UC-880 TELEMETRY RELAY AIRBORNE COMMAND SYSTEM

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ABSTRACT

The Naval Air Test Center, Range Directorate, has developed a Telemetry Relay Airborne Command System (TRACS) utilizing a Convair UC-880 aircraft. In its present configuration, the UC-880 can receive, record, and display telemetry data in real time; reshape and retransmit the telemetry data; act as a command center for TOMAHAWK cruise missile operations; provide radar range surveillance; remotely control instruments, cameras, emitters, and electronic countermeasures equipment on target hulks; provide inflight refueling of aircraft; process and display on CRT's the maps of the area of operations and the missile profiles and tracks on the maps; and provide over-the-horizon target displays using a satellite communication system. This paper will present the development of the UC-880 TRACTS and the results of operations that utilized this system. The system characteristics, design constraints, and future plans will be discussed.

INTRODUCTION

The Naval Air Test Center developed the UC-880 into the Telemetry Relay Airborne Command System (TRACS) to extend the tracking, telemetry, mission control, and target control capabilities beyond the line-of-sight of fixed, ground based instrumentation. The Sea Launched Cruise Missile (SLCM) is fired from both surface and underwater platforms for operational testing and training missions. The TOMAHAWK Land-Attack Missile (TLAM) and TOMAHAWK Anti-Ship Missile (TASM) operate at low altitudes, well below the line-of-sight of fixed ground based instrumentation. The UC-880, because of its size, also offered the advantage of acting as a complete telemetry data center for remote operations away from ground data centers.

The Naval Air Test Center acquired the Convair UC-880 aircraft from the Federal Aviation Administration in February 1981. The aircraft has a modified KA-3 aerial refueling system installed and was primarily used for inflight refueling of the F-18 aircraft from 1981 through 1983. The aircraft has a speed of 0.88 mach, the capacity to carry

70,000 lbs of fuel, a duration of six hours, and has an overall length of 130 feet. The Range Directorate installed a Litton AN/APS-141(V)3 radar and the first phase of the airborne telemetry relay and data display system from December 1983 through April 1984. This system has been expanded three times in the last two years with the last addition completed in May 1986. The present capabilities include a telemetry reception and retransmission system; a real time data processing, display, and recording system; a cruise missile command control system; a communications system; a target hulk equipment remote control system; a range surveillance radar system; and a satellite communications and processing system.

DESIGN OVERVIEW

The Range Directorate performed the total system design, integration, electrical installation, mechanical installation, and aircraft modifications. From the onset of the development program, cost and schedule were prime design parameters. Since the vibration and temperature environment of the main cabin area of the UC-880 is relatively benign, the Range Directorate decided to use standard laboratory equipment for the telemetry reception, processing, display, and recording system. This equipment, however, was inspected, supported, and strengthened where necessary to withstand the expected environment of the UC-880. For example, the telemetry receiving antenna, Electro-Magnetic Processes, Inc. , Model 902, was extensively modified by replacing much of the attachment bolts, screws, and some brackets with aircraft qualified components. The antenna was also given vibration, shock, and temperature tests. This antenna, however, still had structural brackets that bent causing antenna failure during the second year of operation. The entire antenna structural and support brackets have now been replaced with heavier redesigned supports.

The TRACS system was installed in phases between operational missions to minimize schedule impacts. The equipment is housed in nineteen standard 19" racks mounted on the left side of the aircraft. The test conductors, equipment operators, and data analysts sit in eleven chairs that are mounted on slides in front of the equipment racks. Figures 1, 2, and 3 show the crew station manning and rack layouts. The radar and auto tracking, telemetry receiving antenna are located on the center line of the lower fuselage. This location allows complete 360 degree azimuth coverage. The second telemetry antenna and primary missile command and control antenna are located in the nose radome at a fixed -17 degree elevation. This elevation provides maximum telemetry reception and missile control at the UC-880 normal altitude of 18,000 to 20,000 feet and range of 10 to 15 miles from the cruise missile. Figure 4 shows the telemetry, command and control, and communications links.

TELEMETRY RECEPTION AND RETRANSMISSION SYSTEM

The UC-880 telemetry reception system consists of two auto tracking antennas. The first antenna is located on the lower fuselage of the aircraft. It uses a microprocessor antenna controller that provides automatic tracking through 360 degrees of azimuth and 85 degrees of elevation. The antenna is circular polarized, has a beam width of 25 degrees, and has a gain of 13 dB. The operating range is approximately 20 miles. Antenna azimuth is displayed in the cockpit to provide tracking information to the pilot. The second antenna is a nose mounted, gimbaled 36 inch dish. It is linear polarized, both horizontal and vertical. It can be slaved to the 360 degree auto tracking antenna or manually operated. This antenna is fixed in elevation to -17 degrees and tracks ± 45 degrees in azimuth. It has a beam width of 11 degrees, an antenna gain of 23dB, and an operating range of 40 miles.

The received signals are wired to splatters so that signals from each antenna are sent to two receivers. This is to support vehicles that contain two telemetry systems. The outputs of each pair of receivers are input to diversity combiners. Outputs from the combiners reflect the best signal received from the two antennas. The signal outputs from the combiners are shaped through PCM bit synchronizers and retransmitted using two 20 watt, four channel transmitters. The quarter wavelength, omni directional transmitting antennas are located on both the top and bottom of the UC-880 fuselage. The transmitting range is approximately 100 miles.

REAL TIME DATA PROCESSING, DISPLAY, AND RECORDING SYSTEM

The data processing, display, and recording system is depicted in figure 5. The Aydin Monitor model 335 bit synchronizers are tunable from 10 kilobits to 5 megabits. Two DSI model 7103 decommutators are used to extract embedded format data. The two Loral DS 100 PCM decommutators merge, process, and extract specific parameters and distribute them to their respective displays and strip chart assignments. Five strip charts of eight channels each are available for displaying air vehicle and guidance measurements. Time correlation is maintained using IRIG B time code generators with the slow code routed to an edge pen on each recorder. There are a total of six CRT's to display various types of data. Two Honeywell model 101 tape recorders with a 2 MHz capacity are used to record and reproduce the telemetry data.

CRUISE MISSILE COMMAND AND CONTROL SYSTEM

The command and control system consists of a command control panel, tone generator, 20 watt transmitter, and 200 watt power amplifier. The consolidation of missile data displayed on the UC-880 allows the test conductor to monitor missile health and make determinations about control or termination of missile flight if required for range safety reasons. Every function of the vehicle flight can be commanded. The system contains two antennas which can be manually switched. The first is a fixed, nose mounted yagi. It is mounted with a -17 degree elevation, has a beam width of 30 degrees, and has a range of 100 miles with the 200 watt power amplifier. The second antenna is a fixed, lower fuselage mounted omni. It has a range of 20 miles with the 200 watt power amplifier.

COMMUNICATION SYSTEM

The UC-880 is equipped with secure voice capability. The stand alone secure voice system is installed on the operators deck in equipment rack number two. The secure radio set cannot be operated by other flight deck personnel. The pilot and copilot are provided non-secure voice radio communications on ARC-159 UHF, ARC-102 HF, and VHF-618 radio sets. Remotes of the pilot’s ARC-159 UHF radios are mounted in equipment racks 1, 2, and 4. All of the UHF radios can be monitored on the intercommunication system (ICS). The aircraft ICS system was originally wired to all operator positions for communications during the mission. The system had excessive hum caused by noise in the power supply and the extensive wiring addition and modification to route the system to all operator positions.

To eliminate the communication system hum, the Range Directorate designed and built a separate communication system to support all the operator positions on the UC-880. This system is designed so that any station can be treated as either hot mike or push-to-talk. The hot mike mode is especially useful to the telemetry engineers during system preflight, checkout, and setup. Each headset has two slide controls for adjusting the volume of the incoming audio. One ear hears the UHF system and the other ear hears the separate communication system. The communications between operator positions have been greatly improved with the separate communication system.

TARGET HULK EQUIPMENT REMOTE CONTROL SYSTEM

The original target hulk equipment remote control system installed on the UC-880 was a tone system similar to the system used at the Pacific Missile Test Center. The system operated at the low UHF frequency between 400 MHz and 440 MHz which limited the range to approximately 30 miles. It was designed to handle up to 20 separate tones, but in practice could only handle six tones before crosstalk became a problem. This meant that the various target hulk equipment had to time share the tones for proper control.

The Range Directorate decided to completely redesign the target hulk equipment remote control system. The system incorporates an up/down digital link control with PCM format. It operates at VHF frequencies and has the capacity to command up to three separate targets from ranges up to 100 miles. It contains a command and control panel, incorporating electronic countermeasures activation and control, simulated emiters activation and control, hulk instrumentation control, alphanumeric displays, and discrete status displays; a VHF pulse code modulation down-link command; and a VHF pulse code modulation up-link receiver and decommutator.

The electronics countermeasures control can operate various systems either individually or simultaneously with no interaction. The emitter controller can operate power on/off, RF on/off, and emitter rotation. The camera control can power and run up to ten cameras. The system can display target hulk pitch, roll, heading, relative humidity, wind speed, and wind direction.

RANGE SURVEILLANCE RADAR SYSTEM

The range surveillance radar system installed on the UC-880 is a Litton AN/APS-141(V)3 system. Three basic operating modes are provided by the system: the search radar mode, the beacon mode, and the weather mode. All three modes are controlled from the radar operator's position located at rack 1, while the weather mode can also be controlled from the pilot's position. The radar has an azimuth coverage of 360 degrees and a maximum range of 200 miles. In the search radar mode marine surface contacts can be detected and identified during range surveillance and clearance.

In the beacon mode, the radar is used to track chase aircraft equipped with special X-band beacons. During a typical mission, once the UC-880 is in position for missile telemetry auto tracking, the radar operator acquires the chase aircraft beacon and displays this position to the UC-880 pilot's radar repeater cockpit monitor. The pilot adjusts the UC-880 position to maintain a 10 to 15 mile separation for best telemetry coverage. If the telemetry auto track is lost, the radar operator passes the azimuth and elevation position of the chase aircraft to the telemetry antenna operator for manual reacquisition of the missile telemetry signal.

SATELLITE COMMUNICATIONS AND PROCESSING SYSTEM

The satellite communication over-the-horizon USQ-81(V) system was installed in the UC-880 during April 1986. A block diagram of the system is shown in figure (6). The system has the following capabilities: the ability to pass secure messages between the cruise missile shooter and the UC-880, the display of the planned and actual path of the missile, the display of over-the-horizon targets, and the display of tailored ocean surveillance ship movements. The HP 9020 computer is used to verify the launch platform firing solution. It will display maps of the area in which operations will be conducted. The maps are stored on disk from which they can be loaded into the computer. Overlaid over the map will be the planned route the missile will fly. Actual latitude and longitude of the missile, supplied from telemetry data, will then be plotted on the map. Four selected measurements from the missile will also be displayed.

FUTURE PLANS

The Range Directorate plans to replace the existing Litton AN/APS-141(V)3 radar with a hybrid Hughes APG-63/APG-65 radar. The APG-63 radar is used on the F-15 aircraft and the APG-65 radar is used on the F/A-18 aircraft. The hybrid radar will use the antenna from the APG-63 radar and the signal processor and transmitter from the APG-65 radar. It will meet the range requirements of detection of a Cessna size aircraft at 30 nautical miles, and detection of an 18 foot fiberglass boat at 25 nautical miles. The radar will require some hardware and associated software modifications but the technical risk assessment was favorable. The surface search capability and display will be very good, and the logistics and maintenance support will be excellent. The new radar will provide air to ground surveillance and clearance of the operational area, will enable night/IFR missions, and will reduce or eliminate the need for chase aircraft during cruise missile missions. The expected IOC is the end of 1989. A block diagram of the radar is shown in figure 7.

Other planned additions to the UC-880 are the modification of the auto tracking telemetry antenna mounted on the lower fuselage from circular polarization to linear, both horizontal and vertical, polarization; and the addition of an auto tracking telemetry antenna mounted on the upper fuselage, an airborne command station for the cooperative tracking systems, and an improved telemetry processing and display system.

The modification of the polarization of the lower telemetry antenna will increase the effective gain by 3 dB. The auto tracking telemetry antenna on the upper fuselage will allow tracking of vehicles flying higher than the UC-880 and will eliminate telemetry dropouts from antenna blanking during aircraft maneuvers. The improved telemetry processing and display system will process and display data at a much faster rate than the present ADS 100 systems. This will allow more data to be processed in real time and will increase the flexibility of the data displays and presentations.

CONCLUSION

The TRACS has successfully supported east coast SLCM missions during the past two years. This has included both TLAM and TASM flights and captive carry engine evaluations. The present configuration of the aircraft has solved some of the early problems such as hum in the ICS system, telemetry dropout at some flight attitudes, the need for faster and longer range target hulk control, and the need for over-the-horizon target and ship movement displays. The hardware on the UC-880 has operated successfully and reliably. With the exception of the telemetry auto tracking antenna, there have been no failures due to the environment of the aircraft. The UC-880 aircraft mission reliability has exceeded 91 percent. The TRACS was designed, built, installed, and upgraded with minimum impact on schedule and at a very low cost compared with similar systems. It is expected to successfully support expanded SLCM training and test flights on the east coast for many years.

REFERENCES

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2. Technical Manual, LCH80-351-2, Operating Instructions for the APS-504(V)3 Radar System, Litton Systems Canada Limited, 1980.

3. Gauthier, Kathryn L., “Airborne Telemetry and Cruise Missile Control”, Proceedings, International Telemetering Conference, Vol. XXI, International Foundation for Telemetering, 1985, pp 557-561.

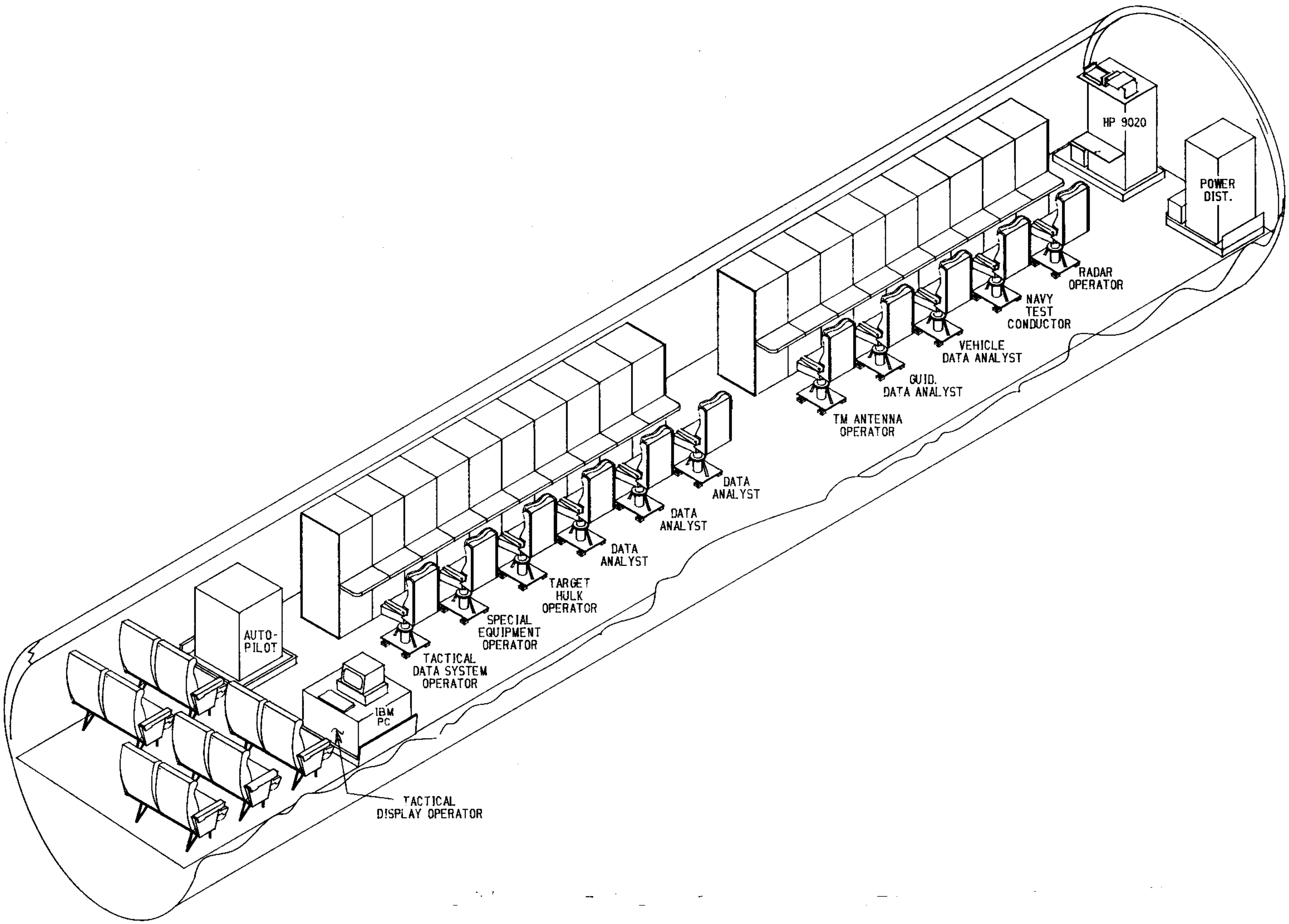

FIGURE 1 - UC-880 TRACS CREW STATION MANNING

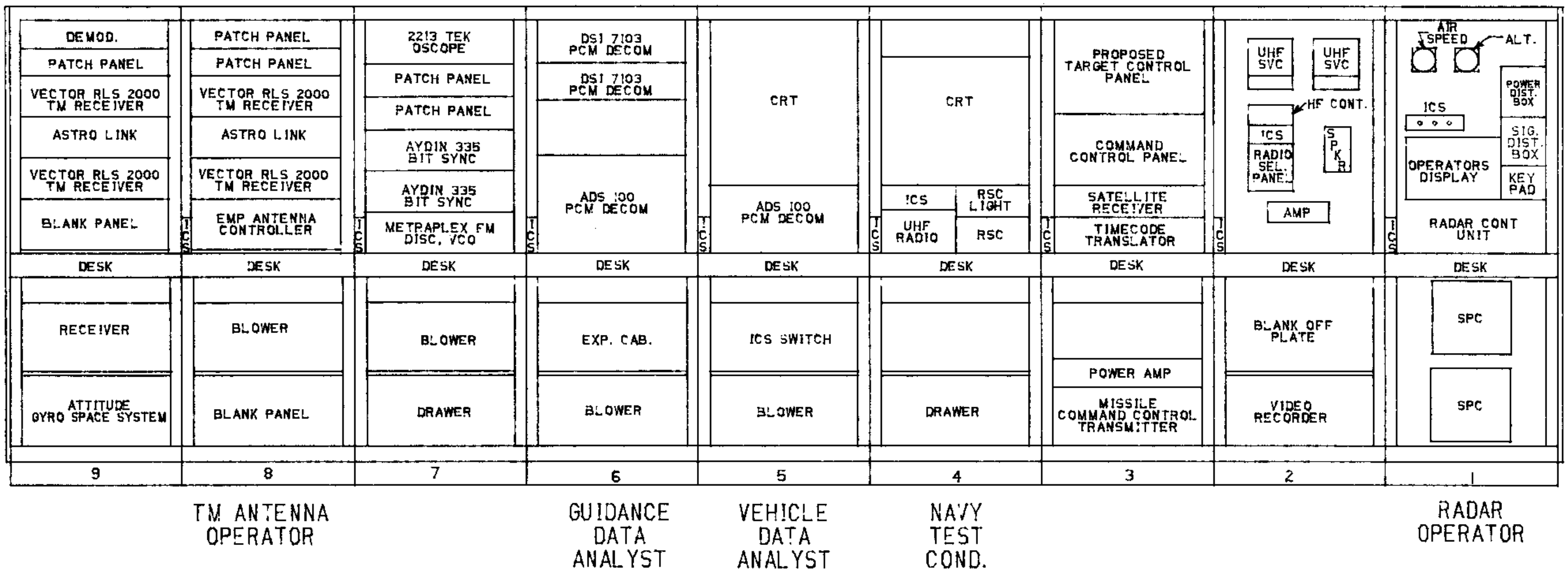

FIGURE 2 - UC-880 RACK LAYOUT

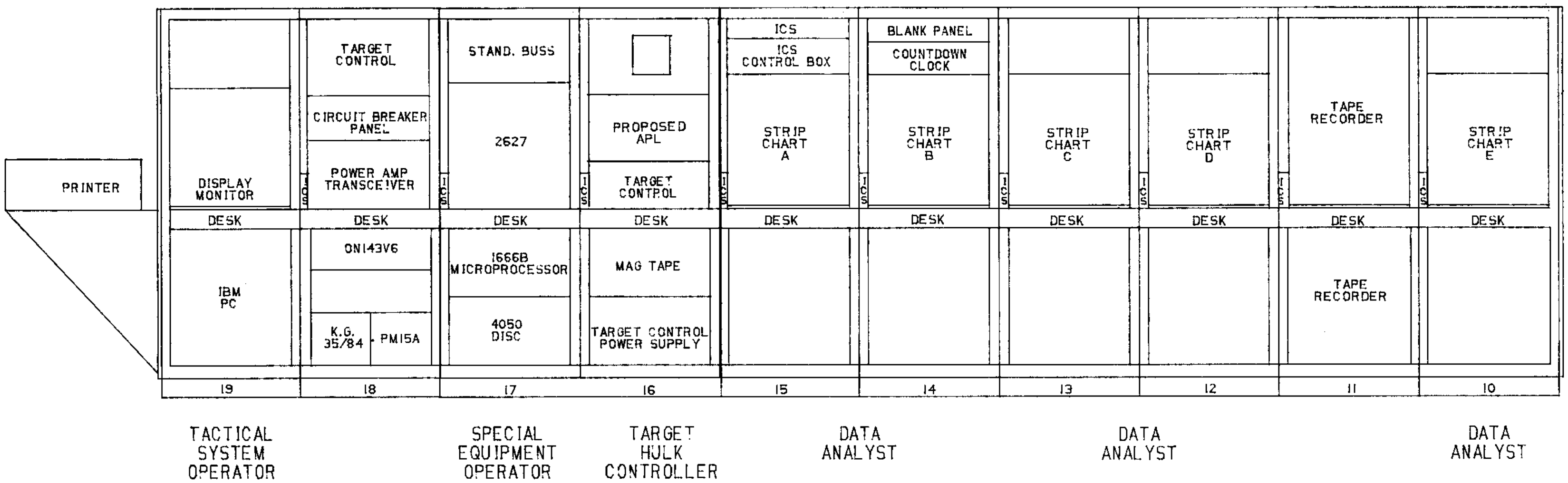

FIGURE 3 - UC-880 RACK LAYOUT

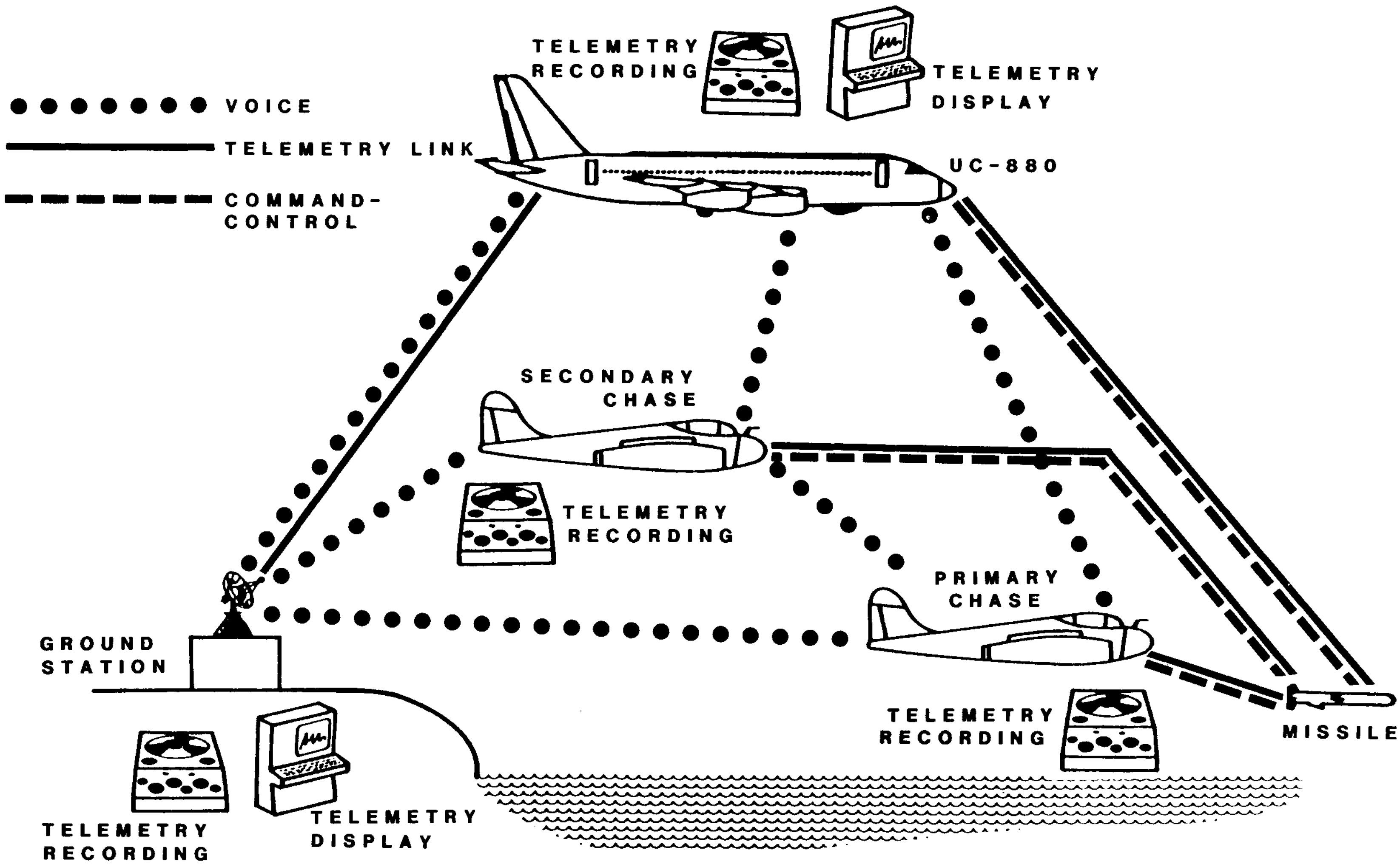

FIG. 4 TELEMETRY, COMMAND/CONTROL, AND COMMUNICATION LINKS

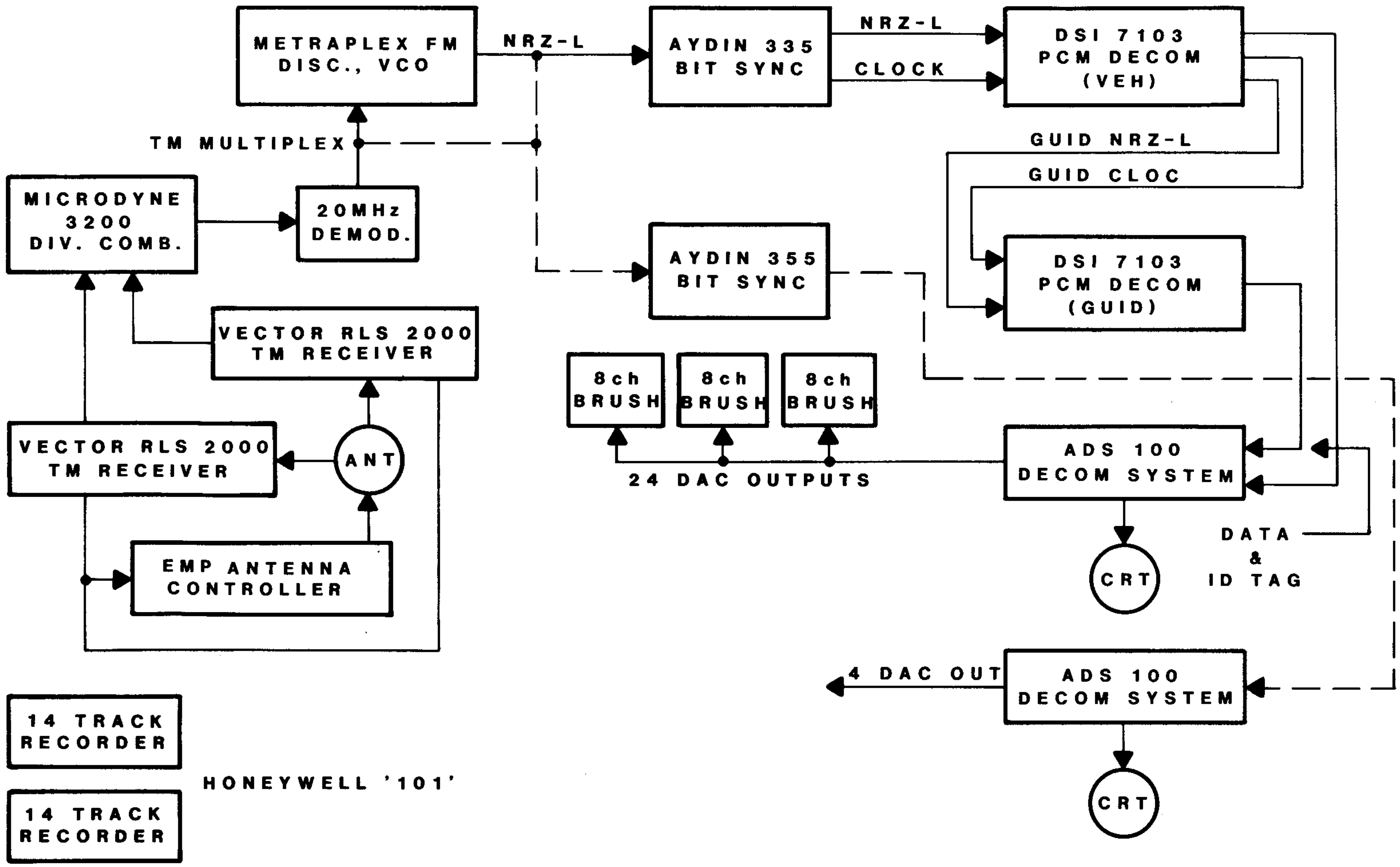

FIG. 5 UC-880 DATA PROCESSING, DISPLAY, AND RECORDING SYSTEM

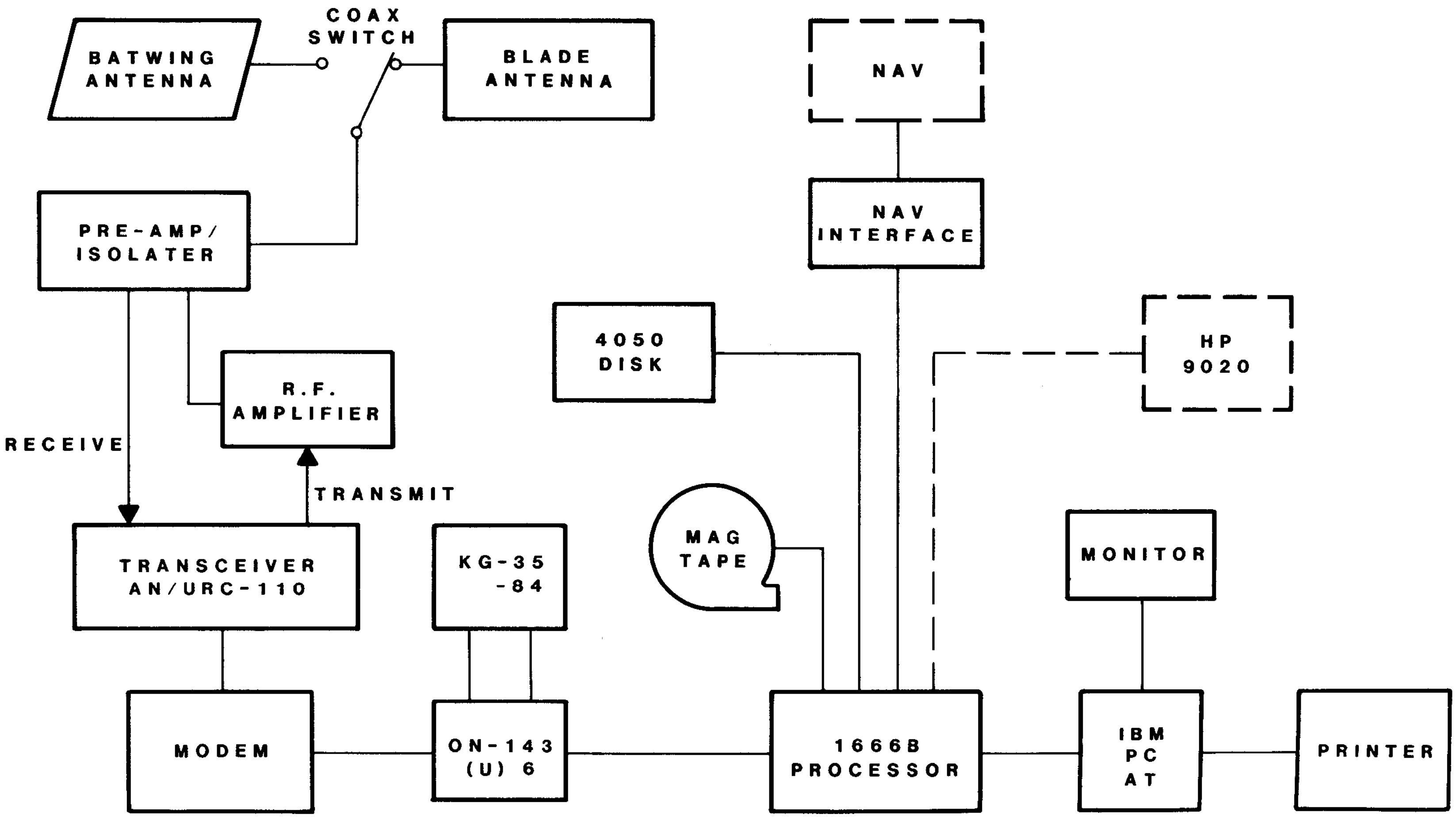

FIG. 6 USQ-81V SYSTEM UC-880 INSTALLATION