Analyzer
Bit synchronizer
Power Meter (L-Band)
Frequency Counter
Bus System Analyzer
Computer

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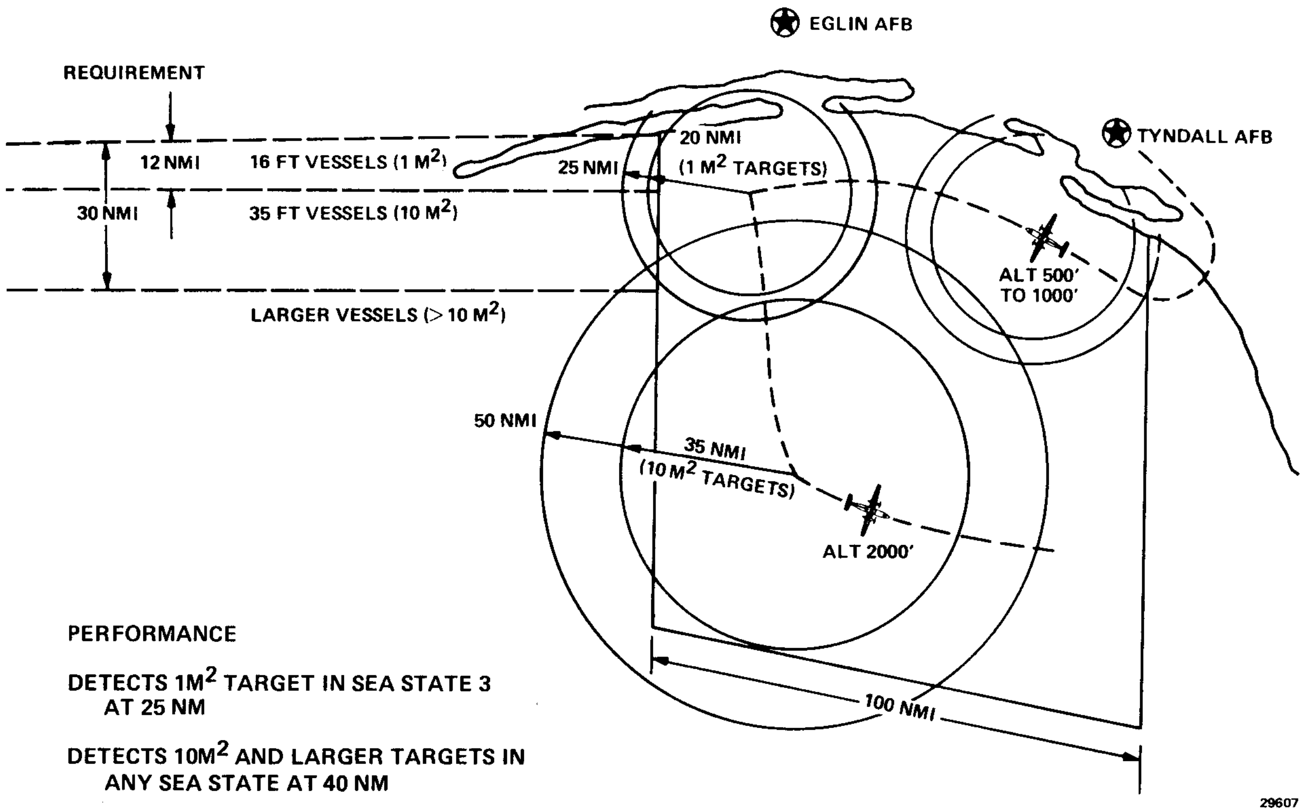

FIGURE 1. SEA SURVEILLANCE SCENARIO

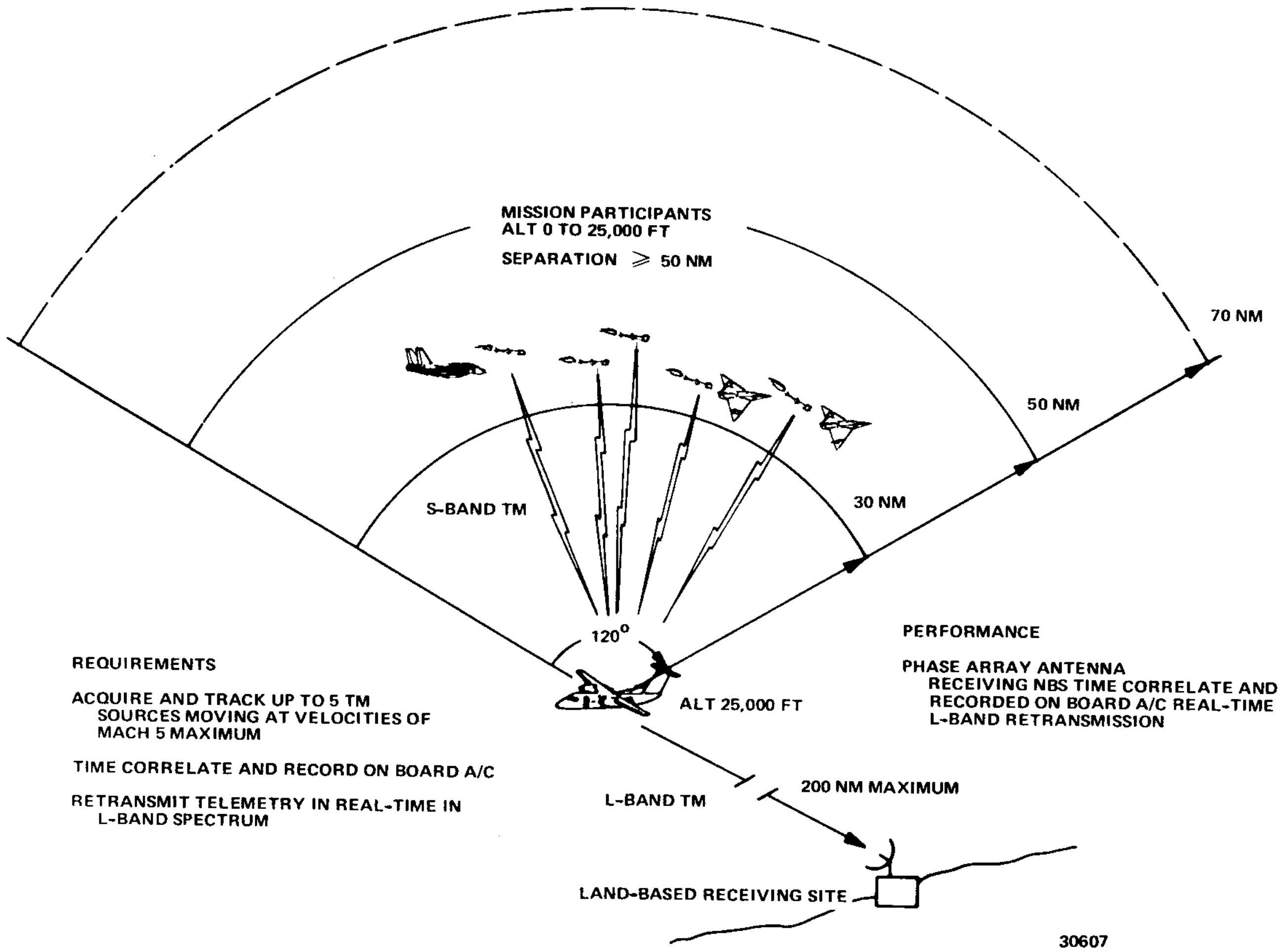

FIGURE 2. TYPICAL TELEMETRY MISSION

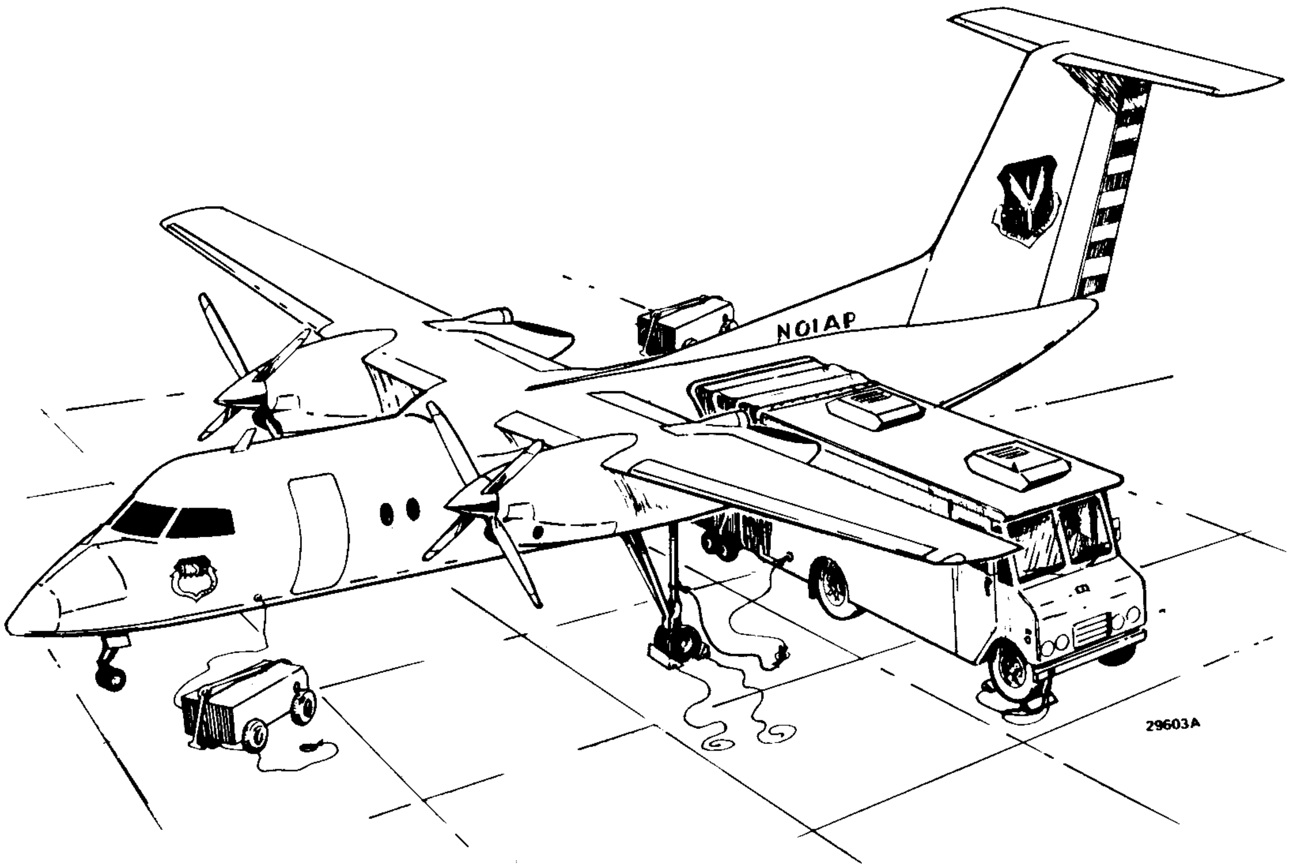

FIGURE 3. AIRBORNE PLATFORM WITH GROUND SUPPORT VAN

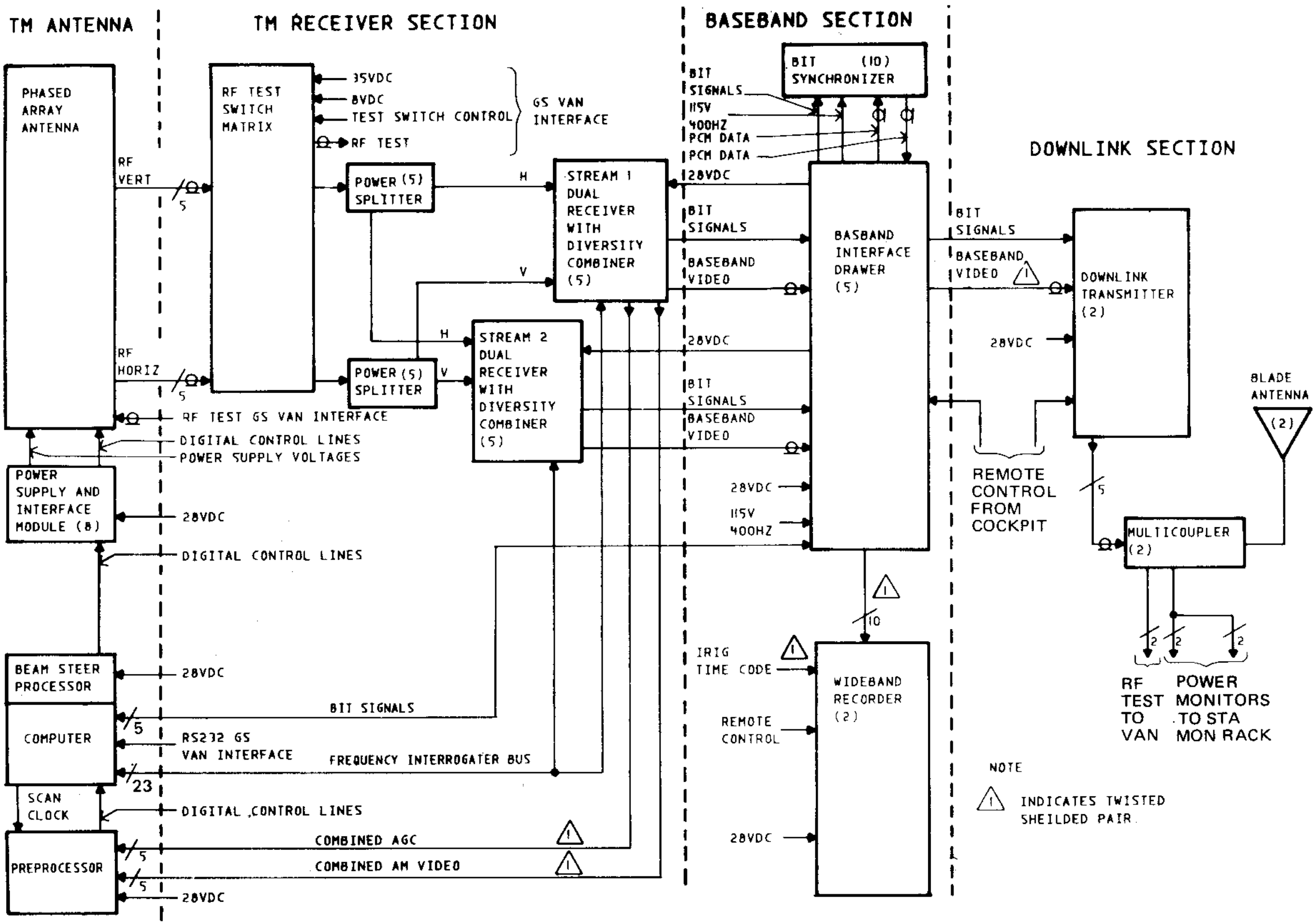

FIGURE 4. TM RELAY SUBSYSTEM BLOCK DIAGRAM

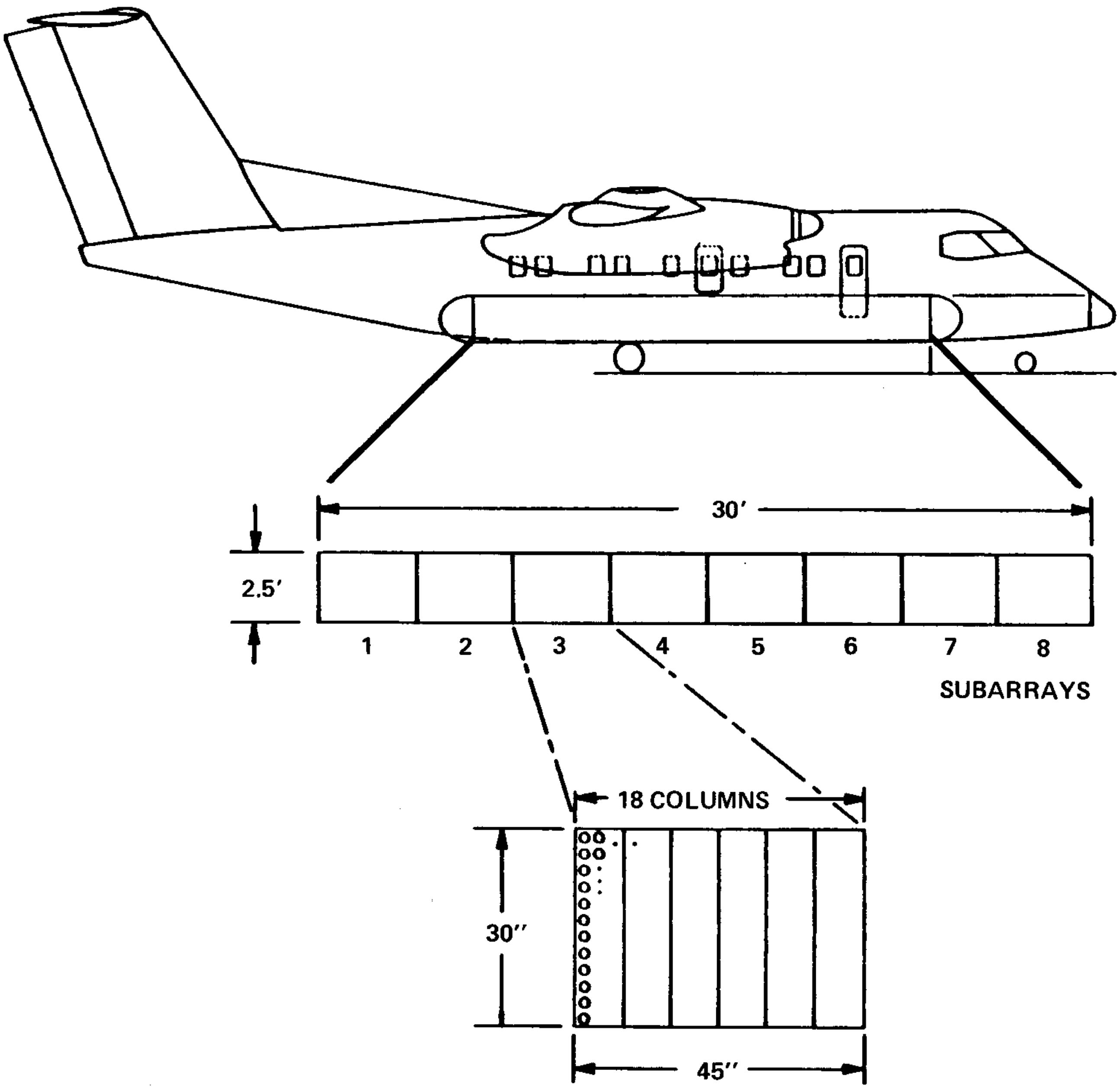

FIGURE 5. MECHANICAL LAYOUT OF S-BAND TELEMETRY PHASED ARRAY ANTENNA

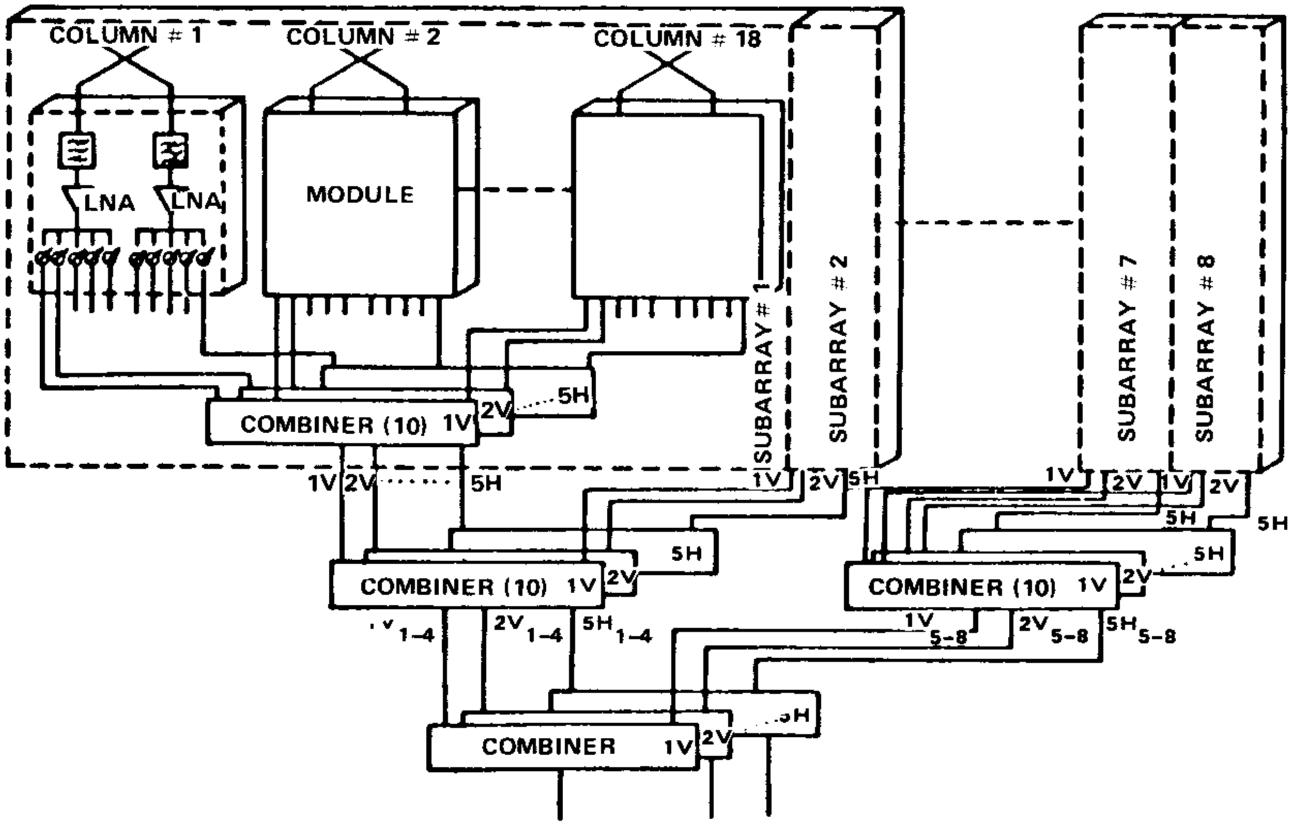

FIGURE 6. ARRAY ANTENNA RF NETWORK

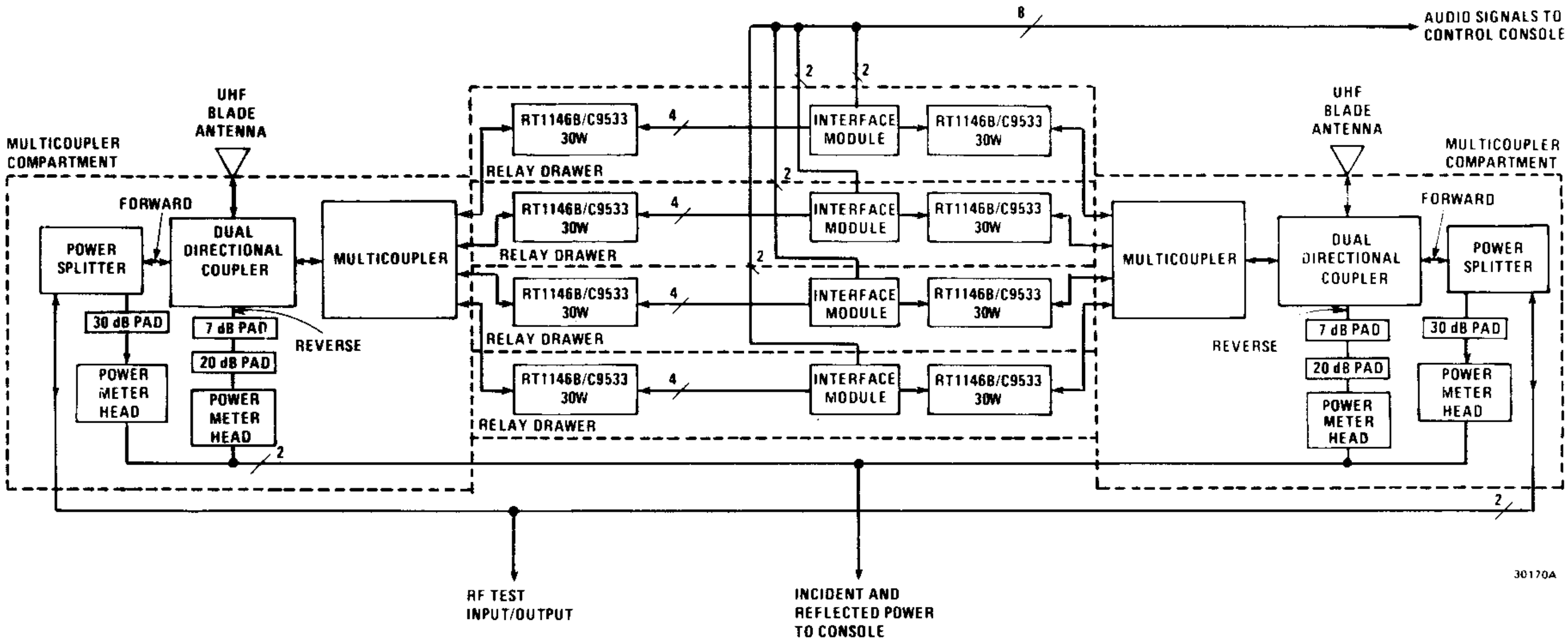

FIGURE 7. 4-CHANNEL UHF VOICE COMMUNICATION RELAY