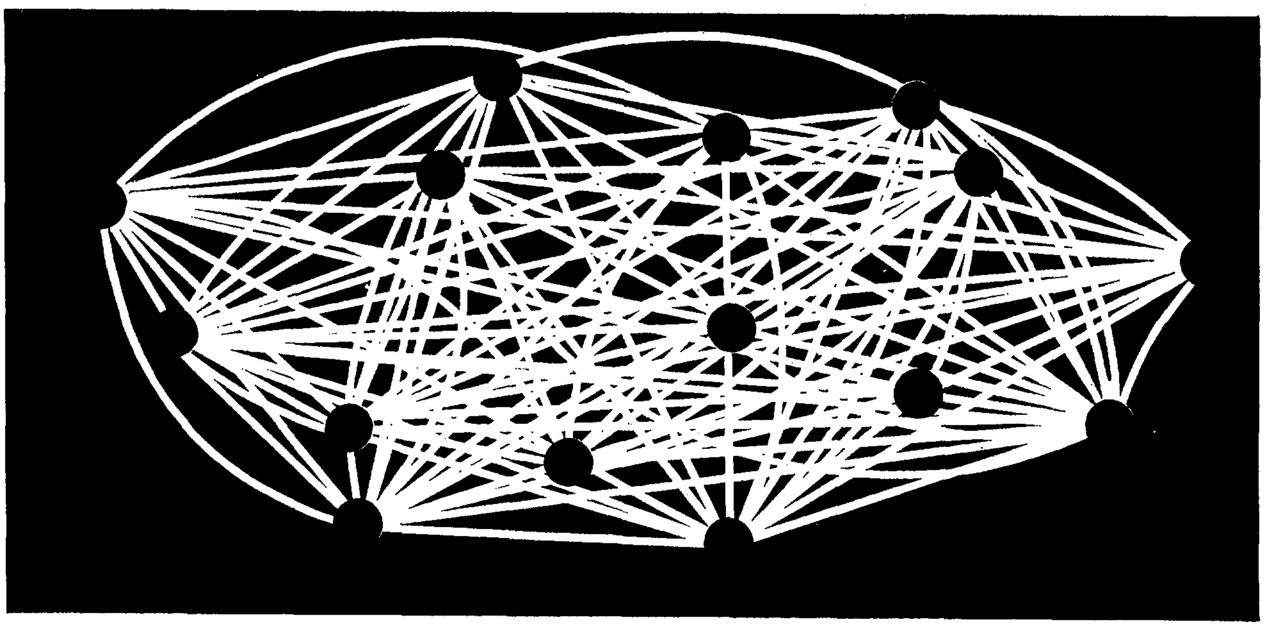
XIV-1

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland Phone (301) 982-4955-56-57 After Hours 474-9000
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BACKGROUND



THE MANNED SPACE FLIGHT NETWORK FOR APOLLO

August, 1968

MSFN - THE APOLLO GROUND NETWORK

The Apollo network, currently consisting of fourteen ground stations, four instrumented ships and eight instrumented aircraft, provides the data link between the manned spacecraft and the control center. The network was developed by the Goddard Space Flight Center under the overall direction of the Associate Administrator for Tracking and Data Acquisition, NASA Headquarters, to meet requirements of the Office of Manned Space Flight (Headquarters) and the Manned Spacecraft Center, Houston, Texas.

Although the design of the Apollo network followed closely behind the modification of the Mercury network for the Gemini program, many site modifications were necessary to provide Apollo support due to the greater scope of the Apollo program. The Apollo program requires instrumentation for support of the S-I, S-II, S-IVB/IU, command Service Module (CSM), and Lunar Module (LM) stages. Support must also be provided at both orbital and lunar distances. Increased data processing capability was required for processing and displaying significantly Larger amounts of information. The ground network requires the capability of processing both Pulse Code Modulation (PCM) telemetry and command data for the CSM, LM, and S-IVB/IU.

MISSION CONTROL AND TRACKING

In support of Apollo, as in Gemini, the NASA Goddard Space Flight Center is responsible for the overall operation of the NASA Manned Space Flight Network (MSFN). For Apollo there will be fourteen land stations and four ships providing one or more of the following real time functions for flight control purposes:

1. telemetry reception and decommuntation,
2. tracking,
3. commanding, and
4. voice communications with the spacecraft.

In addition to the MSFN land stations and ships there are several network aircraft in each of the prime recovery areas to provide a voice relay between the spacecraft and MSFN during the landing phase.

MISSION CONTROL CENTER - HOUSTON (MCC-H)

The Mission Control Center at the Manned Spacecraft Center in Houston is the focal point for all Apollo flight control activities. In performing the control function, and dstermining the progress of the flight, the MCC-H receives tracking and telemetry data from the MSFN. This data is processed through the MCC-H Real Time Computer Complex (RTCC) and used to drive displays for the flight controllers and engineers in the Mission Operations Control Room and Staff Support rooms. In addition to receiving data from the tracking and telemetry systems, the MCC-H flight controllers are able to obtain verbal information concerning the flight by talking to the astronauts via the voice relay facilities at the sites. Real time spacecraft television will be received at the MCC-H from the network's MILA (Merritt Island Launch Area) site at Cape Kennedy & Corpus Christi, Tex.

NETWORK SUPPORT TEAM

The team mans the various communications positions at the Manned Space Flight Operations Center (MSFNOC). The NST is comprised of technical and operational personnel required by the Network Director, Network Operations Manager (NOM) and the Network Controller (NC) to operate the MSFNOC, assist in controlling the MSFN, and coordinating its activities.

The NST is responsible to ensure that all MSFN communications is coordinated in a business-like manner. The team provides the Network Operations Manager and/or Network Controller with the necessary technical assistance required to effectively control and coordinate the MSFN and its activities. The NST is also responsible for communicating with external facilities for assistance not available in-house.

NASCOM NETWORK FACILITIES

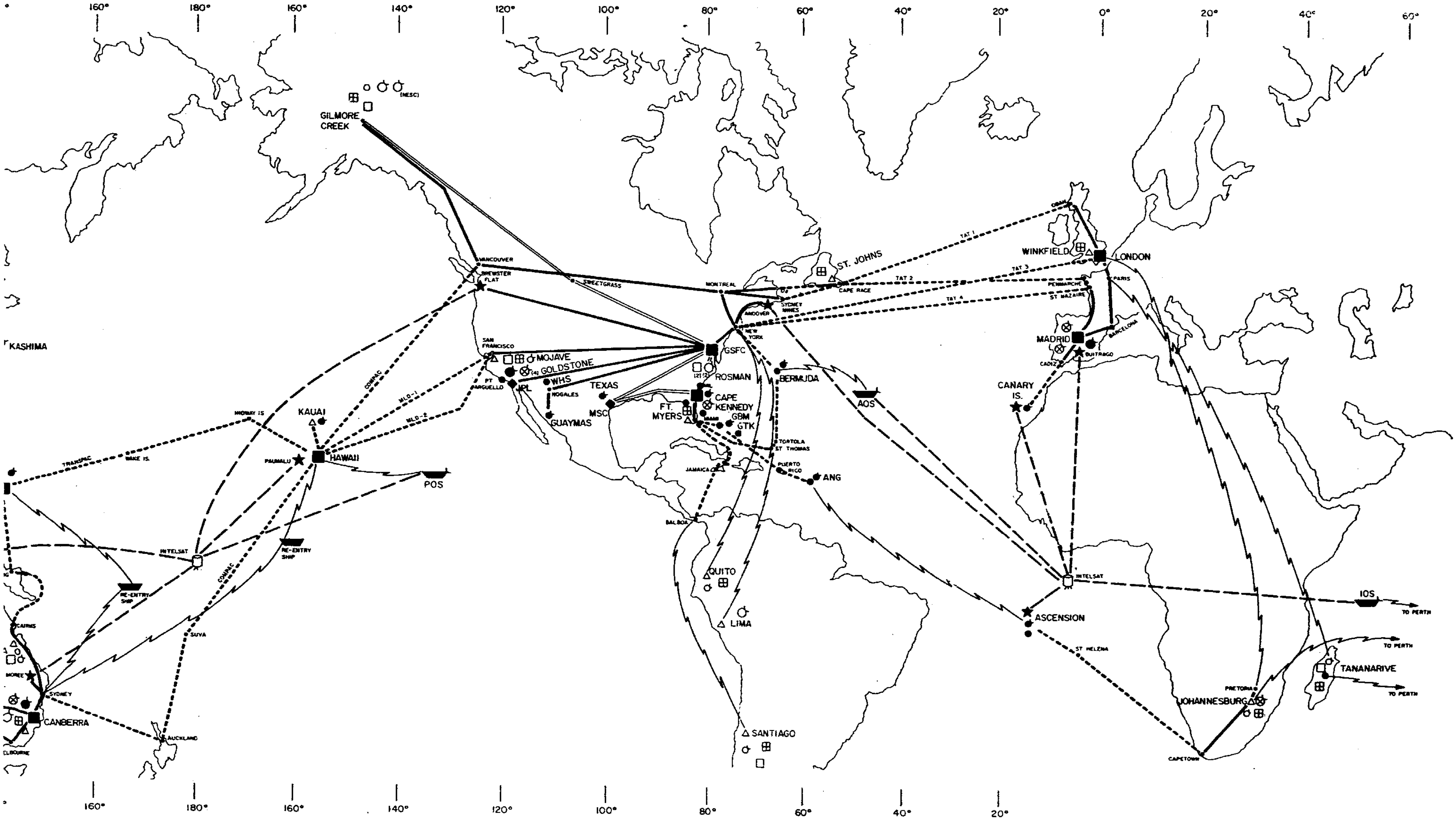
The NASCOM network consists of several systems of diversely routed communications channels leased from various domestic and foreign communications common carriers on a worldwide basis. These channels are leased in landlines, submarine cables, and communications satellites wherever available, and in hf radio .facilities where necessary to provide the access links.

The system consists of both narrow and wideband channels, and some TV channels. Included are a variety of telegraph, voice, and data systems (digital and analog) with a wide range of digital data rates. Wideband and TV systems do not presently extend overseas. To the extent possible, channels are diversified on routes available to minimize system degradation in the event of communications outages, and in instances where necessary, alternate routes or redundancy is provided to meet reliability criteria for critical mission operations.

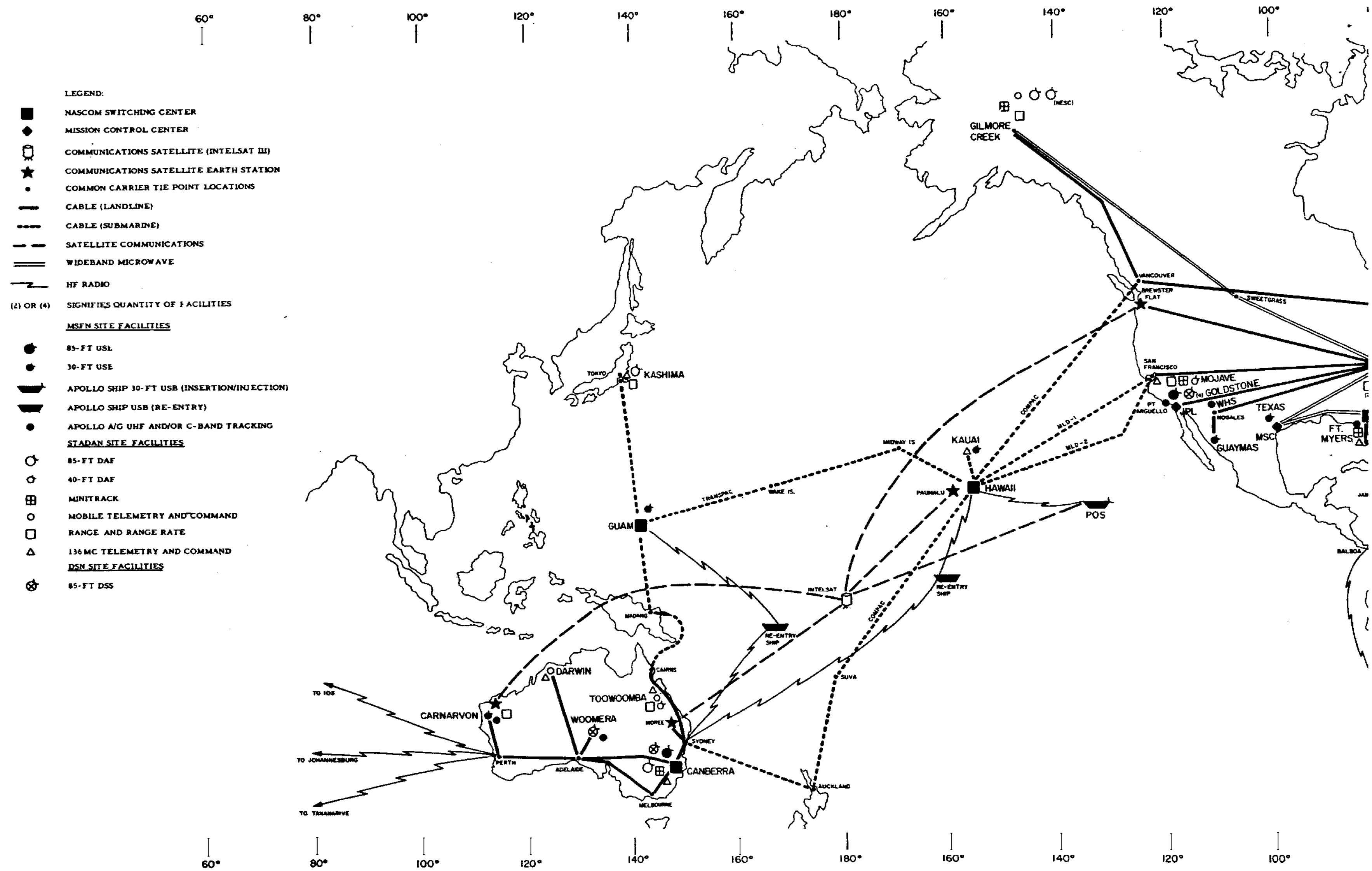
A primary switching center and intermediate switching and control points are established to provide centralized facility and technical control, and switching operations under direct NASA control. The primary switching center is at GSFC, Greenbelt, Maryland, and intermediate switching centers are located at Canberra, Madrid, London, Honolulu, Guam, and Cape Kennedy.

Attached map illustrates approximate geographic locations and ident'ifies the type of long-haul common carrier facilities; important cable and communications satellite tie points used on the major portion of the NASCOM network.

) LAUNCH/ORBITAL NASCOM NETWORK



APOLLO LAUNCH/ORBITAL NASCOM NETWORK

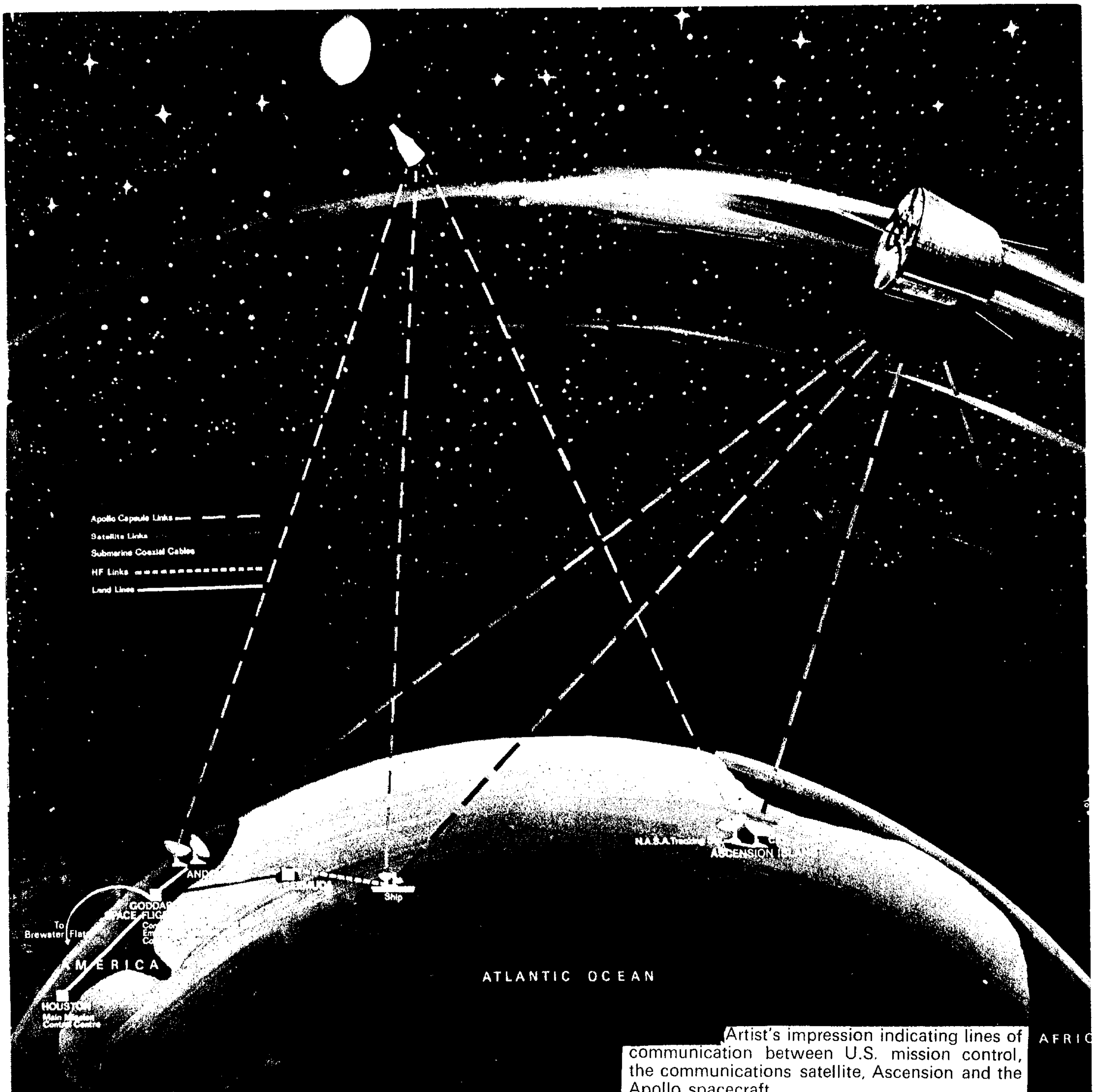


For a typical Apollo launch, Cape Kennedy is connected directly to the Mission Control Center, Houston, by NASCOM's Apollo Launch Data System, a combination of data gathering and transmission systems designed to handle launch data exclusively. A high speed data (2400 bit per second) line connects the Cape to Goddard. At Goddard the transmission rate is increased to 40,800 per second rate from there to Houston.

Once launch is achieved, all network and tracking data is directed to the Mission Control Center, Houston, through Goddard. Upon orbital insertion, tracking responsibility is transferred between the various stations as the spacecraft circles the earth.

There are two Apollo (Intelsat) communications satellites. One is positioned over the Atlantic Ocean in an equatorial orbit varying approximately six degrees between North and South latitude and six deyrees West longitude. The Atlantic satellite will service the Apollo Indian Ocean ship, Ascension Island USB station, the Atlantic Ocean ship, and the Canary Island site.

Only two of these four stations will be transmitting information back to Goddard at any one time; however, all four stations will have the capability of receiving information at



Artist's impression indicating lines of communication between U.S. mission control, the communications satellite, Ascension and the Apollo spacecraft.

all times. During launch, for example, the NASCOM connects with the Apollo Atlantic Ocean ship or will shift to the Ascension Island USB site. For the next revolution, Canary Island and the Indian Ocean ship, or some suitable combination is arranged to achieve the best coverage. During these events, realtime communications (no delay) switching is required.

The second Apollo COMSAT is located at approximately 170 degrees east longitude over the Mid-Pacific near the inter-section of the equator and the international dateline. It will service the Carnarvon, West Australian USB site and the Pacific Ocean ship. Both of these stations will be able to transmit simultaneously through the satellite to Houston via Brewster Flat, Washington, and the Goddard Space Flight Center.

Thirty-nine (UNIVAC 642B) Computers, key components in the globe-encompassing NASCOM network, accept records, and - in critical cases - transmits data originating from the spacecraft ("down" data), computes and transmits commands to the Apollo capsule ("up" data).

A great many more peripheral devices - magnetic tape units, input/output consoles, Teletypewriters, keyboard units, etc. - are included in the "NASCOM" (NASA Communications Net-work).

COMPUTERS AT WORK

At fraction-of-a-second intervals, the network's digital data processing systems, with NASA's Manned Spacecraft Center at Houston, Texas, as the focal point, "talk" to each other or to the astronauts in real-time (without noticeable time loss). High speed computers at the remote sites (tracking ships included) issue commands or "up" data on such matters as control of cabin pressure, orbital guidance commands, or "go-no-go" indications to perform certain functions.

In the case of information originating from Houston, the computers refer to their pre-programmed information for validity before transmitting the required data to the capsule.

Such "up" information is communicated by ultra-high frequency radio at **a** rate of about *2,000 bits per second. communication between remote ground sites, via high-speed communications links, occurs at about the same rate. Houston reads information from these ground sites at a rate of 2,000 bits per second, as well as from remote sites at about 100 words per minute.

The computer systems perform many other functions, including:

.Assuring the quality of the transmission lines by

---

* Four bits equal one digit (Binary 1-9). According to pre-arranged data format, any variation of *600* digits/sec of information may be moved.

continually exercising data paths.

*Verifying accuracy of the messages by redundant (repetitive) operations.

'Constantly updating the flight status.

In the case of "down" data, sensors built into the spacecraft continually sample cabin temperature, altitude of the capsule, or such physical traits of the astronauts as heart beat and respiration. Such data is transmitted to the ground stations at a rate of 51.2 kilobits (12,800 binary digits) per second.

The computers will then:

'Detect and select changes or deviations, compare with their stored programs, and generate the problem areas or pertinent data *to* the *flight* controllers.

'Provide continual display to cognizant personnel.

'Assemble output data in proper formats.

·Log data on magnetic tape for replay.

-Provide storage for "on-call" display for the flight controllers.

'Keep time.

Twelve land stations are outfitted with computer systems to relay telemetry and command information between Houston and Apollo spacecraft: Canberra, Australia: Guam; Kauai, Hawaii; Goldstone, California: Corpus Christie, Texas; Cape Kennedy: Grand Bahama Island: Bermuda; Madrid, Spain: Antigua; Grand Canary Island; and Ascension Island.

At various stages both USB and VHF telemetry links are required. To provide support for the Apollo program, many significant changes have been made to the network systems:

1. Unified S-Band system combines the functions of acquisition, telemetry, command, voice, and tracking on one radio link. The use of this system increases the data processing task, but reduces the number of required antenna mounts, transmitters; receivers, etc.

2. Stored program PCM telemetry decommutators were installed to provide increased data handling capability and flexibility.

3. Computer-driven (alpha numeric) displays were selected to provide a greater operational and decision-making capability to flight directors. This system permits the display of printed information and charts of real-time data on a cathode ray tube.

4. A general purpose data processing system utilizing Univac 642B computers is provided at each site to drive displays, process telemetry, command and teletype data and to select and format data for transmission to the Houston, Texas control center. This system processes and stores command data received from the control center for delayed transmission to the spacecraft. The data processing system at each site is connected to the Houston center by high speed data circuits. This feature provides the control center with the capability of remotely changing data parameters being transmitted to the control center and the capability of remotely up-linking data to the spacecraft.

5. Other miscellaneous systems added to the network for Apollo support include: TV monitors, high speed printers, stored program PCM simulators, VHF predetection (diversity combining) receivers and wide band recorders.

Maximum flexibility, through modularity of design, and high reliability, through selected systems redundancy and the use of solid state circuitry were considered important factors in the design of network equipment.

Planned redundancy was provided in systems design to improve reliability. Expansion and rapid configuration capabilities were also designed into the major equipment. Most modifications to the network due to differences in mission profiles can be made by software change rather than hardware modifications. Programmable units include the computers, PCM decommutators, console computer interface adapter, and the display system. Flexibility of design in network systems will enable the network to support a great variety of future missions.

APOLLO TV SYSTEM

The Apollo television link as currently planned will serve a twofold purpose. First, it will permit visual observation and confirmation of astronaut activities by ground control: secondly, it will enable selected portions of these televised activities to be distributed to the commercial networks for public viewing, pending release approval by NASA.

The television signals are transmitted from the spacecraft in the Apollo slow scan format, are received at the USB stations and then recorded on magnetic tape. The MILA (Merritt Island Launch Area) and TEXAS (Corpus Christi) sites are equipped with slow scan converters to render it compatible with commercial TV requirements. The signal is then transmitted in real time to the MCC.

THE APOLLO SHIPS

The Manned Space Flight Network (MSFN) has four floating sites. Called the Apollo Instrumentation Ships (AIS), these sites are integral parts of the MSFN, equally important to mission success, and more dynamically equipped than some land stations.

The Apollo space vehicle will be launched on a launch azimuth between 72 and 108 degrees from Cape Kennedy.

There is a point over the earth, fixed with respect to the center of the earth and the center of the moon, at which the spacecraft must be injected into its trajectory to the moon. Since the earth is rotating on its axis under this point in space, the required launch azimuth varies with the time of day and month. On any given day, the launch window (that is, the time interval during which an acceptable launch can be made) should be at least 2-1/2 hours in length; thus, the required launch azimuth may vary over a sector bounded roughly by Bermuda on the north and Antigua on the south.

After the lower (booster) stages of the Saturn have burned out and dropped off, the first powered phase of the S-IVB upper stage "inserts" the Apollo into an earth orbit, known as a parking orbit, at approximately 100 miles altitude. This "insertion" maneuver is one of the crucial phases which must be covered by a tracking station, and since it will occur over the broad ocean area between Bermuda and Antigua, a tracking ship is required to fill the gap not covered by either of these two land stations. This ship must be able to track for an interval of at least three minutes in order to determine the suitability of the orbit for the later injection into translunar trajectory.

Three existing T-2 tanker type hulls were converted for Apollo spacecraft insertion/injection coverage and one C-2 victory ship for earth atmosphere re-entry. Instrumentation requirements for the re-entry ship are less demanding than for the insertion/injection ships, therefore, equipment and other comparable items differ.

Along with surface stations and aircraft, these ships will serve as links in the Manned Space Flight Network (MSFN) chain between the Apollo spacecraft and the Manned. Space Flight Control Center (MCC-H), Houston, Texas.

These ships include Apollo support instrumentation for space data acquisition, communications, tracking, in-flight checkout, command control, telemetry reception, data accumulation, processing, display, and retransmission.

These ships participate in the following mission phases:

* Coverage of selected areas to maintain contact with the spacecraft during critical phases of the mission, including periods before, during, and subsequent to any crucial decision on the conduct of the mission.

* Insertion of the spacecraft into a near-earth parking orbit after lift-off, supplementing the land stations with one Atlantic Ocean ship.

* Parking orbit in-flight checkout to assure spacecraft readiness for lunar trajectory injection, supplementing ground station coverage.

* Post-injection of the spacecraft into lunar trajectory from a parking orbit until land station coverage, of the lunar trajectory is reached (Indian and Pacific Oceans are to be covered by one ship each).

* Re-entry using one ship in Pacific Ocean which can make contact before spacecraft return into the earth's atmosphere, and cover spacecraft "skip out" to attain final re-entry coverage.

The ships are operated as an independent unit by civilian Military Sea Transport (MSTS) crews. The instrumentation is operated and maintained by civilian technical crews. These technical crews are trained to NASA specifications and standards, and will operate in accordance with NASA specified procedures in operation, calibration, check-out, maintenance, failure-reporting and modifications control. Goddard is responsible for certifying the mission readiness of these ships as elements of the NASA/MSFN.

During the flight in parking orbit, a complete check-out of the Apollo spacecraft and the S-IVB stage will be accomplished by ships and land stations to assure its readiness for the next powered flight phase, the injection into a lunar trajectory, This checkout is in effect an in-orbit countdown, with telemetry data being transmitted to the ground stations for examination and decisions.

The parking orbit phase will last at least one-half an orbit, and perhaps as long as three orbits, at the end of which the S-IVB engines will be re-ignited to develop the thrust required for injection into the lunar trajectory. Tracking of the spacecraft is required in order to make a go-no-go decision on the mission. This tracking must begin shortly after injection and continue for approximately 75 minutes to provide trajectory data to the degree of accuracy for this decision.

Since the injection phase of flight may occur anywhere over that portion of the earth subtended by the path of three parking orbits (with launch azimuth as determined by the time of the launch), the MSFN has been planned to assure the required coverage for tracking and communication. This requires two tracking ships to fill in gaps between land stations in the network. One of these will be in the Wester'n Indian Ocean, the other in the Western Pacific

Ocean. With this coverage, the ground network will impose minimum restraints on launch opportunities for lunar mission. Tracking and communication coverage during the lunar phase of the mission will be accomplished through the 85-foot deep space antennas of the Apollo network and will impose no additional requirements on instrumentation ships.

During the return flight to earth, the Apollo spacecraft will execute the trajectory corrections needed to attain the proper path for re-entry. Just before re-entry, the service module which contains the engines for these corrections is jettisoned. Re-entry into the earth's. atmosphere is the next critical phase of flight for which tracking is mandatory. Re-entry will occur some 1,500 to 5,000 miles back from the landing area. Because the re-entry areas are located over the Western Pacific, one additional tracking ship is required to cover re-entry only. Since the requirement for this tracking is not as stringent as the insertion and injection tracking, the re-entry ship requires less instrumentation. Modifications to an existing ship.

APOLLO RANGE INSTRUMENTATION AIRCRAFT

The Apollo Range Instrumentation Aircraft (ARIA) are a group of eight EC-135A, four engine jet aircraft which are used to supplement land and ship stations in support of Apollo and other programs. Operating in conjunction with the NASCOM network, ARIA provides two-way voice relay between the spacecraft and MCC, receives and records telemetry (TLM) signals from the spacecraft, and transfers this TLM data to a ground station for relay to MCC. The aircraft have no capability for command, tracking, or real time remoting of TLM data.

These functions are performed by 7' steerable antenna, VHF, S-Band, HF/SSB receivers and transmitters, and recording and playback equipment. It can automatically track a target in P-Band or S-Band.

The ARIA is capable of receiving and recording nine links of TLM data in the P and S-Bands.

Transfer of TLM data to a ground station for relay to MCC may be accomplished if there is a MSFN station within range. Low power (0.5 watt) data transfer UHF and VHF transmitters with blade type antennas on the bottom of the aircraft are provided for this p'urpose. The aircraft must be within approximately 175 miles of the station to effect a transfer.

THE GSFC NETWORK TEST AND TRAINING FACILITY

A new engineering and training center (NTTF) has been established at the Goddard Space Flight Center, Greenbelt, Md., incorporating elements of engineering laboratories and training equipments to which the Apollo-unique equipment has been added. The facility is associated with programs of both the Apollo manned space flight and STADAN (Space Tracking and Data Acquisition) networks. Selected personnel are trained in classroom theory and actual remote site equipment for future duty at one of the worldwide sites and MCC-H Training equipment includes:

Unified S-Band (Apollo Unique)

Apollo operations (Apollo Unique)

communications

Telemetry

Teletype communications center

The Center's function forms an important foundation for NASA projects activity and network integrity. If the facility operates below normal efficiency, all stations ultimately suffer. Concentrated effort is therefore sustained toward maintaining competent staffing and a high order of instructional personnel.

Acronyms and Abbreviations

ACN	Ascension (USB Site)
AEM	APCU Entry Module
AFETR	Air Force Eastern Test Range
A/G	Air to Ground
AGS	Abort Guidance System
AGS	Apollo Guidance Simulator
ALDS	Apollo Launch Data System
ALTDS	Apollo Launch Trajectory Data Subsystem
AM	Amplitude Modulation
ANG	Antigua (USB Site)
ANT	Antigua (C-Band Site)
AOS	Acquisition of Signal
APCU	Apollo Process Control Unit
A REG	A Register
ARIA	Apollo Range ,Instrumentation Aircraft
ASC	Ascension (C-Band Site)
ASCA	Apollo Simulation Control Area
AS CATS	Apollo Simulation, Checkout and Training System
ASR	Automatic Send/Receive
ASRS	Apollo Simulated Remote Site
AVP	Address Verification Pulse
BAPB	Biomedical Analog Patch Board
BDA	Bermuda
BMDADS	Biomedical Data Analysis and Display System
CACC	Communications and Configuration Console
CAM	Computer Address Matrix
CAP	Command Analysis Pattern
CASTS	Countdown and Status Transmission System
CCATS	Communication, Command and Telemetry System
CCC	Command Computer Controller
CCIA	Console Computer Interface Adapter
CCMU	Computer Controller Multiplexer Unit
CDCIS	Computer Display Control Interface Subsystem
CDP	Central Data Processor
CDSC	Command Distribution Switching Center
CEF'	Computer Execute Function
CIM	Computer Input Multiplexer
CLAM	Command Load Acceptance Message
CLC	Command Load Controller
CLT	Communications Line Terminal
C/M	Communication Multiplexer
CMC	Command Module Computer
CMCC	Control Monitor and Control Console
CMD	Command
CMDR	Command Recovery
CP	Central Processor
CP	Communications Processor
CPU	Central Processing Unit

Acronyms and Abbreviations (Cont)

PDSDD	Plotting Displays Subchannel Data Distribution
PM	Phase Modulation
PR	Plotting Register
rf	Radio Frequency
RKV	Rose Knot Victor
R/R	Recorder/Reproducer
RS	Remote Site
RSCC	Remote Site Command Computer
RSDP	Remote Site Data Processor
RSTC	Remote Site Telemetry Computer
RTA	Real Time Accumulators
RTCC	Real Time Computer Complex
RTDL	Real Time Data Link
RTDR	Real Time Data Router
SALDS	Simulated Apollo Launch Data System
S/B	Switch Board
S/C	Space Craft
SCS	Standard Communications Subsystem
SCU	System Configuration Unit
SDD	Subchannel Data Distributor
SLV	Saturn Launch Vehicle
SMC	System Monitor Console
SMCVG	Simulated Memory Character Vector Generator
SMK	Summary Message Keyboard
SOM	Start of Message
SSCR	Select Source and Computer Recommendation
SSEU	System Selector Extension Unit
SSIA	Slow Speed Interface Adapter
SSR	Staff Support Room
TDDF	Telemetry Data Distribution Frame
TDP	Tracking Data Processor
TESAC	Telemetry Synchronizer and Serial to Parallel Converter
TICC	Telemetry Instrumentation Controllers Console
TIP	Telemetry Input Processor
TLM	Telemetry
TOB	Telemetry Output Buffer
TTY	Teletype
TUT	Telemetry User Table
UCS	Universal Command System
UDB	Updata Buffer
UHF	Ultra High Frequency
USB	Unified S-Band
VAL	Validated
VCO	Voltage Controlled Oscillator
V/D	Voice/Data
VER	Verification
VHF	Very High Frequency
WB	Wide Band
WWV-L	US Bureau Standards Time Station (Boulder, Colorado)

Acronyms and Abbreviations (Cont)

GSSC	Ground Support Simulation Computer
GTI	Grand Turk Island
HF/SSB	High Frequency/Single Side Band
HOSC	Huntsville Operation Support Center
HS	High Speed
HSA	High Speed Adapter
HSD	High Speed Data
HSK	Honeysuckle Creek (USB Station Canberra)
HSP	High Speed Printer
HSPB	High Speed Printer Buffer
HSTL	High Speed Telemetry Link
I/D	Identification
I/O	Input/Output
IP	Impact Predictor
IRIG	Interrange Instrumentation Group
IU	Instrument Unit
KSC	Kennedy Space Center
KSC/CIF	Kennedy Space Center/Central Instrumentation Facilities
KWRF	Kilowatt Radio Frequency
LADC	Logic & Data Converter
LGC	Lunar Guidance Computer
LIEF	Launch Information Exchange Facility
LM	Lunar Module
LOS	Loss of Signal
LS	Low Speed
LSB	Least' Significant Bit
LVDC	Launch Vehicle Digital Computer
MPA	Message Acceptance Pulse
MCC	Mission Control Center
MCVG	Memory Character Vector Generator
MDD	Multichannel Demultiplexer and Distributor
MED	Manual Entry Device
MIL	MILA (USB Site)
MILA	Merrit Island
MLA	Multiplexer Line Adapter
MOC	Mission Operational Computer
MOCR	Mission Operations Control Room
MSB	Most Significant Hit
MSFC	Marshall Space Flight Center
MSFN	Manned Spaceflight Network
MSK	Manual Select Keyboard
MSS	Most Significant Syllable
MTU	Magnetic Tape Unit
NASCOM	NASA Communications
NONVAL	Non Validated
PBI	Push Button Indicator
PBT	Polynomial Buffer Terminal
PCK	Phase Control Keyboard
PCM	Pulse Code Modulation
PDM	Pulse Duration Modulation

Acronyms and Abbreviations (Cont)

PDSDD	Plotting Displays Subchannel Data Distribution
PM	Phase Modulation
PR	Plotting Register
rf	Radio Frequency
RKV	Rose Knot Victor
R/R	Recorder/Reproducer
RS	Remote Site
RSCC	Remote Site Command Computer
RSDP	Remote Site Data Processor
RSTC	Remote Site Telemetry Computer
RTA	Real Time Accumulators
RTCC	Real Time Computer Complex
RTDL	Real Time Data Link
RTDR	Real Time Data Router
SALDS	Simulated Apollo Launch Data System
S/B	Switch Board
S/C	Space Craft
SCS	Standard Communications Subsystem
SCU	System Configuration Unit
SDD	Subchannel Data Distributor
SLV	Saturn Launch Vehicle
SMC	System Monitor Console
SMCVG	Simulated Memory Character Vector Generator
SMK	Summary Message Keyboard
SOM	Start of Message,
SSCR	Select Source and Computer Recommendation
SSEU	System Selector Extension Unit
SSIA	Slow Speed Interface Adapter
SSR	Staff Support Room
TDDF	Telemetry Data Distribution Frame
TDP	Tracking Data Processor
TESAC	Telemetry' Synchronizer and Serial to Parallel Converter
TICC	Telemetry Instrumentation Controllers Console
TIP	Telemetry Input Processor
TLM	Telemetry
TOB	Telemetry Output Buffer
TTY	Teletype
TUT	Telemetry User Table
UCS	Universal Command System
UDB	Updata Buffer
UHF	Ultra High Frequency
USB	Unified S-Band
VAL	Validated
VCO	Voltage Controlled Oscillator
V/D	Voice/Data
VER	Verification
VHF	Very High Frequency
WB	Wide Band
WWV-L	US Bureau Standards Time Station (Boulder, Colorado)