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WESTERN SPACE AND MISSILE CENTER

WESTERN TEST RANGE

LANDBASED INSTRUMENTATION HANDBOOK

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AIR FORCE SYSTEMS COMMAND

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WESTERN SPACE AND MISSILE CENTER
WESTERN TEST RANGE

LANDBASED INSTRUMENTATION HANDBOOK

This handbook describes the capabilities of the Western Test Range landbased sites. The configuration described herein is current as of 1 July 1981.

Prepared under Contract No. F04703-77-C-0111.

This handbook is in effect on the date of approval and will supersede all previous Landbased Instrumentation Handbooks.

Reviewed by:

R. H. Worhacz 8 Sept '81
R. H. WORHACZ Date
Deputy Director
Maintenance & Support Services
FEDERAL ELECTRIC CORPORATION

Submitted by:

E J Hagin 8 Sept '81
E. J. HAGIN, Vice President Date
WTR Division Director
FEDERAL ELECTRIC CORPORATION

Approved by:

A H Davidson III 8 Sep '81
A. H. DAVIDSON III, COLONEL, USAF Date
Deputy Commander for Western Test Range
Western Space and Missile Center

FOREWORD

This handbook has been prepared for the Western Space & Missile Center (WSMC) under Contract No. F04703-77-C-0111.

The handbook is intended for general use and guidance. It will also be useful as an aid in indoctrination and for general reference. The handbook will be updated periodically to record changes in instrumentation configuration; however, because of the extensive time required for compilation and coordination of data, it cannot reflect day-to-day changes and should not be used for immediate "working" information.

Any questions regarding this document should be directed to the Instrumentation Division (RSIO) of the WSMC.

This handbook has been reviewed and approved.

ABSTRACT

The Western Space & Missile Center/Western Test Range (WSMC/WTR) landbased instrumentation provides launch support capabilities for purposes of range safety, ballistic missile impact prediction and location, telemetry data acquisition and reduction, and satellite tracking and communications. Installed systems and equipments are used to support missile and space programs originating at Vandenberg AFB, California as well as operational programs originating at other service and national ranges.

Principal WSMC/WTR instrumentation facilities and operational support systems are located in California and Hawaii.

Keywords: Guided missile ranges, Launching sites, Ground support, Data reduction, Guided missile tracking systems, Orbital tracking, Radar equipment, Surveillance radar systems, [illegible] systems, Meteorological data. (en)

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SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The Western Space and Missile Center (WSMC) provides launch support instrumentation and communications for missile and space programs originating at Vandenberg Air Force Base (VAFB), California and also supports operational programs originating at other national ranges.

This handbook describes the launch and support instrumentation equipment and systems that are operational on the WSMC landbased sites, stations, and facilities. It provides general information to range users and organizations internal to the WSMC for familiarization and planning purposes. Included herein are descriptions of launch and launch support instrumentation. Software, data products, and communications are covered in other WSMC handbooks. (Refer to Paragraph 1.4).

1.2 SCOPE

This handbook covers individual services performed by the WSMC including missile flight control, scheduling, weather forecasting, radio frequency (rf) monitoring and control, communications, area clearance, optical and electronic data acquisition, tracking, and reduction, telemetry acquisition and reduction, satellite tracking, ICBM impact scoring and recovery of reentry vehicles and data packages.

1.3 GENERAL

The Western Test Range (WTR) (See Figure 1-1), operated by a part of the Air Force Systems Command (AFSC), extends from the coast of California west toward the Indian Ocean. Principal WSMC facilities and operational system are located at:

a. Vandenberg AFB, Calif. - WSMC Headquarters, Range Operations Center, radar, telemetry, optics, and other launch area instrumentation.

b. Pillar Point AFS, Calif. - Radar, telemetry, and command control, all with a side view of Intercontinental Ballistic Missiles (ICBM) launched from VAFB to minimize flame attenuation of radar and telemetry signals.

c. Anderson Peak Optical Site, Big Sur, Calif. - Optical coverage of westerly launches.

d. Wheeler AFB, Hawaii - Radio, wire, data and voice communications.

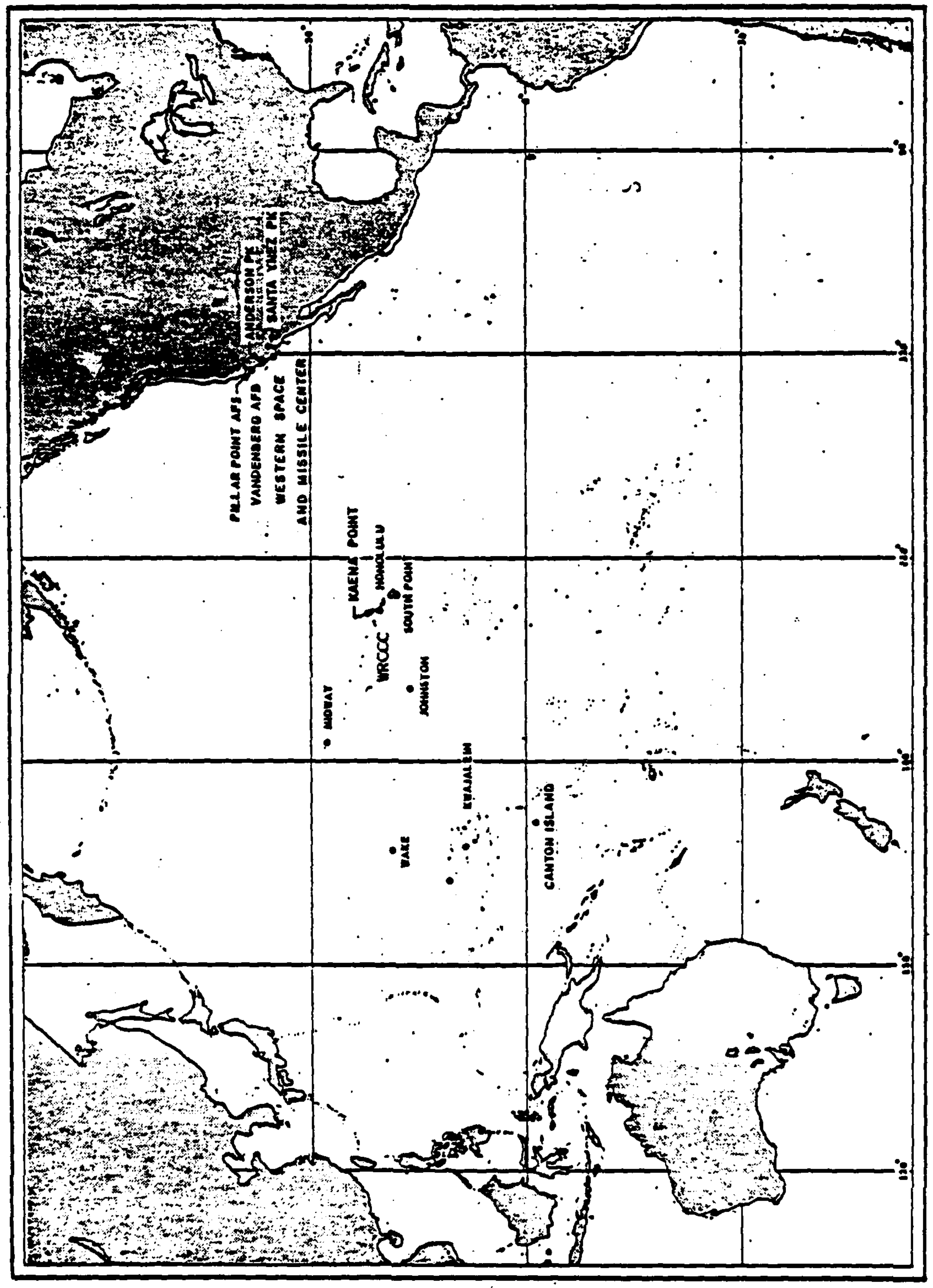

Figure 1-1. Western Test Range

e. Santa Ynez Peak - Optical coverage of westerly and southerly launches.

f. Kaena Point, Hawaii - High precision mid-range radar coverage of westerly launches.

1.4 REFERENCE DOCUMENTS

The following documents contain detailed information of other WSMC facilities and services not specifically covered in this handbook.

a. WSMC Communication Systems Handbook, OPR: RSD.

b. WSMC Standard Operational Data Item Manual, OPR: RSCS.

c. WSMC Systems Performance & Accuracy Report. OPR: XR.

d. WSMC Launch Site CCTV Handbook, OPR: RSD.

e. WSMC Baseline CCTV Distribution System Handbook, OPR: RSD.

f. WSMC Frequency Management Handbook, OPR: RSD.

g. WSMC Microwave Systems Handbook, OPR: RSD.

Table 1-I is an overview of the major landbased instrumentation system operated and maintained on the WSMC.

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*For a complete description of WRCCC and installed equipment, refer to the WSMC Data Transfer System Handbook.

Table 1-I LANDBASED INSTRUMENTATION OVERVIEW

MAJOR SYSTEM/ EQUIPMENT	VAFB	PILLAR POINT	SANTA YNEZ PEAK	ANDERSON PEAK	KAENA POINT
<u>Electronic Tracking</u>					
AN/FPS-16	2	1			
AN/TPQ-18	1				
AA/M-33	1				
GERTS	1				
ARSR-1D	1				
AN/FPQ-6		1			
AN/FPQ-14					1
MPS-36	1				
<u>Optical Tracking</u>					
ROTI			1		
LA-24	1				
Deployment Tracking Instrument (DMI)				1	
<u>Data Processing</u>					
IBM 360/65	1				
IMB 360/30	1				
XDS SIGMA 2	4				
XDS SIGMA 5					1
XDS SIGMA 7	2				
CDC 1700	1				
CDC 3300	2				
SDS 930	1				
UNIVAC 1218	1	1			

Table 1-I

MAJOR SYSTEM/ EQUIPMENT	VAFB	PILLAR POINT	LAGUNA PEAK	SANTA YNEZ PEAK	ANDERSON PEAK	KAENA POINT
<u>Command/Control</u>						
Command Control Transmitter	2	1	1			
<u>Telemetry</u>						
SGLS Receive/Record	1					
Telemetry Receive/Record	3	1				
Telemtry Display	5					
80-Ft. Autotrack		1				
40-Ft. Autotrack		1				
35-Ft. Autotrack	1					
GKR-7 (30-Ft. Autotrack)	1					
8-Ft.	1					
Quad Helix	2					

SECTION 2.0

INSTRUMENTATION SITES

2.1 VANDENBERG AIR FORCE BASE

The Western Space and Missile Center, VAFB, is equipped to support ballistic missile, orbital and space launch operations originating at VAFB and other national and service ranges. This support involves such varied functions as target tracking, telemetry reception, command control, communications, timing, data transmission, range control, optical tracking, launch control and frequency monitoring.

The instrumentation systems located at VAFB have three primary purposes: radar and optical metric data acquisition, telemetry data acquisition and distribution, and range flight control. Table 2-I is a listing of all major equipments and systems installed and maintained at VAFB.

Vandenberg AFB (See Figure 2-1), primary missile test center of the West Coast, is located on the California coast 140-miles west of Los Angeles and is divided into two major areas: North VAFB (NVAFB) and South VAFB (SVAFB).

North VAFB was assigned to the United States Air Force (USAF) 21 June 1957. On this date the Strategic Air Command (SAC) took command of the area and on 16 December 1958 the first missile was successfully launched from VAFB.

South VAFB, formerly the Naval Missile Facility, Point Arguello, was transferred to the USAF 1 July 1964. The Air Force Systems Command (AFSC) assumed responsibility of all range operational support facilities on 1 February 1965. These facilities include all of the operational support system (instrumentation) at NVAFB and SVAFB.

The majority of the tracking type instrumentation systems and certain telemtry functions are designed to provide real-time trajectory data to the Missile Flight Control Center (MFCC) for use by the Missile Flight Control Officer (MFCO). Other systems provide support to these tracking systems. Trajectory data from the tracking systems, as well as additional information from other data gathering systems, such as telemetry and photo-optics, is used to analyze the performance of ballistic missiles and space vehicles.

The principal technical advantage inherent in the location of VAFB is that southerly launches can be accomplished to achieve polar orbit without flying over inhabited land masses. In fact, this is the only location in the continental United States where southerly launches may be conducted without over-flight of our own or neighboring territories. The geographic location of VAFB also permits operational launch support of ballistic missiles launched from VAFB to target areas in the Western Pacific.

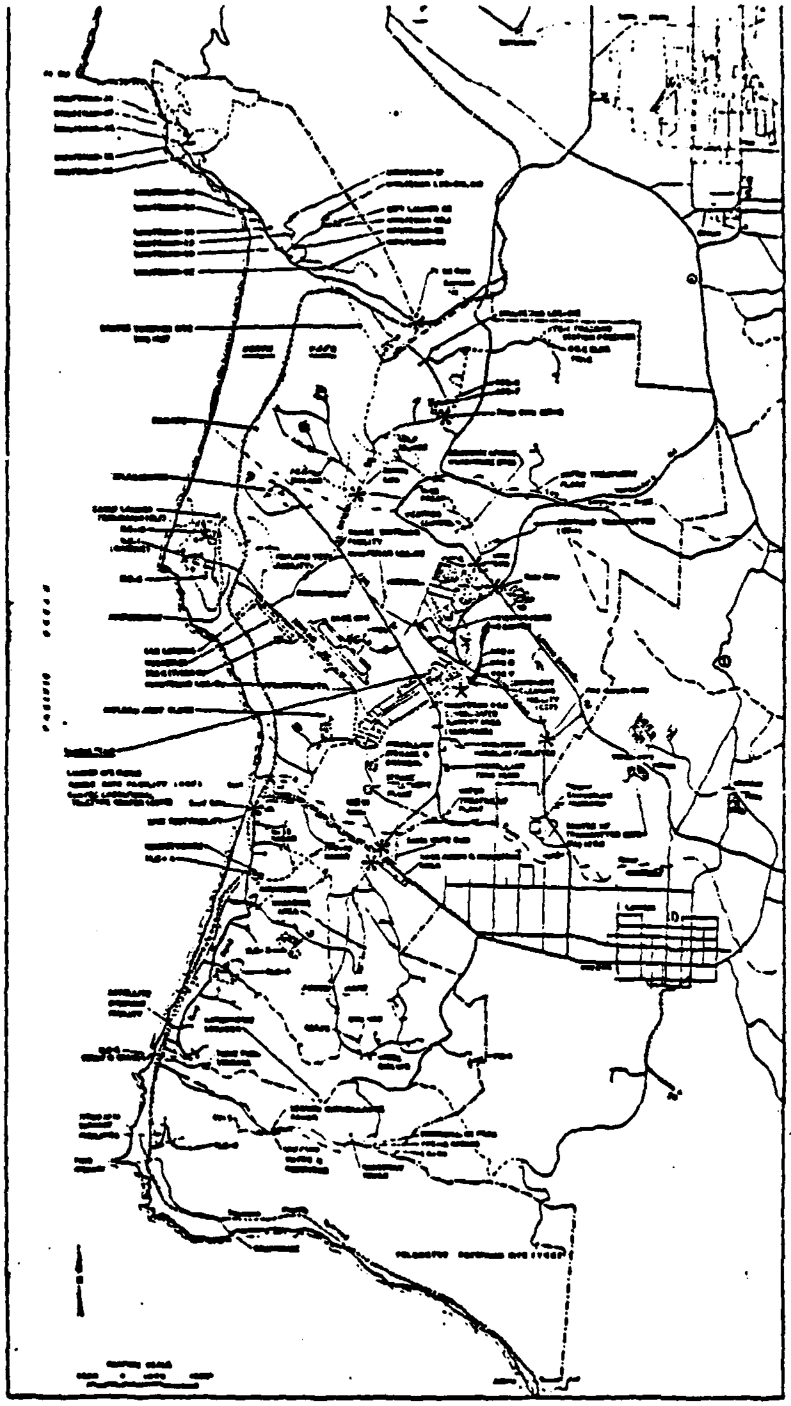

Figure 2-1. Vandenberg Air Force Base (VAFB)

Table 2-I. VAFB INSTRUMENTATION SUMMARY

Bldg. No.	Instrumentation	Qty.
	Electronic Tracking	
907	AN/TPQ-18	1
175, 178	AN/FPS-16	2
488	GERTS	1
Van Mtd.	AA/M-33	1
500	ARSR-1D	1
Van Mtd.	MPS-36	2
	Optical Tracking	
	Recording Optical Tracking Instrument (ROTI)	1
	Deployment Mapping Instrument (DMI)	1
	LA-24	1
	Intermediate Focal Length Optical Tracker (IFLOT)	9
	Cine Sextant	9
	Telemetry	
75	35-Foot Antenna	1
75	Eight-Foot Antenna	1
75	AN/GKR-7 Antenna	1
75	Quad Helix Antenna	2
75	Space Ground Link Subsystem	1
75	Data Evaluation and Display Station	1
75	Post/Pre-detection Diversity Receive/Record Station	3
	Command/Control	
510/21200	10 kW Amplifier (2 each site)	4
	Data Processing	
175	UNIVAC 1218	1
21150	SDS 930	1

2.1.1 Missile Flight Control Center The Missile Flight Control Center (MFCC) is located in the Test Operations Control Center (TOCC), Building 7000A. The MFCC provides the Missile Flight Control Officer (MFCO) with a real-time display of launch vehicle position to assist in mission abort decisions if safety criteria are violated. Figures 2-2 and 2-3 show the physical and functional configuration of the Center. The MFCC is capable of supporting a major launch operation and comprises the following control stations and equipments:

- o Real-Time Data Controller (RTDC) Consoles.
- o Missile Flight Control Officer (MFCO) Consoles.
- o Command Transmitter Controller (CTC) Consoles.
- o Display Equipment.

a. RTDC Console

The RTDC Console (2 each) provides the capability of all data selection for the MFCC. Each console has the capability of selecting one of four analog systems in the single mode. The consoles also select one of two input modes for each of its eight assigned plotting boards. The consoles serve as a remote control console for the 360-65 Data Processor and the Metric Integrated Processing System (MIPS) program by controlling and indicating data selection, mode of operation, record functions, program reload, and other discrete functions. In addition the console provides the required communications and status capabilities.

b. MFCO Console

The MFCO Console (2 each) provides communications modules, Status and Alert (S&A) light modules, and a Destruct Panel. The communications modules give the MFCO the capability to communicate with designated support sites and with the launch team for countdown support. The S&A modules give the MFCO a visual indication of the status (red or green) of discretes to the Command Control Transmitter to terminate launch vehicle flight. The MFCO can initiate Optional Command (OC), All Fuel Cut-Off (AFCO) or ARM, and DESTRUCT via the WSMC Command Transmitter. The MFCO Console contains additional status panels with inputs such as: IPP Drag table selection, GERTS discrete outputs, CCT status, sensor status and an auxiliary command panel. BOMARC flight termination functions can be initiated from the MFCO console via the BOMARC guidance van. The MFCO can also enable the IBM 360-65 Computer/MIPS to automatically generate and allow to be transmitted, flight termination signals (OC and AFCO or AFCO and DESTRUCT) should the computer determine that missile flight should be terminated (on selected operations).

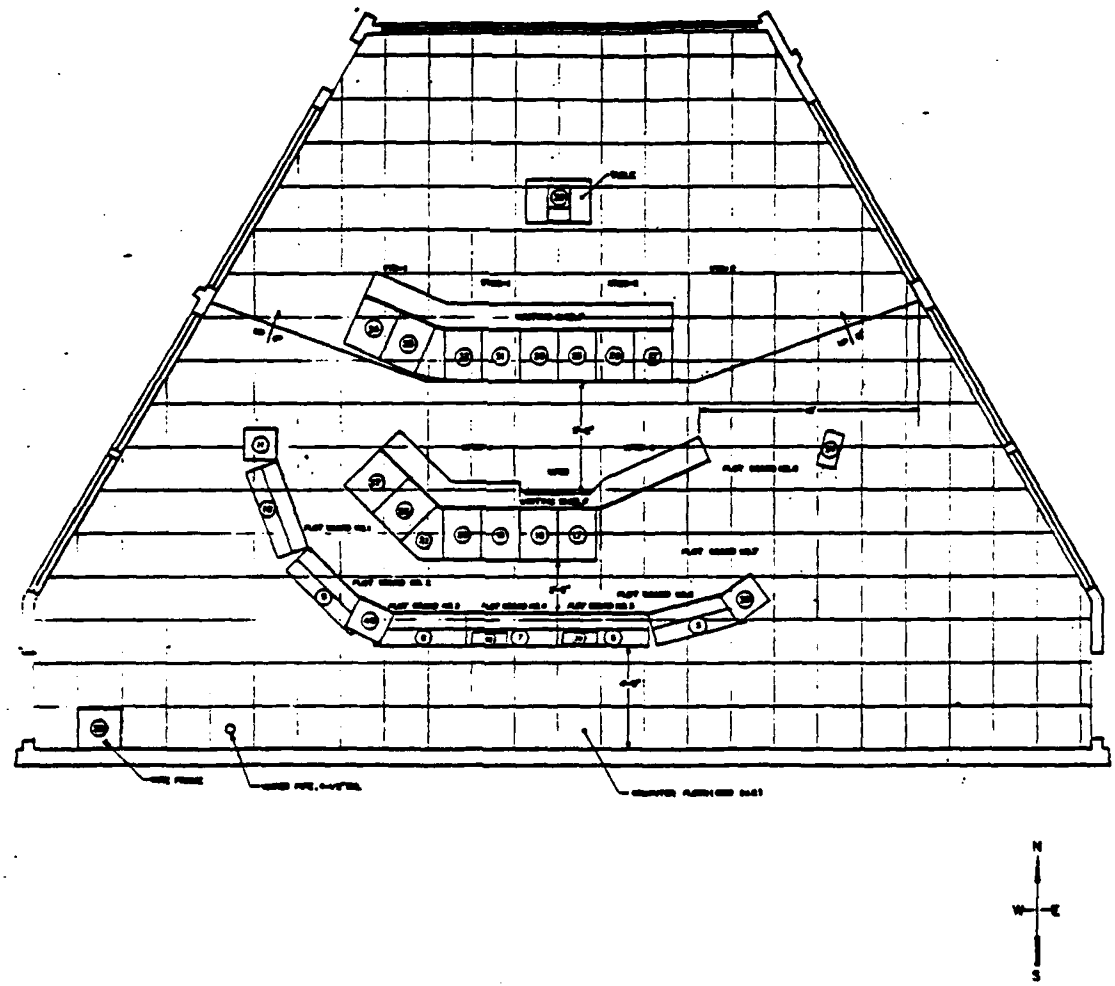

Figure 2-2 Missile Flight Control Center, Physical Layout

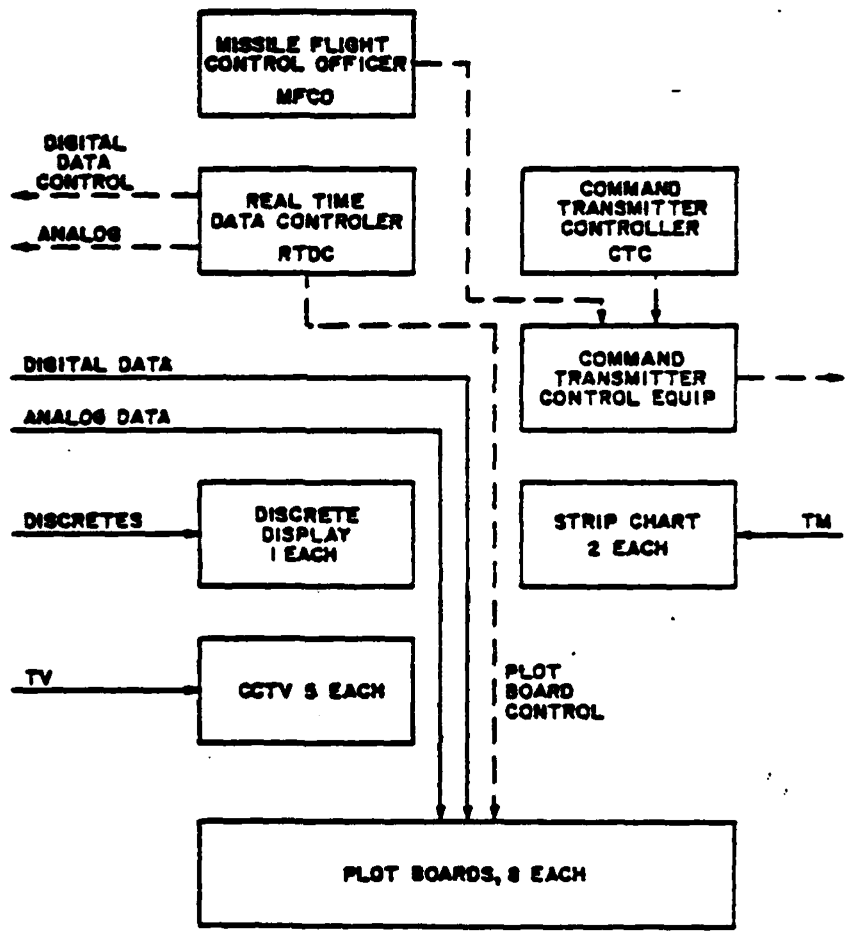

Figure 2-3. Missile Flight Control Center, (Functional Layout)

c. CTC Console

There are two CTC Consoles. Each of these two consoles can select MFCO/Command Transmitter/Computer configuration to control Command Control Transmitter operation. These capabilities exist for control of transmitter sites at VAFB, Pillar Point, and Laguna Peak. The CTC console controls the Command Control Transmitter equipment which provides tone generation and readback capabilities. Communications and S&A capabilities are also provided by the CTC console.

d. Display equipment consists of X-Y Recorders, Strip Chart Recorders, Closed Circuit Television (CCTV), and a Discrete Display Panel. The X-Y Recorders display, as selected by the RTDC, Impact Position and Present Position of vehicle flight as generated by the computer or Present Position as generated by the Analog System. There are eight plotboards in the MFCC. There are four strip chart recorders to provide telemetry data regarding vehicle performance. The center has five CCTV monitors to display back-azimuth, program, weather, boresight, and surveillance information. The Discrete Display Panel displays computer and radar status and discrete functions.

2.1.2 Area Control Center The Area Control Center exercises control of assigned air and surface craft during scheduled launch operations. The center is equipoed with command control and communications consoles, plotting and status boards, radar scopes, and X-Y data recording equipment. Data to the center is provided by the local search and tracking radars. Figures 2-4 and 2-5 show both functional and physical configuration of the Center.

2.1.3 Console Control & Distribution System The Console Control & Distribution System (CCDS) is a network of control panels, logic, and cables designed to distribute controls and data between the TOCC consoles and the various computer systems associated with the Missile Flight Control Center. The console interface logic is the center of the system and contains cable receivers and drivers, as well as logic level conversions, to interface the computer systems to the consoles and various indicator panels (see Figure 2-6).

The computer systems shown at the bottom of the block diagram, are the Real Time System (RTS), the Digital Information Processing System (DIPS), and the Backup Information Display System (BIDS). The data between these systems and the consoles are enabled by the Console Assignment & Control Panel. The four consoles which can be assigned to the computers, are the Computer Control Center (CCC), the Area Control Center (ACC), and the two Realtime Data Controller (RTDC) consoles. The two RTDC consoles interface to the Missile Flight Control Center and Range Control Center. Within these two Centers, status panels are provided on the Range Operations Supervisor (ROS) consoles, the Range Control Officer (RCO) consoles, the Operations Control Supervisor (OCS) consoles, and the Radar Optics Controller consoles.

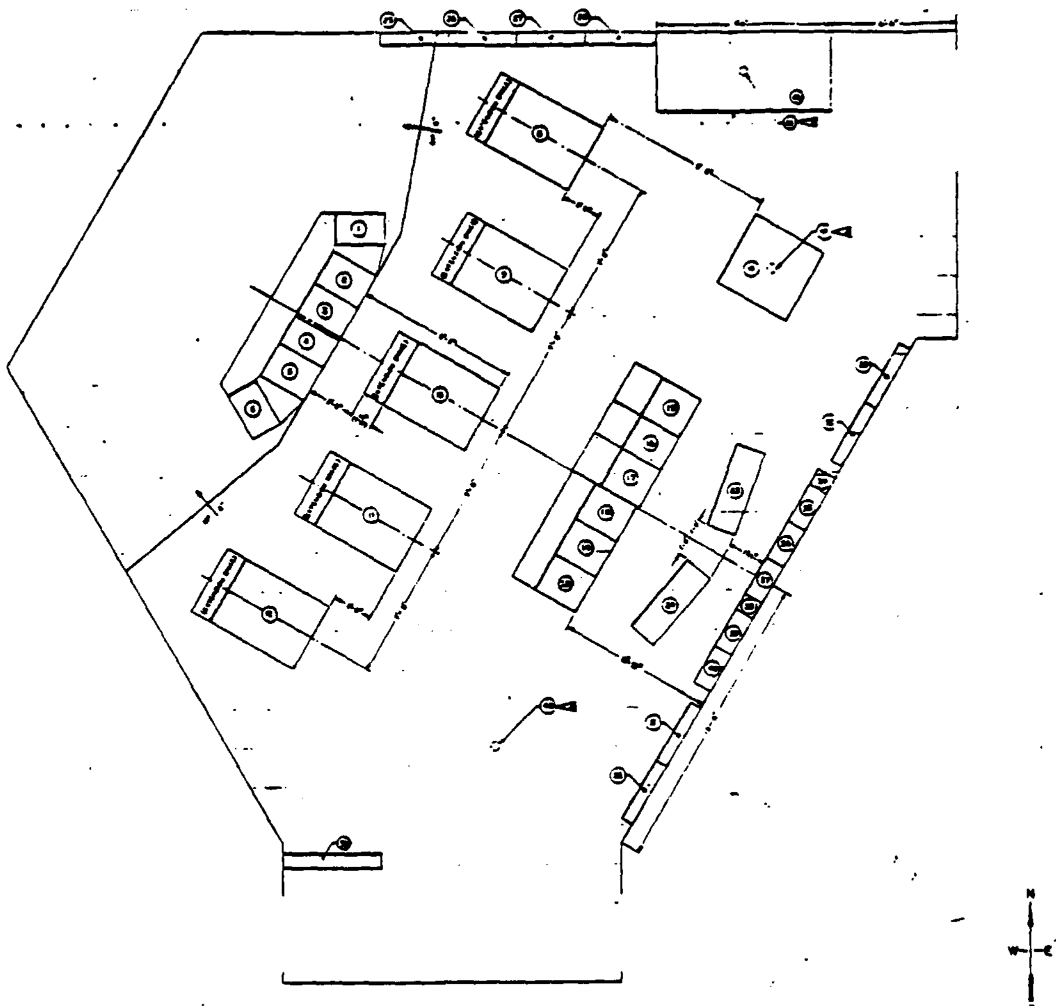

Figure 2-4. Area Control Center, (Physical Layout)

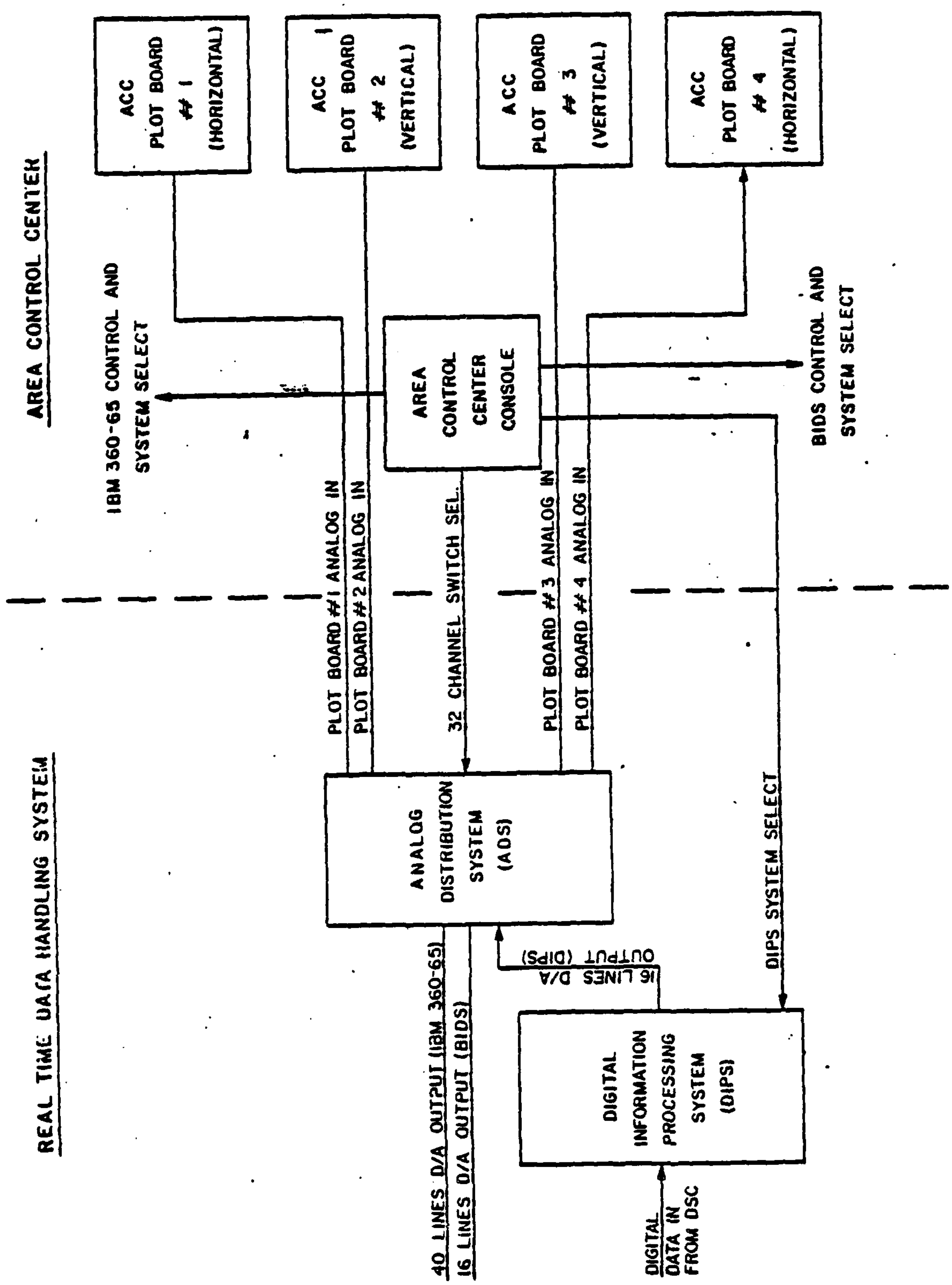

Figure 2-5. Area Control Center Analog Distribution and Control

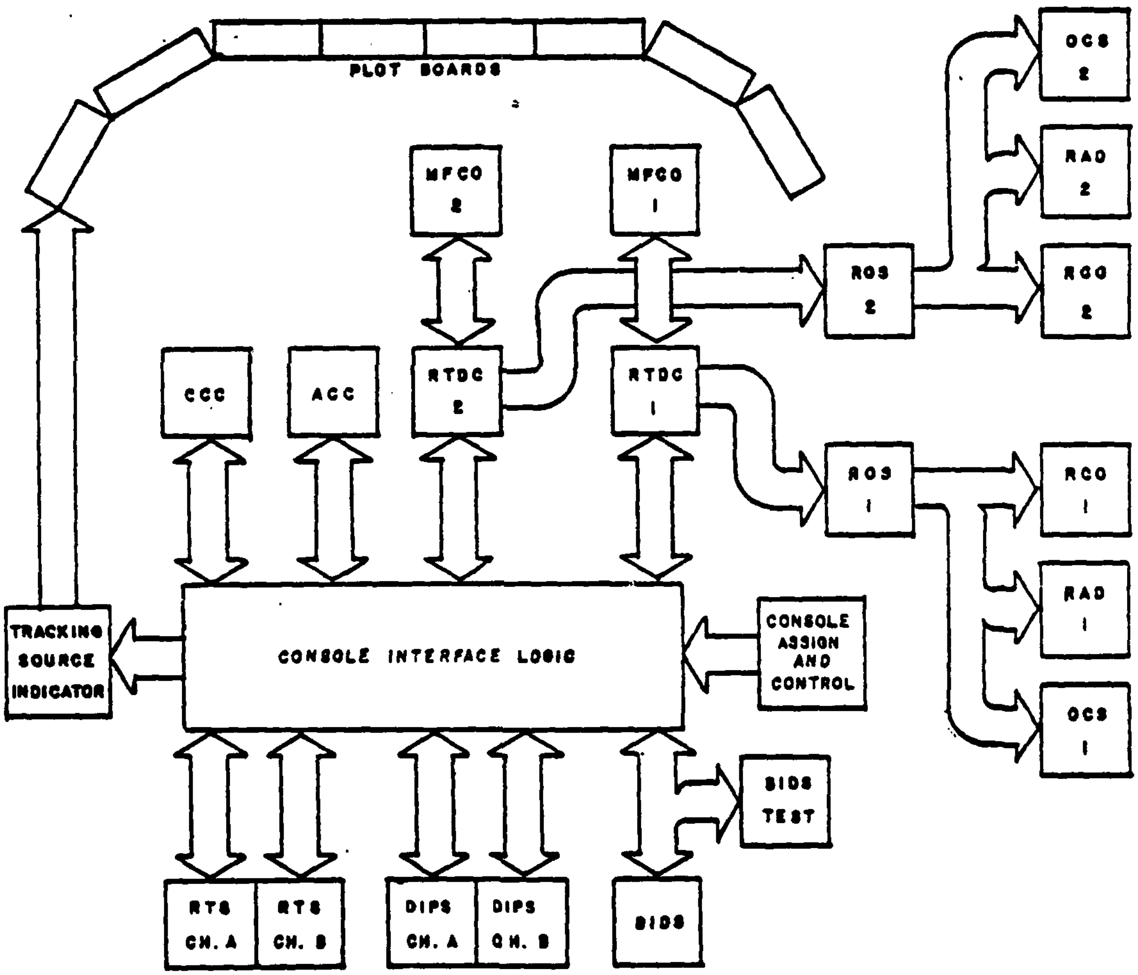

Figure 2-6. Console Control and Distribution System, Block Diagram

2.1.4 Telemetry Receiving Site Telemetry Receiving Site (TRS) Building 75 (See Figure 2-7) is designed to meet the Interrange Instrumentation Group (IRIG) telemetry and recording standards. The primary mission of TRS is to provide the various WSMC data handling and processing systems with telemetry data for support activities (See Figure 2-8). The major equipment systems located at the TRS are:

- GKR-7 30-Foot Autotrack Antenna System.
- 35-Foot Autotrack Antenna System.
- Right-hand Quad Helix #1 Manual Track Antenna System with UHF Satellite Uplink Transmitter.
- Right-hand Quad Helix Manual Track Antenna System.
- 8-Foot Antenna System.
- Omni Antenna System
- Space Ground Link Subsystem - Receive/Record System.
- Pre-D Diversity Receive/Record System (TPRS-11).
- Pre-D Diversity Receive/Record System (TPRS-6).
- Pre-D Diversity Receive/Record System (TPRS-10).
- Data Evaluation and Display Station.
- Microwave System.
- Telemetry Antenna Pointing System.
- Telemetry Validation System (TVS).
- 2 Each Fixed Single Helix, S-Band Antenna.

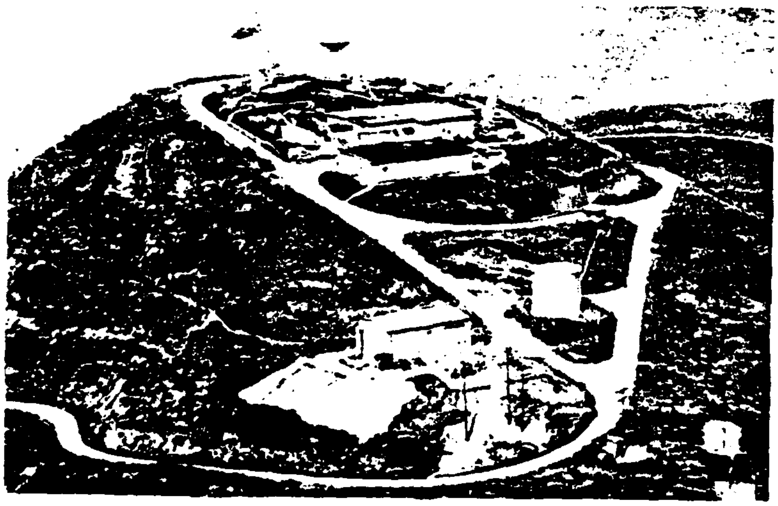

Figure 2-7. Telemetry Receiving Site (TRS) Sudden Peak

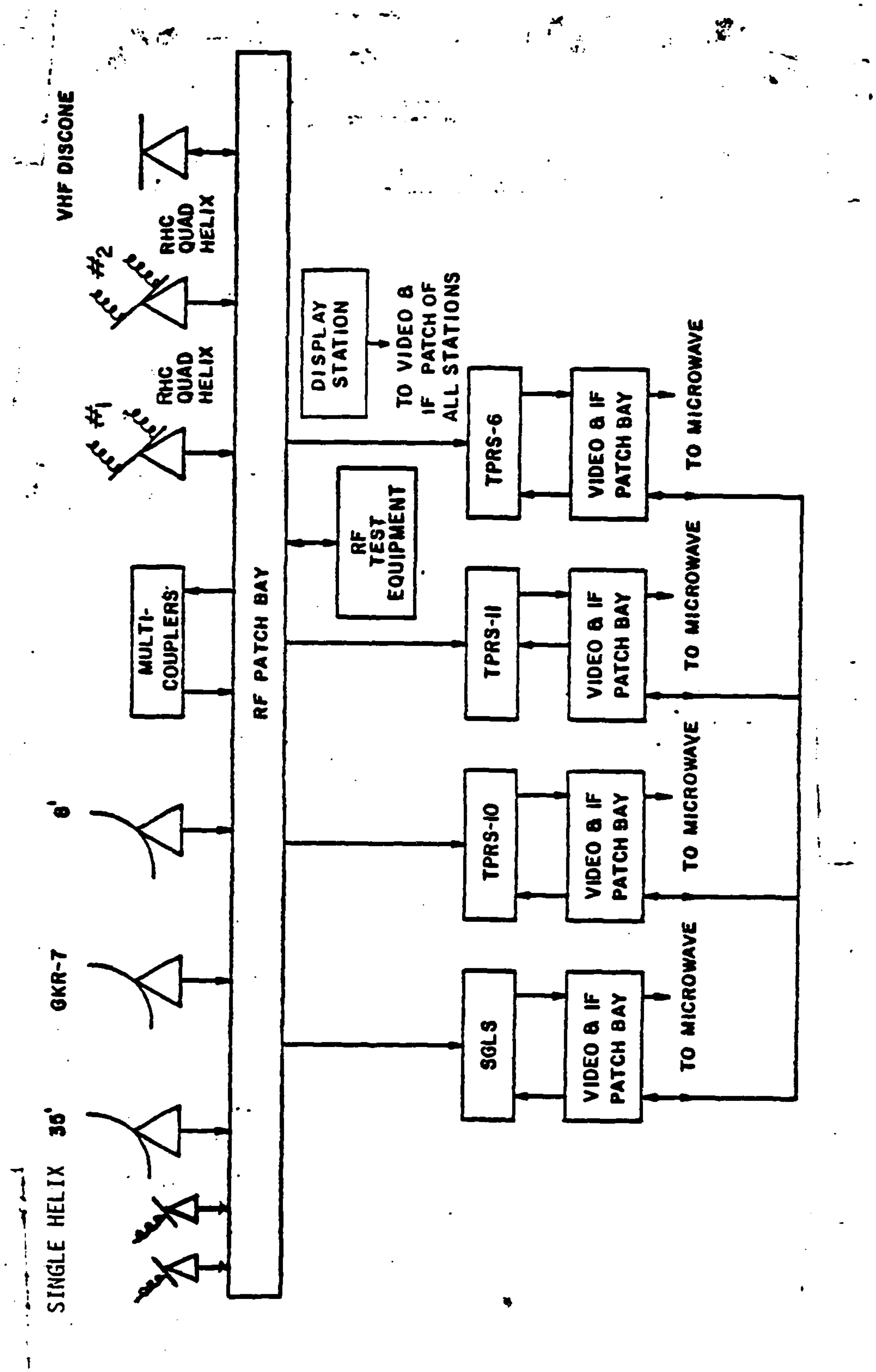

Figure 2-8. Inter-Station Trunks (TRS), Sudden Peak

2.1.4.1 GKR-7 Autotrack Telemetry Antenna The Autotrack Telemetry Antenna (See Figure 2-9), GKR-7 provides automatic tracking of suitably equipped airborne vehicles for the reception of telemetry signals in the 1435 to 1540 MHz, and 2200 to 2300 MHz range of frequencies. The GKR-7 automatically tracks incoming signals in either of the two bands and records/displays digital and analog angle data. The system uses fixed-scan monopulse rf tracking electronics. A digital subsystem accepts shaft-angle position information from the antenna pedestal along with IRIG-B timing. The decoded timing data and the azimuth and elevation angle position data are formatted for recording (digital tape). A strip chart is also produced, which records azimuth and elevation angle, antenna modes and servo error.

2.1.4.1.1. GKR-7 Autotrack Technical Data

- Antenna: 30-ft parabolic
- Frequency Ranges: 1435 to 1535 & 2200 to 2300 MHz
- Gains (3 dB points): 37 dBi (1435 to 1535 MHz)
  42 dBi (2200 to 2300 MHz)
- Beamwidth (3 dB points): 1.4 deg (1435 to 1535 MHz
  1 deg (2200 to 2300 MHz)
- Polarization: Right- & Left-Hand Circular
- Tracking Rate: Up to 10 deg/sec with acceleration up to 5 deg/sec^2

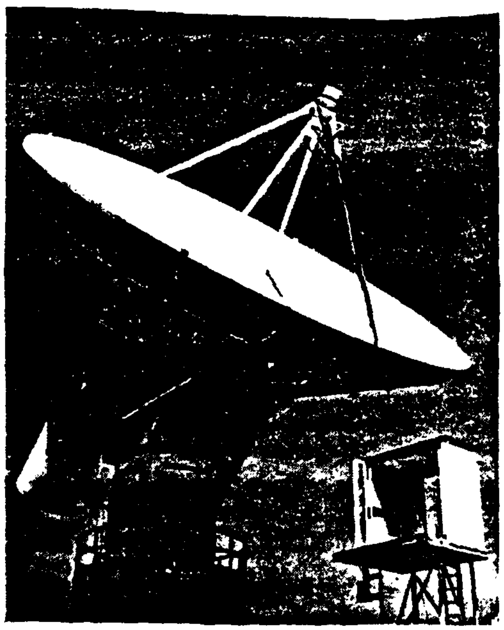

Figure 2-9. GKR-7 Antenna, Side View

- o Tracking Accuracy: 0.1 deg rms, both bands
- o Drive Limits: -2 to 90 deg, elevation± 350 deg azimuth
- o Figure of Merit: (2200 to 2300 MHz) 17.0 (approx) (1435 to 1535 MHz) 7.0 (approx)
- o Noise Temperature: (2200 to 2300 MHz) T = 275°K (avg) (1435 to 1535 MHz) T = 1012°K (avg)
- o. Slave Source: TMAE, TAPS, 35-Foot Antenna, Synchro
- o Shaft Angle Encoders: 13 Bit (MSB - 180 deg, LSB - .044 deg)

2.1.4.2 35-Foot Autotrack Antenna The 35-foot Autotrack Telemetry Antenna System (See Figure 2-10), is an elevation-over-azimuth type, using a 35-foot parabolic reflector. The antenna system will operate in the 1435 to 1540 MHZ and 2200 to 2300 MHz frequency bands in automatic tracking, manual and slaved control modes of operation. The 35-foot antenna has the same capabilities as the GKR-7. A digital subsystem accepts shaft angle-position information from the antenna pedestal along with IRIG-B timing, for recording on digital tape. A strip chart is also produced which records azimuth and elevation angles, antenna mode, and servo error.

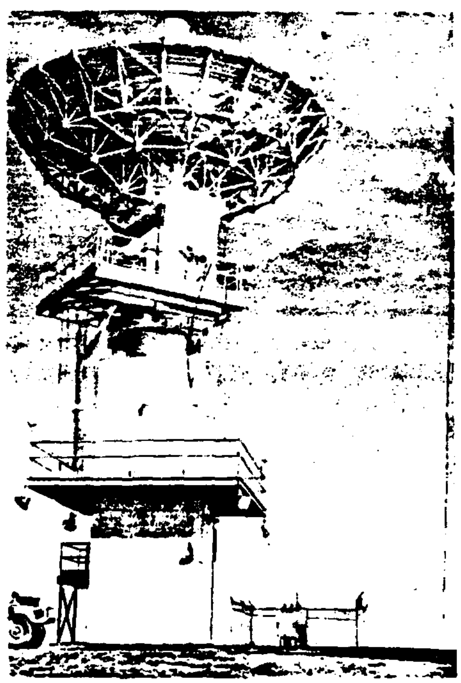

Figure 2-10. 35-Foot Autotrack Antenna (TRS)

2.1.4.2.1 35-Foot Autotrack Technical Data

o Antenna:	35-ft parabolic
o Frequency Range:	2200 to 2300 MHz & 1430 to 1535 MHz
o Gain (3 dB points):	43.3 dB (S-Band) 39.7 db (L-Band)
o Beamwidth (3 dB points):	0.8 deg (S-Band) 1.3 deg (L-Band)
o Polarization:	Simultaneous Right- and left-hand circular
o Tracking Rate Acceleration:	10 deg/sec 5.0°/Sec./Sec.
o Drive limits:	-3 to +92 deg elevation ± 365 deg azimuth
o Figure of Merit:	(2200 to 2300 MHz) 17.8 avg. (1430 to 1539 MHz) 14.0 avg.
o System Noise Temperature:	190°K (2200 to 2300 MHZ) (1430 to 1535 MHz)
o Tracking Modes:	Manual, Automatic and Slave
o Slave Source:	TAPS TMAE/GKR-7 Synchro
o Shaft Angle Encoders	13 Bit (MSB = 180 deg, LSB = .044 deg)

2.1.4.3 Quad Helix Technical Data Two quad helix antennas. both righthand, are used to provide VHF support at the TRS (See Figure 2-11). The antennas are designed to operate in the 225 to 260 MHz range with a nominal gain of 18 dB. The antennas can be operated in the manual/slave modes only. In the manual mode the antennas are positioned by the azimuth and elevation handwheels. The slew rate in the elevation and azimuth planes is 30 degrees per second.

2.1.4.3.1 Quad Helix Technical Data

- o Frequency Range: 215 to 320 MHz
- o Gain: > 18 dB
- o Beam Width: 17 deg. Horiz-vertical planes at mid-band
- o Noise Figure: 4.5 dB
- o Slave Source: 35-Ft and GKR-7 Synchro, TAPS & TMAE

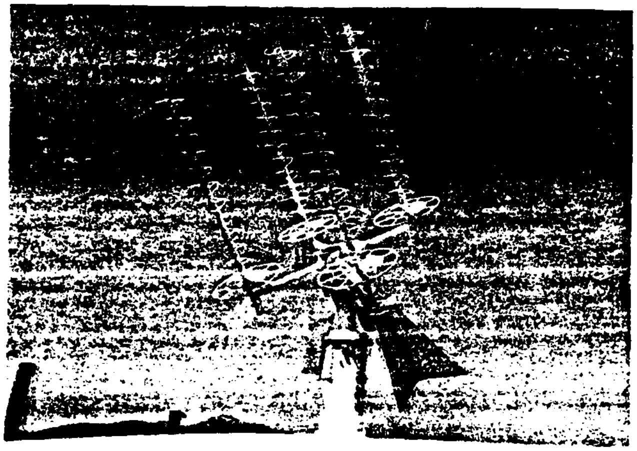

Figure 2-11. Quad Helix Antenna TRS, Overall View

2.1.4.4 Eight-Foot Antenna System The 8-foot antenna uses an 8-foot paraboloid reflector with a dual polarized feed installed on a pedestal similar to the quad helix antennas (See Figure 2-12). The antenna has a circular dual polarized feed providing simultaneous right and left circular polarization capable of receiving telemetry signals from 2200 to 2300 MHz and down converted to 215 to 315 MHz. It is a broadbeam, manually adjustable antenna.

2.1.4.4.1 Eight-Foot Antenna Technical Data

- o Figure of Merit: 3.3 avg
- o System Noise Figure: 5.29 dB
- o Manual Tracking Rate: 20 deg/sec
- o Slave Source: TAPS, TMAE, 35-ft and GKR-7 Synchro
- o Gain 32 dB
- o Beamwidth 4.0 deg

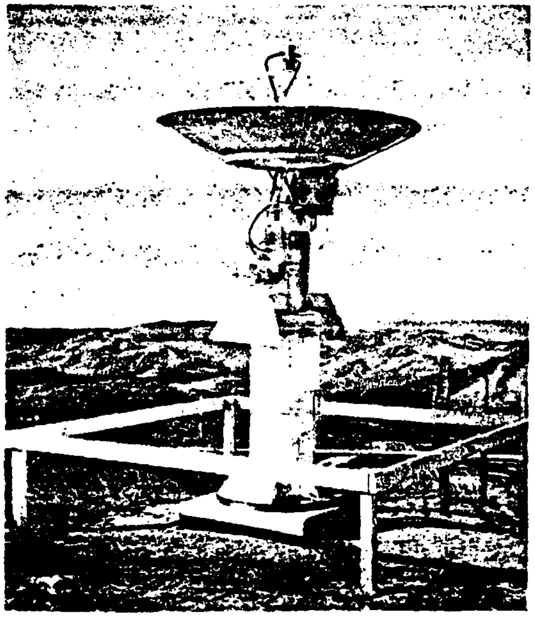

Figure 2-12. 8-Foot Antenna, TRS

2.1.4.5 Space Ground Link System The system has the capability to receive one dual diversity combined telemetry signal in the 2200 to 2300 MHz frequency ranges, and to demodulate the three SGLS subcarriers as follows:

a. 1.024 MHz bi-phase PCM with bit rates of 7.88 BPS to 128 kBPS. Loop bandwidths available are 10 to 100 Hz. Data filters available are 3, 10, and 300 kHz.

b. 1.25 MHz FM: Bandwidths of 3 kHz for voice or 20 kHz analog data are available.

c. 1.7 MHz (bi-phase) with bit rates of 125 BPS to 256 kBPS. Loop bandwidths are 25 Hz or 150 Hz.

d. 1.7 MHz (FM) with bandwidths of 7.5 kHz, 75 kHz, and 600 kHz.

Received data may be recorded in either Pre-D or Post-D form. Two Model 3700 (all one-inch tape) recorders, located in Station TPRS-11 are used with the SGLS. Receive Data may also be transmitted via microwave from TRS for further processing.

2.1.4.6 Diversity Receive/Record System (TPRS-11) The TPRS-11 comprises six dual-channel receivers with their respective dual spectrum displays, six Pre-D/Post-D diversity combiners, four 1-inch tape recorder/reproducers, six playback upconverters, four playback monitors with plug-in demodulators, twelve video amplifiers, two data insertion-converters, two reference oscillator/mixer amplifiers, a data retrieval converter, a multi-channel stylus recorder and removable patch panels with patch cords. In addition, the system incorporates test equipment necessary for system set-up, calibration and operation. The TPRS-11 is capable of receiving and recording six links of Pre-D/Post-D combined PM or FM rf telemetry signals. This system has been designed to operate in the 2200 to 2300 MHz range, but with a change of the rf tuners and/or down converters this system can also operate in the 215 to 320 & down converted 1430 to 1535 MHz frequency ranges. Playback monitors monitor either the combiner output or the tape recorder/reproducer electronics output. All plug-in modules that are provided with the monitors are interchangeable with the dual channel receivers which provide different operational configuration of the operational components. However, the receiver-combiner pairs are fixed in that the AGC lines and the video signal lines are hardwired between the units. A 10 MHz output is available from each combiner.

2.1.4.7 Diversity Receive/Record System (TPRS-6) This telemetry predetection Receive/Record Station (TPRS-6) at TRS will receive/record five links of Pre/Post-Detection combined rf signals. Through the use of plug-in rf heads/converters, the system will operate in the 215 to 320 MHz frequency ranges, the down converted 1435 to 1535 MHz and 2200 to 2300 MHz frequency ranges. The station will also provide real-time video from both the receiver and diversity combiner outputs. The combiners also provide a 10 MHz output.

2.1.4.8 Diversity Receive/Record System (TPRS-10) The TPRS-10 comprises five dual-channel receivers with respective dual spectrum displays, six Pre-D/Post-D diversity combiners, four 1-inch magnetic tape recorder/reproducer, playback up-converters, data insertion units, video amplifiers, reference mixer/amplifiers and AGC recorders. The rf, I-F, and video patch bays provide the flexibility to meet various operational configurations. In addition, the system incorporates test equipment necessary for system set-up, calibration and operation. The TPRS-10 is capable of receiving and recording five links of Pre/Post Detection combined PM or FM telemetry signals. Through use of receiver front panel plug-in rf heads, the proper selection of multicouplers and convertors, the system can operate in the following frequency bands: 215 to 320 MHz, down converted 1435 to 1535 MHz and in 2200 to 2300 MHz. A 10 MHz output is provided from each combiner.

2.1.4.9 Data Evaluation Station This station contains one set of 12 discriminators, equipment for wow and flutter compensation for tape-analysis, one PCM decommutator and Bit Error Rate indicator, two 8-channel pen recorder, and one optical oscillograph. A composite video signal is obtained from the Pre-D receive/record stations and patched to the evaluation station for separation. Under normal operating conditions, the Cont of 27A oscillograph is capable of seven analog data channels; however, by using unusually small bandwidths or overlaping traces, up to 18 information channels can be evaluated. These data segments can be FM/FM from the discriminators or decommutated channels from the decommutators. Various galvanometers are available ranging in frequency response from 90 to 5000 Hz. Timing and lift-off may be used for reference as required. The eight-channel pen recorder is of the thermal type, capable of recording timing along with eight data channels and is normally used for low frequency data display. The inputs and outputs of all equipment are terminated at the video patch panels. This arrangement provides maximum flexibility for data evaluation.

2.1.4.10 Telemetry Antenna Pointing System The Telemetry Antenna Pointing System (TAPS) serves as a buffer between the 360/65 and the 35-foot autotrack antenna system. Acquisition (remote designate) data input to the TAPS from the 360/65 will be converted from digital into synchro (analog) voltages that are compatible with the 35-foot autotrack antenna servo loops.

2.1.4.11 Telemetry Acquisition Equipment The Telemetry Acquisition Equipment (TMAE) serves the AN/GKR-7 30-foot antennas in a manner similar to the TAPS/35-foot antenna arrangement. It provides the interface for decoding computer designate angles for slaving the AN/GKR-7 antenna and encodes the AN/GKR-7 angles which may also be used (through a synchro slaving selector configuration) by other site antennas after D/S conversion.

The TMAE Model 6500 comprises three separate units. Interconnecting cables are provided with the equipment.

2.1.4.11.1 Transmit Buffer

The Transmit Buffer, Model 6500-1, accepts parallel azimuth (Az) and elevation (El) data at a 20 pps rate, a serial IRIG A or IRIG B modulated time code, and on On-Target (OT) input. The serial binary time-of-day and time-vernier data are extracted from the selected time code, and all of the input data, along with frame synchronization, frame error check code, and site identification are formatted into the IRIG standard format (Figure 2-13) for serial transmission via modems at a 2400 bit per second rate. The transmit buffer generates a 2400 pps clock signal. This clock signal is used by the modem to clock the serial data out of the Model 6500-1 Transmit Buffer. Both the data and clock interfaces to the modems are in accordance with MIL-STD-188C for low level signaling.

The Transmit Buffer Model 6500 also provides parallel Az and El outputs to the Difference Display Model 6500-3. These outputs are updated at a 20 pps rate.

2.1.4.11.2 Receive Buffer

The Receive Buffer, Model 6500-2, accepts 240-bit IRIG standard messages (Figure 2-13) at a 2400 bit per second rate, provides frame synchronization and code error checking, detects the site ID code, and provides parallel Az and El outputs at a 10 pps or 20 pps rate. The OT bit is also provided to three types of interfaces. A time-data output storage is also provided for possible future use. Input data are transferred to the outputs only when a combination of valid synchronization, no frame bit errors, detected OT bit, and recognition of a valid site ID code exist. The last known good data are provided as outputs when these conditions are not met. Once the frame synchronizer is in the LOCK mode, it does not return to the SEARCH mode until a selected number of frames (0 through 3) with lost synch have been detected. A frame bit-error counter and display are also provided.

The Receive Buffer Model 6500-2 also provides parrallel Az and El outputs and a 10 pps update pulse to the Model 6500-3 Difference Display.

LEGEND

Error Check	Refer to IRIG Document 102-64
OT	1 = On Target
Time Vernier	Binary, LSB = 25 ms
Time of Day	Binary, LSB = 1 second
R	Rate
	Logic ZERO = 10 Samples per second, load Field 2
	Logic ONE = 20 Samples per second, load Fields 2 and 4

NOTE: The Transmit Buffer updates Fields 2 and 4 at a 20pps rate (R bit = 1). The Receive Buffer transfers Field 2 data when the R bit is a 0, and transfers Fields 2 and 4 when the R bit is a 1.

Figure 2-13. IRIG Sta~~ard Data Transmission Format

2.1.4.11.3 Difference Display

The Difference Display, Model 6500-3 provides a variable sensitivity display of the difference between the position data being processed by the transmit buffer and the position data at the Receive Buffer output. A two-pointer (vertical and horizontal) meter displays elevation and azimuth differences of 0 to $\pm$ 10 degrees, with the sensitivity being greatest at small angles, the position difference. An ON-TARGET indicator is also provided.

2.1.4.11.4 Telemetry Antenna Pointing System (TAPS). The Taps consists of the following assemblies:

a. Datex Programmer PC-194-0

b. Datex Programmer PC-760-1

c. Datex Programmer PC-760-2

d. Datex Digital-to-Synchro Converter DS-107-1

e. Synchro Amplifier 732-901

f. Datex Light Bank LB-187-0

g. Technipower Power Supply PS-203-1

The TAPS, functions to receive and transmit acquisition data in the IRIG Standard Format for data transmission described in Document 102-64, Phase II, through a data modem at a rate of 2400 bps. Incoming data is sampled at the rate of 10 samples per second (the 10 sample rate is the rate at which TAPS utilizes the received (incoming) modem data. For example, 10 frames per second). The rate of data transmission is switch selectable at 10 or 20 samples per second (for data transmission, at 10 samples per second rate, encoder data appears once in each transmitted frame, at 20 samples per second rate, encoder data appears twice in each frame).

Received acquisition messages are converted to synchro signals in a digital-to-synchro converter, amplifier by buffer amplifiers and fed to control transformers to drive the 35-foot azimuth and elevation antenna. In addition, buffer amplifiers are provided to drive position synchros for Antenna Control Panel azimuth and elevation position indicators.

In the process of receiving and transmitting acquisition data, the TAPS simultaneously performs security checks. It detects and generates error code bits and displays error counts; detects and generates received site identification (ID) bits; detects, displays, and generates data bits; transfers the last known good data when a transfer inhibit results from error detection, loss of synchronization, or loss of the OT bit; displays received and transmitted pointing data. Patch panels are provided in the TAPS programmers which allow access to each bit of received and transmitted data.

2.2 PILLAR POINT AIR FORCE STATION

This most northern WSMC instrumentation site has as its primary mission the tracking of solid fuel missiles whose burning propellants create a flame attenuation problem for instrumentation located behind the launched vehicle. Data collected by Pillar Point radar and telemetry systems are used for real-time range safety display and for post-flight data analysis. This station also provides means for emergency flight termination via a command transmitter facility. Pillar Point Air Force Station (AFS) is located near Half Moon Bay, 21 miles south of San Francisco, California. The station conists of approximately 45.8 acres of Government-owned property. (See Figure 2-14).

Pillar Point, which juts out into the Pacific Ocean to overlook the small boat harbor at Half Moon Bay, was once planned as a control site to support one particular missile program. In 1959, a radar building was constructed, but cancellation of the missile program brought about deactivation of the site. The site was re-activated in 1962 for the prime purpose of supporting another missile program. Since site re-activation the operational requirements demanded of the site have been increased to encompass considerably more than the single missile program which initiated reactivation. The station is equipped to support both ballistic and orbital operations with radar tracking, telemetry reception, command control, and communications services. Data obtained at Pillar Point is displayed in the Missile Flight Control Center at VAFB for use by the MFCO. Pillar Points' AN/FPS-16 Radar and AN/FPQ-6 Radar complement other radar sites at Vandenberg and the Pacific Missile Test Center (PMTC). Table 2-II provides an overview of installed instrumentation.

2.2.1 Pillar Point Telemetry Facility Pillar Point Telemetry Facility is designed to meet the Interrange Instrumentation Group (IRIG) telemetry and recording standards. The primary mission of the Pillar Point Facility is to provide the various WSMC data handling and processing systems with telemetry data for launch support activites. The major equipment systems located at Pillar Point are:

- o 40-Foot Autotrack Antenna System
- o 80-Foot Autotrack Antenna System
- o Diversity Receive/Record System
- o SGLS
- o Telemetry Validation System (TVS)

Basically, the receiving system consists of preamplifier/multicoupler units, telemetry receivers and simultaneous pre- and post-detection diversity combiners. Two antennas, the 80- and 40-foot automatic tracking antennas are used for telemetry reception and are patched through the multicouplers to the receivers. Each receiver is equipped with appropriate rf, if and demodulator plug-in modules to handle signals of various types and frequencies. Telemetry Display Units are available for rf spectrum display of the received signals.

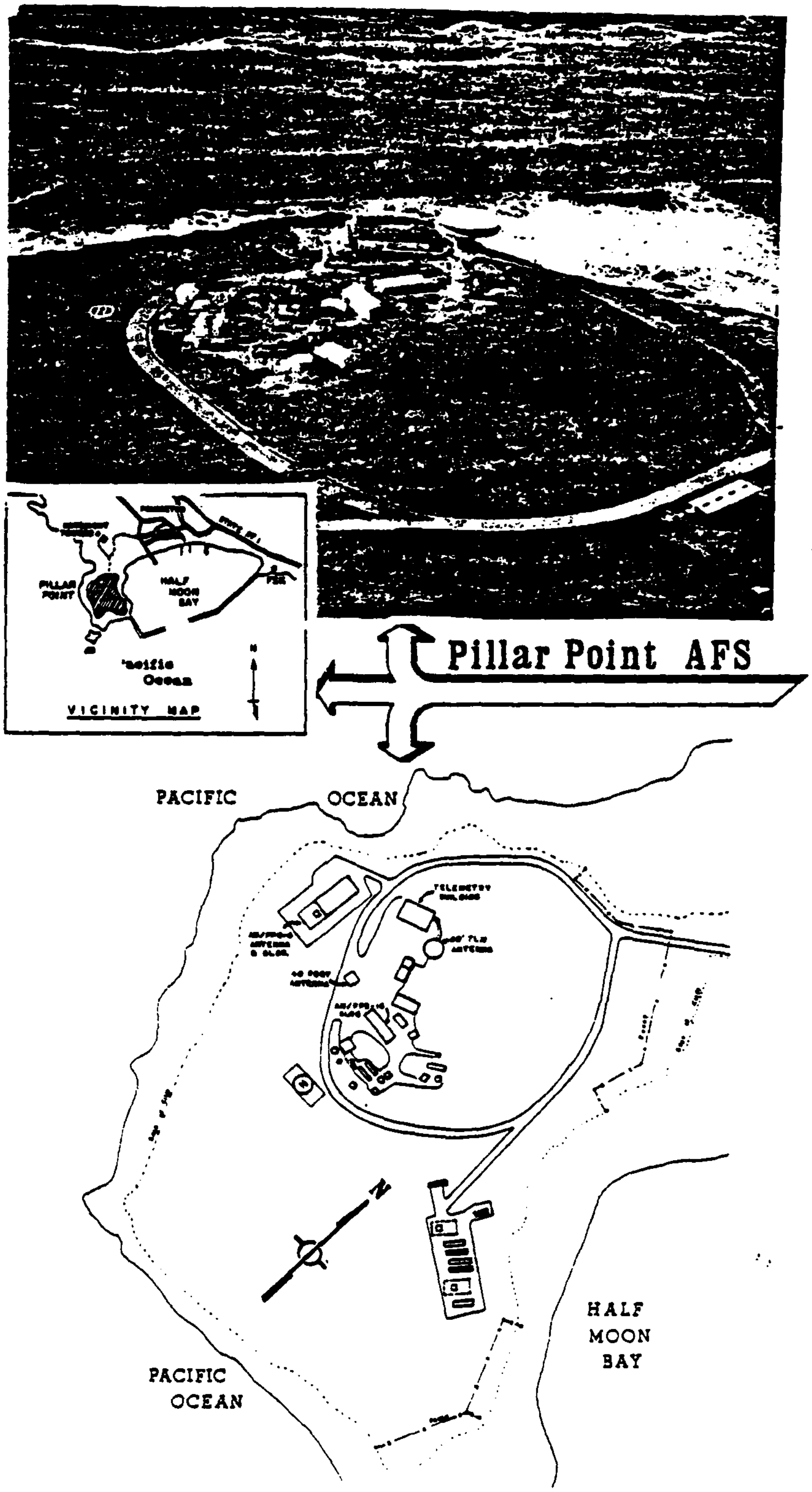

Figure 2-14, Pillar Point AFS

Table 2-II. PILLAR POINT INSTRUMENTATION SUMMARY

Equipment	Function	Quantity
AN/FPS-16 Radar	Precision Tracking	1
8672 Timing Center	Range Timing	1
Command Control Transmitter (CCT)(10 kW)	Command Control	2
Pre/Post-Detection Diversity Receive/Record	Telemetry	1
UNIVAC 1218 Data Processor	Data Handling (RTDHS)	2
AN/FPQ-6 Radar System	Precision Tracking	1
40-Ft. Autotrack System	Telemetry	1
80-Ft. Autotrack System	Telemetry	1
Telemetry Acquisition Data Interface (TADI)	Acquisition Aid	1
AN/GMD-2A RAWIN Set	Upper Air Data	1
SGLS	Telemetry	1
Master Synchro Slaving System (MSSS)	Antenna Slaving	1

Twelve dual-channel receivers, 12 pre/post-detection diversity combiners, 8 pre-detection up/down converters, 24 display units and five wide-band magnetic tape recorders comprise the system to receive/record, playback and demodulate telemetered inputs. The input is a down converted signal dervied from 1435 to 1535 & 2200 to 2300 MHz transmission. The system will receive/record AM, FM, and PM signals in all IRIG data formats from the 80-and 40-foot autotrack antenna systems. The system is capable of simultaneously processing 12 telemetry channels having diversified polarization, employing the necessary equipment to receive, combine, and record post/predetection telemetry signals. Playback monitor equipment is employed to up convert and demodulate the recorder predetection playback ouput. The outputs from the diversity combiners or receivers are recorded on wideband tape recorders as are reference signals for use in tape and speed compensation during playback. Display units are provided for monitoring the rf spectrum. A data retrieval converter is included to recover voice and timing signals during playback.

Five wideband recorders make it possible to record simultaneously the outputs of all receivers and combiners both post- and pre-detection. The 12 dual-channel receivers are capable of monitoring 12 different frequencies simultaneously and simultaneously providing diversity and single polarization post detection reception. A 10 MHz output is available from each combiner. Signal mixers are used to mix timing, voice, AGC, and other low frequency data signals for recording signal. Three eight-channel direct writing pen recorders are used to record received signal strength versus timing and two are used for antenna orientation readings. A Telemetry Acquisition Data Interface (TADI) serves as a buffer between UNIVAC 1218 Peripheral Computer and the 40- and 80-foot autotrack antenna systems. Acquisition data input to the TADI from the UNIVAC 1218 comprises a 32-bit data word as follows:

- Azimuth, 12 bits
- Elevation, 12 bits
- Identification, 6 bits
- On target, 1 bit
- Repeated data, 1 bit

2.2.1.1 40-Foot Automatic Tracking Telemetry Antenna System The 40-foot automatic tracking telemetry antenna system (See Figure 2-15) provides automatic tracking of targets transmitting telemetry signals on one of two designated IRIG frequency bands: 1435 to 1535 MHz, and 2200 to 2300 MHz.

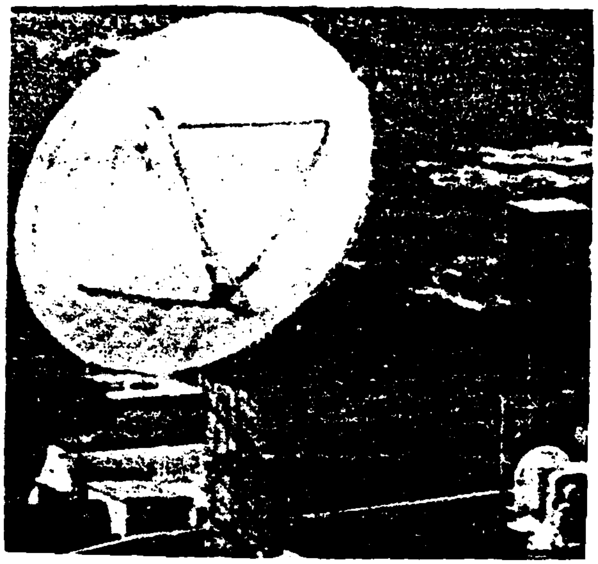

Figure 2-15. Pillar Point 40-Foot Autotrack Antenna, Side View

- Autotrack Mode - Received signals are collected by a 40-foot parabolic reflector. Two channels provide simultaneous right circular and left circular polarization. The system uses fixed-scan monopulse rf tracking electronics. A down converter transfers received VHF telemetry signals directly to multicouplers located in the rf distribution area; 1435 and 1535 MHz and 2200 to 2300 MHz signals are first down converted to 215 to 315 MHz and then transferred to their respective multicoupler.

2.2.1.1.1 40-Foot Automatic Tracking Telemetry System Technical Data

o	Antenna:	Parabolic, 40-ft, Apex type feed
o	Frequency	1435 to 1535 & 2200 to 2300 MHz
o	Gain (3 dB points):	42.2 dB 1435 to 1535 MHz 46.2 dB 2200 to 2300 MHz
o	Beamwidth (3 dB points):	1.15 deg 1435 to 1535 MHz 0.72 deg 2200 to 2300 MHz

o	Polarization:	Right and Left-Hand Circular
o	Tracking Rate:	Autotrack up to 10 deg/sec with accelerations up 5 deg/sec
o	Drive Limits:	Elevation: Elec Limits, -2 deg to 90 deg Azimuth, ± 360 deg
o	Figure of Merit:	2200 to 2300 MHz 20.5 1435 to 1535 MHz 16
o	System Noise Temperature:	2200 to 2300 MHz 400 K 1435 to 1535 MHz 380 K
o	Tracking Modes:	Manual, Automatic and Slave
o	Shaft Angle Encodes:	13 Bit (MSB = 180 deg, LSB = .044 deg)

2.2.1.2 <u>80-Foot Automatic Tracking Antenna System</u> The 80-foot Automatic Tracking System (See Figure 2-16), provides automatic tracking of active space vehicles and missiles which transmit radio signals in the frequency range of 2200 to 2300 MHz. The system can receive a Right Circularly Polarized (RCP) or Left Circularly Polarized (LCP) signal and supply multiple rf outputs for telemetry data recovery.

2.2.1.2.1 <u>80-Foot Automatic Tracking Telemetry Antenna System Technical Data</u>

o <u>UHF Feed/Reflector</u>

Frequency Range:	2.2 to 2.3 GHz
Type of Feed:	Cassegrain
Polarization:	LCP and RCP
Gain:	51.8 dB
Noise Temperature:	$380^{o}K$
Noise Figure	3.64 dB
Beamwidth at 3 dB:	0.45 deg
Figure of Merit:	26

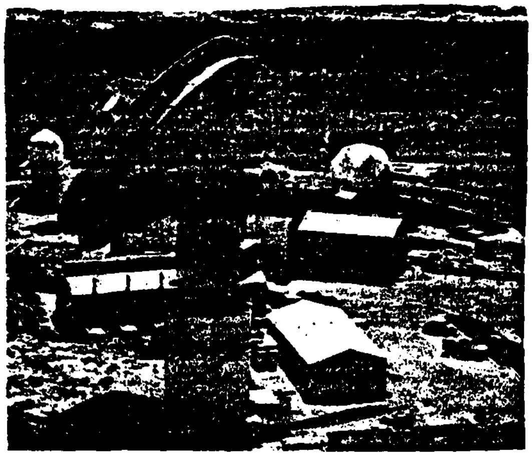

Figure 2-16. Pillar Point Automatic Tracking 80-Foot Antenna

- Drive and Control

Velocity:	10 deg/sec
Acceleration:	5 deg/sec, 50 mph wind

- Azimuth Angle Rangers

Rate Limits:	±360 deg
Servo Limits:	±365 deg
Electric Limits:	±375 deg

- Elevation Angle Ranges

Rate Limits:	4 and 87 deg
Servo Limits:	-1 and 92 deg
Electric Limit:	-1 1/4 and 94 deg

- Antenna Structure

Main Reflector	
Diameter:	80 ft.
Subreflector	7.6 ft.

- Tracking Modes: Automatic, Manual, and Slave

- Shaft Angle Encoder 13 Bit (MSB = 180 deg, LSB - .044 deg)

2.2.1.3 Space Ground Link System The system has the capability to receive one dual diversity combined telemetry signal in the 2200 to 2300 MHz frequency range, and to demodulate the three SGLS subcarriers as follows:

a. 1.024 MHz bi-phase PCM with bit rates of 7.88 BPS to 128 kBPS. Loop bandwidths available are 10 to 100 Hz. Data filters available are 3, 10, and 300 kHz.

b. 1.25 MHz FM: Bandwidths of 3 kHz for voice or 20 kHz analog data are available.

c. 1.7 MHz (bi-phase) with bit rates of 125 BPS to 256 kBPS. Loop bandwidths are 25 Hz or 150 Hz.

d. 1.7 MHz with bandwidths of 7.5 kHz, and 600 kHz.

Received data may be recorded on station tape recorders. Receive Data may also be transmitted via microwave from Pillar Point for further processing.

2.2.2 Pillar Point Enviromental Support An Upper Air Observatory is activated at Pillar Point for specific operations to enhance the value of the acquired radar data. The basic unit of equipment is an AN/GMD-2A RAWIN Set, normally used in the GMD-1 mode, which obtains the rawinsonde data. This equipment and the Pillar Point Upper Air Observatory are further described in Section 5.0.

2.3 Anderson Peak Optical Tracking Station

This station is located atop Anderson Peak in the Big Sur region. Anderson Peak is at 4,050 feet elevation, edging the Ventana Primitive area in the Santa Lucia Mountain Range. (See Figure 2-17.)

Access to the site is gained over a 13 1/2 mile dirt fire trail (maintained by the Federal Aviation Agency). The road transgresses U.S. Forest Service and privately owned land; access is restricted by locked gates.*

This station is equipped with a Deployment Mapping Instrument (DMI) telescope. The DMI is a precision optical telescope on a hydraulic servo driven AZ-EL mounting. The DMI is used to collect engineering sequential and relative metric film and video tape data for general test range application. Slaving is provided by the 360-65 computer through data modems located at the site.

The primary optical system of the telescope is an F/8, 36" clear aperture, modified cassegrain (Ritchey-Chretien) having a 288 inch basic focal length. An optical flat located in the dome is used for minor calibrations and alignments.

The DMI is used primarily to track and record missiles launched from VAFB, located 110 miles to the south of Anderson Peak. The altitude of this station and the geographical location** eliminates a high percentage of atmospheric interference.

This station also houses, maintains and operates three UHF radios (AN/GRC-121). Two of the radios can be remotely keyed from Vandenberg AFB. The radios have most recently been used in the B1 Program and the early Cruise Missile Testing program.

*Persons having prior official clearance to Anderson Peak should call the station well in advance of departure for the Big Sur area to insure that roads are passable and that entry though secured areas has been coordinated.

**Big Sur is considered to be one of the few remaining clear sky areas in the Continental United States.

2.4 RANGE COMMUNICATION

2.4.1 Vandenberg Network Control Center The Vandenberg Network Control Center (**VNCC) Building 7011 is the hub of the WSMC Data Transfer System. Portions of every major data transfer system may be found in Building 7011 as well as the voice, radio, and television switching and conferencing equipments. VNCC, as the focal point for all range data transfer systems, is designated by WSMC as the Network Control Station (NCS). All trouble reports involving communications equipment or circuitry are handled by the Center Technical Services Contractor personnel in the VNCC. All requirements for use of WSMC communications are coordinated and scheduled through the VNCC.

2.4.2 Wheeler Network Control Center The Wheeler Range Network Control Center (WNCC) Wheeler Air Force Base, Oahu, Hawaii, functions as the focal point of the WSMC downrange Data Transfer System and as an intermediate switching hub for the USAF world-wide communications system. WNCC also operates as a circuit switching center between Vandenberg Network Control Center (VNCC) at VAFB, California, and WSMC downrange facilities. WNCC is a manual switching matrix and the hub of communications to other facilities including Kokee Park, Barking Sands, Kaena Point, Amos and Kwajalein.

**VNCC, WNCC, installed equipments are described in the Data Transfer Systems Handbook.

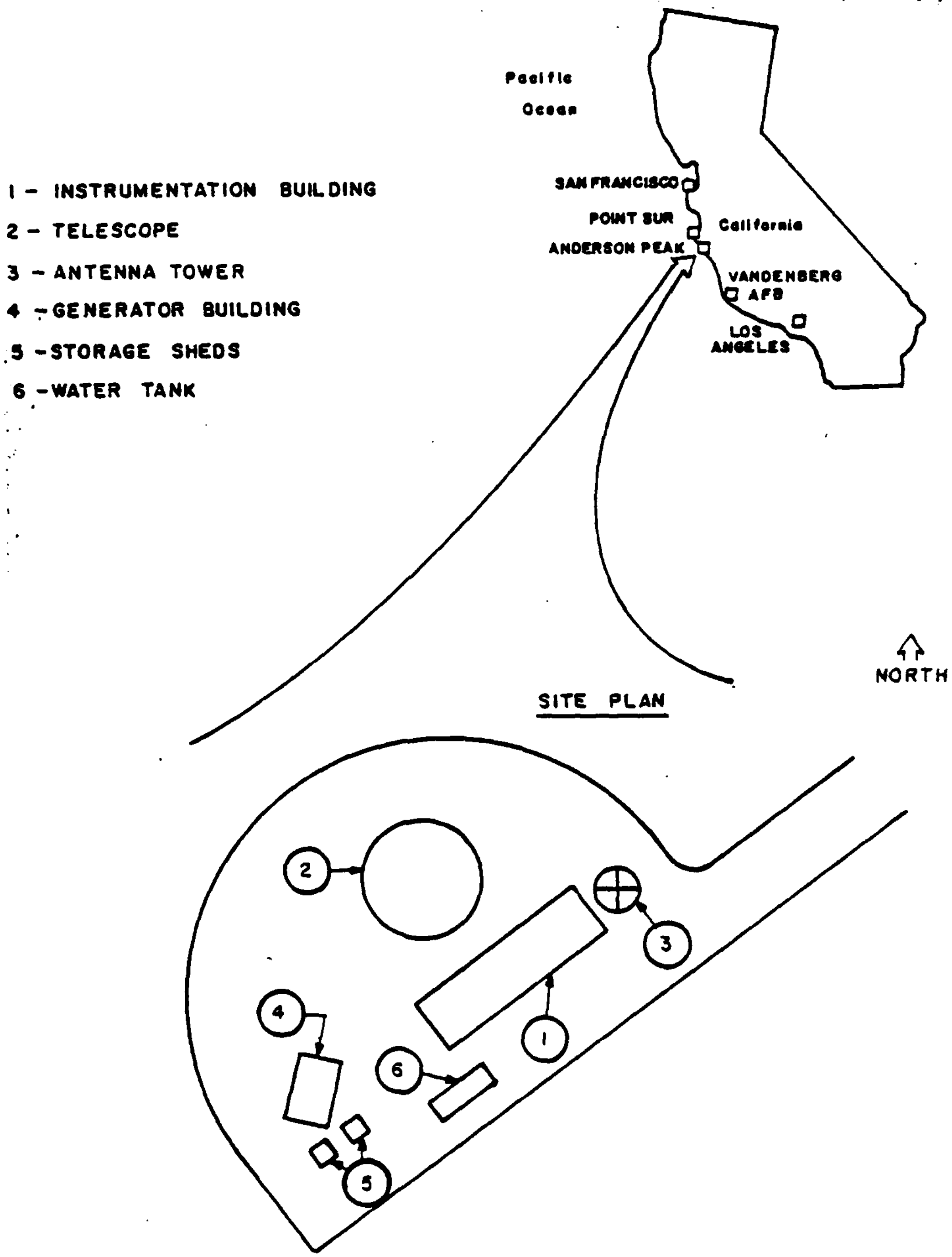

Figure 2-17. Anderson Peak Optical Tracking Station, Site Plan

2.5 SANTA YNEZ PEAK OPTICAL TRACKING STATION

The Santa Ynez Optical Tracking Station (See Figure 2-18) is located at 4100 feet at the summit of Santa Ynez Peak near Santa Barbara, California. The elevation of the site places it above the local marine haze layer eliminating a high percentage of atmospheric interference. The site provides long-range optical engineering sequential coverage for missiles and space boosters launched from Vandenberg into westerly and southern azimuths. The film data is processed and merged with the film data gathered at Anderson Peak to derive and develop relative metric data. Slaving data is provided by the 360-65 computer through data modems at the site. An optical flat located inside the dome is used for minor calibrations and alignments.

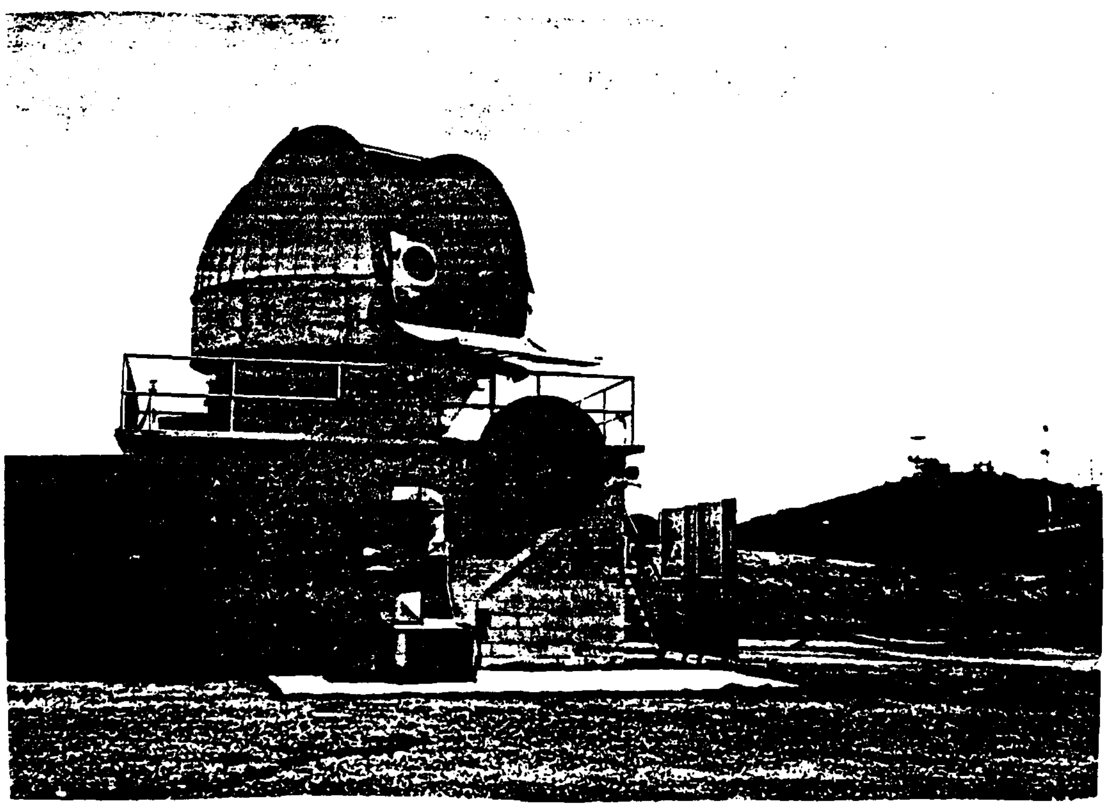

Figure 2-18. Santa Ynez Peak Optical Tracking Station

The Recording Optical Tracking Instrument (ROTI) at this site has a 24-inch Newtonian telescope with focal lengths from 100 through 500 inches in 100-inch increments. The telescope's five-inch naval gunmount has 17-bit encoders in each axis. A fixed 80" focal length quiston lens providing range safety video mounted on left side of trunnion. Other lens include a 20-inch operator tracking finder telescope plus a wide-angle lens with zoom features for manual target acquisition. Telescope sensors and detectors include:

a. A 35 mm precision motion picture instrumentation camera.
b. Gunship image intensification enhancement systems for recording low-light level events.
c. CCTV 525 line camera
d. High resolution Electron Beam Recorder (EBR) for recording gunship video.
e. 875 line magnetic tape video Gunship recordings.

The site is supplied with commercial power for normal operation. An emergency 100 kW diesel generator is on site as a backup power source.

2.6 KAENA POINT, HAWAII

The WSMC Kaena Point AN/FPQ-14 (See Figure 2-19) is located at the western most protrusion of the island of Oahu, approximately two miles west of the Hawaii Tracking Station of the Air Force Satellite Control Facility. The AN/FPQ-14 is an On-Axis Radar. On-axis tracking provides accurate mid-range trajectory data to support Minuteman launches. The prime purpose of the 'Directed Track' is to reduce radar systematic errors to a level where these errors are negligible in the long-arc data reduction and processing used to verify the performance of the Minuteman Weapon System Guidance Subsystem. Site layout is shown on Figure 2-20.

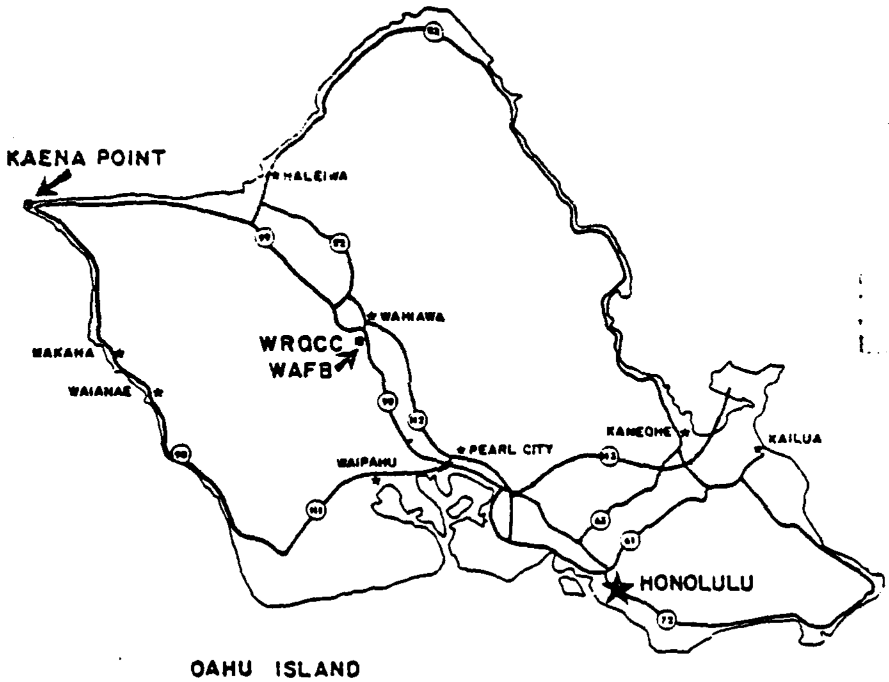

Figure 2-19. WSMC Facilities, Oahu, Hawaii

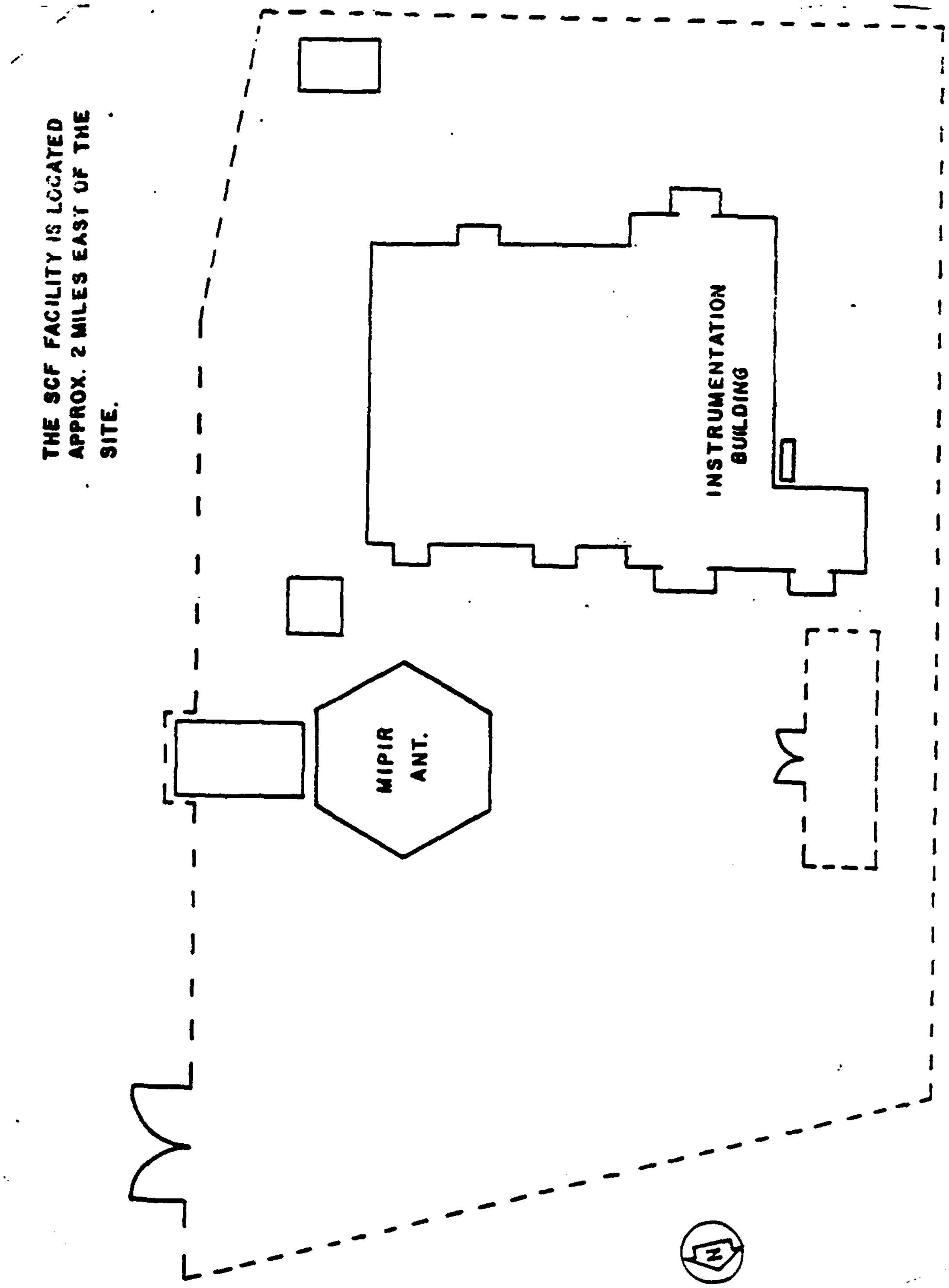

Figure 2-20. Site Plan, AN/FPQ-14 Kaena Point, Oahu, Hawai

SECTION 3.0

DATA ACQUISITION INSTRUMENTATION SYSTEMS

3.1 AN/TPQ-18 RADAR SET

The AN/TPQ-18 Radar Set (See Figure 3-1) is a high-accuracy, long range amplitude comparison, 5400 to 5900 MHz, monopulse radar capable of manual or automatic acquisition and tracking of objects in flight or in orbit. The system provides three-coordinate and range rate data in digital format which is processed by its own RCA 4101 Data Processor.

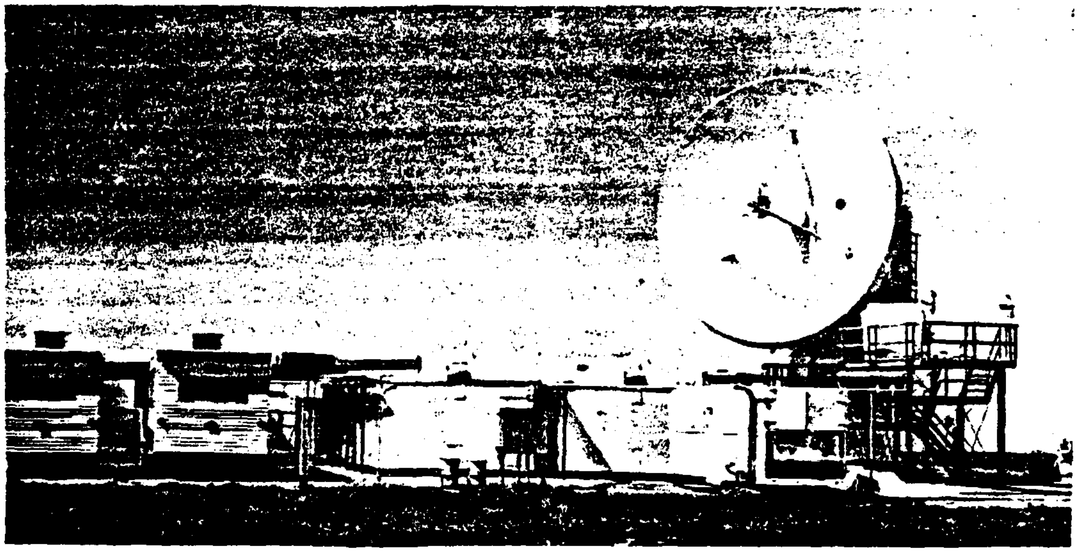

Figure 3-1. AN/TPQ-18, East Side View

This radar set is a transportable version of the AN/FPQ-6 Radar Set comprising: antenna and pedestal, nine 8 by 16-foot equipment shelters, a Data Interface van, a maintenance van, an office and a Computer Annex Trailer (CAT), and a boresight tower. The Data Interface van contains the data handling, timing, and communications equipment necessary to support launch and tracking operations. Figure 3-2 shows the WSMC AN/TPQ-18 site plan.

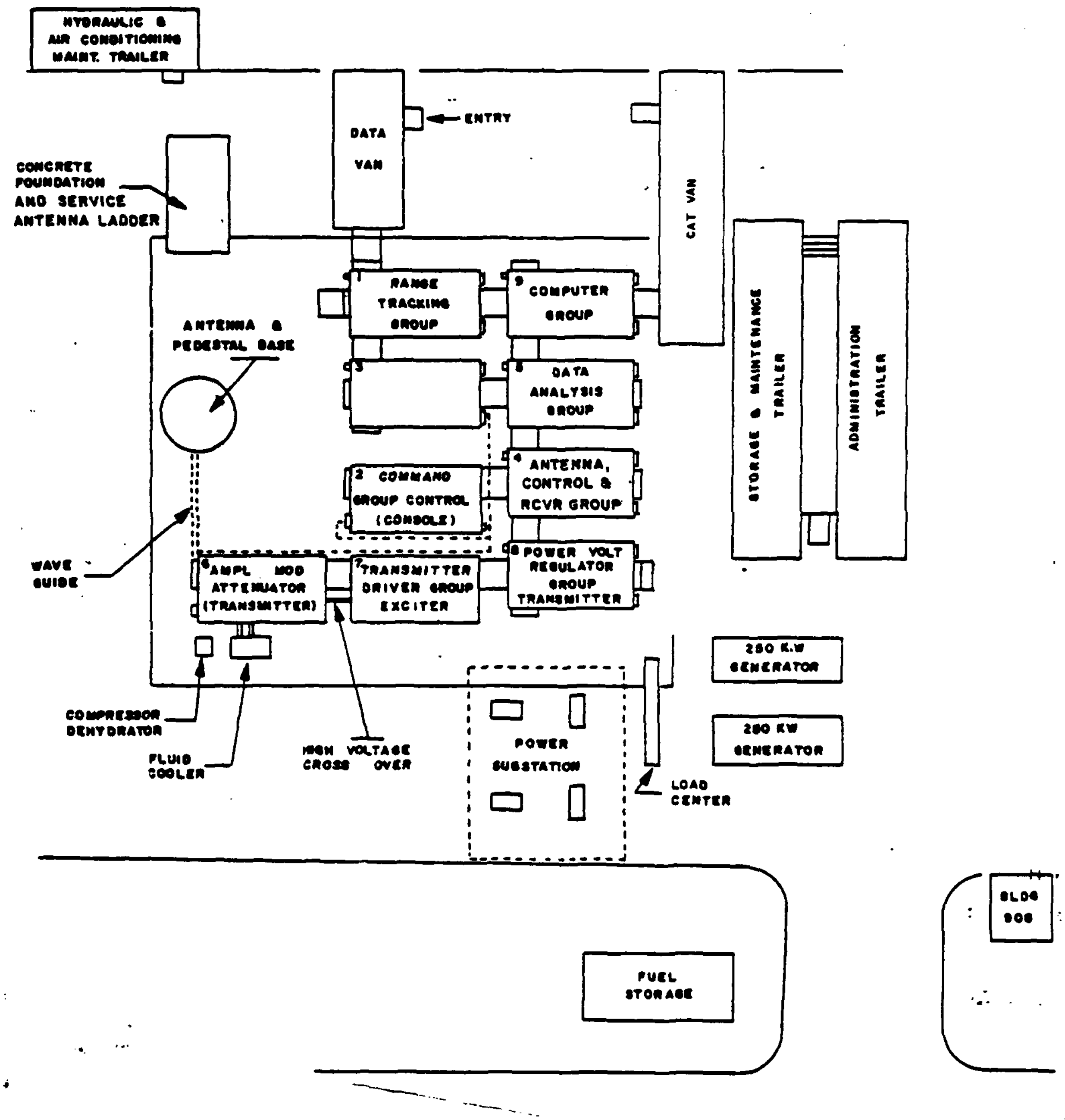

Figure 3-2. Site Plan, AN/TPQ-18, VAFB, California

The AN/TPQ-18 is capable of providing continuous, accurate spherical-coordinate information on appropriate targets at ranges out to 32,000 nmi. The equipment is designed to complement the existing WSMC tracking systems. During a flight test operation, the radar antenna is automatically constrained to follow, continuously, missile or other airborne target with a minimum of tracking jitter or biases. The radar is capable of acquiring and accurately tracking missiles or a satellite, and providing trajectory or orbital data, including range rate, in real-time for operational analysis. This radar has the capability of either skin or beacon tracking modes of operation with the option of displaying either or both video returns. This feature permits switching from skin tracking to beacon tracking. Acquisition sources include computer programs, and a data modem designation to external radars (used for reacquisition).

3.1.1 AN/TPQ-18 Operation. The AN/TPQ-18 uses the monopulse principle in tracking a target. Figure 3-3 is a simplified block diagram of the AN/TPQ-18; The illustration is also typical of the AN/FPQ-6; system differences are noted. Zero-range triggers generated in the range tracking section, are supplied to the transmitter to initiate the transmit-receive cycle. The transmitter develops a high power rf pulse which is transferred through microwave components to the antenna. At the antenna the energy is formed into a narrow beam and transmitted into space. When the antenna is pointed toward a target, it receives either the transmitted pulse, reflected by the target, or a transponder reply from a transponder in the target. The received signal comprises three components, reference, azimuth error, and elevation error. The signals are routed to the receiver where the reference is compared to the angle error signals to provide signals for use in the angle tracking section. The angle tracking section then provides the appropriate signals to control antenna position.

The following paragraphs describe the relationship of the basic subsystems which comprise the AN/TPQ-18. Descriptions are an overall functional basis and are only intended to provide an understanding of subsystem relationships within the complete system.

a. Transmitter Subsystem

The transmitter subsystem consists of a high voltage power supplies and trigger pulse amplifier, a radio frequency exciter, and a radio frequency Klystron amplifier. The transmitter generates approximately 2.5 MW of peak power over a frequency range from 5400 to 5900 MHz. A power programmer is incorporated to allow adjustment of the transmitter output.

b. Antenna Pedestal Subsystem

The antenna is a 29-foot Cassegrainian reflector with a beamwidth of 0.40 degrees and an efficiency of 74 percent. The rf feed can radiate and receive linear or circular polarized signals. The antenna is supported by a two-axis pedestal using a low friction hydrostatic bearing in azimuth and phased ball bearings in elevation. Natural-binary, single-speed encoders derive azimuth and elevation position data.

c. Receiver Subsystem

The receiver subsystem comprises a microwave section, tracking section, a nontracking and AFC section. The receiver is used to resolve the off-axis error of the target and provide the appropriate input signals to the angle tracking subsystem to correct the error. The receiver also develops a gated video signal which is provided to the range tracking subsystem.

d. Digital Range Machine (DIRAM)

The Digital Range Machine (DIRAM) subsystem gives the AN/TPQ-18 an unambiguous range of 32k miles with a range granularity of 2 yards. The DIRAM is a hybrid system incorporating vacuum tube and solid-state circuitry in its design. Digital techniques are used in range timing for fixed and movable trigger generation, range measurement, and target detection. The system operates in an inertia-free servo loop and uses an nth time around tracking approach to maintain high pulse repetition rates for extended unambiguous range tracking. Additional system functional capabilities are automatic target detection, acquisition and ambiguity correction (find and verify), auxiliary tracking, radar phasing and synchronization, transmitter pulse coding, receiver AGC, and doppler correction of receiver LO AFC.

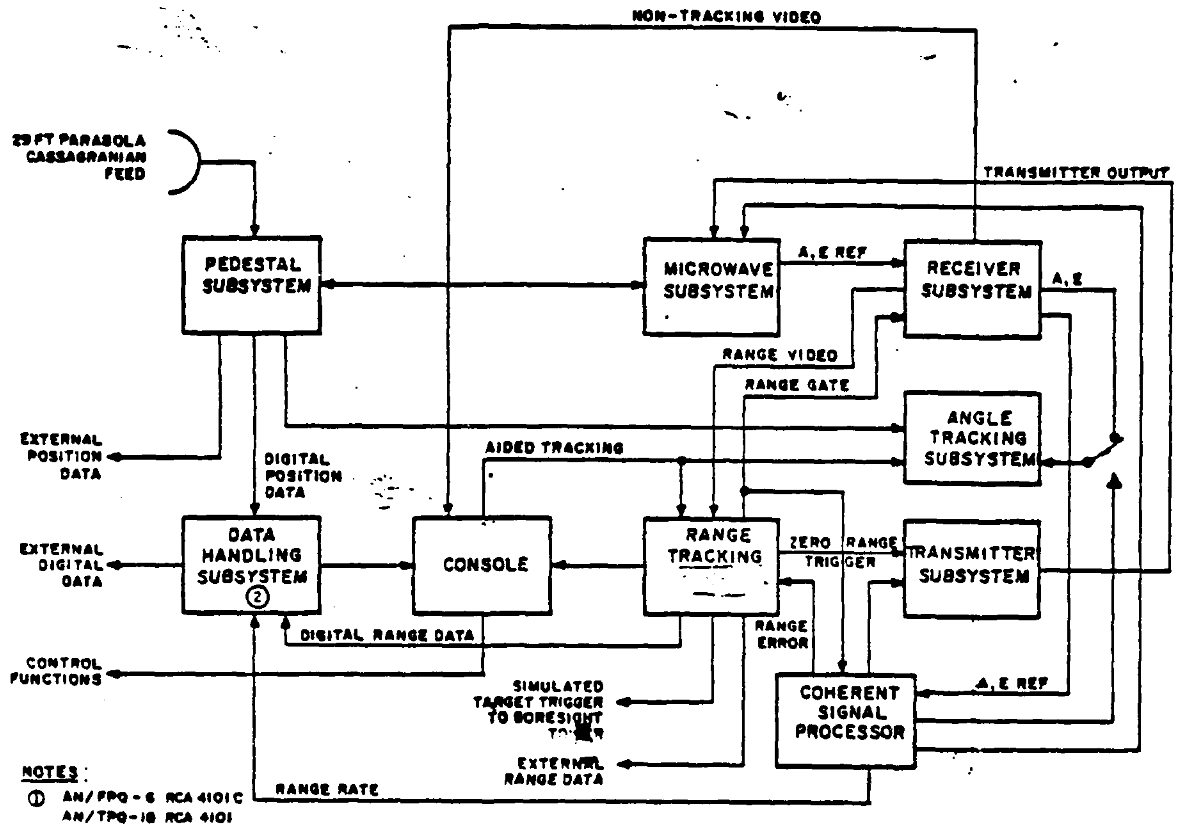

Figure 3-3. AN/TPQ-18 or AN/FPQ-6 Radar Set, Simplified Block Diagrams

e. Angle Tracking Subsystem

The Angle Tracking Subsystem consists of two high torque-to-intertia electro/hydraulic servo loops. Error signals developed during tracking operations are converted into control signals to determine direction and rate of travel in each of the antennas' two axes. The error signals are generated in solid state AZ and EL servo systems from the IF error signals of the three-channel receivers or from the pedestal mounted optical data corrector sub-system U&V error signals.

f. Mode Switch and Console Subsystem

The mode switch and console subsystem provides the control and display circuits for the radar. These circuits operate in conjunction with associated units in the other system to effect complete operational control of the radar; provide monitoring facilities for checking equipment performance, and aid the operator in acquiring and tracking a target. The console also supplies command signals to the mode switch section of the subsystem to initiate the desired equipment operation.

g. Data Handling Section

The data handling subsystem comprises all elements for the collection, processing, display, and transmission of digital and analog information to and from internal or external sources concerning the three radar coordinates (azimuth, elevation, and range) and various control commands. It is divided into two sections: a data handling section, and a data processing section. The data handling section accepts digital and analog data from various sources and provides for digital data communications and control commands, into and out of the data processor, other portions of the radar, and external sources. The data processing is performed by an RCA 4101 Data Processor, a stored program computer, organized for both on-line and off-line operation, whose primary role is realtime processing of tracking date. The computer is programmed to correct raw position data and certain radar errors and make the results available for internal or external use.

h. Coherent Signal Processor Subsystem

The Coherent Signal Processor (CSP) Subsystem gives the AN/TPQ-18 and the AN/FPQ-6 the capability to provide radial velocity data. The radial velocity data is obtained by direct measurement of the doppler effect from the target. The CSP makes use of the RCA 4101 or 4101C Data Processor, digital frequency expansion techniques, and digital oscillators (frequency synthesizer). The data processors convert the doppler information to analog and digital radial rate outputs.

i. Power Distribution Subsystem

Each system in the AN/TPQ-18 is equipped with its own primary power load center. With the exception of the transmitter subsystem each load center is of similar design and construction. Two sources of unregulated primary power are required: 227/480V, 3 phase, 60 Hz and 120/208V, 3 phase, 60 Hz.

k. Boresight Subsystem

The boresight subsystem is used to optically and electrically align the radar system. The subsystem consists of a 150-foot tower and an equipment shed, both located approximately 2000 feet from the antenna pedestal. The shed contains the subsystem electronic equipment using a pulse generator, rf signal generator, rf amplifier, and an rf precision attenuator.

3.1.2 AN/TPQ-18 Technical Data

- Location (Coordinate Ref.: North American 1927 Datum)

  Station: VAFB

  Site: 023003

- Transmitter

  Frequency: 5400 to 5900 MHz (tunable)

  Peak Power: 2.5 MW

  Pulsewidth: 0.25, 0.50, 1.0, 2.4 usec

  Pulse Rate: 160 to 640 PRF

- Receiver

  Frequency: 5400 to 5900 MHz (tunable)

  Bandwidth: 0.6 to 4.8 MHz

  Noise Figure: 11 dB (3.5 dB with parametric amplifiers)

- Antenna

  Type: 29-ft Cassegrainian

  Gain: 51 dB (nominal)

  Beamwidth: 0.45 deg (nominal)

  Polarization: Vertical and Circular

- Coverage

  Azimuth: 360 deg

  Elevation: -2 to +182 deg

  Range: 32 knmi (unambiguous)

  Tracking Rates: Azimuth, 28 deg/sec

  Elevation, 28 deg/sec

  Range, 20 kyds/sec

- **Output**

Range:	25-bit binary LSB = 1.953125 yds
Range Rate:	20-bit binary LSB = 0.03125 yd/sec
Angular:	19-bit binary LSB = 0.0122 mils

- **Precision** - The design goal precision for skin tracking a one square meter target is:

Azimuth:	±0.05 mil (rms)
Elevation:	±0.05 mil (rms)
Reduced Range Data:	±3-yd (rms) (at 300 nmi with S/N of 15 dB)
Range Rate	Refer to Coherent Signal Processor

- **RCA 4101 Data Processor**

Maximum Work Length:	30 bits, including 2 parity bits
Memory Capacity:	16,384 words
Add Time:	16.5 usec
Multiply Time:	75.5 usec
Read-In/Read-Out Time/Bit (memory):	2.0 usec

- **Coherent Signal Processor**

Radial Velocity Capability:	Up to ±20 kyds/sec
Radial Acceleration Capability:	Up to ±2 kyds/sec squared
Measurement Accuracy:	0.038 yd/sec rms*
Digital Radial Velocity LSB:	1/32-yd/sec

*including dynamic lag errors but excluding propagation errors on a 10 dB target.

3.2 AN/FPQ-6 RADAR SET

The AN/FPQ-6 Radar Set (See Figure 3-4) is a high-accuracy, long-range 5400 to 5900 MHz, monopulse radar capable of automatic acquisition and tracking of cooperative and non-cooperative vehicles in flight or orbit and is a fixed-station installation using a one-story building to house all electronic equipment. The antenna pedestal is mounted atop a concrete tower adjacent to the main building.

Figure 3-4. AN/FPQ-6 Overall View

3.2.1 AN/FPQ-6 Operation Operation of the AN/FPQ-6 is essentially the same as that for the AN/TPQ-18 Radar, therefore, Paragraph 3.1.1 should be referred to for AN/TPQ-18 operating principles and description.

The following paragraphs describe the relationship of the basic subsystems that comprise the AN/FPQ-6. Descriptions are on an overall functional basis and are intended to provide an understanding of subsystem relationships within the complete system.

a. Transmitter Subsystem

An ultra-stable frequency synthesizer-multiplier and a *twystron power amplifier is the heart of the transmitter subsystem. The transmitter is capable of developing rf peak power outputs in excess of 3.2 MW over a frequency range of 5400 to 5900 MHz.

*A hybrid TWT klystron.

b. Antenna Pedestal Subsystem

The antenna is a 29-foot parabolic Cassegrainian reflector with five feed horns. Linear or circular polarization may be designated by the operator from the control console. The subreflector is a 2.5-foot hyperbola. The antenna is supported by a two-axis pedestal using a low friction hydrostatic bearing in azimuth and phased ball bearings in elevation. Natural binary, single-speed optical encoders derive azimuth and elevation position data.

c. Receiver Subsystem

The receiver subsystem comprises a microwave section, a tracking section and AFC section. The tracking section is a solid state, low noise, broadband three channel system. The receiver is used to resolve the antenna off-axis error of the tracked trarget and provide the appropriate input signals to the angle tracking subsystem. A gated video signal for the range tracking subsystem is also provided by the receiver. Phase shifters for beacon and skin operation with linear or circular polarization are installed in each channel to maintain proper phase relationships in all operating modes. Local oscillator gating, selectable at the control console (see Figure 3-5), enables simultaneous reception of both skin and beacon signals without degradation of receiver sensitivity. AFC loops are provided to maintain a constant IF frequency for skin or beacon tracking.

d. Angle Tracking Subsystem

The Angle Tracking Subsystem consists of two high torque-to-inertia electro/hydraulic servo loops. Error signals developed during Tracking operations are converted into control signals to determine direction and rate of travel in each of the antennas' two axes. The error signals are generated in solid state AZ & EL servo systems from the IF error signals of the three channel receivers or from the pedistal mounted optical data corrector subsystem. U&V error signals.

e. Range Tracking Subsystem

The Integrated Digital Ranging (IDRAN) subsystem gives the AN/FPQ-6 an unambiguous range of 32,000 nmi with a range granularity of 2 yards. The IDRAN design is all solid state circuitry using digital techniques where applicable. The system operates in an inertia-free servo loop and uses an "nth" time around tracking approach to maintain high pulse repetition rates for extended unambiguous range tracking. For range tracking, four sections of the subsystem are used: (1) range timing, (2) range error, (3) receiver control and (4) data handling. The timing produces the triggers necessary for synchronization of the range system components and the radar system. The range error section produces the necessary trigger pulses and gates to detect and null target range errors to maintain automatic target track and develop target range data. The target range triggers initiate receiver control timing in the receiver control section for receiver range gating, local oscillator gating and generation of commutation voltages for application to the receiver subsystem. The data handling section interfaces and controls the transfer of input range designation data or output range position data in/out of the subsystem. Additional functional capabilities are automatic target detection, acquisition and ambiguity (zone ambiguity resolution) correction; auxiliary tracking; radar phasing and synchronization; transmitter pulse coding; receiver AGC; and doppler correction of receiver LO automatic frequency control.

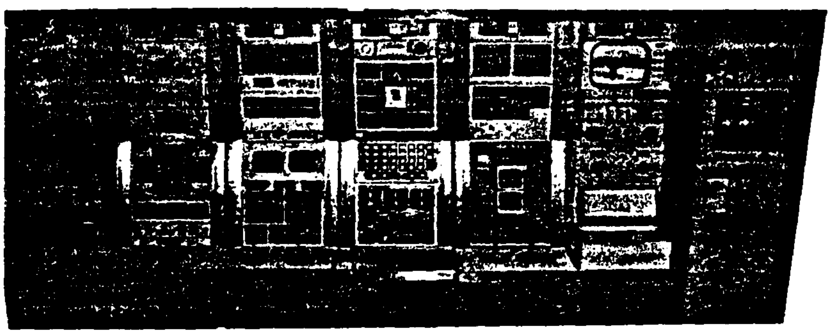

Figure 3-5. AN/FPQ-6 Control Console, Front View

f. Data Handling Subsystem

The data handling subsystem comprises all elements for the collection, processing, display, and transmission of radar coordinate data. This subsystem comprises various input and output buffers, D/A and A/D converters, a time code translator, teletype equipment, and a Model 4101C Data Processor. The data processor is a 16,384-word, stored-program computer, bus-organized for both on-line and off-line operation. The role of the computer is, primarily, the real-time processing of tracking data.

The computer automatically corrects the trajectory data for tracking errors such as null shift, feed droop, pedestal leveling, and axis nonorthogonality. The Model 4101C Data Processor also handles data for the decimal and first difference displays at the control console and for automatic reacquisition during automatic side-lobe detection.

g. Coherent Signal Processor Subsystem

Refer to 3.1.1 h. for the description of the coherent signal processor subsystem.

3.2.2 AN/FPQ-6 Technical Data

o Location (Coordinate Ref.:	North American 1927 Datum)
Station:	Pillar Point AFS (213002)
o Transmitter	
Frequency:	5400 to 5900 MHz (tunable)
Peak Power:	3.25 MW
Pulsewidth:	0.25, 0.5, 1, 2.4 usec
Pulse Rate:	160 and 640 pps
o Receiver	
Frequency:	5400 to 5900 MHz (tunable)
Bandwidth:	0.5 to 4.8 MHz
Noise Figure	11 dB (3.5 dB with parametric amplifiers)
o Antenna	
Type:	29-ft Cassegrainian
Gain:	51 dB (nominal)
Beamwidth:	0.45 deg (nominal)
Polarization:	Vertical and circular
o Coverage	
Azimuth:	360 deg
Elevation:	-2 to +182 deg
Range:	32K nmi unabiguous
Tracking Rates:	Azimuth, 28 deg/sec Elevation, 28 deg/sec Range, 20 kyds/sec
o Output	
Range:	25-bit serial binary word. LSB = 1.953125
Range Rate:	20-bit binary LSB = .03125 yd/sec
Angular:	19-bit single speed binary LSB = .0122 mil

- **Precision** - The Design goal precision for skin tracking a one square meter target is:

Azimuth:	±0.05 mil (rms)
Elevation:	±0.05 mil (rms)
Reduced Range Data:	±3-yd (rms) (at 300 nmi with S/N of 15 dB)
Range Rate:	Refer to Coherent Signal Processor

- **RCA 4101C Data Processor**

Maximum Word Length:	32 bits + 2 parity bits
Memory Capacity:	16,384 words
Add Time:	5.0 usec
Multiply Time:	37.5 usec
Read-In/Read-Out Time/Bit (memory)	2.0 usec

- **Coherent Signal Processor**

Radial Velocity Capability:	Up to ± 20 kyds/sec
Radial Acceleration Capability:	Up to ± 2 kyds/sec squared
Measurement Accuracy:	0.038 yd/sec rms*
Digital Radial Velocity LSB:	1/32 yd/sec

*Including dynamic lag errors but excluding propagation errors on a 10 dB target.

3.3 AN/FPS-16 RADAR SET

The AN/FPS-16 Radar Set is a high-precision, 5400 to 5900 MHz mono-pulse tracking radar designed specifically for missile tracking operations. The WSMC has three landbased AN/FPS-16's. The landbased installations are housed in two-story concrete structures at SVAFB (systems 1 and 2) and Pillar Point AFS (See Figures 3-6 and 3-7). Simultaneous tracking operations using WSMC and PMTC AN/FPS-16 radars are possible. The AN/FPS-16 is able to obtain and transmit to using activities high accuracy trajectory data from launch vehicles undergoing tests or orbital data from earth satellites. Modifications have increased the range, acquisition, and control capabilities of each radar set (refer to Table 3-I). Real-time radar data is transmitted to the Missile Flight Control Center plotboards for use by the MFCO in making command control decisions. Data is also transmitted to other sites for antenna slaving and to recorders for later data reduction.

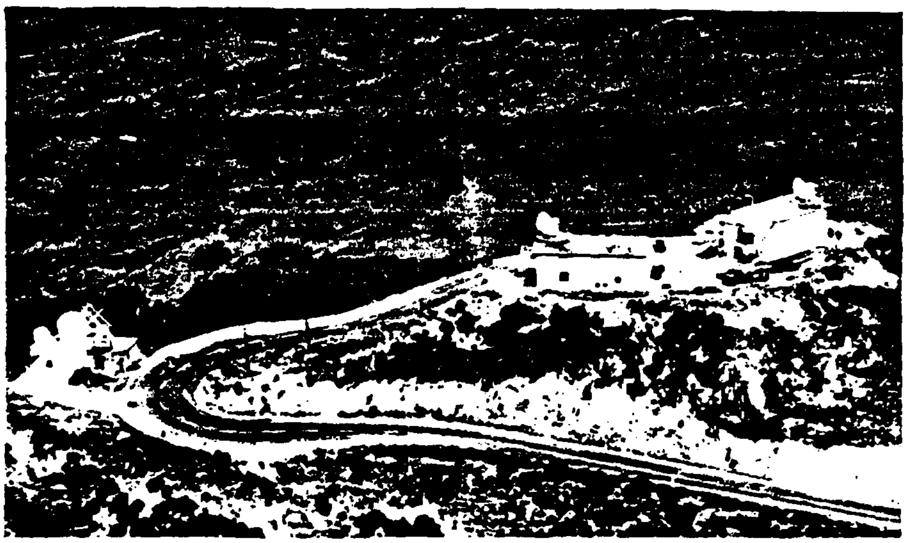

Figure 3-6. AN/FPS-16, Overall View

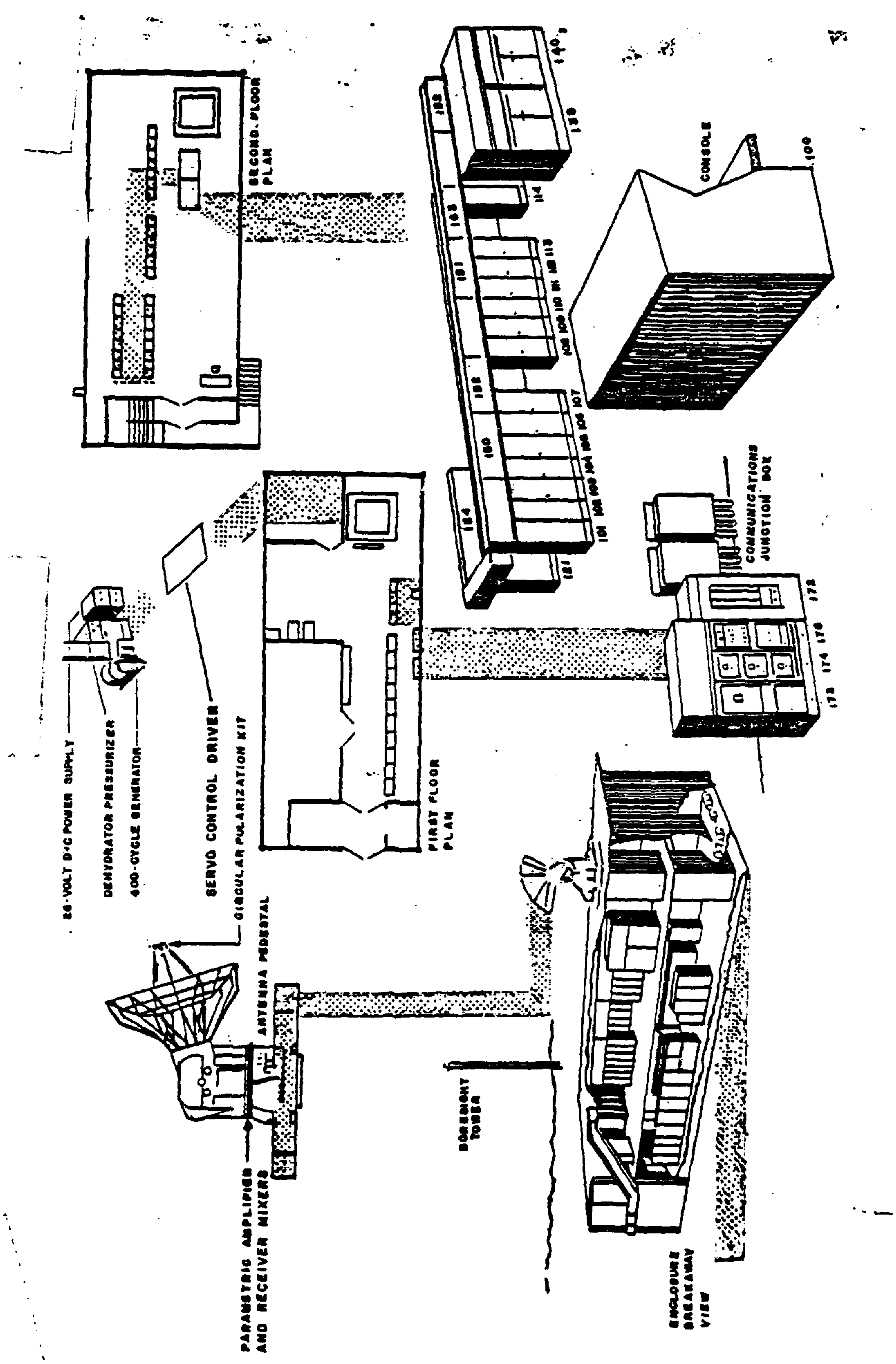

Figure 3-7. AN/FPS-16, Typical Installation, At VAFB and PPAFB

Table 3-I. MAJOR MODIFICATIONS TO WSMC AN/FPS-16 SYSTEM

MODIFICATION	VAFB SYSTEM #1	VAFB SYSTEM #2	PILLAR POINT
32,000-Mile Tracking Kit (IDRAN)	X		X
Digital Range Mod (DIRAM) 8000 Mile Tracking		X	
CP (Circular Polarization) Kit	X	X	X
High-Power Tunable Magnetron	X	X	X
Closed Circuit TV	X	X	
Parametric Amps	X	X	X
Integrated Console		X	X
Digitized AGC	X	X	X
Automatic Phasing System	X	X	X
19-Bit AZ/EL Optical Encoders	X	X	X
Radar Calib Sys (RCS)	X	X	X
Solid State Receivers	X	X	X
Solid State Angles & Drive Motor Breaks	X	X	X

3.3.1 AN/FPS-16 Operation The complete AN/FPS Radar Set consists of the radar equipment, suitably mounted in an enclosure, and its associated ancillary equipment. The enclosure consists of the pedestal tower, two floor levels on which the radar equipment is located, the enclosure air conditioner, and other items such as heating equipment, water supply, etc. The radar equipment consists of the radar antenna/pedestal, an operator console, radar cabinets, interconnecting cables, the radar air cooling system, and supporting components. The major portion of the equipment is located on the second floor and consists of the operators console, cabinets, and overhead assemblies. The cabinets are arranged in banks (groups), affixed to base assemblies which are connected through an overhead assembly. Cooled air from the radar air conditioner is circulated up through the cabinets via the base assembly and directed back to the air conditioner via the overhead assembly and other air ducts.

The following paragraphs discuss briefly the relationship of the above subsystems to the overall system. Figure 3-8 is a composite simplified system diagram of the WSMC AN/FPS-16.

a. Transmitter subsystem

The transmitter subsystem generates rf pulses using a tunable magnetron. The transmitter pulses are used to illuminate a target when the skin tracking mode is selected, or to trigger a target transponder when in the beacon tracking mode. During skin tracking, a modulator triggers, occurring at the radar's Pulse Repetition Frequency (PRF), is supplied to the pulse generator from the reference trigger generator in the range tracking subsystem. During beacon tracking, the coded pulses required to trigger the target's beacon (transponder) are supplied to the pulse generator from the system's code pulse generator. Upon receipt of the coded or uncoded trigger, the pulse generator and driver-modulator generate and amplify pulses, which, in turn, excite the magnetron oscillator. The magnetron's generated high power pulses are fed through a variable attenuator and waveguides to the antenna's 4-horn feed, and radiated into space by the 12-foot antenna reflector.

b. Receiver Subsystem

The signal reflected from the target during skin tracking, or the transponder rf signal during beacon tracking is focused by the antenna's reflector on the input (4-horn feed) of the microwave reciver section, of the receiver subsystem. Here, the returned rf signal is resolved into three if signals. Two of the If signals represent the difference between the target position and the antenna's position in the azimuth and elevation planes. The other If signal is a system generated reference from which the target's direction and amount of deviation with respect to the actual antenna position is determined. The received signals are mixed with the output of the two klystron local oscillators (skin or beacon) to produce constant 30 MHz If signals. During the skin tracking mode any deviation from the 30 MHz between TX + LO frequency produces a dc Automatic Frequency Control (AFC) signal in the AFC section. This signal is applied to the skin local oscillator.

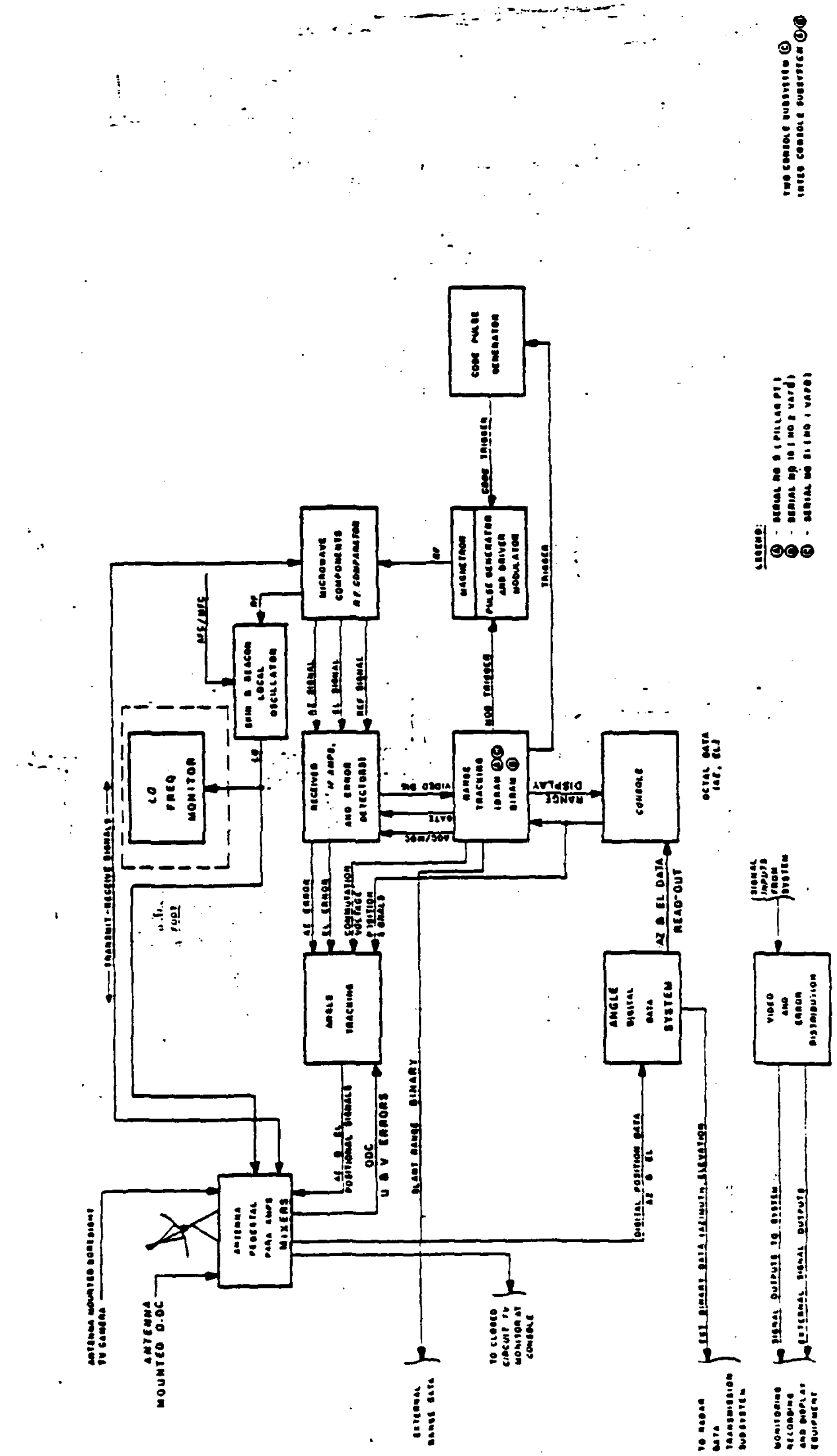

Figure 3-8. AN/FPS-16, Simplified Block Diagram, VAFB and PPAFS

Each AN/FPS-16 Radar Set has been modified to allow the skin or beacon local oscillator to be operated simultaneously or independently during a tracking operation. The elevation, azimuth and reference amplifiers receive automatic or manual gain control voltages (AGC) from the mode control section located in the range tracking subsystem. The reference, azimuth, and elevation rf signals from the microwave section are mixed and amplified in the receiver subsystem by if amplifiers. The reference 30 MHz if signal is gated, detected, and supplied to the range tracking subsystem for use in range determination. The azimuth and elevation 30 MHz if signals are compared with the reference If signal to produce the elevation and azimuth gated error signals. The amplitude and polarity of the gated error signals are proportional to the difference between the target and antenna position. The error signals are then suppliedto the associated angle tracking section as signals used to position the antenna.

c. Range Tracking Subsystem

The range tracking subsystem automatically tracks a target in range and provides range information to other subsystems within the AN/FPS-16 and to external equipment. The range tracking subsystem also supplies external equipment timing triggers, the modulator trigger for the Transmitter Subsystem, the gate voltages for the receiver subsystem, and other necessary timing pulses for internal system use. In addition, the range tracking subsystem provides the AGC and commutation voltages for the receiver and angle tracking subsystem.

d. Angle Tracking Subsystem

The angle tracking subsystem enables azimuth and elevation antenna control during acquisition and automatic track. This is accomplished by the solid state azimuth and elevation servo system which respond to error signals from the receiver subsystem during automatic tracking, external drive signals during acquisition, and the angle handwheels on the console during manual operation.

e. Antenna Pedestal Subsystem

The antenna pedestal subsystem consists of a stationary base, an azimuth turntable, an elevation assembly, an rf head, and reflector assembly. The stationary base houses data take-off devices (encoders) which provide azimuth and elevation data outputs. The antenna pedestal is positioned in azimuth by the two drive motors which respond to tracking error signals from the angle tracking subsystem. Mountings for an optical data sensor used for short distance tracking of a missile flame, and a T.V. camera for visual observations of targets being tracked are on the trunnion assembly. The antenna (See Figure 3-9) is a 12-foot parabolic reflector with a 4-horn monopulse feed.

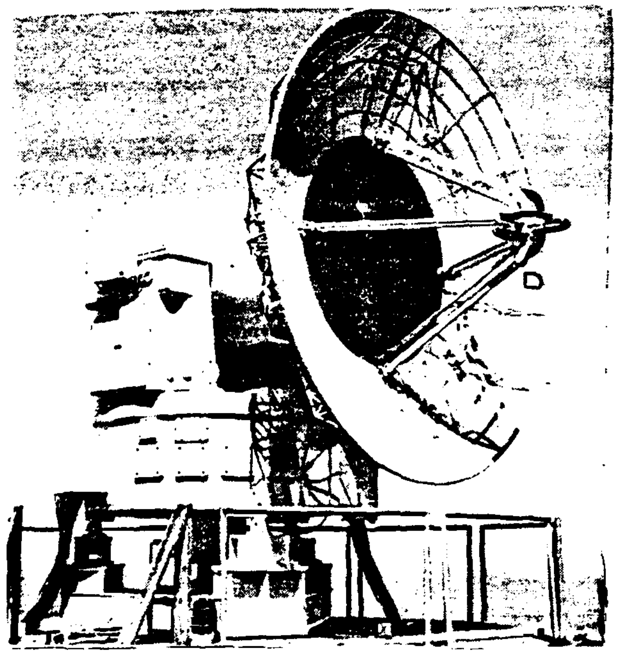

Figure 3-9. AN/FPS-16 Antenna, Front View

f. Boresight Tower

A boresight tower, approximately 1500 feet from the antenna, is used to optically and electrically align the AN/FPS-16. The boresight tower is topped by a platform on which is mounted the rf feed horn and its associated optical targets. The boresight signal generating equipment is housed in an enclosure located at the base of the tower. Figure 3-10 shows a typical boresight tower installation.

g. Control Subsystem

The control subsystem enables the control console operator to exercise complete operational control over the radar system. The control subsystem provides operating personnel with voice communications and monitoring facilities for checking equipment performance and to assist target acquisition and tracking. The target is tracked through received beacon transmissions or skin returns. Initial angle acquisition of the target is accomplished using a predetermined acquisition point.

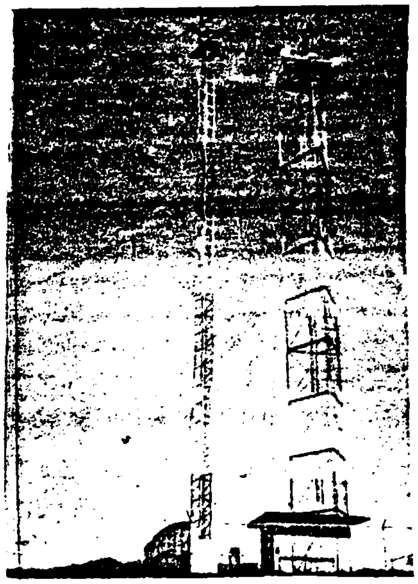

Figure 3-10. Radar Boresight Towers, Typical Installation

h. Data Subsystem

The Data subsystem has four major functions:

1. Develop azimuth, elevation, and range position versus time information.
2. Develop supplementary self-check data.
3. Record azimuth, elevation, range error, and AGC voltage data for post-operational analysis.

Data take-off in angle coordinates is in digital form. Range and angle digital data output is in straight binary form, with least significant digit first (23 or 25 bits, range and 17-bits, angle). The Digital Range Machine (DIRAM) has a 23-bits in range and Integrated Digital Range (IDRAN) has 25 bits in range.

i. Power Distribution & Control Subsystem

The power distribution & control subsystem includes all equipment necessary to provide regulation and distribution of the primary and secondary power supply.

3.3.2 AN/FPS-16 Technical Data

- Location (Coordinate Ref: North American 1927 Datum)

  Station/Site

  VAFB/023001

  VAFB/023002
  Pillar Point

  213001

- Transmitter

  Power Ouput

Tunable Frequency Magnetron:	High Power, 1 MW ±2 dB peak
	Low Power, 250 kW ±2 dB peak (VAFB only)
Dynamic Range Power Program:	30 dB
Frequency	
High Power Magnetron:	5400 to 5900 MHz
Low Power Magnetron:	5450 to 5825 MHz
PRF (Inertial):	160, 320, 640 pps
Pulsewidths:	0.25 ±0.05, 0.5 ±0.08 and 1.0 ±0.1 usec

- **Receiver**

Noise Figure:	11 dB (3.5 dB with parametric amps)
Intermediate Freq:	30 MHz
Wide B andwidth:	6 MHz
Narrow Bandwidth:	2 MHz
Dynamic Range of Gain Control:	73 dB

- **Antenna**

Size:	12-ft parabolic reflector, four-horn monopulse feed
Gain:	43.5 dB (nominal)
Beamwidth:	1.2 deg
Polarization:	Vertical or circular. Two axis mount

- **Radar Coverage**

Azimuth Tracking Range:	360 deg continuous
Azimuth Tracking Rate:	42 deg/sec
Azimuth Tracking Acceleration:	550 mil/sec (max)
Elevation Tracking Range:	-10 to +85 deg
Elevation Motion Range:	-10 to +190 deg
Elevation Tracking Rate:	25 deg/sec
Elevation Tracking Acceleration:	550 mil/sec (max)
Range Tracking Range:	500 yd to 32,000 nmi (System #1) 500 yd to 8,000 nmi (System #2) 500 yd to 32,000 nmi (PPAFS)
Range Tracking Rate (slant):	20 kyd per sec
Range Tracking Acceleration:	2,000 yd/sec^2 (max)

- **Output**

Synchro Azimuth and Elevation:	60 Hz, 2-speed (36/1, 1/1)
Digital:	Angle: 19-bits (0.0122 mils bit) binary
	Range: 25-bits (2-yd/bit) binary (System #1)
	23-bits (2-yd/bit) binary (System #2)
	25-bits (2-yd/bit) binary (PPAFS)
	Sample Rate: 20/sec

- **Precision** (exclusive of propagation errors)

Range:	±30-ft (System #1)
	±30-ft (System #2)
	±30-ft (PPAFS)
Azimuth:	±0.1-mil
Elevation:	±0.1-mil

3.4 AA/M-33 RADAR SET

The AA/M-33 Radar Set (See Figures 3-11 and 3-12) is a modified, van mounted fire control radar used for balloon tracking. Figure 3-13 shows AA/M-33 data flow.

The tracking capability of the AA/M-33 radar was extended when it was reconfigured and equipped with a MR 17-A Meteorological Receiver. This receiver works in conjunction with a lightweight (less than one pound) BT-20 self-contained transponder. A weather balloon, equipped with the transponder allows the radar to readily acquire and auto-track the transponder balloon carrier.

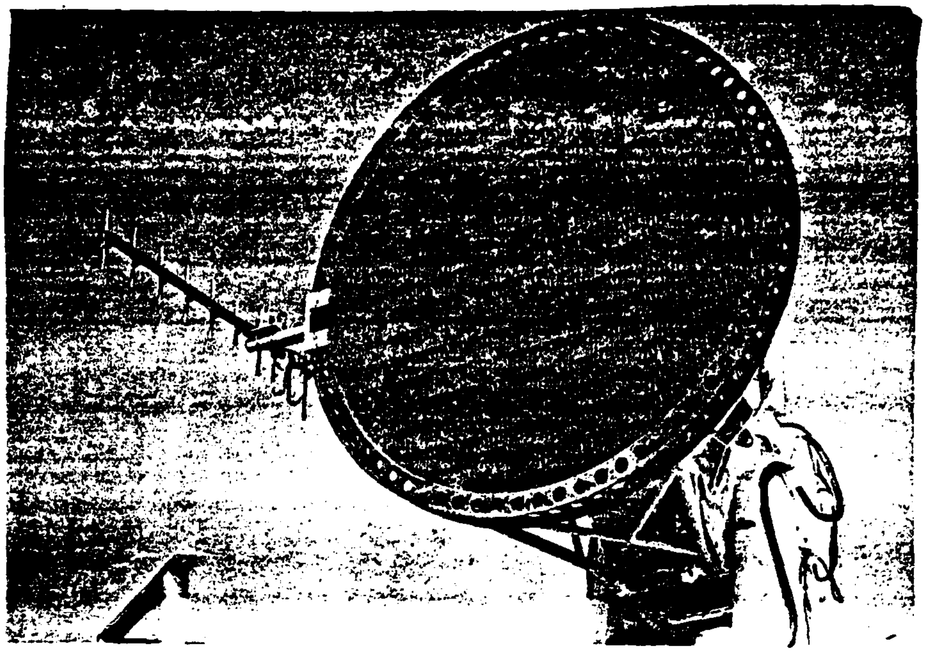

Figure 3-11. AA/M-33 Side View

The target range is obtained by an electro-mechanical range computer. Target azimuth and elevation angles are obtained by accurately pointing the antenna at the target. Visual presentation of target video is obtained on three A- type indicators; one indicator each for azimuth, elevation, and range. The system comprises five groups: a transmitting group, a receiving group, a range data channel, an azimuth data channel, and an elevation data channel.

3.4.1 AA/M-33 Technical Data

o Location

Station/Site

SVAFB/023702

- **Location** (Coordinate Ref.)

Station:	SVAFB
Site:	023702

- **Transmitter**

Frequency:	8500 - 9600 MHz (Tunable)
Peak Power:	250 KW
Pulsewidth:	0.25 usec.
Pulse Rate:	1000 PRF

- **Receiver**

Frequency:	8560 - 9660 MHz
Bandwidth:	10 MHz (IF)
Noise Figure:	12.5db (Better than)

- **Antenna**

Type:	Metal-plate, phase-advance lens
Gain:	39db
Beamwidth:	20 mils or (1.125 deg.)
Polarization:	Vertical

- **Coverage**

Azimuth	0 to 6400 mils or 360 deg.
Elevation:	-180 to +1600 mils or (-10.13 to 90 deg.)
Range:	100 Kyds
Tracking Rates:	Azimuth: 700 mils per sec. Elevation: 500 mils per sec. Range: 4,000 yds per sec.

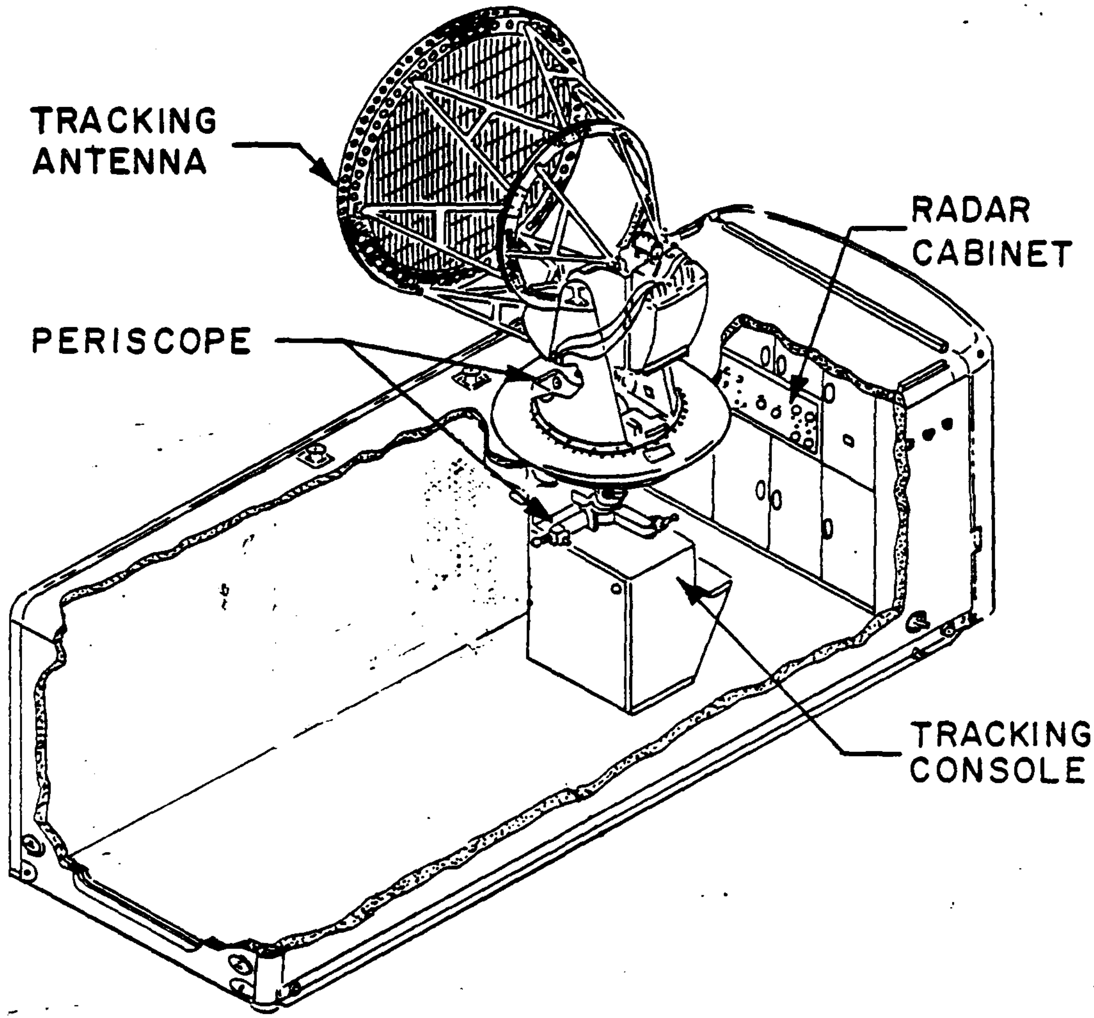

Figure 3-12. AA/M-33 Radar Van, Cutaway View

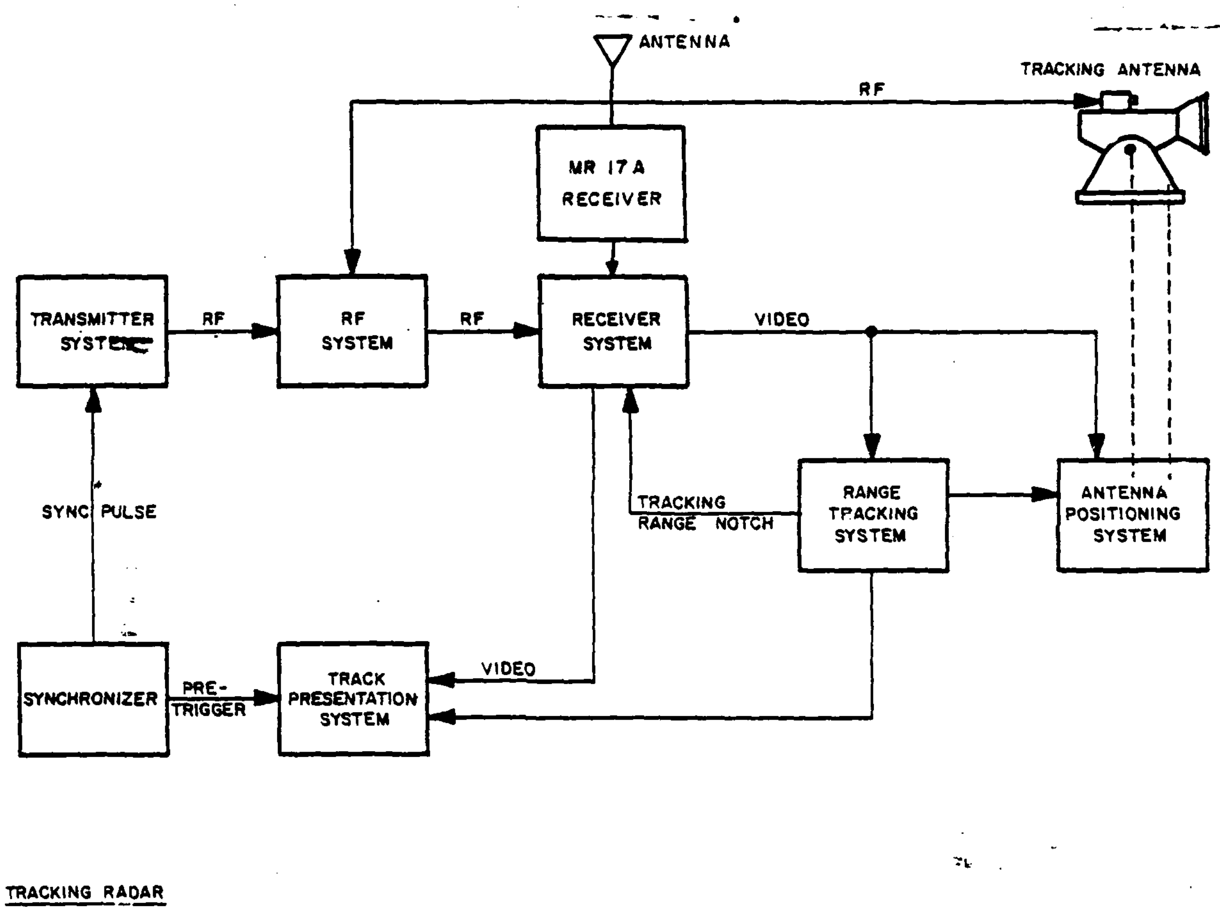

Figure 3-13. AA/M-33 Data Flow Diagram

3.5 GENERAL ELECTRIC RADIO TRACKING SYSTEM (GERTS AN/URW-12)

The GERTS is a modified MOD III Guidance System which was designed for ground guidance of the Atlas D Series weapon system. The GERTS is a highly accurate missile tracking and trajectory measuring system with command guidance capabilities and utilizes a Harris S120/4 computer which is dedicated to the guidance function. The GERTS is currently being used simultaneously as a missile guidance system and a range flight control instrumentation system. The GERTS operates with a missile-borne system comprised of a pulse beacon decoder, antenna, and associated hardware. (See Figure 3-14).

3.5.1 GERTS Operation The GERTS comprises the following subsystems:

- o Automatic Position Tracking Radar Set, AN/GRQ-2B
- o Rate Measuring Set, AN/GRS-1A, *equipment is in place but deactivated.
- o Flight Data Recording System (FDR)
- o Computer System (Harris 5-120/4)
- o Interface Equipment

a. Position measuring (Track) Subsystem (AN/GRQ-2B

The position measuring (track) subsystem is a precision 9220 MHz phase amplitude monopulse beacon-tracking radar. This subsystem has four basic functions as follows:

o Accurate measurement of missile position in real time throughout the powered flight and a sufficient amount of the ballistic flight to allow accurate impact or orbit prediction.

o Supplying antenna pointing information for rate measuring *

o Providing basic timing for the system.

o Providing a ground-to-missile data link for the purpose of transmitting missile steering commands and as many as 10 discrete commands.

* Equipment is in place but deactivated.

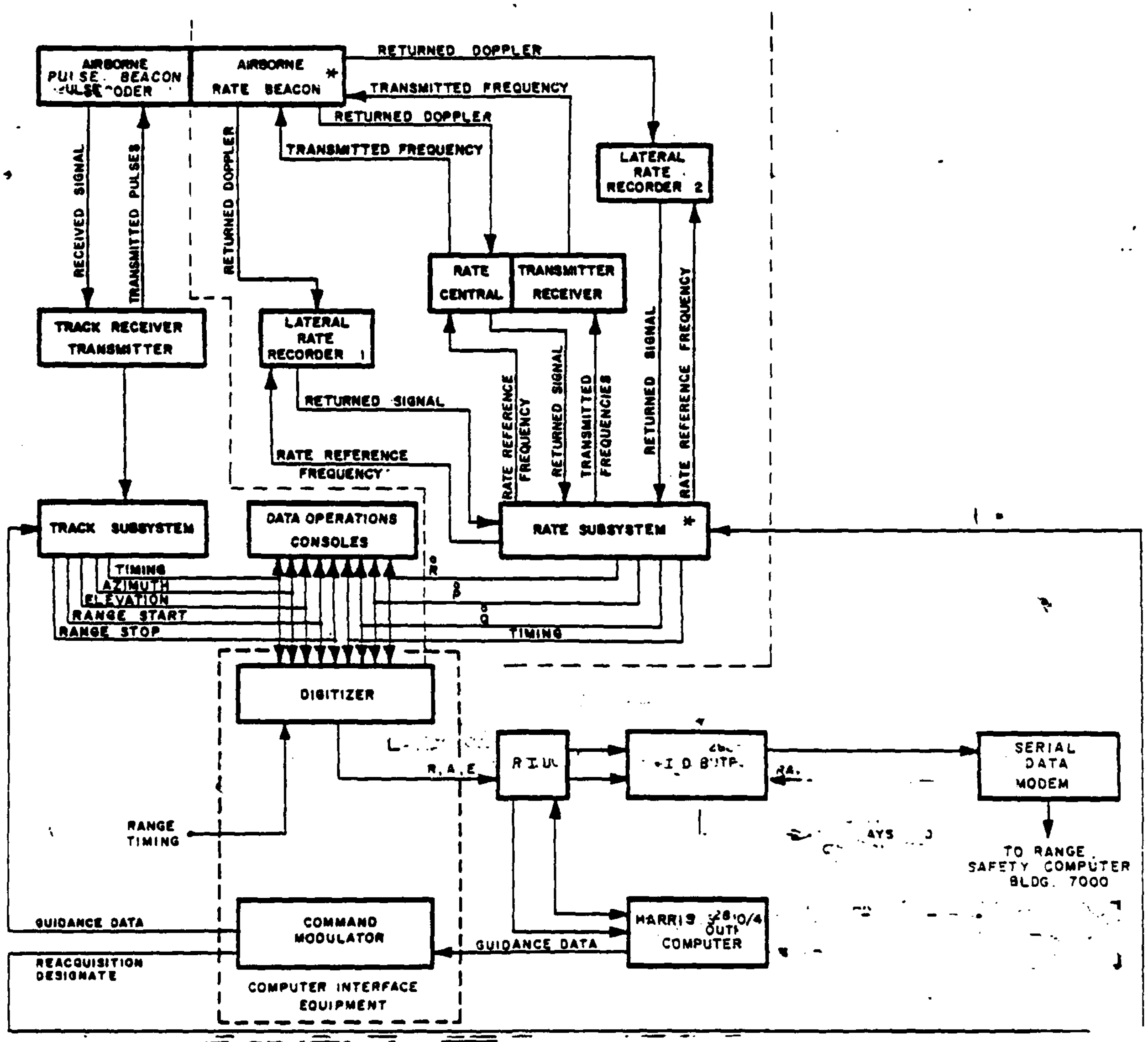

Figure 3-14. GERTS, Data Flow Diagram

The track subsystem determines the missile position by measuring the range, azimuth, and elevation of the missile. Range is determined by measuring the elapsed time between the transmitted rf pulse and the received missile transponder return rf pulse. The missile azimuth and elevation angle measurements relative to the track antenna are made by measuring the angles in the horizontal and vertical planes, respectively, between the anenna axis and pre-determined references in each plane. The track subsystem also provides initial in-flight acquisition and in conjunction with a built-in memory, enables reacquisition in the event of signal loss (See Figure 3-15).

b. Rate Measuring Subsystem (AN/GRS-1A)*

The Rate Measuring Subsystem used interferometer doppler techniques to measure frequency changes corresponding to the radial and lateral components of missile velocity.

The 8387.5 to 8462.5 MHz CW signals, f_1 and f_2, separated by 75 MHz, are tran^mitted from the central rate antenna. The missile-borne rate beacon receives both signals (doppler shifted) and transmits a CW carrier whose frequency is midway between the two received signals. This carrier, again doppler shifted, is received by the central rate antenna and by each of the two remote rate antennas. The remote rate stations are located 2000 feet from the central rate station and form an "L" configuration with the central station at the apex. The signal frequency received at each antenna is thus a function of the vehicle velocity relative to each ground station antenna. This information is processed to derive three frequencies proportional to the range rate (R) and the lateral rates (P and Q) of the missile. Data Quality flags are also provided, as indications of phase-lock with the rate beacon, for each of the three rate functions (See Figure 3-16).

* Equipment is in place but deactivated.

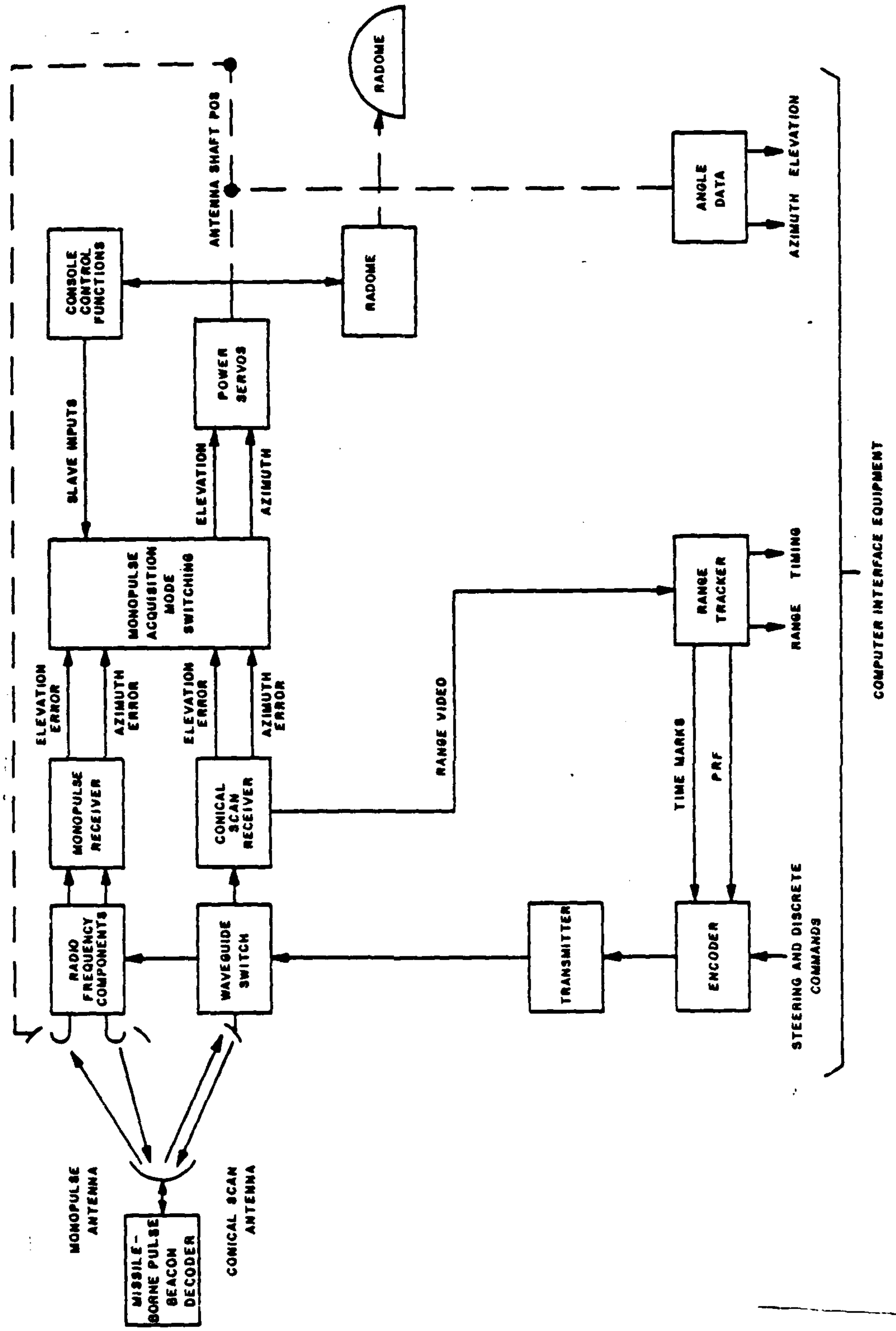

Figure 3-15. GERTS Track Subsystem Block Diagram

c. <u>Flight Data Recording System (FDR)</u>

Raw data from the position tracking system and the rate measuring system is sent to the flight data recording system where it is converted to digital, formatted, and routed to the Harris 5-120/4 Computer System. This data, along with analog and timing functions is recorded on oscillographic recorders. These recordings are used to determine system readiness to support prior to an operation, and to evaluate system and missile performance during flight (See Figure 3-17).

d. <u>Computer Systems</u>

o Harris 5-120/4

During guidance operations, the Harris Computer System receives data from flight data recording system where it is compared to a desired flight trajectory. The computer system generates necessary guidance commands and sends them to the position tracking system for transmission to the missile-borne equipment. Tabular prints and magnetic tape recordings are generated in the computer system for post-flight analysis.

o IBM 360/65

The range flight control function is performed by the Range Safety Computer System receiving data via the serial data modem from the flight data recording system where it is compared with a nominal planned flight trajectory. Missile present-position and impact prediction is determined by the computer system and sent to the range flight control display and control area.

e. <u>Interface Equipment</u>

o Digitizer

The digitizer, a part of the FDR subsystem, is the interface point linking GERTS output data to the computer system. The digitizer performs necessary conversion and formatting to make the radar data acceptable tc the computer system.

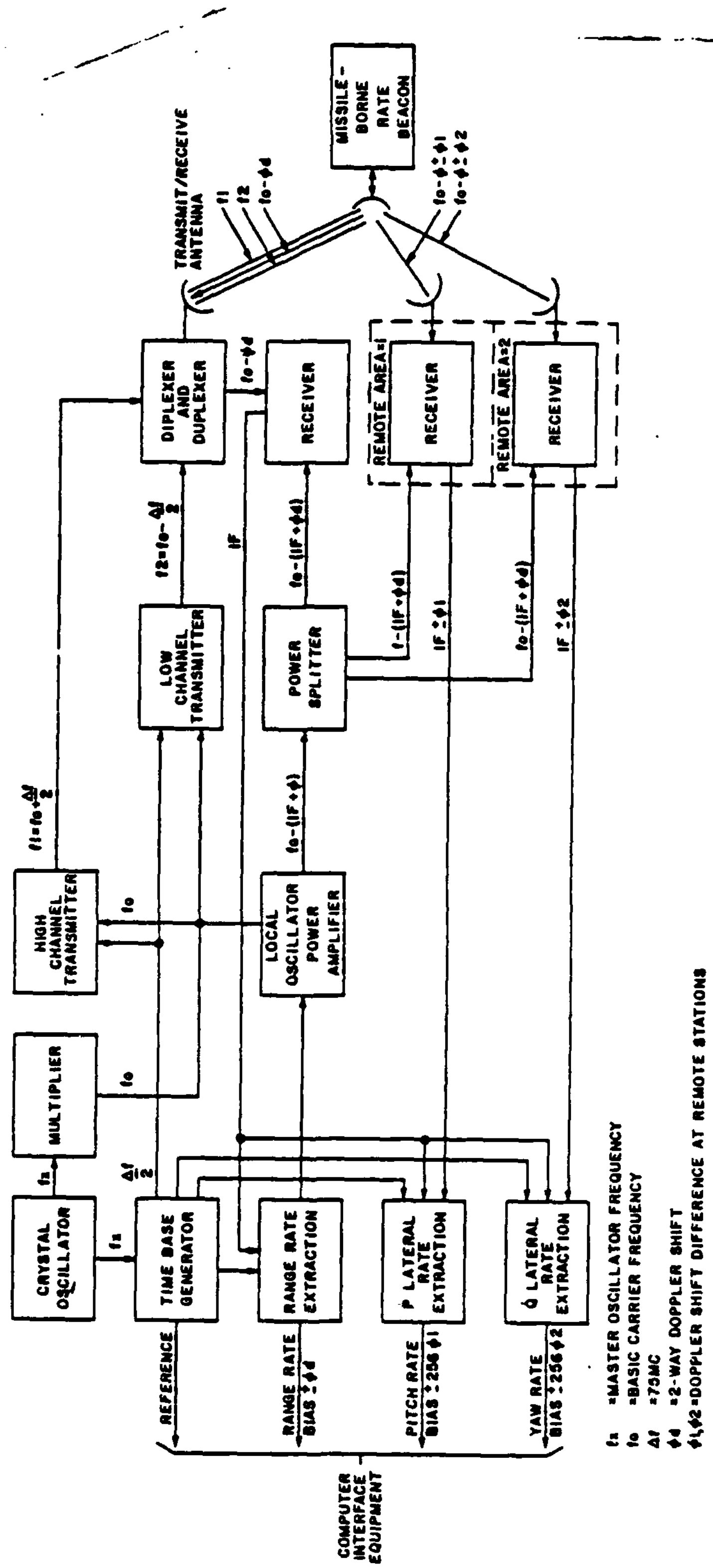

Figure 3-16. GERTS Rate Subsystem Block Diagram
(Equipment is in place but deactivated)

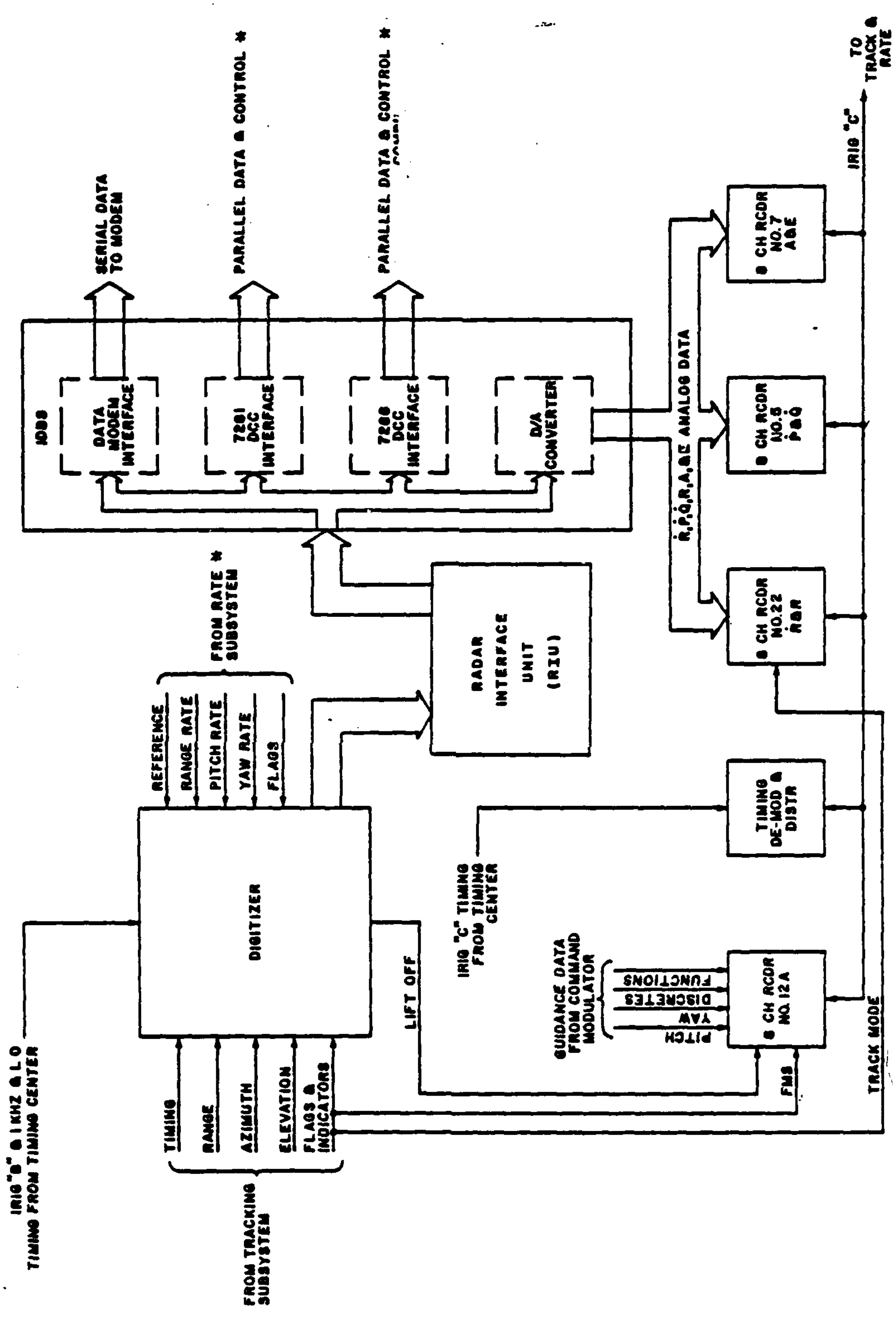

Figure 3-17. GERTS Flight Data Recording Subsystem Block Digram

o Command Modulator

The command modulator, a part of the position tracking subsystem, is the interface point linking guidance commands from the Harris 5120/4 Computer System into the position tracking system. Guidance commands are received by the command modulator where they are shifted into the position tracking system encoder for transmission.

o Isolation Data Buffering System (IDBS) (Part of the flight data recording system.)

The IDBS is the distribution point for all digital data leaving GERTS. The digital data is sent in parallel format to the Harris 5120/4 Computer. The digital data is converted to serial format for transmission via data modems to the range safety computer located in Building 7000. The digital data is converted to analog for recording on the oscillographic recorders.

3.5.2 GERTS Technical Data

Location (Coordinate Ref: North American 1927 Datum)

Station/Site

GERTS Track/023701
Central Rate/023301
East Rate/023302
South Rate/023303

a. Track Subsystem Operating Parameters:

o Transmitted frequency:	9220 MHz
o Transmitted power:	60 kW peak
o Transmitted message:	14-bit pulse coded
o Discrete capability:	10
o Steering commands:	Proportional (delta modulated)
o Received signal frequency:	9310 MHz
o Bandwidth:	2 or 4 MHz
o Receiver sensitivity:	-92 dBm
o PRF:	300 PPS (staggered)

o	Maximum range:	3200 nmi
o	AZ coverage:	330deg (86 deg ccw to 116 deg)
o	EL coverage:	-2 to +85 deg
o	Acquisition/ reacquisition:	Conical scan
o	Method:	Memory Cube designate Optical tracker
o	Monopulse antenna:	
	Beamwidth:	0.7 by 0.9 deg
	Gain	43 dB
	Polarization	Vertical
o	Conical antenna:	
	Beamwidth	5 deg
	Gain	28 dB
	Polarization	Vertical
o	Antenna Mount:	Direct drive (no gearing, no slip rings)
o	CCTV & 35 mm Camera:	Mounted on track antenna

b. Rate Subsystem Operating Parameters:*

o	Transmitted frequency:	8387.5 & 8462.5 MHz
o	Transmitted power (each freq.):	500 W
o	Received Frequency:	8425 MHz
o	Received signal range:	-40 to -108 dBm
o	Minimum trackable signal:	-120 dBm
o	Antennas:	3
o	Gain:	40 dB

* Equipment is in place but deactivated.

- o Slaving accuracy: $\pm$0.25 deg
- o Coverage:

Azimuth:	360 deg
Elevation:	-5 to +90 deg
Polarization:	Vertical
Beamwidth:	1.2 deg
Acquisition/ reacquistion:	Sweep & designate

c. Data Output:

Parallel	36 bit
Serial	240 bit

d. Data Words (8):

#1 IRIG B Time of Day
#2 Rate reference
#3 Range rate (18 bits, LSB = 0.29 fps
#4 Pitch rate (18 bits, LSB = 0.0023 fps)
#5 Yaw rate (18 bits, LSB = 0.0023 fps
#6 Range (19 bits, LSB = 10.4 ft)
#7 Azimuth (18 bits, LSB = 0.00137 deg)
#8 Elevation (17 bits, LSB = 0.00137 deg)

e. Accuracy (one Sigma):

NOTE

The accuracies shown are representative only, Actual accuracies are dependent upon mission, vehicle, elevation, signal strength, and other variables, therefore, the General Electric document, GERTS Accuracy Model, dated 1968 should be consulted for determinations of a more precise nature.

3.6 AN/FPQ-14 On-Axis Radar

The AN/FPQ-14 installed at Kaena Point, Oahu, Hawaii is basically a new system designed to perform with greater pointing accuracies, increased tracking smoothness, and a high loop gain than the AN/TPQ-18 system it replaces. Only the modified pedestal is used as a component of the On-Axis System.

3.6.1 AN/FPQ-14 Operation

The prime purpose of the AN/FPQ-14 is to reduce radar systematic errors to a level where these errors are negligible in the long arc data reduction and processing used to verify the performance of the Minuteman Weapon System Guidance Subsystem. The modification reduces the noise error of the radar by using an orbit simulator corrected by smoothed radar data to drive the radar servo mechanism rather than the raw radar error signals. Heavy emphasis is placed upon star and satellite tracking to determine radar error coefficients on a daily basis.

The AN/FPQ-14 is switchable between skin and beacon modes (vertical linear and horizontal linear polarization). The system is capable of tracking in the following modes:

Auto-Mode: Operating as a conventional radar with system being driven directly from detected radar rf errors.

Computer Drive: Radar being driven by computer based on prior information programmed into the system.

On-Axis (Directed Track): Radar being driven by computer with drive vector information. Radio frequency errors are processed in the computer on a real-time basis to update the drive vector so as to minimize detected rf errors with a continuous on-axis pointing condition as the result.

3.6.2 AN/FPQ-14 Configuration

a. Antenna Feed Subsystem

The modified antenna feed subsystem includes the following new equipment: Sub-reflector, high efficiency feed, horizontal/vertical polarized microwave comparator, duplexer, TR tubes, parametric amplifier, solid-state microwave mixer, pre-amplifiers, and protective circuits for all components.

b. Antenna Pedestal Subsystem

The modified pedestal includes a new optical boresight telescope of increased focal length, a Talyvel level, and rotary joints.

c. Transmitter Subsystem

The transmitter is a single chain system using a Varian 913B or 146C Twystron final output tube. It is capable of developing approximately 4 MW of rf power for skin tracking in the frequency range of 5400 to 5900 MHz. When beacon interrogate signals are developed, power is reduced to 1.5 MW. The pulse repetition rate of the system is fixed at a 160 Hz with one of two pulsewidths selectable. The 12.5 usec pulsewidth is selectable only in skin mode. The 1 usec pulsewidth may be selected in either skin or beacon mode. Pulse compression is available in the 12.5 usec mode with a compressed receiver output pulse width of 0.3 usec.

d. Receiver Subsystem

The receiver subsystem is a solid-state 3-channel monopulse device. Angle receiver gain is controlled from an IAGC (hard limiting) circuit. The portion of the reference channel used to produce display and range servo video is gain controlled from a conventional wide-dynamic range AGC system. IF bandwidth in the wide pulsewidth mode is determined by filters.

e. Range Subsystem

The electric servo is an analog/digital device with a granularity of one yard and a maximum unambiguous range of 8192 nautical miles. A CFAR circuit is used in conjunction with the computer for rapid automatic target acquisition, hit-processing.

f. Computer Subsystem

A Sigma 5 Computer is incorporated into the radar system to allow versatility of programming and sophisticated operational techiques. This results in greater tracking accuracies, smoother tracking and improved pointing information during the acquisition phase.

g. Data Handling Subsystem

The Data Handling System uses computer compatible logic cards in the digital portion of the sensor to interface data between the sensor and the Sigma 5 Computer. This technique effectively integrates the computer into the overall system.

h. Angle Tracking Subsystem

All components used in the angle servo external to the pedestal are comprised of solid-state devices. The system operates to Type 1 or Type II mode during the acquisition phase and Type II during data gathering sequencies.

i. Control Subsystem

The operator has complete control over the sensor and its integrated computer through a variety of controls interfaced through a sophistiated digital mode switching network. A large number of displays provides the operator a means by which to monitor the operation of all subsystems during the tracking or acquisition process. Equipment in this category includes: A transmitter power monitor, decimal displays, meters, lamps, CRT, and television displays.

j. Television Subsystem

A television system is incorporated to allow the optical boresight information to be observed by the operator and be recorded on a video tape recorder. Boresight images are recorded simultaneously with the console digital display through the television system.

k. Timing Subsystem

The timing subsystem consists of two identical independent time code generators driven from cesium frequency standards. The system is synchronized to a master timing system within ± 1 usec via LORAN-C transmissions. Long term stability from the frequency standards prevents time drifts between the synchronization processes and standby power supplies prevent the loss of synchronization during periods of local power interruption.

3.6.3 Equipment Characteristics

o Transmitter

Output Peak Power	4.0 MW nominal
Pulsewidth	1 usec, 12.5 usec, CMF of 0.3 usec
PRF	160
Pulse Coding	Two 1 usec Pulses
Pulse Coding Spacing	3 to 9 usec
Duty Cycle	0.002 maximum

- **Antenna & Dielguide Feed**

Gain	53.6 dB
Beam Width	0.4 deg
Depth of Null	35 dB minimum
Error Pattern Attenuation below REF pattern	5 dB maximum
Ref. Side Lobes (down from main)	15 dB (minimum)

- **Receiver**

Bandwidth (1 usec P W)	1.25 MHz ± 0.25 MHz
(12.5 usec P W)	80 kHz ± 20 kHz
CMF	8 MHz
Receiver Noise Figure with Paramps	3 dB or ,300 K (Noise Temp)
W/O Paramps	5 dB

- **Angle System**

AZ Track Bandwidth	3.5 Hz minimum
EL Track Bandwidth	3.5 Hz minimum
Scans	Computer generated, 3 selections
AZ Velocity (max)	500 mils/sec
EL Velocity (max)	500 mils/sec
AZ Ka Computer Drive	15 minimum/sec^2
EL Ka Computer Drive	15 minimum/sec^2

- **Range System**

PRF	160 IRIG Standard
Maximum Range	8192 nmi
Range Bandwidth (in wide Position)	16 HZ minimum
Granularity	1 yd
Range Slew & Track Velocity	Slew 82 kyd/sec Track 20 kyd/sec

- o Control Displays

Range Indicator	Dual-trace CRT. Top sweepequal to 1024 kyds. Bottom sweep expanded 6 kyd centered about the range gate.
Television Monitor	Displays image in optical boresight.

3.7 OPTICAL TRACKING TELESCOPE, LA-24

A large aperture Tracking Telescope, LA-24 (See Figure 3-18), is used to track targets at long ranges. The LA-24 consists of a 24-inch diameter Newtonian telescope, mounted on a modified, hydraulic, servo-driven five-inch naval gun mount. It is equipped with a high-speed 35 mm precision instrumentation camera. The telescope may be slaved to the data bus and receive range information for automatic focus from either of the VAFB AN/FPS-16 radars. It can point either Tran Peak AN/FPS-16 system and receive pointing information from either system. The telescope is positioned manually with a "stiff-stick" control. This system has been updated with a Range Safety Video System, complementing the one on Santa Ynez Peak. An optical flat located in the dome is used for minor calibrations and alignments.

Normally, recording is done with color film during daylight operations. The focal length of the LA-24 telescope may be varied from 225, 315, + 426 inches by changing the amplifying lenses. With the primary mirror diameter of 24-inches, the F stop can vary to 9.4, 13 + 17.8. Time-of-day information is r corded on film along with the target image (IRIG-B timing).

3.7.1 LA-24 Technical Data

o Location:	
Site:	020T01
o Primary mirror:	24-in. dia.
o Focal length:	Basic 120-in. extended to 225-in., 315-in., or 426-in. With optical amplifiers
o Camera Type:	35 mm Precision registration Instrumentation

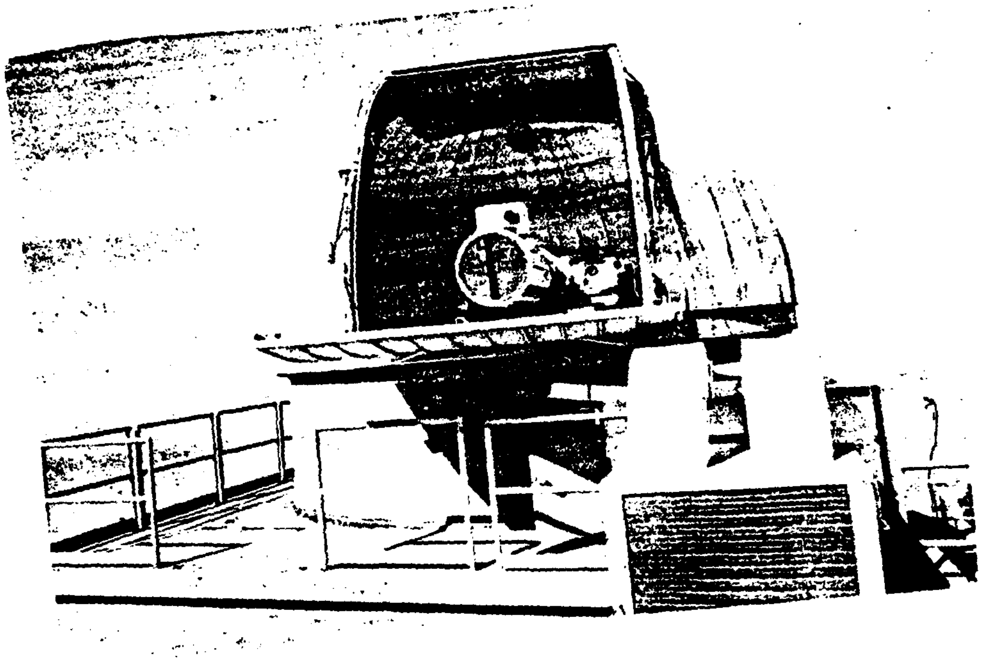

Figure 3-18. LA-24 Tracking Telescope, Front View

- o <u>Film capacity</u> 1200 ft (35 mm)
- o <u>Run time:</u> 35 mm: 7 min at 48 fps
- o <u>Sighting Telescope:</u> 20 X special tracking telescope

3.8 <u>Santa Ynez Peak Optical Tracking Station</u>

The optical tracking station at Santa Ynez Peak provides long-range optical coverage of launches from Vandenberg AFB. This coverage is accomplished using a Recording Optical Tracking Instrument (ROTI) (See Figure 3-19). This large aperture telescope system produces time-correlated, high-resolution, long-range photographic recordings of objects in space. The primary telescope has a 24-inch diameter reflector and is a basic 100-inch focal length Newtonian optical system. Focal length increases in 100-inch increments to a maximum of 500 inches are provided by introduction of Biotar relay lenses.

The ROTI is protected by a 20-foot weather-proofed air-conditioned astrodome. The astrodome is automatically positioned in azimuth by a drive assembly and is synchronized to the rotation of the telescope. The entire unit is place atop a permanent support building.

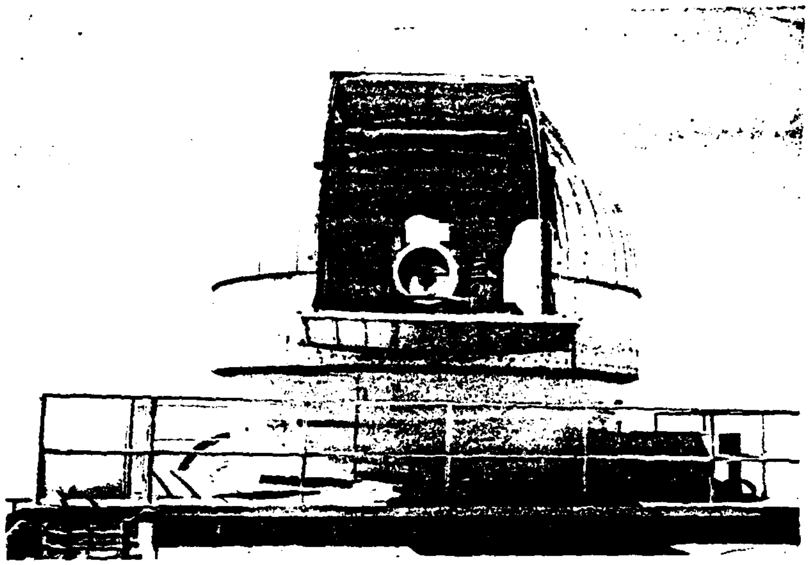

Figure 3-19. Recording Optical Tracking Instrument (ROTI)

Commercial power or emergency generator power (100 KW) is available to power the facility.

The recorded images are time tagged from IRIG B 100 PPS timing. A timing terminal generator synchronized to the WSMC Timing Center supplies this timing.

The ROTI has been modified to accommodate:

a. Range Safety Video camera mounted to a questar lens.

b. A wide-angle acquisition lens (200 mm)

c. 35mm camera

d. Gunship low-light level cameras

e. Zoom lens

f. Selectable filters on LLLTV cameras

g. Digital insertion generators

3.8.1 Santa Ynez Peak Optical Tracking Station Technical Data

o Site Identification 110T01

- o <u>Lenses</u>

  a. Prime

  Aperture 24-inch dia

  Focal length, selectable 100-, 200-, 300-, 400- and 500-inch

  b. Range safety

  80" Questar

  c. Wide angle LLLTV (Gunship)

  200 mm f4.0 Nikon

  d. Acquisition aid

  Cohu Zoom (Angienieux)

NOTE: Suggest that information concerning detailing all 3 optical sites be standardized in one format.

- o <u>Recording Media</u>

  Film

  Camera, format size 35 mm

  Photosonics 4 ML

  Capacity 1200 feet

  Frame rate, variable 16 - 200 F.P.S. (continuous)

  Electron Beam Recorder, EBR-100

  Format size 16 mm

3.9 ANDERSON PEAK OPTICAL STATION

The Anderson Peak Optical Tracking Station (see figure 3-20) is situated at an elevation of 4098 feet approximately 20 miles from the Big Sur area on the central coast of California. Permission to use the property on which the station is located is by agreement with the Federal Aviation Administration (FAA) and the U.S. Forest Service. *Access to the

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*Persons having prior official clearance to Anderson Peak should call the station well in advance of departure for the Big Sur area to ensure that roads are passable and that entry through secured areas has been coordinated.

station is over U.S. Forest Service and privately owned roads. At the present time the station is equipped with a Cine-Sextant Tracking System which is used to track the flight of missiles launched from VAFB. The Cine-Sextant has been configured to accept an Image Intensifier (Gunship Camera System) for night launch recordings. The use of these devices permits the recording of low lumen energy targets. During daylight operations, conventional color or black and white films are exposed depending on the requirement. The altitude of the station eliminates a high percentage of atmospheric interference. The geographic location permits good geometry for optical coverage of westerly launches. The recordings obtained provide a continuous, time-coded record of missile flight. The recordings are used to evaluate missile flight events and post-powered coverage of events such as decoy deployment.

3.9.1 ANDERSON PEAK OPTICAL TRACKING STATION TECHNICAL DATA

- Site Identification — 100T03
- Lenses

  Prime - (Narrow Angle)

  Aperture — 36" diamaeter

  Wave Length — 1/10 Wave

  Focal Length — Selectable, in inches

Power	Inches	Field of View	
1X	288	11.93 Min	
2X	576	5.97 Min	F.O.V. for a
3X	264	3.98 Min	25 mm format
4X	1152	2.98 Min	will vary with
5X	1440	2.38 Min	camera used.

  Narrow angle focal length may be changed during an active track without losing target.

- Tracking Rate: 10 deg/sec Azimuth
  5 deg/sec Elevation
- Drive Limits: Electrical Limits -5 to 90 deg Elevation
  + - 720 deg Azimuth
- Acquisition: Visual or Radar Selectable in RTDHS

- o Acquisition TV
  1. Wide Angle, Gunship TV

     Focal Length 200mm (7.87")
     Field of View 5.8°

  2. Intermediate Angle, Telemation TV, Celestron Lens

     Aperture 8"
     Focal Length 80" °

- o Recording Media

  Film
  - Camera Type: Photosonics 4 ML
  - Frame Rate, Variable: 16 - 200 F.P.S. (continuous)
  - Film Capacity 1200 feet
  - Format Size 35MM
    - Source: Prime Lens only

  Electron Beam Recorder
  - Frame Rate, Fixed 60 F.P.S.
  - Film Capacity 1200 feet
  - Format Size 16MM
    - Source: T.V. Video (875 Lines)
      Lens Selectable Prime Lens (Gunship)
      200MM (Gunship)
      80" Celestron (Telemation)

  Video Recorders:
  - Type - Arvin Echo WRR-411
  - Reel Size 8 inch diameter
  - Tape Width One inch
    - Source: Composite T.V. Video Selectable
      Prime Lens (Gunship)
      200MM (Gunship)
      8" Celestron (Telemation)

  Sensor Detectors
  - Cameras
    - Film 35MM Photo Sonico 4 ML ***
      Through Prime Lens Only
    - T.V. Telemation, 875 lines, through 8" Celestron Lens used primarily as an acquisition device. May be recorded on VTR and EBR.
    - T.V. AN/ASQ-145 "Gunship" (Low Light Level) through 200MM Lens - used as an acquisition device. May be recorded on VTR and EBR.
    - T.V. AN/ASQ-145 "Gunship" (Low Light Level) through Prime lens *** May be recorded on VTR and EBR.

*** May use film or T.V. cannot use both at same time.

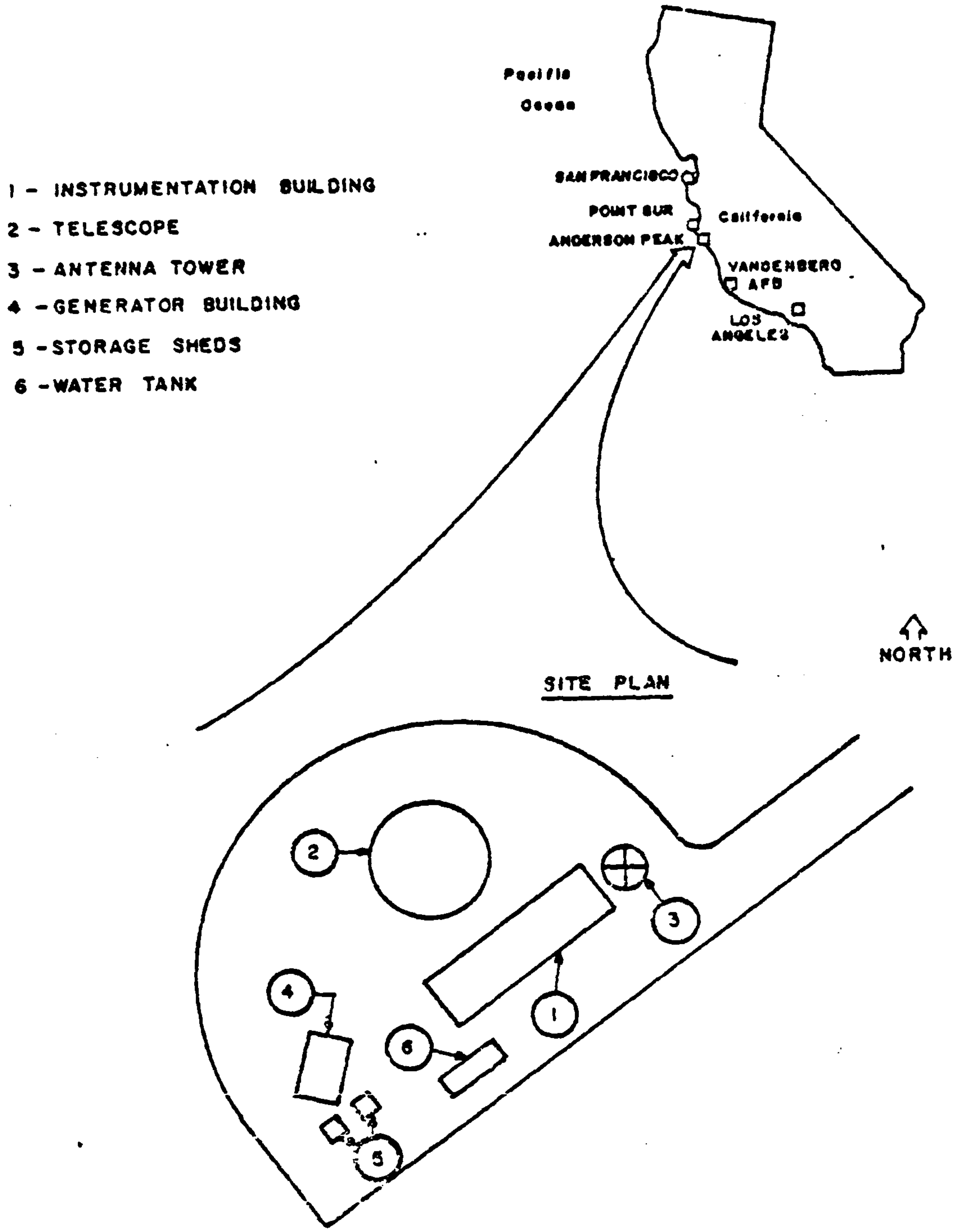


Figure 3-20. Anderson Peak Optical Station, Site Plan

Capacity	1200 feet
Frame rate, fixed	60 FPS
Source	TV Video 875 lines
Video Recorder, Aruin Echo	1-inch mag tapes
Reel Size	8-inch diameter
Source	Composite TV Video

o <u>Sensor Detectors</u>

Cameras	
Film	35 mm cine
TV	Telemation 525 line
TV	Cohu 525 line system
<u>Low-Light Level</u>	
Image Intensifier	GE Gunship AN/ASQ-145 LLLTV camera

3.10 ENGINEERING SEQUENTIAL PHOTOGRAPHY - LAUNCH COMPLEXES AND INTERMEDIATE EARLY TRACKING

The primary purpose of engineering sequential photography is to provide event versus time data, correlation, i.e., engine ignition, umbilical disconnect, booster staging, etc. A secondary purpose is to provide motion picture records for film reports and historical documentation. Timing is printed in a binary coded decimal format, serially along the film edge. The following paragraphs briefly describe the major equipment used to photograph and provide photo-engineering records. All engineering sequential photography is accomplished by direction of WSMC by the 1369th Audio-Visual Squadron except for large aperture tracking telescope operations previously discussed.

3.10.1 Milliken Camera, 16 mm The Milliken DMB-5A (See Figure 3-21) is a compact motion picture camera designed to produce high-quality films at frame rates ranging from 4 to 400 fps. It accepts standard C-mount lenses in focal lengths of 5 mm or greater. Its compact design permits its use in protective and explosion proof housings at locations very close to the launch vehicle. Adaptions are available to give automatic exposure control, 1200-foot external magazine, 28 Vdc operation etc.

3.10.1.1 Milliken Technical Data

- Film load: 400-ft internal load,

  1200-ft. external magazine load
- Movement: Intermittent type, double pulldown claw, single pin registration
- Frame rates: 4, 6, 8, 12, 16, 24, 32, 48, 64, 128, 200, or 400 fps
- Exposure Times: Fixed opening shutters available from 7.5 to 160 deg. Minimum exposure at 4 fps is 1/190 sec. Maximum exposure at 400 fps is 1/900 sec.
- Running time: 40 sec at 400 fps.
- Power required: 115 Vac normally.
- Boresight: Through taking lens before loading.

3.10.2 Photo-Sonics 1B Camera, 16 mm The Photo-Sonics 1B camera (See Figure 3-22) is designed to make high-speed motion pictures under extreme conditions of temperature and vibration. The normal operation is a full capacity run. The camera uses a rotary prism for image compensation on continuously moving film. A rotary disc shutter is incorporated with the prism to give a more even exposure, higher resolution and greater shutter efficiency. The format is full frame 16 mm.

3.10.2.1 Photo-Sonics 1B Technical Data

- Film load: 400- or 1200 ft magazine
- Operation: Rotary prism, full capacity run.
- Frame rate: 1000 fps
- Exposure time: Variable with shutter opening, 9, 18, 36, or 72 deg
- Lenses: 5 mm to 250 mm focal length
- Power required: 115 Vac
- Boresight: Through taking lens before loading

3.10.3 Mitchell, 16 mm The Mitchell 16 mm (See Figure 3-23) is a precision camera for operation in the low-to-medium speed range. The film transport system uses dual registation pins to give extremely accurate positioning control during exposure. The Mitchell 16 mm is normally used in fixed installations for overall launcher surveillance. Can be used with lenses from 10 mm to 200 inches in focal length.

3.10.3.1 Mitchell 16 Technical Data

- Film load: 400 ft magazine - 10 minutes run at 24 fps

  1200 ft magazine - 30- minutes at 24 fps
- Operation: Claw pulldown, dual pin registration
- Frame rate: 75 fpm with special motor. Variable 12 to 144 fps (normally limited to 72 fps)
- Exposure time: Variable to maximum shutter opening of 170 deg (1/50 - 1/864 sec at 24 fps)
- Boresight: Through the lens except during run
- Power required: 115 Vac

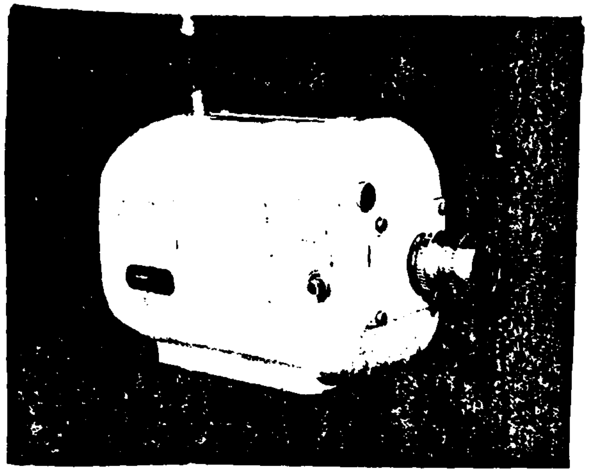


Figure 3-21. Milliken 16 mm Camera

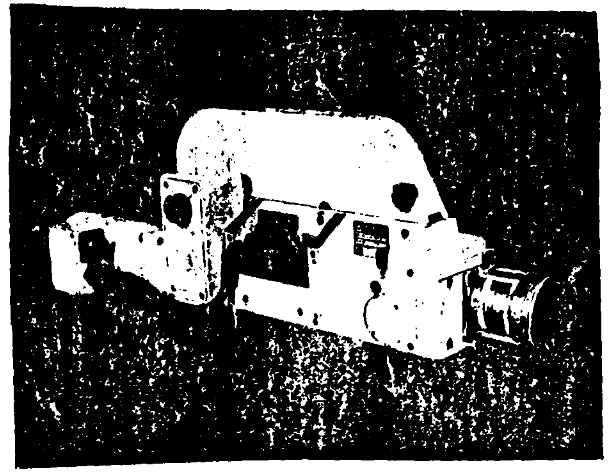


Figure 3-22. Photo-Sonics 1B, 16 mm Camera

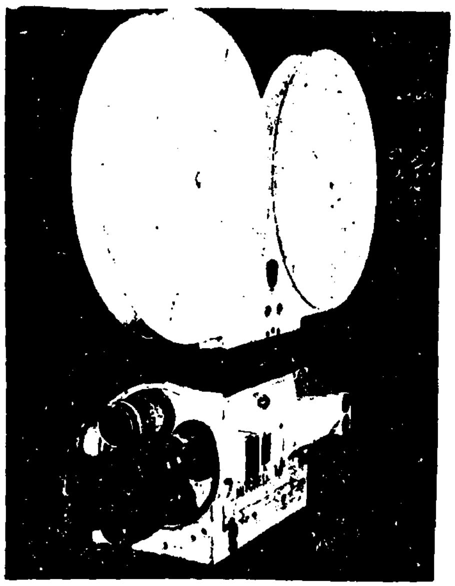


Figure 3-23. Mitchell 16 mm Camera

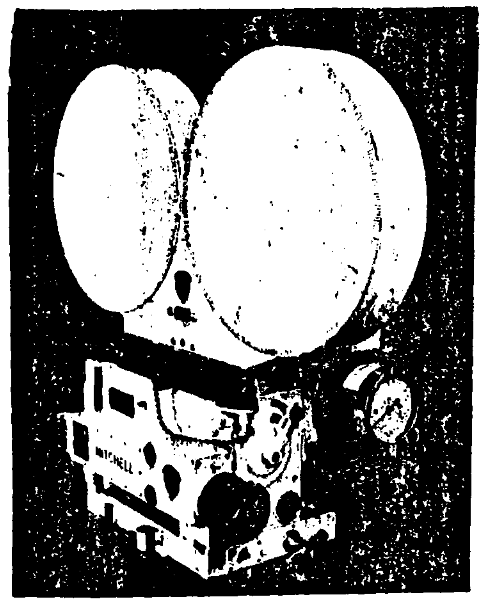


Figure 3-24. Mitchell 35 mm Camera

3.10.4 Mitchell 35 mm The Mitchell 35 (See Figure 3-24) is a precision camera for operation in the low- to medium speed range. The film transport system has dual registration pins to give extremely accurate positioning control during exposure. It is used only at sites where it can be attended by an operator. It is the primary camera for use on tracking mounts with long focal length lenses. It can be fitted with lenses from 25 mm to 200 inch focal length.

3.10.4.1 Mitchell 35 Technical Data

- Film load: 1000 ft magazine - 10 minutes run at 24 fps
- Operation: Claw pulldown - dual pin registration
- Frame rate: Variable 12 to 144 fps (normally limited to 72 fps)
- Exposure time: Variable to maximum shutter opening of 70 deg
- Boresight: Through the lens except during run
- Power required: 115 Vac

3.10.5 Photo-Sonics Hi-Speed, 35 mm The Photo-Sonics 35 mm-4E camera (See Figure 3-25) produces high resolution pictures in the standard motion picture format at rates up to 360 fps. The film transport is of the intermittent type with the film held stationary during exposure by four register pins and a vacuum back. The primary use of this camera is on tracking mounts with long focal length lens. Will accept lens from 2 to 200 inches focal length.

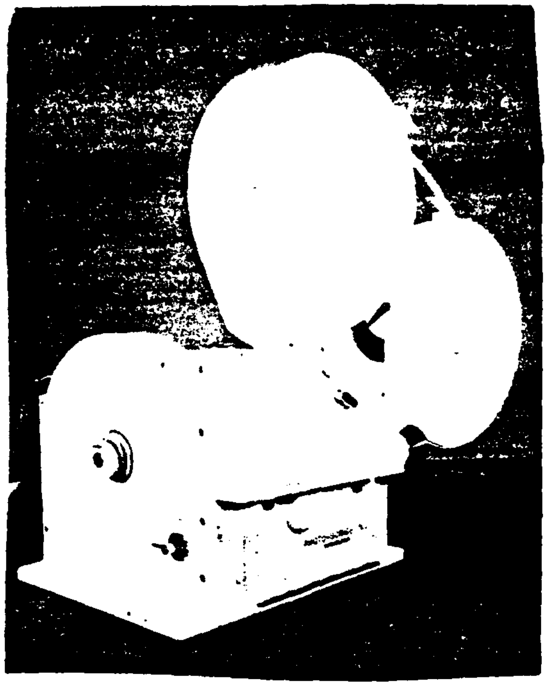


Figure 3-25. Photo-Sonics 1B 35 mm Camera

3.10.5.1 Photo-Sonics 35 mm-4E Technical Data

o	Film load:	1000 ft magazine - 44 sec run at 360 fps
o	Operation:	4 claw (12 pin) pulldown with 4 pin registration
o	Power required:	208 Vac, 3-phase
o	Frame rate:	Any number from 6 to 360 fps
o	Exposure time:	Variable to maximum 120 deg
o	Boresight:	Through the lens before loading

3.10.6 Hulcher Camera, 70 mm (Model 102) The Hulcher Camera (See Figure 3-26) is used for obtaining a rapid sequence of still photographs for use as a series illustrating an action; or to enable the selection of a single exposure that best illustrates an action. It is used for both fixed and tracking items and for engineering or documentary requirements. A variety of lenses are available from 90 mm to 60-inch focal length.

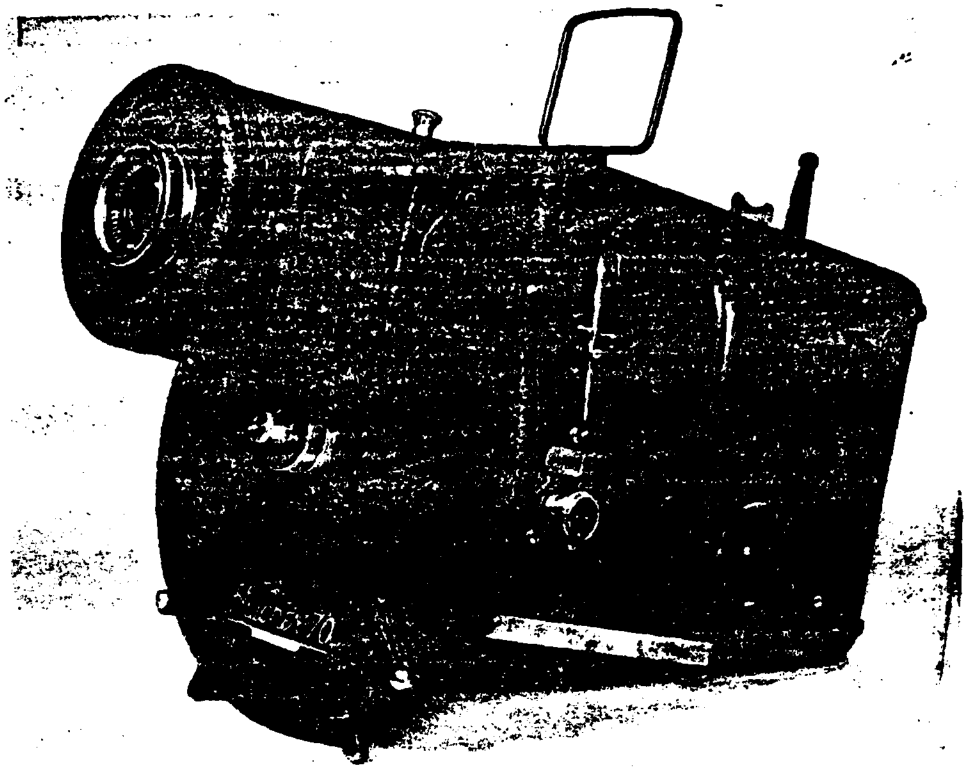


Figure 3-26. Hulcher 70 mm Camera

3.10.6.1 Hulcher Technical Data

o	Film load and Format:	100-foot internal load, pictures 2-1/4 inches square
o	Operation:	Rotary paddle pulldown (no registration during exposure)
o	Frame rate:	5 to 30 fps
o	Exposure time:	Variable from 1/125 to 1/2880 sec at 20 fps
o	Boresight:	Through the lens except during run
o	Power required:	115 Vac; 28 Vdc for some

3.10.7 Cine-Sextant Optical Tracking Mount The Cine-Sextant (See Figure 3-27) is a mobile tracking instrument which provides smooth, vibration-free tracking of a target anywhere in the 0 deg to 180 deg hemisphere. It has four payload platforms each capable of carrying 250 pounds. It will accept a variety of payload configurations. A typical equipment complement would be a PhotoSonics 4E camera with a 200-inch lens; and a Mitchell 35 mm camera with a 100-inch lens. The operator has a choice of an 8-, 15-, or 24-power telescope for a viewfinder. Power required in 208 V, 3-phase, 4-wire Y-connected.

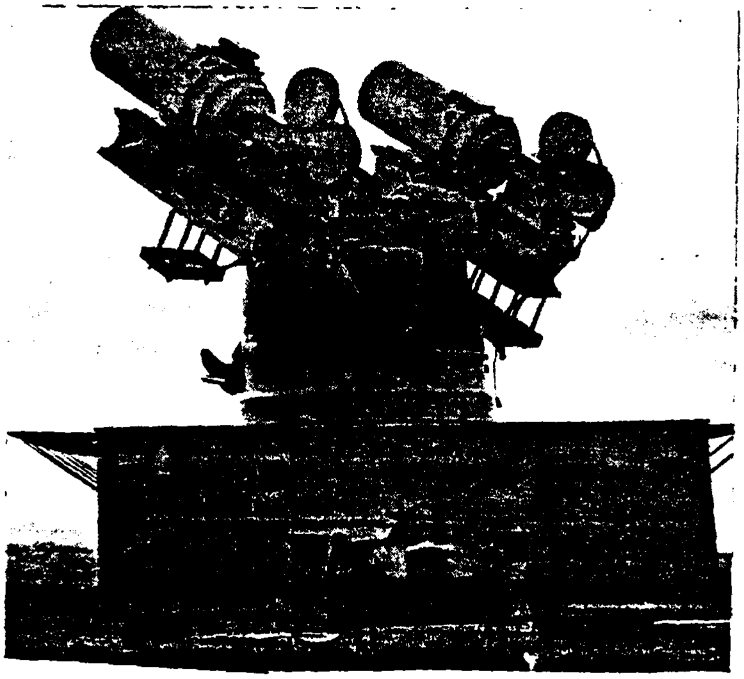


Figure 3-27. Cine-Sextant Optical Tracking Mount

3.11 DOCUMENTARY PHOTOGRAPHY

Documentary photography provides photographic record of important events of historical value. It is frequently used for engineering reports, failure analysis records and for training. Documentary photography both ground and aerial, is done in both still and motion picture formats.

a. Motion Pictures

Motion picture documentary films are produced with equipment that is conventional in nature. Most work is done in the 16 mm format in color. The 35 mm format is available to a limited extent. A limited amount of film editing, sound recording and sound-on-film capability is available locally.

b. Still Photography

Documentary and engineering still photography is done with a variety of camera types and sizes. Black and white and both color negative and color reversal processes are used. A wide variety of services are available.

3.12 PHOTOGRAPHIC LABORATORY SERVICES

The 1369th Audio-Visual Squadron reacting to WSMC approved requests, furnishes laboratory service to other film exposing organizations. These services are extensive but limited by facilities to certain processes. Any range user should contact the WSMC Range Staff Photographic Office before selecting a film type intended to be processed locally.

a. Motion Picture Laboratory

The motion picture laboratory processes all film exposed on the WSMC. This service is also offered to other film exposing agencies which use films compatible with the process formulas available. Continuous processing is offered for motion picture lengths of: Ektachrome MS and EF in 16 and 35 mm sizes; Ektachrome Commercial (Type 7252) 16 mm; and most types of black and white film in 16 and 35 mm. Prints in same size as original or reduction from 35 to 16 mm is available in all types.

b. Still Picture Laboratory

All normal still photo laboratory services are available. In addition to the more conventional films and formats, 70 mm rolls of black and white or color in lengths of less than 100 feet can be developed and duplicated. The lab has facilities for producing color prints and enlargements and this service is available for approved projects.

3.13 AN/MPS-36 Radar The AN/MPS-36 Radar is a mobile system contained in two vans; one van houses the major electronics hardware, and the other is a flatbed trailer which contains the antenna/pedestal. The radar operates at 5400 to 5900 MHz with a peak output of one megawatt. The AN/MPS-36 Radar is a monopulse tracking radar specifically designed to obtain direct measurement of target velocity by coherent pulse doppler techniques. The antenna includes a solid 12-foot diameter reflector, with a five-horn monopulse feed and allows a complete range of polarizations. The operator may select horizontal, vertical, left circular or right circular polarizations. The digital range tracking system is capable of a non-ambiguous range of 32 knmi.

The AN/MPS-36 Radar have data subsystems communicating to and from a DDP-124 Computer, the heart of the radar's Data Output and Recording Subsystem (DORS). DORS input will be azimuth (A) and elevation (E) data from angle encoders, Range (R) from the range tracking subsystems; and Range Rate (R) from the Velocity Extraction Subsystems (VESS) and are transferred in parallel from the Input/Output (I/O) holding registers of the data subsystems TO THE DDP-124 Computer. Error corrections and scale factoring are performed and the data are returned to the I/O holding registers for availability to the Instrumentation Processing System (IPS). In addition to the track and rate data, digital Automatic Gain Control (AGC), azimuth servo error, and elevation servo error data are also available.

Through addition/modification of a Data Exchange Interface (DEI) buffer subsystem and a data modem, the AN/MPS-36 Radar capability was expanded to enable the systems to accept and use real time tracking acquisition data from an outside sensor, and a means of transmitting real time AN/MPS-36 TAER data to an off-site data user. The DEI reformats outside (VAFB compatible) data into an AN/MPS-36 usable format, and accomplishes a similar task of radar data transmitted to user facility.

3.13.1 AN/MPS-36 Technical Data

- Location

Station:	NVAFB

- Transmitter

Frequency:	5400 to 5900
Peak Power:	1 MW
Pulsewidth	0.25, 0.5 and 1.0
Pulse Rate:	160, 320 and 640

- Receiver

Frequency:	5400 to 5900 MHz
Bandwidth:	4.8, 2.4 and 1.6 MHz
Noise Figure:	45.0 dB

- **Antenna**

Type:	12-ft. parabolic, front-feed
Gain:	43 dB
Beamwidth:	1.2 deg
Polarization:	Linear (H&V), Circular (RH&LH)

- **Coverage**

Azimuth:	360 deg
Elevation:	-5 to +185 deg
Range:	32knmi (non-ambiguous)
Tracking Rates:	Azimuth, 890 mr/sec Elevation, 500 mr/sec Range, 20 kyd/sec

- **Output**

Range:	26-bit binary
Angular:	17-bit binary

- **Precision**

Azimuth:	0.2 mil (rms) (S/N 20 dB)
Elevation:	0.2 mil (rms) (S/N 20 dB)
Range:	3 yds (rms) (S/N 20 dB)
Range Rate:	1 fps (rms) (S/N 20 dB)

- **Honeywell DDP-124 Data Processor**

Work Size:	24 bits
Memory Capacity:	8,196 words

SECTION 4.0

DATA HANDLING AND PROCESSING SYSTEMS

4.1 REAL TIME DATA HANDLING SYSTEM

The Real Time Data Handling System (RTDHS) is that portion of the range instrumentation concerned with handling and processing range information in real-time. This is accomplished for the purpose of display, control and permanent recording. The RTDHS consists of many types of digital and analog data handling equipments. The heart of the system is its real-time digital computers. These are: the IBM 360-65 Computer with an IBM 2909 Data Communication Channel, the UNIVAC 1218 peripheral Computers, and the RCA 4101 Computers. The RTDHS has the capability of:

a. Transmitting raw tracking data from sensors, such as the AN/FPS-16 and AN/TPQ-18 radar sytems, etc., to the central processor, (IBM 360-65) to enable computation and display of present position, instantaneous impact prediction, and velocity data.

b. Generating and outputing, in conjunction with the central processor, the Missile Flight Control Automatic Flight Termination Functions.

c. Providing control capabilities and status information of the central processor.

d. Providing a means of transmitting acquisition data between peripheral sites (Pillar Point, Tranquillon Peak) for the acquisition or reacquisition of a target.

4.1.1 TOCC/RTDHS (See Fig. 4-1) The central portion of the RTDHS is located at NVAFB Building 7000A. This portion of the RTDHS provides the Analog Distribution System (ADS) required to handle the real time data that is presented by the central processing computer (IBM 360-65), the Back-up Information Display System (BIDS), the Mission Safety System (MSS), and the Digital Information Processing System (DIPS) for display in the Missile Flight Control Center (MFCC).

The central processing computer, BIDS, MSS and the DIPS are remotely controlled via the Console Control and Distribution System (CC&DS). The CC&DS is also used as a data path between the central processing computer and the Missile Flight Termination Control Ground System (MFTCGS) for the Automatic Flight Termination Functions. The MFTCGS is comprised of the Command Transmitter Controller (CTC) Console and the four Command Transmitter Sites utilized.

The central processing computer (IBM 360-65) provides present position, impact prediction and velocity information for display in the MFCC, the acquisition data for radar target acquisition or re-acquisition, and the Automatic Flight Termination Functions.

The BIDS provides present position, impact prediction and velocity information for dispaly in te MFCC.

The MSS in RTDHS (See Fig. 4-2) receives impact prediction, present position, and velocity information from GGS-6/7, accomplishes digital-to-analog conversion, and makes the data available for display in the MFCC at the RTDC's selection. This system provides a range flight control input that completely bypasses the range flight control computers.

The DIPS provides coordinate conversion from 10 points on the Earth spheroid to a single reference point, screen the data for quality, scale, parallax, rotate, and convert the data to any of 14 selectable parameters which are available to 32 analog outputs for display purposes. System accepts translated data from the basic system and converts it to a third coordinate system for acquisition purposes. This data is in the standard WSMC Radar Transmission Format.

The central portion of the RTDHS also provides the interface between the RTDC Console and the Range Safety Display System (RSDS) for the RTDC's control of the RSDS computer (PDP 11).

The Tracking Source Indicator (TSI) equipment located within the central portion of the RTDHS is used to display to the Missile Flight Control Officer (MFCO) the radar selected for display and which range safety computer is processing that information.

The Malfunction Detection Indicator (MDI) equipment is used to display discrete bit information from the TMIG data stream, the central processing computer or the GERTS discrete bits via the central processing computer. These discrete bits can be given any operational label and can be assigned any of four colors (red, amber, blue, green) for each of the discrete bit levels as may be assigned by operational requirements.

The data handling flow at the remote instrumentation sites are shown in figure 4-5.

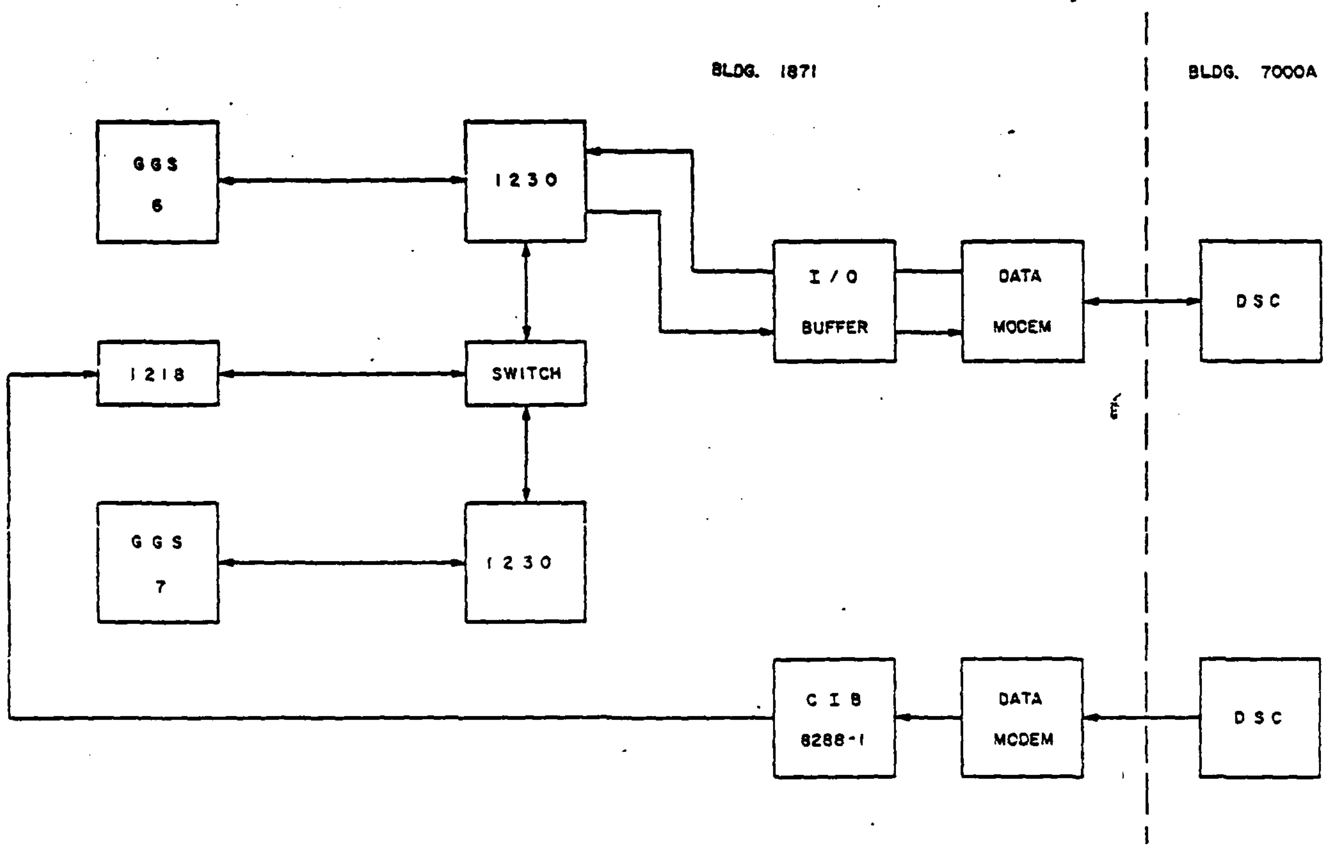


Figure 4-1. TOCC/RTDHS Data Flow Diagram

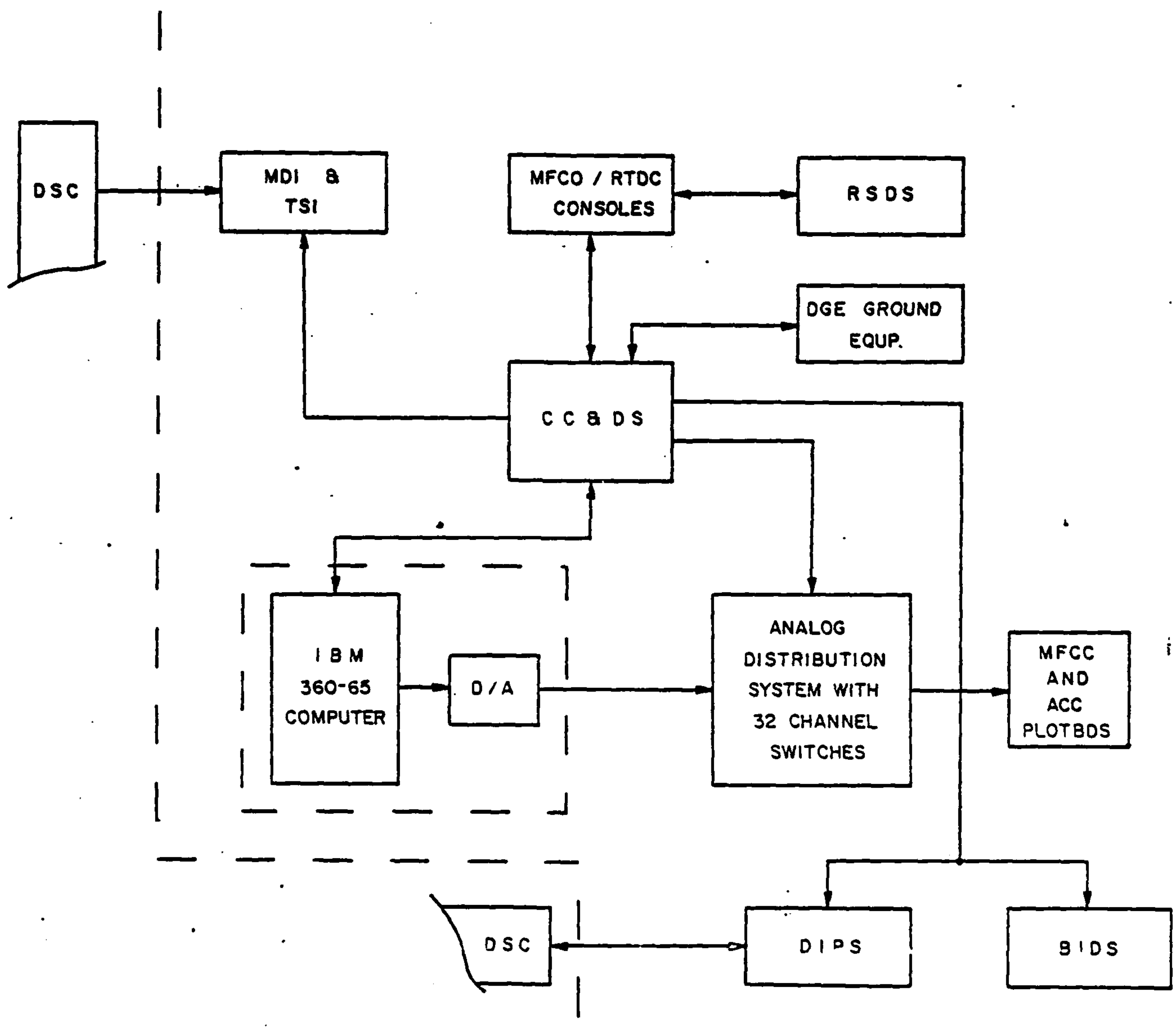


Figure 4-2. RTDHS Main Site Functions Diagrams

4.1.2 The Data Switching Center (DSC), located in Building 7000A, room 115, is the data technical control for all the circuits involved with the WSMC Switched Narrow Band Data System, and most of the Non-Switched Narrow Band Data Networks. Located within the DSC are 112 modems of various types and capabilities, 4 high speed Multiplexing Systems, associated analog and digital patching facilities, and the 100 X 100 Digital Data Switching System ((DDSS), which forms the heart of the WSMC Switched Narrow Band Data System.

The heart of the Switched Narrow Band Data System is the 100 X 100 Digital Switch Matrix. The switch permits the interconnection of a data signal from any one connected source with any desired number of connected terminators, or destinations. The switch can accomodate a total of 100 Full Duplex (simultaneous two way communications on separate send and receive paths) circuits. Presently connected to the switch are:

52 Full Duplex circuits from remote sites - Radar, Optics, Instrumentation, Tracking, Pillar Point, Edwards AFB, PMTC, Wheeler AFB, and Eastern Test Range, all of which employ various types of DCE.

38 circuits to various DTE located within Building 7000A - IBM 2909 (360-65 computer), BIDS (Back Up Information Display System), DDS (Digital Display System), MDI (Malfunction Detection Indicators), DIPS (Digital Informatin Processing System), TMIG (Telemetry Inertial Guidance), ATS (Aquisition Transmission subsystem), RSIS (Range Safety Interface Subsystem), TIPS (Telemetry Intergrated Processing System), and Bomarc Buffers.

10 equipments for test and evaluation.

Of the above listed switch ports, all are presently handling 2400 BPS data with the exception of 5 ports devoted to GERTS data, which are configured for 9600 BPS. The primary function of the switched network is to bring metric data from the remote sensors to the various DTE located within the TOCC area, and to extend aquisition and slaving data from DTE to the remote sensors. See figure 4-3 for the data flow into the Digital Data Switching System.

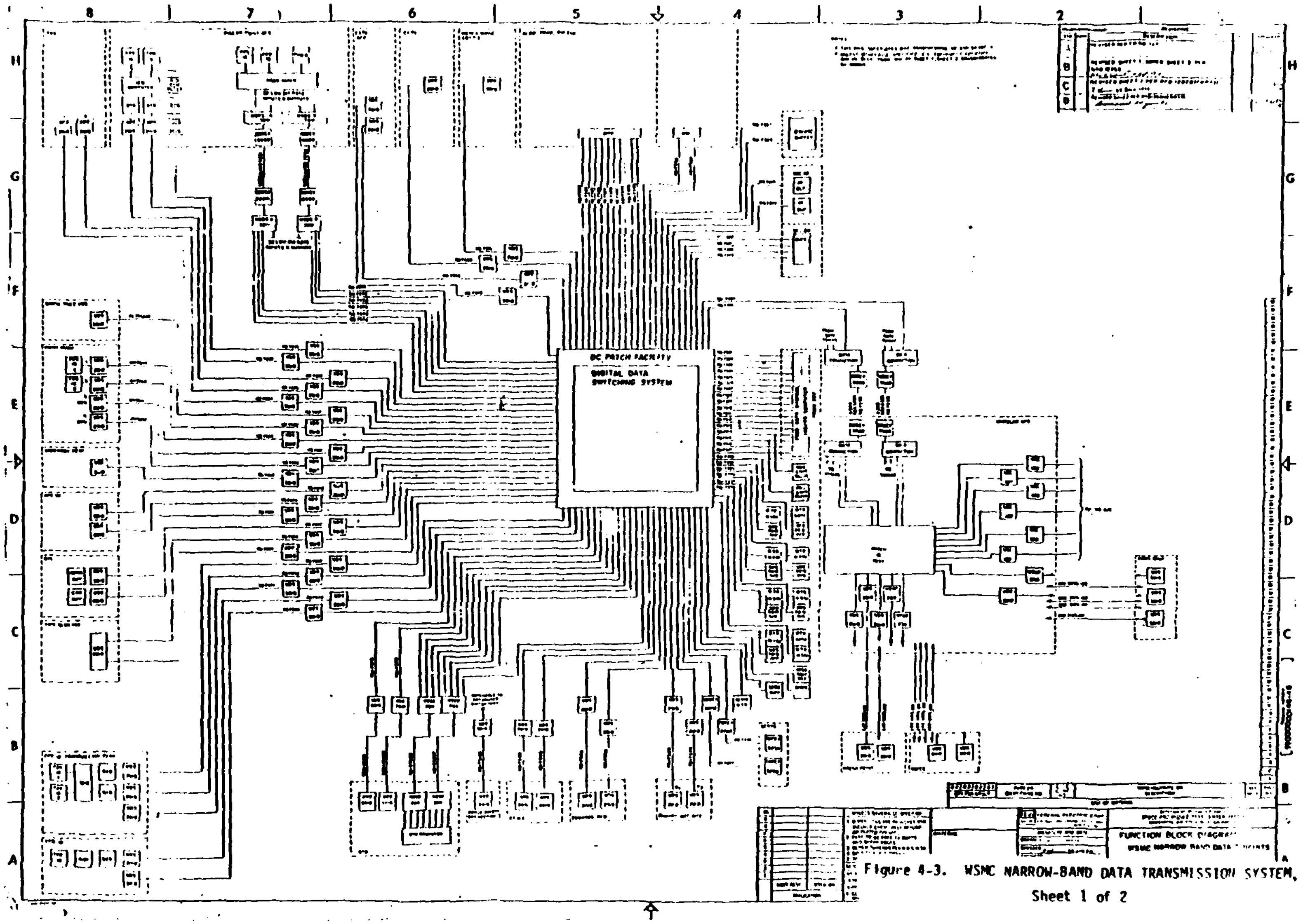


Figure 4-3. WSMC NARROW-BAND DATA TRANSMISSION SYSTEM,
Sheet 1 of 2

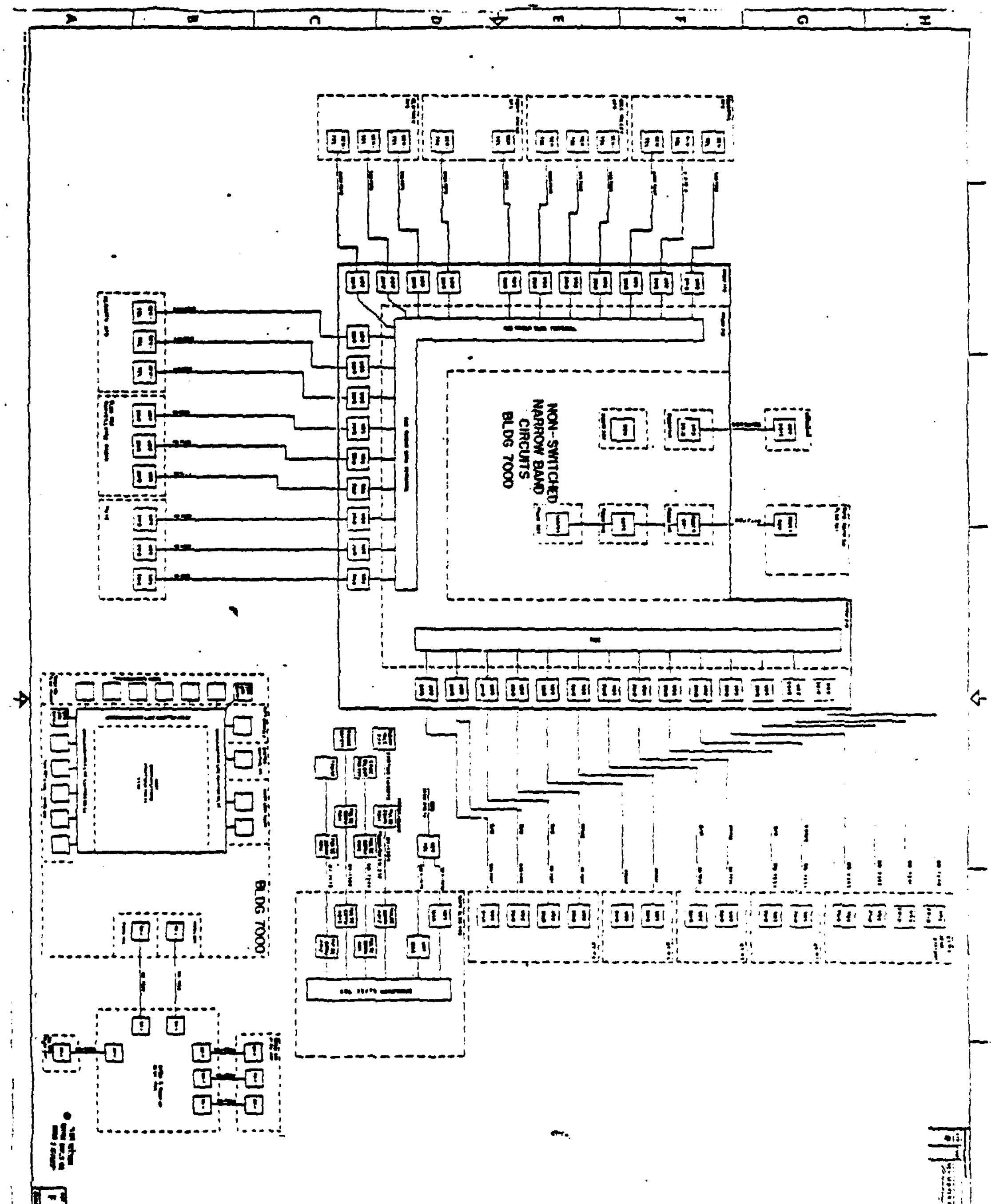


Figure 4-3. WSMC NARROW-BAND DATA TRANSMISSION SYSTEM, Sheet 2 of 2

4.1.3 Pillar Point RTDHS Pillar Point RTDHS is connected to VAFB, Building 7000A by the High Speed Data System (HSDS) and additional data modems for the transmission and reception of teletype, antenna pointing, and Narrow Band tracking data. The data circuits terminate at the digital data switch in Building 7000A where data is switched to appropriate computers or other sites at VAFB. Additonally, slaving information from other radars is passed to Pillar Point by way of this same system. The narrow band data system is also used to pass specific telemetry mark events to the computer in the VAFB RDF. The HSDS has two 9600 bps data streams plus up to sixteen 150 baud teletype channels, all in full duplex configuration. The primary functions assigned to Pillar Point RTDHS are:

o Receive data from local sources and transmit to VAFB.

o Receive real-time data from selected sources at VAFB and compute acquisition data for local instrumentation.

o Record and reproduce (playback) received data.

o Receive Inter-Range Vector (IRV) messages and convey orbital acquisition data to local systems via the UNIVAC 1218 computer.

o Transmit data to VAFB for patching to remote stations.

Real-time information is received and transmitted via a high speed data system (HSDS). A Data Terminal Buffer (DTB) converts it to 18-bit bytes acceptable to the UNIVAC 1218 Computer. The UNIVAC 1218 Computer accepts the data from the DTB, reformats it for use by the D/A converter. The D/A feeds designate errors to the radar's systems. The tracking radars (AN/FPS-16 and AN/FPQ-6) transmit continuous R, A, E, data to the Multiple Radar Interrogator (MRI) which converts the digital data to a computer format. The computer reformats this data and feeds it to the 1240 Magnetic Tape Unit. At the same time data is transferred to the DTB for transmission on a data modem.

4.2 INSTRUMENTATION DATA TRANSMISSION SYSTEM

The Instrumentation Data Transmission System (IDTS) is a microwave system which links the VAFB Range Operations Control Center (ROCC) with the PMTC at Point Mugu and San Nicolas Island. Repeater/relay stations are located at the surveillance radar site (Building 500, SVAFB) and on Santa Cruz Island. Figure 4-4 shows the geographic locations of terminals and repeater stations.

The IDTS is used for the transmission of voice, timing, radar data, beacon signals, video, teletype, and facsimile. These signals are used at, or originate from, any one of the stations within the system. The IDTS is also used to provide operational support for Eastern Test Range (ETR) programs.

The rf portions of the IDTS operate in the Government bands of the SHF frequency spectrum (7100 to 8300 MHz) and in the frequency and space diversity modes. The carrier portions use frequency division multiplexing and single sideband, suppressed carrier modulation. The IDTS is composed of three subsystems, each of which performs a specific function in the transmission of the different types of communications signals. These three subsystems are: communications and data, radar data relay, and radar data multiplex.

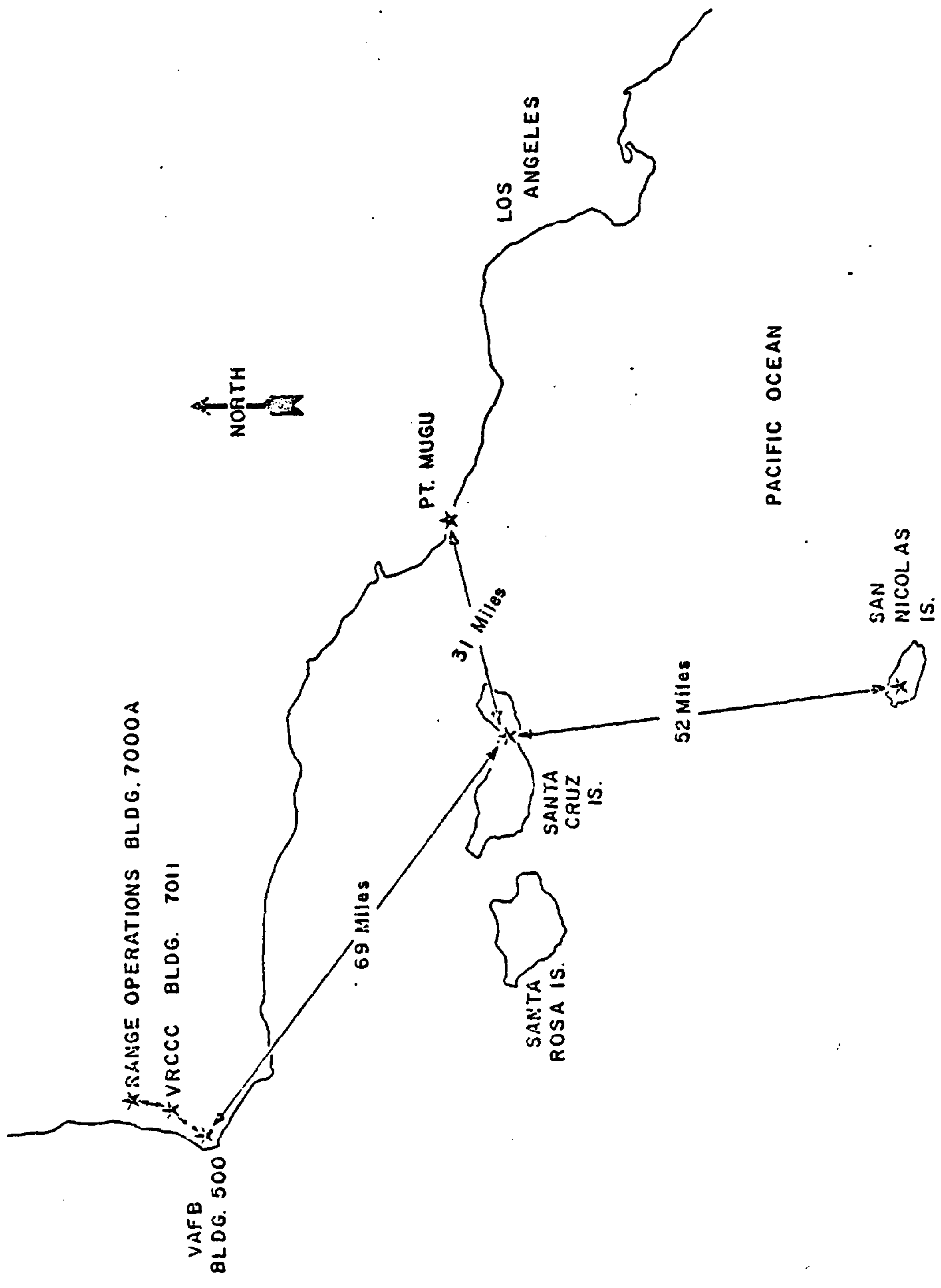


Figure 4-4. IDTS Microwave System Location Diagram

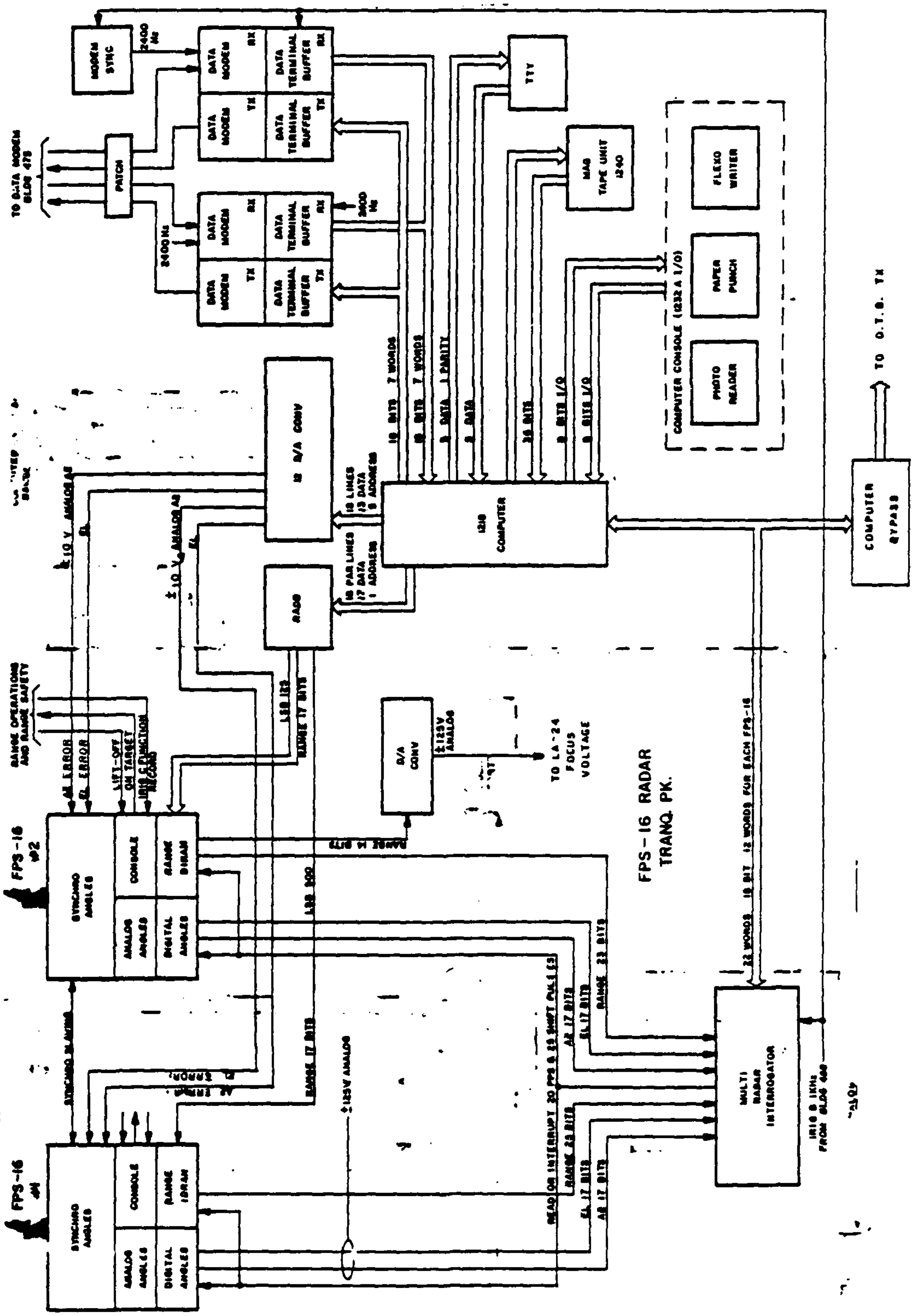


Figure 4-5 RTDHS Data Flow Diagram, Sheet 1 of 5

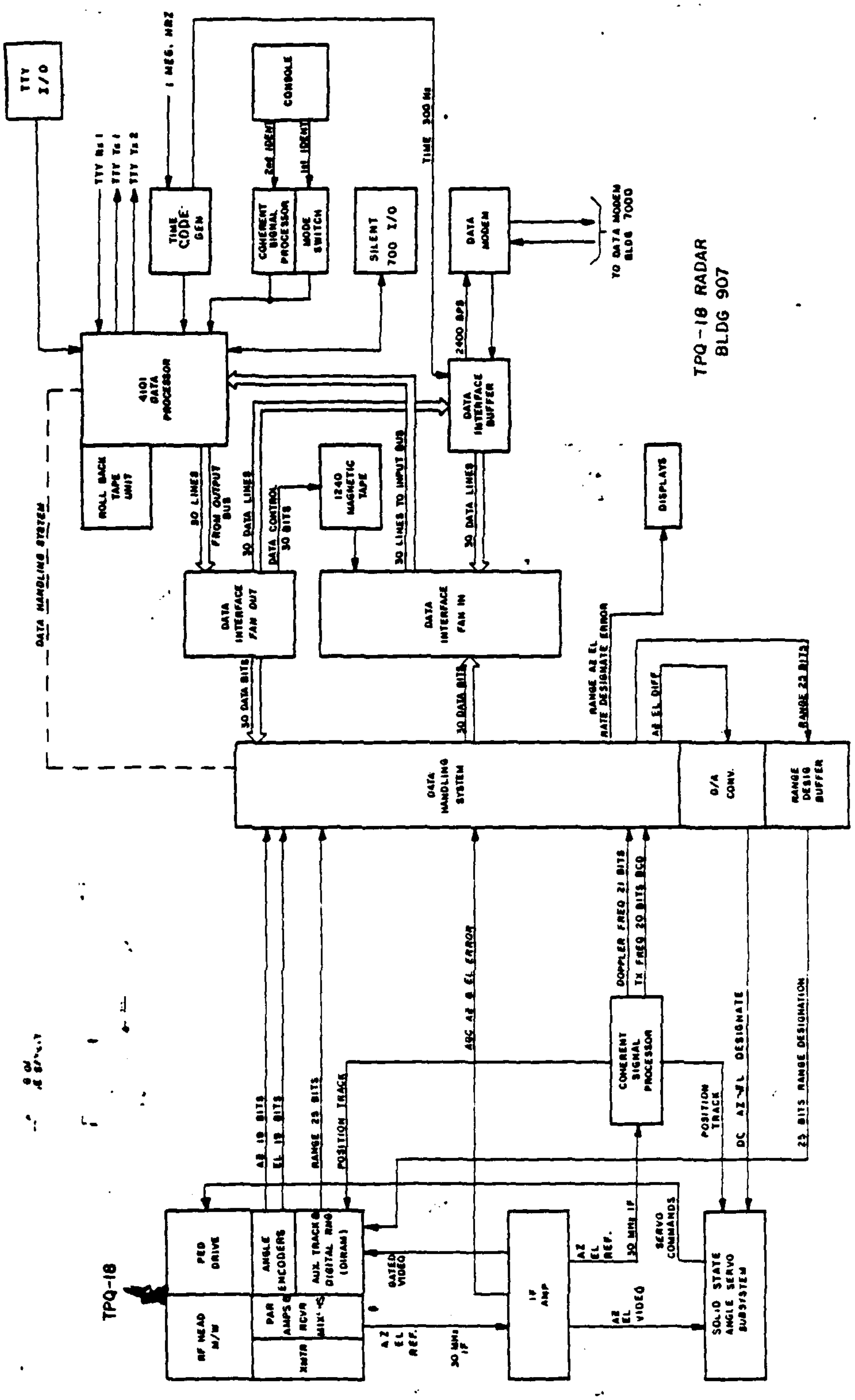


Figure 4-5 RTDHS Data Flow Diagram, Sheet 2 of 5

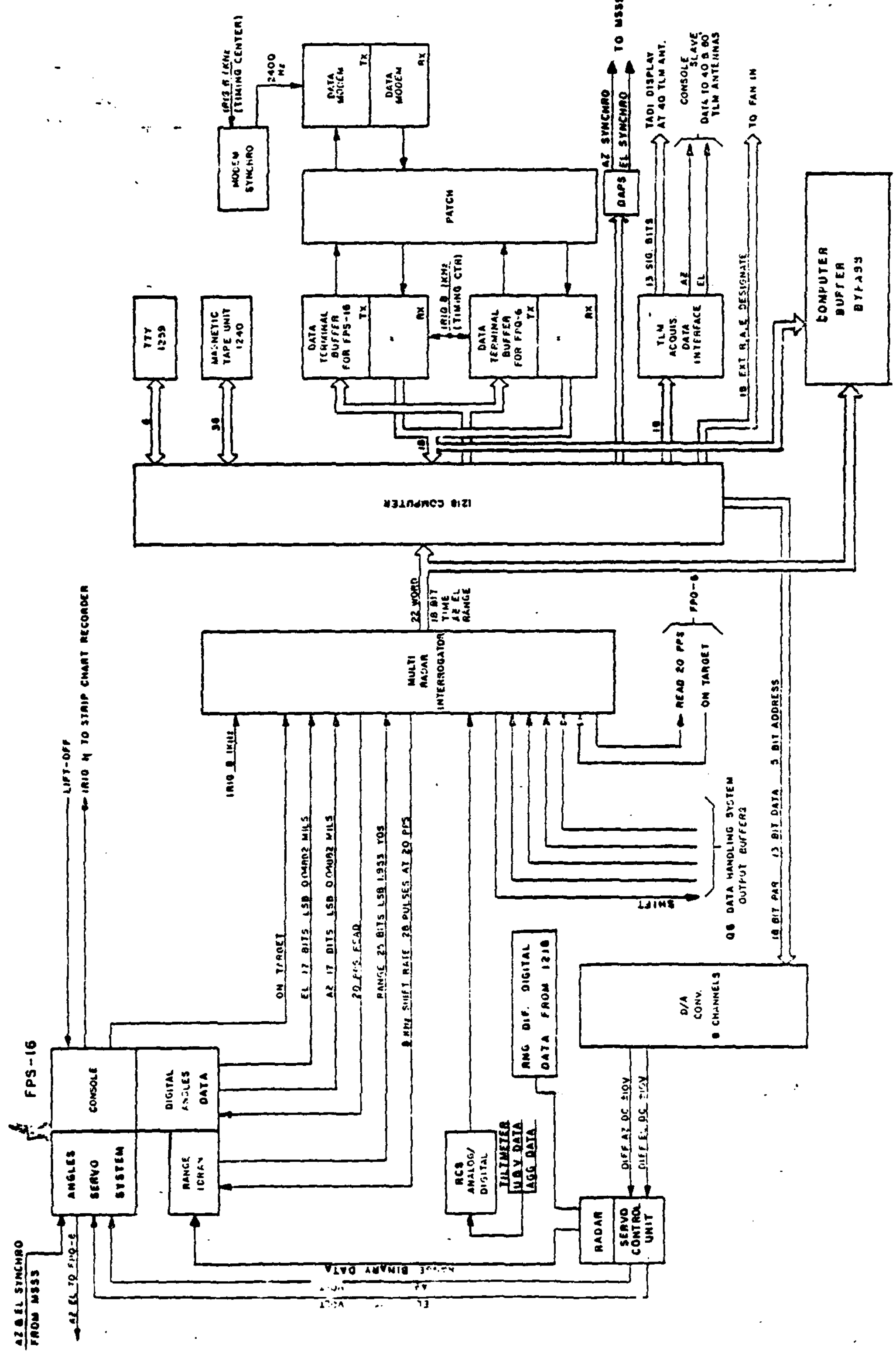


Figure 4-5 RTDHS Data Flow Diagram, Sheet 3 of 5

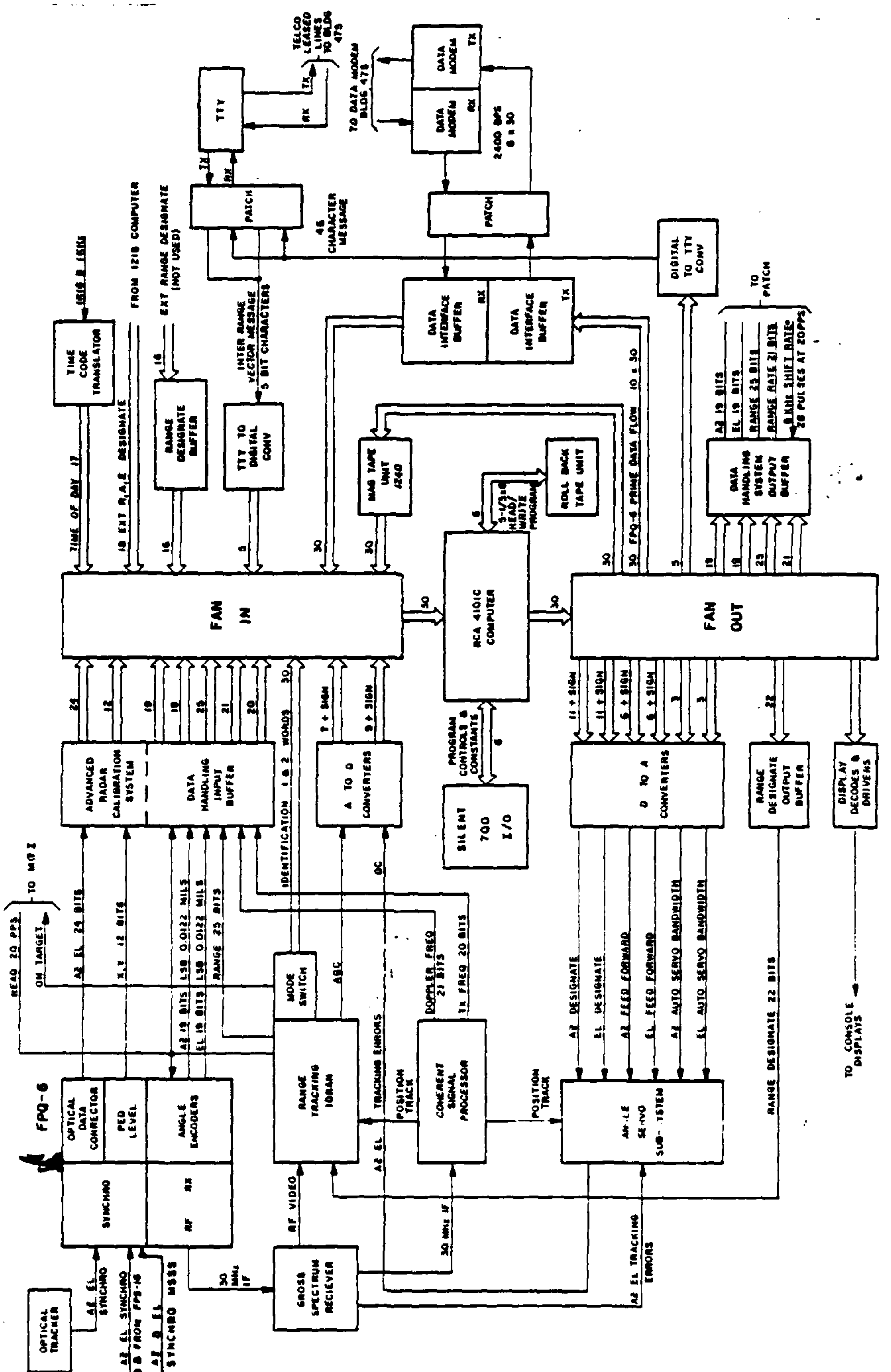


Figure 4-5 RTDHS Data Flow Diagram, Sheet 4 of 5

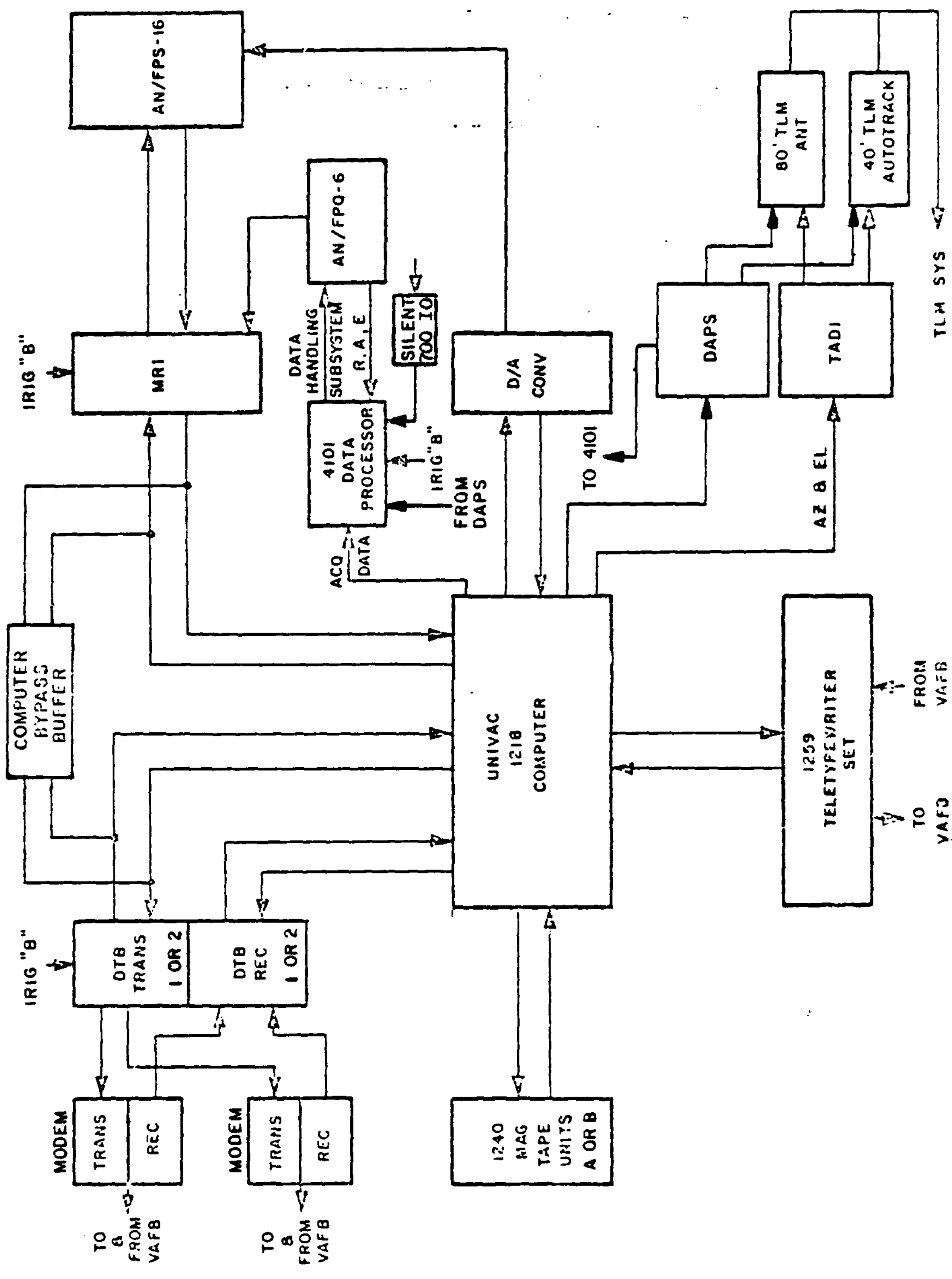


Figure 4-5 RTDHS Data Flow Diagram, Sheet 5 of 5

TELEMETRY DATA PROCESSING CENTERS

4.3 General. Telemetry data from missile launches (both ballistic and space), orbiting satellites, or aircraft flybys is collected at WSMC telemetry receiving sites and retransmitted via microwave links to Building 7000. The WTR Telemetry Data Processing Center (TDPC), located in the Building 7000 Complex, processes and displays the data in any of the following modes: pre-launch, launch, or post-launch. The TPDC is composed of the Telemetry Integrated Processing System (TIPS), the Telemetry Decommutation Validation System (TDVS), the Telemetry Analog Equipment Room (TAER), and several other Telemetry Stations. Figure 4-6 depicts the general telemetry data flow.

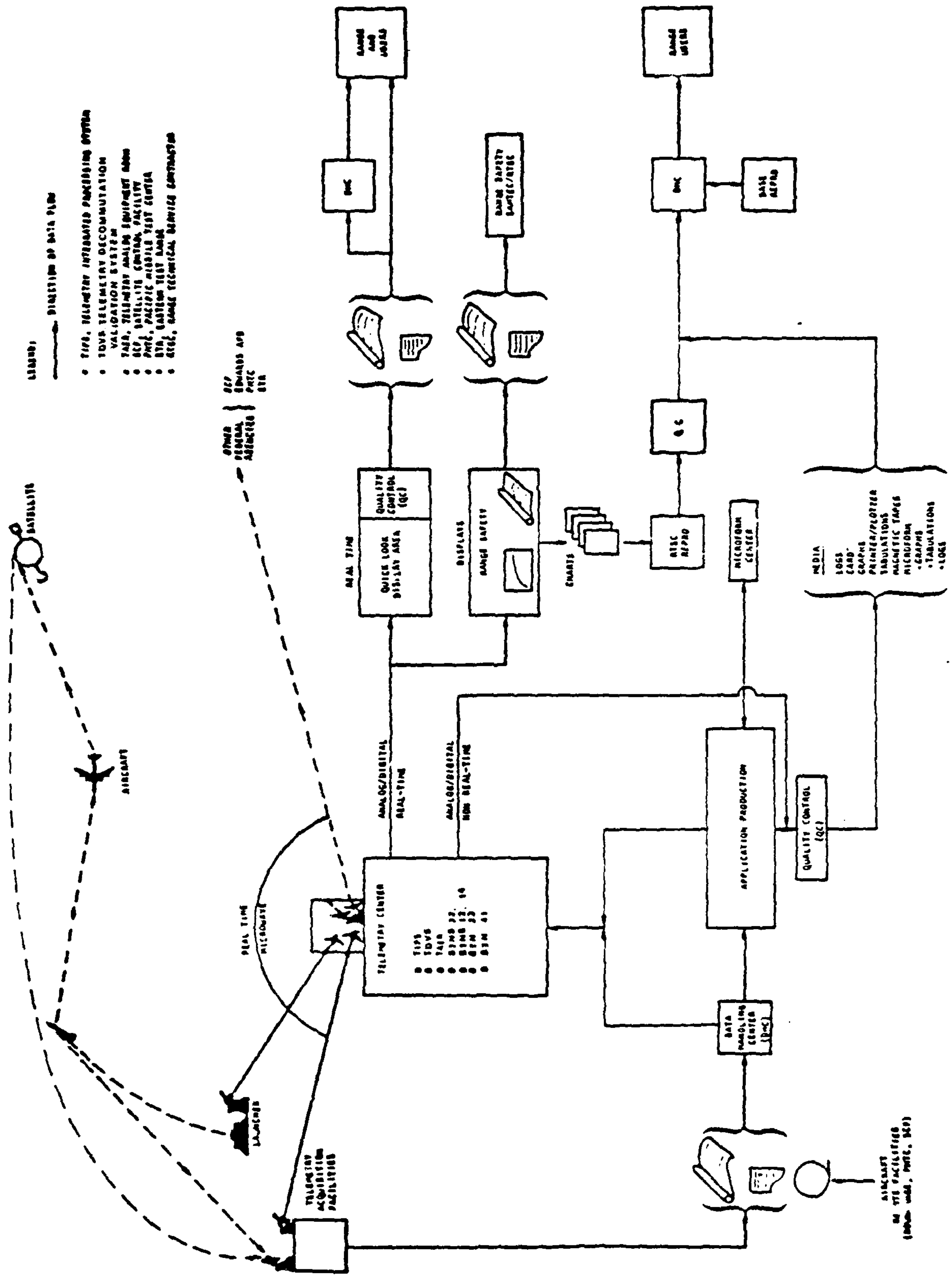


Figure 4-6. General Telemetry Data Flow

4.3.1 TELEMETRY ANALOG EQUIPMENT ROOM (TAER) TAER can provide the general capability to Receive, to Record and to Playback Telemetry data. In addition, TAER has the capability to configure the equipment in the room by use of a computerized switching system known as the Analog Data Equipment Switching System (ADESS).

The TAER configuration includes:

- One (1) Tape Cleaning & Certification Station
- One (1) Analog Data Equipment Switching System
- Three (3) Pre-Detection Receive/Playback Stations
- Four (4) Magnetic Tape Record Stations
- Six (6) Magnetic Tape Playback Stations
- Four (4) Analog Processing Discriminator Stations
- One (1) Optical Recorder Station
- One (1) Data Source Selector (DSS)
- One (1) Tape Duplicating System (TDS)
- One (1) Missile Flight Safety Station (MFSS)

The following paragraphs describe the configuration and support capabilities.

4.3.1.1 TAPE CLEANING & CERTIFICATION STATION The GKI 740 Winder Cleaner is a self-contained unit capable of maintaining and conditioning magnetic tape. Although primarily designed for instrumentation tape users, the unit is capable of being converted to other tape types as well. Also the 740 is equipped with a high speed rewind mode which is capable of rewinding tapes for various reasons.

Cleaning and restacking tape helps the users to be more efficient. This also assists the recorder heads to produce more error-free data. Cleaning prolongs the head life of tape recorders, because the user has cleaner and better tape to work with.

Although the 740 cleans and rewinds tape, it doesn't give any indication as to the quality of tape being used. This, however, is accomplished by the utilization of the Tape Dropout Analyzer/Certifier. The Tape Dropout Analyzer is capable of performing dropout testing of fourteen magnetic tape channels simultaneously, providing for each channel, a five digit LED display for operator monitoring and an external distribution output for permanent data records. The Dropout Simulator generates a signal that simulates what might be received from a magentic tape recorder channel and superimposes perscribed dropout characteristics upon either one of two test signal sources, or the signal received from an external input.

4.3.1.2 ANALOG DATA EQUIPMENT SWITCHING SYSTEM (ADESS)

The ADESS is an automated switching system which was procured as a replacement for the manual patching scheme for telemetry data distribution within Data Centers 10, 20, 30, and 40. The system contains eight matrices which vary in size and capabilities. The ADESS is an integral part of the Telemetry analog Equipment Room (TAER) in DC-30 and its capability is to function as the switching hub for all analog telemetry data that is processed in the Data Centers in Building 7000. It serves this same function for the TIPS. Under computer control, the ADESS is able to configure combinations of Tape Recorders, Receivers and various other Analog equipment for simultaneous support of up to six (6) different operations. Configurations may be changed as required and operations support configurations may be deleted or added at any time. All changes are under keyboard control of the Console operator.

The control system has the capability of exercising control of the signal flow through the switching matrices, and displays the status of the matrix configurations. Control commands are entered by the operator at the keyboard. The keyboard is an input device to the keyboard controller, and is capable of producing alphanumeric character and command codes in ASCII format. The keyboard commands are translated by the processor to binary signals which are applied to the switch matrices. Status and busy signals are returned from the matrices to the control interface units; status and busy information are returned from the control interface units to the processor. Operator requested information is displayed on the CRT, through the CRT Controller, and upon operator command. The floppy disc memeory provides storage of often-used mission configurations, and the ADESS program.

4.3.1.3 PRE-DETECTION RECEIVE/PLAYBACK STATION

Three groups of six (6) receivers comprise each Receive/Playback Station. Each Receiver is connected via Matrix 7 and Coaxial Cables to the Microwave Room (345). For realtime support, these receivers accept 10 MHz I.F. data from the Microwave system. This data is processed by receiver circuitry and is output either as video information or as down converted I.F. (pre-detection) data. The video data is then distributed to any of the TIPS Stations, tape recorders or other equipment within the TAER, and the pre-detection data is distributed to the tape recorders. For playback support the receivers accept pre-detection data from tape. The video output of the receivers is distributed to the TIPS Stations or other analog equipment within the TAER.

4.3.1.4. MAGENTIC TAPE RECORD STATIONS

Four (4) Magnetic Tape Record Stations are available in the TAER. Each station contains two (2) tape recorders which have their inputs paralleled track-for-track through AGC video distribution amplifiers, This configuration is capable of providing over-lapped recording on the second recorder as required. Two of the stations contain one inch tape recorders and two contain one-half inch tape recorders. Each of the four (4) stations contain some or all of the following equipment.

A. AGC Amplifier Assemblies with one (1) channel per tape track.

B. Monitor Oscilloscopes for monitoring the input and output of each tape track.

C. Mixers, one per 1/2" Station and two per 1" Station.

D. Monitor Oscilloscopes for monitoring the mixer inputs.

E. Communications Panels.

F. Time Code Translators and Readers.

G. A Tunable Discriminator and Mini Patch Panel for providing a means of checking the mixer outputs.

H. A Signal Generator to perform tape recorder signal confidence checks.

The Realtime record stations are capable of recording four different tape formats simultaneously. Frequencies in the range of 400 Hz to 2 MHz can be recorded in the direct record mode at 120 ips. In the FM Mode, the signal capabilities from DC to 500 KHz at 120 ips. The FM Record Modules contain filters with the capability of 15, 30, 60 and 120 IPS operation.

4.3.1.5 MAGNETIC TAPE PLAYBACK STATIONS

Six (6) Magnetic Tape Playback Stations are available in the TAER. Each station contains one tape recorder and associated support equipment. Three of the stations have one inch tape recorders and the other three have one-half inch tape recorders. The support equipment rack in each station contain a DEMUX assembly capable of discriminating data from the mixer tracks on the analog tapes. Certain support racks contain Time Code Readers with the capability to read and display tape timing data. Rack mounted support equipment includes an Oscilloscope capable of monitoring tape information, and a Monitor Panel which is used to select the desired Recorder inputs and outputs or DEMUX outputs to be displayed on the oscilloscope. Associated with the DEMUX is a Digital Voltmeter for use in calibrating the Discriminators. This voltmeter is located in a portable test equipment rack for tape recorders.

4.3.1.6 ANALOG PROCESSOR DISCRIMINATOR STATIONS

Four (4) Analog Prccessor Discriminator Stations (APDS) are located in TAER. These four stations contain fixed and tunable discriminators with the capability of discriminating Proportional and Constand Bandwidth F.M. data for application to the TIPS PAM/PDM front-ends and the Digitizer front-end. Along with the fixed and tunable discriminators, some of the stations contain associated support equipment such as the following:

1) Oscilloscopes; for monitoring the input and output of discriminators.

2) Digital voltmeters; for setting band center and band edge voltages on the discriminators.

3) Counters; for checking the frequencies of the various discriminators.

4) CBW and PBW Calibrators; for calibration of both proportional and constant bandwidth discriminators.

5) Two Brush Strip Chart Records; for displaying discriminator outputs.

6) A Video and Monitor Patch Panel; for more flexibility, especially in turn-around time when a failure occurs.

Discriminators have the capability of providing a data output signal suitable for further processing equipment such as Recording Galvonometers, Decommutators, Analog-to-Digital Converters and Computers. Each discriminator is capable of at least three functions in the processing system:

1) Selection of the assigned subcarrier channel from the multiplex.

2) Detection of the selected FM Signal or conversion of frequency to a voltage representative of the telemetered data.

3) Filtering and amplification of the detected data.

TAER mission support capability is enhanced by the added capability to demodulate FM signals of from 300 Hz to 1.5 MHz with standard deviations of from $\pm 1\%$ to $\pm 40\%$. Output filter cut-off frequencies range from 4.0 Hz to 1.0 MHz. A total of fifteen tunable discriminators, five universal discriminators and eighty-four fixed discriminators complement the TAER instrumentation.

4.3.1.7 OPTICAL RECORDER STATION

One (1) Optical Recorder Station is located in TAER. This station contains six (6) optical type oscillogram (Honeywell Model 1858 CRT Visicorders) recorders for use in displaying analog data.

The Model 1858 CRT Visicorder is capable of multichannel recording of up to 18 simultaneous data channels on photo sensitive paper. Plug-in modules convert input data signals into time referenced unblanking signals synchronized with the FO-CRT beam sweep. All data and reference line signals recorded by the Model 1858 are presented on the 8 inch by 0.2 inch FO-CRT. The fiber-optics faceplate conducts the light from the phosphor to the moving photosensitive paper with negligible diffusion. All signals are presented to the CRT in the form of an unblanking signal which allows signal crossovers or convergence without affecting the accuracy of the recorded traces. Each sweep of the CRT beam unblanks briefly to print the instantaneous position of each trace. The 50 KHz sweep rate gives the record the appearance of unbroken traces for static or slowly varying traces. Rapidly transiting signals use a collected sampling system built into each module to unblank the CRT to connect significant sweep to sweep changes in the instantaneous position of the signal trace. Focus, intensity, and sweep rate are automatically controlled by the recorder.

The paper transport incorporates a dc servo-controlled drive motor capable of providing a wide range of operating speeds from 0.1 to 120 inches per second. The use of adding the multiplying speed pushbuttons allows the selection of more than 42 discrete speeds within the range.

The recorder unit generates signals to allow the signal conditioning modules to synchronize with the CRT beam. The recorder also has the capability to generate signals to print gridlines, timelines, and trace identification on the record.

4.3.2 DATA SOURCE SELECTOR (DSS)

The HELIX System 1010 Data Source Selector (DSS) is capable of accepting up to six asynchronous pre-detection PCM signals from a single transmitting source, delaying each signal an appropriate amount to establish time synchronization between channels, comparing the resulting data streams on a bit-by-bit basis to determine the most likely logic state based on the pre-detection signal-to-noise ratio in each channel, and outputting a single PCM data stream which represents the lowest bit error rate probability obtainable using all available input signals. The single PCM data signal so developed is called the "best-merged" data stream. A clock signal, synchronous in time with the best-merged data stream, is also developed as an output. The DSS is available with two, four, or six channel capability. The two and four channel versions may be upgraded to a larger number of channels (to a maximum total of six) by installing the appropriate input subsystems, memory, and plug-in circuit boards. The DSS system also accepts a modulated time code and delays it an appropriate amount to compensate for telemetry signal relay channel and DSS processing, propagation times. Time synchronized serial PCM data stream outputs which have not been subjected to the merging process, are available for individual channels. See figure 4-7. (The DSS in TAER is a 4-channel version).

Three primary functions are accomplished in the System 1010:

- o Signal Quality Measurement
- o PCM Data Synchronization
- o PCM Data Merge.

A Frame Sync Status Monitor was designed, fabricated, and installed by FEC with the capability of providing a realtime display of the performance and output data quality of the DSS. It is also a valuable tool for pre-op verification and for troubleshooting the DSS. Each data quality signal is available at a patch panel for recording purposes.

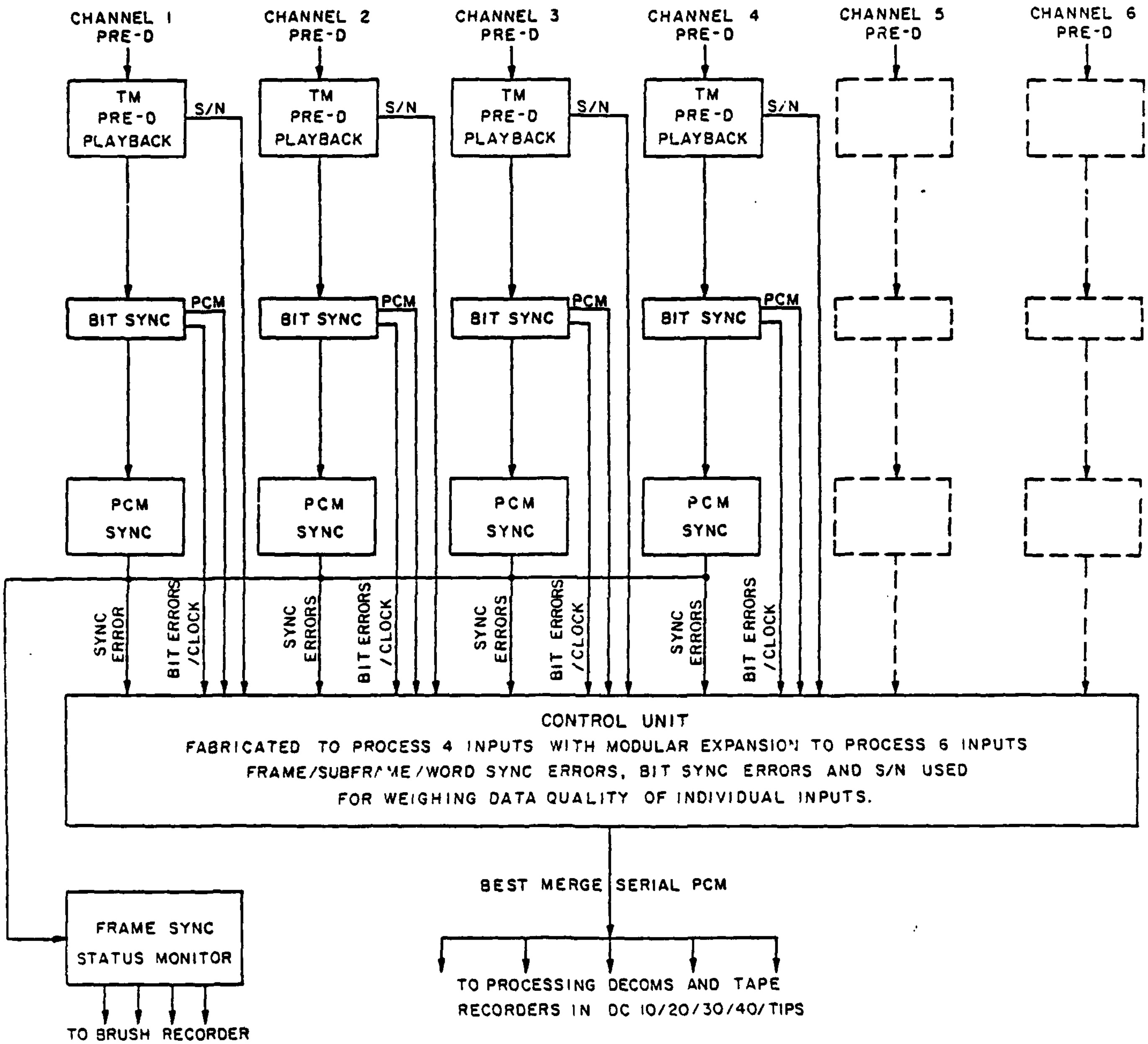


Figure 4-7. DSS TM-3316 Block Diagram

4.3.3 TAPE DUPLICATING SYSTEM (TDS)

The Tape Dub Station is capable of being a stand-alone station with its own four pre-d playback units, bit synchronizers and PCM Decommutators used for the Tape Signal Quality evaluation. (See figure 4-8.) Some of the capabilities of the Tape Dub Station are as follows:

1) FM/FM data recorded on a tape can be reformatted and dubbed onto another tape.

2) Pre-detection tapes can be processed, the predetection signal can be converted to post-detection data using the telemetry receivers and duplicate post-detection tapes can be produced.

3) Two or more tape recorders can be time slaved to a common time code carrier such as IRIG "A".

4) Multiple dub capability in the following formats:

   Pre-D to Pre-D; Pre-D to Post-D; and Post-D to Post-D.

Apart from producing duplicate tapes, and being able to evaluate their signal quality, the Tape Dub Station has the capability of producing special plots data for the Performance Analysis Department (PAD). These plots provide all signal strength channels from the mixer(s) versus all data tracks from each mag tape, including S/S calibrations, spectrum display trace, sync status and IRIG "H" timing.

The primary objective of these PAD plots is an in-depth analysis to indicate the individual site and total range performance in support of selected operations. Since the Tape Dub Station has the capability of containing much associated support equipment such as, Mux/Demux units, Time Code Readers/Translators, Oscilloscopes, Brush Direct Write Recorders, Tunable Discriminators, Spectrum Analyzers, AGC Amplifiers, etc. These plots can be produced on it with little difficulty. Also, for the sake of expediency, an FEC Shops fabricated spectrum sampler installed in the Tape dub Station provides the capability of recording the spectrum trace from four sources on a Brush Recorder simultaneously. All of the Tape Recorders and support equipment associated with the Tape Dub Station are interfaced together with the addition of a miniature patch panel. All inputs and outputs of all the equipment appear at this patch panel. This patch panel provides for greater flexibility in setting up the Tape dub Station or to troubleshoot any defective piece of equipment.

Interface lines between the Tape Dub Station patch panel and the Data Source Selector patch panel eliminate the limitation of having only four receivers, bit boxes and decomms in the TDS. Down range magnetic tape generally have more than four data tracks recorded on them. With the use of the Data Source Selector via the interface lines between the two patch boards, dub tapes are produced while evaluating the signal quality of the dubs for up to eight data tracks.

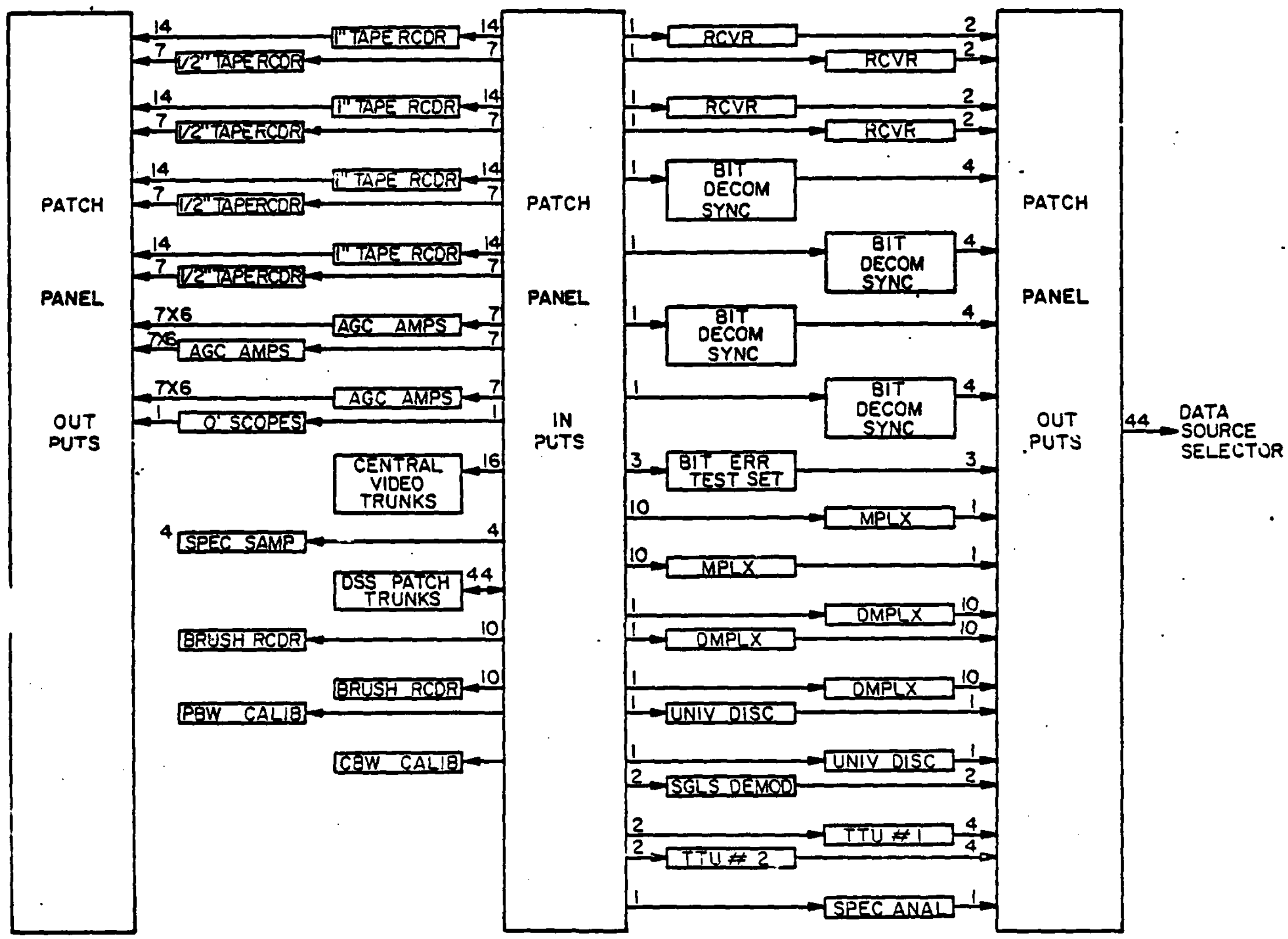


Figure 4-8. Tape Dub & Evaluation System

4.3.4 MISSILE FLIGHT SAFETY STATION (MFSS)

The Missile Flight Safety Station, (MFSS) is an assembly of PAM/PDM and PCM decommutators and support test equipment, calibrators, discriminators and timing equipment.

The MFSS also includes a very limited recording capability - two Brush recorders and provision for connecting to one portable Brush. The MFSS is intended to drive two Sanborn recorders located in the Missile Flight Control Center (MFCC).

The MFSS will include the capability of driving the BOMARC pilot's recorder in the Area Control Center (ACC), Room 224 of Building 7000A. The BOMARC display is not related to range safety functions, but does require display of PAM/PDM analog values on a Brush chart.

Currently Range Safety is supported by DC-10, 20, or 40. All of these stations are scheduled to be replaced by TIPS.

TIPS is a digital system. It has no analog signal outputs. Therefore, it cannot drive the MFCO's stripchart recorders. Since the TIPS output printer/plotters have a four inch delay, TIPS cannot offer real-time hardcopy display.

MFSS provides the only station capable of generating analog voltage representation of PCM or PAM/PDM wavetrains when TIPS is fully implemented. The MFSS will be the only station with any analog interface to MFSS after TIPS has displaced DC-10.

The station capabilities can be classified under three general headings:

- o FM Discriminators
- o PAM/PDM Decommutators
- o PCM Decommutators

FM Discriminators

The discriminators consist of 46 EMR 210s with Tape Speed Compensation and tuning units and filters for most IRIG channels thru 21, H and many of the CBW channels.

PAM/PDM Decommutators

The initial operating configuration has 4 Astrodata Model 603/602/624 decommutator/output module/oscilloscope assemblies. Two of the 602's have 45 gates; two have 90. The 624 is a large display oscilloscope.

PCM Decommutators

The two PCM decommutators are Monitor Model 1126B's driven by one each (total of two) Monitor Model 335 Bit Synchronizers. The PCM system can accept most IRIG PCM codes - basically RZ, NRZ, BIO and DM at 5 megabit rates.

The DACs - Stellarmetrics DAC -33 and DAC -34 are capable of outputing up to 32 different analog conversions of 8 bit words and up to 128 events of single bit DACs provided that all 128 are contained in sixteen 1 bit groups.

One other very important function that the MFSS is capable of is the support of re-entry vehicle links of the MM III programs in Realtime and playback modes.

With the installation of interface patch lines from the MFSS patch board to the DC-30 central patch facility to the DC-30 Quick Look Rooms, this capability is possible, since the MM III program is PCM. Utilizing the two PCM 1126B Monitor Decoms and the Stellarmetrics DACs 33 & 34, PCM RV data is capable of being displayed in the DC-30 Quick Look Rooms.

SECTION 5.0

INSTRUMENTATION SUPPORT SYSTEMS

5.1 RANGE TIMING SYSTEMS

The WSMC Timing System generates timing for use by landbased sites. These signals are used to correlate all telemetry, optical, radar, etc., data transmitted to, and received from, ballistic missiles and space vehicles. Range Timing Systems comprise the main Central Timing Signal Generator (CTSG), Building 7011, NVAFB, one each CTSG at Pillar Point, and Kaena Point. The typical WSMC CTSG (See figure 5-1) is made up of the basic equipment required to generate, control, and distribute the following range timing:

- o Frequency Standard (Time Base Oscillators)
- o Time Generators
- o Alarm, Test, Monitor, Patch, and other Support Facilities
- o Distribution Amplifiers

5.1.1 Central Timing Signal Generator - Pillar Point

The purpose of the CTSG is to generate from a single source all the reference timing signals used in the Pillar Point AFS area. (See figure 5.2) The CTSG provides 90 separate, accurate and reliable output timing signals, all synchronized to a precision frequency standard. For reliability the CTSG provides identical master and back-up time code generators (TCG A and TCG B) with provisions for automatic transfer from master to back-up source in case signal loss or degradation occurs in the master signals. The system contains circuits that continuously monitor the outputs of both TCGs for signal loss or degradation. When a failure is detected visual and audio alarms actuate. Status indicators are provided to indicate the source of signal failure.

Figure 5.2.A is a functional block diagram of the CTSG. The CTSG contains two identical Time Code Generators (TCG A and TCG B) each of which is clocked by a precise 1-megahertz sine wave obtained from an HP 5061A Cesium Frequency Standard. Each TCG produces a 1-kilohertz sine wave and the 20 IRIG time codes listed below:

1. A000	6. B003	11. E001	16. G142
2. A003	7. B120	12. E002	17. H001
3. A130	8. B123	13. E121	18. H002
4. A133	9. D002	14. E122	19. H121
5. B000	10. D122	15. G002	20. H122

Each TCG also produces seven decade pulse rates ranging from 1 M pulses per second to 1 pulse per second.

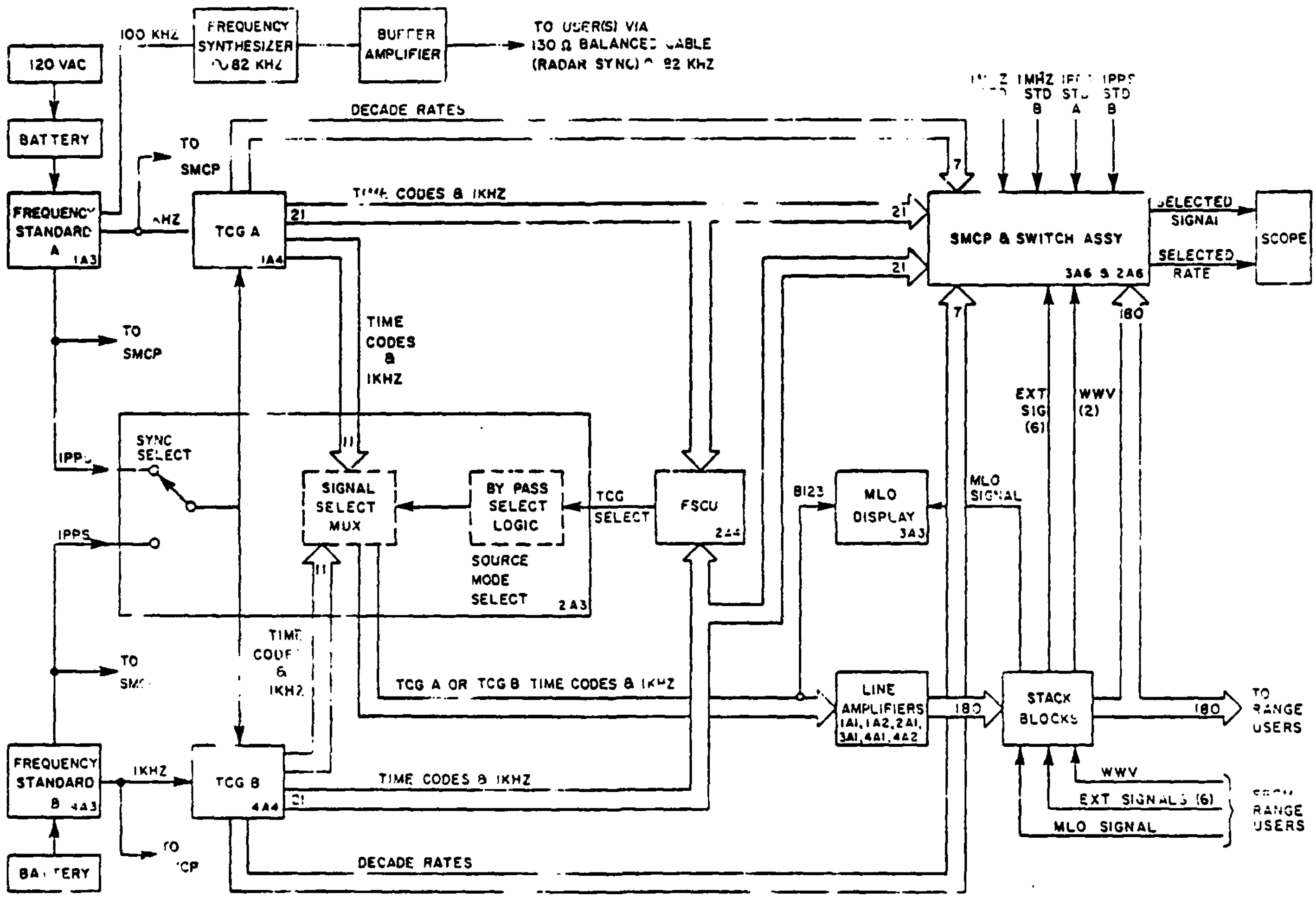


Figure 5-1. Central Timing Signal Generator

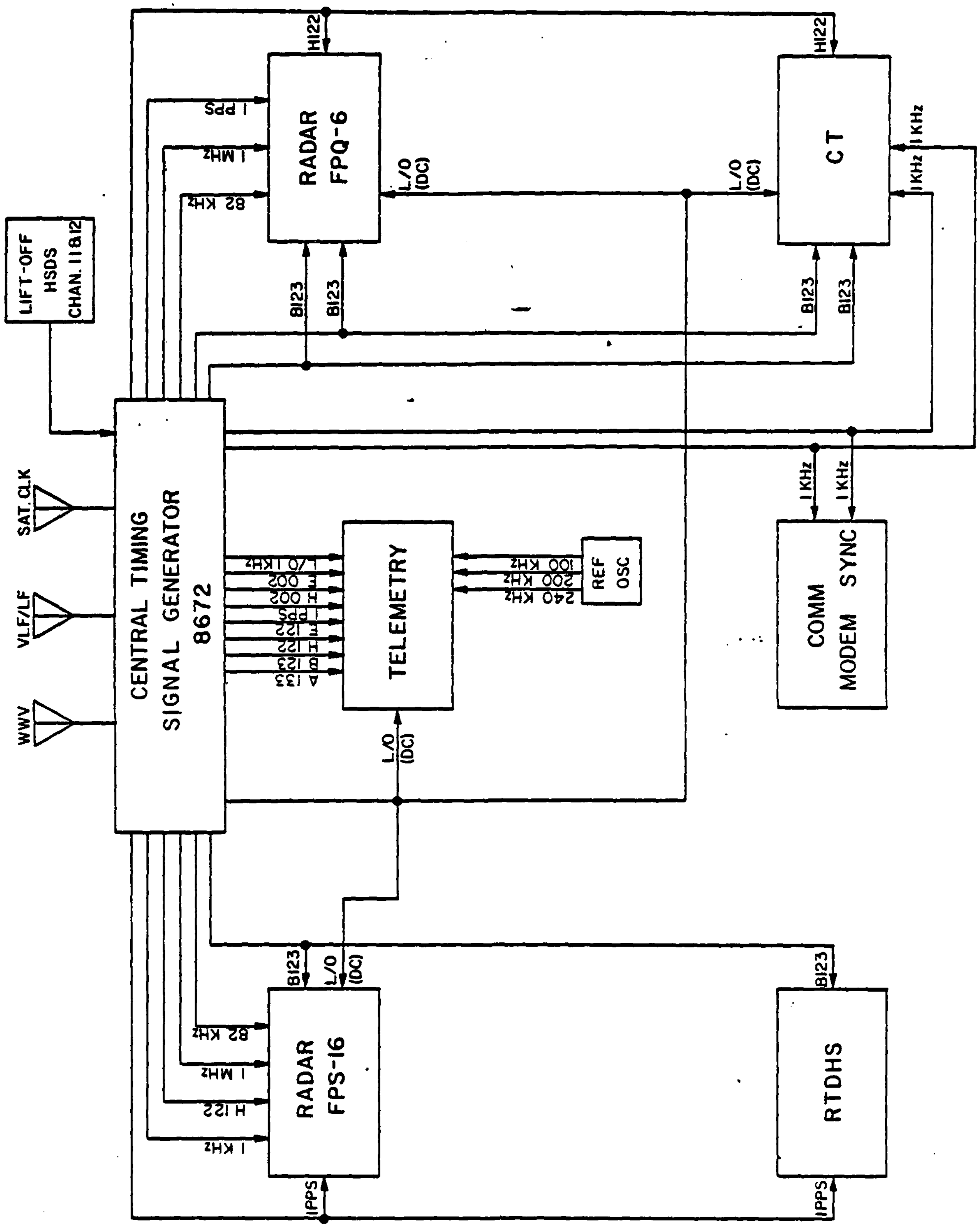


Figure 5-2. Pillar Point, Timing Data Flow Diagram

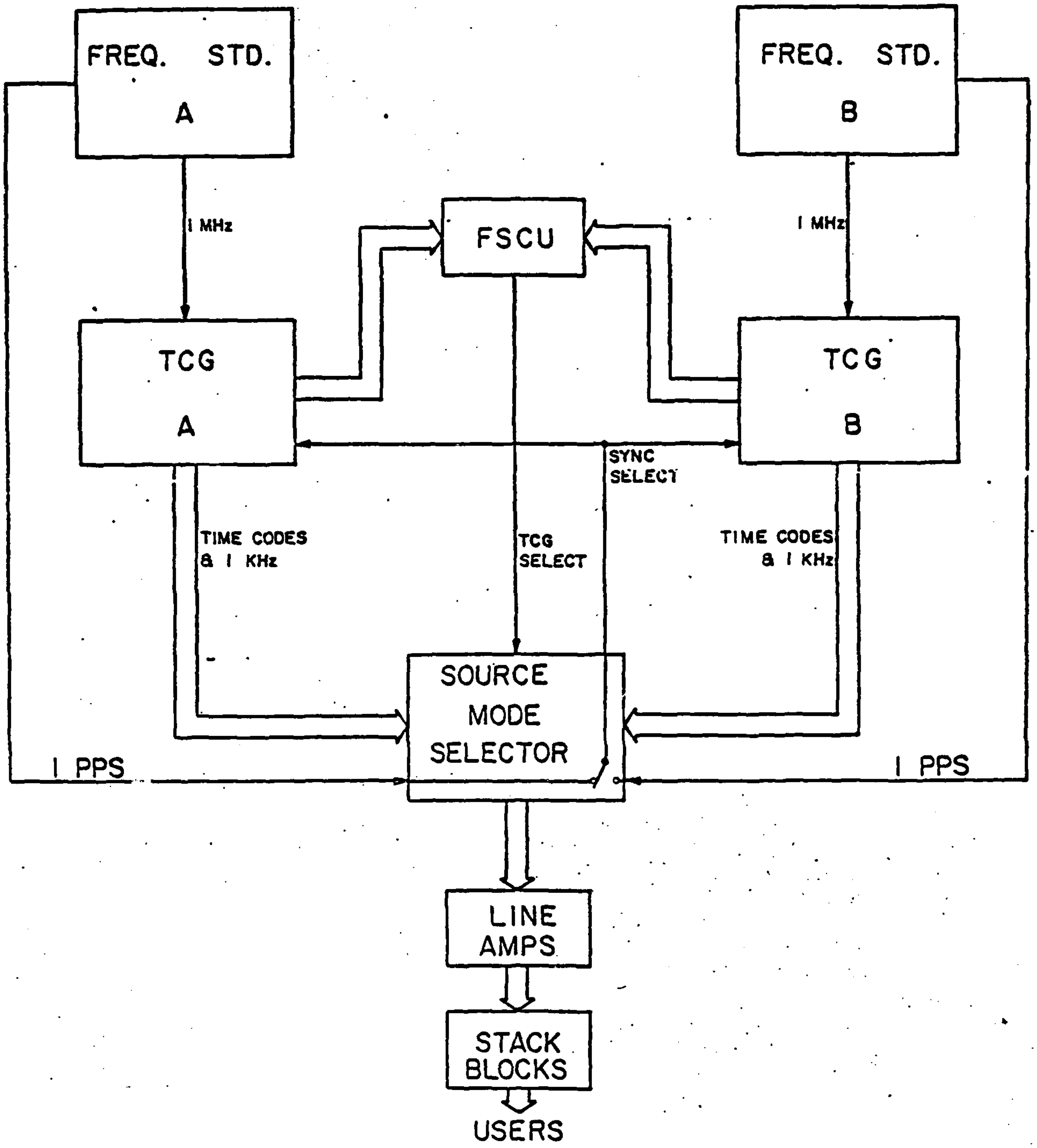


Figure 5-2.A CTSG Functional Block Diagram

5.1.2 Timing Subsystem, AN/FPQ-14 at Kaena Point The Kaena Point AN/FPS-14 Timing Subsystem comprises two identical timing stations, a switcher unit and synchronization equipment necessary to correlate timing to an accurate master external epoch. At any specific time, one of the two timing stations will be the source of all timing signals generated by the subsystem. The remaining system is normally closely synchronized to the same master epoch and requires minimal operator effort or time to be switched to the on-line condition.

Each of the two timing stations consists of a Cesium clock source, three logic nests, two control and display panels and power supplies. The output of a timing station may be divided into one of three general categories:

a. Rates

b. Serial Time Codes

c. Parallel Time Code

All outputs used external to the subsystem with the exception of a 5 MHz signal from the Cesium standard used in the transmitter subsystem are interfaced through the switcher.

The Switcher unit comprises a logic gate and relay circuits. A single toggle switch is used to select which of the two timing stations is to be the source of all time signals. All rates and parallel time code data is switched through the logic gating circuitry; the relay switching circuits are used to select the serial time code source.

Synchronization to an external epoch is accomplished by receiving CBS WWV or WWVH for coarse alignment and very accurate alignment is accomplished by receiving LORAN-C signals. Data received from the HF receiver allows synchronization of time within ± 5 ms while data derived from the LORAN-C system allows refinement to within + 2 usec.

Pulse repetition rates from the LORAN-C system are subject to change and are often not in exact multiples of one second intervals. Thumbswitches are provided that allow the LORAN-C receiver to be adjusted to track any existing LORAN-C chain.

Long-term stability of the Cesium clocks prevents appreciative drift of the time code generator from the master timing system between LORAN-C epoch adjustments. Drifts of not more than $\pm$ 1 usec per day can be exacted. A standby battery source supply prevents loss of synchronization during periods of local power failure.

Each of the two timing stations comprise an HP5061A Cesium Beam Standard, a Standby Power Supply, and a Time Code Generator. Timing accuracy is measured on a monthly basis at the IPPS output jack of the Time Code Generator.

5.2 COMMAND CONTROL TRANSMITTER SYSTEM

The Command Control Transmitter (CCT) System (See figure 5-7) consists of consoles and equipment installed in the Missile Flight Control Center, four UHF transmitter sites, and interface/interconnecting equipment. The purpose of the CCT system is to terminate the flight of a launch vehicle that is determined by the Missile Flight Control Office (MFCO) to be performing abnormally or is outside of the predetermined safe flight corridor.

The commands, OPTIONAL COMMAND (OC), ARM and DESTRUCT are initiated by the MFCO operating from the MFCO console in the Missile Flight Control Center. These commands are sent to the particular site selected and from these transmitted to the launch vehicle in the form of a coded signal.

Three CCT sites are located at VAFB, one at Pillar Point, and one site at Laguna Peak (operated by PMTC).

CCT Sites 1, 2 and 3 are configured for ICRS Mode as well as the standard mode of operation.

The Laguna Peak CCT (Site 6) is operated and maintained by the PMTC. This site is also equipped with the ICRS Mode support capability similar to CCT Sites 1 and 3.

5.2.1 Missile Flight Control Center CCT Interface There are two types of consoles within the Missile Flight Control Center having CCT functions. These are two MFCO Consoles, and two CCT Controller Consoles. The MFCO console is discussed in Section 2. The CCT Controller Consoles are used to control CCT site configurations during launch operations. The CCT Controller Consoles also present displays of CCT status and functions. Either of the CCT Controller Consoles can select, turn-on, or turn-off, the transmitter at any of the CCT sites.

The distribution of command and control data from the Missile Flight Control Center is by landline to CCT# 1, 2, 3 & 4. Laguna Peak (CCT# 6) uses both landline and microwave.

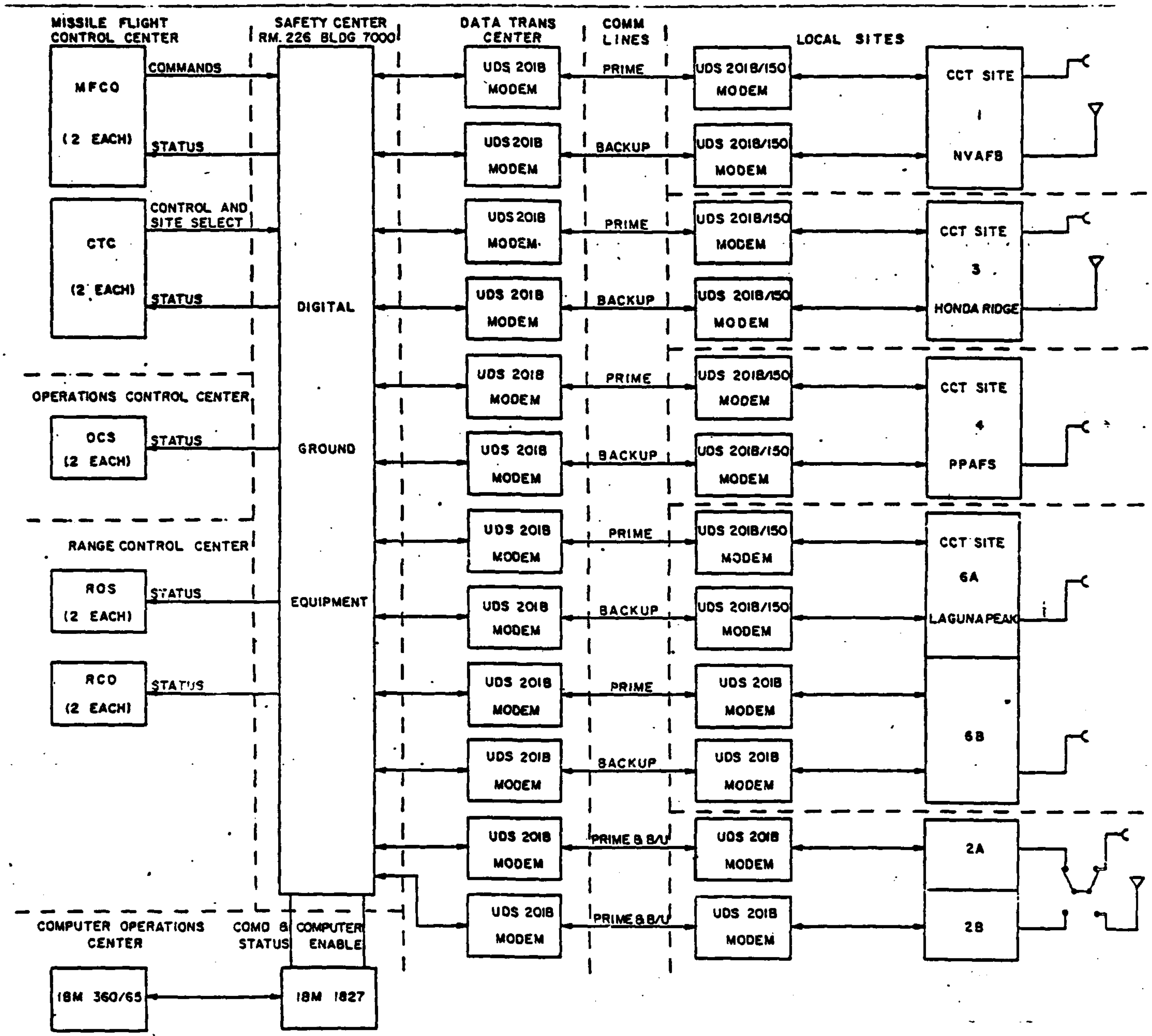


Figure 5-3. Simplified Block Diagram,
Command or Status Transmissions Links - TOCC and CCTs.

5.2.2 CCT Site No. 1 CCT Site No. 1 is a dual (primary and standby) - Command Control System installed in Building 21200, NVAFB (See figure 5-8). Basically, the site consists of the equipment listed in Table 5-III.

Changeover from primary to standby systems is automatic or manual. The system automatically switches from primary to standby if high reflected power or low incident power is detected. Primary electrical power is provided by commercial power with a standby diesel generator.

5.2.3 CCT Site No. 2 CCT Site No. 2 is a dual (primary and standby) Command Control System installed in two 8'x40' vans located at the west end of Building 644, SVAFB. Basically the site consists of the equipment listed in Table 5-III. Capabilities are similar to those of CCT Site No. 1.

The following data, reflecting the operational condition of the CCT site, is transmitted to the Missile Flight Control Center, as ON or OFF functions, for display on the CCT Controller, RTDC, and MFCO Consoles:

- o Carrier Status.
- o OMNI #1.
- o Directional #1.
- o OMNI #2.
- o Directional #2.
- o Check Channel.
- o OC Received.
- o ARM Received.
- o DESTRUCT Received.
- o CPOF (Carrier Present on Frequency) York D1062 Receiver

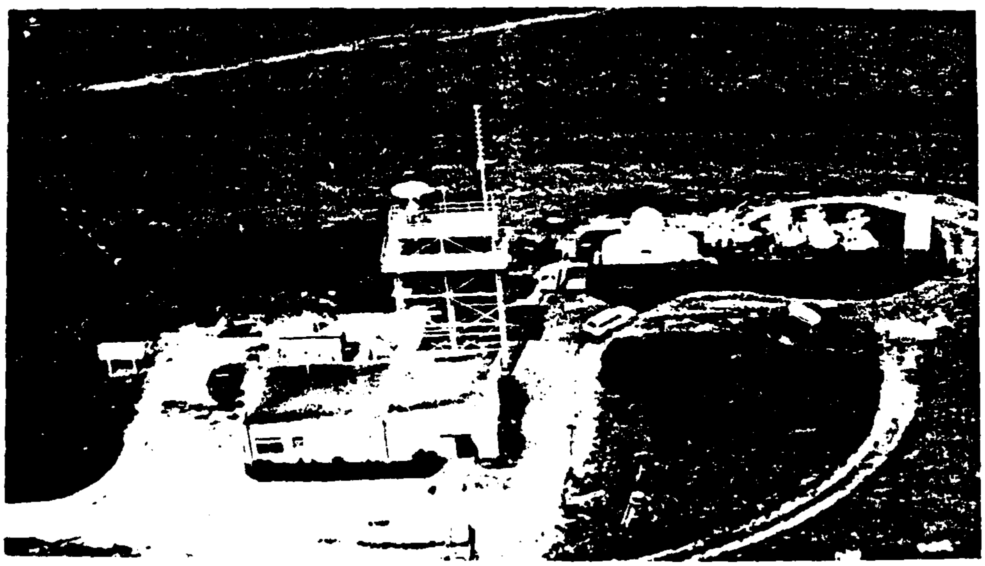


Figure 5-4. CCT Number 1, Site, Overall View

5.2.4 CCT Site No. 3 CCT Site No. 3 (See figure 5-9) is a dual (primary and standby) Command Control System installed in Building 510, SVAFB. The site's control circuitry is solid-state Xerox logic. Basically, the site comprises the equipment listed in Table 5-III.

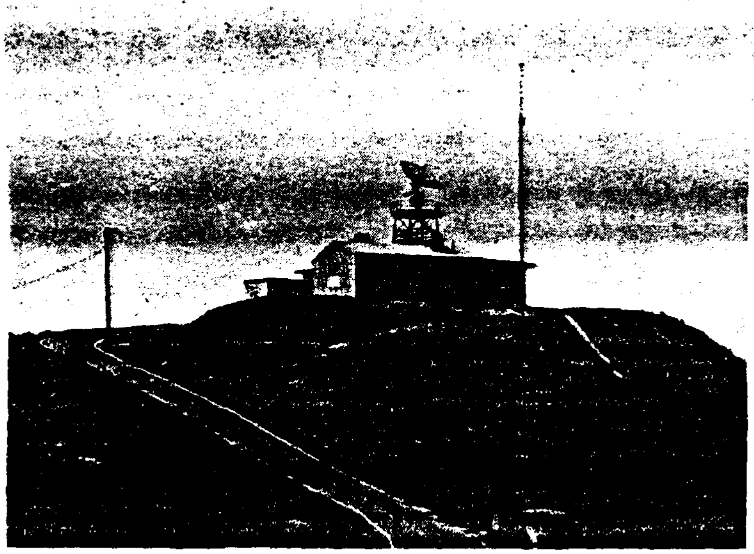


Figure 5-5. CCT Number 3 Site, Overall View

5.2.5 Pillar Point CCT The Pillar Point CCT transmits frequency modulated command signals to selected vehicles in flight under the control of the MFCO at VAFB. The MFCO remotely controls the Pillar Point CCT System via leased communication lines, and the DGE. The system may also be operated locally, transmitting a command signal independent of the MFCO remote control. This system is operated locally only in the case of emergency and upon the receipt of a specific request from the MFCO. The Pillar Point CCT is housed in two (primary and standby) 40-foot vans.

Primary electrical power is provided by an engine driven generator. Commercial power is used for standby and is switched-in automatically in the event of primary power failure.

Table 5-I. CCT SYSTEM EQUIPMENT

	VAFB-Site #1	VAFB-* Site #2	VAFB-Site #3	Pillar Point	Laguna *Peak
1. SK-11482 Audio Freq. Coder	2	2	2	2	
2. 2400-2 Power Amplifier (10 kW)	2	2			
3. 1206A Power Amplifier			2	2	
4. ANDREWS 63608 Omnidirectional Ant. (10kw)	1	1	1		
5. 15-Ft. Parabolic Dish (10 kW)	1	1	1	1	2
6. Synthesized Signal Generator (HP-8660A)	2	2	2	2	
7. SK-10999 Sequencer			2		
8. Energy System 50 Watt Amplifier	2	2	2	2	
9. D1062 Dual Carrier Detector and Decoder	1	1	1	1	
SK12902 Tone Generator					2
AYDIN 1206A Power Amplifier					2
406.5-416.5 Frequency Source					2
Excitor, Dual 10W Amplifier					2
SK12901 RF Monitor					2

*Van Mounted

5.2.6 CCT Technical Data

- SK-11482 Audio Frequency Coder:

Channels:	20-ON/OFF
Channel frequency:	Standard IRIG
Channel frequency stability:	± 1%
Frequency range:	7.5 to 73.95 kHz
Channel utilization:	Simultaneously

- 240D-2 Power Amplifier:

RF power output:	10 kW
RF output impedance:	50 Ohms
Output frequency range:	400 to 550 MHz
Output bandwidth (3 dB):	3 MHz
Gain:	27 dB
Spurious emission:	-80 dB
Residual modulation:	-50 dB
RF input driving power:	25 W
RF input impedance:	50 Ohms

- AYDIN 1206A Power Amplifier:

RF Power Output:	10 kW
RF Output Impedance:	50 Ohms
Output frequency range:	425 MHz.
Output Bandwidth (3 dB):	1 MHz
Gain:	33 dB
Spurious Emissions:	-75 dB

RF Input Driving power:	2 W
RF Input Impedance:	50 Ohms

63608 Omnidirectional Antenna:

	EC020
Frequency range:	400-425 MHz
VSWR:	1.4:1
Impedance:	50 Ohms
Radiation patterns:	Spatial coverage throughout a cylindrical volume with range-to-height ratio of 10:1
Gain:	.75 dB to -6dB
Power (CW):	10 kW
Polarization:	Left-hand circular

15 kW 15-Foot Parabolic Antenna:

Diameter:	15 ft
Frequency range:	400 to 549.5 MHz
Gain, Mid-band, dBi, (min):	24.5
VSWR (max):	2.0
Beamwidth:	10.0 deg
Side lobes (dB max):	-11 (relative to main beam)
Power (DW):	15 kW
Wind velocity (operational):	50 mph
Polarization:	Left-hand circular

5.2.7 Digital Ground Equipment (DGE) The DGE is an integral part of the Test Operations Control Center (TOCC). DGE is the central control for WSMC command transmitters located at VAFB, Pillar Point, and Laguna Peak. The DGE has the capability of controlling up to six command transmitter sites. (See figure 5-10)

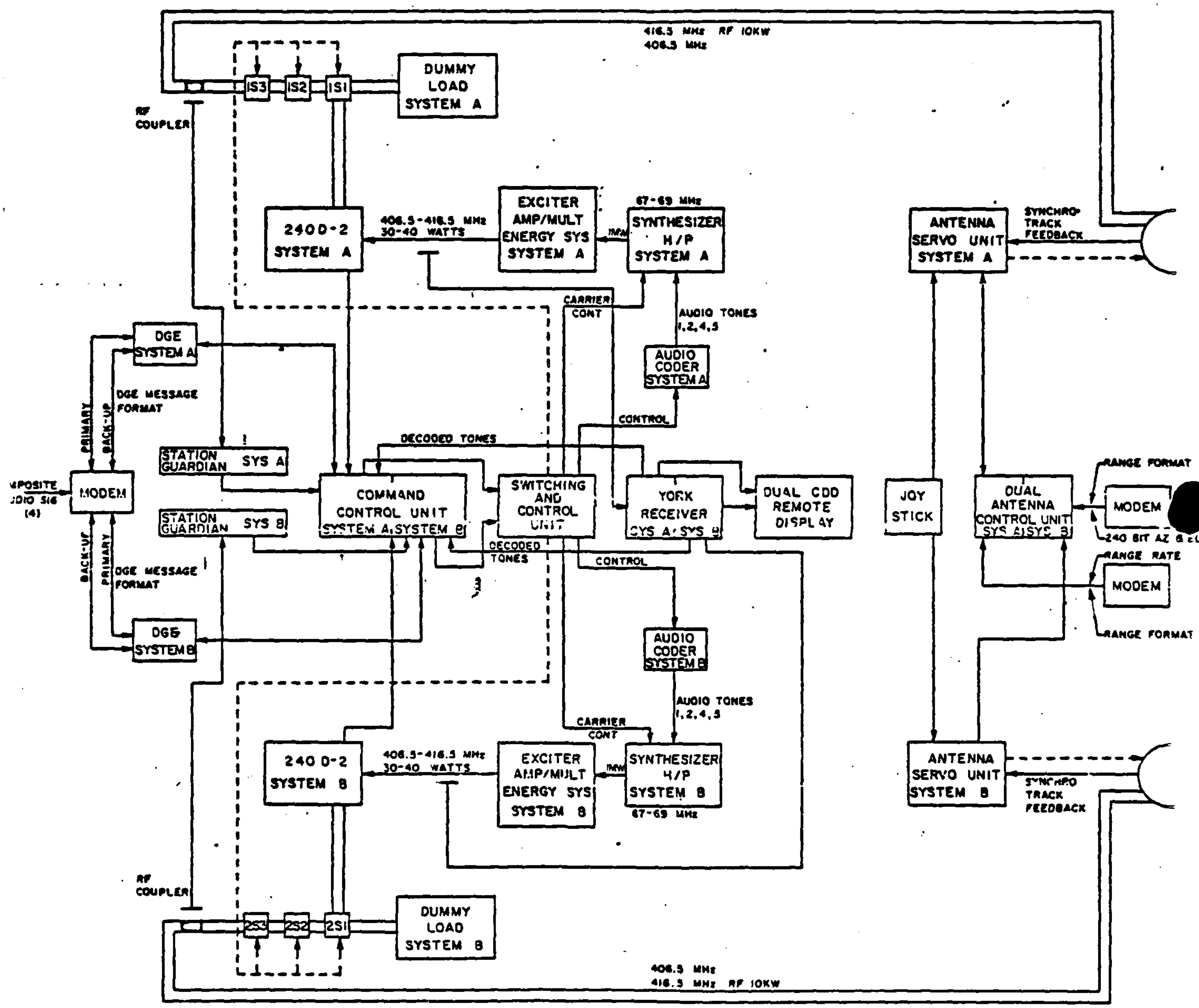


Figure 5-6. Digital Ground Equipment (DGE)

The DGE system consists of two identical digital encoding systems which enables the support of one or two simultaneous operations. The DGE also is interfaced with the Range Safety Computer System which when enabled and armed allows functions initiated within the computer to be processed and fed to the appropriate site for action. Site control and selection is accomplished through the controllers console which configures the selected site to the operational requirements. Command functions, when required, are initiated on the MFCO console. The command and control functions are fed to the central processor which formats the basic message. The processor also inserts ID bits for the selected site, a Barker code and generates an error code which completes the message. The codes are processed by the receiving sites to confirm the validity of the message. After coding the message is output in serial form through a site select matrix and level converter to UDS 201 Data Modems for transmission to the command transmitter sites. The transmission is received by the site Data Modems and fed to the site DGE receiver where it is processed. The message that arrives at the site is checked for correct ID, sync and error code before processing. After the validation, the message is processed through decode logic to the transmitter control logic, where commands and functions are initiated. Status monitoring of the site configuration is processed in the site DGE transmitter for transmission back to the TOCC, where it is decoded and displayed on the appropriate console.

Control and display for the DGE is applicable to five types of consoles in the Test Operations Control Center: the Mission Flight Control Officer (MFCO), Command Transmitter Controller (CTC), Operations Control Supervisor (OCS), Range Operations Superintendent (ROS) and Range Control Officer (RCO). The following is a description of each of these consoles:

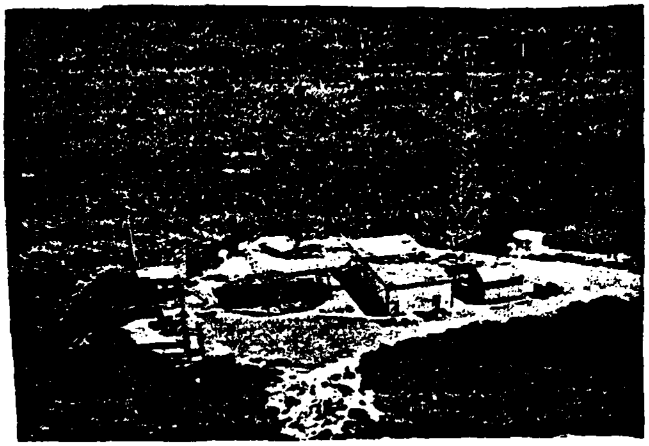
The CTC console selects and controls the configuration of the command transmitter. It is the obligation of the CCT controller to provide the MFCO with a CCT site in proper configuration at all times during an operation. To this end the CTC console is equipped with controls and readbacks for all functions required to control the CCT sites. The CCT console has displays to monitor the initiation of flight termination and control functions from the MFCO console, or functions from the auto abort logic of the computer. The AUTO ABORT SELECT switches select which automatic abort channel of the computer will be controlled by the MFCO selected. The SITE STANDBY SELECT switches select the CCT sites which can be controlled by the CCT Controller. The SITE SELECT switches are used to select the site, which will be controlled and will transmit commands.

The MFCO console is the control center for flight termination and auxiliary command functions. This console contains the switches for manual activation of termination functions as well as a means for initiation of automatic abort logic functions from the computer and control of the CCT site sequencer in the AUTO/MANUAL mode. Indicators are provided to display functions successfully transmitted from the central processor and acted upon by the CCT sites. On the MFCO status panel, site STATUS indicators display the site selected for MFCO control, central or site control, CARRIER ON, HIGH POWER 1 or 2, and SEQUENCER SECURE 1 or 2. In addition, indicators are provided to display computer AUTO ABORT status, command status, and local receiver functions.

The OCS, ROS and RCO status panels are provided with indicators which show the site selected for control, ON indication and status of functions successfully transmitted to and acted upon by the site selected.

5.3 SURVEILLANCE RADAR SYSTEMS

The WSMC Surveillance Radar systems provide the MFCO and other operational support activities with the traffic status of the sea and air spaces adjacent to WSMC. The major equipments are installed in Building 500, SVAFB (See figure 5-11). Included are the equipment for the microwave system interfaces linking VAFB with the rest of WSMC and the PMTC. Two major surveillances systems are installed, the Air Route Surveillance Radar, ARSR-1D, and Radar Recognition (IFF) system, AN/UPX-23. These systems are digitized by the AN/FYQ-49 Common Digitizer.



Fiqure 5-7. Surveillance Radar, Overall View

The Air Route Surveillance Radar ARSR-1D operates a PRF of 360 pps. It is located along Honda Ridge approximately 2 miles from the Pacific Ocean, at an altitude of approximately 1500 feet, overlooking VAFB and the surrounding area. The structures at the site include a radar antenna tower, two 15-foot towers each supporting a microwave parabolic reflector, one 140-foot tower for a microwave reflector support, television system trailers, the main equipment building, and an auxiliary power generator buldinq. *UHF/VHF radio receivers, transmitters, and associated antennas are also located at this site.

Data gathered by the surveillance systems are transmitted to the Area Control Center for display. (Refer to Section 2.0)

5.3.1 <u>Air Route Surveillance Radar, ARSR-1D</u> The ARSR-1D Radar was developed and manufactured to meet requirements specified by the Federal Aviation Agency (FAA). The set was designed for long-range radar surveillance of commercial air routes under the control of the FAA. The system is a pulse type radar operating in the 1280 to 1350 MHz frequencies and produces a map-like display of the locations of aircraft within a 200-nmi radius of the radar's antenna. The display is presented on PPI at the master console located at the surveillance site, and at remote PPI indicators at other locations, such as the Area Control Center, Bldg. 7000A, NVAFB and PMTC. (See figure 5-12).

An important feature of the ARSR-1D Radar System is the inclusion of two complete operating channels so that one channel may remain operational while the other is in the standby status. The standby channel can be completely energized for maintenance or may be tested without interference to the operating channel. Only the final waveguide runs, antenna assembly, master control PPI, and certain control circuits are common to both channels. This configuration provides maximum system reliability as well as eliminating the necessity for operation support interference because of maintenance downtime.

5.3.1.1 <u>ARSR-1D Technical Data</u>

o <u>Transmitter</u>

Source of RF power:	Magnetron oscillator, manually tuned
Frequency range:	1280 to 1350 MHz
Average power input to magnetron:	1000 W
Peak power input:	1.4 MW
Peak power output:	500 kW
Pulse rate:	360 pps
Pulse width:	2 s ±0.2 s, at half-power points

Duty cycle:	0.00068
Modulator type:	dc resonant using thyratron tube
Trigger generator:	Blocking oscillator, synchronized through one of the two delay channels in the MTI system

- <u>Amplitron Amplifier</u>

Type:	Amplitron
Frequency range:	1280 to 1350 MHz established by magnetron driver
Nominal peak power output:	5 MW
Approx. Power gain:	10

- <u>Amplitron Modulator</u>

Type:	Thyratron tube

- <u>Receiver</u>

Frequency range:	1280 to 1350 MHz
Type:	Superheterodyne
Intermediate frequency:	30 ±0.5 MHz
IF bandwidth MTI:	3 ±0.5 MHz at 3 dB points
IF bandwidth normal:	1 ±0.2 MHz
MTI feature:	Dual clutter cancellers with adjustable feedback
Anticlutter circuits:	IAGC, STC, FTC
Sensitivity, normal:	-109 ±2 dBm
Sensitivity, integrated:	-113 ±2 dBm
Sensitivity, MTI:	-108 ±2 dBm
Overall system noise figure:	Not greater than 8.5 dB

o <u>Video Indicator (CA-4080)</u>

Type:	Intensity modulated PPI
Diameter of display tube:	16-in.
Sweep deflection:	Magnetic, fixed-sweep coils driven from rotating-sweep resolver
Sweep ranges:	25, 50, 100 and 200 miles each with on radius off-centering available

o <u>Antenna System</u>

Antenna feed:	Horn feed with choice of linear or circular polarization
Reflector:	40 by 11 ft expanded metal reflecting surface
Antenna gain:	34.3 dB along axis of max. radiation
Beamwidth at half-power points:	Horizontal, 1.35 ±0.3 deg approx, parabolic pattern. Vertical, 6.2 ±0.5 deg essentially cosecant-squared pattern
Beam tilt:	From -1 to +5 deg by means of a manually operated wormdrive screw
Antenna rotation speed:	Clockwise at 6
IFF provision:	Supports and rotates an IFF antenna

5.3.2 <u>Radar Recognition System, AN/UPX-23</u> The Radar Recognition (IFF) System is an auxiliary to the Air Route Surveillance Radar System, ARSR-1D. The Radar Recognition System provides ground observers with methods of identifying a particular radar target. Operation of the system depends upon the transmission of a coded interrogation signal and the receipt of a reply from a transponder carried in the aircraft. Two types of coding are available: coding of interrogation and the coding of replies. Ground operators have the choice of transmitting any of the three interrogation codes. More than 50 reply codes are available but the selection of reply coding is the responsibility of the aircraft.

The VAFB Radar Recognition System consists of one AN/UPX-6 Radar Recognition set as a basic transmitter-receiver, an antenna, and several AN/UPA-24A Decoder Group Assemblies (one for each PPI scope on which IFF is to be displayed). The system also contains accessory units for system testing and for distribution of IFF information.

5.3.3 Production Common Digitizier (PCD) AN/FYQ-49 The PDC extracts aircraft returns from radar video and transmits the aircraft returns to a remote control center over voice quality communication equipment.

The PCD provides both primary (ARSR-1D video) and secondary (IFF video) video processing.

5.3.4 Area Control Center Display System (ACCDS)

5.3.4.1 System Description

The ACCDS is a radar data procesing and display system which provides the WSMC air traffic controller with complete, concise, and up-to-date information on the air traffic currently under his control and on traffic expected in the immediate future. It automates a number of manual tasks and provides the controller with a wide variety of display options so that he can carry out his assigned function more efficiently.

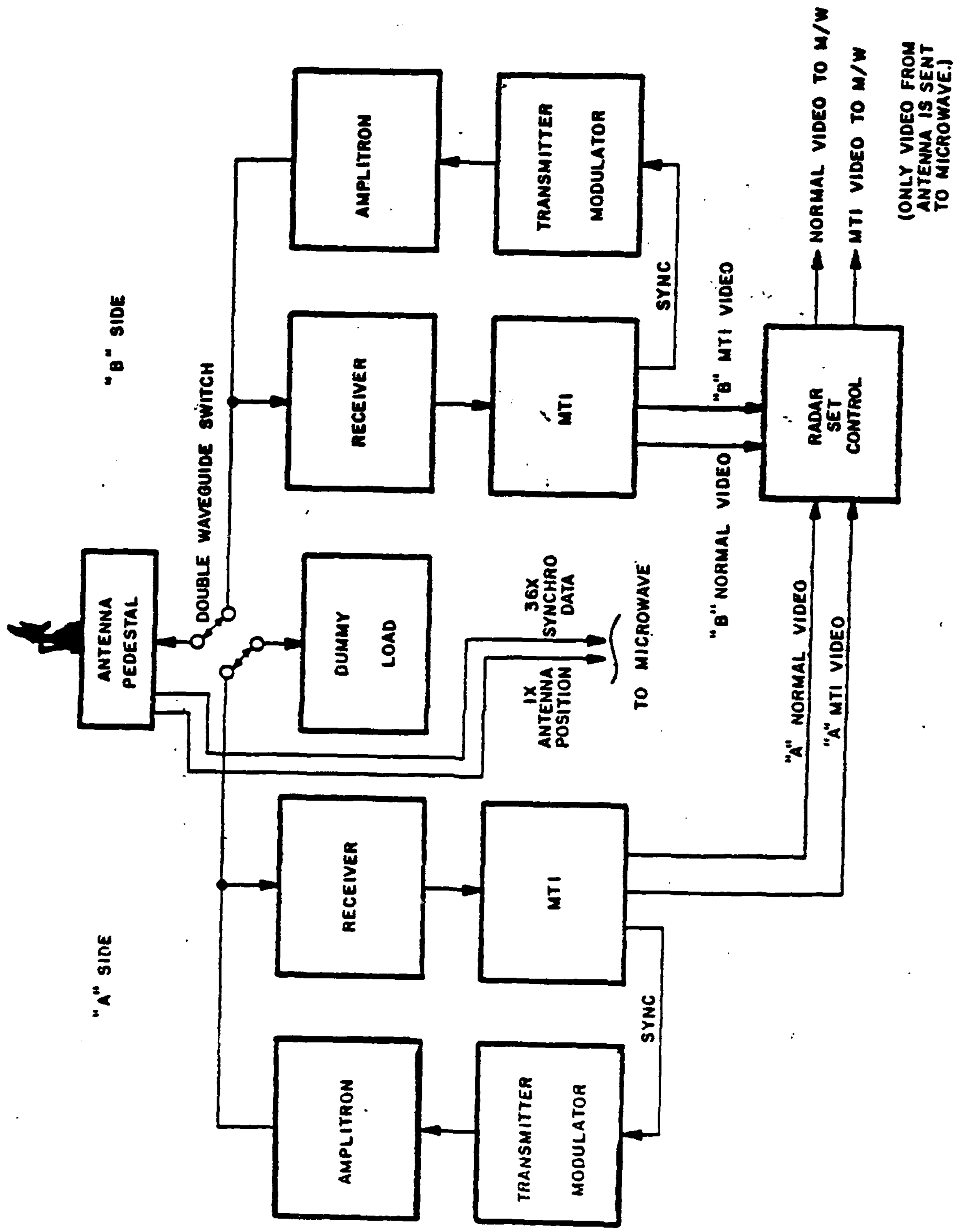


Figure 5-8. ARSR-1D, Data Flow Diagram

The ACCDS consists of the following major elements or sub-systems:

- o Central Processor (CP) which acts as the system supervisor. (Interdata Model 7/16 minicomputer) The CP has a data communications channel to every other processor in the system. The CP subsystem includes the disk and magnetic tape system peripherals.
- o Tracking Processor (TP) which accomplishes target prediction, tracking and track-to-track correlation. (Interdata Model 7/16 minicomputer)
- o Display Processors (DP) which accepts target updates from the CP's, drives the display and provides the air controller/system interface. (Interdata Model 7/16 minicomputer) The DP subsystem includes the Air Controller Display Position (ACDP) Console.

The system physical configuration consists of four (4) equipment cabinets located in Building 7000, Room 210 and three (3) Air Controller Display Position consoles located in Building 7000, Area Control Center. See figure 5-13.

The first equipment cabinet contains the CP peripherals. The second cabinet contains the CP and the TP. The third and fourth cabinets contain (2) DP's and (1) DP respectively.

5.3.4.2 System Features

The ACCDS has the following features and capabilities:

- o Handle 1000 total radar messages maximum.
- o Track 100 aircraft, composed of 50 primary and 50 beacon targets of random distribution, with automatic initiation and maintenance of track.
- o Handle 300 clutter messages/scan.
- o Provide (3) ACDP's which can look at any one of (7) radar inputs.
- o Handle 400 returns/radar scan for a single radar or 1000 returns/scan for (3) radars.
- o PRIME ASSIST feature ("crawling worm").

- Display 400 primary target present position (PP) symbols and 100 history trails.
- Handle beacon tracks at speeds up to 1500 Knots with 0.25 blip/scan ratio.
- Display 20 primary targets/display position.
- Altitude block filtering.
- Beacon code block filtering.
- Emergency code display.
- Non-block selected target display.
- Geographical filtering.
- Radar source switching.
- Map backgrounds.
- Display data filtering.
- (7) range scales - 4 mi to 250 miles.
- Display center offset - maximum range can be positioned with minimum range scale.
- Full azimuth range within 240 mi radius of any radar.
- Relative range and azimuth (0.1 mile & 0.1") between (2) points in a surveillance area.
- Intercept control parameters, range and bearing, 0.1 mile and 0.1^{o} between (2) beacon tracks or between a beacon and one stationary point.
- Predicted target positions of up to (5) tracks with intervals of up to 2, 4, 6, 8, 10 minutes ahead.
- Generation of flight profile line segments.
- Generate and maintain a system data list of basic display status information -

  Radar Source

  Time of Day

  Altitude Filter Limits
- Display raw video from Vandenberg ARSR.

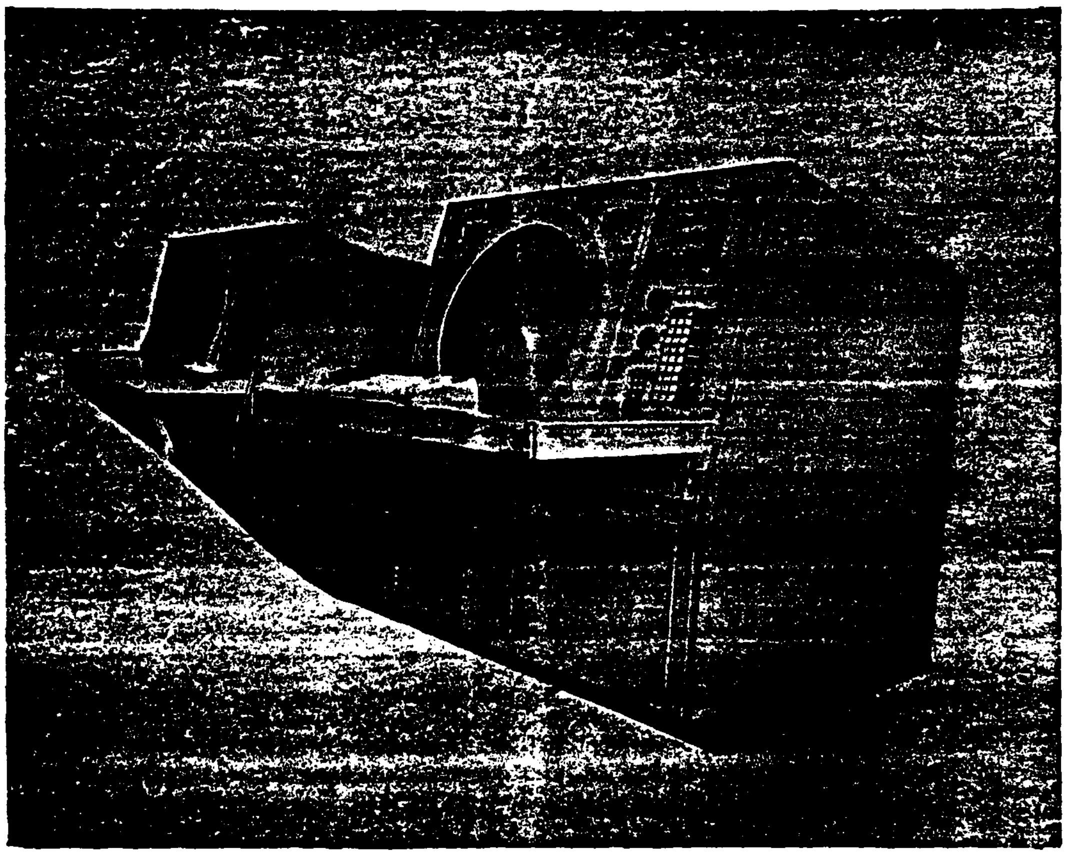


Figure 5-9. Air Controller Display Position (ACDP) Console

5.3.4.3 System Operation

Digitized radar information from radars located at Klamath, Pt Arena, Mill Valley, Almaden, Cambria, Vandenberg, and San Nicolas Is. CA. is transmitted remotely from the AN/FYQ-47 (or 49) common digitizers modems in a serial format at 2400 baud. The Modem Interface Unit (MIU) converts the serial data stream to a 16-bit parallel field which is then read by the Central Processor (CP). The CP assembles the received data fields into a complete target report which typically contains the Label Field, Range Field, Azimuth Field and Mode C Field (altitude).

Once the target report has been assembled, the processor performs checks to ensure the validity of the data, converts the data to X-Y coordinates and corrects the received azimuth data for site parameters. The target report is then fed to the Tracking Processor (TP). The TP attempts to correlate the received return against its active tracks. When a radar return-to-track correlation is established, an updated track message is transmitted to the CP. The CP, upon receipt of this message, transmits the track update message to all Display Processors (DP's) which have selected the appropriate radar source.

The DP transforms the positional information contained within the update to a display referenced axis system. If the target is contained within the display grid and is also within the display filters settings established by the controller, then the target is displayed on the screen.

5.3.4.4 Radar Input System

The ACCDS System accepts two types of radar data, primary and secondary.

Primary radar data is generated by the radar transmitting a pulse of high frequency radio energy and determining the time to receive the energy reflected from the aircraft skin. Primary radar information is limited to only range and azimuth, range being determined by the time between pulse transmission and receipt of reflection. The azimuth is derived from the instantaneous antenna orientation.

Secondary radar data is also generated by transmitting a pulse of energy. However, instead of a simple reflection, the pulse triggers a transponder in the aircraft which in turn transmits coded signals back to the radar. This method, though more reliable than primary, cn only be usedwith transponder-equipped aircraft. Range and azimuth are derived in a similar fashion to the promary data. The coded reply will also contain as assigned SSR (Secondary Surveillance Radar) code which will be (4096 codes) depending on transponder type. In addition, some transponders are coupled to an altimeter and will transmit the current altitude of the aircraft. The SSR code is assigned by a ground controller and is used for identification purposes described later. If only one aircraft has been assigned a particular code, that code is classed as discrete. If more than one aircraft uses the code it is non-discrete.

The data received from the aircraft, both primary and secondary, is processed by the radar receiver, and the output may be presented on a PPI type CRT. However, it is in analog form and is not suitable for transmission over telephone lines or for use by ACCDS. In addition, due to the beamwidth of the radar antenna, several "hits" will occur on each target during a single revolution of the antenna. The data is, therefore, passed to a digitizer which consolidates all the returns from each particular target, establishes the azimuth of the center of the target, and presents the resultant information at its output in the form of digital messages. The digital data is sent over telephone lines and received by modems at the inputs to the ACCDS.

The data available to the ACCDS is contained in a message made up of either five or seven fields of thirteen bits each, containing some or all of the following information:

- o Range
- o Azimuth
- o SSR Code
- o Altitude
- o Digitizer and Radar Status

The receive modems or data sets (Model 201B) are located in the ACC area of Vandenberg AFB. There are (3) modems per digitizer for a system total of (21) modem pairs for the (7) radar sites.

The digital output of the modems is then routed through an interconnection panel and into the ACCDS.

The PDC consists of an electronics unit and a console unit. These are both at the radar site. The PCD output digitized data is sent in serial format over telephones to the Area Control Center. The primary radar video is quantized entered into a detector at the appropriate cell of memory. Secondary video is also quantized, beacon bracket pulses are detected and entered into the appropriate cell for detection beacon codes are extracted for association with these statistically detected aircraft. Detected beacon aircraft are correlated with detected radar aircraft and a single report is made. Messages are transmitted over three output channels (telephone lines) each at 2400 bits per second.

5.3.4.5 ACCDS Software Development System

The Area Control Center Development System provided the means to document the existing software of the ACCDS. It will be used for making software changes in the operation programs of the ACCDS as needed to meet new support requirements.

The Development System hardware consists of:

1. Perkin Elmer 1630 Processor
2. Nine Track Digital Tape Drive
3. 10 Mega Byte Disk Pack
4. Line Printer
5. Two Remote Terminals

5.4 METEOROLOGICAL-GEOPHYSICAL FACILITIES AND EQUIPMENT

5.4.1 Environmental Support Center. The Vandenberg Environmental Support Center (ESC) serves as the hub of weather data acquisition and processing systems supporting operations at Vandenberg (fig. 5-14-1). The Center operates 24 hours every day to meet the collective needs for monitoring meteorological conditions which may inhibit or be hazardous to operations. In addition to a full complement of weather instrumentation facilities at the airfield, several types of measurement systems (fig. 5-14-2) are available to satisfy support requirements of Range users. Data for other locations also are available at Vandenberg via a communications link with the Air Weather Service network (fig. 5-14-3).

5.4.2 Measurement Accuracy Range Commanders Council Document 110-77, entitled "Meteorological Data Error Estimates," provides an extensive discussion on the accuracy of meteorological measurements and a listing of appropriate error estimates for many different parameters. Meteorological instrumentation systems normally provide data which are representative of conditions in a volume of the atmosphere for a reasonable length of time. Staff Meteorologists should be consulted whenever engineering studies or applications of measure data are unusually sensitive to small or rapid changes in meteorological conditions.

5.4.3 Representative Observation Site (ROS) This facility is located in the airfield control tower adjacent to the runway, to enable visual observation of weather conditions of importance to aircraft. Read-outs for the standard airfield instrumentation are located in the ROS. Observations are transmitted electronically to the ESC and on the Continental US Meteorological Data System (COMEDS). Data from this site are used in standard climatological summaries prepared at the USAF Environmental Technical Applications Center.

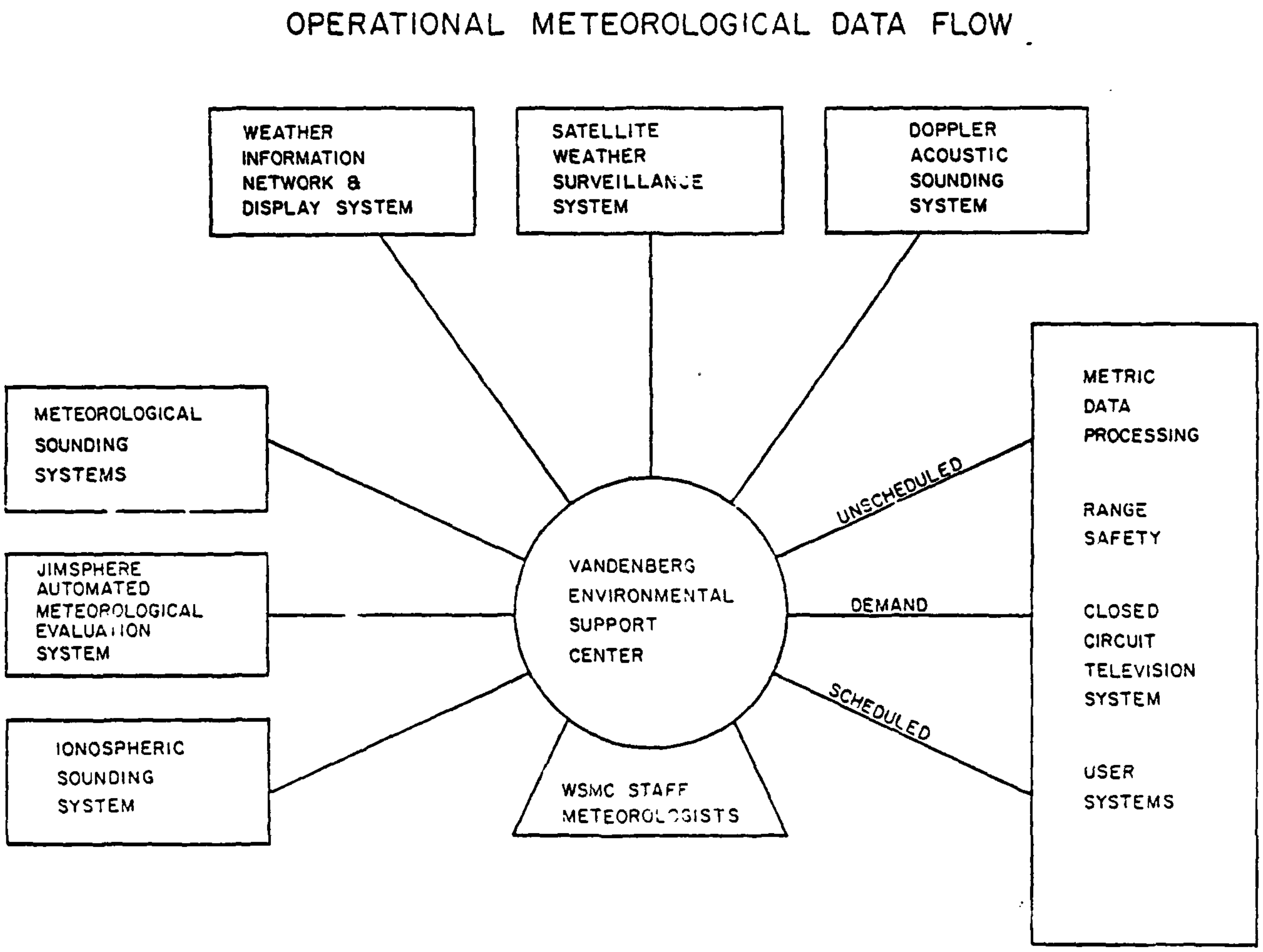


Figure 5-10-1. OPERATIONAL METEOROLOGICAL DATA FLOW

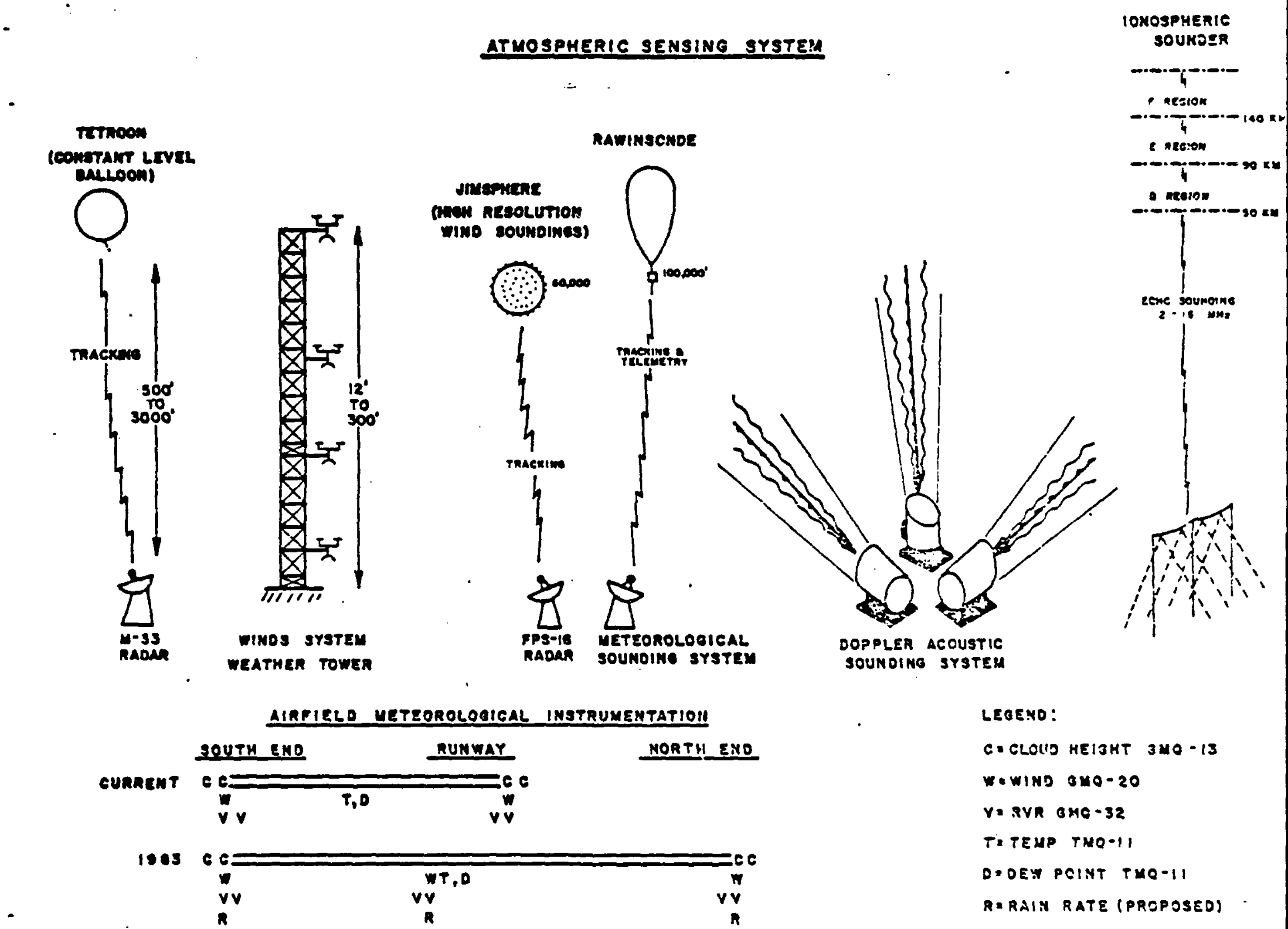


Figure 5-10-2 Atmospheric Sensing System

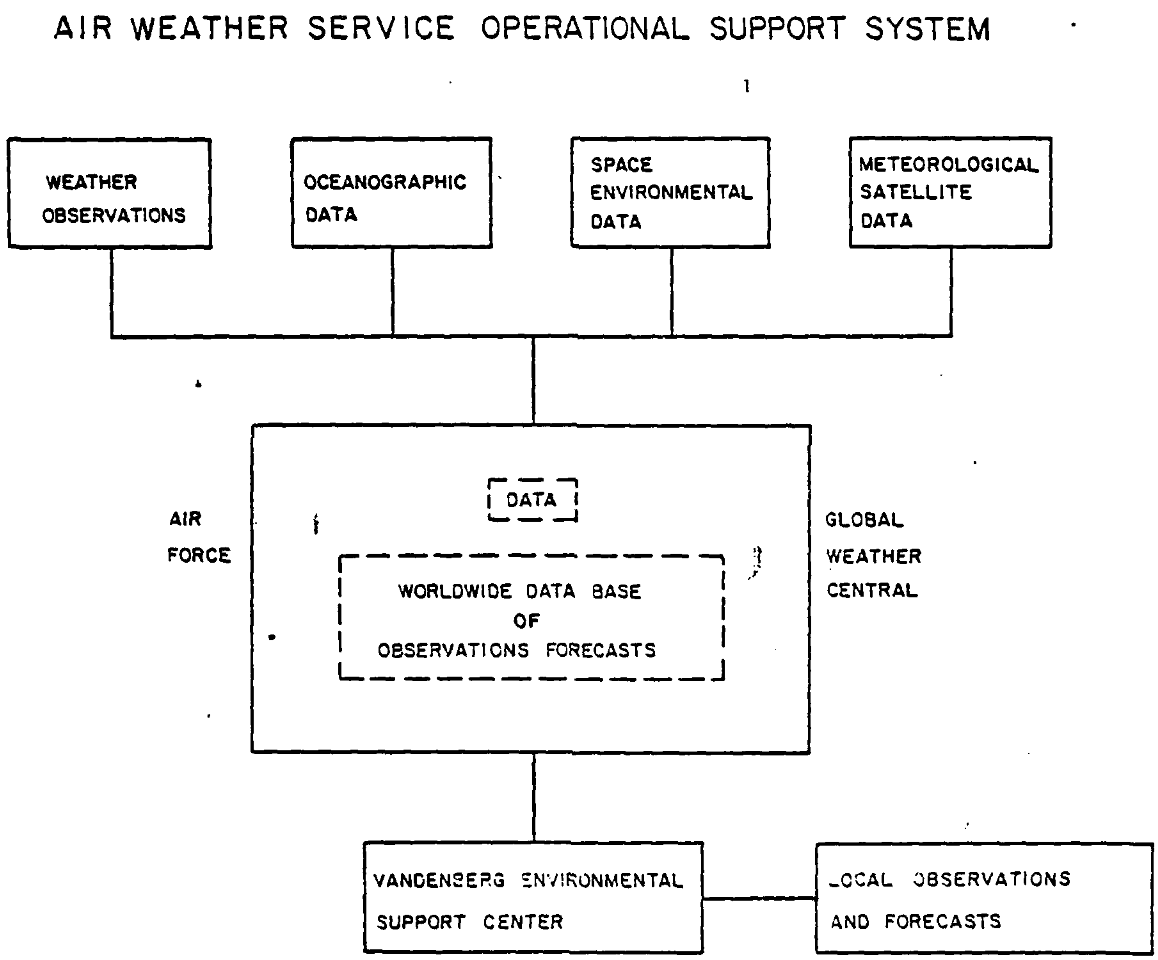


Figure 5-10-3. AIR WEATHER SERVICE OPERATIONAL SUPPORT SYSTEM

5.4.4 Satellite Weather Surveillance System (SWSS) This system includes a Scanning Radiometer Data Manipulator, a tape recorder, and a Laser-Fax recorder which produces 9 x 10 inch photo-quality hard copies. Imagery is received at 30 minute intervals from the National Environmental Satellite Service facility in Redwood City, California. The satellite pictures provide information on the geographic distribution of clouds, plus the effective radiating temperature and approximate altitudes of the tops of clouds. Several display are available to highlight cloud details of operational interest and to enable viewing at different scales. The satellite imagery most frequently received is from the US Geostationary Operational Environmental Satellite (GOES) located 22,300 miles above the equator at 135W longitude. Full disc imagery from the GOES-West enables monitoring of clouds from the East-Central US to westward of the International Date Line.

5.4.5 Storm Surveillance Radar (FPS-77) This weather radar set detects echoes from precipitation within its 200 mile range and displays the returns on three different scopes. The plan-position indicator (PPI) shows the distribution of precipitation surrounding Vandenberg on a horizontal plane. The range-height indicator (RHI) allows depiction of a vertical cross-section along any azimuth, with correction for earth-curvature. An amplitude vs range (A-Scope) displays the intensity of signal return, with correction for range. The combination enables monitoring of the areal coverage, movement, vertical development and approximate rate of precipitation occurring in the vicinity of Vandenberg. Subjective interpretation provides a very limited capability to identify thunderstorms, to distinguish between types of precipitation and to estimate the location and heights of clouds producing the precipitation.

5.4.6 Remote Weather Radar Terminal A remote terminal located at the ESC enables monitoring of precipitation detected by the weather radar system at Kwajalein Missile Range.

5.4.7 Weather Television A terminal at the ESC enables transmission of graphical plots, radar or satellite imagery and other information via the WSMC Closed Circuit Television System.

5.4.8 Weather Information Network and Display System. (WINDS) This instrumentation network includes several types of sensors (fig. 5-14-4) mounted on towers from 12 to 300 feet tall. The towers are located near several fuels storage, tracking and launch facilities (fig. 5-14-5) to enable monitoring of operational constraints and safety criteria for the sites. Data from the entire network is continuously digitized on-site for transmission to the Environmental Support Center for processing, quality control, display and archival on magnetic tape. At a few towers, data also are provided to a site operations control facility. Data recorded on the magnetic tapes are forwarded to the USAF Environmental-Technical Applications Center for use in engineering studies and climatological analyses required to support Range users.

5.4.9 Doppler Acoustic Sounding System (DASS) This wind profile measuring system consists of five sub-systems: the sound producing and sensing hardware, processor, printers, storage devices, and command keyboard. The sensor subsystem is composed of three transceiving antennae with their supporting electronics. In operation, the three antenna are pointed along orthogonal axes with the origin at the antenna site, and obtain doppler shift data on wind motion components along these axes. These components are processed by an LSI-4 micro-computer with 64Kb memory, using software which is automatically loaded from dual floppy-disc drives. Wind data are printed on a 40 column printer, and time-height profiles of the intensity of acoustic signal returns are printed on a 132 character per line, dot-matrix printer. The sounder printer uses a special character set enabling display of ten shades of gray to represent different sound intensity levels. Wind data also can be recorded on a 9 track, 800 bpi tape drive. Near-surface wind data are obtained with a three-axis anemometer. The acoustical signals are at 2 KHz, with a pulse repetition interval of 5 seconds and duration of 80 or 160 msec. The DASS enables continuous measurements of the averages and standard deviations of the three wind components, direction and speed for ten altitude intervals between 50 and 500 meters above the ground. Recording and display intervals between two and 30 minute intervals are available.

5.4.10 Low Level Tetroon Tracking System This system uses expendable balloons (TETROONS) which are designed to float at selected constant

WINDS NETWORK

SITE	TOWER HT. (ft)	SENSOR LEVEL (ft)						
		6	12	40	54	102	204	300
004*	12		DS					
005*	12		DS					
007	12		DS					
008	12	T	DS					
009	12		DS					
014(1)	12		DS					
015(3)	12	T						
017*	12		DS					
018*	12		DS					
019	12	T	DS					
050	54	T	DS		TDS			
052(2)	54	T	DS		TDS			
054*	54	T	DS*		TDS*			
055*	54	T		DS	T			
056*	54	T		DS				
058*	54	T	DS*		TDS			
101	102	T	DS		TDS	DS		
102*(2)	102	T	DS*		TDS*	DS*		
103	102	T	DS		TDS	DS		
200*	204	T	DS*		TDS	DS*	TDS*	
300*(2)	300	T	DS*		TDS*	TDS*	TDS	TDS*
301(3)	300	TT_dVPRI	DS		$TDST_d$	$TDST_d$	$TDST_d$	$TDST_d$

* WIND SPEED/DIRECTION READOUT ON SITE
(1) DATA TRANSMITTED TO SITE 101
(2) AUTOMET III
(3) AUTOMET IV

D = WIND DIRECTION
S = WIND SPEED
T = TEMPERATURE
T_d = DEW POINT TEMPERATURE

V = VISIOMETER
P = PRESSURE
R = RAIN GUAGE
I = RADIATION

Figure 5-10-4. Weather Information Network and Display System (WINDS)

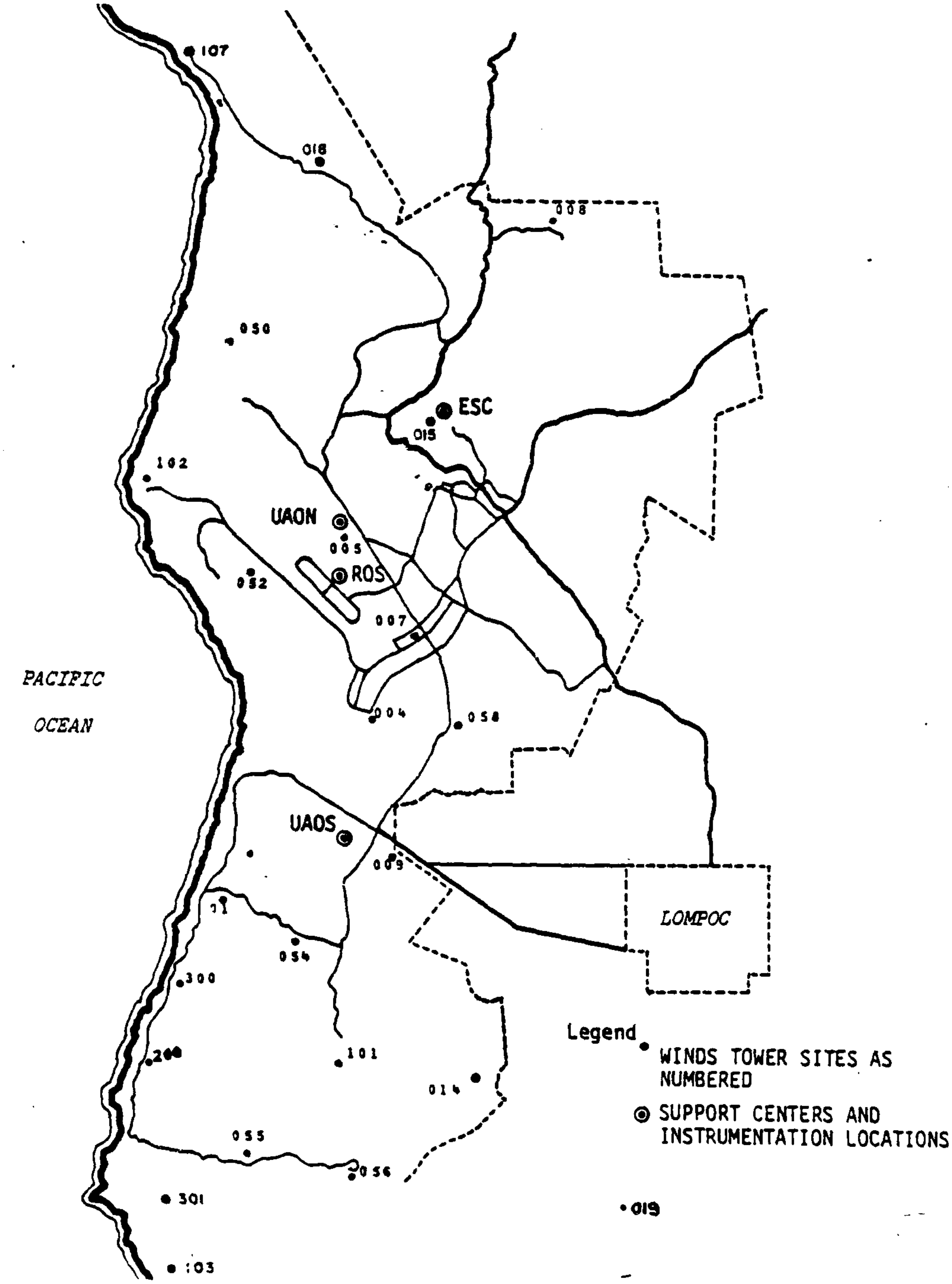


Figure 5-10-5 Environmental Support Facilities, VAFB

altitudes up to a few thousand feet above the ground. Range, azimuth and elevation data from a transponder tracking antenna are transmitted to Data Center 90, which is co-located with the ESC, for processing. The resulting TETROON trajectories are used to simulate the transport direction and speed for clouds of heated toxic effluents from the engines of launch vehicles. TETROONS are calibrated to float at specific altitudes prior to release from sites near the appropriate launch complex.

5.4.11 High Resolution Wind Sounding System This system uses expendable balloons known as Jimspheres, which are made of metal coated mylar to enable precise tracking by radar and responsiveness to rapid changes in wind shears which are encountered in shallow layers found through the upper atmosphere. Jimspheres are constant volume balloons with bumpy rather than smooth surfaces. These features are to minimize the deformation of the balloon surface and consequent unpredictable or self-induced oscillations as the balloon responds to changes in the winds along its ascent trajectory. The Jimsphere's fixed size and weight enable it to rise to a maximum altitude between 55,000 and 60,000 feet in approximately one hour. The tracking radar provide time, azimuth, range and elevation data in real time to Data Center 90, where a Radar Interface Device automatically switches between primary and back-up radar sites to maximize data quality and reliability. Data typically are processed in five minute increments to facilitate near real time quality assurance checks by a Staff Meteorologist prior to electronic transmission of data products to Range users. The data products include wind direction, speed and shear values, normally at altitude intervals of 100 feet to a maximum of at least 55,000 feet. In addition to near real time electronic transmissions, data products are recorded on magnetic tapes to enable historical analyses for applications such as future launch vehicle design.

5.4.12 Meteorological Sounding Systems These systems track expendable rawinsonde instruments which are carried to altitudes above 100,000 feet by flexible balloons which continually expand to maintain a rise-rate of approximately 1,000 feet per minute. The sensors for temperature and humidity measurements and the telemetry package are attached to the balloon by a cord which normally is 70 to 100 feet in length. A resulting pendulum-like motion insures adequate airflow over the sensors even at high altitudes, and reduces the effects of shielding by the expanding balloon, thus enhancing the accuracy of the telemetry data. The responsiveness of the radio-tracking antenna system to rapid changes in velocity of winds along the instruments ascent path varies with range, limiting the ability of the systems to quantify rapid changes in wind velocity (shear) within altitude intervals less than several hundred feet. Time, azimuth, elevation and telemetry data are received and recorded by the tracking equipment, then transmitted electronically to Data Center 90 for processing. The processed data include vertical profiles of the layer-averaged wind direction, speed and shear, plus temperature, dew point, pressure, relative indexes of refraction. The tabulated profiles provide information at fixed altitude increments, with supplementary listings for altitudes where significant changes occur. Data transmission normally is after the rawinsonde balloon reaches burst altitude, but partial soundings through lower altitudes can be produced before processing of the entire sounding is completed (about 2.5 hours after balloon release). A truck-mounted GMD-1 tracking system is available in addition to Upper Atmospheric Observatory Sites (UAOS) on North Vandenberg, South Vandenberg and at Pillar Point Air Force Station. Applications include climatological studies for vehicle design, Range safety evaluations and metric data reduction, plus launch capability and post-flight performance evaluations by Range users.

5.4.13 Ionospheric Sounding System Located at the ESC, this system transmits radio signals vertically to probe the ionized regions above 50 km. Ionograms record the apparent heights of reflection for the radio waves, and provide information on changes in the structure of the ionspheric layers. Analyzed data are encoded for electronic transmission to the Space Environmental Support Center and Astrogeophysical Teletype Network, to aid frequency managers in the choice of optimum HF radio frequencies. Data are recorded on 35 mm film, analyzed, and supplied to Data Center 90 for use in deriving electron density and refractivity profiles through the ionosphere.

5.5 AUTOMATED TRAIN SURVEILLANCE SYSTEM (ATSS)

5.5.1 Remote Sensor Stations (RSS) The sensor system consists of an enclosure containing two 8 ohm speakers mounted back-to-back to form a bidirectional noise detector. As a train approaches, the speaker facing the noise source is activated and begins a sequence of timed events which prepare the station for tone transmission. The channel that first detects the sound is activated and disables the other speaker, thus eliminating occurrence of north and south indication as the train passes. If both channels are simultaneously hit with sound, the sensor rejects it as a false indication. Once a sensor has been activated, a group of three separate tone bursts are transmitted. The first two tones of the group represent the station identification and the third tone denotes train direction. Once the tone bursts have been transmitted three times, the station shuts off for approximately one minute to allow passage of the train. It is then reactivated to a listening mode and the sensor is ready to detect another train.

In addition to this acoustic detection method, selected sites are equipped with Seismic (Geophone) sensors, which are triggered by the ground vibrations of passing trains. The purpose of this dual detection system is to reduce false alarms that are caused by low flying aircraft, high winds and in some instances, off road vehicles.

5.5.2 Receiver Display Station (RDS) The Remote Sensor Tone signals are transmitted to the Receiver Decoder Rack (RDR) via 18 Telephone Lines. The Receiver Decoders convert the tones to logic levels which are fed to the MODAC (modular acquisition) interface. The MODAC interfaces the MOD Comp I computer to input and output devices, e.g., trainboard and receiver decoders.

5.5.2.1 The MOD Comp Computer is a 16 bit, 800 nanosecond minicomputer with TTY, I/O, and High Speed Tape Reader input for program entry. The program language, called "macro assembly", is written in hexadecimal machine code. The present program for the train system contains 2580 program instructions. These instructions determine when a train is in the system and what train information will be displayed. If a remote sensor (that is already in the ATSS) is activated, the computer sets a flashing output indicator on the trainboards indicating the sensor station number. The computer waits a pre-determined length of time for the next sensor in the chain to activate. If the next sensor does not activate within the time limit, the computer assumes a false train indication and extinguishes the flashing light. If two consecutive sensors are activated and a third is not, the computer assumes a stopped train condition and lights both north and south indicators, at the last reporting station, to show the track is blocked.

5.5.3 Train Display The display consists of 48 light emitting diodes (LEDs) which duplicate the train location information of the graphic trainboard. One of the panels is located in the ATSS equipment rack, the second is at the DAC console, and the third at the MFCO console.

The ATSS equipment rack panel is labeled with sensor site number and miles from Surf station. The MFCO and DAC panels are labeled with miles from the Surf trestle. The LEDs are in two rows of 24; the top row is for north bound trains, the bottom row for south bound trains.

APPENDIX A

INTER-RANGE INSTRUMENTATION GROUP STANDARD FORMATS

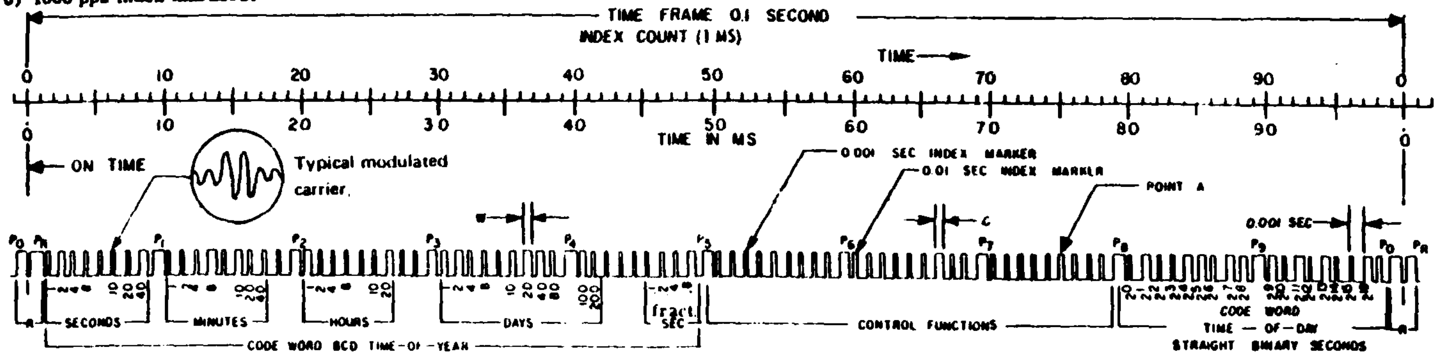
A-1. Inter-Range Instrumentation Group (IRIG) timing codes formats contained herein are as follows:

Figure No.	IRIG Format
A-1	Standard Format A
A-2	Standard Format B
A-3	Standard Format D
A-4	Standard Format E
A-5	Standard Format H
A-6	Standard Format G

General:

Format A, Signal A00, is composed of the following:

1) 10 pps frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (34 digits)
3) Control functions (27 digits)
4) Straight binary time-of-day code word (17 digits)
5) 100 pps position identifiers (P_0 through P_9)
6) 1000 pps index markers.



R REFERENCE MARKER (THE "ON TIME" POINT TO WHICH THE CODE WORDS REFER, IS THE LEADING EDGE OF P_R)
P_R REFERENCE ELEMENT (0.8 MS DURATION)
P_0 - P_9 POSITION IDENTIFIERS (0.8 MS DURATION)
W WEIGHTED CODE DIGIT (0.5 MS DURATION)
C WEIGHTED CONTROL ELEMENT (0.5 MS DURATION)
DURATION OF INDEX MARKERS, UNWEIGHTED CODE & CONTROL ELEMENTS=0.2MS

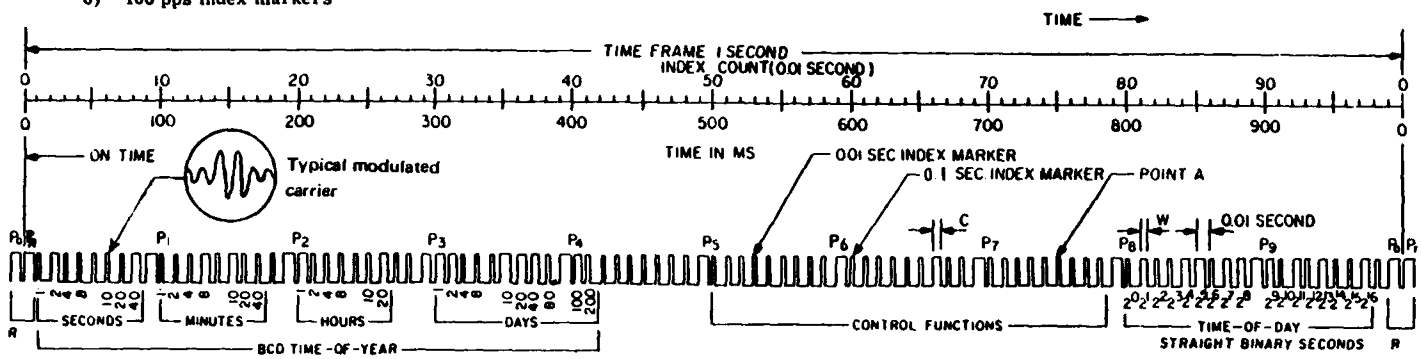
TIME AT POINT A= 21:18 42+0.8+0.07+0.005
21 HOUR 18 MINUTE 42.875 SECOND ON DAY 173

Figure A-1. Standard Format A

General:

Format B, Signal B00, is composed of the following:

1) 1 pps frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (30 digits)
3) Control functions (27 digits)
4) Straight binary time-of-day code word (17 digits)
5) 10 pps position identifiers (P_0 through P_9)
6) 100 pps index markers



R Reference marker (the "on time" point to which the code words refer, is the leading edge of P_R)
P_R Reference element (8.0 ms duration)
P_0 - P_9 Position identifiers (8.0 ms duration)
W Weighted code digit (5.0 ms duration)
C Weighted control element (5.0 ms duration)
Duration of index markers, unweighted code and control elements = 2.0 ms

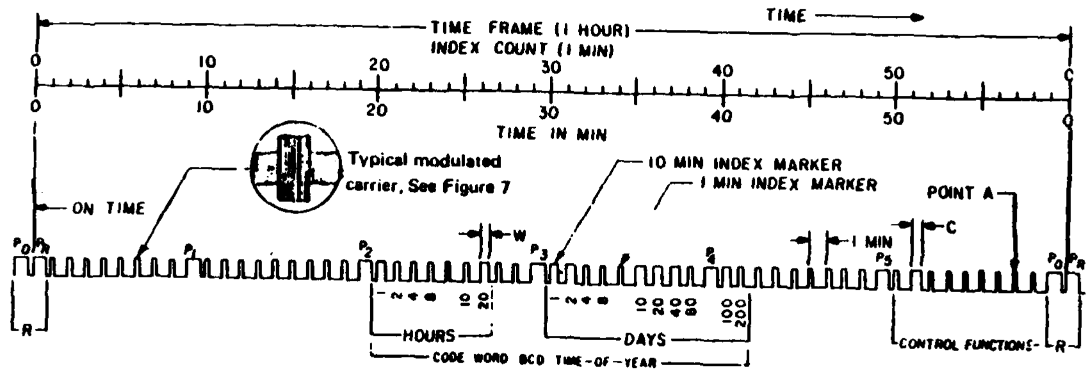
Time at point A = 21:18:42+0.7+0.05
= 21 hour 18 minute 42.75 second on day 173

Figure A-2. Standard Format B

General:

Format D, Signal D00, is composed of the following:

1) 1 pph frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (16 digits)
3) Control functions (9 digits)
4) 6 pph position identifiers (P_0 through P_5)
5) 1 ppm index markers.



R REFERENCE MARKER (THE "ON TIME" POINT TO WHICH THE CODE WORD REFERS IS THE LEADING EDGE OF P_R)

P_R REFERENCE ELEMENT (48 SEC DURATION)

P_0-P_5 POSITION IDENTIFIERS (48 SEC DURATION)

W WEIGHTED CODE DIGIT (30 SEC DURATION)

C WEIGHTED CONTROL ELEMENT (30 SEC DURATION)

DURATION OF INDEX MARKERS UNWEIGHTED CODE AND CONTROL ELEMENTS = 12 SEC

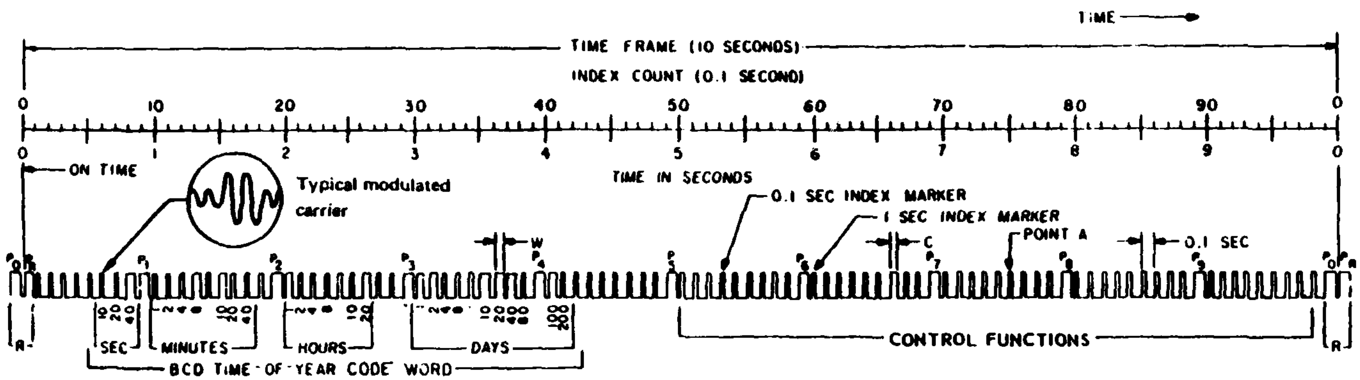
TIME AT POINT A = 21:57:00
= 21 HOUR + 57 MINUTE ON DAY 173

Figure A-3. Standard Format D

General:

Format E, Signal E001, is composed of the following:

1) 6 ppm frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (26 digits)
3) Control functions (45 digits)
4) 1 pps position identifiers (P_0 through P_9)
5) 10 pps index markers



R REFERENCE MARKER (THE "ON TIME" POINT TO WHICH THE CODE WORDS REFER, IS THE LEADING EDGE OF P_R)
P_R REFERENCE ELEMENT (80 MS DURATION)
P_0 - P_9 POSITION IDENTIFIERS (80 MS DURATION)
W WEIGHTED CODE DIGIT (50 MS DURATION)
C WEIGHTED CONTROL ELEMENT (50 MS DURATION)
DURATION OF INDEX MARKERS, UNWEIGHTED CODE & CONTROL ELEMENTS=20MS

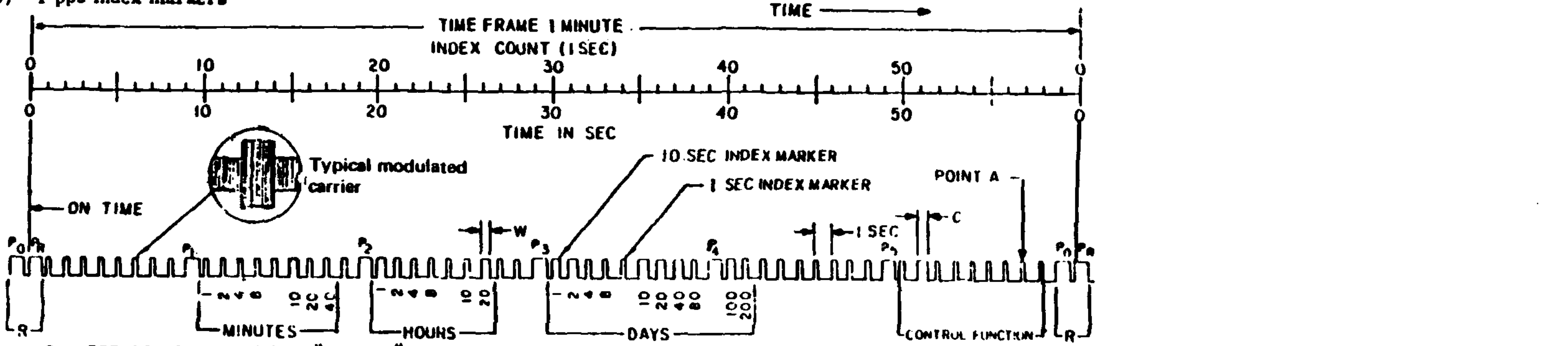
TIME AT POINT A= 21·18 40 + 7 + 0.5
= 21 HOUR 18 MINUTES 47.5 SECONDS ON DAY 173

Figure A-4. Standard Format E

General:

Format H, Signal H001, is composed of the following:

1) 1 ppm frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (23 digits)
3) Control functions (9 digits)
4) 6 ppm position identifiers (P_0 through P_5)
5) 1 pps index markers



R REFERENCE MARKER (THE "ON TIME" POINT TO WHICH THE CODE WORD REFERS IS THE LEADING EDGE OF P_R)

P_R REFERENCE ELEMENT (0.8 SEC DURATION)

P_0-P_5 POSITION IDENTIFIERS (0.8 SEC DURATION)

W WEIGHTED CODE DIGIT (0.5 SEC DURATION)

C WEIGHTED CONTROL ELEMENT (0.5 SEC DURATION)

DURATION OF INDEX MARKERS UNWEIGHTED CODE AND CONTROL ELEMENTS = 0.2 SEC

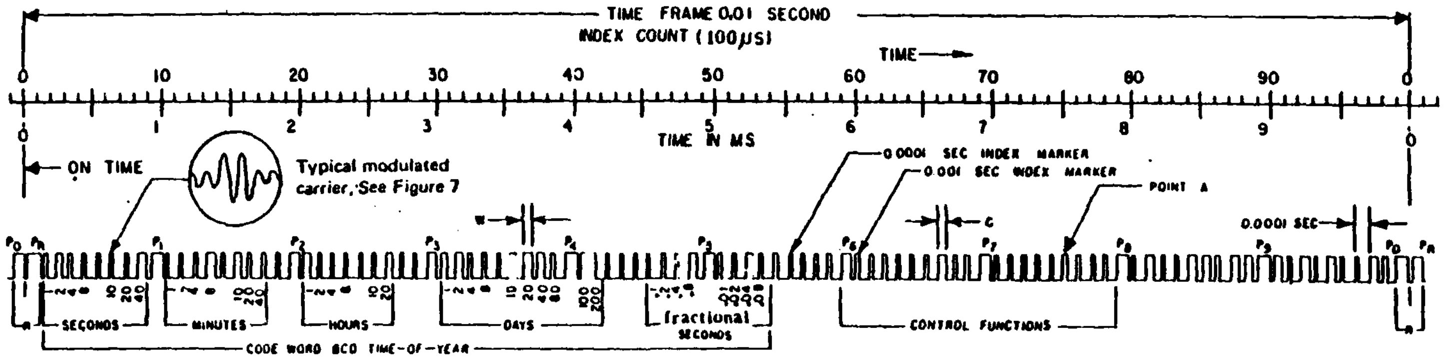
TIME AT POINT A = 21:10:57
= 21 HOUR + 10 MINUTE + 57 SECOND ON DAY 173

Figure A-5. Standard Format H

General:

Format G, Signal G001, is composed of the following:

1) 100 pps frame reference markers R=(P_0 and P_R)
2) Binary coded decimal time-of-year code word (38 digits)
3) Control functions (18 digits)
4) 1000 pps position identifiers (P_0 through P_9)
5) 10000 pps index markers.



R REFERENCE MARKER (THE "ON TIME" POINT TO WHICH THE CODE WORDS REFER, IS THE LEADING EDGE OF P_R)
P_R REFERENCE ELEMENT (0.08 MS DURATION)
P_0 - P_9 POSITION IDENTIFIERS (0.08 MS DURATION)
W WEIGHTED CODE DIGIT (0.05 MS DURATION)
C WEIGHTED CONTROL ELEMENT (0.05 MS DURATION)
DURATION OF INDEX MARKERS, UNWEIGHTED CODE & CONTROL ELEMENTS=0.02MS

TIME AT POINT A= 21:18.42+0.8+0.04+0.0075
21 HOUR 18 MINUTE 42.8475 SECOND ON DAY 173

Specific

The beginning of each 0.01 second time frame is identified by two consecutive 0.08 ms elements (P_0 and P_R). The leading edge of the second 0.08 ms element (P_R) is the "on time" reference point for the succeeding time code. 1000 pps position identifiers P_0, P_1........P_9 (0.08 ms duration) occur 0.1 ms before 1000 pps "on time" and refer to the leading edge of the succeeding element.

The time code word and the control functions presented during the time frame are pulse width coded. The binary "zero" and index markers have a duration of 0.02 ms, and the binary "one" has a duration of 0.05 ms. The leading edge is the 10K pps "on time" reference point for all elements.

The binary coded decimal (BCD) time-of-year code word consists of 38 digits beginning at index count 1. The binary coded subword elements occur between position identifiers P_0 and P_6. (7 for seconds; 7 for minutes; 6 for hours; 10 for days; 4 for tenths of seconds; 4 for hundredths of seconds) until the code word is complete. An index marker occurs between the decimal digits in each subword to provide separation for visual resolution. The least significant digit occurs first except for the fractional second information which follows the day-of-year information. The BCD code recycles yearly. Each BCD element is identified on the BCD Time-Of-Year Code Chart.

Eighteen control functions occur between position identifiers P_6 and P_8. Any control function element or combination of control function elements can be programmed to read a binary "one" during any specified number of time frames. Each control element is identified on the Control Function Chart.

Figure A-6. Standard Format G

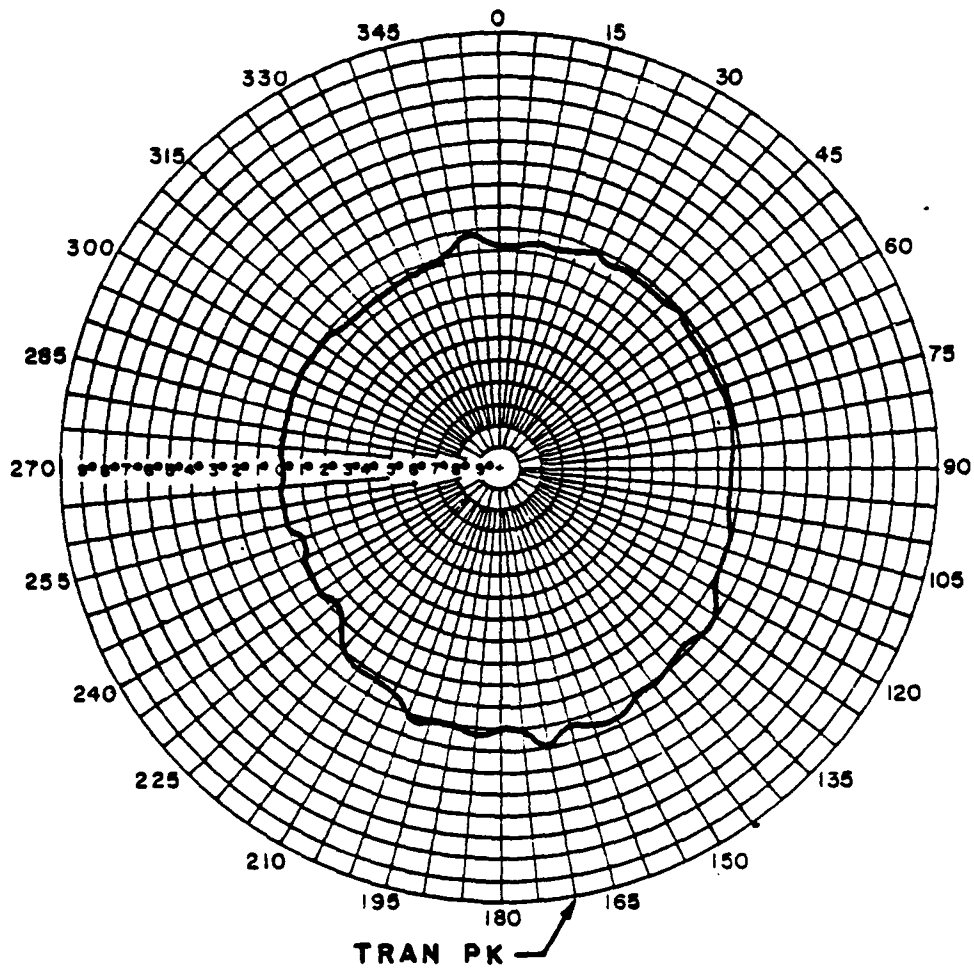
APPENDIX B

INSTRUMENTATION SITE SHADOW CHARTS

B-1. Instrumentation site shadow graphs contained herein are as follows:

Figure No.	Site
B-1	AN/TPQ-18
B-2	AN/FPS-16, No. 1
B-3	AN/FPS-16, No. 2
B-4	GERTS
B-5	AA/M-33, No. 1
B-6	AN/MPS-36-2
B-7	AN/FPQ-6, Pillar Point
B-8	AN/FPS-16, Pillar Point
B-9	35-Foot ATTRAS TRS
B-10	AN/GKR-7 TRS
B-11	8-Foot Dish TRS
B-12	Right Hand Quad Helix TRS
B-13	Left Hand Quad Helix TRS
B-14	40-Foot Antenna, Pillar Point
B-15	LA-24
B-16	AN/FPQ-14 Kaena Point, Hawaii
B-17	CCT No. 1
B-18	CCT No. 3
B-19	CCT No. 4, Pillar Point
B-20	Air Surveillance Radar
B-21	Anderson Peak-DMI
B-22	ROTI

NOTE: Pillar Point 80-Foot antenna graph not available and CCT No. 6 Laguna Peak will be provided at a later date.



DATE FEBRUARY 3, 1971

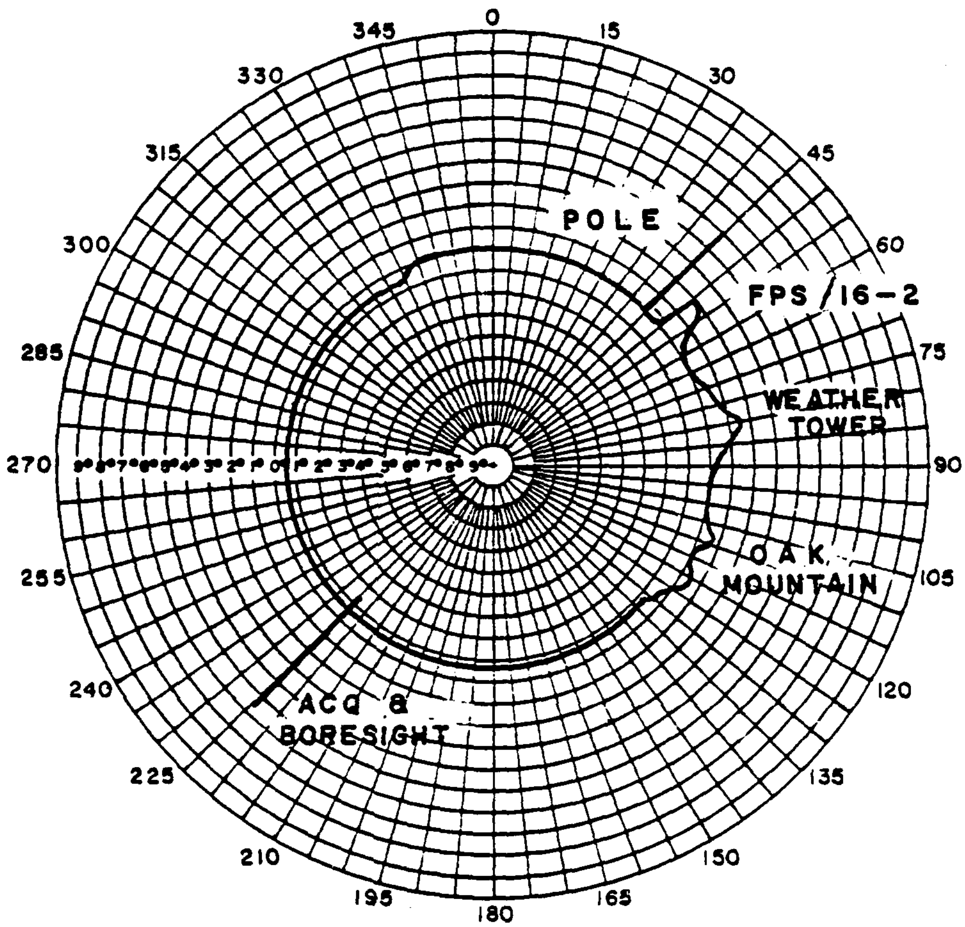
LOCATION AN / TPQ-18

OBSERVER MEMORY

REMARKS

INSTRUMENTATION SITE
SHADOW CHART

Figure B-1. AN/TPQ-18



DATE FEBRUARY 4, 1971

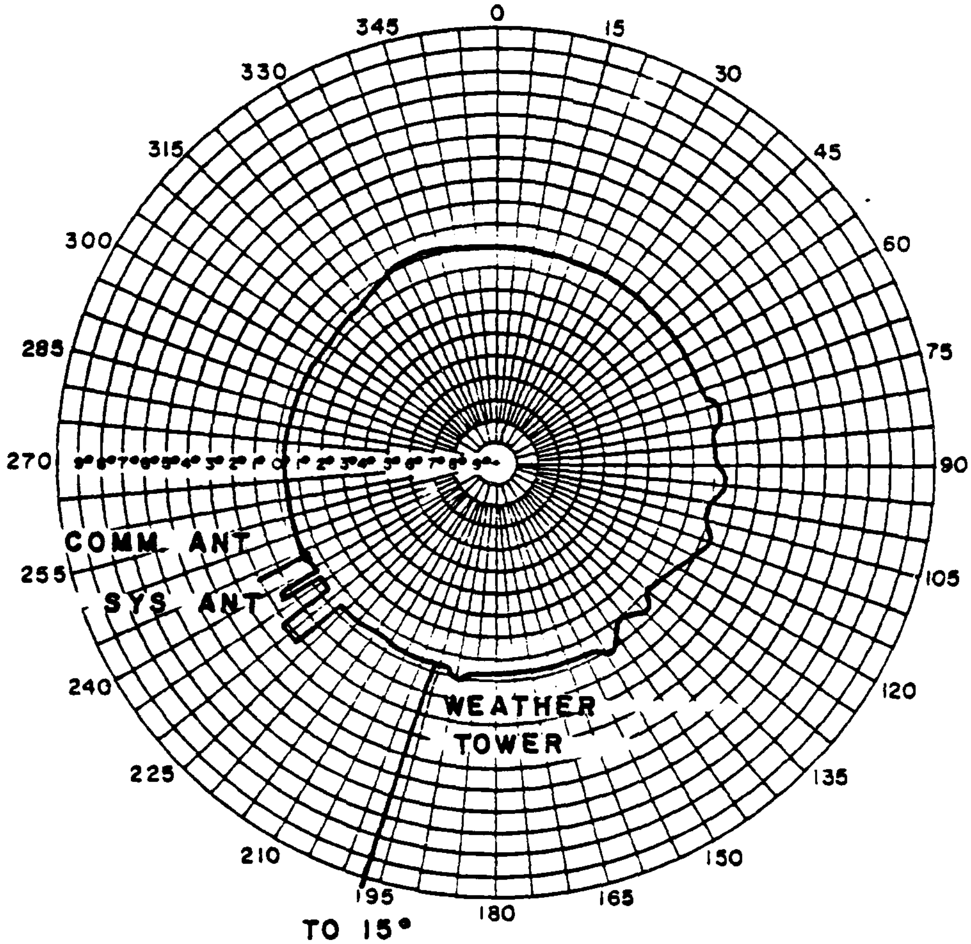
LOCATION FPS / 16-1 023001

OBSERVER CURAY

REMARKS BLDG. 178

INSTRUMENTATION SITE
SHADOW CHART

Figure B-2. AN/FPS-16, No. 1



DATE FEBRUARY 2, 1971

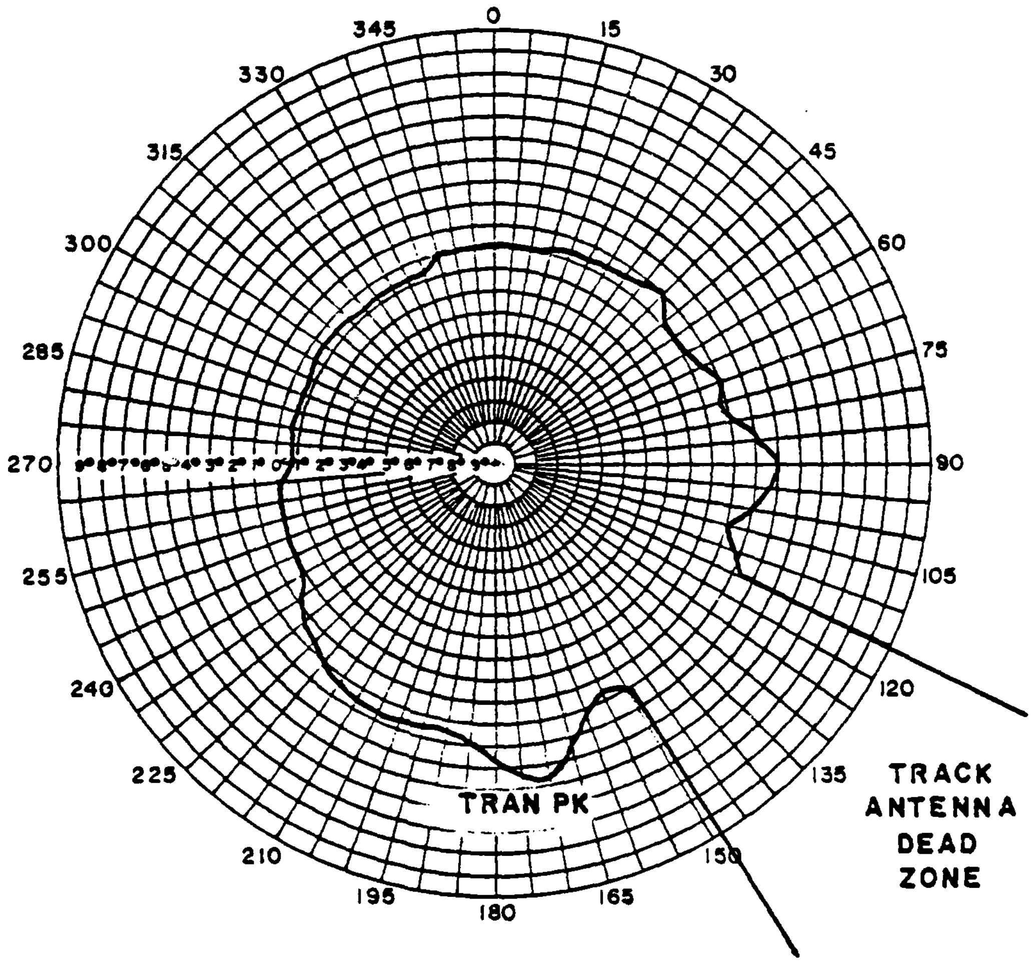
LOCATION AN/FPS-16-2, 023002

OBSERVER PIPPING

REMARKS BLDG. 175

INSTRUMENTATION SITE
SHADOW CHART

Figure B-3. AN/FPS-16, No. 2



DATE OCTOBER 28, 1971

LOCATION GERTS

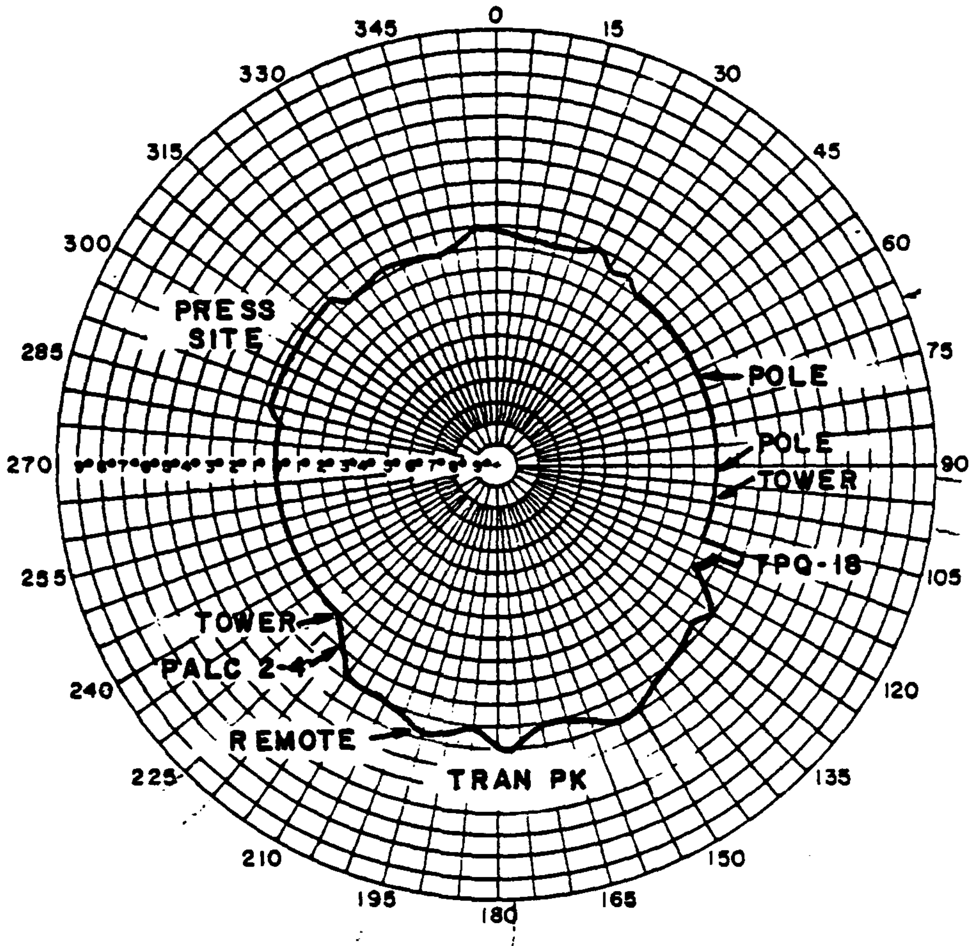
OBSERVER YOUNG

REMARKS TRACK & RATE

CENTRAL ANTENNA PROFILE

INSTRUMENTATION SITE
SHADOW CHART

Figure B-4. GERTS



DATE OCTOBER 27, 1971

LOCATION M-33-1, SVAFB

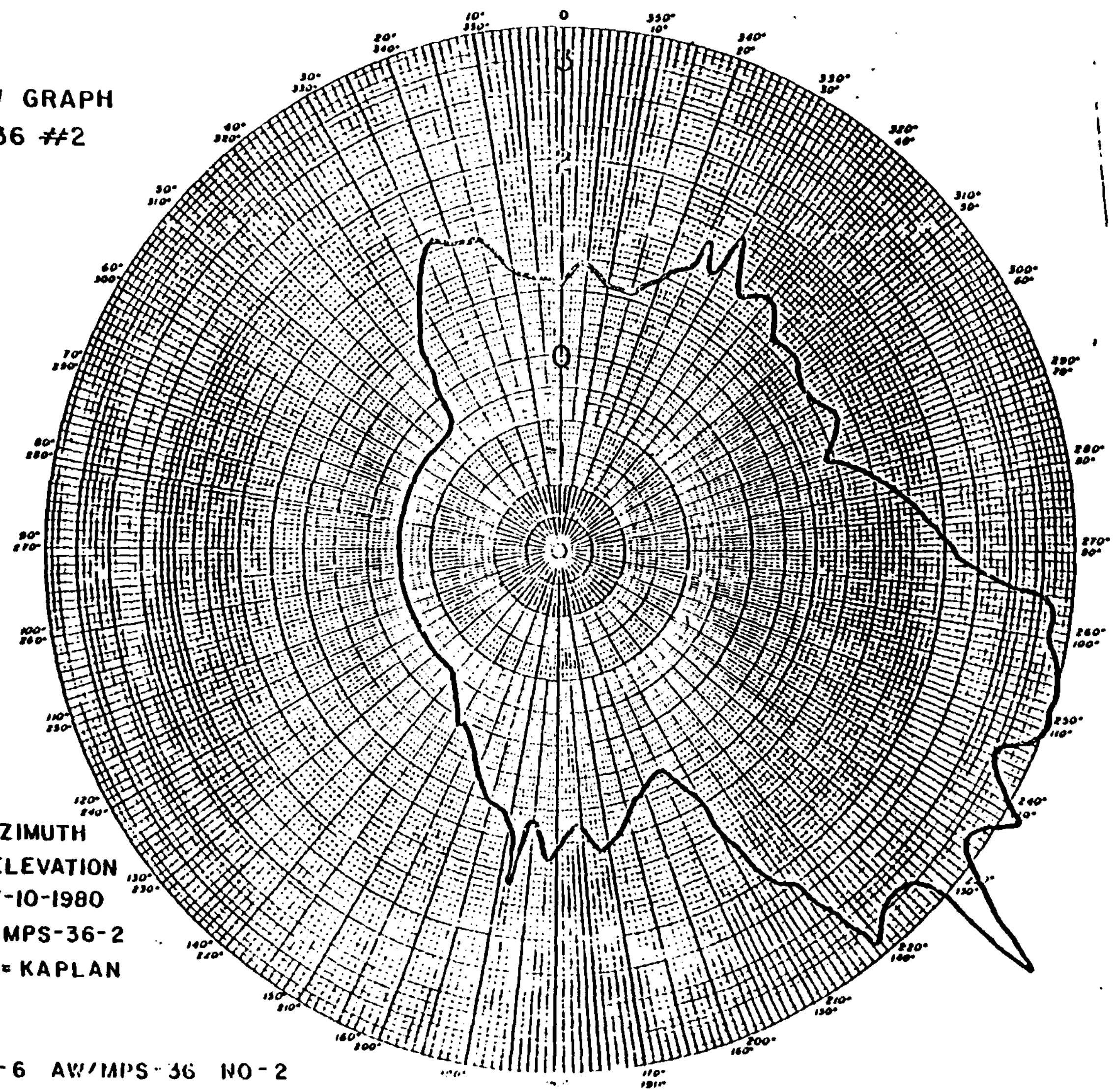
OBSERVER GOLSON

REMARKS

INSTRUMENTATION SITE SHADOW CHART

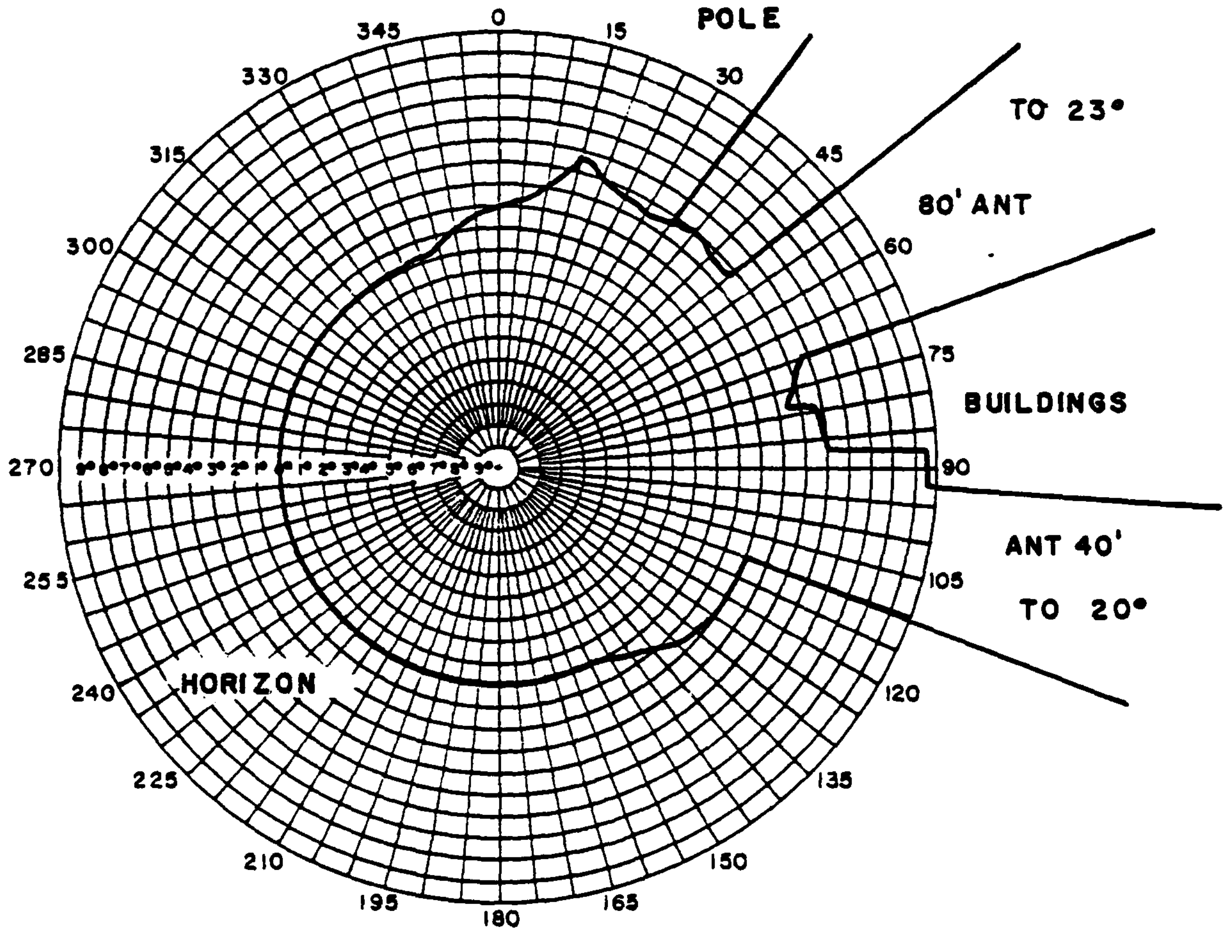
Figure B-5. AA/M-33, No. 1

SHADOW GRAPH
MPS 36 #2



RADIALS = AZIMUTH
CIRCLES = ELEVATION
DATE = JULY-10-1980
LOCATION = MPS-36-2
OBSERVER = KAPLAN

FIGURE B-6 AW/MPS-36 NO-2



DATE JANUARY 20, 1971

LOCATION FPQ-6 213002

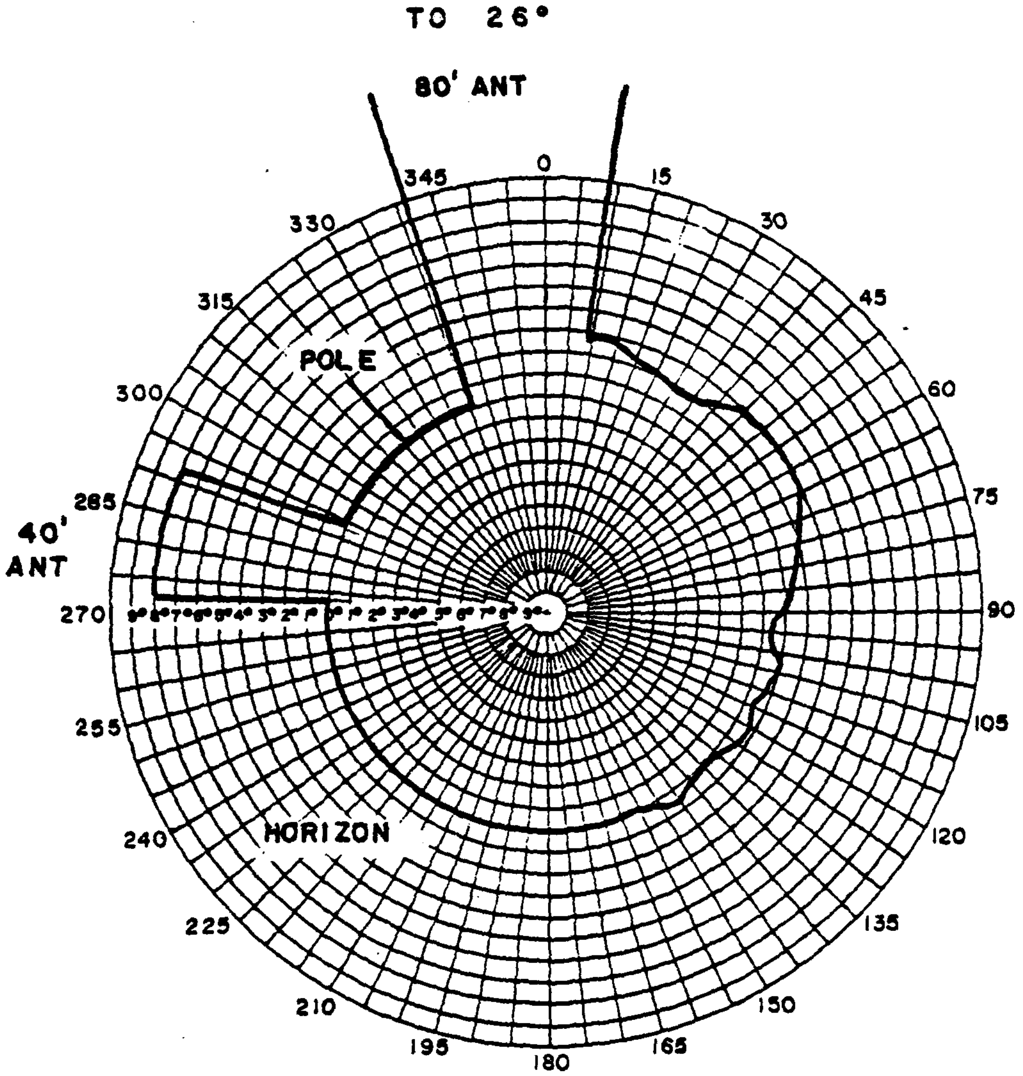
OBSERVER HERMAN

REMARKS

PILLAR POINT

INSTRUMENTATION SITE
SHADOW CHART

Figure B-7. AN/FPQ-6, Pillar Point



DATE JANUARY 14, 1971

LOCATION AN/ FPS-16 213001

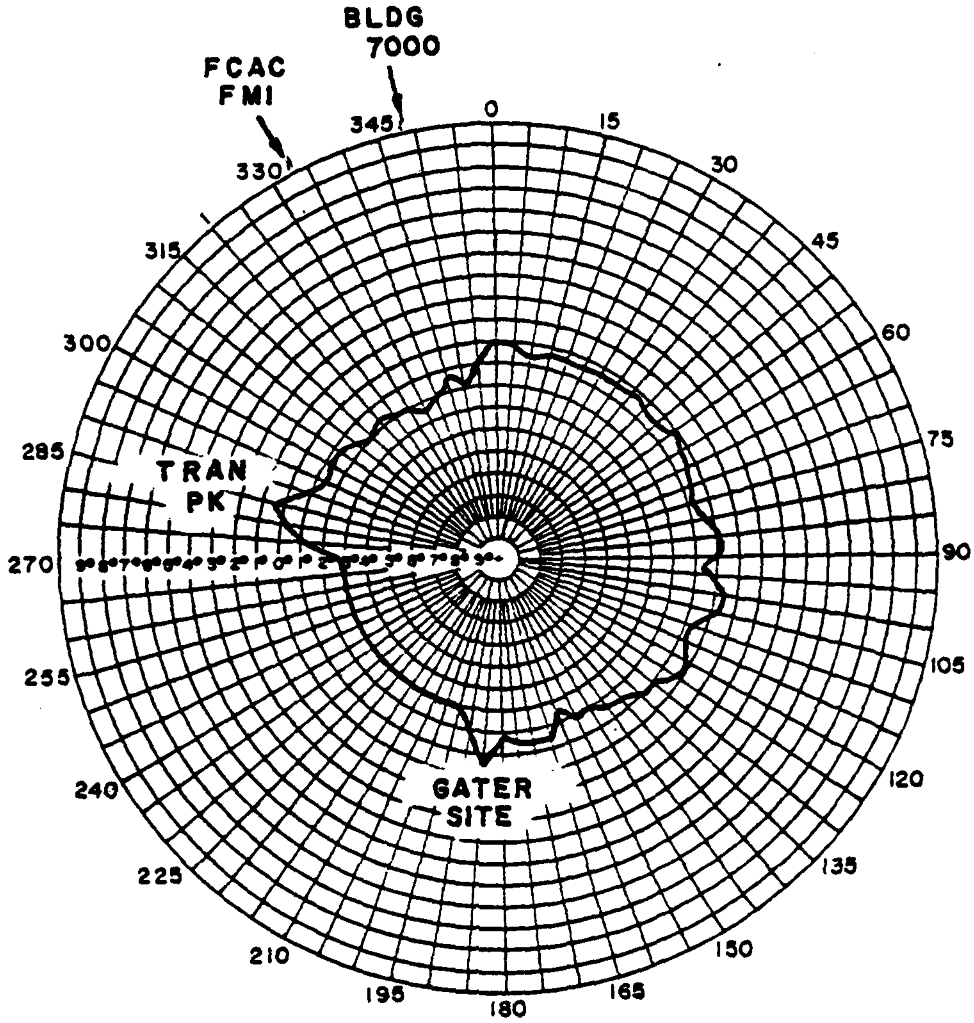
OBSERVER HAWKINS

REMARKS

PILLAR POINT

INSTRUMENTATION SITE
SHADOW CHART

Figure B-8. AN/FPS-16, Pillar Point



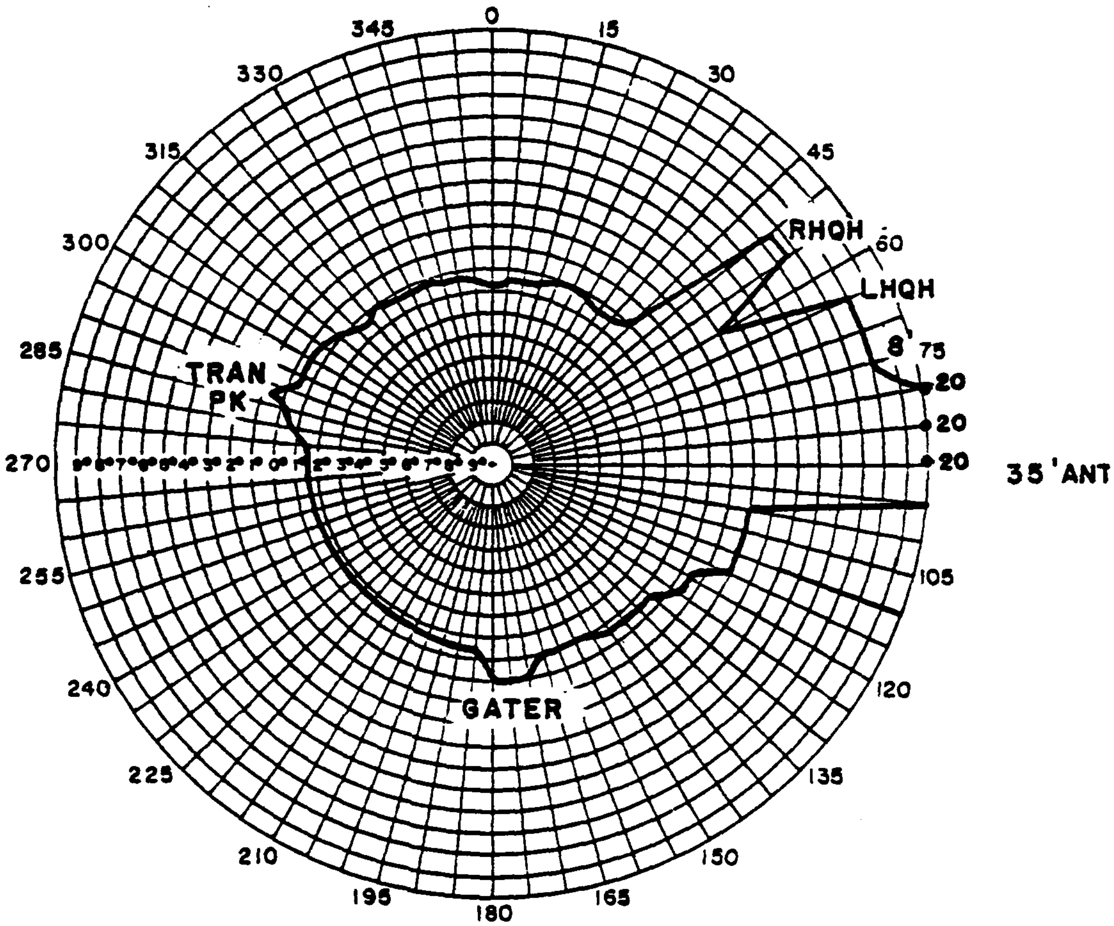
DATE OCTOBER 28, 1971
LOCATION OAK MOUNTAIN / TRS
OBSERVER COURSON
REMARKS

ATTRAS

35' ANTENNA , ATTRAS

INSTRUMENTATION SITE
SHADOW CHART

Figure B-9. 35-Foot, ATTRAS



DATE OCTOBER 28, 1971

LOCATION TRS

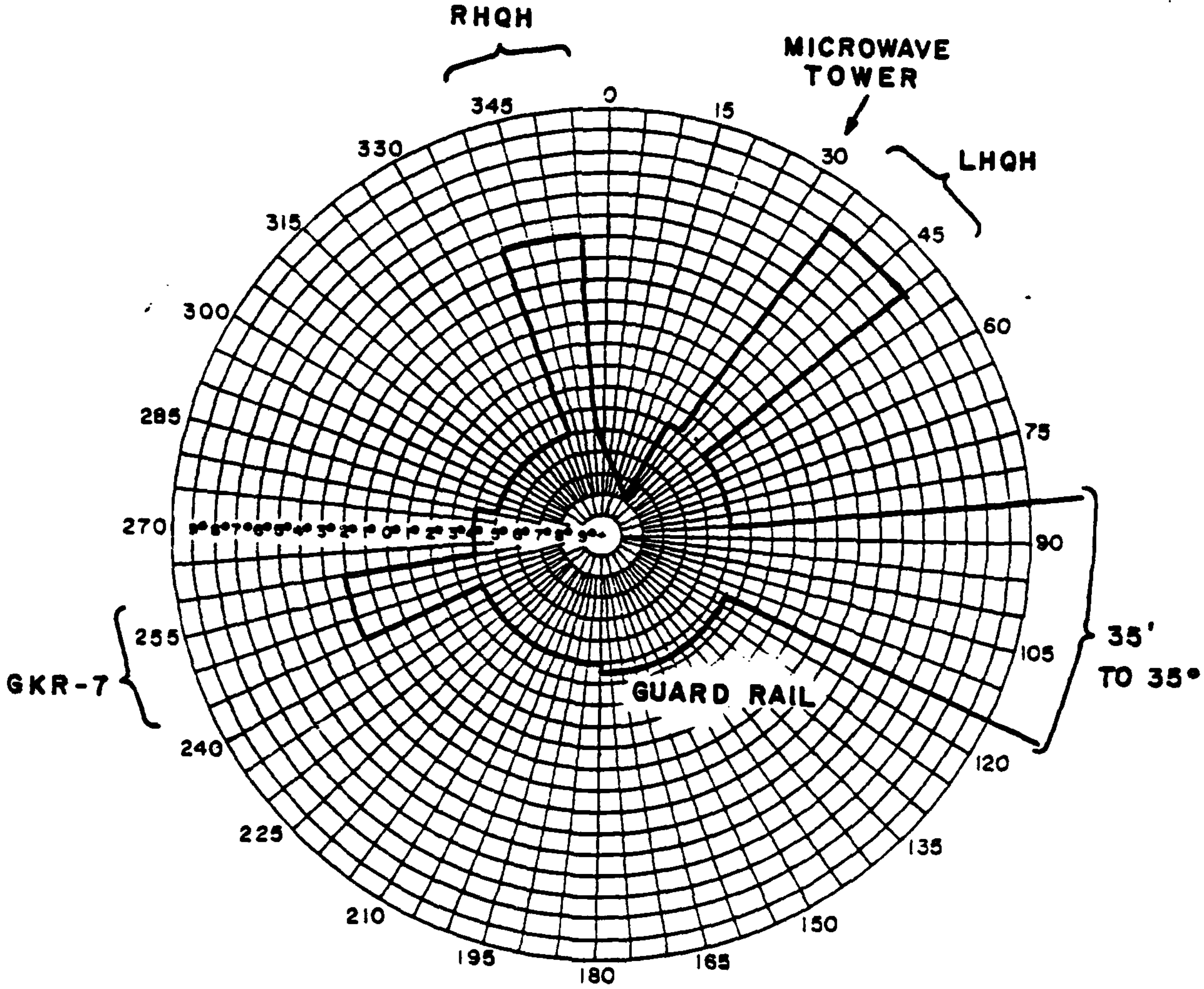
OBSERVER COURSON

REMARKS

INSTRUMENTATION SITE

SHADOW CHART

Figure B-10. GKR-7



DATE OCTOBER 28, 1971

LOCATION TRS

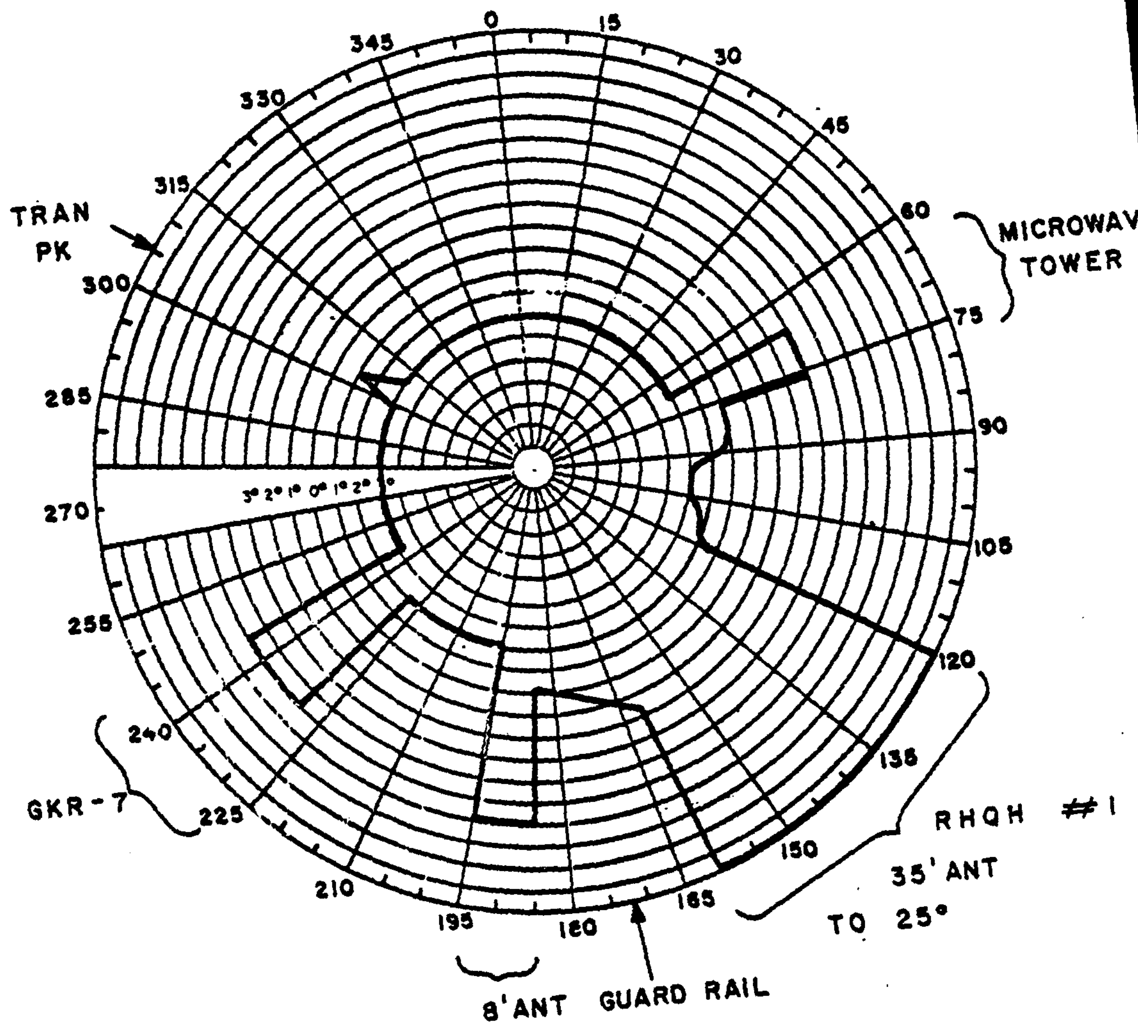
OBSERVER COURSON

REMARKS

8' ANTENNA

INSTRUMENTATION SITE
SHADOW CHART

Figure B-11. 8-Foot Antenna



DATE OCTOBER 28, 1971

LOCATION TRS

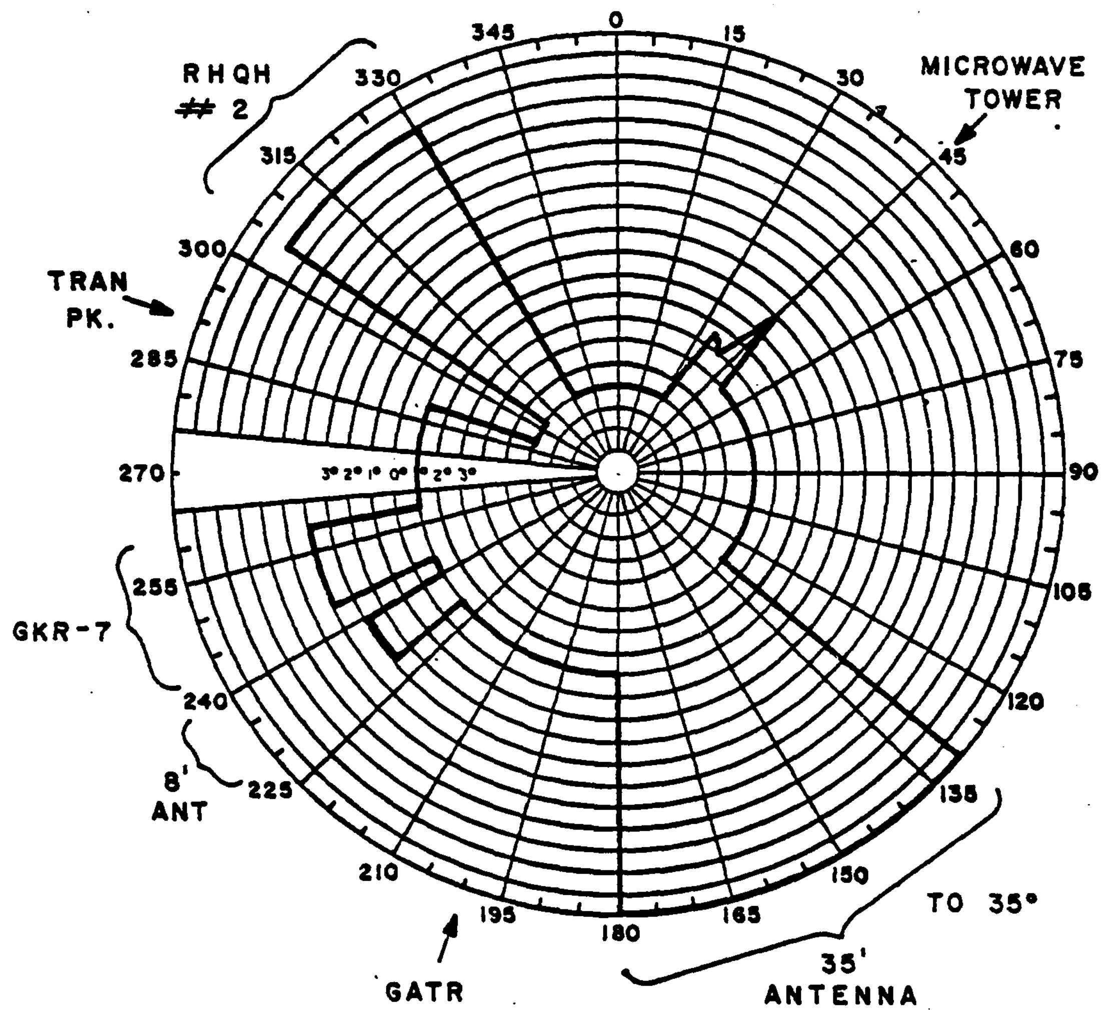
OBSERVER COURSON

REMARKS

RIGHT HAND QUAD HELIX #2

INSTRUMENTATION SITE SHADOW CHART

FIG. B-12. RIGHT HAND QUAD HELIX



DATE OCTOBER 28, 1971

LOCATION TRS

OBSERVER COURSON

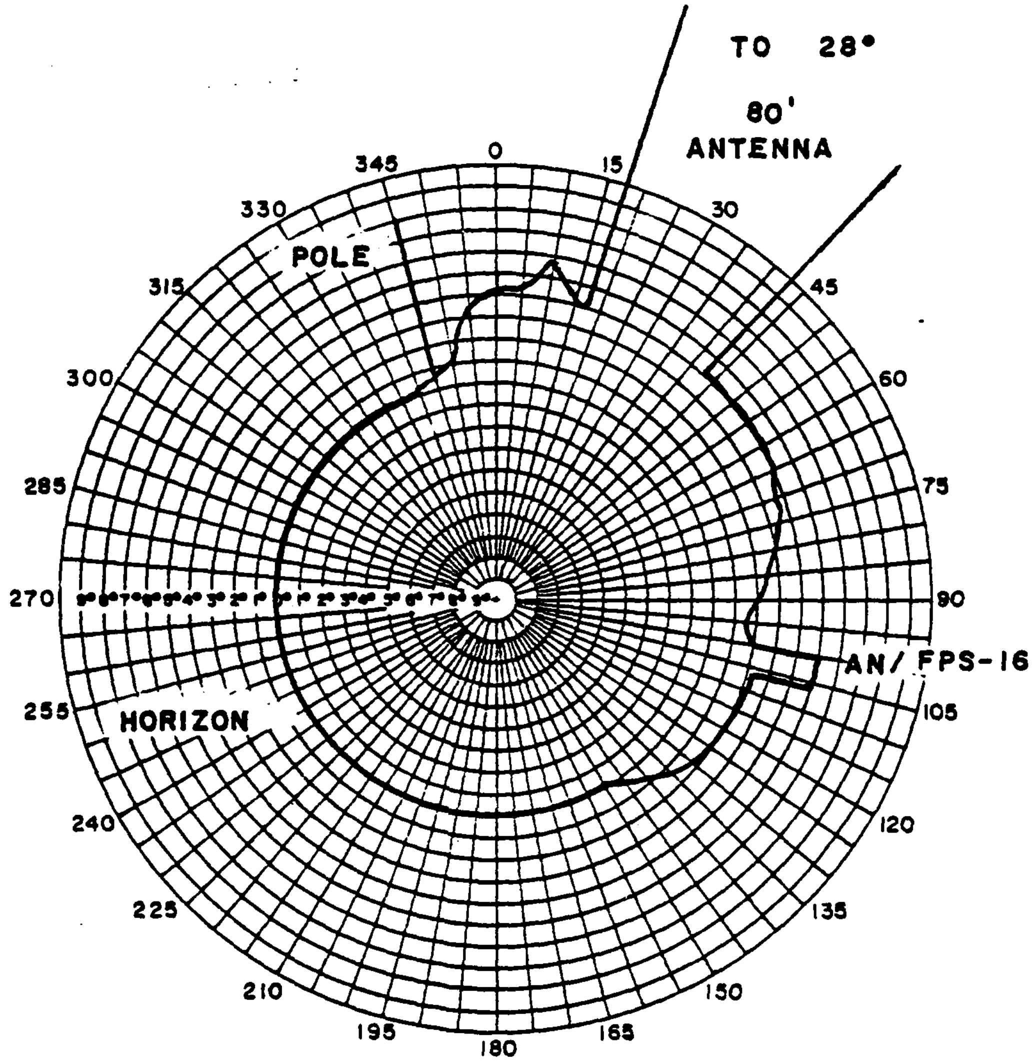
REMARKS

INSTRUMENTATION SITE

SHADOW CHART

RIGHT HAND QUAD HELIX #1

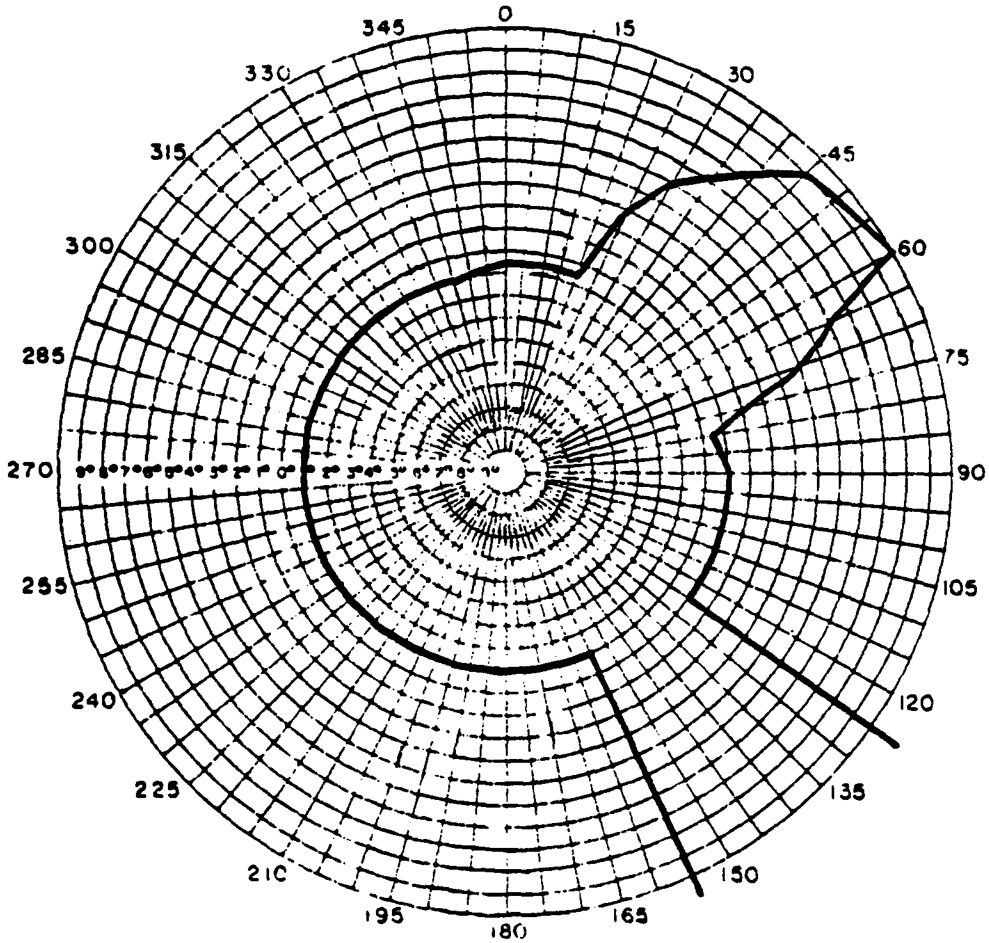
FIG. B-13. RIGHT HAND QUAD HELIX



DATE JANUARY 22, 1971
LOCATION 217601
OBSERVER HAWKINS
REMARKS

INSTRUMENTATION SITE
SHADOW CHART

Figure B-14. 40-Foot Antenna, Pillar Point



DATE 24 JULY 1980

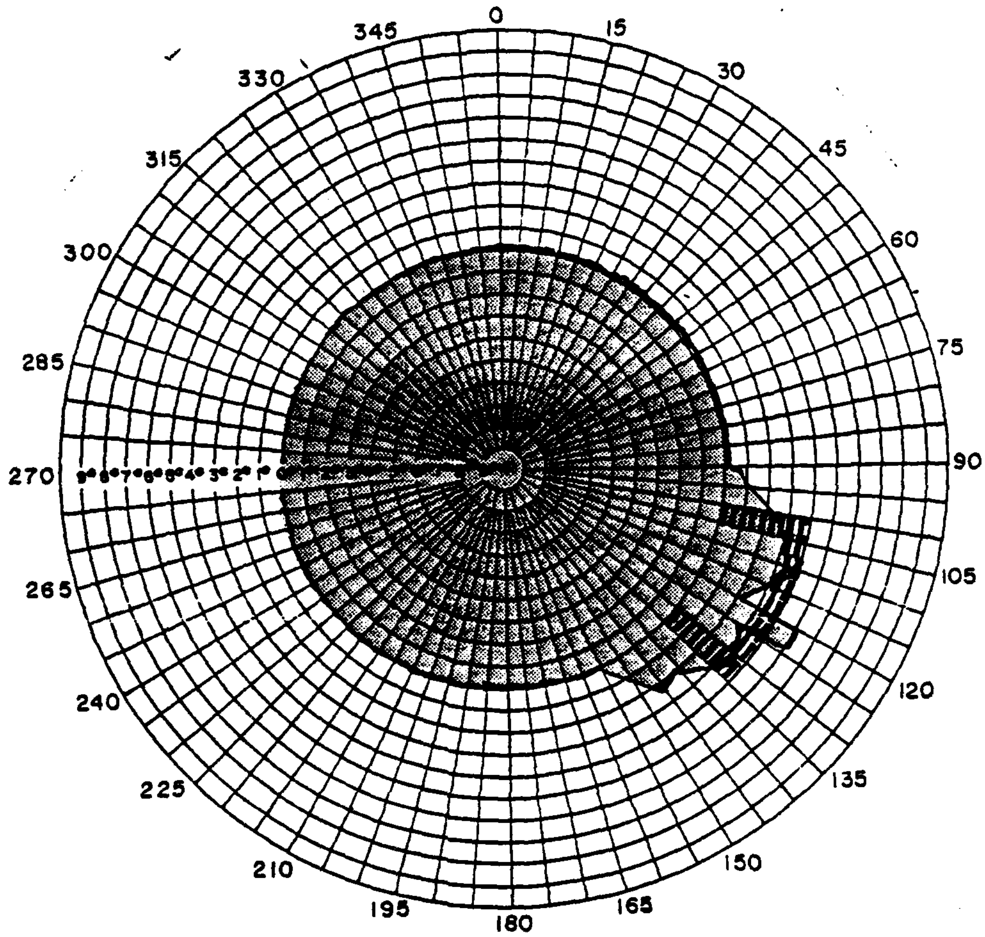
LOCATION 020T01

OBSERVER HEATH-ANDERSON

REMARKS

INSTRUMENTATION SITE SHADOW CHART

Figure B-15. LA-24 Tran. Peak



DATE 11 October 1973

LOCATION Kaena Pt. AN/FPQ-14

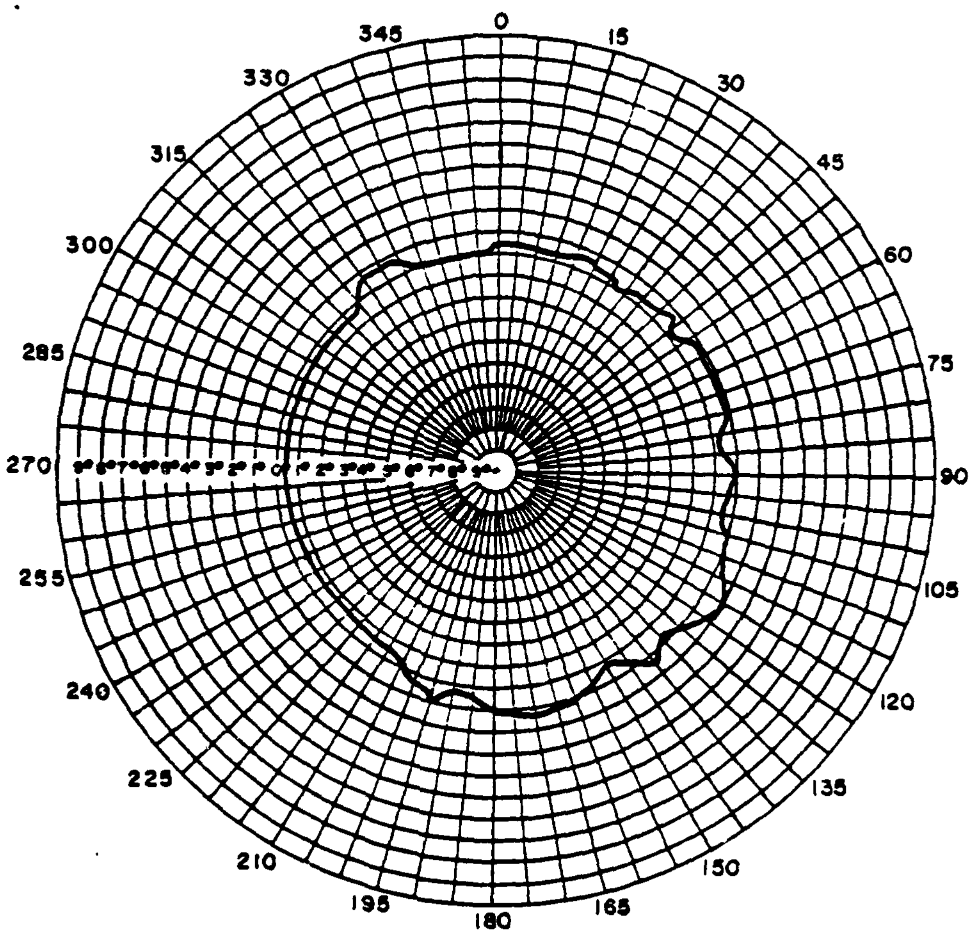
OBSERVER Thomas - Wood

REMARKS

▮▮▮▮▮▮▮▮▮ Radiation limit below 4° and between 98° and 135° azimuth.

INSTRUMENTATION SITE SHADOW CHART

Figure 8-16. AN/FPQ-14, Kaena Point



DATE NOVEMBER 8, 1971

LOCATION CT # 1 038301

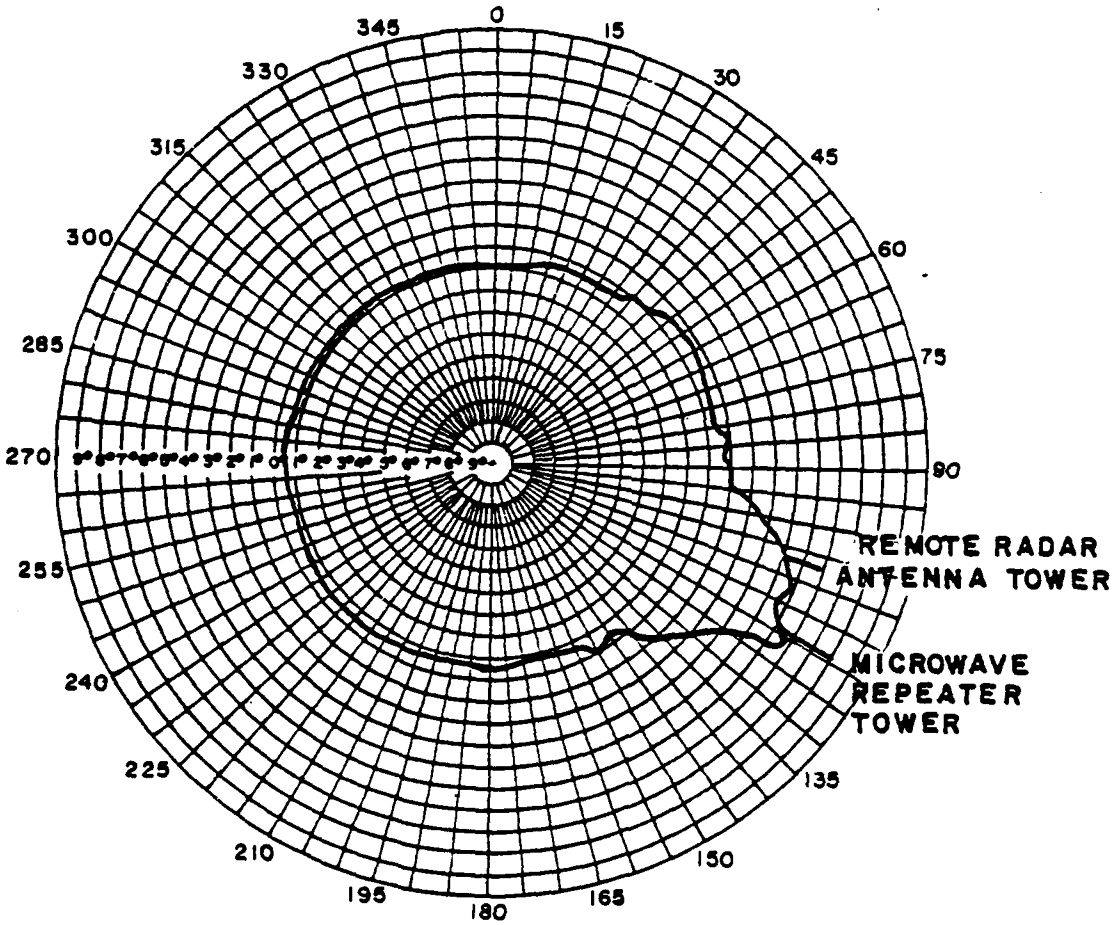
OBSERVER STEADEMAN

REMARKS

SITE 1

INSTRUMENTATION SITE
SHADOW CHART

Figure B-17. CCT No. 1



DATE NOVEMBER 8, 1971

LOCATION CT # 3 028302

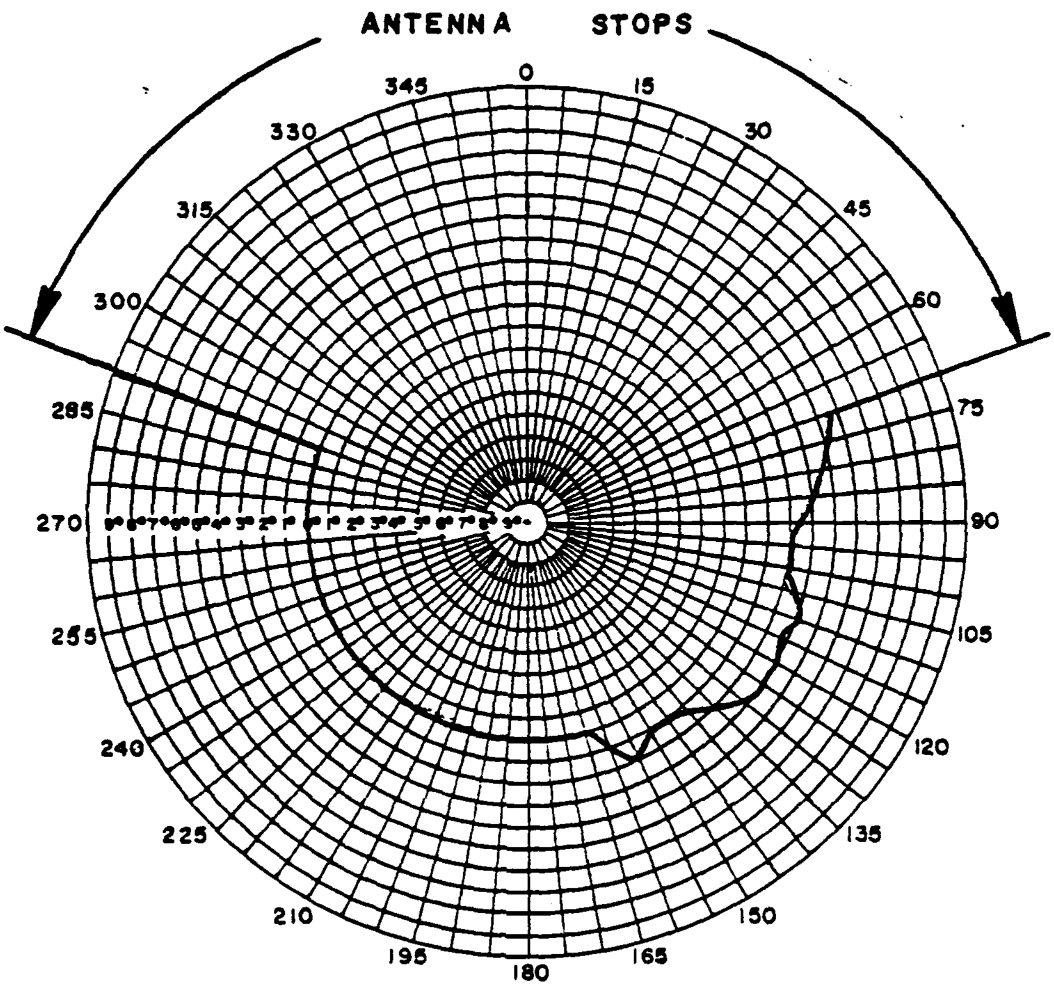
OBSERVER STEADEMAN

REMARKS

SITE 3

INSTRUMENTATION SITE
SHADOW CHART

Figure 8-18. CCT No. 3



DATE JANUARY 14, 1971

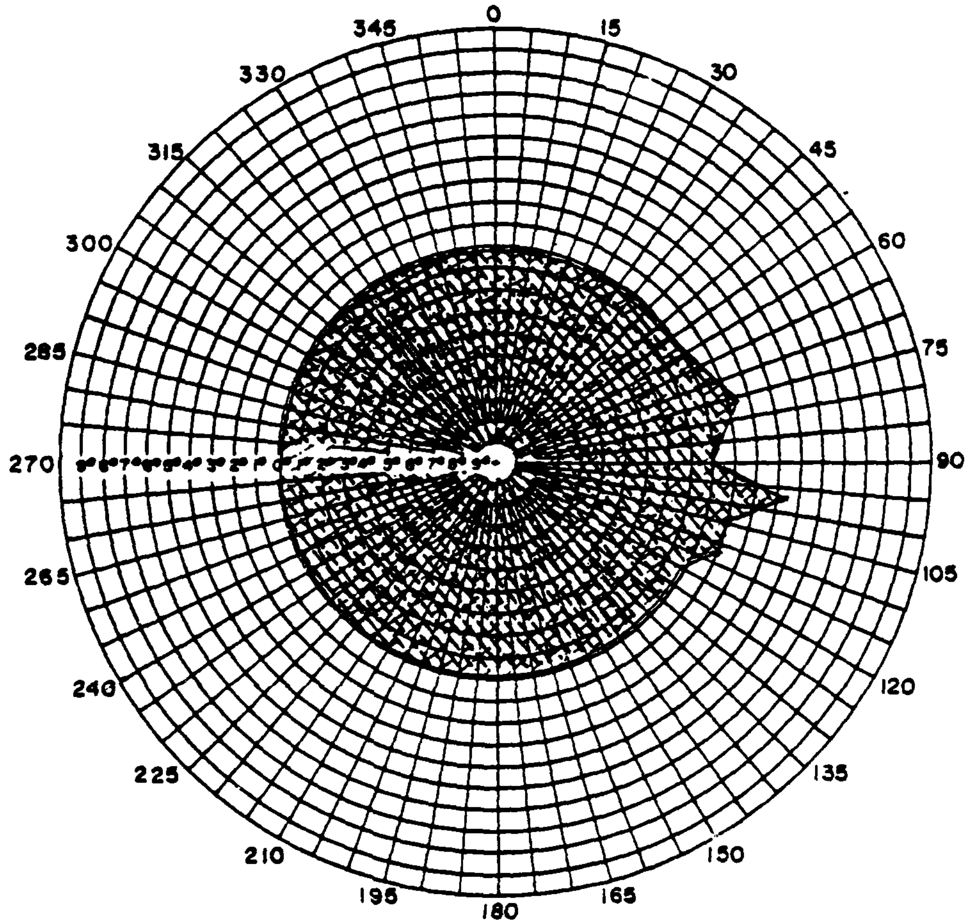
LOCATION CT # 4 PILLAR POINT

OBSERVER HAWKINS

REMARKS

INSTRUMENTATION SITE SHADOW CHART

Figure B-19. CCT No. 4, Pillar Point



DATE 12 Febuary 1975

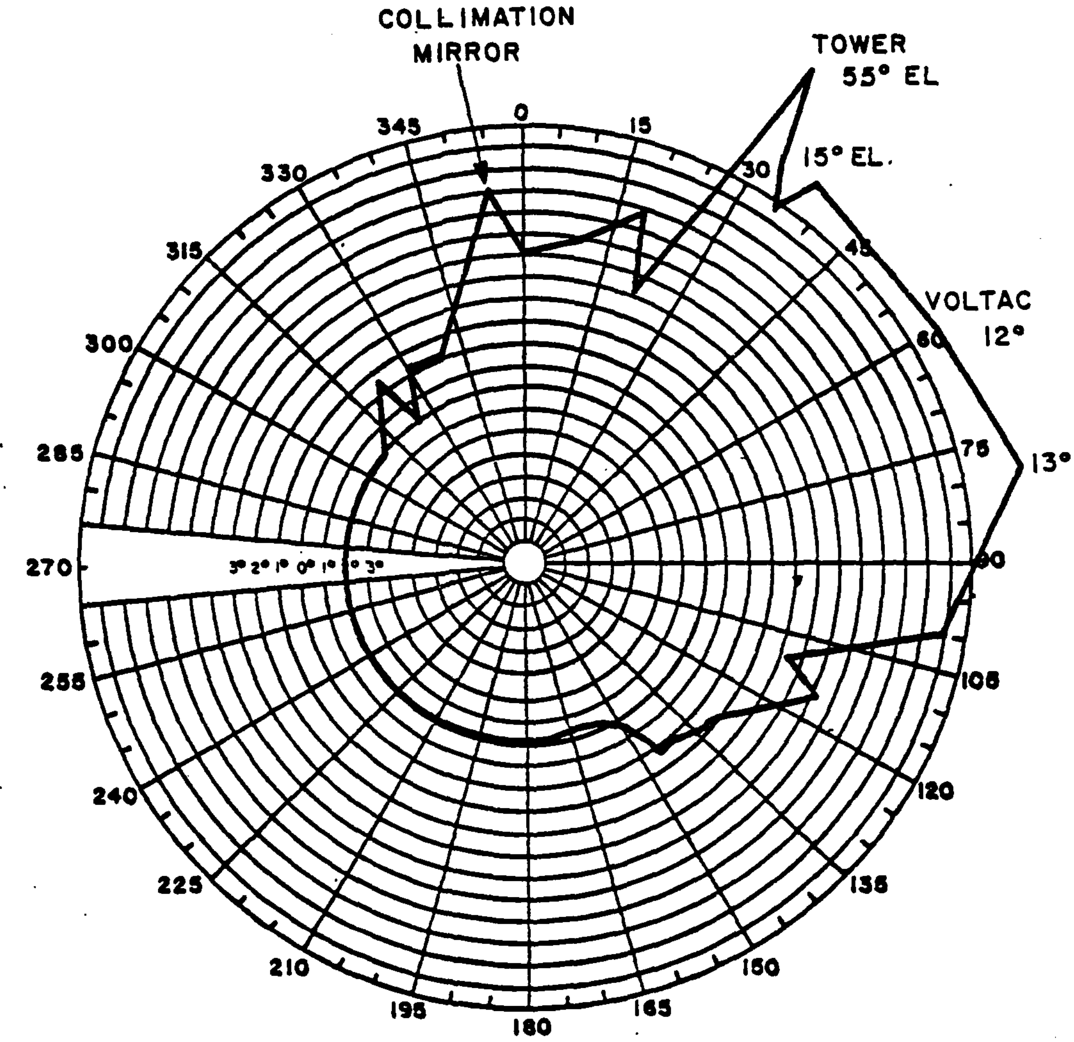
LOCATION Bldg 500 ARSR-1

OBSERVER G.G. GOOKINS

REMARKS

INSTRUMENTATION SITE SHADOW CHART

Figure B-20. ARSR-1D



DATE 11 JULY 80

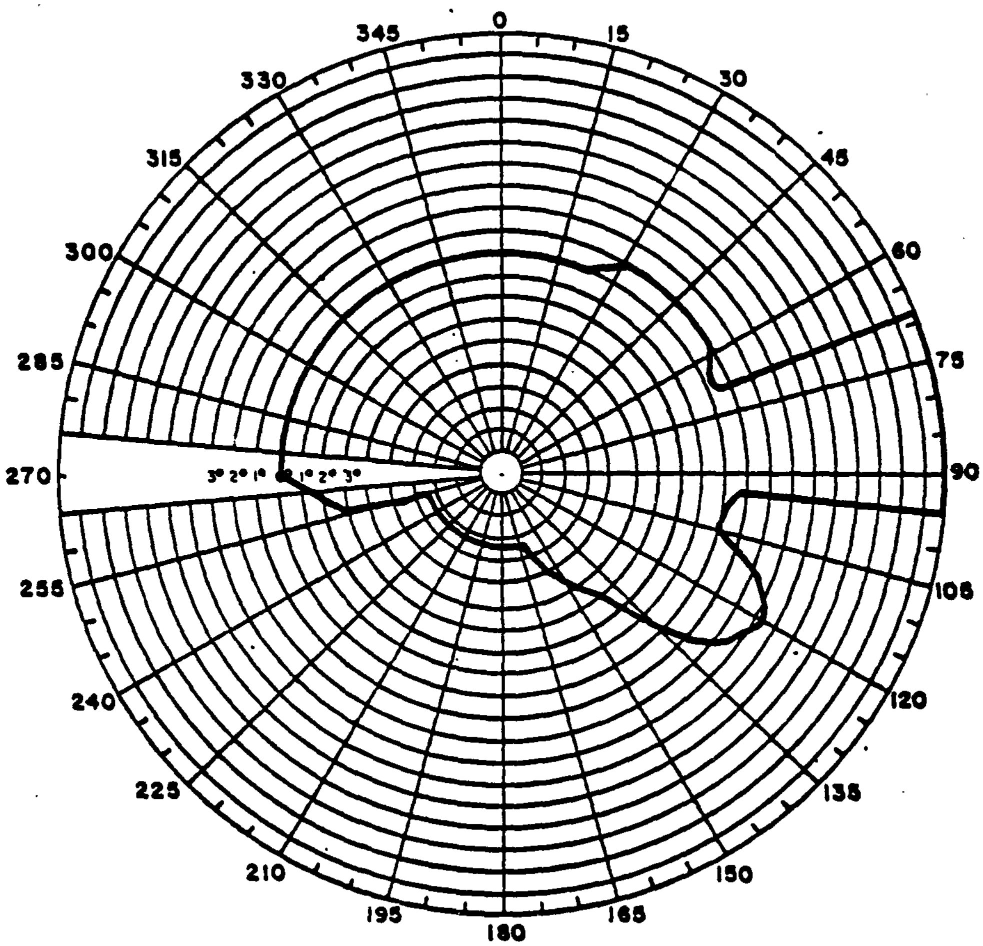
LOCATION ANDERSON PEAK DMI

OBSERVER MIKKELSEN/SOLOVEN

REMARKS

INSTRUMENTATION SITE SHADOW CHART

FIG. B-21 ANDERSON PEAK - DMI



DATE 25 JULY 1980

LOCATION ROTI (SYP) 110T01

OBSERVER HARDY / MURRAY

REMARKS

INSTRUMENTATION SITE SHADOW CHART

FIG. B-22. ROTI

APPENDIX C

GLOSSARY

C.1 TERMS

Term	Definition
TELEMETRY	Aerospace telemetry provides remote display of vehicle performance parameters such as propulsion, structure, guidance, and payload. This is accomplished by suitable encoding the electrical outputs of transducers installed aboard the vehicle and modulating an rf transmitter with the encoded signals. The ground station then receives, decodes, and processes these signals for recording, display, relay, and analysis. The use of directional receiving antennas and phase comparison or doppler techniques enables determination of angle and range rate data.
FM/FM	FM/FM frequency division multiplex is a basic telemetry system wherein several frequency modulated sub-carriers, each operating simultaneously and independently, are combined and used to frequency modulate an rf carrier. The sub-carrier frequencies, which may be separated at the receiving end into individual data channels by appropriate filtering. The standard FM/FM telemetry system now in use provides for 21 sub-carrier channels; other systems now in limited use provide 40 or more channels.
CUBE (Designation)	Cubes are predetermined volumes of space on a programmed launch vehicle trajectory.

TWYSTRON — A twystron is a hybrid traveling-wave-tube.

PCM/FM — PCM/FM makes use of digital techniques to obtain higher accuracy and greater channel capacity that provided by PAM/PDM, and FM systems. The outputs of vehicle transducers are applied to a commutator multiplexer which sequentially samples each signal and outputs a pulse train similar to that used for Pulse Amplitude Moudlation (PAM) telemetry. Each pulse in the train is then converted to an equivalent binary-coded number (digitized) by an analog-to-digital converter and applied to the rf transmitter in the serial digital format.

PAM/FM/FM — PAM/FM/FM is ued in those instances where the FM/FM system does not provide a sufficient number of data channels. The capacity may be increased by time division multiplexing of individual FM/FM sub-carriers (commutation). Pulses of varying amplitude, each pulse representing a separate data channel, is used to sequentially modulate a sub-carrier. The amplitude of these pulses is proportional to the magnitude of the vehicle parameters, thus, the system is referred to as PSM. One or more of the available FM/FM sub-carriers may be multiplexed, providing 100, 200 or more separate data channels.

PDM/FM/FM — PDM/FM/FM is a means of time division multiplexing. The duration of the sequentially applied pulses is made proportional to the magnitude of the vehicle parameter instead of the pulse amplitude. The vehicle transducer outputs are applied to a commutator to produce a PAM pulse train; this pulse train is then fed to a PAM to PDM converter for conversion to a pulse train of constant amplitude with varying duration. These pulses are then used to modulate a sub-carrier oscillator as in PAM.

C.2 ABBREVIATION AND ACRONYMS

ac	alternating current
ACC	Area Control Center
A/D	analog-to-digital
ADRAN	Advanced Digital Range Modification
AEC	Atomic Energy Commission
AFB	Air Force Base
AFC	automatic frequency control
AFCO	All Fuel Cut-Off
AFETR	Air Force Eastern Test Range
AFS	Air Force Station
AFSC	Air Force Systems Command
AGC	automatic gain control
AM	amplitude modulation
AMFCO	Assistant Missile Flight Control Officer
ARSR	Air Route Surveillance Radar
ATT	All Thrust Termination
AWS	Air Weather Service
Az	Azimuth (also A)
BCD	Binary Code Decimal
BCM	Basic Control Monitor
BIDS	Backup Information Display System
bit	Binary digit
CAT	Computer Annex Trailer
CCC	Computer Control Center
CCDS	Console Control and Distribution System
CCTV	Closed circuit television
CDC	Control Data Corporation
CCT	Command Control Transmitter
cm	centimeter
C/P	Cartesian to Polar
CPU	central processing unit
CRT	cathode-ray tube
CSC	Central Switching Controller

CSCCC	Consolidated System Command Control Center
CSP	Coherent Signal Processor
CTC	Command Transmitter Controller
CTSG	Central Timing Signal Generator
CW	continuous wave
cw	clockwise
ccw	counterclockwise
D/A	digital-to-analog
DAC	Digital-to-Analog Converter
dB	decibel
dBm	decibel referenced to one milliWatt
dBV	decibel referenced to one Volt
dBW	decibel referenced to one Watt
DC	Data Center
dc	direct current
DCI	Data Compressor Input
DCS	Data Control System
DCM	Data Compressor Module
DCP	Data Compressor Processor
DDS	Digital Date System
DDU	Data Distribution Unit
DDP	Discrete Display Panel
deg	degree (temperature expressed as ^{o})
DEM	Digital Event Markers
DIRAM	Digital Range Machines
DM	Data Monitor
DME	Distance Measuring Equipment
DoD	Department of Defense
DORS	Data Output Recording System
DPR	Deployment Position Radar
DTB	Data Terminal Buffer
DTM	Direct Tracking Modification
DTU	Digital Test Unit
EBCDIC	Extended Binary Coded Decimal Interchange Code

EBR	Electron Beam Recorder
EL	Elevation (also E)
EMI	Electro-Magnetic Interference
ESC	Environmental Support Center
FAA	Federal Aviation Agency
FDR	Flight Data Recording System
FM	Freqency Modulation
fps	frames per second
FSK	Frequency Shift Keying
FSR	Frequency Shift Reflector
FTC	Fast Time Constant
ft	feet
FY	Fiscal Year
GAT	Ground to Air Transmitter
GE	General Electric
GERTS	General Electric Radio Tracking System
GHz	Gigahertz
GSFC	Goddard Space Flight Center (NASA)
HF	High Frequency (3 to 300 MHz)
HiAcc	High Accuracy Data Transmission System
hr	hour
Hz	Hertz (cycles per second)
IBM	International Business Machines, Corp.
ICBM	Intercontinental Ballistic Missile
ICL	Instrumentation Connection Lists
IDRAN	Integrated Circuit Digital Ranging
IDTS	Instrumentation Data Transmission System
IF	Intermediate Frequency
IFF	Identification, Friend or Foe
IFLOT	Intermediate Focal Length Optical Tracker
IG	Inertial Guidance
IIP	Instantaneous Impact Prediction
in.	inch(es)
IO	Ionospheric Observatory

I/O	Input/Output
IP	Instrumentation Plans
ips	inches per second
IRACQ	Integrated Radar Acquisition
IRBM	Intermediate Range Ballistic Missile
IRIG	Inter-Range Instrumentation Group
IRV	Inter-Range Vector
ITT	International Telephone and Teletraph Corporation
K	Kelvin
k	kilo
Khz	Kilohertz
KSR	Keyboard Send/Receive
kt	knot
kW	kilowatt
LAT	latitude
LHC	Left Hand Circular
LO	Local Oscillator or Lift-Off
LON	Longitude
LSB	Least Significant Bit
LSI	Lear Seigler, Inc.
mA	milliamperes
max	maximum
MFB	Multifunction Buffer
MFCC	Missile Flight Control Center
MFCO	Missile Flight Control Officer
MHz	megahertz (106 cycles per second)
mi	miles (statute)
MILS	Missile Impact Location System
min	minimum
MIOP	Multiple Input/Output Processor
MISS	Miniature Impact SOFAR System
mm	millimeter
MMRTRS	Mobile Medium Range Tracking Radar System

Modem	Modulator-demodulator
MOTS	Mobile Optical Tracking System
MOTU	Mobile Significant Bit
MSB	Most Significant Bit
MRI	Multiple Radar Interrogator
MSL	Mean Sea Level
MSOS	Mass Storage Operating System
MSS	Mission Safety Sytem
MTI	Moving Target Indicator
mW	milli (10) watt
MW	Megawatt
NCS	Network Control Station
NASA	National Aeronautics and Space Administration
nmi	nautical mile (s)
NRZ (L)	Non-Return-to-Zero (Level)
NVAFB	North Vandenberg Air Force Base
NWS	National Weather Service
OBLSS	Operational Base Launch Safety System
OC	Optional Command
OD	Operational Directives
O&M	Operations and Maintenance
OPR	Office of Primary Responsibility
OS	Optical Station
PAM	Pulse Amplitude Modulation
Paramp	Parametric Amplifier
PB	Plotboard
PC	Peripheral Computer
PCM	Pulse Code Modulation
PDM	Pulse Duration Modulation
pk-pk	peak-to-peak
PPAFS	Pillar Point Air Force Station
PLC-A	Probe Launch Complex-A

PTP	Paper Tape Punch
PTR	Paper Tape Reader
PMEL	Precision Measurements Equipment Laboratory
PMTC	Pacific Missile Test Center
PP	Present Position
PPI	Plan Position Indicator
ppm	parts per million
pps	pulses per second
PRF	Pulse Repetition Frequency
R	Range
RADAC	Radar Data Acquisition Converter
RAD	Rapid Access Disk
RATAC	Radar Analog Target Acquisition Computer
RBM	Realtime Batch Monitor
RCA	Radio Corporation of America
RCCC	Range Communication Control Center
RCO	Range Control Officer
RDF	Range of Data Center
rf	radio frequency
RHC	Right Hand Circular
RHI	Range Height Indicator
RILS	Radar Impact Location System
RML	Range Measurements Laboratory (AFETR)
rms	root mean square
r/min	revolutions per minute
ROCC	Range Operations Control Center
ROS	Representative Observation Sounding Equipment
ROSE	Rising Observation Sounding Equipment
RSV	Range Safety Van
RSDS	Range Safety Data System
RTDC	Real Time Data Controller
RTDHS	Real Time Data Handling System
RTS	Real Time System
RTSC	Range Technical Services Contractor
RV	Re-Entry Vehicle
RZ	Return-to-Zero

SAC	Strategic Air Command
SAMTEC	Space and Missile Test Center
S&A	Status and Alert
SCD	Subcarrier Discriminator
SDS	Scientific Data Systems
sec	second (sometimes expressed as s)
SGLS	Space Ground Link Subsystem
SNI	San Nicolas Island
S/N	Signal to Noise (ratio)
SOFAR	Sound Fixing and Ranging
STAFFMET	Staff Meteorologist (SAMTEC)
STC	Sensitivity Time Control
SVAFB	South Vandenberg Air Force Base
TBE	Time Base Expansion
TCT	Time Code Translator
TDE	Time Displacement Error
TDF	Telemetry Data Formatter
TM	Telemetry (also TLM)
TOCC	Test Operations Control Center
TPRS	Telemetry Prediversity Recieve/Record Station
TPS	Telemetry Processing Station
TTG	Time Translator Generator
TTY	Teletype
TVS	Tel .metry Validation System
TWT	Traveling Wave Tube
Tx	Transmit (ter)
UAO	Upper Air Observatories
UAOM	Upper Air Observatory-Mobile
UAON	Upper Air Observatory-North
UAOPP	Upper Air Observatory-Pillary Point
UAOS	Upper Air Observatory-South
UHF	Ultra-High Frequency (300 to 3000 MHz)
USAF	United States Air Force
UTC	Universal Time Coordinated

V	Volt(s)
Vac	Volt(s), alternating current
VAFB	Vandenberg Air Force Base
VCO	Voltage Controlled Oscillators
Vdc	Volt(s), direct current
VESS	Velocity Extraction Subsystems
VFLO	Variable Frequency Local Oscillator
VFO	Variable Frequency Oscillator
VHF	Very High Frequency (30 to 300 MHz)
VIPS	Vandenberg Impact Prediction System
VLF	Very-Low Frequency (0 to 30 kHz)
VRCCC	Vandenberg Range Communications Control Center
VTR	Video Tape Recording
VWSS	Vertical Wire Skyscreen
W	Watt(s)
WINDS	Weather Information Network and Display System
wpm	words per minute
WRCCC	Wheeler Range Communications Control Center
XMTR	Transmitter
yd	yard
usec	Microsecond (10^{-6} second)

DISTRIBUTION LIST

Organization	Nr Cys	Organization	Nr cys
SAMTO		MISSILE TEST GROUP	
CC	1	6595 MTG/CC	1
CA	1	MX	5
RM	1	BP	5
DO	1		
DOX	1		
DOS	1		
PM	1		
WSMC		SPACE TEST GROUP	
CC	1	6595 STG/CC	1
CE	1	AS	5
HO	1	TS	5
PA	1	DS	3
AC	1		
SP	1		
SE	5		
DEC	2	6595 SHUTTLE TEST GROUP	
PM	1	CC	1
XR	4	SO	5
CDWTR	1		
RO	15	TECHNICAL LIBRARY	50
RS	1	RESERVE	20
RSC	5		
RSI	20	AIR FORCE	155
RSD	5	FEC	81

Organization	Nr Cys
Federal Electric Corporation Vandenberg AFB, CA 93437	
DP 100	1
DP 300	3
DP 400	2
DP 700	6
DP 800	1
IC 200	7
IC 400	1
IC 600	5
MS 200	1
MS 600	5
MS 700	3
MS 800	5
PA 100	1
PA 200	2
PA 300	10
PA 400	4
PA 500	12
RC 100	1
RC 400	3
RC 500	4
RC 600	1
RO 424	3