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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AS-508
MCC/MSFN
MISSION CONFIGURATION/
SYSTEM DESCRIPTION

MARCH 1970

Prepared by: FLIGHT SUPPORT DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

APOLLO

MCC/MSFN MISSION CONFIGURATION

COMMAND COMMUNICATION TELEMETRY TRACKING

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FEBRUARY, 1970

February 2012 Publication Note

The AS-508 MCC/MSFN Mission Configuration/System Description was issued shortly before the launch of Apollo 13. It provides a detailed description of the interface between stations of the Manned Space Flight Network and the Apollo Mission Control Center in Houston, Texas. It provided reference material for those who need additional information about the communication and data flow between the MCC and the Apollo spacecraft. It was published in March of 1970 by NASA. The original document was provided by George Ojalehto who was a Johnson Space Center Network Controller during the Apollo missions.

This PDF version was produced by Bill Wood. The original pages were scanned with an Epson Expression 10000XL, using SilverFast AI Studio, to produce high quality 600 pixel per inch, 48-bit images, for further processing. Each page image was straightened and cleaned up in Photoshop CS5.1 prior to producing 600 pixel-per-inch EPS page images. Adobe Acrobat 10 Professional was used to prepare the final PDF edition. The document is made searchable by using Adobe ClearScan.

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PREFACE

This document is intended as a convenient reference for those that require a knowledge of how the Manned Space Flight Network and the Mission Control Center are configured for the main line Apollo missions. Included are explanations of the command, communications, telemetry, biomedical, television, and tracking systems data flow. This is accomplished by describing the operation of both software and hardware systems that are required to support these systems. Also included is a description of the MCC Simulation System.

Due to the complexity of the main line Apollo missions, the Apollo Lunar Surface Experiment Package will be described in the ALSEP Mission Configuration/System Description document. Comments and questions concerning this, the Apollo MCC/MSFN Configuration/System Description document, are solicited and should be directed to Mr. E. H. Clark of the Data Systems Integration Section at 713-483-2603.

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1.0 Apollo Universal Command System (UCS)

The UCS is designed to support all missions under project Apollo. The system provides a means of transmitting data and other essential information required for command purposes by standardizing most of the interfaces and allowing only mission specific contents to vary. It is also used for transmitting data between ground computers in the Manned Space Flight Network (MSFN) and the Mission Control Center (MCC).

The UCS is a relatively small portion of the overall communication system interlinked to form a closed loop between the MCC and the receiving vehicles. The system is composed of four basic units; (1) MCC in Houston, Texas; (2) Goddard Space Flight Center (GSFC) in Greenbelt, Maryland; (3) command sites in the MSFN, and (4) receiving vehicles.

All command information is initiated by the Flight Controllers at MCC utilizing the RTCC and CCATS computers or voice request to the M&O. This information may be Command Loads, Execute Command Requests (ECR's), or Computer Execute Functions (CEF's). A command load is information generated for use by the onboard computer. An ECR contains instructions sent to the remote site directing the transmission of command load or realtime command information to the receiving vehicle. The CEF contains instructions sent to the remote site directing a certain function to be performed by the Remote Site Command Computer (RSCC), such as command history requests, etc. In order to describe the UCS in detail, it is desirabel to consider how each of the three types of command information flows through the command system. First, consider command loads generated in the RTCC and transferred to the site via CCATS and GSFC.

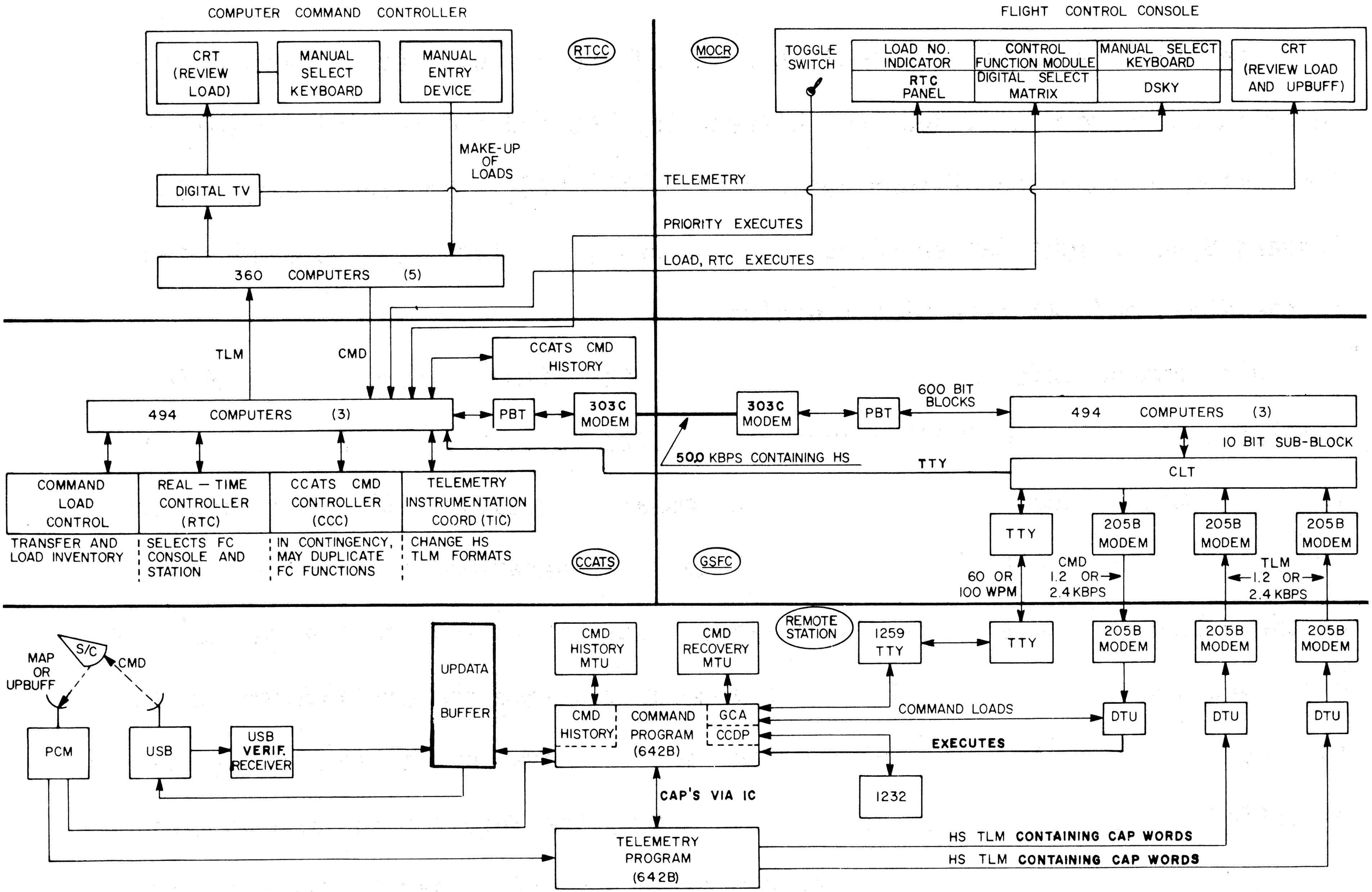

FIGURE 1: Command Data Flow

1.1 RTCC-to-CCATS Command Load Routing

The RTCC generated command load data is based upon information supplied via manual entry by the Computer Command Controller (CCC) and received from the Flight Controller (FC).

When the FC requests a command load to be generated, he will specify the primary site and backup site if desired to which the load is to be sent, the type of load, and any other details that the CCC will need for the generation of the load. The data transfer from the RTCC includes any additional quantities that are required for the TTY load message which is formulated in CCATS.

In the RTCC 360/75 computer system a separate makeup buffer is used for each vehicle. Each buffer being further subdivided into separate sections for each load. The requested load is made up in a section of the appropriate makeup buffer. After load generation is complete, a load-ready light will illuminate on the console to alert the CCC. The CCC and FC's review the load on their consoles CRT which is driven via Digital-to-TV Converters (D/TV).

If the FC approves the command load displayed, he requests the CCC to transfer the load to CCATS. In order to transfer the load it is placed in the transfer buffer (one per vehicle) and the CCC must make a manual entry via MED. Prior to transfer of the load parity bits are added and the data to be transferred is formatted into 18 36-bit words for output to the 2902 parallel to serial converter. Data is then transferred to the 360-75/494 adapter which separates each of these words into three 12-bit bytes, adds 15 externally specified index bits and three fill bits to each byte to form 54 30-bit words, and then transfers these 30-bit words in parallel to the Scanner Selectors.

The Scanner Selectors time-multiplex six adapters onto a single input/output channel for input to CCATS 494.

A Command Load Acceptance Message (CLAM) is returned to the RTCC for all loads validly received by CCATS from the RTCC and placed on output queues in CCATS. This message illumniates a light on the CC Console on the appropriate vehicle indicator module.

1.1.1 CCATS Load Processing

Upon receipt of load data from the RTCC, the CCATS input processor routines perform certain checks on the data and if no error exists a CLAM message will be initiated. If an error exists, or if the load input is unintelligible, an error message will be generated from output on the Command Load Controller (CLC) high speed printer indicating the nature of the error and the load message will be discarded.

Once load input requirements have been satisfied, the content of the input buffer is transferred to the High Speed Output Routine (HSOR). The HSOR converts the input data into load data subblocks 60 bits in length where 30 bits are data, 27 bits are Polynominal Error Protection (PEP) code and three bits are fill. This data is then placed in the HSD output buffer. Prior to transmission from CCATS, the load subblocks are inserted into a 600-bit NASCOM segment which contains a 33-bit error code. This code is used to error protect the data transfer between the CCATS and GSFC.

The NASCOM segment (2) are output through the PBT into the switching matrix which causes the PBT's to time share its single input/output channel into a 303C modem which places the NASCOM segment on the 50.0 wide band data lines to GSFC. The high speed load is outputted at one- and five-second intervals. Receipt of a load validation/nonvalidation Command Analysis Pattern (CAP)** will stop the load in transmission at the end of the load block (two blocks of data comprise one iteration). If a load was not validated and is still on output queue, then the entire sequence may be manually restarted by the CCATS CLC.

At the same time the HSD load is transmitted, the command program outputs a Baudot-coded TTY load message, if this function is not inhibited. The TTY load message will consist of a standard header, load number, data word count, verb XX for CSM/LM sector, line ID's ET data, two iterations of the load data, and RSCC codes. TTY load message are transferred from CCATS to a low speed CLT (100 words per minute TTY circuit) which outputs the message one time to GSFC via TTY lines.

1.2 Goddard Space Flight Center

The GSFC receives the high speed 600-bit block via the NASA Communication (NASCOM) system wide band data lines from MCC. The 600-bit block enters the 303C data modem which routes the command message to a Polynomial Buffer Terminal (PBT). The PBT checks the 33 bits of polynomial error protection of the 600-bit block and if no data error exists, the PBT strips the polynomial and transfers the data to the GSFC 494 Communications Processor (CP) computer.

The GSFC CP checks the source, destination, and data format codes and reformats (strips header and trailer subblocks, and any subblocks containing only octal 40 fill) the data for output on the 1.2/2.4 kbps link to the appropriate site.

**VAL may be PERM VAL or NONVAL or TEMP VAL or NORMAL CAP

This reformatting consists of adding two 8-bit DTU Sync Words, one 8-bit SOM word and one 8-bit LOC word following the data, and adding one 10-bit EOM word following the data. The CP outputs the command data message in 10-bit parallel bytes to the CLT. The serial output of the CLT is routed to a 205B modem which transmits the data in a serial stream via 1.2/2/4 kbps link to the Remote Site, or Switching center. The TTY backup message is processed through the TTY transfer switch into the low speed/high speed (LS/HS CLT and thence through the multiplexer and 494 for routing back through the CLT to the proper remote site.

1.3 Remote Site Load Processing

The serial 10-bit subblocks received by the 205B data modems at the remote site is transferred to the DTU. The DTU synchronizes on the sync words, determines byte rate (8 or10-bit) by the LOC, and converts the serial input received by the data modem to a parallel output to the RSCC.

The RSCC performs a gross check on the incoming data and if the incoming data passes the gross checks, more detailed checks are made of the data and a CAP is then generated for transmission to the MCC to notify FC that all inputs were accepted and validated or nonvalidated.

These CAP VAL/NONVAL messages are generated for all loads received and accepted by the RSCC. The HSD CAP is then transferred to the RSCC into the RSTC and sent to CCATS via TLM HSD formats in three consecutive TLM frames. If a load block is received containing polynomial coding errors, it will be flagged and the RSCC will wait for the next transfer of the command load.

If a valid permanent Load VAL is not recognized by CCATS, then the load may be retransmitted to the RSCC from MCC or the Maintenance and Operation (M&O) Supervisor may be directed to load the TTY load tape into the RSCC. The TTY tape is manually loaded in the computer through the 1232 I/O Optical Reader or the 1259 TTY system. The TTY load message is then decoded for validity. If the decoding indicates that the TTY message is valid, a check is made to determine if a valid load has already been received via the high speed data lines and stored in the RSCC. If a valid load has been stored the program will type out the TTY image and discard the TTY message. If a valid load has not been stored, the program will load the TTY message into the TTY storage area and provide a HS printout. If the decoding of the TTY data is invalid, an error message identifying the error is printed out on the High Speed Printer (HSP).

1.3.1 Remote Site Storage of Command Loads

Valid high speed and TTY converted loads are stored in the RSCC Generalized Core Area (GCA). Loads stored in GCA are classed as permanent or temporary. Only one temporary load may be stored in GCA at any one time. A maximum of 60 loads may be placed in GCA at any one time (load type 60, GMTLO update, is not considered in this total as it is not stored in GCA, but transferred to the RSTC through the intercomputer channel after receipt and validation). Under the UCS concept, more than one load of a given type may be stored simultaneously. The only restriction to this concept is that two loads having the same sequence number cannot be stored simultaneously (e.g., 1201, 1202, 1203 may be stored simultaneously, but not 1201 and 1201).

Control of temporary and permanent storage is accomplished by the Load Enable/Load Disable function of the RSCC and is activated via CMD Computer Address Matrix (CAM) entry. If a load is received by the RSCC and the load disable mode is active and no load resides in GCA as temporary and no load exists in GCA with the same load type/sequence number and the load passes all other RSCC input checks, the received load will be placed in GCA and flagges as temporary and a valid temporary CAP transmitted to MCC. If a CMD CAM entry is made which switches the mode from Load Disable to Load Enable, then the temporary flag is removed and the load is classed as permanently stored in GCA and a permanent validation CAP is transmitted to MCC. If a load is received by the RSCC and passes all input checks with the Load Enable mode active, then the load is placed in the GCA and classes as permanently stored.

NOTE: A load stored and flagged as temporary is not available for uplink to a vehicle upon receipt of an execute request from MCC or on site CMD CAM request.

Command loads stored permanently in GCA are also recorded by the 1540 Magnetic Tape Unit (MTU) at the remote site. If a command load should become invalid for any reason after permanently stored, it may be recovered from tape. The MTU will retrieve, check, delete parity, and reassemble the data upon request, into computer sized words and transfer the data to the RSCC program.

1.3.2 Execute Command Request/Computer Execute Functions from MCC

ECR's and CEF's originate from CIM inputs representing PBI's on command modules or toggle switches on toggle modules in the MCC's Missions Operations Control Room (MOCR) or via inputs representing PBI depressions from the Command

Support Control Console (CSCC) in the CCATS support area.*

The PBI contact closures are converted to digital words by the Computer Input Multiplexer (CIM). The CIM output word identifies, by scan address and PBI count, the input source and the logical function to perform by the CCATS command program. The CCATS command program then formats the RS ECR or RS CEF into a 60-bit subblock. The 60-bit subblock is then formatted into the 600-bit NASCOM format and transmitted via 50.0 kbps (WBD) lines to GSFC where it is reformatted into a 10-bit HSD subblock for output to the remote site via the 1.2/ or 2.4 link.

The RS command program performs gross checks on the input words, determines the validity of the input, and generates, if valid, a CAP VAL for the execute received. If the input request is accepted, but is invalid, the request will be discarded and the proper routines are activated in the RSCC to generate a CAP NONVAL for execute received. If the valid input was a CEF, then the RSCC performs the function requested by activating the proper routines and providing the required outputs. After the UDB subprogram has been flagged, in the case of uplink execute requests, the command to be uplinked (that is located in the RSCC storage) is called up and formatted for uplinking to the vehicle for which the command or commands were requested.

For CSM or LGC load uplinks, the RSCC takes the 5-bit keycoded data word (K), adds the complement of each bit in K ($\overline{K}$) and then adds K again to yield $K\overline{K}K$. To this, a vehicle address, system address and sync bit are prefixed thus forming the complete command data word. Then, each of the binary bits

*Uplink execute requests and computer function requests may also be initiated on site via the CMD Computer Address Matrix entry.

of the command data word are subbit encoded.* After the command word has been subbit encoded, the entire word will be output from the RSCC to the UDB, 25 subbits at a time. On each transfer from the RSCC to the UDB logic is inserted five control bits, thus making the RSCC output to the UDB modem a 30-bit word. The UDB samples the 25 data bits and enters it into the A register (A REG) in parallel for storage and subsequent transmission. Prior to transmission, the UDB control bits determine the Radio Frequency (RF) carrier, which may be either the Unified S-band (USB) or Ultra High Frequency (UHF). The output of the UDB A REG is transmitted serially through the 1and 2KC PSK subsystem which then Frequency Modulates (FM) a 70KC subcarrier oscillator which in turn Phase Modulates (PM) the baseband carrier to the receiving vehicle. If the vehicle is CSM, the following number of subbits will be transmitted for each word specified:

- Command Module Computers (CMC) words - 110 subbits
- Real Time Command (RTC) words - 60 subbits
- Test Words - 150 subbits
- Central Timing Equipment (CTE) words - 150 subbits

If the vehicle is a LM, the following number of subbits will be transmitted for each word specified:

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*Subbit encoding is a process whereby each data bit is replaced by a specific 5-bit code. There is a unique 5-bit code for a logical "1" and a unique 5-bit code for a logical "0". The subbit code for the vehicle address is different from the subbit code for the system address and the remainder of the data bits. In order for the CSM vehicle to accept and adequately process the CMC word respectively, a 50 millisecond delay is provided between uplink words. Therefore, the transmission time of CMC words becomes 160 milliseconds.

- LM Guidance Computer (LGC) words - 110 subbits
- Real Time Command (RTC) words - 60 subbits
- Digital Command Assembly (DCA) test words - 110 subbits

If the vehicle is an S-IVB, the following number of subbits will be transmitted for each word specified:

- Launch Vehicle Digital Computer (LVDC) words - 175 subbits
- Real Time Command (RTC) words - 175 subbits

An RF loop check is made on the CMD system during uplink to ensure that the valid data is being uplinked. For example, on a CMC word uplink, the UDB subprogram takes the RF radiated information received via the monitor receiver, demodulates, decodes, checks subbit decoding, if unsucessful gives indication thereof by printing (HSP), and compares the rsulting 22 data bits against the original 22 data bits that existed prior to subbit encoding and transfer to the UDB. If this comparison is not correct and the MAP (see following Note) waiting period has elapsed during which no verification was received from the vehicle, the RSCC activates the proper routines to generate a Ground Reject CAP for transmission to MCC. In addition, the command transmission from the UDB is terminated. If no Ground Reject condition occurs and the vehicle returns the proper MAP for the command uplinked, the RSCC generates a VER CAP to be generated for transmission to the MCC.

NOTE: A MAP is downlinked from the CSM vehicle and Computer Reset Pulses (CRP's) are downlinked from the S-IVB vehicle to signify that the onboard receiver/decoder system has received a properly encoded command.

The TLM bit stream is received by the Pulse Code Modulation (PCM) telemetry subsystem and transferred to the RSCC. The RSCC processes the TLM data, selects the proper verification words (MAP, AVP, CRP), and verifies that the MAP or AVP/CRP structure is correct. If incorrect, a request to the UDB subprogram for retransmit of the uplinked command word is initiated provided the retransmission counter has not been exceeded. The counter for normal retransmittable commands is variable from 0-7; (for priorities the uplink count is unlimited). If the RSCC does not receive a valid MAP or AVP/CRP upon expiration of the retranscounter, the RSCC will generate a Spacecraft Reject CAP which is sent to MCC.

NOTE: For CSM and LM load uplinks spacecraft verification is determined by the RSCC in the form of comparison between load data in storage and data downlinked from the vehicle computer up-buffer via the downlink telemetry. If the comparison is valid, a pair of Comparison Error Messages are generated, but specific bits are configured within to indicate the reasons for an nonvalid comparison.

CAPS generated by the RSCC routines are transferred to the Remote Site Telemetry Computer (RSTC) via the Intercomputer Channel (IC). The RSTC places the CAP in the proper location in the TLM format and then forwards the data to the DTU which serializes the parallel data output of the RSTC. The DTU then transfers the CAP message to the 205B data modem. The DTU outputs the TLM data in 8-bit bytes, transmitting the least significant bit of the most significant syllable of the message first. Each CAP is then transmitted three times in successive telemetry frames at 1.2/or 2.4 kbps rate to GSFC which reformats the 8-bit serial data to the 600-bit NASCOM format and sends the data to the MCC via the 50.0 kbps (WBD) lines. If the CAP data is accepted for logic processing, VAL, VER, or REJ information is displayed on the MCC MOCR and/or CSCC command control module by the inllumination of a specific PBI or indicator which is driven by the CCATS Digital Display Driver (DDD) output. In addition, all recognizable incoming CAP messages received by CCATS Command are printed out on the high speed printer in the CCATS support area.

APOLLO COMMAND NETWORK CONFIGURATION

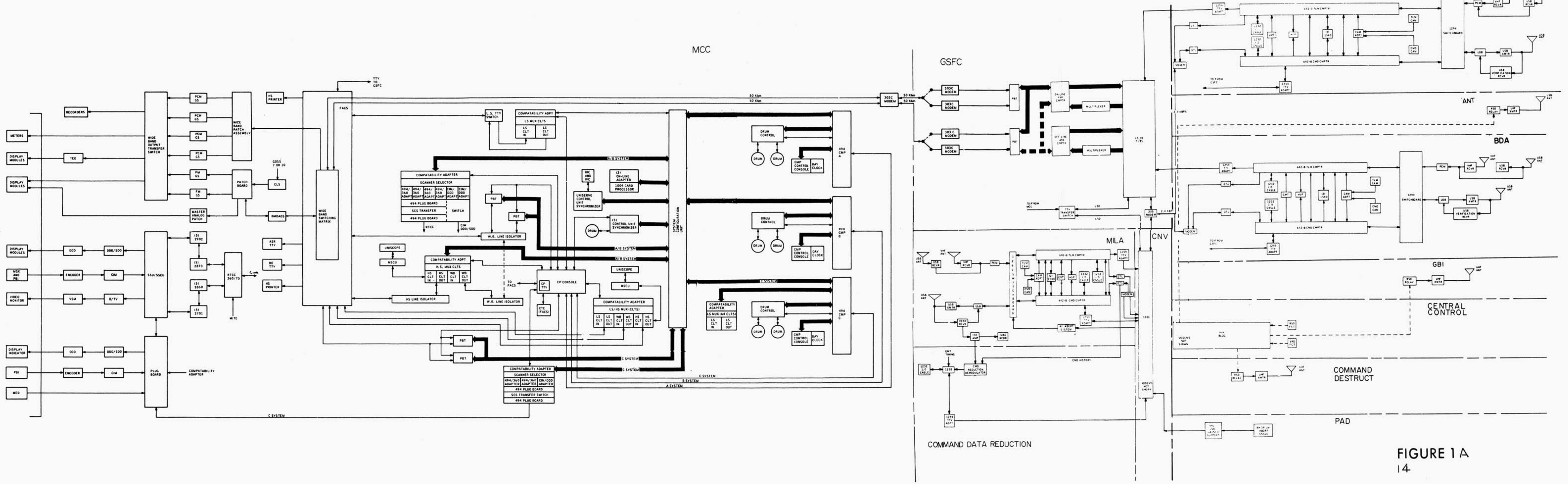


FIGURE 1A

APOLLO COMMAND NETWORK CONFIGURATION

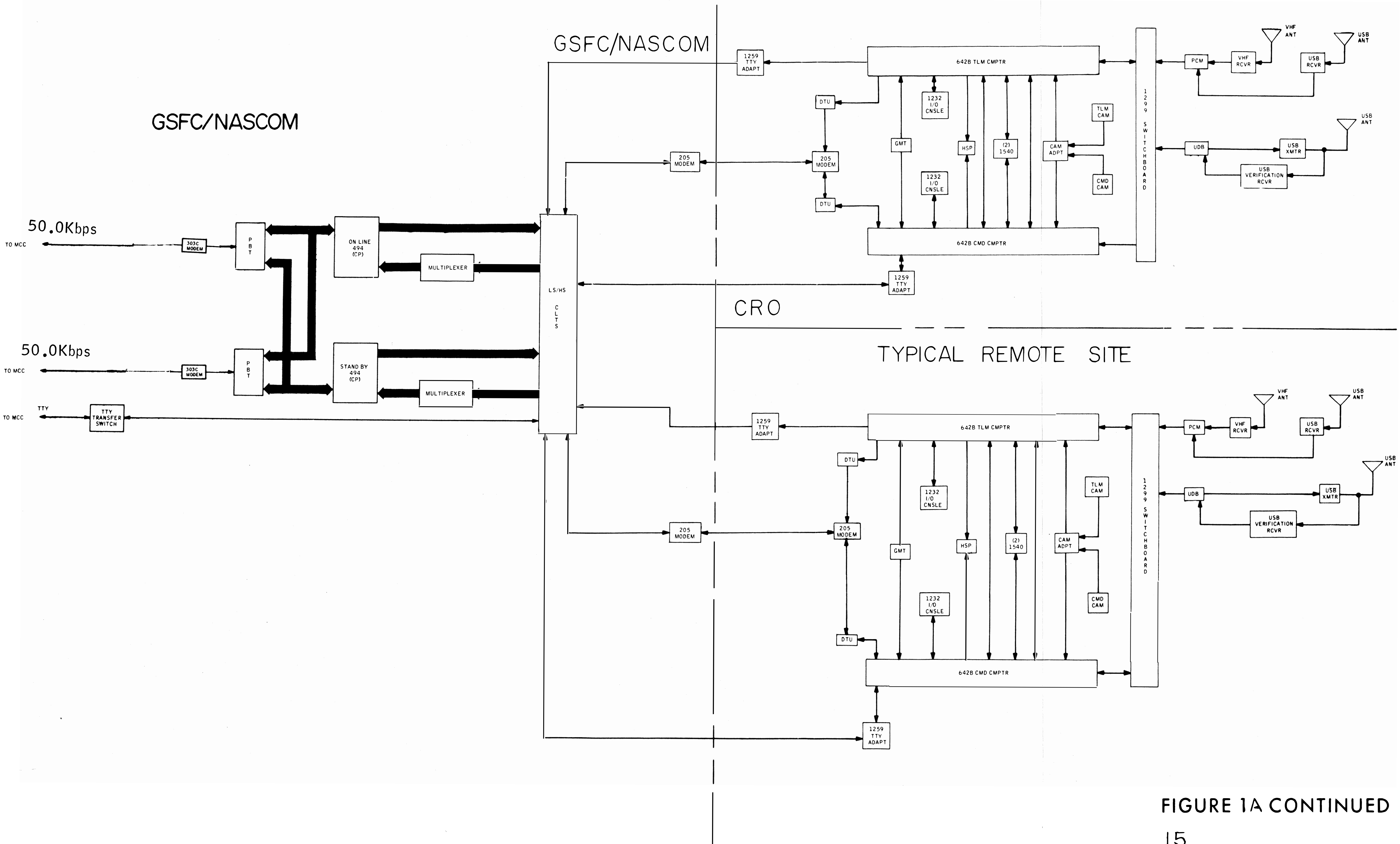
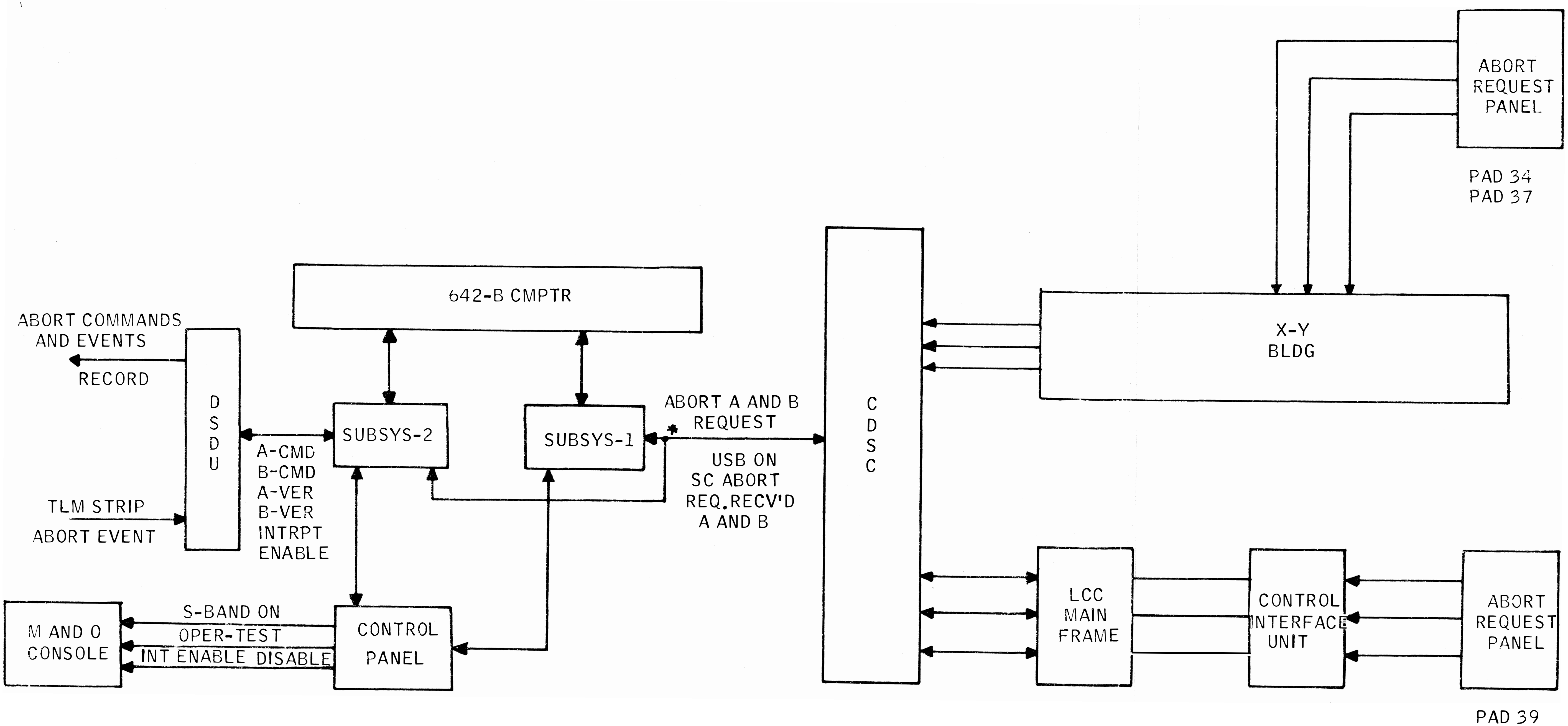


FIGURE 1A CONTINUED

LAUNCH CONTROL ABORT ADVISORY SYSTEM



* 3 PARALLEL TRANSMISSION LINES FROM PAD 34, 37 AND 39

FIGURE 1B.

COMMUNICATION NETWORK CONFIGURATION

2.0 NASCOM Network Facilities

The NASCOM network consists of diversely routed full period 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. To the extent possible, channels are diversified on routes available to minimize system degradation in the event of communications failures, 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 and intermediate switching centers are located at Canberra, Madrid, London, Honolulu, Guam, and Cape Kennedy.

Figure 2 illustrates the approximate geographic location and identifies the type of long-haul common carrier facilities, important cable and communications satellite tie points, approximate location of the various types of Tracking and Data Acquisition Network Stations, NASCOM Switching Centers, and Mission Control Centers.

2.1 MCC/GSFC Wide Band Data Flow

All Apollo wide band data transmitted between GSFC and MCC is contained in standard 600-bit blocks. Each block contains 120 header bits (sync words;

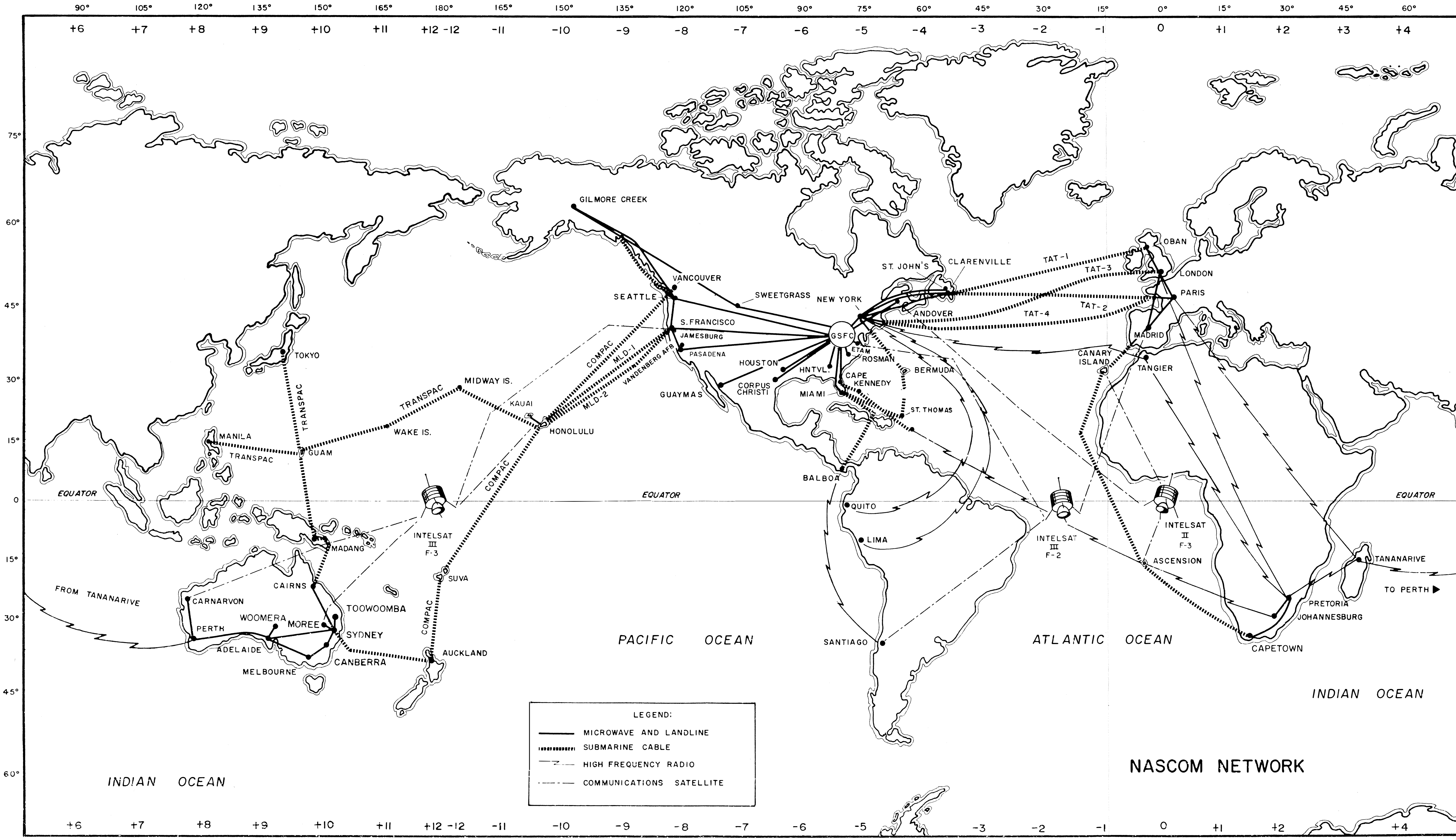

NASCOM NETWORK
LEGEND:
MICROWAVE AND LANDLINE
SUBMARINE CABLE
HIGH FREQUENCY RADIO
COMMUNICATIONS SATELLITE
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
EQUATOR
GILMORE CREEK
VANCOUVER
SEATTLE
SWEETGRASS
NEW YORK
GSFC
S. FRANCISCO
JAMESBURG
PASADENA
HOUSTON
CORPUS CHRISTI
GUAYMAS
HNTVL.
ETAM
ROSMAN
CAPE KENNEDY
MIAMI
BERMUDA
ST. THOMAS
BALBOA
QUITO
LIMA
SANTIAGO
ST. JOHN'S
CLARENVILLE
ANDOVER
TAT-1
TAT-3
TAT-4
TAT-2
OBAN
LONDON
PARIS
MADRID
CANARY ISLAND
TANGIER
ASCENSION
PRETORIA
JOHANNESBURG
CAPETOWN
TANANARIVE
TO PERTH
FROM TANANARIVE
INTELSAT III F-2
INTELSAT II F-3
INTELSAT III F-3
TOKYO
TRANSPAC
MIDWAY IS.
WAKE IS.
KAUAI
HONOLULU
MANILA
GUAM
COMPAC
MLD-1
MLD-2
VANDENBERG AFB
MADANG
SUVA
AUCKLAND
CAIRNS
CARNARVON
WOOMERA
MOREE
TOOWOOMBA
SYDNEY
PERTH
ADELAIDE
MELBOURNE
CANBERRA
90° 105° 120° 135° 150° 165° 180° 165° 150° 135° 120° 105° 90° 75° 60° 45° 30° 15° 0° 15° 30° 45° 60°
+6 +7 +8 +9 +10 +11 +12 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4
75° 60° 45° 30° 15° 0 15° 30° 45° 60°

Figure 2

source, data format, and destination codes; message and segment numbers; status; acknowledgement sequence number, sequence number; control data; and polynomial error protection code) and 480 data or bill bits. The data field is variable and depends on the type of data. The header bits are used for message accounting, routing, and error detection.

These 600-bit blocks (message segments) are transmitted on two fully duplexed 50.0 kbps lines. One is used as the primary line and the other is the overflow line. The two lines are fully redundant and either can be designated primary. If acknowledgement for five consecutive data blocks is not received, then the overflow line will be designated primary and the failed line will be checked out via test data. All message segments are received in the sequential order that the remote site transmitted the data in, but other message segments may be dispersed between them. One segment can not contain more than one type of data (command, tracking, telemetry, etc.), but each segment can contain data from more than one vehicle.

The line rate of the 50.0 kbps lines will not be the same as bit rate at which the remote site transmitted the data. However, the data will be reformatted and output in the same time distribution.

2.2 Tracking and Data Acquisition Networks

The design of the NASCOM network evolves from the tracking and data acquisition stations existent, their equipment configurations and capabilities, the number of frequency of spacecraft using them, and the resultant communications loads determining the number and type of communications channels needed in and out of each site.

2.3 Manned Space Flight Network (MSFN)

The MSFN is essentially a system of 30-feet and 85-feet high gain unified S-band tracking, telemetry, and command (land, shipborne, and airborne) stations, and other sites with C-band tracking, vhf telemetry and air/ground voice capabilities established, maintained, and operated by the GSFC Manned Flight Support Directorate. In addition, there are sites of the Eastern Test Range (ETR) supporting these missions in the launch phase which are linked with the NASCOM network. The primary purpose of this network is to support manned space missions, both earth-orbital and lunar, although it is called upon to support other programs. The term MSFN is often used, in the system sense, to also include the MCC which is part of the Manned Spacecraft Center, the launch operations facilities at Kennedy Space Center, and also portions or particular configurations of the NASCOM network which link the various remote MSFN stations with MCC.

2.3.1 Long-Haul Communications Provision

The basic complement of permanent circuits required for an Apollo Unified S-band 30-foot site is normally six voice/data circuit plus two teletype circuits. Other remote sites, such as the Apollo Range Instrumented Aircraft (A/RIA) and Reentry Ships, have communications constrained by hf radio limitations. The reentry ship will have a flight control voice circuit, and teletype tracking and coordination circuits. The A/RIA will be provided with a flight control circuit for relay and voice communications, plus a teletype circuit for acquisition data.

In addition, these Apollo USB sites generally are provided, where possible, with three additional voice/data and one additional TTY channel as a minimum via an alternate route on a temporary basis during manned missions. The functional requirements complement of circuits at all USB sites are as follows, with exceptions as noted:

Site to GSFC/MCC

2 - High speed data (2.4 kbps) for telemetry
1 - Voice conference circuit - flight control (air/ground)
1 - Voice/Biomed data circuit - analog (realtime) GSFC (M&O) coordination
1 - Tracking data channel (1.2/2.4 kbps) USB (realtime)
1 - Voice channel - MSFN coordination (MCC)
1 - Tracking data channel (2.4 kbps) USB (realtime)
1 - Tracking data channel (2.4 kbps) - DSN collocated 85-foot sites (realtime) wing site only
1 - Tracking data channel (2.4 kbps) - (BDA C-band only) (realtime)
1 - Teletype channel - tracking data (realtime or backup)
1 - Teletype channel - operational coordination
1 - Teletype channel - tracking data (realtime or backup) - DSN collocated 85-foot sites - wing site only

MCC to GSFC/Site

1 - High speed data (1.2/2.4 kbps) - digital command (realtime)
1 - Voice conference circuit - flight control
1 - Voice/Biomed Data circuit - M&O coordination
1 - Voice channel - MSFN coordination
1 - Teletype channel - operational coordination
1 - Teletype channel - predictions/acquisition aid (realtime or backup)

In addition to the above, a system of direct teletype, voice, narrow and wide band data, and TV channels, called the Apollo Launch Data System (ALDS), is provided between MCC and KSC for prelaunch countdown, telemetry monitoring, and launch-to-insertion control.

NASCOM ADSS NETWORK

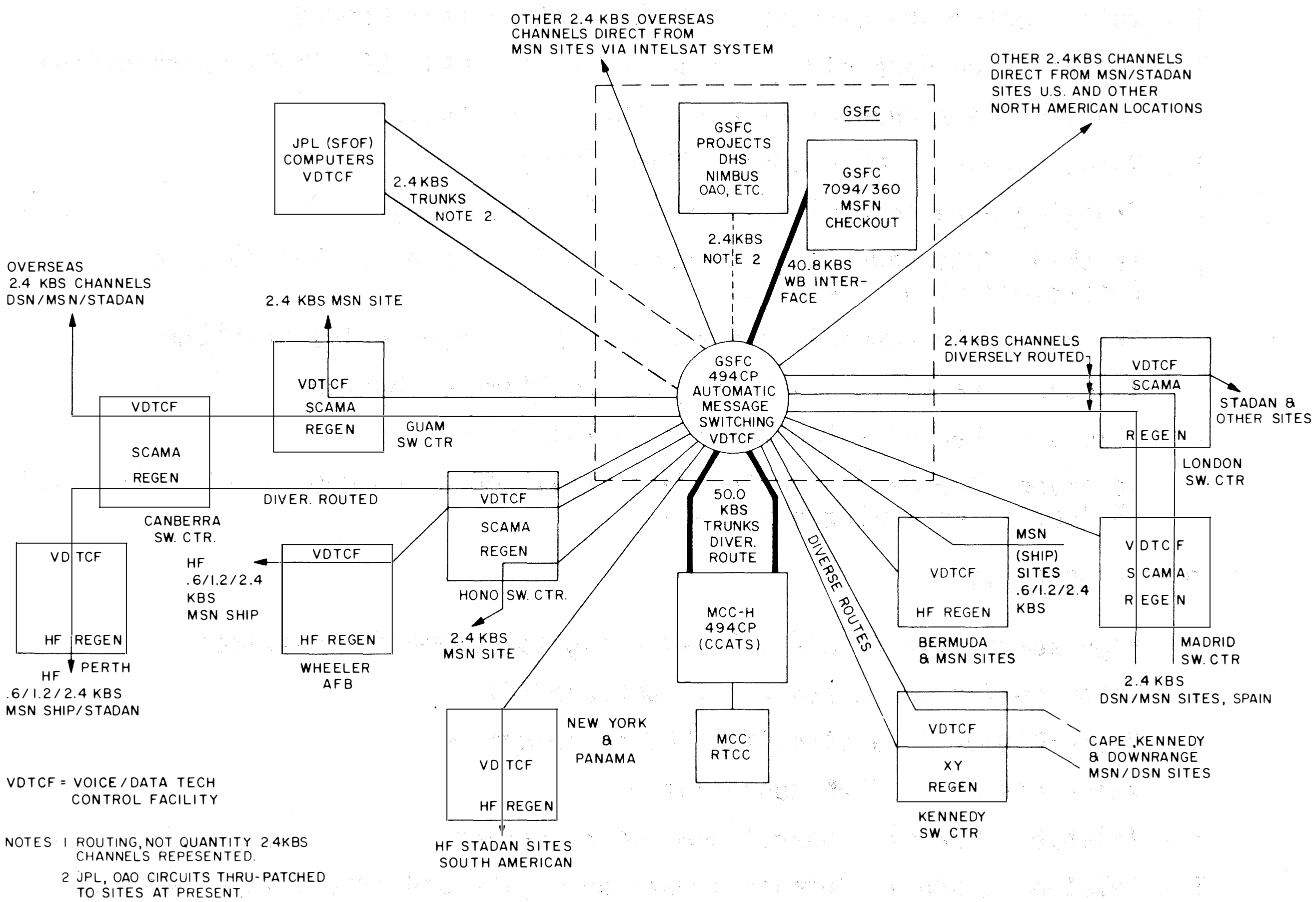


FIGURE 2-A

2.4 Teletype (TTY) Systems, Switching and Control

The NASCOM network provides TTY communications between all overseas tracking and data acquisition sites, and control centers. Generally, these are full duplex (two-way simultaneous) circuits leased on a full-period basis, routed direct or via the switching centers to remote sites in accordance with the basic network arrangement. A few TTY circuits are arranged for simplex (one-way) or half duplex (two-way nonsimultaneous) mode of operation. Each TTY leased channel in the network can be identified (by carrier-assigned identification number, activation date, operating mode and speed, and terminal points) in Figure 2-B.

All traffic on this network uses a standard Baudot code (five information bits, plus start-stop bits, per character) which includes encoded data for data-processing machine use, as well as for teleprinter applications.

2.4.1 Speed of Operation

Circuit operation speed are generally 100 wpm (75 Baud) on domestic and overseas circuits. Rates of 60 and 66 wpm are retained on some hf radio systems for reliability purposes, (all tracking data is routed on 100 wpm circuit) and in some instances where 100 wpm is not yet available. The 66 wpm rate conforms to the (CCITT) International Telegraph Telephone Consultative Committee standards. It is anticipated that all TTY channels will be standardized on 100 wpm operation. In some instances, where transistions between 100 wpm and 60 or 66 wpm circuits occur, NASCOM electromechanical or electronic speed change equipment is provided.

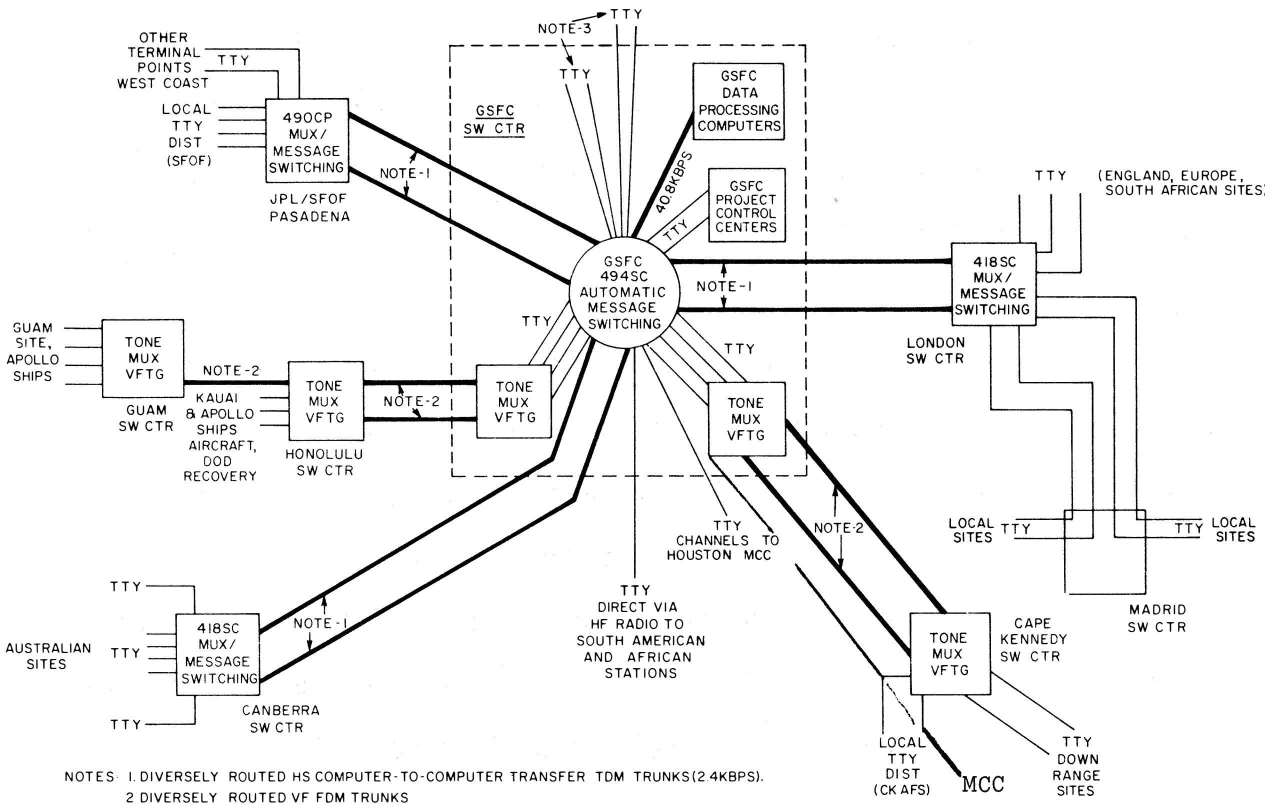
2.5 Teletype Automatic Message Switching System

TTY communications, being a record,or data form of communication, lends itself particularly well to circuit time sharing and automatic message switching through the use of store-and-forward or buffer techniques. With minor exceptions, all leased TTY channels and TTY multiplex systems are hubbed on a Univac 494 Switching Computer (SC) system at GSFC. This system configuration is illustrated in Figure 2-B. The SC system is a realtime, solid state, software-oriented processor specifically designed, applied, and programmed for automatic switching of TTY and digital data messages. It is provided with a family of peripheral units for terminating communications lines and mass storage of traffic and other control systems. The system is provided with online redundancy for reliability and service continuity considerations.

The system is equipped with peripheral multiplexed with 160 full-duplex TTY line terminations. In operation, each incoming teletype signal is connected to the inputs of both online SC's separately; in this way, both SC's operate simultaneously, but independently on the incoming traffic. The output of only one SC is connected to outgoing teletype lines to avoid the possibility of both units sending signals to the lines at slightly different times. Monitor routines operate continuously to validate the proper functions of each system. If the active unit fails, all output channels are transferred to the standby unit without loss of traffic.

Each SC contains a large, rapid-access core storage and operates with very short (less than a microsecond) cycle time. Each SC has considerable intermediate drum storage capacity.

NASCOM TTY NETWORK



NOTES: 1. DIVERSELY ROUTED HS COMPUTER-TO-COMPUTER TRANSFER TDM TRUNKS (2.4KBPS).
2. DIVERSELY ROUTED VF FDM TRUNKS
3. LOCAL MESSAGE TERMINAL AND VARIOUS OTHER DOMESTIC AND OVERSEAS DIRECT TTY CIRCUITS (45, 50, AND 75 BAUD) INCLUDING CHANNELS VIA INTELSAT, TO REMOTE SITES AND CENTERS.
4. CONFIGURATION, NOT QUANTITY, OF TTY CHANNELS IS REPRESENTED.

FIGURE 2-B

External TTY circuits interface with Communications Line Terminals (CLT's) which are connected through multiplexers that permit the lines to time share on input/output channels of the central processor.

A Model 35 teletype automatic send and receive machine (35 ASR) is used for entering console instructions into the SC's. Two Model 35 receive-only page printers are provided to print out information from the SC's.

An automated display system keeps communications operators continuously informed on the status of each channel and the internal functions of the SC. A technical control position is provided to allow individual channels to be changed to spare channels if an input/output CLT fails. The technical control has specialized equipment to monitor and test communications facilities.

2.6 Automatic High Speed Data Switching

The Univac 494 system which terminates TTY lines on an automatic message switching basis, also terminates high speed lines through redundant peripheral CLT equipment. Similarly, as in TTY, message switching is accomplished by software operating on routing and other header information.

A significant difference between TTY and high speed message switching is that there is no queuing of traffic and no message accounting with the basic routing header, unless a special control header is added. The system is designed strictly for realtime, high speed data operations. The switching system delivers data with a maximum delay of 750 ms. The major portion of high speed data traffic in the network is in the inward direction (sites to GSFC). The system internal traffic handling capacity and major transfer links must be capable of handling all expected active inputs simultaneously or inputs

NASCOM HIGH-SPEED DATA INTERFACE

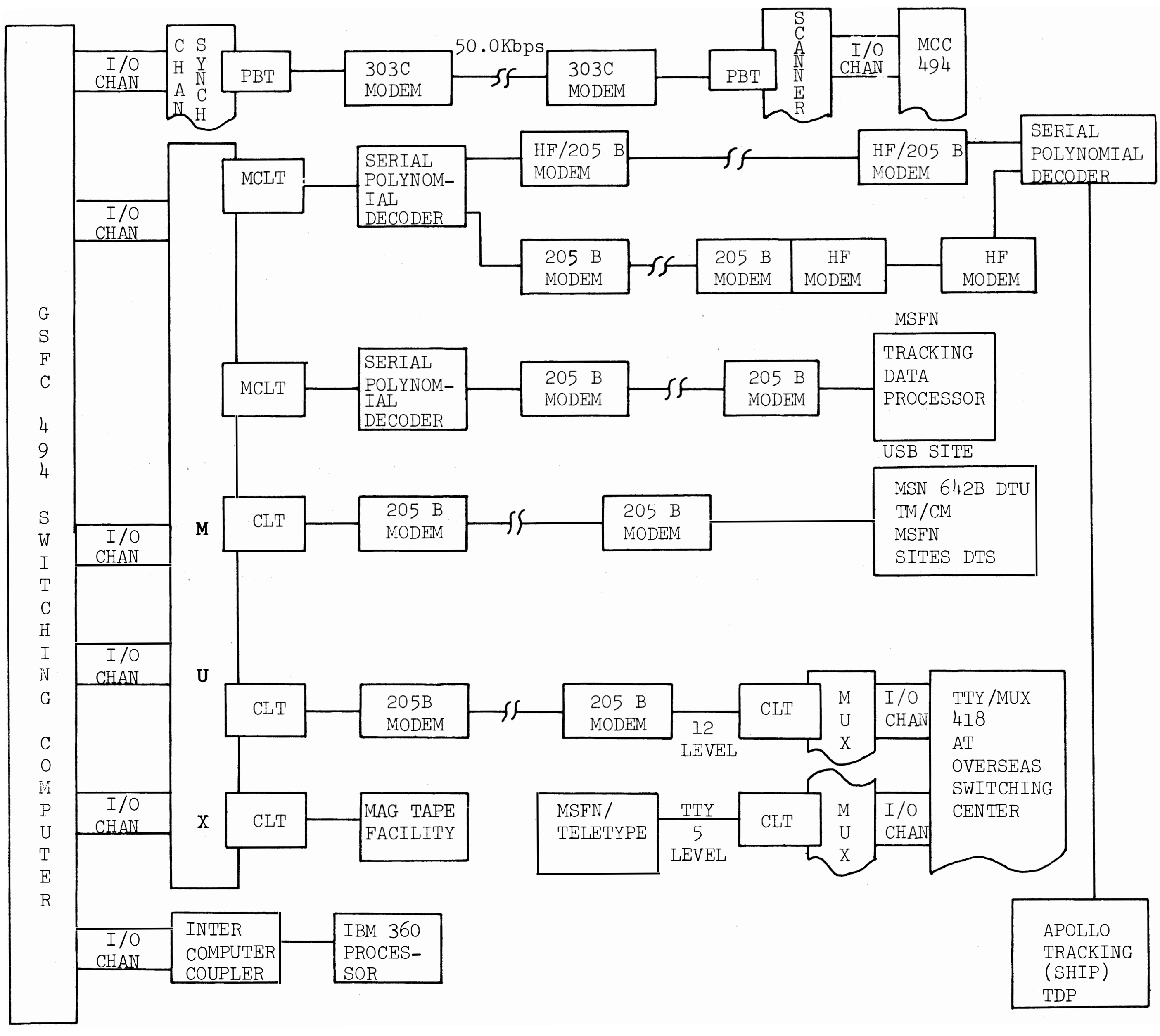


Figure 2C

must be inhibited or constrained not to exceed this capacity to avoid loss of data. Thus, the wide band interface with the MCC is designed to handle the maximum simultaneous traffic expected within the MSFN. However, the second (redundant, alternately routed) wide band channel is available to handle overflow traffic.

2.6.1 Equipment Configuration

As described for the TTY automatic switching system, the three 494 Switching Computer's are arranged for dual standby redundancy with two operational systems; one online, the second in constant readiness for switching in the event of online system fault; the third is available for backup replacement of either operational system, and for maintenance or for new program checkout operations. SC interface with 2.4 kbps high speed transmission channels in the NASCOM network is accomplished by the communication subsystem which interfaces on the standard data interchange side of the 205B modems. This subsystem is used to provide initial synchronization, buffering, serial-to-parallel conversion, and multiplexing of input channels.

The communication subsystem consists of a CLT which buffers the incoming serial input for parallel transfer to the processor or accepts parallel data from the processor for serial output to the transmission line, and a multiplexing device which connects a number (up to 16) of high speed circuits to the central processor through an input-output channel on a time-shared basis. A capacity for terminating 80 high speed lines is provided, with ability to expand, if necessary, by the addition of multiplexers and CLT's to the system. Decoder equipments are interjected between the CLT and 205B modems where the

NASCOM network is required to provide error detection and error status indications to the user. On the redundant wide band interface with MCC, polynomial buffer terminals, operating on separate I/O channels, are provided.

The system has expanded core and auxiliary drum storage capacity for handling the high speed message switching program, and console capability for program monitoring and program modification. In addition, CRT and hard copy displays are provided. These are operated through a display program under console control for central monitoring of the status of communications facilities at switching cneters and remote sites.

2.7 Kennedy Space Center (KSC)

KSC Merritt Island, Florida, retains responsibility for providing intrasite communications facilities. KSC communications consist of a variety of networks and switching systems linking KSC to MSFC, MSC, and GSFC by means of the NASCOM network provided by GSFC.

KSC operations are at KSC on Merritt Island, Florida, and CKAFS, Cape Kennedy, Florida, KSC communications facilities include LIEF terminals; voice bandwidth data circuits via the Western Union 304/758 automatic switching center at Merritt Island; termination of wide band, voice band, and TTY circuits to MCC and ALDS. The LIEF system links KSC to the Huntsville Operations Support Center (HOSC) by means of voice, video, and data circuits for transmitting and displaying information during prelaunch, launch, and flight evaluation operations in realtime. Switching and conferencing capability is provided by a leased integrated 304/758 four-wire cross bar system at the Communications Distribution and Switching Center (CDSC). All KSC communications facilities are hubbed at the CDSC on Merritt Island including voice band and TTY channels from the GSFC Unified S-band (MIL) site.

2.8 Marshall Space Flight Center (MSFC)

MSFC communications consist of a variety of networks and switching systems linking its operation at Huntsville with the Kennedy Space Center, Mississippi Test Facility, Michoud Assembly Facility, other NASA centers, and with various MSFN contractors on a nationwide basis. These facilities are used for the exchange of scientific, technical, and logistics information in support of the Saturn/Apollo Program.

The MSFC Huntsville Operation facilities include (a) the LIEF/HOSC systems of communications between MSFC, MSC, GSFC, and KSC; (b) the Plan 311 communications processor, which provides automatic data and record communication switching services for MSFC and other NASA centers; and (c) the NASA 304/758 Alternate Voice and Data Switching System which provides automatic switching centers at Washington, D.C.; Cocoa Beach, Florida; New Orleans, Louisiana; Los Angeles, California; and Huntsville, Alabama.

2.8.1 Launch Information Exchange Facility (LIEF) System

The LIEF system (Figure 2D) is a communications link between the KSC and the HOSC. It consists of voice, video, facsimile, and data circuits for transmitting and displaying formation during prelaunch, launch, and flight evaluation operations, thus permitting exchange of information between HOSC and KSC as the events occur.

A 758C wideband switch is installed in Huntsville, Alabama and provides switching for LIEF/HOSC and Third Generation Computers to permit resources sharing and to provide operational circuitry. Switching is accomplished on a four-wire basis (four-wire voice plus four-wire wide band) using a common control crossbar arrangement.

2.9 Apollo Range Instrumentation Aircraft (ARIA)

The ARIA have the following communications capabilities:

a. Two-way voice communications with the ground via HF.

b. Two-way teletype communications with ground via HF teletype.

c. Two-way voice communications with the spacecraft via the VHF and USB systems from the aircraft or from MCC when the ARIA is in the remote mode.

The ARIA system is capable of receiving USB and VHF voice from the spacecraft and relaying the received voice signals to a ground station by HF/SSB. Conversely, the aircraft can receive HF voice from a ground station and relay the voice to the spacecraft by VHF and USB. The ground to ARIA HF link is full duplex, whereas the ARIA to spacecraft link is simplex on VHF and duplex on USB (refer to page for detailed block diagram).

2.10 Mission Control Center (MCC)

The MCC Communications system processes and distributes all signals, except television, entering and leaving MCC and provides internal communication capabilities for the MCC. The MCC is comprised of five basic systems: the Display/Control System; and the Apollo Simulation, Checkout and Training System (ASCATS). These systems are designed to provide the flight operations team with the necessary realtime data and associated reference data for rapid assessment of mission progress and rapid decisions in the event of abnormal or emergency situations.

LIEF/HOSC COMMUNICATIONS

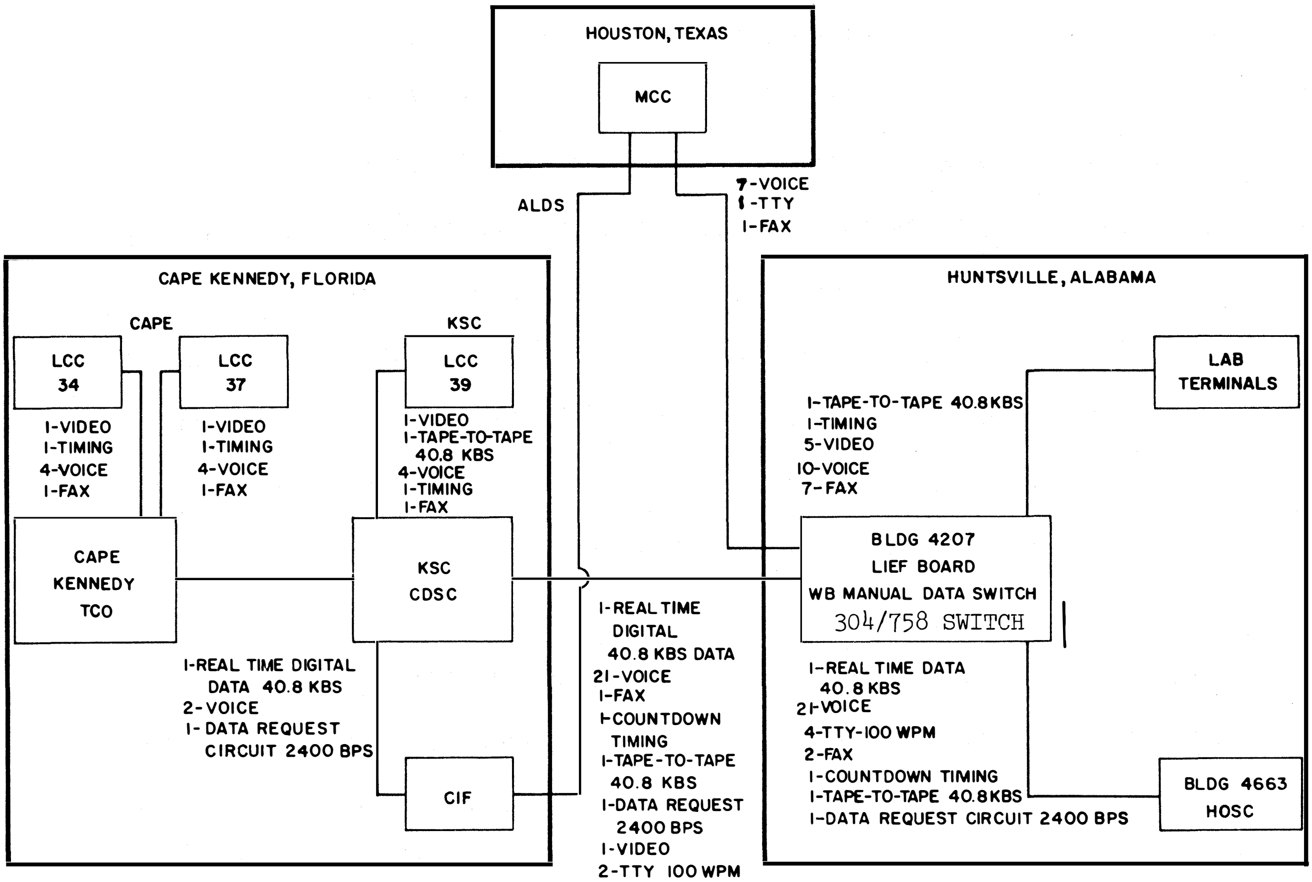


FIGURE 2-D

.The Communications Processor (CP), the MCC message switching center, is a stored-program digital computer which processes large quantities of data on a realtime basis. Telemetry data is routed to a Pulse Code Modulated (PCM) telemetry system for data processing and display.

.Teletype and facsimile traffic are routed through the teletype message center for distribution to printers for test and picture messages.

.The voice communication system enables voice communication between persons within MCC, and between the MCC, and flight crew training facilities, Manned Space Flight Network, and the spacecraft.

.The facility control system centralizes quality control and maintenance for all high speed data, teletype, and audio frequency communications circuits that enter and leave MCC.

All of these external circuits terminate in the telephone company building at MSC and are extended by tie cables to the MCC, Building 30.

3.0 Apollo Telemetry Network Configuration

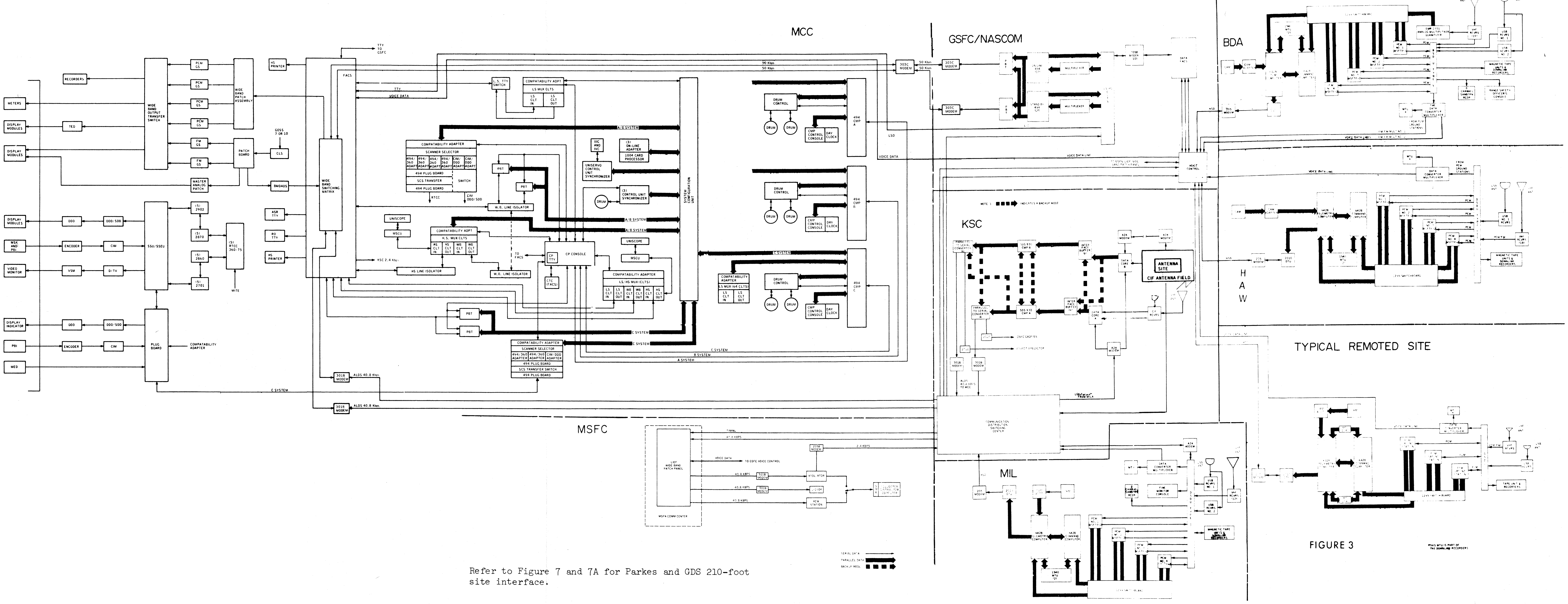
For Apollo missions the Lunar Module (LM), Saturn Launch Vehicle, (SLV), and Command Service Module (CSM) parameters will be routed to MCC. The telemetry (TLM) system acquires spacecraft Air-to-Ground (A/G) downlink and routes selected parameters to MCC via the NASA Communication (NASCOM) network. The A/G downlink signals are received, demodulated, decommutated, repacked if necessary, formatted in the HS data formats, transmitted back to MCC, and displayed to flight controllers in realtime. The Apollo remote sites receive, format, and transmit upon the direction of MCC.

In addition to the remote sites, the Apollo Launch Data System (ALDS) routes selected data from the A/G downlinks to MCC over Wide Band (WB) transmission lines. The remote site MIL provides ALDS with the USB downlinks. The WB data from ALDS is sent directly to MCC, while all HS data from the remote sites is sent via NASCOM through GSFC where it is multiplexed onto a WB data link for transmission to MCC.

GSFC and ALDS WB data are received at MCC by the Communication, Command, and Telemetry System (CCATS). CCATS performs the routing of input data to other systems at MCC, routing of input data for displays in the Mission Operation Control Room (MOCR), and the routing of SLV data received from GSFC to MSFC via KSC/CIF. The Real Time Computer Complex (RTCC) is one of the MCC systems served by CCATS. It performs certain additional processing prior to MOCR display.

Figure 3 illustrates MCC, ALDS, and the differenc configurations of the remote sites to be used during the Apollo missions. The following is a system-by-system description of the TLM data flow.

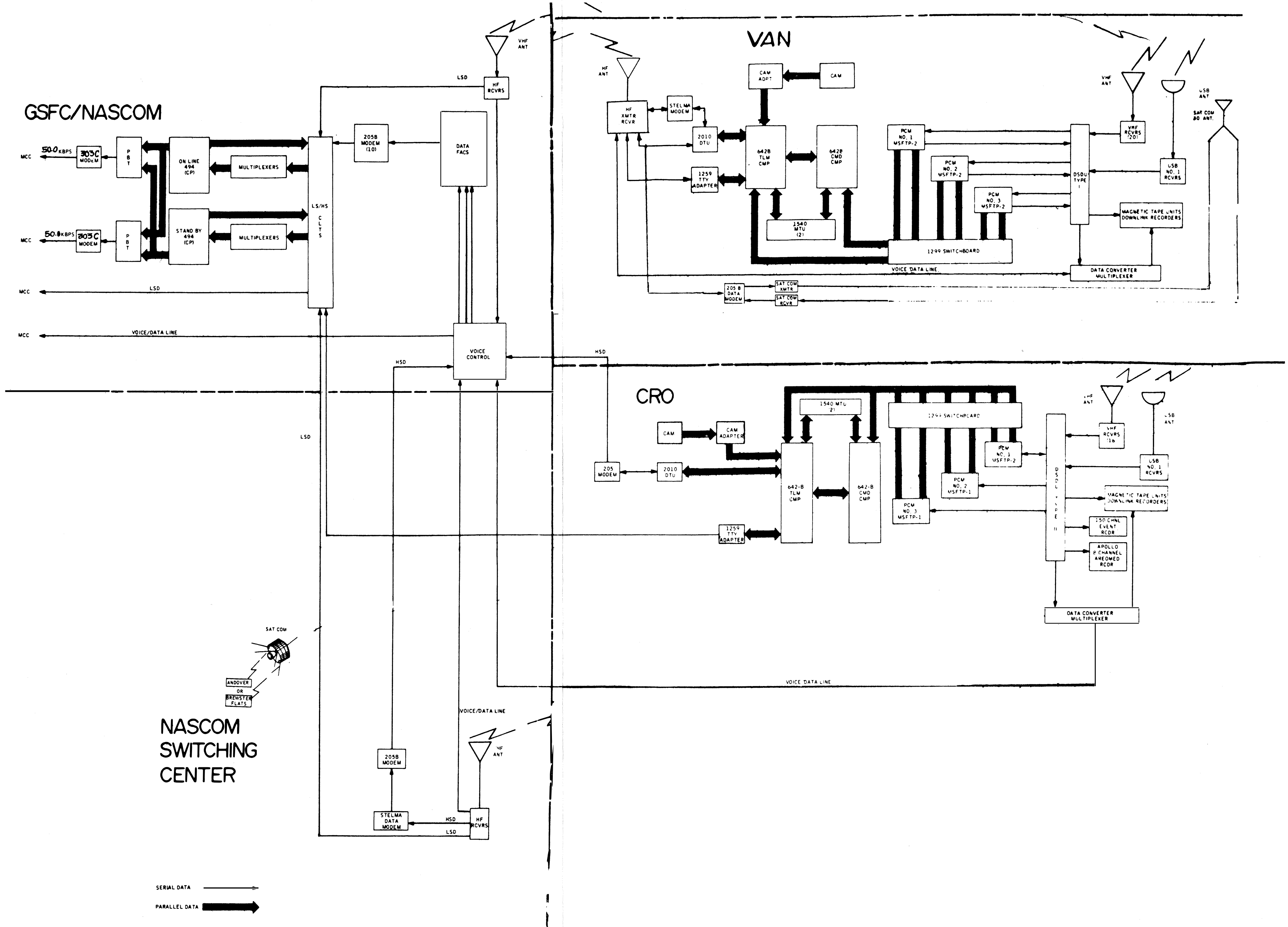
APOLLO TELEMETRY NETWORK CONFIGURATION



Refer to Figure 7 and 7A for Parkes and GDS 210-foot site interface.

FIGURE 3

APOLLO TELEMETRY NETWORK CONFIGURATION



Refer to Figure 7 and 7A for Parkes and GDS 210-foot site interface.

FIGURE 3 CONT'D

3.1 Telemetry Data Downlinks

Remote site telemetry data handling can be better explained in the spacecraft-to-ground telemetry data streams are briefly reviewed. A PCM telemetry data stream is assembled by an onboard commutator which is programmed to "time-multiplex" or assemble successively different measurements or "parameters." Each parameter is represented by one or a group of bits which are the encoded representation of a sensor output, a switch position, onboard computer output, etc. These parameters are "sampled" in a specified sequence by the commutator. The sequence of commutation is repetitive over a set time interval (or data cycle) and an exact knowledge of the position of all parameters within that data cycle is used by preflight-programmed ground equipment to identify and route individual parameters. This function is the inverse of commutation or "decommutation."

The layout of parameters within a data cycle for an Apollo PCM stream is usually called a "downlink format" or "downlink." The exact parameter content of PCM streams transmitted by each Apollo vehicle (e.g., LM, CSM, etc.) varies with mission requirements. Further discussion here describes only those downlink characteristics that are not mission dependent, but are vehicle peculiar, e.g., CSM and LM downlinks are each transmitted at a 51.2 or 1.6 kbps rate and IU, S-IVB, SII, and SIC downlinks at 72 kbps each.

3.1.1 IU and S-IVB Downlinks

Each of these two downlinks share basic characteristics with each other and with each of the SII and SIB/C downlinks. It should be pointed out that in the case of the IU and S-IVB stages, the majority of flight control data originated by both stages are redundantly transmitted via the IU downlink, the S-IVB acting as backup source.

The 72 kbps stream is subdivided into 10-bit "words." The resultant word rate is, therefore, 7200 words/sec. To conveniently handle this mass of information, a format is organized. First, 60 words are called a frame. Each successive frame devotes one or more of its words to a standard, known bit pattern (sync pattern) for use by ground equipment in decommutation. The frames are grouped into master frames which are groups of ten frames. The master frame is identified with its sync pattern. Master frames are further grouped by three's into master-master frames. The resulting master-master frame rate is 4/second. The significance of the master-master frame in the SLV downlinks is that it corresponds to the "data cycle," which is a minimum groups of words containing at least one sample of every parameter that can be downlinked. Within that data cycle a parameter may be seen more than once. The frequency of occurrence of that parameter per second is its "sampling rate." The SLV stage's PCM telemetry equipment design limits the choices of sample rates that can be used for any parameter to 4, 12, 40, or 120 samples per second.

3.1.2 CSM and LM Downlinks

These vehicles can each transmit PCM telemetry streams at either 51.2 kbps, 1.6 kbps for low bit rate respectively. In both vehicle cases, the bit groupings (words) are 8 bits in length which results in a word rate of 6400 words/second. Words are grouped into 128 word "frames." (Here again standard sync patterns occur in every frame for the benefit of ground decommutation equipment.) Thus, 50 frames are transmitted each second. This frame grouping is the data cycle. A parameter may appear one or more times in the data cycle and the choices of sample rates for either CSM or LM in the 51.2 kbps mode are 1, 10, 50, 100, and 200 samples per second (in the 1.6 kbps mode the only sample rates are 1 s/s and 10 s/s).

3.1.3 Portable Life Support Subsystem (PLSS)

The -6 PLSS will be used for lunar surface Extravehicular Activity (EVA). The two PLSS's are designated EVA #1 and EVA #2. Both have transceivers which operate on 296.8 MHz and 259.7 MHz. EVA #2 has an additional transmitter which operates at 279.0 MHz. EVA #1 has a 279.0 MHz receiver to receive voice and data from EVA #2 to be relayed to the LM in the dual mode. There are three relay modes used to transmit data. These are pictorially summarized in Figure 3A. When both astronauts are on the lunar surface outside the LM both of their Electrocardiograms (EKG's) can be relayed to the MSFN. When both are inside the LM only one of two EKG can be relayed to the MSFN.

The -6 PLSS uses four separate standard Interrange Instrumentation Group (IRIG) Subcarrier Oscillators (SCO) to transmit physiological and engineering information to the LM, (refer to Figure 3D). EVA #2 transmits EKG on IRIG 9 and engineering data on IRIG 11 to EVA #1. EVA #1 combines its EKG (IRIG 10) and engineering data (IRIG 12) with EVA #2 and relays the mixed signal to the LM. The LM transmits the data to the ground in a PAM/FM/FM format. In other modes either back pack can transmit individually to the LM. In the nominal configuration both EVA's voice and data will be received in the LM and put on the 1.25 MHz SCO for transmission to the MSFN on the vehicles USB PM or FM downlink.

PLSS DUAL MODE

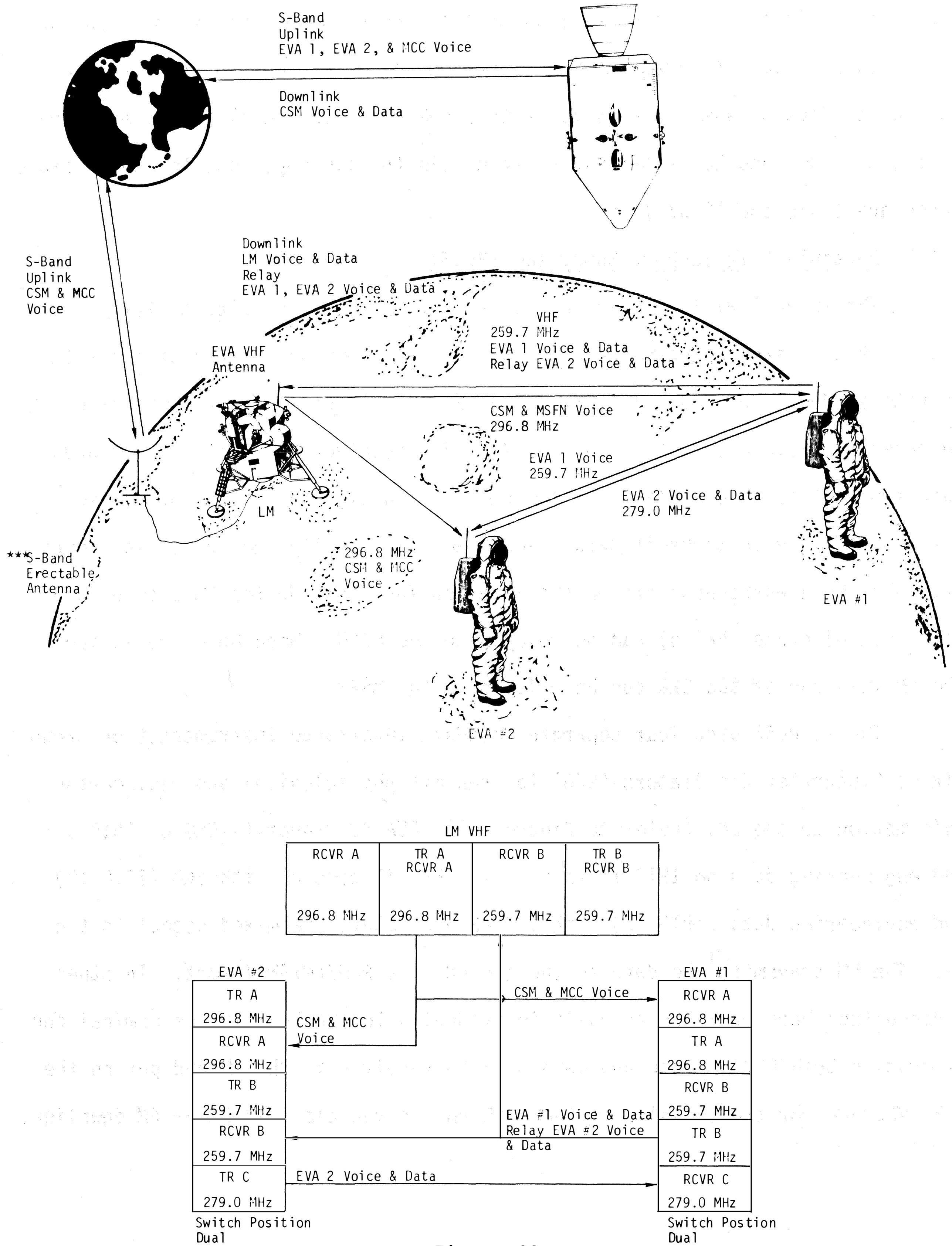


Figure 4A

PLSS CONTINGENCY MODE

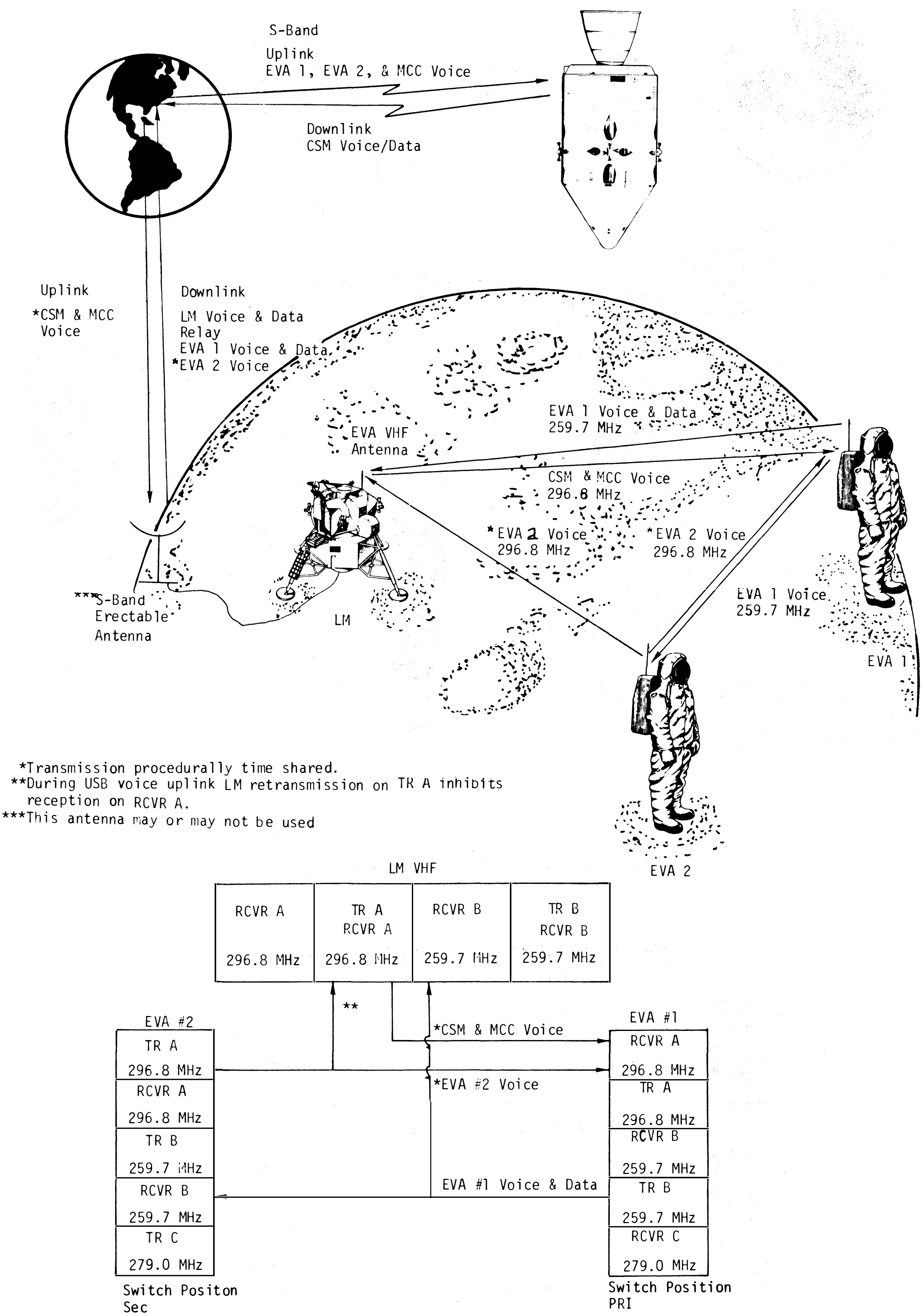
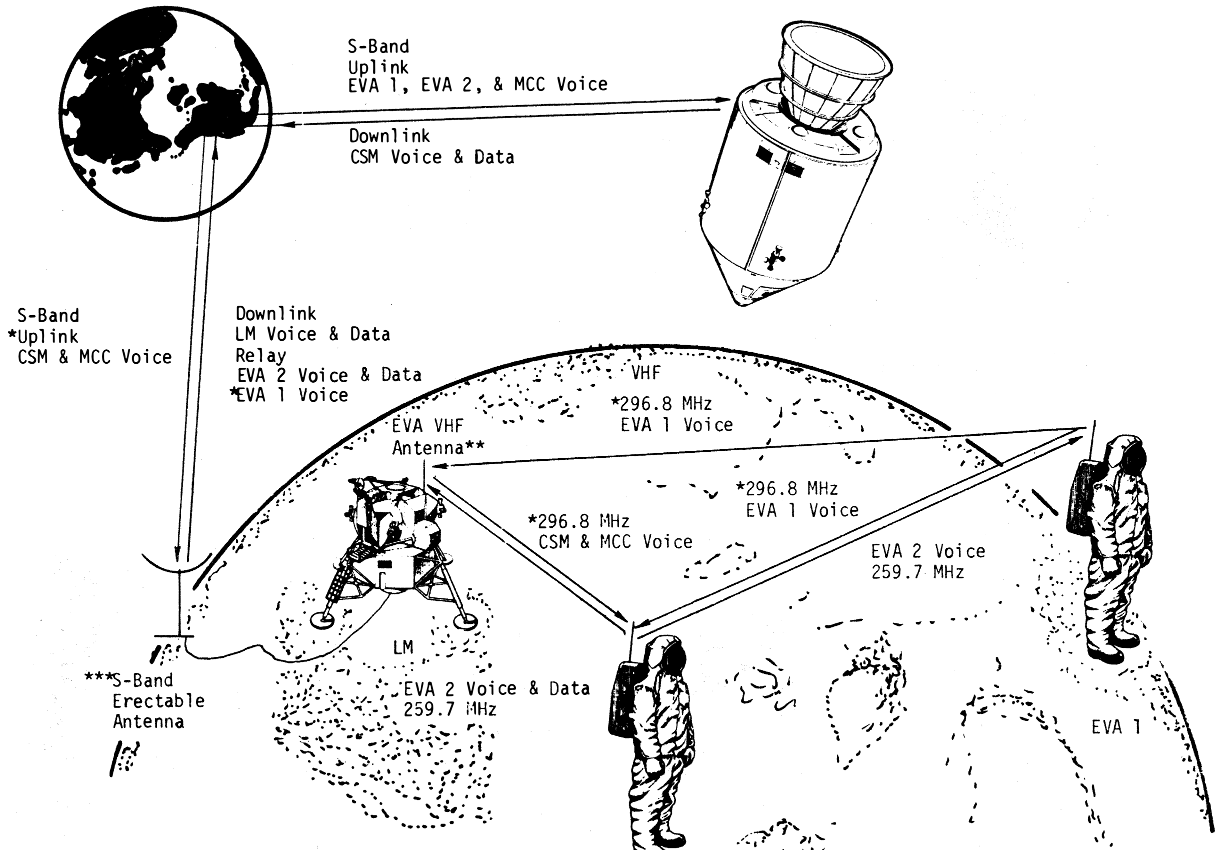


Figure 3B

PLSS CONTINGENCY MODE



**During S-Band voice transmission uplink LM retransmission on TR A inhibits reception on RCVR A.

*Transmission procedurally time shared.

EVA 2

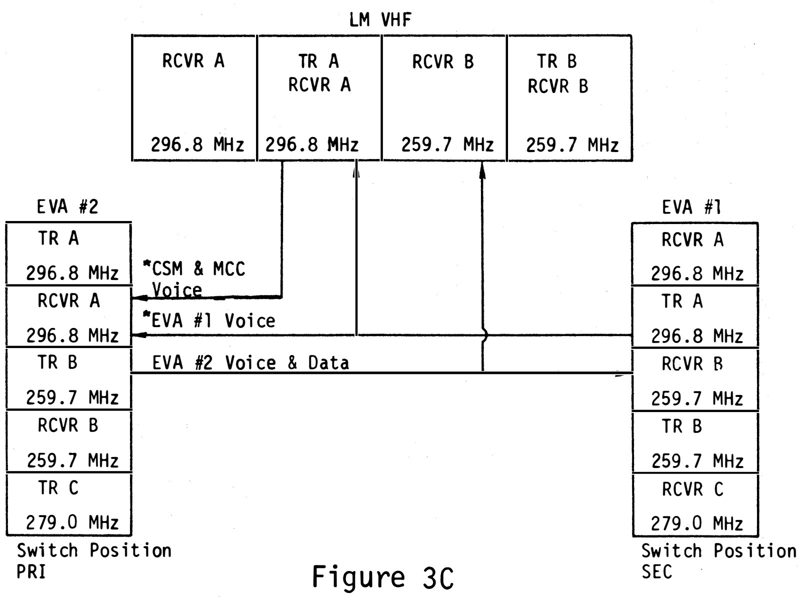


Figure 3C

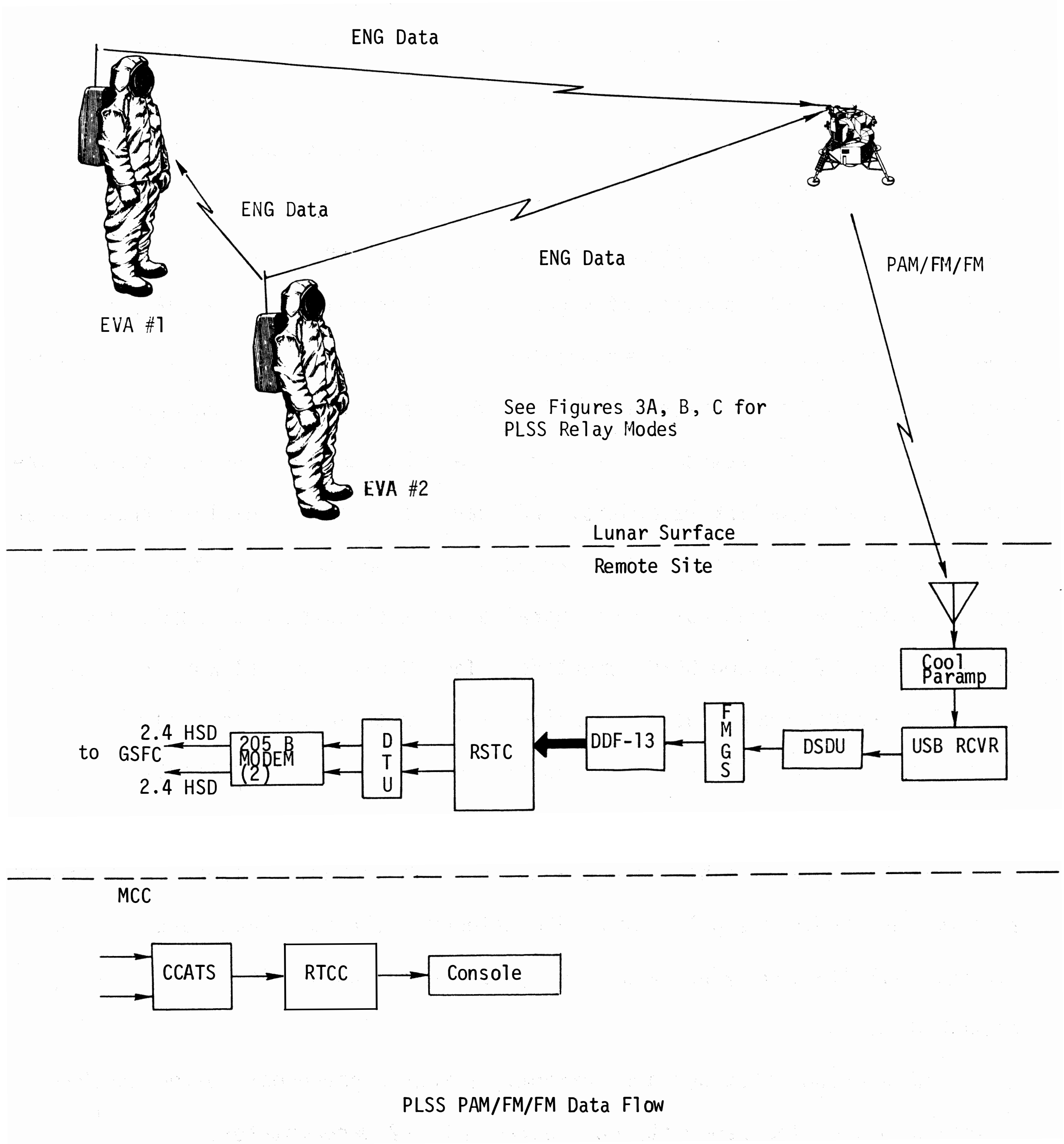

ENG Data
ENG Data
ENG Data
PAM/FM/FM
EVA #1
See Figures 3A, B, C for
PLSS Relay Modes
EVA #2
Lunar Surface
Remote Site
Cool
Paramp
to GSFC
2.4 HSD
2.4 HSD
205 B
MODEM
(2)
D
T
U
RSTC
DDF-13
F
M
G
S
DSDU
USB RCVR
MCC
CCATS
RTCC
Console
PLSS PAM/FM/FM Data Flow

Figure 3D

Engineering PAM/FM/FM data (suit cabin delta pressure, oxygen partial pressure, etc.) are received through the USB receiver into the Digital Data Formatter-13 (DDF-13), is decommutated, digitized, and routed to the RSTC where the data is reformatted and transmitted to MCC via one of two lines.

The physiological parameters are discriminated at the FM GS and patched to the FM/FM data system for transmission to MCC.

3.2 Data Acquisition, Synchronization, and Conversion

The VHF and USB downlink rf signals are demodulated by the VHF and USB receivers respectively. The demodulated PCM signals are routed to the Decommutation System Distribution Unit (DSDU) which acts as the patchboard for all input signals to the remote sites. From the DSDU, the USB and VHF signals are recorded by the downlink recorders. PCM wavetrain signals derived from USB or VHF rf signals are patched to PCM ground stations which search for and acquire sync, forming two identical 30-bit parallel data streams, each stream transmitted to one of the two 642B computers. The 30-bit parallel word is sent to each 642B computer contains one downlink word (8 or 10 bits in length) plus certain tagging to indicate sync acquisition and format identification.

3.2.1 PCM Ground Stations

Each remote site has from one to four PCM ground stations. Each ground station can handle a single serial PCM telemetry stream. Thus, each remote site can simultaneously process as many telemetry PCM downlinks as it has ground stations.

MSFN ground stations are currently either a patchboard-wired MSFTP-1 Decommutator, or the newer stored program MSFTP-2 Decommutator.

As mentioned above, the PCM ground station converts the demodulated telemetry data stream into parallel form for processing by the telemetry computer. The ground station (or decommutator, or decom) may also pull out (strip) selected parameters and route these via the DSDU to displays adn recorders within the remote site. It does this usually in two different ways. Parameters found in downlink data streams that are identified by the ground station program to be "stripped" and are analog quantities, (i.e., 8 or 10 bits each are needed for their description), are routed by the program to Digital-to-Analog Converters (DAC's) which convert one digital word to voltage form which can then drive a meter, analog recorder pen, etc. Some bilevel event parameters (that require only one bit each for description) are "stripped out" and routed to "event stores" which convert the bits to bilevel voltages which drive lights, event recorder pen, etc. The MSFTP-2 stations each contain 60 DAC's and 127 event stores. These stations may store up to ten different programs. These programs can be changed instantneously by PBI depression at the ground station. Generally, a different program must be used to handle each different PCM downlink format (e.g., pme !rpgra, ,au jamd;e a CSM 51.2 kbps format, another for CSM 1.6 kbps format, another for IU 72 kbps format), etc.

3.2.2 <u>Remote Site Telemetry Computer Data Handling Functions</u>

3.2.2.1 <u>Input Data</u>

As mentioned above, all downlinked words are paralleled by the PCM ground station for input to the RSTC. Up to four different paralleled data streams are received by the RSTC. Each stream is 30 bits wide. Eighteen of the 30 bits are allocated for the telemetry data word itself (8 or 10 bits), the unused bits in this 18 bit field being zeros. The remaining 12 bits in the 30 bit word contain source status:

Loss of sync (if set)	1 bit
Recorder playback	1 bit
Subframe count	4 bits
Format ID (downlink ID)	5 bits
Normal/Abnormal Flag	1 bit

Such information is used by the RSTC program's Telemetry Input Processor (TIP) routine to construct buffers of incoming words which correspond to downlinked frames of data and to validate them. The TIP transferes these frames into Telemetry User Tables (TUT). A TUT is filled with the equivalent of one second's worth of CSM and LM data, and is validated, time-tagged simultaneously. The time tag is then considered a part of the available data. Upon TUT validation a new TUT begins to fill and the validated data TUT may be used for output.

3.2.2.2 High Speed Output Data

The High Speed Telemetry Link (HSTL) routine accesses the validated TUT and uses that data to assemble a buffer that will be output eight bits at a time in parallel to the DTU which then serialized the data and transmits it at 2.4 kbps through one of the two 2.4 HSD lines to MCC via the GSFC/NASCOM system. Data received from SLV downlinks are encoded in 10-bit words. Such analogs have the two least significant bits truncated before being assembled. Ten-bit downlinked words containing up to ten different parameters each described by a signal bit must be repacked into specified new or "repacked" 8-bit bilevel words prior to their insertion into an output buffer. Special processing on certain data is also accomplished prior to HSTL assembly. LM Digital Uplink Assembly (DUA) status and SLV APS Thruster quantities are examples. The CMC, LGC, AGS, and LVDC data are derived from onboard computers and are received by the RSTC as part of operational PCM streams (CSM, LM, and IU). Prior to HSTL assembly, these data each require repacking, selection, and in the case of the CMC and LGC data further processing to minimize delay of their transmission to MCC.

A buffer being prepared by HSTL for transmission over a one-second period is 300 eight-bit words in length. The first twenty words consist of synchronization patterns (for use by receiving equipment at GSFC), remote site identification, destination code (MCC), format number, format status, vehicle downlink status, and CAP. This data is control (or overhead) data generated by the RSTC itself and derived from the program constants, the 12-bit PCM ground station source status, and data received via the inter-computer channel from the RSCC (CAP data). The next 270 eight-bit words are TUT derived PCM downlink-originated data. The last word in the buffer is the frame counter (another control word). Thus, 279 eight-bit words or 2232 bits are actual data in each buffer.

Since this useful data would be small indeed if it were transmitted identically every second to the MCC, the frame counter is allowed to count from one to ten and the HSTL may assemble ten completely different uffers over ten successive seconds. They are transmitted in order with the frame counter incrementing by one until a frame count of ten is reached to be followed by a frame count of 1, 2, 3, etc. A frame count of "two" indicates always the same buffer composition. However, since this still allows only a small part of the downlinked data to be transmitted back to MCC in near real-time, many different sets of ten buffers can be called up. Each set is a "format." A format is designed to meet specific mission-phase parameter needs. It is identified by the format number (see above). The ten successive buffers comprising a single format are each called a "frame," thus the term "frame counter." Frames of different formats cannot be interspersed.

As mentioned above, parameters may be downlinked at various "sample rates." Similarly parameter sampling rates may vary in high speed data formats. Samples of the same parameter may appear once in each frame or more than once. Once per frame is therefore a sample rate of one sample per second. It is allowable to have sample rates of 2, 5, and 10 per second corresponding to 2, 5, 10 samples per frame. It is also allowable for a parameter to be sampled every other frame, every five frames, or once every tenth frame corresponding respectively to a sample rate of 0.5, 0.2, 0.1 samples per second. It is not allowable for a parameter's successive samples in a high speed format to be spaced greater than ten frames apart. Thus, one can conclude that the high speed format's data "data cycle" is ten frames or ten seconds long, fitting the definition of data cycle found in paragraph 3.2.

A format being transmitted by the RSTC can be canceled and replaced by another format by high speed command sent from MCC via GSFC/NASCOM, received by the RSCC and sent to the RSTC via the inter computer channel. For AS-508 two of the available telemetry formats may be transmitted to MCC at one time on the 2.4 kbps HS telemetry lines. The RSTC contains one HSTL which assembles the two formats in two different buffers for transmission to MCC. MCC can change formats by sending two CEF's to the RS. The first CEF specifies what format will be called up and the second CEF specifies what format will be replaced. Table 3-D shows what formats are available for AS-508 and during what mission phases that they are applicable.

3.2.2.3 High Speed Format 30

A new 2.4 kbs format (HS FMT 30) for post pass playback of high sample rate CSM/LM analog data will be available for Apollo missions. This format provides the capability to retrieve any one of the 29 CSM subformats and 21 LM subformats. Each subformat can contain four analogs at 50 s/s, four analogs at 10 s/s, seven discretes at 10 s/s, and the Central Timing Equipment (CTE) or Mission Elapse Time (MET). The subformat are defined premission and are selected in realtime by CEF at the Telemetry Instrumentation Controllers Console (TICC). The presently used FM/FM contingency formats and the new HSD format 30 will be selectable on an either/or basis to the same dedicated chart redorder for AS-508.

3.2.2.4 FM/FM Biomedical Data Output

In addition to high speed PCM formats output by the remote site, biomedical parameters are output on a voice/data (V/D) line. This allows an exclusive line per remote site for biomedical data and FM/FM formatting allowing this data to be available regardless of high speed format selection and without impact to RSTC program loading.

Biomedical parameters are received from the CSM, LM, and PLSS in the downlink. At the PCM ground station decommutating the CSM PCM downlink, the

2.4 KB FORMAT DUAL LINE MATRIX

THIS MATRIX DEFINES THOSE FORMATS WHICH ARE TO BE COMPATIBLE USING TWO TRANSMISSION LINES FROM A SINGLE SITE. ANY FORMAT SHOULD BE CAPABLE OF TRANSMISSION SINGLY FOR LOSS-OF-ONE-LINE CASES.

FMT NAME	DATA CONTENT							FMT NO.	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	SLV	LM	LGC	AGS	CSM	CMC	PLSS															
SLV/CSM BACKUP	X				X	X		2			X										X	
SLV ONLY (LAUNCH)	X							3			X	X	X	X	X	X	X	X			X	X
LM ONLY		X	X	X			X	4	X	X					X	X	X			X		
CSM-LM PCM		X			X		X	5		X				X				X		X	X	X
CSM + LM BACKUP		X	X	X	X	X	X	6		X										X		
OBC CMC + LGC CST			X	X		X		7		X		X				X				X		
CSM ONLY					X	X		8		X	X									X	X	
CSM PCM ONLY					X			9		X	X			X				X		X	X	X
SPS BURN					X	X		10		X	X									X	X	
OBC CMC + LGC MAN			X	X		X		11		X		X				X				X		
ERASEABLE MEMORY DUMP			X			X		12	OFF-LINE PROGRAM													
SLV ONLY (ORBIT)	X							13			X	X	X	X	X	X	X	X			X	X
ASCENT/DESCENT		X	X					14	X	X		X			X	X	X			X		
ASCENT/DESCENT BACKUP			X	X		X		15		X		X				X				X		

AS-508 UTILIZATION MATRIX

Table 3-D

HIGH SPEED FORMAT 30

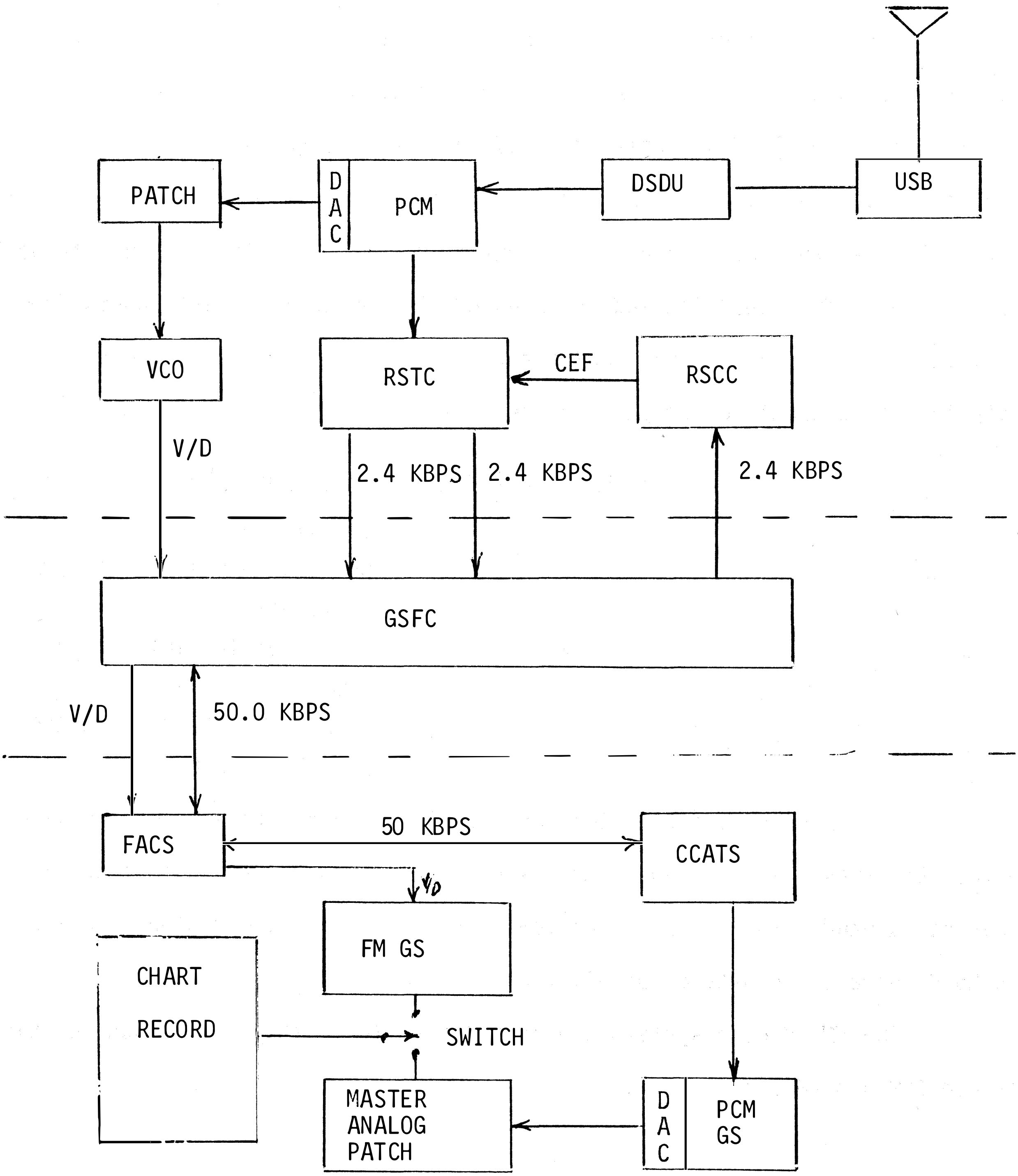


Figure 3E

PCM ground station program will strip the three EKG's and three respiration parameters and route them to DAC's. At the FM ground station at the LM EKG and the PLSS EKGS are discriminated and routed to DACS. The analog voltage output of each of these nine DAC's are brought to a bank of voltage controlled oscillators (VCO's). The active data of these nine signals must be patched to the seven available VCO's such that the following requirement is met. The nine input signals are couch (downlink) oriented leaving the output as an astronaut orientation. The scheduled and unscheduled movements of the astronauts from position to position requires realtime patching. The patching of input to output must be specified prepass to the site.

IRIG Channel No.	Measurement Name
1	Unassigned
2	Command Module Pilot's ZPN
3	Commander's ZPN
4	Lunar Module Piolt's ZPN
5	Commander's EKG
6	Command Module Pilot's EKG
7	LM Pilot's EKG

The FM signals output the seven IRIG channels onto a mixer amplifier which sums these discrete audio frequencies onto a four-wire voice channel that has a bandwidth of 3-KC. The composite signal is then routed on NET 3 to GSFC where it is patched on NET 7 or 10 to MCC.

The FM/FM data system is also utilized for post pass playback of high sample CSM and LM analog data.

BIOMEDICAL DATA FLOW

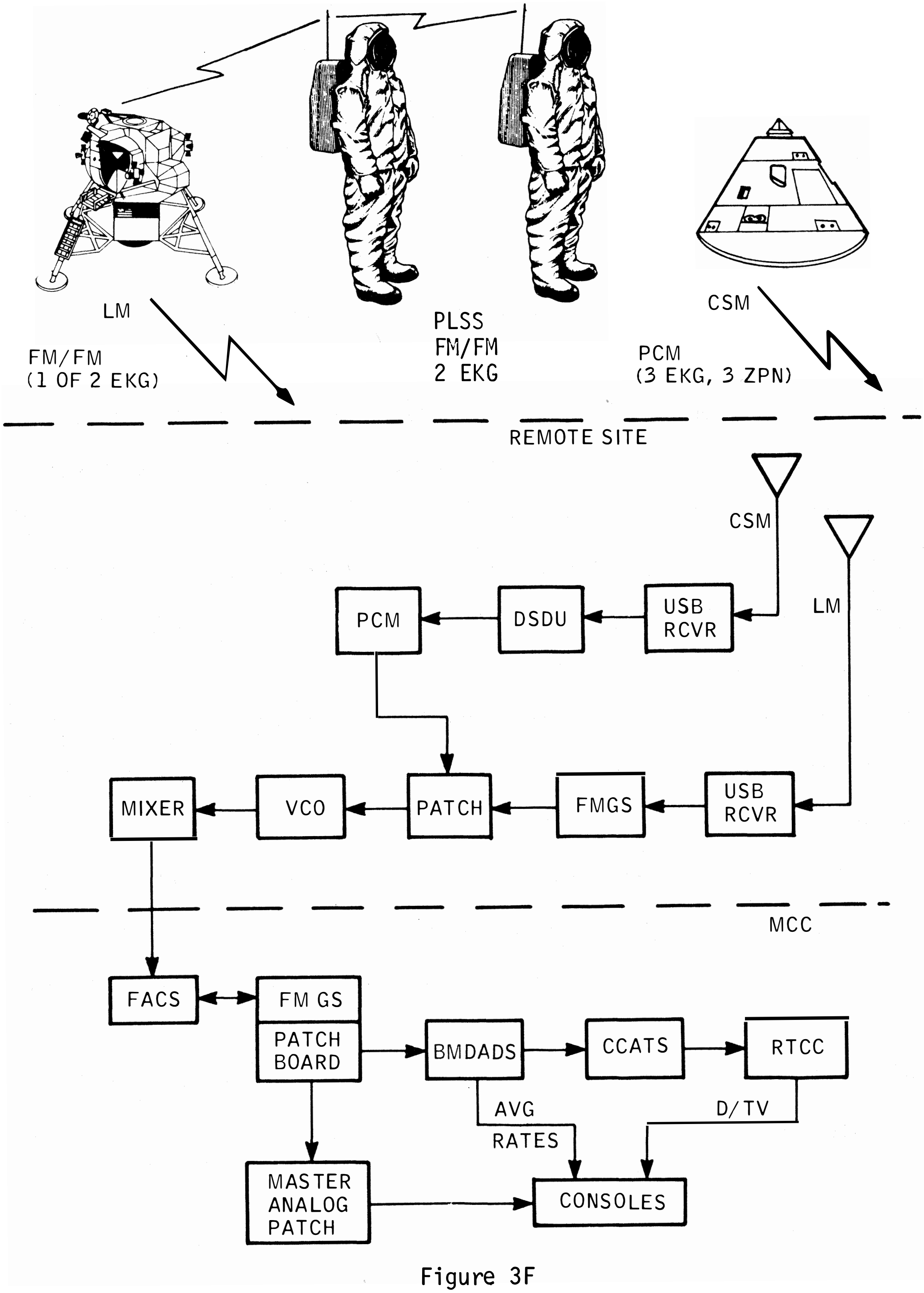


Figure 3F

3.3 Apollo Launch Data System/KSC

The ALDS at KSC has the capability of receiving, decommutating, distributing and processing data during the launch phase of Apollo missions. Two Data Cores receive the downlinks from the CIF antenna facility (Mandy) and USB downlinks from MIL. There is a backup for VHF downlinks from the VHF receivers. Data Core can handle various types of analog and digital input data from up to 32 asynchronous sources and can process these inputs into a common digital format. Each of the Data Cores are configured to accept simultaneously six PCM links, 12 PAM/PDM links, three FM/FM channel converters, and three time code converters in support of Apollo launches. The main function of Data Core is to convert all the data into a common format. This format is a 26-bit parallel word which consists of 12-bit binary data words, a 13-bit binary address or data identification word, and one control bit. After words are transferred through the scanner, they are transmitted in parallel to the ALDS interface buffer and from there to the SDS 930 computer.

The SDS 930 computer.selects the data from the access memory unit and formats the data into a wide band ALDS format (launch only). The computer outputs the wide band data format to a parallel-to-serial converter, and then the serial bit stream is transmitted via 303G modems on redundant 40.8 kbps links directly to MCC. The Countdown and Status Transmission Subsystem (CAST) of ALDS will transmit 120 discrete events and three separate countdown time words to MCC via a 2.4 kbps line.

The CCATS receives ALDS data, via CLT's, from two 40.8 kbps wideband, simplex lines. One line is designated as primary and the other as alternate.

Identical data, related to only one mission at a time, is transmitted on both lines simultaneously. Data on one line (normally primary) is processed for output and the alternate data line is provided to supply backup capability during launch operations. The data is synchronous and transmitted in frames of 204 10-bit words at a rate of 20 frames per second. The eight most significant bits of each 10-bit word will be processed for use. The remaining two bits will be truncated. The external equipment will not input data to the program until sync is detected. At sync detection, data will be input, via parallel transfer, to the CCATS Processor (CP). The telemetry program will internally verify sync at each frame thereafter (by frame count).

The ALDS/CCATS format contains the following characteristcs: (a) 40.8 kbs, (b) 10 bits/word eight MSB's data, two LSB's zeros), (c) 204 words/frame, (d) 20 frames = 1 data cycle, (e) 1 data cycle/second, (f) data is transmitted MSB, MSS, and (g) available sample rates are 1, 2, 4, 5, 10, 20, 40, 60 s/s. The first 16 words of each frame are reserved for synchronization pulses, a frame counter, a format status label and the vehicle status words.

Simulated ALDS data will be received on only one 40.8 kbps wideband, simplex data line patched to the primary and alternate CLT's. The ALDS input processor will accept either real ALDS or simulated ALDS data.

3.3.1 Launch Information Exchange Facility (LIEF)/KSC

The LIEF is a network of communication resources that facilitate day-to-day, realtime, data exchange between KSC and MSFN. The two broad areas of support are: (1) MSFN advisory support of KSC prelaunch and launch operations and (2) KSC data support of MSFC postflight evaluation. The scope of LIEF services is: (a) advisory support, (b) realtime data and data request, (c) tape-to-tape (Univac 1004 digital tape transmission), (d) facsimile, (e) closed loop TV, (f) countdown and liftoff, (g) classified teletype, and (h) voice circuits.

The LIEF realtime data/data request system has a storage memory which is transmitted from Data Core with the sampled values of all vehicles. Each parameter is assigned a storage memory address, prior to test and this information is transmitted to MSFC along with parameter sampling rates.

The realtime data output frame contains 1023 data words of 10-bits each plus a 30-bit sync word. A complete data request instruction assigns a parameter in each of the 1023 word slots by designating the storage memory and executed automatically at the 40.8 kbps (see Figure 3F).

3.3.2 Meteorological Data Recording System

The Meteorological Data Recording System receives data from several C-band radar sites which tracks, ground released weather ballons. The system is compatible with land lines inputs from the (MIL) TPQ-18, (KSC) FPS-16, and (PAT) FPQ-6.

The incoming data is processed by digital logic into a formatter and recorded. This tape recorded data is then reduced at the Central Computation Complex after the conclusion of a ballon ascent. A parallel output of the Meteorological Data System digital logic is interfaced with the LIEF system to allow unprocessed meteorological radar data to be transmitted to MSFC via the 40.8 kbps wideband link.

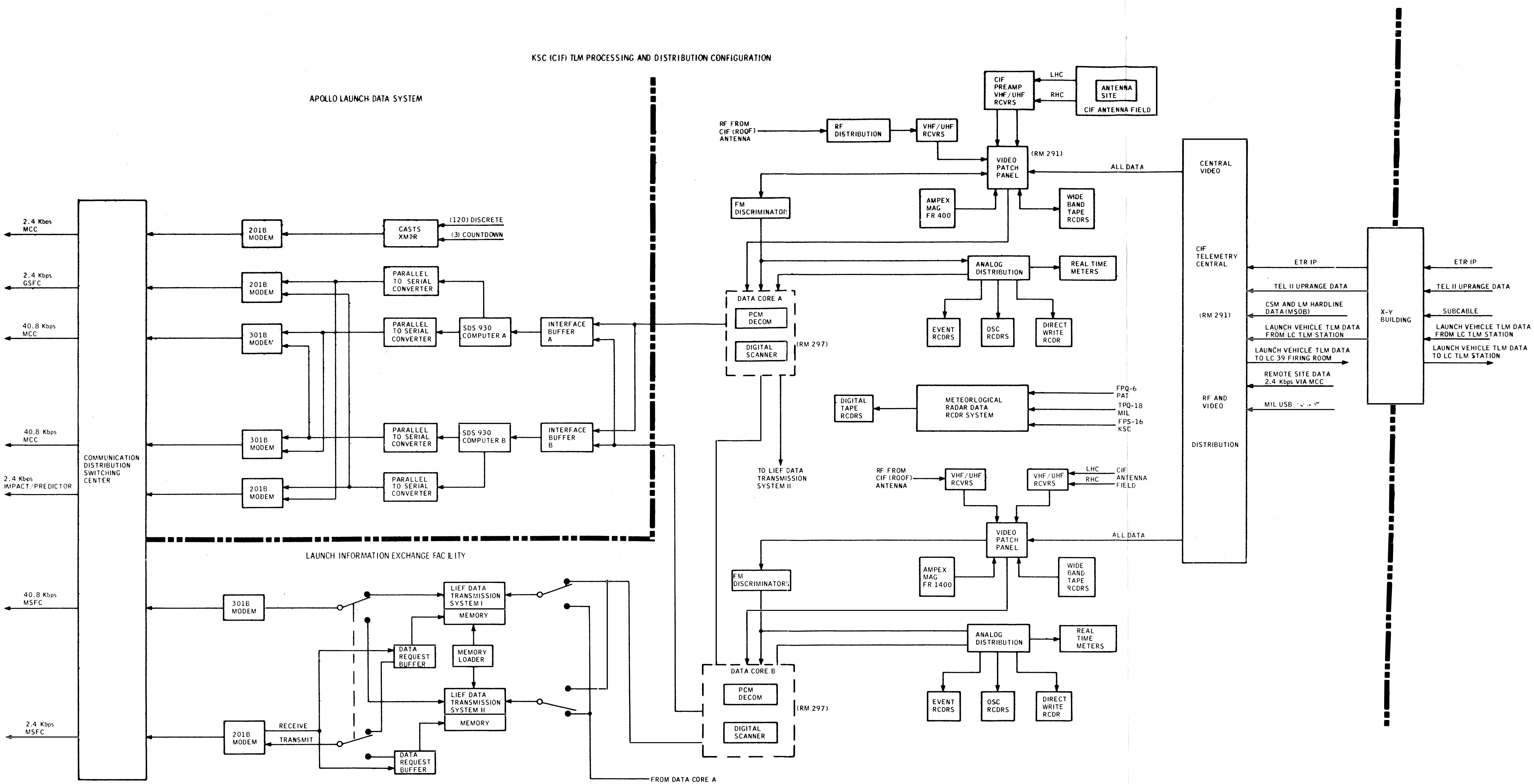

KSC (CIF) TLM PROCESSING AND DISTRIBUTION CONFIGURATION
APOLLO LAUNCH DATA SYSTEM
LAUNCH INFORMATION EXCHANGE FACILITY
COMMUNICATION DISTRIBUTION SWITCHING CENTER
2.4 Kbps MCC
2.4 Kbps GSFC
40.8 Kbps MCC
40.8 Kbps MCC
2.4 Kbps IMPACT/PREDICTOR
40.8 Kbps MSFC
2.4 Kbps MSFC
201B MODEM
301B MODEM
CASTS XMTR
(120) DISCRETE
(3) COUNTDOWN
PARALLEL TO SERIAL CONVERTER
SDS 930 COMPUTER A
SDS 930 COMPUTER B
INTERFACE BUFFER A
INTERFACE BUFFER B
LIEF DATA TRANSMISSION SYSTEM I
LIEF DATA TRANSMISSION SYSTEM II
MEMORY
MEMORY LOADER
DATA REQUEST BUFFER
RECEIVE
TRANSMIT
FROM DATA CORE A
DATA CORE A
DATA CORE B
PCM DECOM
DIGITAL SCANNER
(RM 297)
TO LIEF DATA TRANSMISSION SYSTEM II
RF FROM CIF (ROOF) ANTENNA
RF DISTRIBUTION
VHF/UHF RCVRS
CIF PREAMP VHF/UHF RCVRS
LHC
RHC
ANTENNA SITE
CIF ANTENNA FIELD
VIDEO PATCH PANEL
(RM 291)
FM DISCRIMINATOR
FM DISCRIMINATORS
AMPEX MAG FR 400
AMPEX MAG FR 1400
WIDE BAND TAPE RCDRS
ANALOG DISTRIBUTION
REAL TIME METERS
EVENT RCDRS
OSC RCDRS
DIRECT WRITE RCDR
METEORLOGICAL RADAR DATA RCDR SYSTEM
DIGITAL TAPE RCDRS
FPQ-6 PAT
TPQ-18 MIL
FPS-16 KSC
CIF ANTENNA FIELD
ALL DATA
CENTRAL VIDEO
CIF TELEMETRY CENTRAL
(RM 291)
RF AND VIDEO DISTRIBUTION
ETR IP
TEL II UPRANGE DATA
CSM AND LM HARDLINE DATA (MSOB)
LAUNCH VEHICLE TLM DATA FROM LC TLM STATION
LAUNCH VEHICLE TLM DATA TO LC 39 FIRING ROOM
REMOTE SITE DATA 2.4 Kbps VIA MCC
X-Y BUILDING
SUBCABLE
LAUNCH VEHICLE TLM DATA TO LC TLM STATION

Figure 3G

3.4 Goddard Space Flight Center (GSFC)

In GSFC/NASCOM vernacular, a one second, 2400 bit high speed telemetry frame is called a "message." When a message is received at GSFC, it is examined for proper synchronization code, stripped of six overhead words and processed in the GSFC 494 CP. MSFN telemetry messages are identified as telemetry data by the data format code and forwarded to the MCC over the wide band trunk to MCC/CCATS together with other messages containing other types of data bearing the same destination code.

Each 2400 bit high speed telemetry message is reformatted into five 600-bit segments by the GSFC message switching center's 494 before being transmitted over the wide band link to MCC. Each 600-bit segment consists of 75 eight-bit words. Overhead functions are provided by 120 bits of each segment. These functions are synchronization (24 bits), source and destination (16 bits) format code (8 bits) derived from the six stripped high speed data words, message counts and status (12 bits), and error-control code and control bits (60 bits). Words 7 thru 300 of the high speed format are split into five groups of respective length 60, 60, 60, 60, and 54 eight-bit words and placed in the remaining 480 data bits of each successive segment. Fill bits are placed in the fifth segment following the 54 data words.

The wideband link from GSFC to MCC is a 50 MHz bandwidth group circuit with a modem signaling speed of 50.0 kbps.

3.5 Mission Control Center

3.5.1 Facility Control Subsystem (FACS)

All wide band and voice data lines are patched into the FACS areas. Wide band lines are patched to the CCATS and voice data lines to the FM ground stations.

3.5.2 Data Routing and Displaying by CCATS

The wide band data is inserted into the input buffer channels of CCATS 494 computers by the Polynominal Buffer Terminal (PBT). The PBT's change the data to parallel words to be compatible with the computer word length, and decode the polynomial error code from GSFC. ALDS wide band data is transmitted into the 494 computer by the wide band CLT's.

The computer multiplexers time multiplex the low speed/wide band CLT inputs into the 494 computer input channels. The 494 computer routes Low Speed (LS) data to RTCC. It takes wide band originated telemetry data and decommutates, repacks, converts certain analogs to percent-full-scale, performs some truncation, and routes the required wide band data to RTCC, the MCC PCM ground stations, the TICC, and to KSC/Data Core.

3.5.3 Telemetry Instrumentation Control Console and Intra MCC Data Routing

The primary function of the CCATS telemetry processing program is to process near realtime telemetry data received from ALDS and MSFN. After converting the MSFN telemetry data segments into a format which is acceptable to the telemetry processing program, main frame synchronization is determined. Synchronization status is then sent to the TICC and the data is sent to decommutation and header processing programs. At this point, input selection is received from the TICC and header validation to the TICC. Certain miscellaneous processing is required within the telemetry processing programs and conversion of analog signal levels to full scale for direct readout. Frame count and format number are used by decommutation routines to call up decommutation tables. Thére is a unique decom table for every frame of every format. The decommutated telemetry data is then assembled into output message frames and routed to the scanner selector, CIM/SDD adapters and the 494 plugboard which provides the capability for the 494 to interface with the DDD for digital event light displays in the operational area. Also, the scanner selector, 494/360 adapters, 494 plugboard and system selector unit provide the capability for the 494 to transmit telemetry data to the RTCC. Decommutated telemetry data is also delivered to the MCC PCM ground stations, for event and analog display drive directly to consoles via a 40.8 kbps CLT. Decommutated SLV telemetry data received from MSFN high speed sources (not the ALDS source) is also sent to the KSC/Data Core via a 2.4 kbps CLT.

3.5.4 Data Processing and Display by RTCC

The telemetry processor in CCATS, after decommutating incoming telemetry data, constructs individual vehicle related buffers of eight-bit para= meters (one for each vehicle whose data is being decommutated plus additional ones for each onboard computer data and for playback data) and transmits each of these to the RTCC once per second. The RTCC's telemetry processor performs limit sensing, scaling and other special processing as required. It provides data to a selection of digital-to-television formats that are accessable by flight controllers at MCC consoles. Also, one-bit event parameters and "computed" events may be transmitted via the RTCC's Subchannel Data Distributor/ Digital Display driver (SDD/DDD) directly to console light indicators. High speed telemetry data thus received by RTCC provide the source for RTCC generated telemetry rebroadcast low speed summaries to be sent via TTY back to remote sites not in spacecraft acquisition.

3.5.5 MCC PCM Ground Station Telemetry Data Display

High sample rate analog and one-bit event data are packed into 480 eight-git word buffers by CCATS and transmitted to the ground station ten times per second via a 40.8 kbps interface. The ground station "decommutates" each buffer and routes all samples of each parameter to an assigned DAC (for analogs) or to an assigned event store (for one-bit events). The ground station can store up to ten different routines for such routing (i.e., ten different programs). This capability along with replaceable patchboards at the Output Switch allows meters, analog chart recorders, event recorders, and event lights to be driven with a different selection of parameters for different mission phases. However, the selection must be made out of the constant, fixed CCATS-to-ground station parameter buffer sent throughout the entire mission. High rate analog and event selection flexibility exists only with the ground station program and its output patching, not in the CCATS program.

3.5.6 MCC Biomedical Data Handling

FM/FM biomedical data received via GSFC from a remote site at MCC FACS is patched to be the MCC FM/FM ground station. This "ground station" is nothing more than a bank of seven subcarrier discriminators per MOCR/SSR, each discriminator being sensitive to one of the first seven IRIG channels. The resulting (seven possible or six for AS-508) analog signals are patched to the master analog patchboard and from there directly to analog recorder displays in the MOCR/SSR. The six analog signals that are biomedical data (IRIG channel 2 - 6) are also patched to the Biomedical Data Analysis and Display System (BMDADS) cardiotachometer and respiration rate processor. Resultant rate parameters are then patched directly to MOCR/SSR analog chart recorders. In addition, BMDADS will simultaneously and independently digitize, analyze, and transmit several parameters to CCATS at a rate of 2.4 kbps for retransmission to RTCC.

3.5.7 CCATS Telemetry Data for KSC/Data Core

Each second the CCATS telemetry processor prepares and transmits at a 2.4 kbps rate a buffer of all SLV parameters decommutated from MSFN originated high speed telemetry data. After launch, the KSC/LIEF switches from its local data core source to this 2.4 kbps data stream in order to acquire SLV telemetry data. The LIEF system then transmits these SLV parameters on command to Marshall Space Flight Center (MSFC)/HOSC.

3.6 Huntsville Operation Support Center (HOSC) Data Processing

The primary data processing equipment in the HOSC is the Collector/Distributor (Burroughs 5500), the Real Time Data Link (RTDL); and the Real Time Data Router (RTDR). The RTDR specifies the format to be used on the RTDL while the Burroughs 5500 processes this data as it is received from the Data Core equipment located at KSC. During the prelaunch and launch countdown, data from the MILA area is transmitted over the RTDL to the HOSC. Later during orbit S-IVB and IU data is collected at the MCC and passed on to the HOSC via the Data Core equipment at KSC.

3.7 Apollo Range Instrumentation Aircraft (ARIA)

The ARIA are a group of four 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 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 preformed by seven foot steerable antenna, VHF, S-band, HF/SSB receivers and transmitters, and recording and playback equipment. The antenna feed is a monopulse (instantaneous phase comparison) type tracking arrangement with separate elements for P-band and S-band. It can automatically track a target in P-band or S-band. However, procedurally, when both bands are being received simultaneously, S-band track will be used. The beamwidth of the antenna is approximately 40° in the P-band range and 4.7° in the S-band range. The gain is 12db in the P-band range and 29db in the S-band range.

The ARIA is capable of receiving and recording nine links of TLM data in the P and S-bands. Seven dual channel data receivers may be arranged in any combination of S and P-band assignments. In addition, there are four tracking receivers operating in pairs which supply two more links. Telemetry modulation may be in IRIG or USB formats; however, only one USB link can be demodulated for PCM/FM recording. Simultaneous reception and recording of P-band and S-band TLM is possible during periods of voice relay. The following data will be recorded onboard each aircraft:

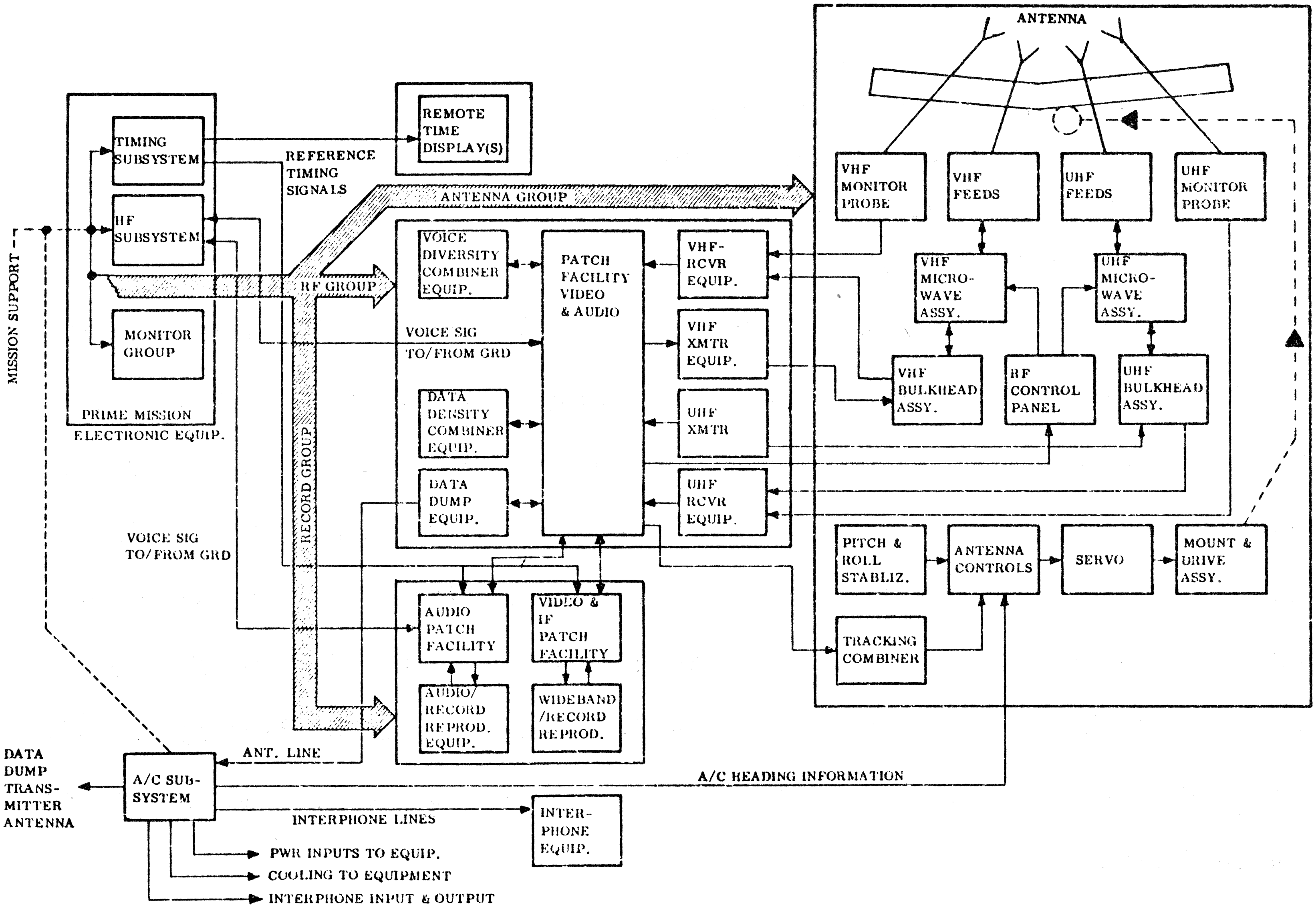


Figure 3H ARIA INTEGRATED

- Wide band magnetic tapes (TLM) - two per aircraft/TSP
- Narrow band magnetic tapes (voice) one per aircraft/day
- AFETR FORM 40 - one per aircraft/TSP which contains:
  1. Airborne Telemetry LOG (ARIA configuration setup)
  2. ARIA Pre/Post Calibration Procedures
  3. Mission Coordinator's Quicklook Reports
  4. Navigation Logs (navigators Plot of Flight Profile)
  5. Telemetry Support Summary
     a. Antenna Operator's Data/Log
     b. Voice Operator's Data/Log
     c. Telemetry Operator's Data/Log
     d. HF Operator's Data/Log
     e. Recorder Operator's Data/Log

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 purpose. The aircraft must be within approximately 175 miles of the station to effect a transfer. Transfer frequencies will usually be 237.8 MHz CPM /FM and 2287.5 MHz PCM/FM/PM. Data transfer at the 51.2 kbps rate requires the same time as the live spacecraft pass. One ARIA run can transfer two tracks of recorded data, one on VHF and one on S-band.

Four ARIA will be available to support the Apollo missions. The aircraft will operate in the Pacific or Atlantic as appropriate. Operational control of the ARIA will be exercised through the Air Operations Control Center (AOCC) at Patrick AFB and the worldwide ARIA communication network. The MSFN will interface with ARIA through the AOCC.

The mission calls for ARIA support of Translunar Injection (TLI) on revolution two or three and from reentry (400,000-foot altitude) to recovery of the spacecraft crew after splashdown.

4.0 Introduction

During the Apollo missions the MSFN stations and the Apollo ship will supply realtime spacecraft position information to the MCC at Houston. This task is accomplished through a series of C-band and Unified S-band System (USBS) tracking radars as well as related processing and support equipment. The MSFN tracking stations will use the tracking formats and the support equipment for transmission of tracking data. This tracking data varies depending upon station location and capability, transmission bit rates, and new equipment implementation schedules. It is the purpose of this chapter to show how the network stations fulfill the mission tracking requirements.

Tracking data is provided to MCC in both high speed and low speed formats. HSD is required during the launch phase and orbital powered flight phase of a mission. When the spacecraft is in free flight, LSD (teletype) is used. TTY transmission provides one sample of tracking data per six seconds while HSD provides rates up to 10 samples per second dependent upon system and site configuration. (One sample of tracking data consists of all the information necessary to determine the spacecraft's position at a particular moment in time.) All formats are 240 bits in length, except for the Apollo Insertion Ship, and each format contains one trajectory data point from the radar or tracking system which is sending the data.

With the exception of Apollo Launch Trajectory Data System (ALTDS) radars, all high speed tracking information is sent to MCC via the NASCOM network (through GSFC to MCC on 50.0 kbps lines). All teletype tracking data is throughput at GSFC and sent to Houston on regular TTY communication lines. Each format (or tracking data sample) contains data ID bits, trajectory data bits, and error coding bits.

The following description is intended to be an indication of the stations' tracking requirement capabilities. Not all the capabilities of the sites are listed, only those that are most linkely to be used during the mission. In addition, a series of charts which contain information pertinent to the tracking capabilities of the network are included.

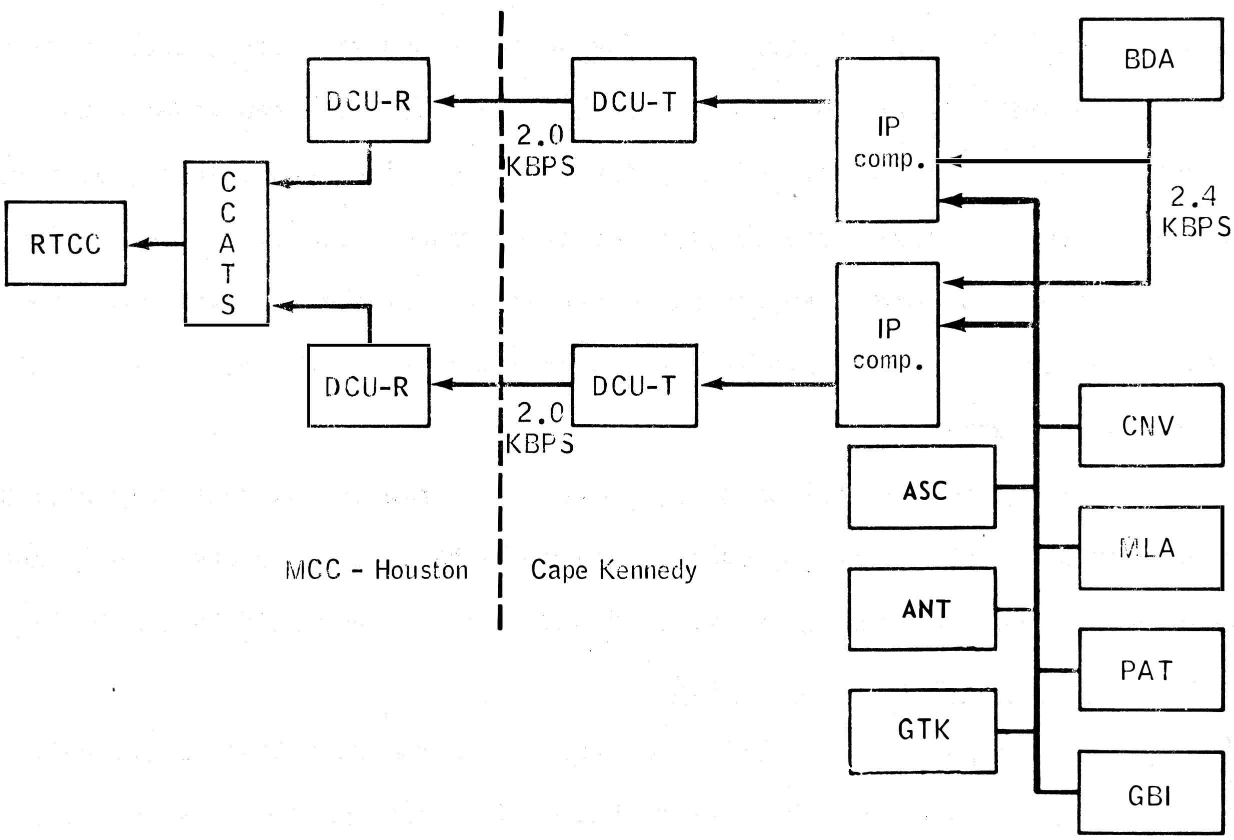
4.1 System Description

4.1.1 C-Band Radars

The C-band tracking radars determine the position of a spacecraft by measuring the range, azimuth, and elevation of the vehicle with respect to the radar. These radars are capable of both skin and beacon tracking. However, since there is no C-band transponder on the Command and Service Module (CSM), beacon tracking will be accomplished only on the S-IVB/IU from launch until battery depletion (approximately 17 hours after launch) or until the slant range exceeds the capability of the system. (Refer to 6.7.12 for land based C-band radar specifications.)

4.1.1.1 Apollo Launch Trajectory Data System (ALTDS)

The ALTDS consists of C-band radars located on the Eastern Test Range (PAT-6, CNV-16, MLA-18, GTI-18, ANT-6) and at BDA (-6, -16M), which supply high speed data to the Real Time Computer Facility (also known as the Impact Predictor) at Cape Kennedy. The IP computer performs a best-source selection of raw incoming data and perms preprocessing (smoothing) of the received data. The



ALTDS TRACKING DATA FLOW

Figure 4

primary purpose of this system is to assist the Range Safety Officer (RSO) in locating the instantaneous impact point of the vehicle in case of an abort situation during launch. Also, it is used to provide launch trajectory data to the RTCC at MCC over two 2.0 kbps lines. The message rate is one message per 0.25 second raw or smooth data; i.e., 0.25 second raw, 0.25 second smooth.

The IP complex has two CDC 3600 computers operating in an active/standby configuration. The high speed C-band output of these sites are input simultaneously to each IP computer. The active computer outputs data to each of two transmitters in two forms: smoothed radar data and raw radar data. Smoothed radar data consists of computer time, position, and velocity vectors (T, R, V) and raw radar data consists of time, range, azimuth, and elevation. The IP computer performs preprocessing (smoothing) of the received raw data points and then output 10 samples/second of raw data and 2 samples/second of smooth vector data.

During the orbital phase of a mission, normally raw data only will be transmitted to MCC; however, smooth data could be sent on request. Only one mission will be supported at a time. No USB data is ever used by the ALTDS.

4.1.1.2 Central Data Processor (CDP)

The ships' CDP is a Univac modified 1230 computer that functionally replaces the Tracking Data Processor at USB sites and the computer and other equipment that processes tracking data at the C-band radar sites. In addition to processing C-band and USB tracking data, this computer performs several other functions (such as navigation, antenna positioning, etc.). The CDP receives ships' position and attitude data, timing system signals, antenna pedestal flexure data, control signals, target acquisition information, and realtime tracking data. It processes the received information to provide data for antenna pointing, ship's position and attitude, trajectory, data recording and display, plotting board tracing, target acquisition, and data transmission. Primary operations are accomplished in standby, acquisition, and tracking modes.

The standby mode is in effect during the countdown prior to acquisition and during the period following a tracking mode operation if a subsequent pass of an orbiting vehicle is to be supported. During this mode, navigation is the principle function handled, and the primary objective is to prepare for the tracking mission.

The main function of the acquisition mode is to enable the tracking system antennas to acquire the target and begin tracking. The tracking mode is entered automatically from the acquisition mode after target is acquired by either the C-band or the USB radar system and sufficient valid data is selected to compute the target's apparent position and velocity.

In this mode computer procedures correct tracking data for ship's attitude and errors caused by:

a. Antenna zero offset, servo lag, droop, and misalignment as computed from ballon tracking tests.

b. Antenna mount flexure due to twisting of the ship.

c. Atmospheric refraction.

The C-band radar is assisted by feed-forward stabilization signals from the CDP. The computer filters the roll, pitch, and reading data received from the attitude reference source and determines the rates of change. These rates are transformed to antenna bearing and elevation rates and transmitted to the C-band radar system as anticipatory corrections to reduce the servo lags.

4.1.2 Unified S-Band (USB) Systems

The USB tracking systems determine the position of a spacecraft by measuring X and Y angles, range, and range rate of the vehicle with respect to the radar. They can be classified in three categories: single 30-foot sites, dual 30-foot sites, and dual 85-foot sites. The difference between a single and a dual system with regard to tracking is that a dual system can determine range and range rate on two vehicles simultaneously (as long as they are within the beamwidth of the single antenna) and angle track on one. There are two USB RER systems at a dual site. The single system has only one RER, one doppler vector, and a "single " TDP. The dual system must have an additional set of the first three components and a "dual" tracking data processor (refer to 6.7.11 for detailed USB specifications).

4.1.2.1 Tracking Processor

The Tracking Data Processor (TDP) is a subsystem used in the USB tracking data handling system and is located at each of the USB sites. It accepts and processes various types of data and provides for the recording (LSD only) and transmission of this information. The inputs to the processor are derived from the ranging subsystem, the shaft angle encoders, the timing subsystem and the tracking receiver. The TDP provides time, X and Y angle information and range and doppler information in serial form, which is compatible with two types of ground communications links: high speed (as high as 2400 BPS) and low speed teletype (60 or 100 words per minute). The processor arranges the above data in the proper format, adds station identification and quality status information, generates a 22 or 33 bit (selectable) polynomial error protection code and inserts it at the end of each frame of HSD.

There are both single-system and dual-system TDP's. The single system displays and transmits range and range rate (doppler) information from only one vehicle, whereas the dual system displays and transmits range and range rate information from two vehicles by alternately transmitting data frames from each vehicle.

4.1.2.2 Ship USBS

The T-AGM-19 Class ship has a dual USB system which is capable of acquiring and automatically tracking the space vehicle in bearing (azimuth), elevation, range, and range rate. A broad beam 3-foot diameter antenna which has a beamwidth of 10° is mounted on the perimeter of the main 30-foot reflector and functions as a target acquisition aid. Additional acquisition data is available from the CDP in digital form or from other selftracking units (such as the main TM antenna) in single speed synchro data. Unlink the land-based USB antennas which have X-Y mounts, the ships' USB antennas are on AZ-EL mounts. The transmitter associated with this radar has a maximum power output of 20 KW when operating in the single mode and 2 KW per link in the dual mode.

4.1.2.3 Central Data Processor (CDP)

As mentioned previously, the CDP performs the function of the TDP as far as USB tracking data is concerned. It corrects the data in the same manner as the C-band data with one exception. The USB data is also corrected for doppler errors. This procedure computes a correction for the doppler measurement reported by the S-band radar to compensate for the motion of the antenna while tracking the spacecraft.

The CDP has the capability to process C-band and USB tracking data simultaneously. This allows the ship to track two vehicles (one S-band and one C-band). However, the CDP does have a limitation in that it can only designate for one vehicle. As soon as the vehicle is acquired, the computer comes out of the acquisition mode and enters the track mode. Once in the track mode the CDP cannot designate for acquisition of another vehicle. Thus, acquisition of the second vehicle would have to be done manually. At that time, the CDP could simultaneously process data from both vehicles and multiplex it into one 600 bit block. The combined data is sent to MCC at the HSD rate of 1.2 KBS. However, the format does not allow for two vehicles to be tracked on USB.

The low speed or TTY data is sent at a 100 WPM rate and is either C-band or USB data, but not both. The HSD is in vector form, whereas the LSD contains range, range rate ((the range rate contains no useful information), X and Y angles or range, azimuth angle, and elevation angel.

Although the HSD rate of 1.2 kbps remains constant for orbital and powered flight, the sample rate changes from one sample/two second to two samples/second. The effective vector rates are:: one vector every two seconds for free flight and one vector every second for powered flight

4.1.2.4 Tracking Data Subsystem

This subsystem is composed of a Shipboard Doppler Counter (SDC) and the USBS data registers. The primary function of the SDC is to count the doppler shift frequency and furnish this count to the Data Registers for end application to the computer in the CDPS. This keeps the range rate of the target utilized by the computer constantly updated.

The function of the Data Registers is to acquire and format data from subsystems within the USBS and, when interrogated, to furnish this to the USBS Interface Buffer in the CDPS in a format suitable for insertion into the computer. The Interface Buffer, in turn, furnishes the data to the computer in the CDPS.

4.1.3 USB Ranging Process

The following is a brief description of the ranging system that is unique to the USBS. It applies to all USB stations both ships and land based.

The ranging system provides information which yields the instantaneous range between the Apollo spacecraft and the ground station. It permits determination of range up to 800,000 KM.

A group of pseudo-random binary sequences are utilized by this system in the formation of a range code. The range code phase modulates an S-band carrier which is transmitted to a spacecraft, where the code is demodulated and then used to modulate a new (phase-coherent) carrier. The new carrier is transmitted back to the ground where a correlation scheme is used in measuring the round trip propagation time of the signal. The system is capable of continuous, realtime measurement of spacecraft range. The pseudo-random ranging code is used to obtain the initial range; thereafter, updating or range is achieved by doppler measurements.

4.2 GSFC CP/MCC Data Transmission

Two 50.0 kbps lines are used for transmission of high speed tracking data from the GSFC communications processor to the CCATS at the MCC. Data is formatted in 600-bit blocks which contain inter-CP control information, trajectory data information, and necessary filler bits.

TTY tracking data will be transmitted from remote sites via TTY lines to the GSFC CP where it will be throughput on TTY lines to MCC. The data appears at CCATS in the TTY form transmitted from the site.

4.2.1 MCC CCATS to RTCC Data Transmission

CCATS receives tracking data from two sources: (1) NASCOM data network and (2) ALTDS data network.

High speed tracking data is received by CCATS in 600-bit blocks from ANSCOM via 50.0 kbps lines from GSFC. These formats are described in the ATDFCB, Section 4.1. In processing this data, CCATS removes bits 1-60, bits 541-600, and any filler bits used in the 600-bit format. Data is then transferred to the RTCC in 36-bit words, the first two words being a Label and Time Word provided by CCATS.

The TTY tracking data is throughput by the GSFC CP to MCC CCATS on long line communication links in the same TTY form transmitted from the remote site. The Univac 494 computer removes the SOM and EOM from the format before adding a CCATS Message Label and Time word. The TTY data is then transferred to the RTCC in the same manner as high speed data.

When data is received by CCATS from the ALTDS, bits 1-12 (DCU-R Label) are removed by CCATS and the remainder of the data is transferred in 36-bit words with the first two words being the CCATS Label and Time Word.

4.2.2 MCC RTCC to CCATS Data Transmission

The RTCC generates acquisition messages and ephemeris data which must be transferred to CCATS for transmission to final destinations. The RTCC to CCATS data formats are composed of the following:

.RTCC/CCATS Message Label
.RTCC/CCATS Time Word
.Routine Indicator Words
.Text of Message

The Message Label, Time Word and Routing Indicator words used for RTCC to CCATS data transfer are described in ATDFCB, Section 4.2.1. The text of each message is transferred in TTY (Baudot) code.

4.3 Mission Configuration

Stated here is what is expected of the MSFN stations in supplying tracking data (launch, free flight, and powered flight) for this mission. Launch will be from Complex at Merritt Island Flordia on a flight azimuth between 72° and 96° into a 100-N. mi. circular Earth Parking Orbit (EPO). During the second EPO revolution, the first opportunity for TLI will occur over the paciffic. The second opportunity for TLI will occur over the Pacific during the third EPO revolution. The following stations and radar have been required to support.

4.3.1 C-Band Support

Station & Radar	Launch	Free Flight	Powered Flight
CRO FPQ-6		1s/6s	10 s/s, 1s/6s
MLA TPQ-18	10 s/s (IP), 1s/6s	1s/6s	
**CNV FPS-16	10 s/s (IP)		
*BDA FPS-16(M)	10 s/s (IP), 1s/6s	1s/6s	
*BDA FPQ-6	10 s/s (IP), 1s/6s	1s/6s	
HAW FPS-16(M)		1s/6s	10 s/s, 1s/6s
Insertion Ship	2 s/s, 1s/6s	1s/6s	2 s/s, 1s/6s

IP = ALTDS (Impact Predictor) Data
*Range Safety Requirement
**Balloon Tracker

Actual site support will be determined in realtime by Site Configuration Message's (SCM's). The C-band radar on this ship will be used to monitor and transmit LSD (no HSD capability) to MCC. Also, certain C-band radars will be required to skin track the CM on entry.

4.3.2 Unified S-Band Support

Station & System	Launch	Free Flight	Powered Flight
MIL 30' Dual	10 s/s, 1s/6s	1s/6s	10 s/s, 1s/6s
BDA 30' Single	10 s/s, 1s/6s	1s/6s	10 s/s, 1s/6s
CYI 30' Single	10 s/s, 1s/6s	1s/6s	10 s/s, 1s/6s
ACN 30' Dual	10 s/s, 1s/6s	1s/6s	10 s/s, 1s/6s
CRO 30' Dual		1s/6s	10 s/s, 1s/6s
GWM 30' Dual		1s/6s	10 s/s, 1s/6s
HAW 30' Dual		1s/6s	10 s/s, 1s/6s
GYM 30' Single		1s/6s	10 s/s, 1s/6s
TEX 30' Single		1s/6s	10 s/s, 1s/6s
GDS 85' Dual		1s/6s	10 s/s, 1s/6s

Station & System	Launch	Free Flight	Powered Flight
HSK 85' Dual		1s/6s	10 s/s, 1s/6s
MAD 85' Dual		1s/6s	10 s/s, 1s/6s
Insertion Ship	2 s/s, 1s/6s	1s/6s	2 s/s, 1s/6s
RID 85' Dual		1s/6s	10 s/s, 1s/6s
NBE 85' Dual		1s/6s	10 s/s, 1s/6s
PIR 85' Dual		1s/6s	10 s/s, 1s/6s

USB Tracking data will be transmitted in realtime or postpass to GSFC and MCC in accordance with the SCM . When required the following rates will be used for transmission.

a. All USB land stations will transmit HSD at a sample rate of ten per second and a bit rate of 2.4 kbps.

b. The Vanguard will transmit HSD at a sample rate of two per second and a bit rate of 1.2 kbps.

c. All LSD will be transmitted at a sample rate of one every six seconds. A DD routing indicator will be used unless data transmission to MCC is required.

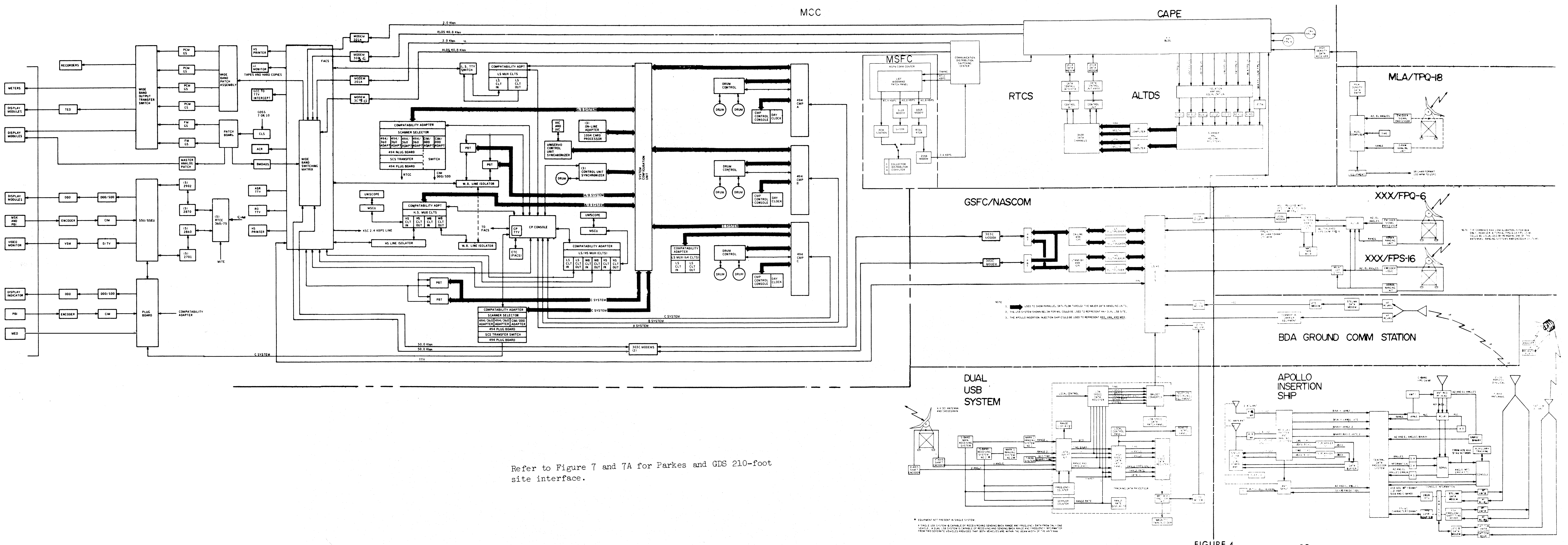
d. After TLI plus three hours, no realtime HSD will be transmitted, except when requested furing lunar orbit.

4.3.3 Apollo Ships

During Apollo the Vanguard (VAN) will be used to support the Insertion pahse of the mission.

The VAN will provide orbital insertion coverage and, at the same time, act as a recovery ship. Its prime functions are to receive, record and transmit, in realtime, telemetry and tracking data (both HSD and LSB) and also to remote A/G voice. However, the ship may be assigned to support abort contingencies. In the event of an abort during the ascent phase of the mission, the recovery coordinator at MCC will determine the need for VAN to support recovery operations.

APOLLO TRACKING NETWORK CONFIGURATION



Refer to Figure 7 and 7A for Parkes and GDS 210-foot site interface.

FIGURE 4

APOLLO TRACKING NETWORK

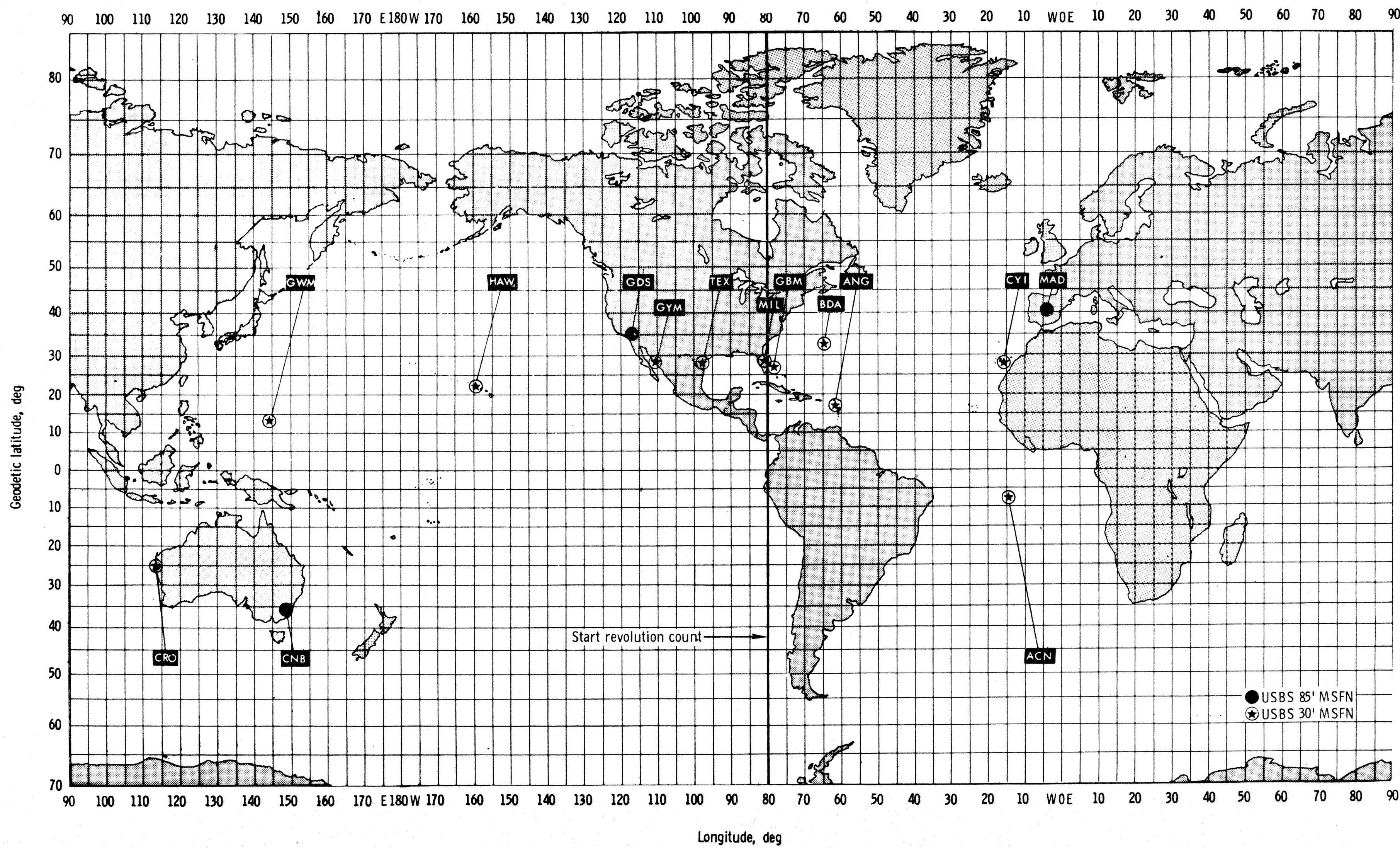


Figure 4B

MSFN INFORMATION CHART

	MIL	MLA	CNV	PAT	BDA	BDA	CYI	ACN	MAD	RID	ARIA	CRO	CRO	PKS	HSK	NBE	GWM	HAW	MAR	GDS	PIR	GYM	TEX	VAN	VAN
USB CAPABILITY	D				8̸		Ⓢ	D	D	D	Ⓢ			Ⓢ	D	D	D	D	S	D	D	Ⓢ	Ⓢ	D	
STATION TTY ID	71	71		21	02	01	04	75	23	94		08	08		25	93	24	12	AE	28	92	14	16	62	62
TYPE ANTENNA MOUNT	XY	AE	AE	AE	XY	AE	XY	XY	XY	HA		XY	AE	AE	XY	HA	XY	XY	TR	XY	HA	XY	XY	AE	AE
TV CAPABILITY	TR				R		R	R	TR	TR		R		T	R	R	R	R		TR	TR	R	TR	R	
NR. DECOMS (DYN)					2			3	3			1			3		3	1		3			1	3	
NR. DECOMS (EMR)					2		3					2						2				3	2		
HIGH SPEED DATA	X				X		X	X	X	X		X			X	X	X	X		X	X	X	X	X	
VHF TLM CAPABILITY	X				X		X	X			X	X					X	X				X	X	X	
NR OF VHF ANTENNAS	2				3		2	1			1	2					1	2				2	2	2	
UHF CMD CAPABILITY			X		X		X	X				X					X	X					X	X	
VHF A/G VOICE	X				X		X	X			X	X					X	X				X	X		
C-BAND RADAR TYPE		18	16	6									6												16
HIGH SPEED DATA		X	X	X									X												X
29 POINT ACQ MSG	X				X		X	X	X	X		X			X	X	X	X		X	X	X	X		
6 POINT ACQ MSG		X	X	X		X							X												X
IRV		X	X	X							X		X												

LEGEND

Ⓢ = NO COMMAND CAPABILITY D = DUAL USB STA S = SINGLE USB STA 8̸ = SITE AND 1/2 XY = XY MOUNT AE = AZ EL MOUNT

T = REALTIME TV TRANSMISSION TO MCC HA = HOUR ANGLE-DECLINATION MOUNT R = RECORD TV (MINCOM 22 RCDR)

Table 1

C - BAND RADAR INSTRUMENTATION CHART

	MLA	PAT	CNV	CRO	BDA	BDA	VAN	
TYPE SYSTEM	TPQ 18	FPQ 6	FPS 16	FPQ 6	FPQ 6	FPS 16	FPS 16	
RNG SYS CAPABILITY	32K NM	32K NM	1K NM	32K NM	32K NM	32K NM	32K NM	
PARAMPS	YES	YES	YES	YES	NO	YES	YES	
ANTENNA POLARIZATION	VC	VC	V	VC	VC	V	VC	
ANTENNA GAIN	51 db	51 db	43 db	51 db	51 db	43 db	46.5 db	
TRANSMITTER POWER	3 MW	3 MW	1 MW	3 MW	3 MW	1 MW	1 MW	
ANTENNA SIZE (FT)	29 FT	29 FT	12 FT	29 FT	29 FT	12 FT	16 FT	
PHASING	AUTO	AUTO	AUTO	IN ONLY	AUTO	AUTO	AUTO	
ANCILLARY COMPUTER	4101	4101	NO	4101	4101	Q-6'S 4101	1230	
MAG TAPE RECORD	YES	YES	YES	YES	YES	YES	YES	
DATA TRANSMISSION H L	2.0 TTY	2.0 TTY	2.0 NO	2.4 TTY	2.4 TTY	2.4 TTY	1.2 TTY	
PLOT BOARD	NO	NO	NO	YES	YES	YES	YES	
DIGITAL DESIGNATE	YES	YES	NO	YES	YES	SLAVE Q-6	YES	
MSFN STATION TTY ID	71	21	N/A	08	01	02	62	
DOD STA DES	19	0	1		2A	2		

TABLE 2

CSM SKIN TRACK CAPABILITY

Site/System			Acquisition Range 12 db		Max Range 0 db	
			Horiz/Vert Polarization n.mi.	Circular Polarization n.mi.	Horiz/Vert Polarization n.mi.	Circular Polarization n.mi.
FPS-16 FPS-16-M	VAN	w/paramp	237	188	474	376
		w/o paramp	168	133	336	266
	CNV	w/paramp	168	139	336	278
		w/o paramp	126	99	252	188
TPQ-18 or FPQ-6 MLA PAT	WBW	w/paramp	720	569	1440	1138
		w/o paramp	540	427	1080	854
BDA CRO	NBW	w/paramp	972	795	1944	1590
		w/o paramp	763	596	1526	1192

Table 3

GENERAL USB DATA

SINGLE USB SITE

EQUIPMENT

1 Power Amp	1 Updata Buffer
1 Exciter	1 Ranging System
1 Subcarrier Oscillator System	1 Doppler Detector
1 Verification Receiver	1 Single Tracking Data Processor
1 TR-104 Receiver (FM Voice & TLM only)	

CAPABILITY	REMARKS
Angle Track, 1 Vehicle	2-way Phase Lock
Ranging, 1 Vehicle	2-way Phase Lock
Doppler Measurement, 1 Vehicle	2-way Phase Lock
Updata (Command), 1 Vehicle	2-way Phase Lock
Up-Voice, 1 Vehicle	
Receive 3 downlink frequencies	

DUAL USB SITE - 85'

EQUIPMENT

2 Power Amps	1 Updata Buffer
2 Exciters	2 Ranging Systems
2 Subcarrier Oscillator Systems	2 Doppler Detectors
2 Verification Receivers	1 Dual Tracking Data Processor

TABLE 4

CAPABILITY	REMARKS
Angle Track, 1 Vehicle	2-way Phase Lock
Ranging, 2 Vehicles	Both must be in antenna beam width
Doppler Measurement, 2 Vehicles	Both must be in antenna beam width
Updata (Commands), 2 Vehicles	Commands are sequential, not simul.
Up-Voice, 2 Vehicles	Simultaneous
Receive 4 downlink frequencies	

DUAL USB SITE - 30'

Same as Dual 85' Site except 1 power amplifier only - both exciters feed the power amp through a compiner. 2.0 KW max when operating in dual (2-frequency simultaneously) uplink mode.

USB SITE-AND-A-HALF

EQUIPMENT

1 Power Amp	1 Updata Buffer
2 Exciters	1 Ranging System
2 Subcarrier Oscillator Systems	1 Doppler Detector
2 Verification Receivers	1 Single Tracking Data Processor
TR-104 Receiver (FM Voice & TLM only)	

CAPABILITY	REMARKS
Angle Track, 1 Vehicle	2-way Phase Lock
Ranging, 11 Vehicles	2-way Phase Lock
Doppler Measurement, 1 Vehicle	2-way Phase Lock
Updata, 2 Vehicles	Commands are sequential, not simul.
Up-Voice, 2 Vehicles	Simultaneous
Receive 3 downlink frequencies	

UPLINK MODES - CSM: 2106.4 MHZ LM/SLV - 2101.8 MHZ

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	SUBCARRIER FREQUENCY (MHZ)	PEAK SUBCARRIER DEVIATION (KHZ)	PEAK CARRIER DEVIATION
0	No Carrier	---	---	---	---
1	Ranging	PM on Carrier	---	---	1.34 ± 0.13 Rad
2	Voice	FM/PM	30	7.5	1.85 ± 0.18 Rad
3	Command	PSK/FM/PM	70	5.0	1.85 ± 0.18 Rad
4	Ranging	PM on Carrier	---	---	0.38 ± 0.04 Rad
	Voice	FM/PM	30	7.5	1.2 ± .12 Rad
5	Ranging	PM on Carrier	---	---	0.38 ± 0.04 Rad
	Command	PSK/FM/PM	70	5.0	1.2 ± .12 Rad
6	Ranging	PM on Carrier	---	---	0.44 ± 0.04 Rad
	Voice	FM/PM	30	7.5	1.0 ± 0.1 Rad
	Command	PSK/FM/PM	70	5.0	1.0 ± 0.1 Rad
7	Voice	FM/PM	30	7.5	1.1 ± 0.1 Rad
	Command	PSK/FM/PM	70	5.0	1.1 ± 0.1 Rad
8	Ranging	PM on Carrier	---	---	0.38 ± 0.04 Rad
	Backup Voice	FM/PM	70	5.0	1.2 ± 0.12 Rad
9	Carrier Only	---	---	---	---
			ALSEP - 2119 MHZ		
3	Command	PSK/PM on Carrier	---	---	±3.0 Rad

Table 5-A

CSM PM DOWNLINK MODES (2287.5 MHZ)

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	INFORMATION FREQUENCY (KHZ)	SUBCARRIER FREQUENCY (MHZ)	PEAK SUBCARRIER DEVIATION	PEAK CARRIER DEVIATION (Rad)
00	No Carrier	---	---	---	---	---
01	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.2 + 20%, -10%
	*Voice	FM/PM	---	1.25	7.5 KHZ	0.7 + 20%, -10%
02	Ranging	PM on Carrier	---	---	---	Varies with Received uplink
	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.2 + 20%, -10%
	*Voice	FM/PM	---	1.25	7.5 KHZ	0.7 + 20%, -10%
03	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.2 + 20%, -10%
	*Voice	FM/PM	---	1.25	7.5 KHZ	0.7 + 20%, -10%
04	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	0.7 + 20%, -10%
	*Voice	FM/PM	---	1.25	7.5 KHZ	1.2 + 20%, -10%
05	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.6 + 20%, -5%
06	KEY	AM/PM	---	512 (KHZ)	100%AM	1.0 + 15%, -10%
07	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
08	Backup Voice	PM on Carrier	---	---	---	0.7 + 15%, -10%
	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.2 + 20%, -10%
09	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.6 + 15%, -10%
10	Backup Voice	PM on Carrier	---	---	---	1.2 + 15%, -10%

Table 5-B

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	INFORMATION FREQUENCY (KHZ)	SUBCARRIER FREQUENCY (MHZ)	PEAK SUBCARRIER DEVIATION	PEAK CARRIER DEVIATION (Rad)
11	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
	*Voice	FM/PM	---	1.25	7.5 KHZ	1.2 + 20%, -10%
12	*Voice	FM/PM	---	1.25	7.5 KHZ	1.2 + 20%, -10%
13	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.6 + 15%, -10%
14	Backup Voice	PM on Carrier	---	---	---	0.7 + 15%, -10%
15	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.6 + 15%, -10%
16	Backup Voice	PM on Carrier	---	---	---	1.2 + 15%, -10%
	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.2 + 20%, -15%

*May be CSM or LM voice relay. In the relay mode, the peak S/C deviation for relayed LM voice is 8.0 KHZ and for CSM voice is 4.0 KHZ (only if CSM is in Duplex A).

NOTE: Ranging can be added to any CSM PM downlink mode that has backup voice.

Table 5-B (Con't.)

CSM FM DOWNLINK MODES (2272.5 MHz)

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	SUBCARRIER FREQUENCY	PEAK SUBCARRIER DEVIATION	PEAK CARRIER DEVIATION
00	No Carrier	---	---	---	---
01	P/B Voice 1:1	FM Baseband	---	---	100 KHz +20%,-40%
	P/B SCI 1:1	FM/FM	95 KHz		
	P/B SCI 1:1	FM/FM	125 KHz		
	P/B SCI 1:1	FM/FM	165 KHz		
	P/B HBR 1:1	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
02	P/B Voice 32:1	FM Baseband	---	---	100 KHZ +20%,-40%
	P/B SCI 32:1	FM/FM	95 KHz		
	P/B SCI 32:1	FM/FM	125 KHz		
	P/B SCI 32:1	FM/FM	165 KHz		
	P/B LBR 32:1	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
03	P/B LM LBR 32:1	FM Baseband	---	---	200 KHz +25%,-50%
04	Television	FM Baseband	---	---	1 MHz ±10%
05	R/T SCI	FM/FM	95 KHz		
	R/T SCI	FM/FM	125 KHz		
	R/T SCI	FM/FM	165 KHz		
06	R/T HBR	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
07	R/T LBR	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
08	P/B SCI 1:1	FM/FM	95 KHZ		
	P/B SCI 1:1	FM/FM	125 KHz		
	P/B SCI 1:1	FM/FM	165 KHz		
	R/T HBR	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
09	P/B SCI 1:1	FM/FM	95 KHz		
	P/B SCI 1:1	FM/FM	125 KHz		
	P/B SCI 1:1	FM/FM	165 KHz		
	R/T LBR	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
10	P/B LM LBR 8:1	FM Baseband	---	---	200 KHz +25%,-50%
11	P/B Voice 1:1	FM Baseband	---	---	100 KHz +20%,-40%
	P/B HBR 1:1	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%
12	P/B Voice 32:1	FM Baseband	---	---	800 KHz +20%,-40%
	P/B LBR 32:1	PCM/PM/FM	1.024 MHz	PSK ±90°	600 KHz ±15%

TABLE 5-C

LM PM & FM DOWNLINK MODES (2282.5 MHZ)

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	INFORMATION FREQUENCY (KHZ)	SUBCARRIER FREQUENCY (MHZ)	PEAK SUBCARRIER DEVIATION	PEAK CARRIER DEVIATION
00	No Carrier	---	---	---	---	---
01	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.3 + 21%, -15% Rad
	Voice	FM/PM	---	1.25	5.5 - 10.45 KHZ	0.9 + 22%, -14% Rad
	EVCS(EVC-2 EKG)	FM/FM/PM	3.9	1.25	.347 - 2.14 KHZ	
	EVCS(EVC-1 EKG)	FM/FM/PM	5.4	1.25	.576 - 2.63 KHZ	
	EVCS(EVC-2 PAM)	FM/FM/PM	7.35	1.25	1.365 - 5.5 KHZ	
	EVCS(EVC-1 PAM)	FM/FM/PM	10.5	1.25	2.56 - 7.40 KHZ	
	H.L. Biomed	FM/FM/PM	14.5	1.25	2.9 - 3.8 KHZ	0.9 + 22%, -14% Rad
02	Ranging	PM on Carrier	---	---	---	Varies with Received Uplink
	HBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.3 + 21%, -15% Rad
	Voice	FM/PM	---	1.25	5.5 - 10.45 KHZ	0.9 + 22%, -14% Rad
	EVCS(EVC-2 EKG)	FM/FM/PM	3.9	1.25	.347 - 2.14 KHZ	
	EVCS(EVC-1 EKG)	FM/FM/PM	5.4	1.25	.576 - 2.63 KHZ	
	EVCS(EVC-2 PAM)	FM/FM/PM	7.35	1.25	1.365 - 5.5 KHZ	
	EVCS(EVC-1 PAM)	FM/FM/PM	10.5	1.25	2.56 - 7.40 KHZ	
	H.L. Biomed	FM/FM/PM	14.5	1.25	2.9 - 3.8 KHZ	0.9 + 22%, -14% Rad
03	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.3 + 21%, -15% Rad
04	Backup Voice	PM on Carrier	---	---	---	0.8 + 25%, -15% Rad
	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	1.3 + 21%, -15% Rad
05	Backup Voice	PM on Carrier	---	---	---	0.8 + 25%, -25% Rad
06	Key	AM/PM	---	512 KHZ	100%	1.4 + 20%, -16% Rad
07	LBR TLM	PCM/PM/PM	---	1.024	PSK ±90°	0.7 + 21%, -15% Rad
	Voice	FM/PM	---	1.25	5.5 - 10.45 KHZ	1.3 + 22%, -14% Rad
	EVCS(EVC-2 EKG)	FM/FM/PM	3.9	1.25	.347 - 2.14 KHZ	
	EVCS(EVC-1 EKG)	FM/FM/PM	5.4	1.25	.576 - 2.63 KHZ	
	EVCS(EVC-2 PAM)	FM/FM/PM	7.35	1.25	1.365 - 5.5 KHZ	
	EVCS(EVC-1 PAM)	FM/FM/PM	10.5	1.25	2.56 - 7.40 KHZ	
	H.L. Biomed	FM/FM/PM	14.5	1.25	2.9 - 3.8 KHZ	1.3 + 22%, -14% Rad

Table 5-D

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	INFORMATION FREQUENCY (KHZ)	SUBCARRIER FREQUENCH (MHZ)	PEAK SUBCARRIER DEVIATION	PEAK CARRIER DEVIATION
08	Backup Voice	PM on Carrier	---	---	---	0.73 + 63%, -34% Rad
	H.L. Biomed	FM/PM	---	14.5 KHZ	1088 HZ	0.2 + 25%, -20% Rad
	EVCS(EVC-2 EKG)	FM/PM	---	3.9 KHZ	293 HZ	0.16 + 69%, -38% Rad
	EVCS(EVC-1 EKG)	FM/PM	---	5.4 KHZ	405 HZ	0.18 + 67%, -33% Rad
	EVCS(EVC-2 PAM)	FM/PM	---	7.35 KHZ	551 HZ	0.31 + 65%, -36% Rad
	EVCS(EVC-1 PAM)	FM/PM	---	10.5 KHZ	788 HZ	0.36 + 67%, -36% Rad
	LBR	PCM/PM/PM	---	1.024	PSK ±90°	See Note
09	*HBR or LBR TLM	PCM/PM/FM	---	1.024	PSK ±90°	450 + 21%, -15% KHZ
	Voice	FM/FM	---	1.25	5.5 to 10.45 KHZ	225 + 22%, -14% KHZ
	EVCS(EVC-2 EKG)	FM/FM/FM	3.9	1.25	.347 to 2.14 KHZ	
	EVCS(EVC-1 EKG)	FM/FM/FM	5.4	1.25	.576 to 2.63 KHZ	
	EVCS(EVC-2 PAM)	FM/FM/FM	7.35	1.25	1.365 to 5.5 MHZ	
	EVCS(EVC-1 PAM)	FM/FM/FM	10.5	1.25	2.56 to 7.40 KHZ	
	H.L. Biomed	FM/FM/FM	14.5	1.25	2.9 to 3.8 KHZ	225 + 22%, -14% KHZ
10	Television (Color)	FM	---	---	---	1.3 + 23%, -15% MHZ
	HBR or LBR TLM	PCM/PM/FM	---	1.024	PSK ±90°	450 + 21%, -15% KHZ
	Voice	FM/FM	---	1.25	5.5 to 10.45 KHZ	225 + 22%, -14% KHZ
	EVCS(EVC-2 EKG)	FM/FM/FM	3.9	1.25	.347 to 2.14 KHZ	
	EVCS(EVC-1 EKG)	FM/FM/FM	5.4	1.25	.576 to 2.63 KHZ	
	EVCS(EVC-2 PAM)	FM/FM/FM	7.35	1.25	1.365 to 5.5 MHZ	
	EVCS(EVC-1 PAM)	FM/FM/FM	10.5	1.25	2.56 to 7.40 KHZ	
	H.L. Biomed	FM/FM/FM	14.5	1.25	2.9 to 3.8 KHZ	225 + 22%, -14% KHZ
11	Carrier, PRN	PM on Carrier	---	---	---	Varies with Received Uplink

NOTE: Peak carrier deviation in the low power mode is 0.7 + 21%, -15% Rad
Peak carrier deviation in the high power mode is 1.3 + 30%, -24% Rad

*Bit rate will be specified in the site configuration message.

Table 5-D (Con't)

SLV PM DOWNLINK MODES (2282.5 MHZ)

MODE	SIGNAL COMBINATION	MODULATION TECHNIQUE	SUBCARRIER FREQUENCY(MHZ)	PEAK SUBCAR-RIER DEVIATION	PEAK CARRIER DEVIATION (Rad)
00	No Carrier	---	---	---	---
01	PRN Ranging	PM on Carrier	—	—	Varies with received uplink
	72 KBPS Data	PCM/PM/PM	1.024	PSK ±90°	1.22 ±25%
02	AUX. OSC. (72 KBPS)	PCM/PM	1.024	PSK ±90°	1.22 ±25%

TABLE 5-E

ALSEP DOWNLINK MODES

MODE	BIT RATE	MODULATION TECHNIQUE	PEAK CARRIER DEVIATION (Rad)
01	0.53 KBPS	PCM/PM	1.25 ±5%
02	1.06 KBPS	PCM/PM	1.25 ±5%
03	10.6 KBPS	PCM/PM	1.25 ±5%

Currently planned ALSEP frequencies:

SYSTEM	Apollo Flight	Frequency
EASEP	11	2276.5
ALSEP - A	12	2278.5
ALSEP - B	13	2275.5
ALSEP - C	14	2279.5
ALSEP - A2	15	2278.0

ALSEP UPLINK frequency will be 2119 MHZ.

TABLE 5-F

SIMULATION NETWORK CONFIGURATION

5.0 Introduction

The Apollo simulation data flow is composed of two categories: MCC/ASCATS and Net Sim. Each category is defined according to its capabilities. The MCC/ASCATS category is used for Attitude Control Sims, Launch Sims, and Sim Net Sims. The NetwSims category is an end-to-end integrated system data flow test used only for MSFN Simulations.

The Apollo mission simulations (Sim Net Sim) are generated and controlled in Building 30 by the Apollo Simulation, Checkout, and Training System (ASCATS). The mission data exchange which trains MOCR and SSR flight controllers and exercises MCC mission operations equipment and programs, is provided by the MCC interface with ASCATS.

Vehicle telemetry and tracking data for all mission phases are output by the Ground Support Simulation Computer (GSSC). During launch CCATS receives Impact Predictor (IP) data at a 2 kbps rate from GSSC. The Multichannel Demultiplexer and Distributor (MDD) decommutates the vehicle telemetry data from the GSSC. The MDD routes the data in each of two ways: it returns the decommutated data to the GSSC telemetry processor for output of Apollo Launch Data System (ALDS) 40.8 kbps wide band telemetry to CCATS; and MDD output is also sent to the Apollo Process Control Unit (APCU), which performs the remote site data processing functions. Vehicle tracking information received from GSSC is combined with telemetry data by the APCU which routes it to CCATS via the 50.0 kbps MSFN format. Multiplexed remoted site data normally output to CCATS by the GSFC Central Processor, is contained in the MSFN format. The CCATS/ASCATS simulated MSFN interface is used as a two-way line, a network command and teletype exchange, and a simulator for Countdown and Status Transmission System (CASTS) events.

Since GSSC and APCU data are monitored on CRT's which receive their inputs via an MCVG, they form part of the Apollo Simulation Control Area (ASCA) which is responsible for controlling and moniotring simulation exercises. The ASCA interfaces with the GSSC and APCU for entering vehicle math model faults, controlling the ground track program, requesting displays, and assigning sites is provided for by the Slow Speed Interface Adapter (SSIA). When a given site is assigned, the APCU (which can receive a maximum of three site assignments at once) will perform the remote site command, tracking, and telemetry data processing functions for that site. After site assignment, a site's Loss of Signal (LOS) and Acquisition of Signal (AOS) will be controlled automatically by inputs to the APCU from the GSSC ground track program. The GSSC begins prelaunch at one minute intervals from T-30 minutes to T-3 minuets, while T-1 mission phases are simulated continuously through reentry. Until separation plus 60 seconds, the GSSC outputs S-1C and S-II data. The GSSC outputs S-IVB and IU data until terminated by Manual Engry Device (MED) control or a negative flight path angle is reached for trajectories that do not go above 10,000 feet. The GSSC will output CSM data until a negative flight path angle is reached for trajectories that do not go above 10,000 feet, or until an altitude of 10,000 feet is reached on reentry. If a program stop occurs after earth parting orbit insertion, the GSSC can be restarted (reinitialized). The capabilities exist to restart the GSSC in orbit and to step ahead the simulation in time from one non-thrusting point to another non-thrusting point, provided there is no intermediate thrusting maneuver. The minimum orbital restart points (reset points) required are T + 02:45:00, T + 07:00:00, and T + 07:30:00.

5.1 Network Simulation Data

The ASCATS is not required for Net Sims. All tracking and telemetry data is supplied by tapes while normal MSFN data processing and routing are used. Telemetry tapes are prepared in the appropriate vehicle air/ground format and are played back at the remote sites during the Net Sims.

All IP data sources, trajectory tapes are played into the operational Impac Predictor Program while all other high speed tracking is supplied by tapes played at the appropriate stations during launch and ignition. The normal command loading and uplinking procedures for the operational network to support mission simulation are voice, teletype, and high speed.

5.1.1 Mission Control Data Link

Simulated data is distributed between ASCATS Building 30 and other MCC buildings (Building 47, Bell Telephone and Building 5, Flight Crew Trainers). The Mission Operations Wing (MOW) data links simulate the interface between the MCC and the MSFN. These links are shown in Figures 5-5-E. The following equipment is included:

5.1.2 Standard Data Modulator-Demodulators (Modems)

The modems provide the interface between ASCATS data circuits and standard communication lines. Their function is to mix the characteristic of the standard communications carrier wave with the wave characteristics of intelligence carried (modulate) and to separate such waves on the receiving end (demodulate). ASCATS utilizes:

SIMULATION NETWORK CONFIGURATION

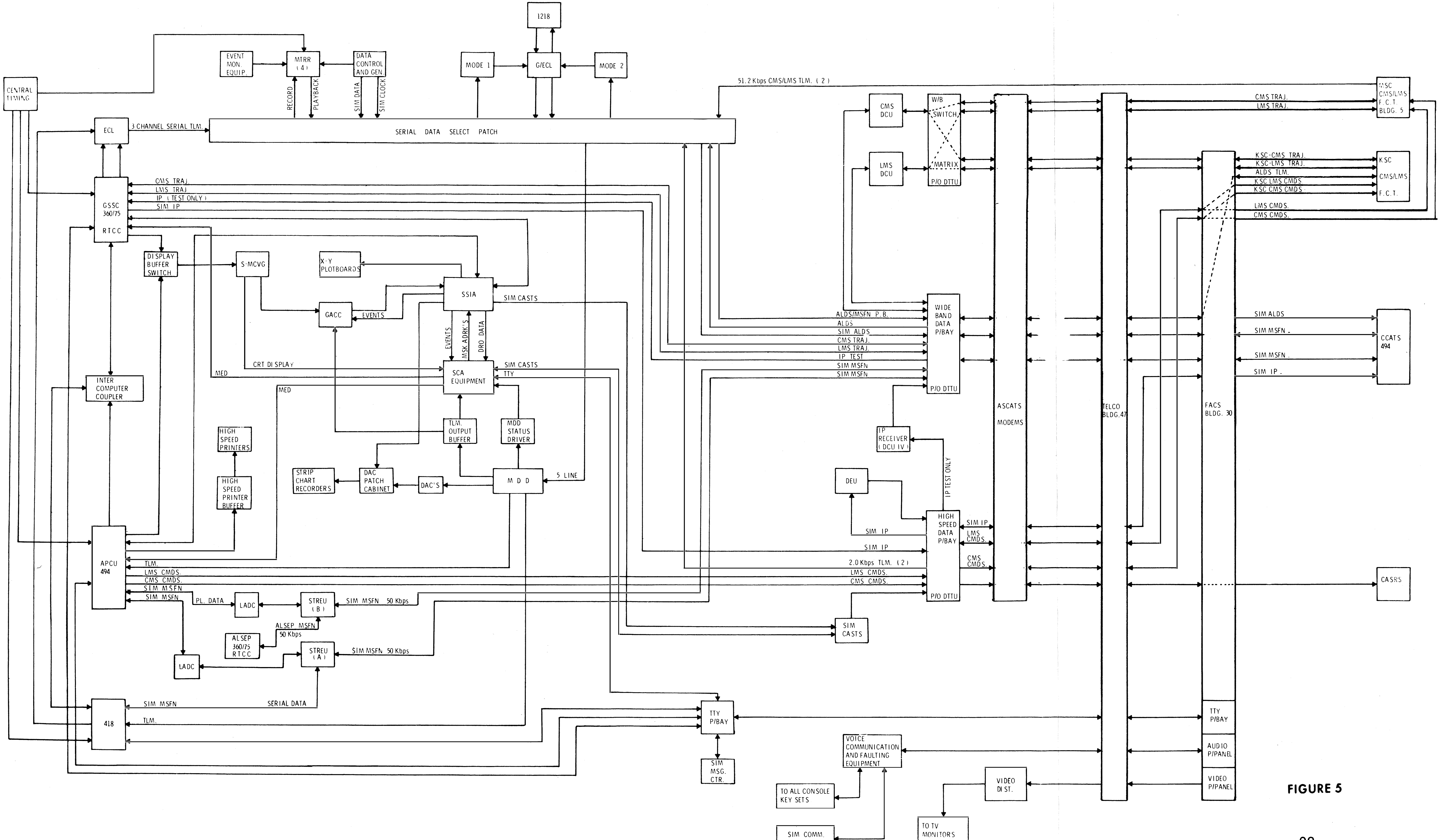


FIGURE 5

•303G Modems

The 303G modulates/demodulates circuits having a capacity of 40.8 kbps. The ASCATS 303G's and the corresponding ones located in FACS are involved in the flow of simulated ALDS data to and from CCATS, simulated trajectory data to and from CSM/LM mission simulators. (Refer to page 139 for 303C modem description.)

•201B Modems

The 201B modulates/demodulates circuits having a capacity of 2.4 kbps. The ASCATS 201B's and the corresponding ones, are involved in the flow of simulated IP data to and from CCATS, CASTS data to and from CCATS and CSM/LM command data to and from flight crew trainers.

5.1.3 Logic and Data Converter (LADC)/Simulation Transmit/Receive Encoder Unit (STREU)

The STREU functions as the error checking and synchronization unit for transfer of simulation MSFN multiplex data between a 303G full duplex data modem and either the SSP or the LADC which interfaces the APCU computer. The STREU and LADC each function as two independent sections, one for transmit and one for receive. The STREU uses a polynomial encoding and validating system to check all data transmission for errors. A 33-bit modified polynomial error code is added to each data block being transmitted from the STREU to the 303G modem. Data transfer from the STREU to LADC and LADC to APCU does not contain the polynomial code.

The STREU/LADC data rate is 50.0 kbps. Either a 600-bit or 1200-bit format is selectable. Consecutive message segments must be of the same format.

The APCU to LADC shall be a 19 or 39, 30-bit parallel, data word transfer (570 or 1170 bits), with the last three bits (227, 228, 229) of the last word as filler bits. The LADC-to-STREU shall be a 576- or 1184-bit serial data transfer with filler bits after data bits 567 or 1167. In addition of the 33-bit polynomial in the STREU completes the 600 or 1200-bit format. Logic conversion and data formatting is accomplished in the LADC to make the STREU and APCU compatible. The data format from the STREU-to-LADC and the LADC-to-APCU shall be a 30-bit parallel, nominal 600- or 1200-bit length, and does not include the polynomial. STREU-to-LADC and LADC-to-APCU shall be a 19 or 39, 30-bit parallel data transfer. The 33-bit polynomial error code shall be filler bits and the message status bit defining the validity of the 33-bit polynomial shall be bit 2^{29} of the last word of the buffer. The LSB (2^0) of the 30-bit word is the first data bit on the line to MCC and also from MCC.

5.1.3.1 <u>Data Control and Encoder Units</u>

The Data Control Units receives or transmit via the GSSC and flight crew trainers for 40.8 kbps trajectory data. Date Encoder Unit (DEU) provides the interface between GSSC and CCATS for 2.0 kbps simulated IP data. Serial STREU provides the interface between the APCU and CCATS for simulated 50.0 kbps MSFN data.

5.1.4 <u>Multichannel Demultiplexer and Distributor (MDD)</u>

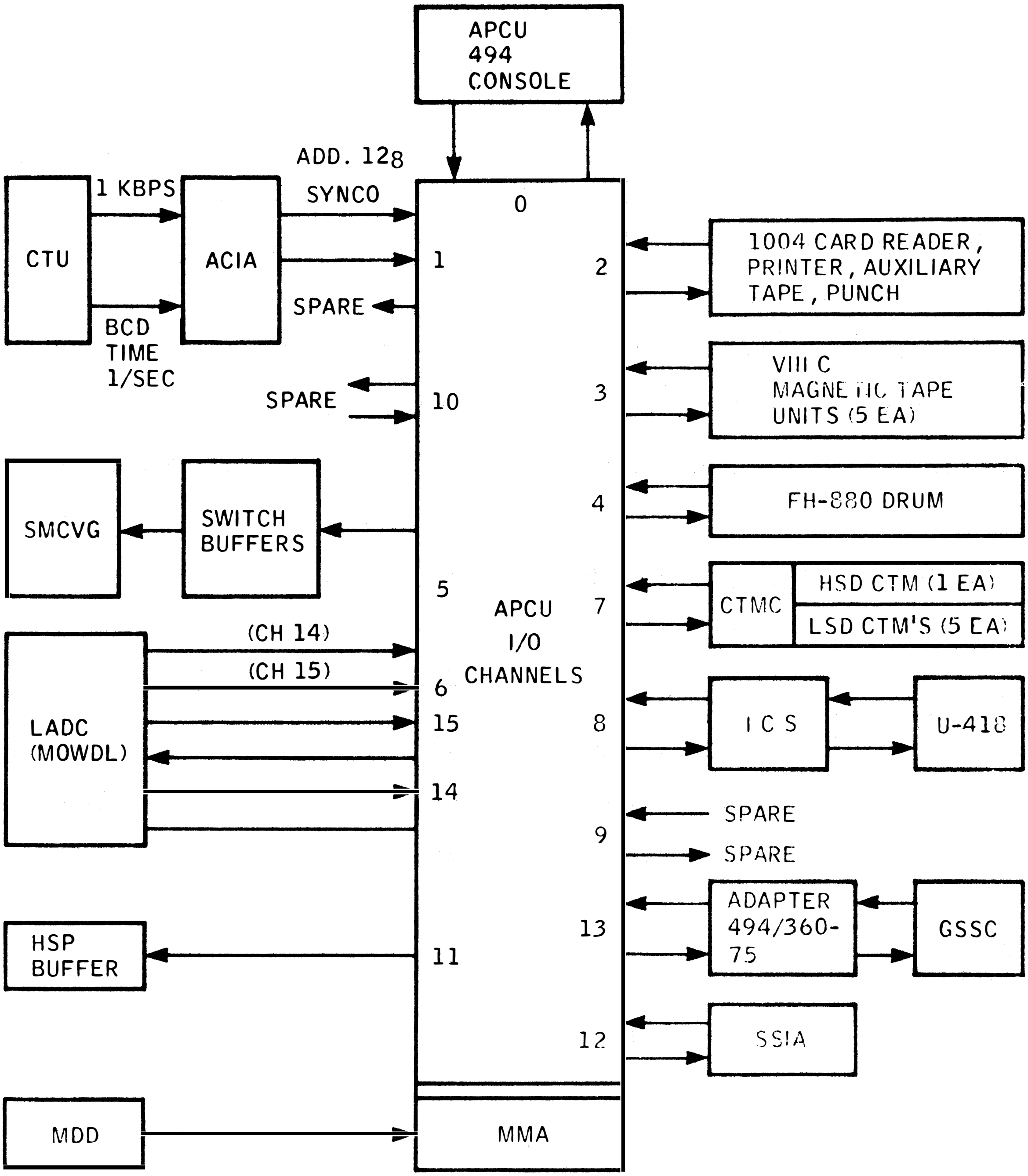
The MDD is a special purpose, hardwired data processing device with an 8K memory which simulates functions performed by the Apollo PCM Telemetry Equipment. The MDD simulates the PCM equipment and is capable of demultiplexing five channels of serial telemetry data simultaneously. The MDD also decommutates, formats, converts from serial PCM to parallel bit form, and distributes telemetry data to ASCATS computers. Input to MDD may be from simulated ALDS KSC or from ASCATS dynamic computer.

5.1.5 Apollo Process Control Unit (APCU)

The APCU is a Univac 494 computer system which performs two primary functions: (a) simulates selected input and output data processing functions normally accomplished by the Remote Site Data Processors (RSDP), and (b) simulates the 50.0 kbps serial data stream between the MCC (CCATS) and the MSFN (GSFC).

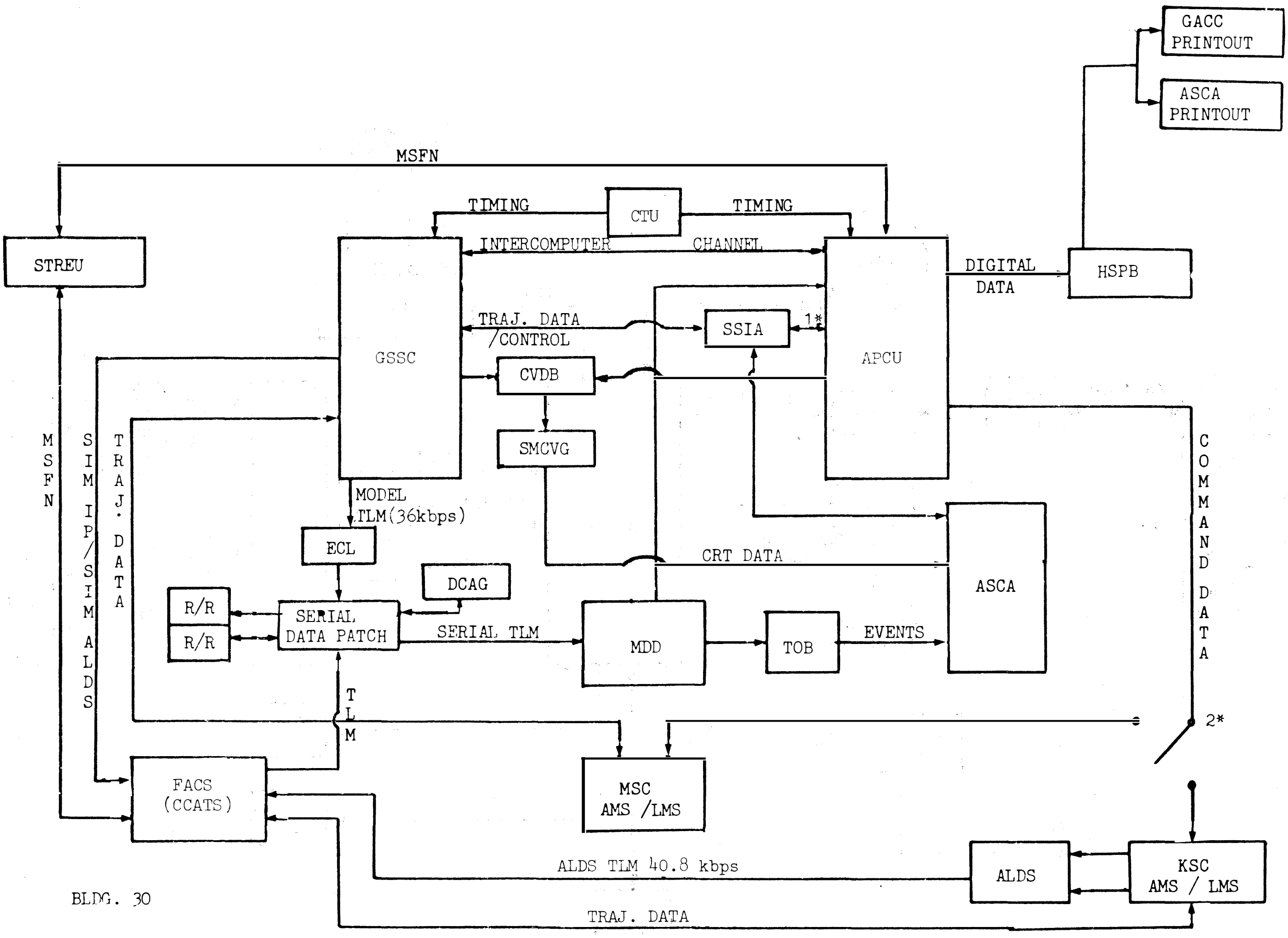
The APCU simulates the functions of the two Univac 642B computers at Apollo remote sites by processing data received from the MDD and placing it in three input decommutation tables (simulating three remote sites). These tables become the source of data for CRT and direct display in flight control areas. In addition, these tables provide the source of data for telemetry faulting and generation of site summary data normally transmitted to MCC through MSFN (GSFC). This data can be displayed at the Apollo Simulation Control Area via high speed printers. The APCU simulates the functions of the remoted site command Univac 642B by processing, validating, and storing simulated commands for transmission to simulated spacecraft.

The APCU simulates the 50.0 kbps MSFN data flow between MCC and GSFC by reformatting the data in the input decommutation tables and tracking data from the GSSC to represent realtime data flowing from three remote sites simultaneously. This data is in a format identical to the received at MCC (CCATS)



APCU Input/Output Channel Characteristics

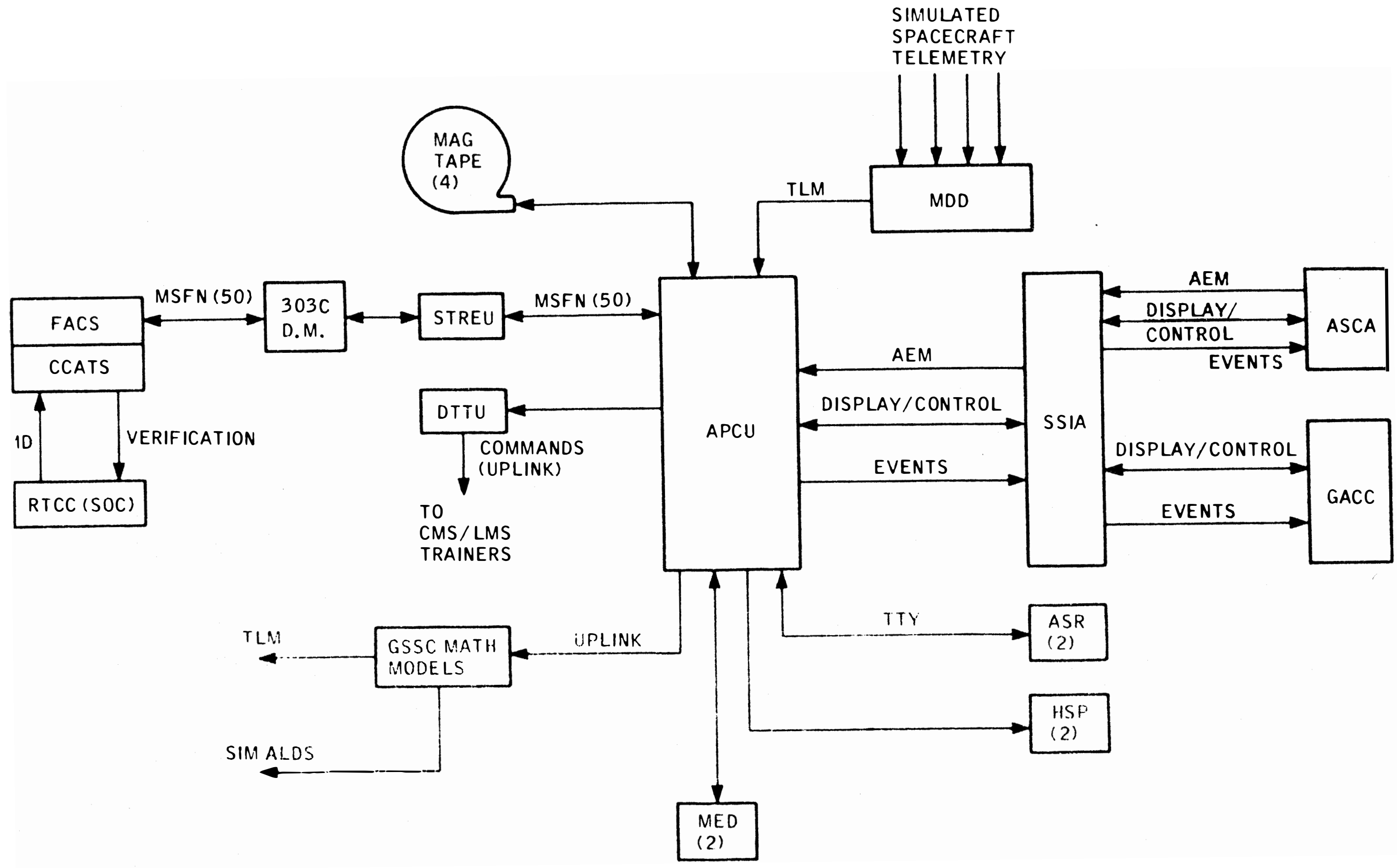
FIGURE 5A



*NOTES: DTTU and Data Modems are not shown.
1) Display & Control Data
2) MSC/KSC transfer switch

GENERAL SYSTEM DATA FLOW

Figure 5-B



Command Data Flow

Figure 5C

from the GSFC's data processor (Univac 494 computer). The APCU simulates GSFC by receiving 50.0 kbps data from MCC.

5.1.6 Ground Support Simulation Computer (GSSC)

The GSSC is an IBM 360/75 computer system which performs the following functions:

.Generates spatial position data and dynamic telemetry and command response data for the CSM, LM, S-IVB, S-IB, S-IC, and S-II vehicles using dynamic models. The GSSC ground track program transforms spatial position data into local radar coordinates for inputting to trajectory display processors and for ground track computations. GSSC models provide dynamic telemetry and trajectory response to fault or control inputs from the ASCA, and have the capability of simulating vehicle onboard faults.

.GSSC models provide realistic vehicle data which can be routed to the ASRS (via the MDD and APCU). This data can also be routed to CCATS in MSFN message format (through APCU) for integrated MOCR simulations.

.The GSSC simulates the ALDS by generating simulated KSC and status information system (CCATS) data. ALDS data may be generated by GSSC and transferred to CCATS as if it were being transmitted from KSC in realtime.

.The GSSC simulates the Apollo Launch Trajectory Data System (ALTDS) by generating impact predictor (IP) and high speed tracking data. The simulated IP data is transmitted to CCATS at 2.0 kbps as if it came from KSC.

5.1.7 Slow Speed Interface Adapter (SSIA)

The SSIA is a nonprogramable, hardwired distributor which provides two channels of interface between the ASCA and the two ASCATS computers (APCU and

GSSC). The SSIA also provides an interface between the APCU and the GACC.

The SSIA acts as a computer input multiplexer for the various control devices located in the ASCA. These include APCU entry modules, Manual Select Keyboards, and Display Request Keyboards. The GSSC/APCU Control Console also operates through the SSIA. The APCU has a two-way parallel interface with the SSIA (40.8 kbps burst rate). There are three types of words from the APCU to the SSIA, and four types of words from the SSIA to APCU All words transmitted across the interface are 30 bits in length.

The information transmitted from APCU to SSIA shall consist of site call letters, status data, and discrete (bilevel) data. The SSIA shall contain 64 cells into which various APCU programs provide data for use by 64 individual data recipients. Segments transmitted to theSSIA may consist of from 1 to 64 words. Each segment must contain one address word preceding the data words. The address word shall contain a number (from 00 octal to 77 octal) corresponding to one of the 64 data cells. This shall indicate the cell into which the first data word of a segment shall be placed. All subsequent data words in a segment must be in a specific order (00 octal to 77 octal) corresponding to to the addresses associated with the intended data recipients. No data word may be skipped in the sequence from the first to the last data word in a segment. The SSIA also distributes data to the ASCA and ASRS for wall displays, event panels, and digital readout devices.

5.1.8 Univac 418 Computer

The Univac 418 computer, provides Magnetic tape reformatting and the magnetic tapes for the GSSC. It is also used to support test and checkout of GSSC and APCU programs in lieu of calling up CCATS.

5.1.9 ASCATS Cathode Ray Tube (CRT) Display System

The ASCATS CRT Display System simulates and supports simulation controllers in the ASCA. The display equipment, is identical to that located at the Apollo remote sites except for the interface required to handle both the APCU and GSSC and the ASCA CRT Displays. The display equipment consists of:

.CRT Display Modules

Each module contains a 17-inch rectangualr CRT which uses a combination of electrostatic and electromagnetic deflection for displaying tabular data in a format of 36 lines with 72 characters in each line.

.Memory Character Vector Generator (MCVG)

The MCVG consists of three independent logic and memory modules, two character/vector generators and a power supply. This provides the capability for three channels, each of which can be selected by the RSDP for data transfer to the MCVG. Each channel contains one 4096, 18 bit core memory with a four micro-second cycle time. The memory in each channel has the capability of receiving, storing, and reformatting information for four CRT display presentations. Three channels X four displays equals the 12 CRT capability. The two character/vector generators have the capability of generating on a CRT two character sizes (.14 inch and .28 inch), with a character writing time of three micro-second, and displaying 4096 characters. The vector generator constructs line segments, using initial and final X, Y positions, at the same rate used by the character generator.

.The Display system has the capability of accepting a computer word every 50 micro-second, displaying 22,980 characters on 12 CRT, and refreshing the data displayed on all 12 CRT's at a flicker-free rate.

.There are two MCVG installed in ASCATS. One is dirven by the APCU and the other is driven by either APCU or GSSC for CRT display in the ASCA. Two MCVG GSSC/APCU Interface Buffer switches are required to allow swiching between the GSSC and APCU and the ASCA.

The display system generates and displays spacecraft telemetered information in the form of block diagrams, tabular listings, meter formats, or a combination thereof. Spacecraft telemetered time and command clock time can also be displayed.

5.2 Miscellaneous Electronic Equipment

5.2.1 Data Control and Generation Equipment (DCAG)

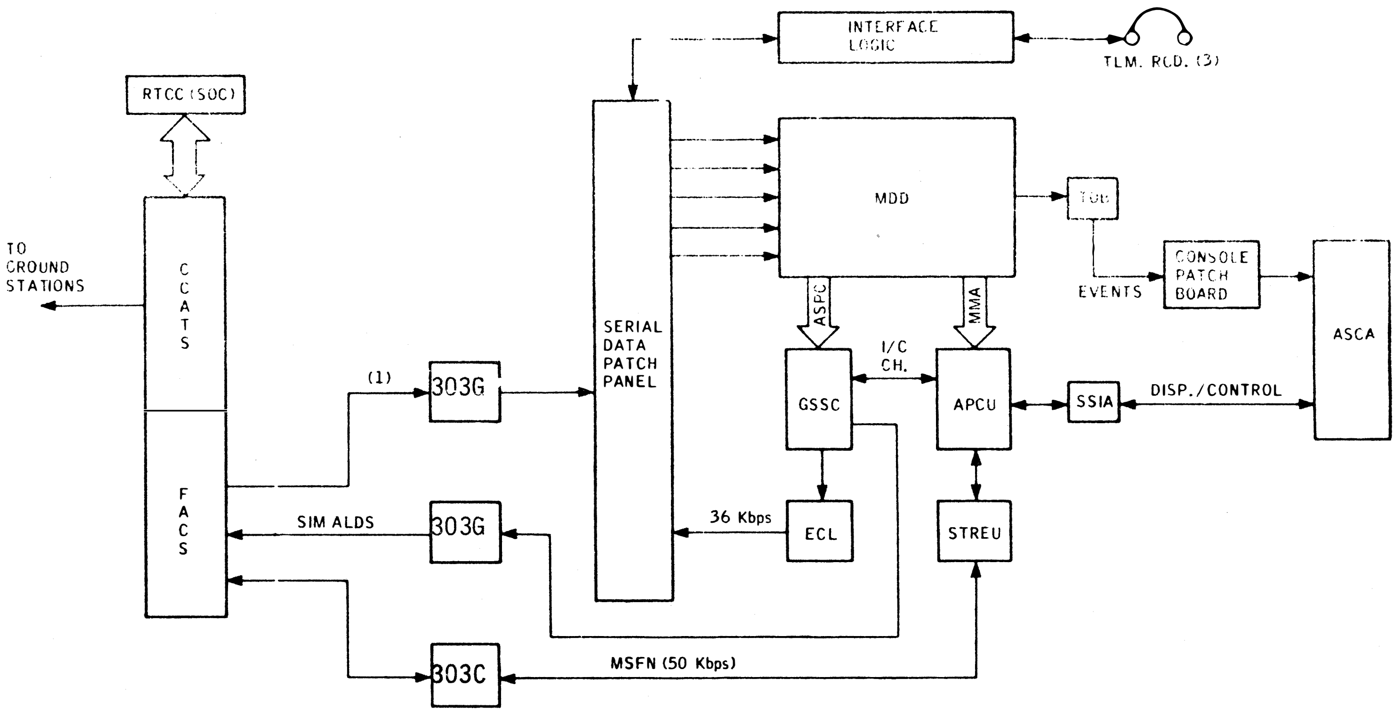
The DCAG works in conjunction with the MDD and the Serial Data Patch to provide a wideband recording/reproducing capability for ASCATS. Two voice circuits are available which allows three channels to be monitored (three recorders are provided). The DCAG can record data from KSC or data generated by the GSSC.

5.2.2 Exchange Control Logic Unit (ECL)

The ECL is the hardwired interface between the GSSC serial data patch, STREU, 12, 18, MDD, and the Recorders/Reproducers.

5.2.3 Display

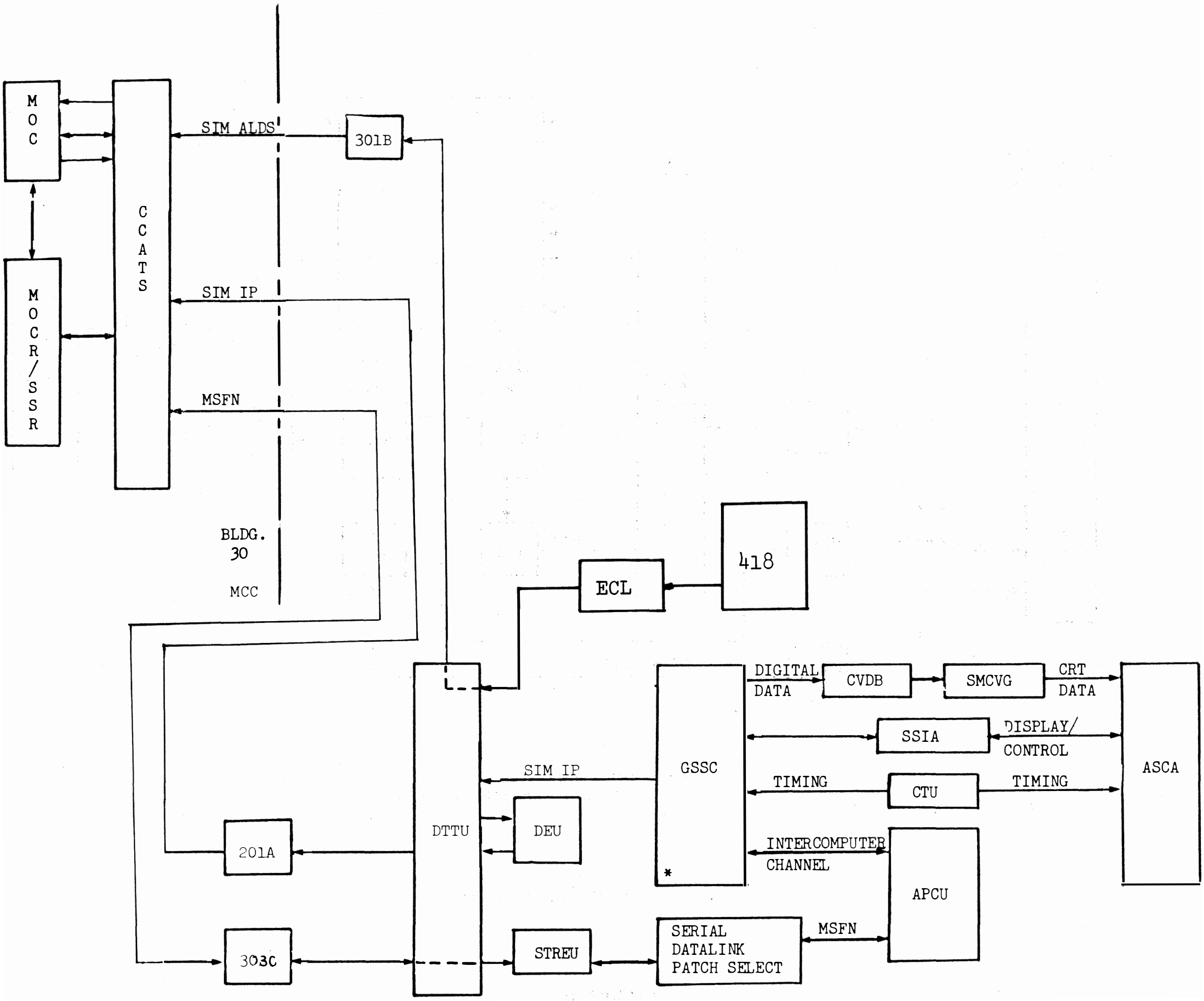
The Display equipment consists of wall-mounted group displays, television viewers, analog and event recorders, X-Y plotboards, high speed teleprinters



NOTES: DTTU NOT SHOWN.
(1) ALDS FROM CAPE TRAINERS.

Telemetry Data Flow

Figure 5E

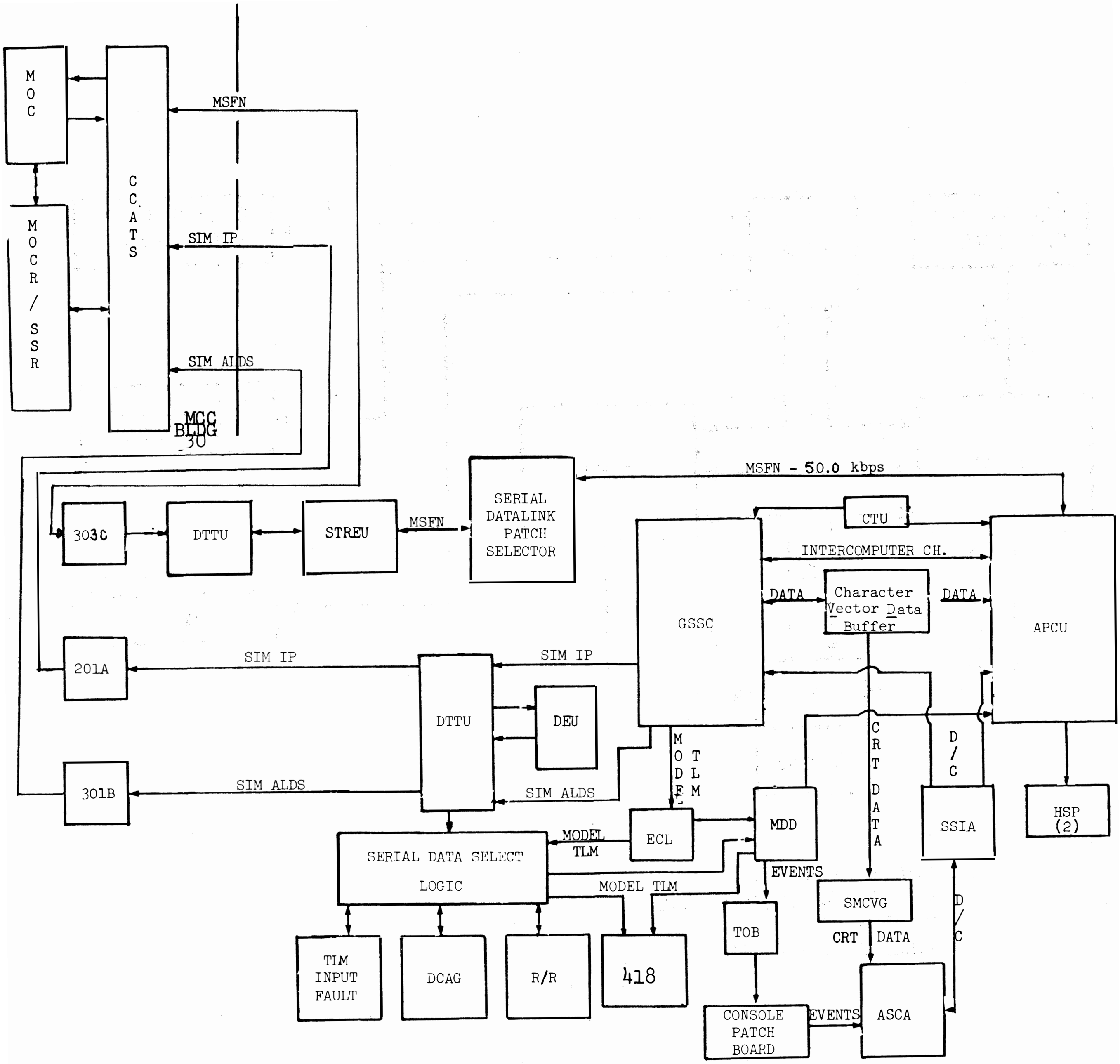


*NOTE: Low speed RADAR Data shipped via TTY lines.

MCC

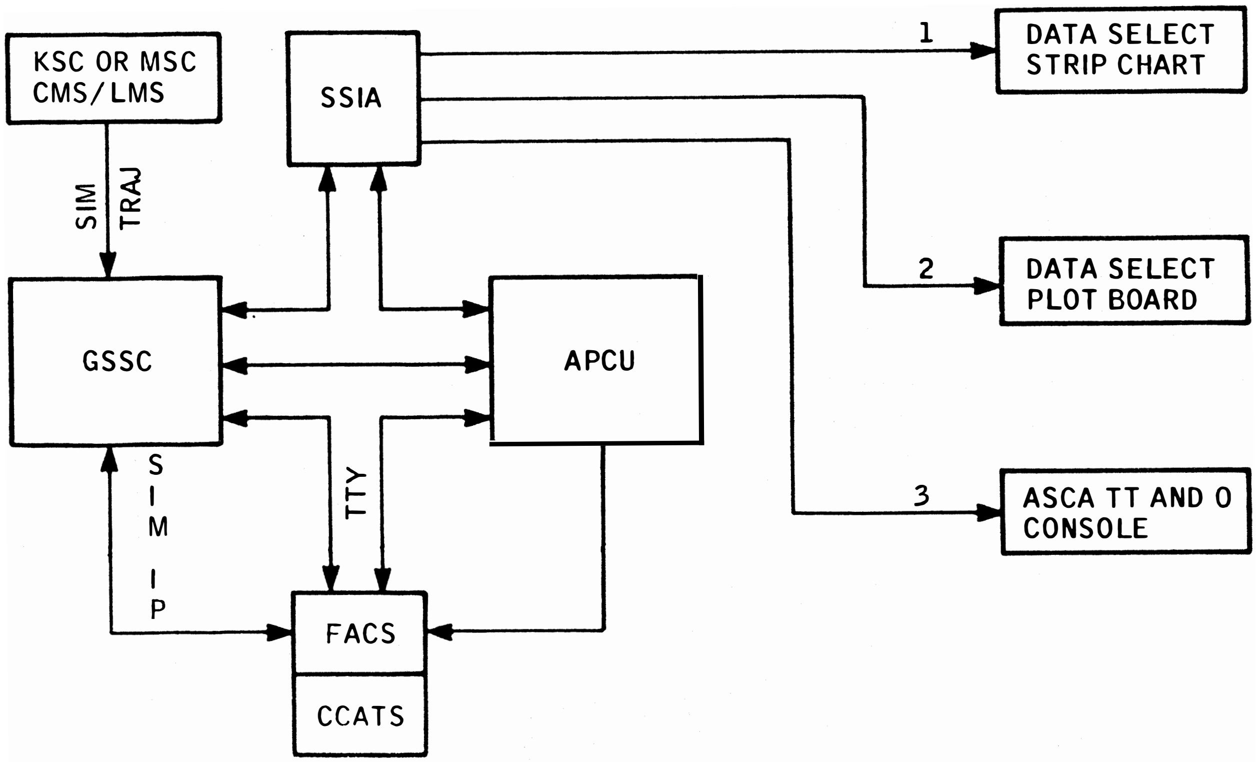
MOCR CLOSED LOOP WITH GSSC MATH MODELS ONLY (MODE CONFIGURATION)

Figure 5E



INTEGRATED APOLLO SIMULATION (MODE CONFIGURATION)

Figure 5G



NOTES:

1. ANALOG EVENTS
2. PATCH BOARD QUANTITIES
3. DIGITAL QUANTITY
   TRAJECTORY CONT.

Trajectory Data Flow

Figure 5H

6.0 Real Time Computer Complex (RTCC) General Description

The RTCC generates load data in the makeup buffer, transfers the contents of the load data in the makeup buffer to the transfer buffers for transmission to CCATS. It provides digital data for flight controllers display requests, update the realtime data base, D/TV converters, and routes digital data for RTCC driven DDD's. This data is displayed by the Display/Control System which communicates primarily with the RTCC and CCATS.

The RTCC provides the capability for manned/unmanned mission support by utilizing dedicated redundant computers; a Mission Operational Computer (MOC) online, and a Dynamic Standby Computer (DSC) for each mission. The DSC executes the same realtime processing functions and furnishes the same realtime outputs as the MOC. As long as the MOC is operating satisfactorily, the DSC's outputs are unused. In the event of failure of the MOC, the DSC becomes the MOC and another computer is activated as a DSC. Each of the IBM 360/75 computers (A, B, D, E, and F) have the capability of being assigned as a MOC, DSC, or offline computer. Each of the IBM 360/75 systems are configured essesntially as shown in Figure 6-A.

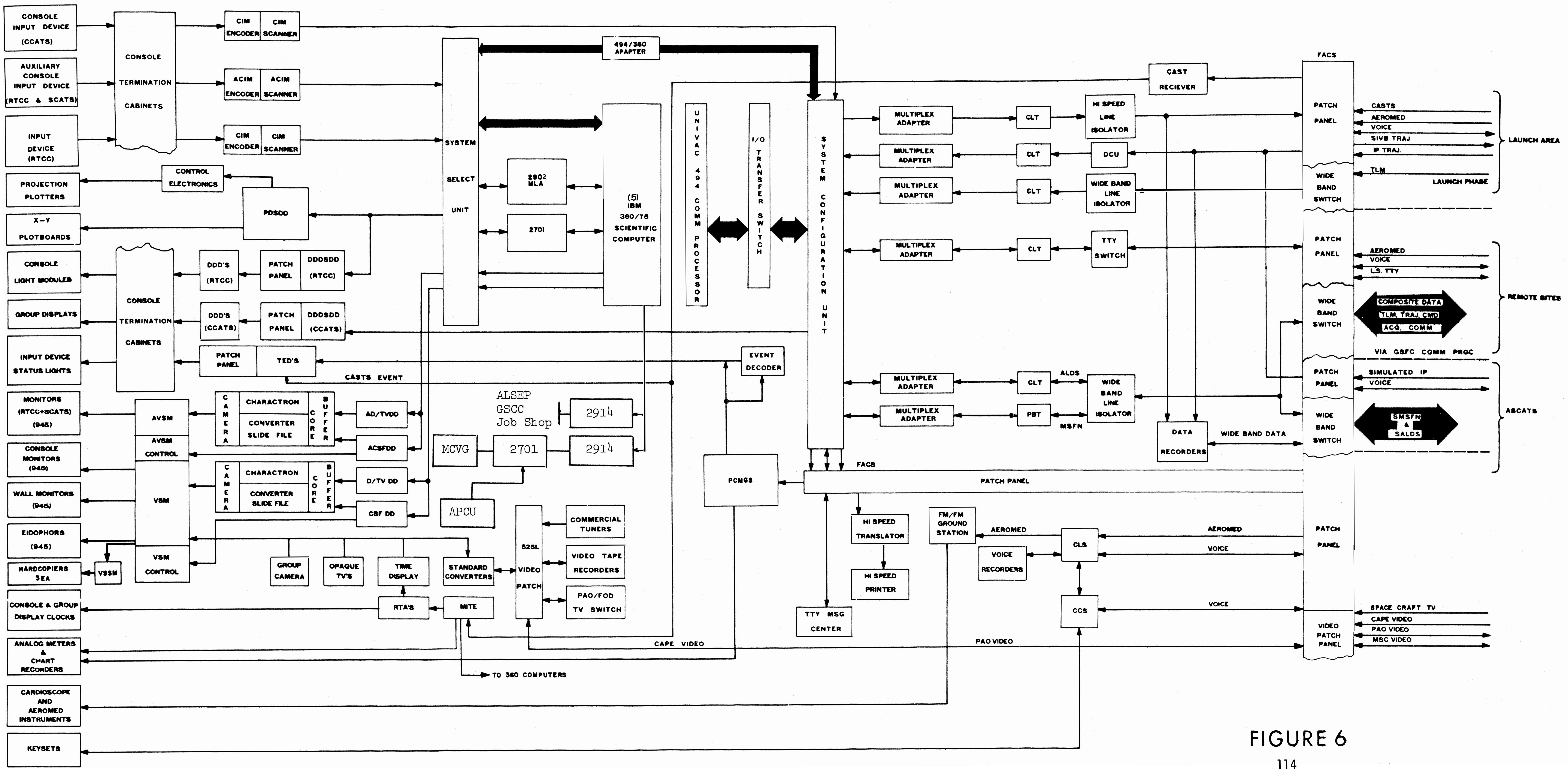
Two serial computer I/O channels are used with the display system. One I/O channel interfacing with the display system is the IBM 2701/2902 PDA/MLA. The other is the Univac 494/360 Adapter of the CCATS system (see Figure 6).

6.1 Peripheral Equipment

6.1.1 Real Time Computer Complex

a. IBM 2075 Data Processor - The IBM 2075 Data Processor is the CPU for the Model 360/75. It contains data registers, interconnecting data paths, and sequence controls for addressing main storage, instruction fetching and

MCC



CONSOLE INPUT DEVICE (CCATS)
AUXILIARY CONSOLE INPUT DEVICE (RTCC & SCATS)
INPUT DEVICE (RTCC)
CONSOLE TERMINATION CABINETS
CIM ENCODER
CIM SCANNER
ACIM ENCODER
ACIM SCANNER
494/360 APAPTER
SYSTEM SELECT UNIT
2902 MLA
2701
(5) IBM 360/75 SCIENTIFIC COMPUTER
UNIVAC 494 COMM PROCESSOR
I/O TRANSFER SWITCH
SYSTEM CONFIGURATION UNIT
CAST RECIEVER
FACS
PATCH PANEL
WIDE BAND SWITCH
MULTIPLEX ADAPTER
CLT
HI SPEED LINE ISOLATOR
DCU
WIDE BAND LINE ISOLATOR
TTY SWITCH
CASTS
AEROMED
VOICE
SIVB TRAJ
IP TRAJ.
TLM
LAUNCH PHASE
LAUNCH AREA
L.S. TTY
COMPOSITE DATA
TLM, TRAJ, CMD
ACQ, COMM
REMOTE SITES
VIA GSFC COMM PROC
SIMULATED IP
ASCATS
SMSFN & SALDS
PROJECTION PLOTTERS
CONTROL ELECTRONICS
PDSDD
X-Y PLOTBOARDS
CONSOLE LIGHT MODULES
GROUP DISPLAYS
INPUT DEVICE STATUS LIGHTS
DDD'S (RTCC)
DDD'S (CCATS)
DDDSDD (RTCC)
DDDSDD (CCATS)
TED'S
EVENT DECODER
CASTS EVENT
MONITORS (RTCC+SCATS) (945)
CONSOLE MONITORS (945)
WALL MONITORS (945)
EIDOPHORS (945)
HARDCOPIERS 3EA
VSSM
AVSM
AVSM CONTROL
VSM
VSM CONTROL
CAMERA
CHARACTRON CONVERTER SLIDE FILE
CORE BUFFER
AD/TVDD
ACSFDD
D/TV DD
CSF DD
ALSEP GSCC Job Shop
2914
MCVG
APCU
PCMGS
ALDS
PBT
MSFN
WIDE BAND LINE ISOLATOR
DATA RECORDERS
WIDE BAND DATA
GROUP CAMERA
OPAQUE TV'S
TIME DISPLAY
STANDARD CONVERTERS
525L VIDEO PATCH
COMMERCIAL TUNERS
VIDEO TAPE RECORDERS
PAO/FOD TV SWITCH
RTA'S
MITE
TO 360 COMPUTERS
HI SPEED TRANSLATOR
HI SPEED PRINTER
TTY MSG CENTER
FM/FM GROUND STATION
VOICE RECORDERS
CLS
CCS
VIDEO PATCH PANEL
SPACE CRAFT TV
CAPE VIDEO
PAO VIDEO
MSC VIDEO
CONSOLE & GROUP DISPLAY CLOCKS
ANALOG METERS & CHART RECORDERS
CARDIOSCOPE AND AEROMED INSTRUMENTS
KEYSETS

FIGURE 6

communications between main storage and I/O devices. The Model 360/75 computer cycle time is 195 nanoseconds with any logical operation requiring at least two cycles. For example, an operand add requires, on an average, 700 nanoseconds or 3.6 computer cycles. In general, the average execution time per instruction is one microsecond.

b. IBM Model 75/2365-3's - The Model 75J's have main storage consisting of four IBM 2365-3's or 1,048,576 bytes. On a storage reference cycle, eight bytes (one double word) are accessed in 750 nanoseconds. The effective cycle time is halved, however, because the Model 370/75 main storage provides four-way interleaving of consecutive double words to and from storage.

c. IBM 2361-2 Core Storage Units - Two IBM 2361-2 Core Storage Units serve as an extension to the main storage and are attached to the Model 360/75 to provide an additional 1,048,567 bytes of storage capacity. The basic 2361-2 storage access time is eight microseconds (four microseconds interleaved). The information is transferred in units of eight bytes to the 360/75.

d. IBM 2870-A Multiplexer Channel - The IBM 2870-A Multiplexer Channel provides for the attachment of amny low-to-medium speed I/O devices. The multiplexer channel can have one basic (low-speed) interface and up to four medium-speed interfaces. The multiplexer channel provides the capability to multiplex up to 192 low-speed devices concurrently, provided the aggregate data rate does not exceed 66,000 bytes per second. The basic multiplexer channel can operate in a burst mode for high-speed devices. In burst mode, the device remains attached to the interface for the time required to complete the I/O sequence.

The medium-speed interfaces of the IBM 2870-A are called selector subchannels. Each selector subchannel can operate one I/O device concurrently with the basic multiplexer channel. The maximum data rate of the selector subchannels is 180K bytes per second (burst mode only).

Up to eight control units may be attached to the basic multiplexer channel. The same is true for each selector subchannel except that a maximum of 16 I/O devices can be attached to each selector subchannel.

e. <u>IBM 2860-2 Selector Channel</u> - Selector channels are used where high-speed devices are attached to the system. The 2860-2 contains two selector channels, and provides for the attachement and control of I/O devices operating in the burst mode. A channel operating in burst mode permits complete blocks of data to be transferred between the I/O device and the channel. The two selector channels can operate simultaneously provided the aggregate data rate does not exceed 1.3 million bytes per second. Each selector channel has one subchannel to facilitate one I/O operation at a time. Up to eight control units may be attached to each selector channel.

f. <u>Storage Channel</u> - The IBM Storage Channel is an attachment to the IBM 2860-2 Selector Channel. It provides the capability of high-speed data transfer from one location in storage to another location in storage. This transmission between storage areas may be within main storage or between main storage and the large core storage or within large core storage.

g. IBM 2902 Multiplexer Line Adapter (MLA) - The IBM 2902 MLA interfaces all of the realtime interfaces (except Digital-to-Television) to the

RTCC. All necessary bit/byte conversions, data control, and matching of signal levels and impedance in each adapter section are accomplished by the adapter.

h. IBM 2701-1 Data Adapter Unit - The IBM 2701-1 Data Adapter Unit interfaces the Digital-to-Television equipment to the RTCC.

i. IBM 1052-7 Printer Keyboards - Attached to the Model 360/75 main frame are two IBM 1052-7 Printer Keyboards which provide for operator communications with the processing unit. Characters are transmitted from the 2075-J at a rate of 14.8 characters per second.

j. IBM 2821 Control Unit - The IBM 2821 Control Unit is used to transmit information between the CPU and the printer and card read punches. It contains the circuitry for controlling these devices and for buffering the information being transmitted. The 2821 is attached to the multiplexer channel of the model 75. A 1,100 line per minute printer (1404-4 or 1403-N1) can also be attached to the 2821.

k. IBM 1403-N1 Printer - The IBM 1403-N1 Printer is capable of printing 132 print positions per line at up to 1100 lines per minute. This printer is equipped with an IBM 1416-1 Interchangeable Train Cartridge (48 character set).

l. IBM 2540-1 Card Read Punch - The IBM 2540-1 Card Read Punch can read up to 1000 cards per minute and punch up to 300 cards per minute. It attaches to the 2870-1 multiplexer channel via the IBM 2821 control unit.

m. IBM 1443-N1 Printer - The IBM 1443-N1 Printer attaches to the multiplexer channel. It has a selfcontained control unit. With the standard 52 character set it is capable of printing 120 print positions per line at up to 240 lines per minute.

n. IBM 2403-3 Magnetic Tape Unit and Control - The IBM 2403-3 Magnetic Tape Unit and Control contains a single tape drive and a control unit. The control unit function can control up to eight tape drives (including the attached tape drive). The model 3 tape drive has nine tracks and has a maximum data rate of 90,000 bytes per second.

o. IBM 2402-3 Magnetic Tape Unit - The IBM 2402-3 Magnetic Tape Unit contains one nine-track read/write tape drive with a maximum data rate of 90,000 bytes per second.

p. IBM-2401-3 Magnetic Tape Unit - The IBM 2401-3 Magnetic Tape Unit contains two nine-track read/write tape drives in a single cabinet with a maximum data rate of 90,000 bytes per second.

q. IBM 2841-1 Storage Control Unit - The IBM 2841-1 Storage Control Unit provides the capability of attaching bit serial random access storage devices to the 360/75. In the RTCC application, two IBM 2841-1's are used with each Model 75, each attaching up to eight IBM 2311-1 Disk Storage Drives.

r. IBM 2311-1 Disk Storage Drive - IBM 2311-1 Disk Storage Drive provides random access storage for 7.25 million bytes. Four drives are attached to each IBM 2841-1 Storage Control Unit, providing a large volume of online storage. The drive uses the removable IBM 1316-1 Disk Packs which consists of six disks mounted on a vertical shaft. Ten of the twelve surfaces are used. Each surface has 200 tracks; approximately 3600 bytes can be stored in each track.

s. IBM 2314 Disk Section - The IBM 2314 Direct Access Storage Facility (DASF) disk file section contains nine drives; eight of which can be online at

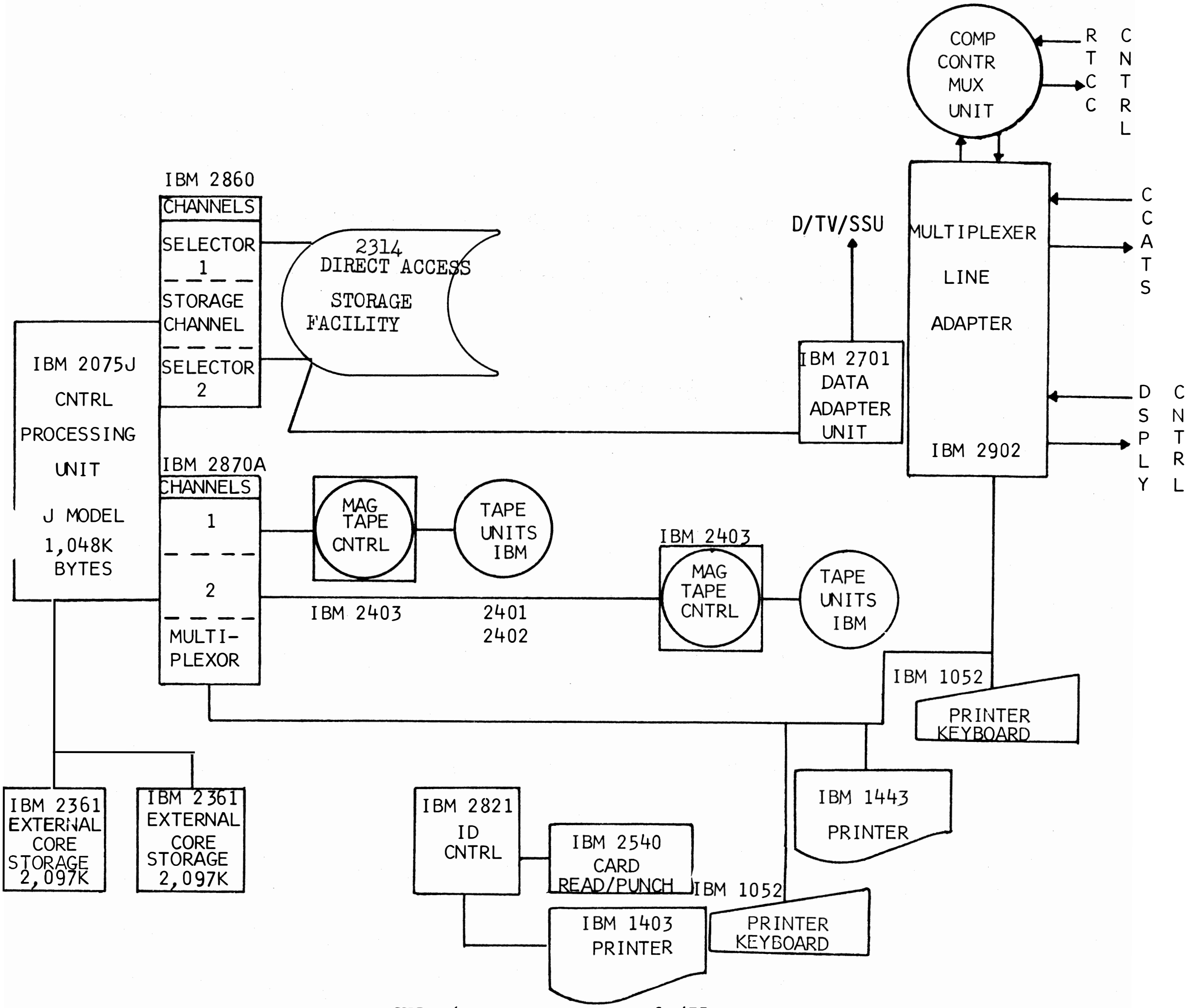


FIGURE 6-A: TYPICAL IBM 360/75 (RTCC)

any time. Each drive is an independent unit with operator-assignable addresses. Twenty recording surfaces and 200 (plus three alternate) "cylinders" with a capacity of 7294 bytes per track. This provides a modular capacity of over 29 million bytes and a total of 233 million bytes per DASF. The control unit section is similar to the IBM 2841 storage control and performs the following functions:

.Transforms the data transferred between the 2860-2 Selector Channel and the disk drives.

.Interprets and executes commands from the selector channel.

.Employs a cyclic code written for each data field to ensure accurate transfer of data.

t. Computer Controller Multiplexer Unit - (Reference Figure 6-A) - The Computer Controller Multiplexer Unit (CCMU) is special equipment built by IBM which provides the data path between the RTCC Control Area and the IBM System Model 360/75. There is one CCMU for each Model 360/75 system. The following types of data are controlled by the CCMU:

.Data between the Manual Entry Devices (MED's) and the computers.

.Data from the RTCC console switch modules to the computers.

.Data between the Computer Monitor and Control Console (CMCC) and the computers.

u. IBM 2914-1 Switching Unit - An IBM 2914-1 Switching Unit may siwtch the Real Time Interface Subsystem (2092 MLA, 2701/ICU), the Computer Control Display (2848/2260) and the Experiments Printer (2821/1403N1) between the multiplexer channel of any one of four selected 360/75 computers in the RTCC.

The 2914-1 is a solid state, passive, manual switching unit with the switching controls on a topmounted control panel. The ALSEP's subsystems are connected to a 2914-1 with a six-by-four channel switch which permits five (one control unit port is not used) CPU's to share up to four I/O strings.

v. System Selector Unit (SSU)/System Selector Extension Unit (SSEU) - The SSU/SSEU, reference Figure 6-B, permits any of the RTCC computers to assume any of the functional assignments. It also provides the capability to exchange rapidly the functional assignments between the dynamic standby and the operational computers. In accomplishing its assignments, the SSU assures that:

.The MOCR's and RTCC control areas can request and receive displays from the proper computer.

.The CCATS input and output data is routed to and from the proper computers.

The SSU accepts up to five outputs from the operational CCATS computer and routes them individually to the proper RTCC computers according to their functional assignments. It also may route one output of all RTCC computers to each of the two operational CCATS computers.

The selectover between the operational and the dynamic standby computers is a combined SSU and programming function. When the selectover action is taken at the Complex Supervisor Console in the RTCC Control Area, the SSU signals the program in both computers to suspend its output operations until selectover has occurred. This insures that selectover does not occur during a message transmission, which would result in partial or erroneous messages.

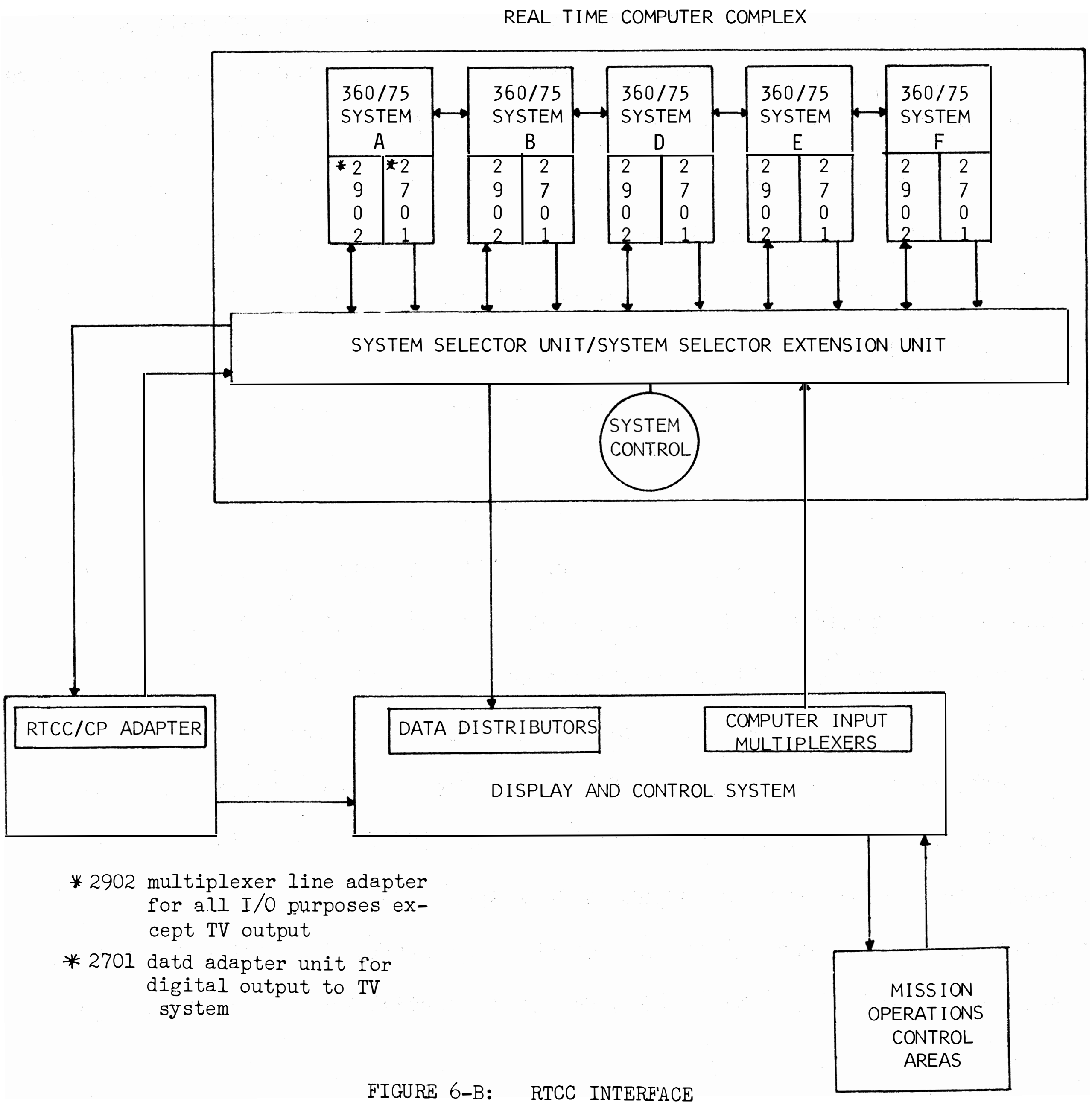
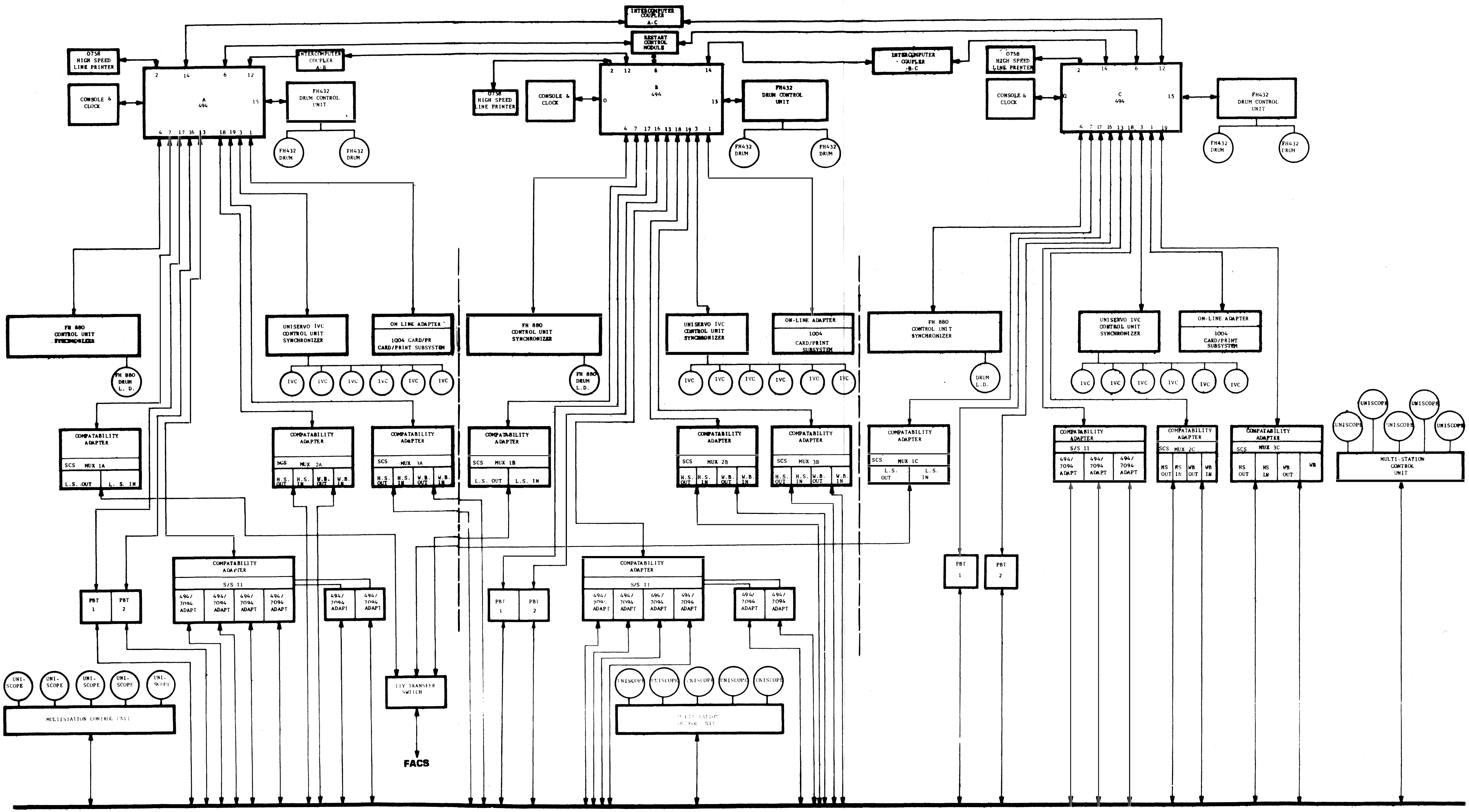


FIGURE 6-B: RTCC INTERFACE



SYSTEM CONFIGURATION UNIT

Figure 6C

6.1.2 RTCC/Display Control Interfaces

The 2902 MLA accepts all RTCC inputs from the display system on one of its subchannels and outputs digital display and plotting display information on two of its output subchannels. There are seven unique encoders which may be set to communicate with the RTCC. The electromechanical console input devices consist of thumb wheel digit switches, pushbutton indicators and toggle switches.

a. Manual Select Keyboard (MSK) - The MSK is the console input switch module containing thumb wheel digit switches upon which flight controllers can set predetermined display request format numbers.

b. The Display Request Keyboard (DRK) - The DRK is a semiautomatic MSK for rapidly accessing D/TV formats. That is, a matrix of 32 pushbuttons with descriptive labels which are made available to the console operator in lieu of manually dialed display requests. The operator may select any of 12 fields, thus enabling the DRK operator to initiate 384 display request formats.

c. Event Sequency Override (ESO) - Three ESO's are provided for each computer/display interface system. Physically they consist of 16 event indicators and 16 double-pole, three position toggle switches with detents at each position. Normally, the computer exercises automatic control over events. However, should the RTCC fail to receive an event, or should the computer receive an erroneous event signal, the controller can reset the event to the correct condition. The center position of the toggle switch is the normal position and during this mode of operation the computer has control over the events. The forward position of the switch is the "no event" position. That

DISPLAY CONTROL INPUTS CCATS INPUTS

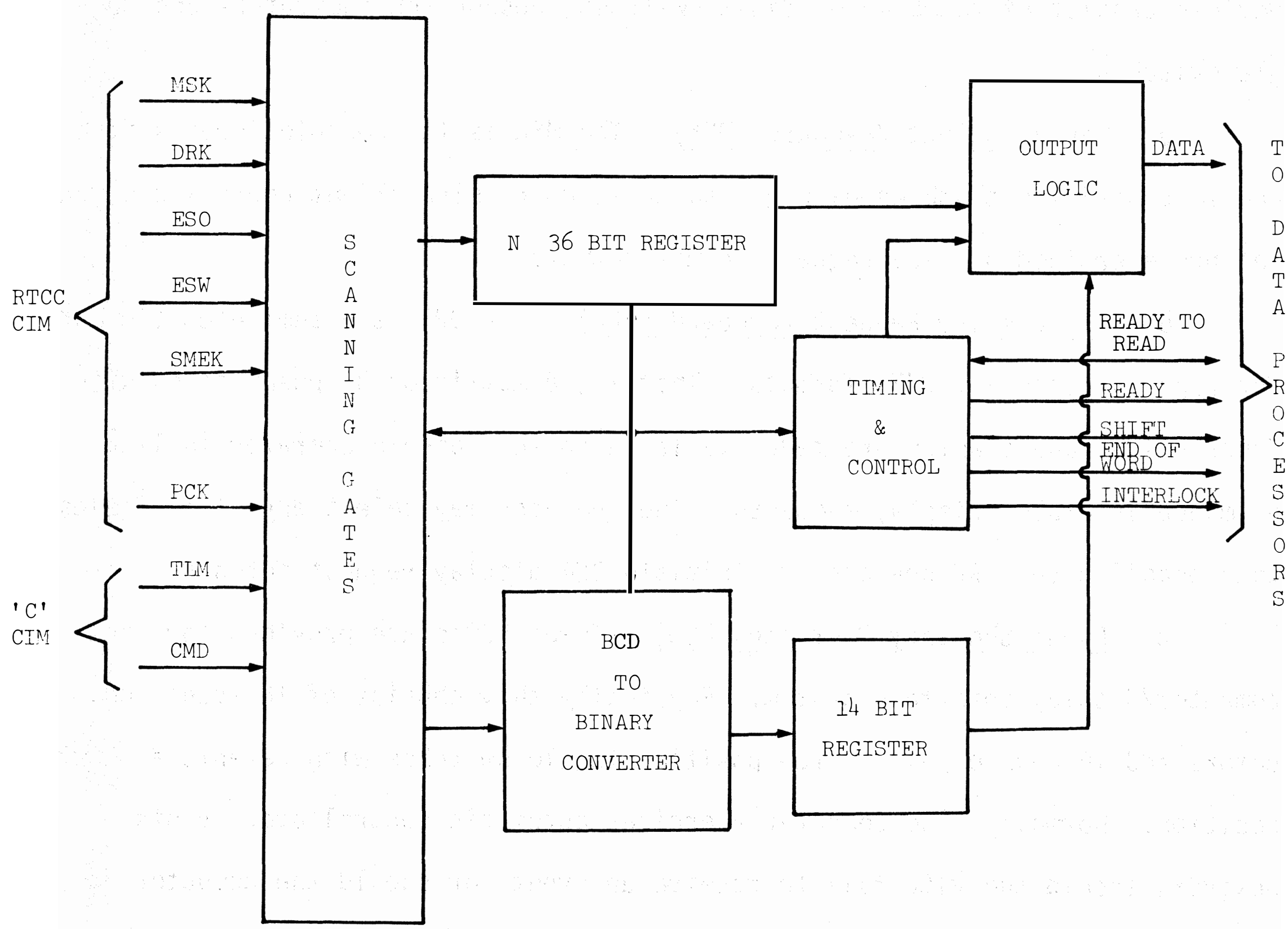


Figure 6D: COMPUTER INPUT MULTIPLEXER

is, if the RTCC prematurely receives an erroneous signal of an event occurrence, the controller can in effect erase this event occurrence. Conversely, should the computer fail to receive a valid signal, the controller can move the ESO switch rearward and manually enter the event into the data processor. Thus, the consoles containing ESO modules can manually update the data base should spurious or omitted event signals cause errors.

d. Phase Control Keyboard (PCK) - Normally, the computer will change programs automatically as mission phases change. However, flight controllers do have the capability to command (via the PCK) the computer to change operational subprograms. The PCK is an 18 pushbutton indicator module which allows an operator to manually control the phase sequence of certain mission subprograms. Some typical phased subprograms are hold, launch, abort, orbit, and reentry.

e. Summary Message Keyboard (SMEK) - There are three SMEK's for each computer/display interface system. The SMEK module consists of 38 format selection pushbutton indicators (PBI), one execute PBI and one clear PBI.

The purpose of the SMEK is to allow certain flight controllers to select and dispatch messages to the remote sites. The controller may accomplish a SMEK routine by depressing one of the 38 PBI's and the execute button. These actions will cause the computer to initiate an RTCC program which will strip certain telemetry information from the data base, compile this data, assemble it into the desired format, and send it to the Communication Processor for dispatch to the remote sites as a teletype message. The clear button on the SMEK simply allows the controllers to cancel any PBI which may have been depressed inadvertantly.

f. Equipment Status Word (ESW) - The ESW encoder receives the current status data of the 38 TV channels and the ten Reference Slide File Channels and transmits this data, via the CIM, to the RTCC upon a program readout request from the Computer's Direct Data Channel Sense Output Line. The status data is contained in a three-word message which is printed out on the RTCC line printer.

g. Computer Input Multiplex (CIM) - The CIM is a scanning device which sequentially examines the gates of 64 positions. The 64 positions correspond to 64 consoles. When an input gate requires servicing, the scanning is inhibited and the contents of the encoders are read out. The CIM adds a seven bit console address to the input data, reformats the message into 36-bit computer words and initiates a ready signal to the 2902/2701 MLA. In the case of MSK inputs, the CIM converts the Binary Coded Decimal (BCD) message into a straight binary code. The CIM scans inputs at a 25 KHz rate and upon receipt of a ready from RTCC it serially clocks out the data at a 2400 bits per second rate to the 2902/2701 MLA.*

6.1.2.1 Encoders

Each input device has its own encoder. All encoders are binary coded with the exception of the MSK encoders which have a binary decimal code. The switch positions on each input device determine the voltage level which will be statically maintained in each bit position of the encoders. The encoders are read out by the CIM upon receipt of a ready signal from the execute switch of the entry device. The ready line to the CIM is a flip projector, light is extended through an etched opaque slide. In the case of the background projection, the etched lines are reference displays. During launch the background slide depicts the nominal curves expected from launch data. During orbit the background slide is an etched world map showing continental land masses and radar coverage circles. The four scribing projectors each etch an opaque slide with a computer controlled stylus. These projectors plot dynamic information as derived from the RTCC. Spotting projectors each contain four symbols etched on a opaque slide. These symbols are selected and positioned by the RTCC generated messages. Each projector has seven color filters which enhance the clarity of the composite display. The 6 by 12 foot system used in the recovery room has one background, one scribing and one spotting projector under computer control. In addition the recovery system has a daylight/darkness generator and a manually controlled plotting projector.

6.1.2.2 X-Y Plot Boards

There are five 30 by 30 inch plot boards in each flight dynamic staff support room. They are standard computer driven plotboards used primarily to yield analog presentations of lfight parameters during the launch phase.

6.1.2.3 Digital Displays

The second output subchannel of the 2902 MLA is used to deliver digital information to the display system. The display system has two uses for this information; the general purpose Relative Time Accumulators (RTA) and the DDD. The RTA's are used to display event times while DDD's are used primarily to drive digital readouts, annunciators and alarms on control consoles.

The interface between the display user equipment and the RTCC is the Digital Displays Subchannel Data Distributor (DDSDD).

6.1.2.4 Digital Display Drivers (DDD)

The 36-bit DDD words consist of a 12-bit address and 24 bits of lamp illumination information. The 12-bit address is made up of six bits of X position and six bits of Y position. These decoded addresses enable selection of any one of 40 X select lines and 40 Y select lines. Where X and Y coincide is the address of a DDD set and the 24 bits are strobed into the output relay drivers. The addressing and storing of the DDD data is analogous to addressing a core storage device. The output relay drivers are 26 vdc lamp drivers loaded by dual 40 mil lamps. In each MOCR there are 11 racks of DDD's with 40 sets of 24 drivers each yielding a total of over 10,000 drivers per system.

6.1.2.5 Relative Time Accumulators (RTA's)

The DDSDD also supplies digital data to two general purpose relative time accumulators of the timing subsystem. Two different data words are necessary. The first word contains BCD timing data with which to set the accumulator. The second word is a 12-bit message to select one of two labels associated with the computed time. In turn the RTA's drive the general purpose time readouts located over the large panel displays.

6.1.2.6 Digital-to-Television (D/TV)

The D/TV converts digital data received from the RTCC into dynamic displays composed of symbols and vectors. The dynamic display is optically mixed with static (background) data from a Converter Slide File (CSF), producing a composite image suitable for viewing by a television camera. This video output is then displayed on selected monitors by elements of the TV subsystem. These displays are changed and/or updated via control and data lines between the RTCC and the D/TV Converter. Input to the converter from the RTCC consists of 36 parallel data lines and two control lines (Channel-Write-Select and Channel-Ready-Write, also known as Ready-to-Read). In addition, one control (Demand)line is provided to the RTCC from the converter.

The D/TV Converter consists principally of a CSF Data Distributor (CSF DD), a dual-channel D/TV DD, seven (expandable to sixteen) 4K-word buffers, and 28 (expandable to 64) display generators.

6.2 Intra MCC Data Routing

The CP/RTCC adapter provides the interface between the CP and the RTCC. The CP/RTCC adapter converts signal levels, changes the speed of data flow, and converts serial data to parallel for input and parallel data to serial for output. The CP/RTCC adapter is contained in three cabinets. Two of the cabinets each contain a scanner selector and six high-speed adapters, and the third cabinet contains the I/O switching.

Data in both directions is transferred over eight sets of lines. Since all transfers are similar, only one set is described.

The interface between the CP/RTCC adapter and the RTCC is a five-pair cable. This five-pair cable carries interlock, ready-to-receive, ready, shift, and data signals. The interlock signal is a negative level that indicates the status of the online computer in the CP subsystem to the RTCC. The ready-to-receive signal is at a negative level when the CP is prepared to receive data. When the ready-to-receive signal goes positive, the RTCC will stop sending.

MCC TV CHANNEL ASSIGNMENT LISTING

01-40	D/TV CONVERTER NO. 1-40
41-48	(SPARE)
49	RECOVERY OPAQUE TV NO. 2
50	RECOVERY GROUP DISPLAY NO. 1 (FRONT)
51	REMOTE TV NO. 3 (525/945 CVTR)
52	RECOVERY GROUP DISPLAY NO. 2 (REAR)
53	CCATS OPAQUE TV
54	(SPARE)
55	MOCR GROUP DISPLAY CENTER
56	(SPARE)
57	TIME SUMMARY CONVERTER
58	LIFE SYSTEM OPAQUE TV
59	BUILDING 45 OPAQUE TV
60	OPN & PROC OPAQUE TV NO. 1
61	OPN & PROC OPAQUE TV NO. 2
62	(SPARE)
63	(SPARE)
64	VEHICLE SYSTEM OPAQUE TV NO. 1
65	VEHICLE SYSTEM OPAQUE TV NO. 2
66	FLIGHT DYNAMIC OPAQUE TV
67	FLIGHT DYNAMIC GROUP DISPLAY
68	METEROLOGY OPAQUE TV
69	(SPARE)
70	TV TEST SIGNAL
71	ANALOG/EVENT RECORDER 61
72	ANALOG/EVENT RECORDER 60
73	OSW - OPAQUE TV
74	SCHEDULING GROUP DISPALY
75	3RD AND 2ND FLOOR VSM OUTPUT 10 (O&P RIGHT MON)
76	RECOVERY OPAQUE TV NO. 1
77	REMOTE TV NO. 1 (525/945 CVTR)
78	REMOTE TV NO. 2 (525/945 CVTR)
79	ALSEP OPAQUE 314B
80	(SPARE)
90-93	ADEG

TABLE 6

The ready signal is a negative level signal from the RTCC that indicates Start of Message (SOM). The positive transition of this signal indicates End of Message (EOM). The shift signal provides clock pulses at a 81.6 kbps rate from the RTCC. Shift pulses cease when either the ready or ready-to-receive signal goes positive. The data signal carries data with a negative level indicating a logic one and a positive level indicating a logic zero.

The output from one of the computers in the RTCC is sent to the CP at a 81.6 kbps rate through the transfer switch in the RTCC adapter. The scanner selector scans the potential inputs from the RTCC (MOC or the DSC), and when a ready signal from the RTCC is detected, the scanner selector sends a ready-to-receive signal to the RTCC. Immediately upon sensing the ready-to-receive signal, the RTCC starts sending data and shift signals to the CP. The CP/RTCC adapter accepts this data in the High Speed Adapter (HSA) registers and shifts the data to the computer in a 12-bit parallel mode.

The output from the CP subsystem to the RTCC is sent from a computer to the CP/RTCC in 12-bit parallel form. The HSA adapts the signal level for compatibility with outgoing lines and shifts this data in serial form to the transfer switch. Depending upon which computer is selected, two of the transfer switches in the RTCC adapter are inhibited and the others are permitted to output to the RTCC at a 81.6 kbps rate.

6.3 <u>Computer Input Multiplexer/Subchannel Data Distributor Adapter</u>

The Computer Input Multiplexer/Subchannel Data Distributor (CIM/SDD) adapter is used to interface the CP subsystem with the Computer Display Control Interface Subsystem (CDCIS). The CIM/SDD adapter is similar to the CP/RTCC adapter. The CIM/SDD adapter, acting as an input device, directs requests from the CDCIS to the CP subsystem. These requests are initiated by Flight Controllers, in the MOCR and Staff Support areas, operating input devices installed in the consoles. These input devices are special purpose input modules associated with generating and transferring command loads and realtime commands to the spacecraft, via the MSFN. The adapter accepts serial data from the CIM at a rate of 2.4 kbps and shifts the data into the appropriate CCATS computer in a 12-bit parallel form.

The CIM/SDD adapter, acting as an output device, sends data to the DDD/SDD, hence to the DDD of the CDCIS. Data output from the CCATS computer is received in 12-bit parallel form by the CIM/SDD and shifted to the DDD/SDD in serial form.

6.4 Communications, Command and Telemetry System (CCATS) General Description

The CCATS is the communications data processing system which provides the interface between MCC and outside data circuits of MSFN.

CCATS terminates outside data (nonvoice) circuits and processes, records and routes incoming and outgoing TTY, high speed (HS) and wide band (WB) data. This includes normal message routing, decommutation of HS telemetry data and special input interpretation and formatting functions relative to command data.

CCATS is a computer oriented, realtime processing system which decommutates and distributes incoming data into RTCC, Console Displays, and various monitoring devices. CCATS also formats and outputs command data to GSFC for distribution to the desired remote sites. CCATS is comprised of the following major components:

a. Communication Processor Unit

1. Mainframe (6.4.1)
2. Memory

b. Communications Peripherals

1. Polynomial Buffer Terminal (6.4.9)

2. Standard Communications Subsystem (SCS) - provides communication line terminals and multiplexers which connect communications lines to the computers and converts serial communication data to parallel bit form and vice versa.

3. Scanner Selector/Adapters - provides the input/output adapters which allows data to flow between CCATS and RTCC and between CCATS and the CIM/SDD's. (6.3)

c. Online/Standby Switching

1. Peripheral Transfer Switch (6.4.5)
2. System Configuration Unit (6.4.6)

d. Processing and Control Peripherals

1. CPU Console (6.4.2)
2. Drums
3. Servos
4. Printer/Punch

e. CCATS Control Consoles

1. Command (Figure 6E)
2. Telemetry Input Console (Figure 6E)
3. Tracking (Figure 6E)

6.4.1 Univac Computer, Type 494

All ditital data routed through CCATS is processed by one of the three Univac 494 computers. Normally, one computer supports the mission, as the MOC, and one operates as DSC. The three Univac 494 (A, B, and C) are

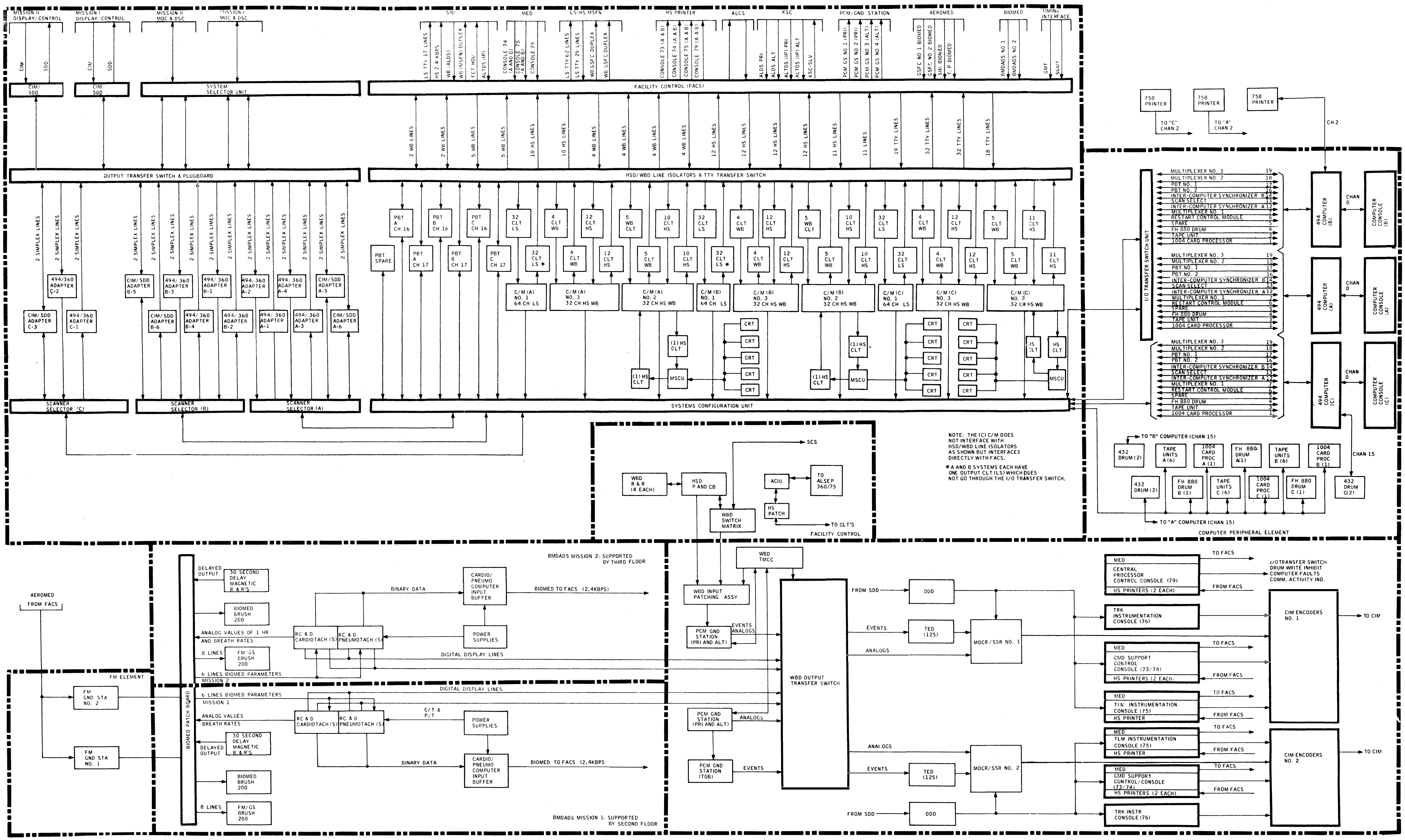


FIGURE 6E: CCATS SUBSYSTEM

interchangeable via a System Configuration Unit (SCU). The A or B system may be manually switched as the Dynamic Standby or MOC in the event of failure of either system. System C is usually used as an offline computer for program checkout, debug, and job-shop operations.

The 494 is stored program, binary computer that is designed to process large quantities of data in both batch processing and realtime modes. The 494 contains a random-access ferrite core memory, control section, storage section, arithmetic section, and registers which are used in the input/output processing of data.

These 494's have four normal input/output channels capable of 555 kbps and 12 compatible channels with transfer rates of 250 kbps. The memory capacity is 131, 072 30-bit words (plus a parity bit for each half word). Double-Precision operations are possible by linking two 30-bit words via software/hardware logic. The 494 has a memory cycle time of 750 nanoseconds and memory overlap permitting an effective cycle time of 375 nanoseconds.

6.4.2 Communications and Configuration Console (CACC)

The CACC provides local operator monitoring and control of selected "A" and "B" system software and hardware functions applicable to communications and CP subsystem configuration. The CACC is a four-bay console containing the modules for monitor and control of the CP subsystem, two communications keyset units.

6.4.3 The Univac Uniscope

The 300 uniscope is a visual communication terminal designed for applications which require direct operator interaction with the centeral computer

(Univac 494). Information generated by the operator is displayed on the uniscope prior to transmission to the computer, so that the operator can make required changes or edit where necessary. Data transmitted from the computer is displayed to the operator for interpretation and understanding.

6.4.4 High Speed Teleprinter

The high speed teleprinter monitors requests initiated from a manual entry device and prints out the computer response. The high speed teleprinter converts digitally coded information into hard copy output. One high speed teleprinter is associated with each computer system.

6.4.5 Input/Output Transfer Switch (IOTS)

The IOTS is used to switch input and output channels between the A and B computers and the peripheral equipment.

6.4.6 System Configuration Unit (SCU)

The SCU provides the capability for interchanging on a group baiss, any one of the three groups of peripheral equipment. The SCU consists of six programing system patch frames. Prepatched patchboards are inserted into these patch frames to establish the desired configuration.

6.4.7 Magnetic Tape Units (MTU's)

The MTU's are used for initial loading of the operational program into the computer and forlogging data during operations. The magnetic tape units are also used for magnetic core and drum dumps. Each computer has six magnetic tape units, a control unit, and a tape adapter cabinet. Each unit contains read amplifiers and write drivers for each of seven channels, read and write heads, and the tape transport mechanism.

6.4.8 Card Processor

The card processor reads information from cards into the computer memory, and prints out information from core memory, drum storage, and magnetic tape. Each computer has a separate card processor, which is a selfcontained unit consisting of a high speed printer, a card reader, a magnetic core memory unit, a power supply, and a maintenance panel.

6.4.9 Polynomial Buffer Terminal (PBT)

The PBT consists of a common buffer section and control for two 50.0 KHz line terminals that are switch selected to serve as either a serial/parallel, or a parallel/serial transmitter/receiver. In the transmit mode, the PBT buffer accepts 567 data bits and 33 poly-encrypted bits from the computer, via 30-bit parallel transfers, and then transmits the 600-bit NASCOM format block, bits serial, over the 50 KHz MSFN line. In the receive mode, the PBT receives the 600-bit blocks, bit serial from the 50.0 KHz MSFN line, performs a polynomial error check, and if this 600 bits pass the check, they are transferred, via 30-bit parallel transfers to the CP. In either the transmit or receive mode, the PBT selectable buffer collects wide band data in blocks of 240, 600, or 1200 bits and encodes or decodes a 33 or 22-bit polynomial code.

6.4.10 Communication Line Terminal (CLT)

The CLT is a combined serial/parallel data converter (for data to the 494) or parallel/serial data converter (for data from the 494). All low speed CLT's are 5-bit, and high speed or wide band CLT's are 6, 8, 10, or 12 bits.

The CLT serves to establish word framing of data accepted from and transferred to serial communication lines. Low speed CLT's operate on the teletype code character framing basis. For the input high speed and wide band CLT's, message framing is accomplished by synchronization character recognition or ready line activation.

Teletype Circuits

See Communications Chapter

6.5 Data Modems

• The 303G data modem (ALDS/MSFC/MCC) accepts serial binary data at the rate of 40.8 kbps. The data is then converted to a phase-modulated carrier signal in the 60 to 180 KHz frequency for transmission over wide band facilities.

At the receiving end of the data transmission system, the line signal is demodulated and the serialized data is delivered to a connection processing or storage device with a synchronized timing signal.

• The 303C data modem (303C) is utilized in the NASCOM (GSFC/MCC) link, for transmission of serial, binary, synchronous polencrypted data over "group" facilities. It is capable of transmitting over voice bandwidth circuits at 50 kbps and synchronous modes of operation. The synchronous mode is used with synchronous serial equipment such as magnetic tape units, computers, etc.

• The 205B wireline modem (GSFC/RS) is capable of transmitting digital data over NASCOM voice/rate circuits at 1200 bps, and 2400 bps. The modem has an

1800 Hz carrier frequency and employs synchronous four-phase modulation at 1200 baud regardless of the data rate. The data set can be used as a full-duplex terminal or as a regenerative repeater. As a terminal data set, it can operate at any of the three data rates independently in either direction.

HF Radio Data Modem

°The HF Radio data modem (Stelma Corporation Model 2400) currently used by the NASCOM network for transmitting high speed data over hf radio circuits is built to NASA Communications Division specifications. The modem consists of a transmitter, two receivers for diversity operation, and a power supply. The transmitter accepts a serial synchronous digital-data input and phase modulates 12, 6, or 2 Voice-Frequency (VF) tone channels when operating at 2400 bps, 1200 bps, or 600 bps, respectively. These tone channels are spaced at 200 Hz intervals from 700 Hz to 2900 Hz and are combined with a 480 Hz pilot tone to produce a composite VF output. The modulation method is differentialy coherent quaternary phase-shift keying.

6.5.5 Power and Airconditioning (MCC)

°Power

°System Description

The MCC "C" power is defined as commercial power furnished by Houston Lighting and Power Company (HLPC). "A" power is highly regulated, uninterruptable power supplied to the following: RTCC, CCATS, FACS, MITE, PCM, D/TV, and emergency lights. "B" power is 20-second interruptable power and is supplied to all loads other than those requiring "A" power. Commercial power is supplied to the electrical substation, Building 221. 12.5 KV feeders supply power to Building 48 (Emergency Power Building). At Building 48, the 12.5 KV is stepped down to 480 volts. Beyond this point, commercial power becomes either "A" or "B" power. (See Figure 6-F.) The "A" power portion energizes motor-generator sets that produce 208 volts for use at equipment panels in the MCC. The "B" power portion feeds stepdown transformers in the MCC, which provide 208 volts for use in the equipment panels.

•C-Power

The substation (Building 221) is fed by two HLPC generating stations, Webster and San Berton. Should one or the other fail, the remaining station continues to furnish power. From the substation, two 12.5 KV feeders furnish power to Building 48. Should either feeder fail, the other is capable of carrying the full load of the MCC.

•A-Power

During mission periods, a 350 KW diesel-generator is operated parallel (equally sharing the load) with each motor-generator. Should commercial power fail, the diesel generators will be synchronized and carry the full load formerly being carried by commercial power.

•B-Power

During mission periods, two 1360 KW diesel-generators are programmed to start automatically in the event of the loss of the commercial power. Within 20 seconds, both diesel generators will be synchronized and carry the full load being carried by commercial power.

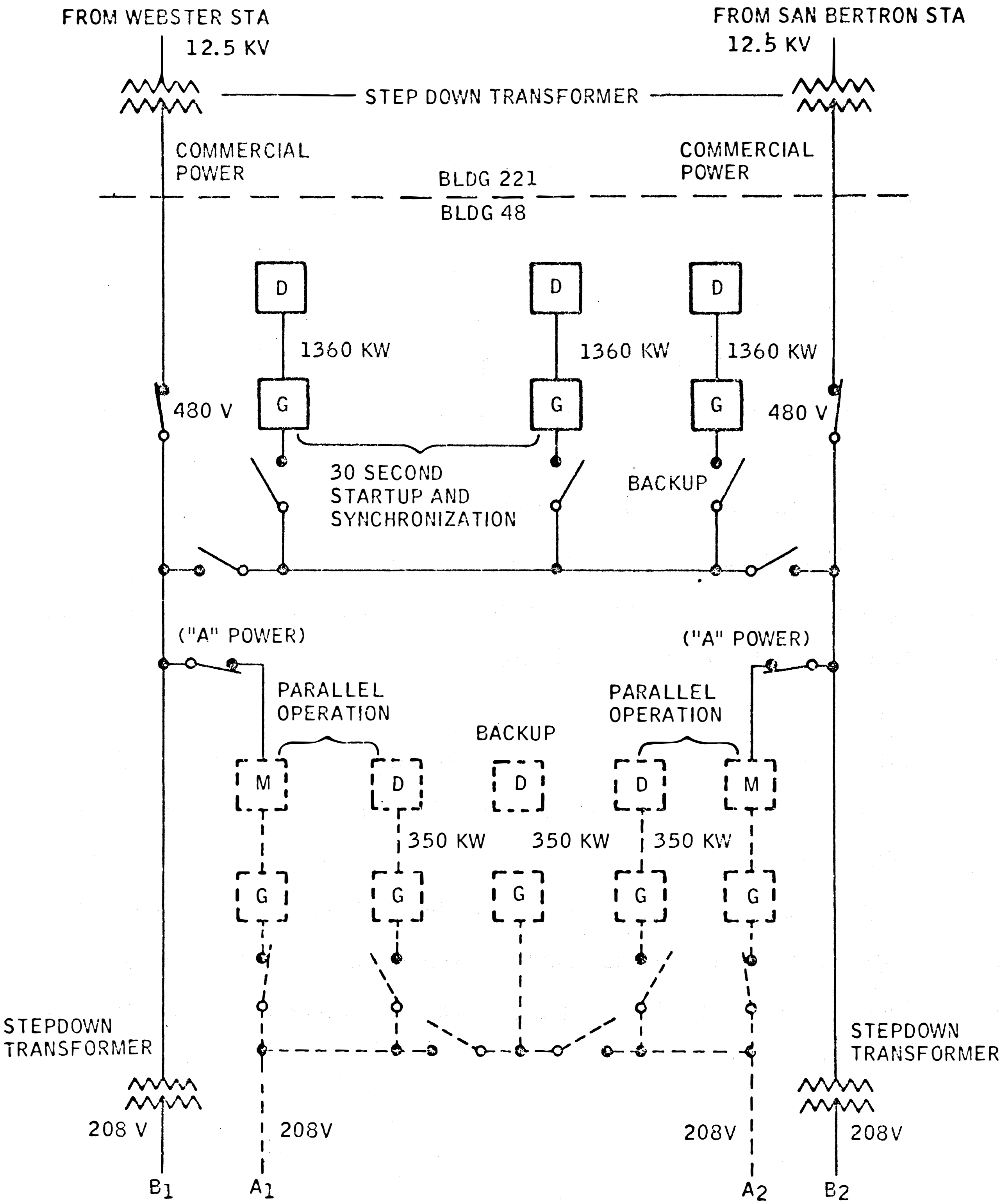


Figure 6F: MCC Power Distribution

°Cooling Tower Water

The primary source of cooling water is the same as domestic water for MCC and is piped into Building 48 on a loop. A 5,000 gallon tanker parked in the rear of Building 48 is used as backup in case of failure of the domestic water system.

°Air Conditioning System

°System Description

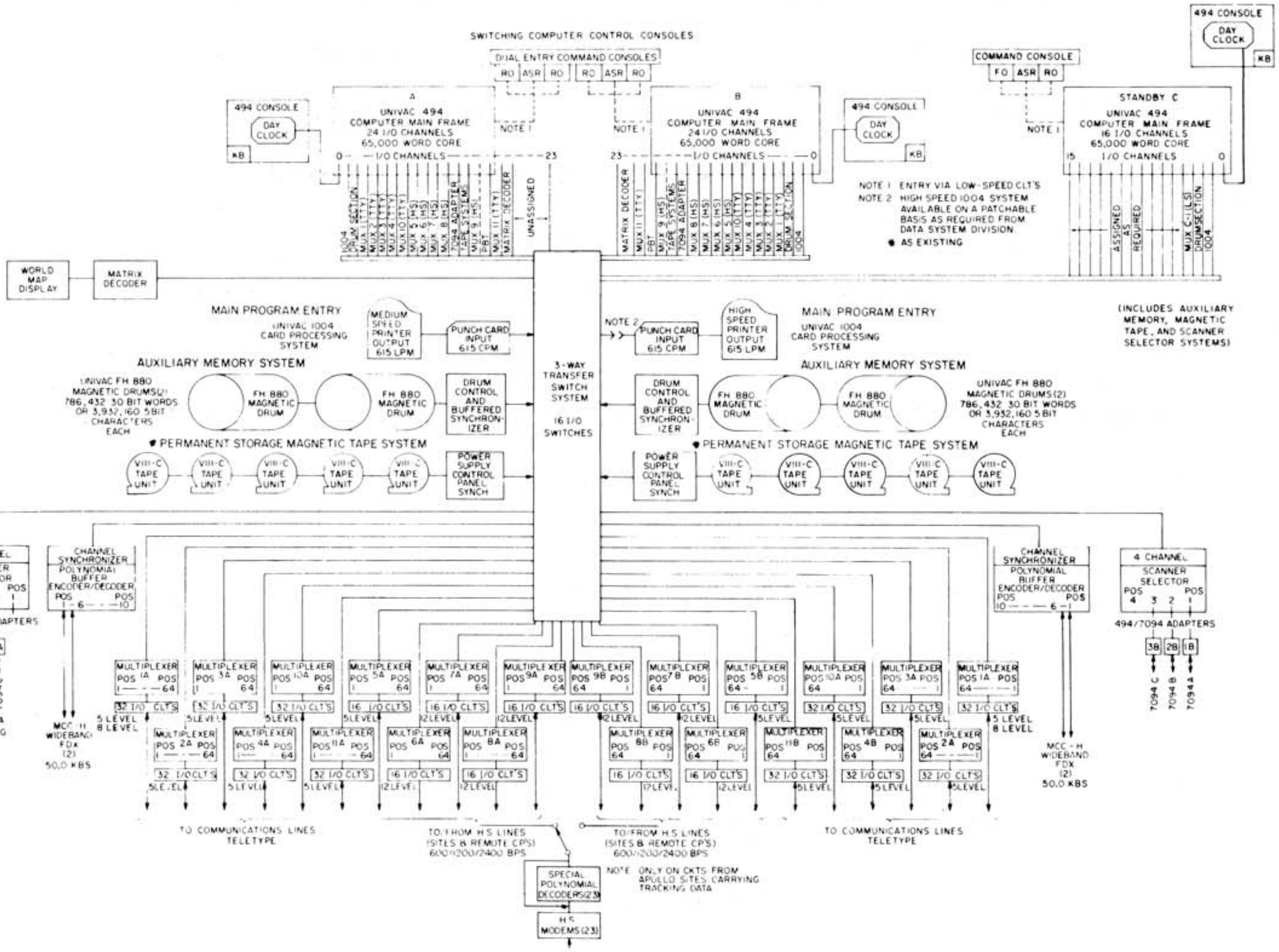
The MCC contains electronic equipment that must be cooled either by ambient air or forced air. Ambient air is supplied by overhead units, separate from chilled water and steam are both piped from Building 24. On each floor of Building 30, the chilled water and steam pass through separate sets of cooling and heating coils. B lowers force air over the coils at rates consistent with the total CFM demand; downstream controlled mixing then takes place to maintain proper temperature and humidity.

°Chilled Water

The primary source of chilled water is Building 24. Chilled water is piped to the MCC on a loop so that an alternate route may be used in the event a piping failure should occur.

Two 700 ton chillers located in Building 48 serve as backup to Building 24. In the event Building 24 is unable to supply chilled water, either of these 700 ton chillers can be brought on-line. The other unit would then serve as backup to the first.

6.6 GSFC



GSFC Univac 494 Switching Computer Equipment Configuration

FIGURE 6G

6.7 Remote Site (Hardware)

6.7.1 Data Transmission Unit (DTU) 2008, 2010 and 4024

The DTU provides computer controlled bidirectional interface between the 642-B and the high speed data link. The DTU can provide 8- or 10-bit parallel transfer between itself and the RSCC/RSTC. The transfer rate is determined by the clock signals provided by the 205B modems. The DTU has a capacity of 80,000 bps, with adjustment. An additional function of the DTU is to provide the RSCC with Greenwich Mean Time (GMT) to the nearest second.

6.7.2 Digital Data Distribution Switchboard (1299 S/B)

The 1299 S/B interconnects equipment of the computer complex. The switchboard provides a means of manually changing the system configuration. The switching function is easily performed through the 1299 S/B by the use of multiple switches, thereby avoiding extensive wiring modification.

6.7.3 Interface System Adapter (ISA)

The ISA includes the Dual GMT Buffer and the CAM Adapter. The Dual GMT Buffer inputs GMT from the site timing system to the 642B RSCC/RSTC. The CAM Adapter applies switch closure information to the computers and indicator outputs to the CAM keyboards.

6.7.4 Computer Address Matrix (CAM)

The CAM is a five by five matrix used for onsite inputs. The CAM serves as an input requrest devide to the RSCC and RSTC. Command CAM are classified in three categories: (1) command uplink inputs, (2) command mode input, and (3) command related function inputs. A unique command CAM is required in order to select each command mode and command related function.

Remote Site Hardware Interface

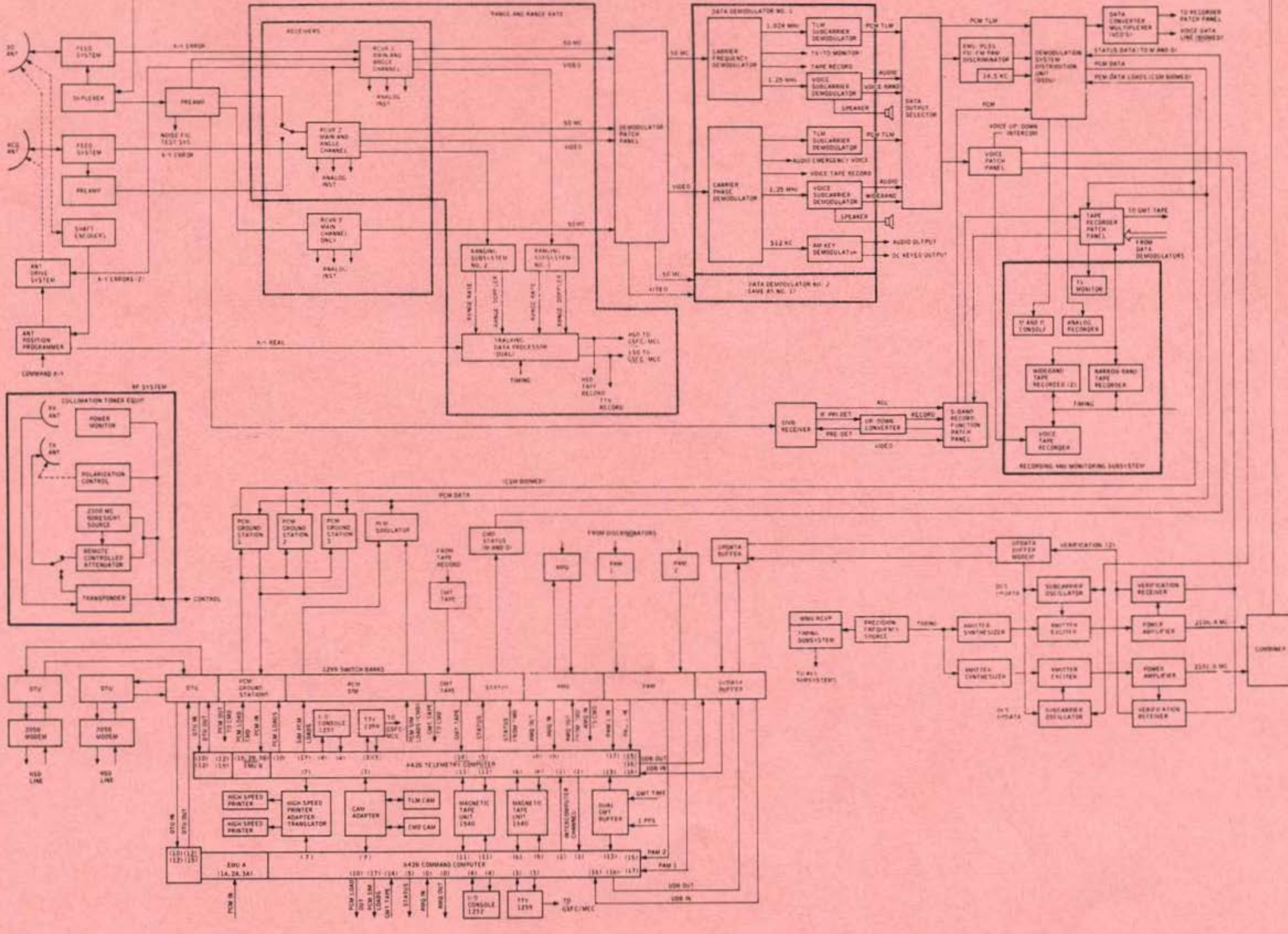


Figure 6H

6.7.5 642B Computer

The 642B computer is a general purpose, stored program, digital computer. Internal operations of the computer are preformed in a parallel mode using "one's complement," binary number notations. Binary calculations and logical translations are static; and only the results (in the form of arithmetic results and control timing) are clocked. The computer word consists of 30 bits, with most operations possible on half words as well as on whole words. Single address logic is used in the format. The memory section consist of three basic memories:

.Main Memory (destructive readout core storage)
.Control Memory (destructive readout thin film storage)
.Bootstrap Memory (nondestructive readout transformer controlled storage)

The main memory contains 34,608 addressable storage locations with a cycle time in nanoseconds. Program instructions and constants are stored in the main memory. The control memory, consisting of 128 storage locations with a cycle time in nanoseconds, is used primarily for I/D functions and for indexing. The bootstrap memory provided storage for two 32-word groups, each of which contains a program load routine, and only one of which can be used at a time.

Computer input and Output (I/O) is fully buffered, eliminating interference of the main process of I/O operations. There are 16 I/O channels, plus provisions for 81 unique interrupts.

6.7.6 Inter Computer (IC)

The IC subprogram controls the flow of data between the RSCC, RSTC and sets up a flag if data is valid for subsequent activities.

6.7.7 Magnetic Tape Unit (MTU) Type 1540/1541

The MTU is a large capacity, medimu speed, magnetic tape storage system capable of either receiving data from a computer and recording it on a magnetic tape, or calling up data from memory (retrieving) information previously recorded on tape and transferring it to a computer.

6.7.8 Teletypewriter Adapter, Type 1259 (CIT 68)

The 1259 teletypewriter consists of a teletypewriter set, Model ASR 28, and a Type 1259 teletype adapter. The adapter modifies data to provide compatibility between the computer and the teletypewriter unit. The teletypewriter is an electromechanical apparatus which serves as a selfcontained message originating and receiving center.

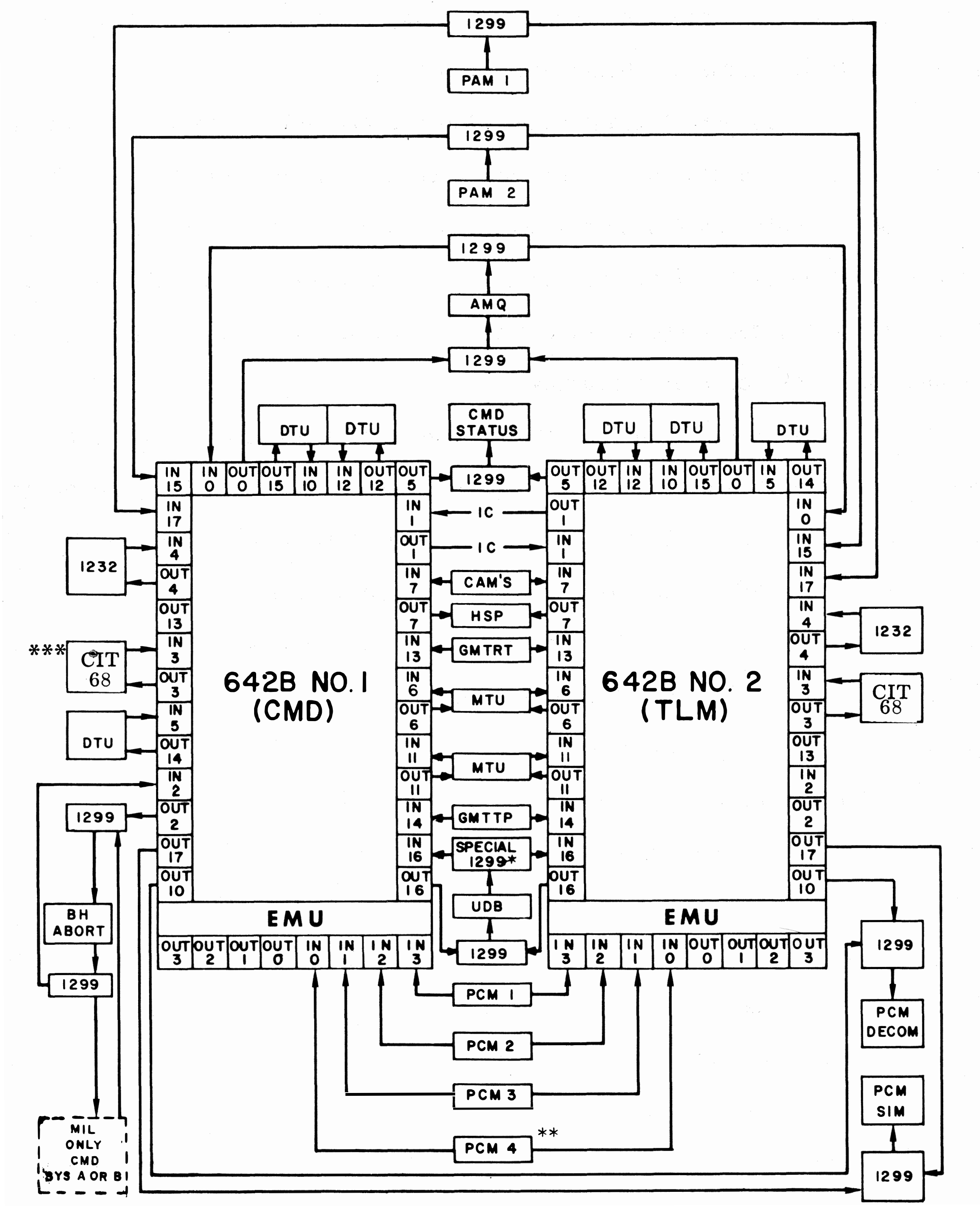
6.7.9 Input/Output Console, Type 1232

The 1232 Input/Output (I/O) console provides the 642B with an input/output device. The I/O console consists of keyboard, printer, paper tape reader and punch, the logic circuitry necessary to control the above units, control panel, and power supply assembly. Information that is either manually input at the keyboard or read from punched tape by the tape reader, is applied to the computer. The computer output to the 1232 is either printed on a page printer or output as preforated tape.

6.7.10 Unified S-Band System

The Unified S-band system provides tracking, ranging, command, telemetry, and voice communications. The system uses separate single transmitting and receiving carrier frequencies. The ground-to-spacecraft link

642B Computer Channel Assignment



*Also used for closed loop testing

**For stations with four PCM decoms

***A standard teletypewriter with a duplex adapter to interface with the CMP

Figure 6I

(uplink) consists of voice, digital command data and ranging signals. Information is modulated onto the S-band carrier by a composite of a voice subcarrier, a digitial command subcarrier, and a range code.

In the spacecraft transponder, the subcarriers are extracted from the RF carrier and detected to recover the voice and command information. The range code is detected and translated to a video signal. Voice and telemetry data to be transmitted from the spacecraft are modulated onto subcarriers, combined with the video range code, and used to phase-modulate the spacecraft-to-ground (downlink) carrier frequency.

The uplink and downlink carrier frequencies are coherently related to permit determination of range and range rate by comparison of the uplink and downlink range code. The transponder can also be frequency-modulated for the transmission of television information or recorded data. A short synopsis of each of the subsystems will be included. A list of USB systems is provided in Table 6-1, and a USB block diagram in Figure 6-J.

6.7.10A <u>Antenna System at Remote Sites</u>

The steerable, S-band antenna provides directional gain for both the transmitting and receiving functions. The antenna system is divided into four functional subsystems: antenna structure, hydraulic subsystem, servo subsystem, and airconditioning subsystem. The antenna structure supports parabolic reflectors with a quadrupod support for a secondary reflectory of the Cassegrain feed assembly. The antenna is positioned, through gears by the hydraulic subsystem. A transistorized electronic servo system remotely controls the operation of the hydraulic subsystem. Position error signals are applied to the

USB Systems

System	Subsystem or Equipment
Antenna systems	Antenna structure Hydraulic subsystem Servo subsystem Air-conditioning subsystem
Acquisition systems	Acquisition zone selection equipment Acquisition antenna
Control data systems	Antenna position programmer (APP) X- and Y-shaft encoders Tracking data processor (TDP)
RF system	Cassegrain feed system Parametric amplifier Power amplifier High-power combiner (85-foot stations) Verification system
Receiver/exciter system	Receiver Exciter
Uplink system	Updata buffer modem Subcarrier oscillator
Ranging system	Receiver, exciter, and digital ranging (RER) subsystem
Signal data demodulation system (SDDS)	Carrier frequency demodulator PCM telemetry data demodulator Voice and biomedical data demodulators
Apollo timing system	Precision frequency standard Time conversion and signal distribution circuits WWV receiver VLF receiver

TABLE 6 1

UNIFIED S-BAND SYSTEM BLOCK DIAGRAM

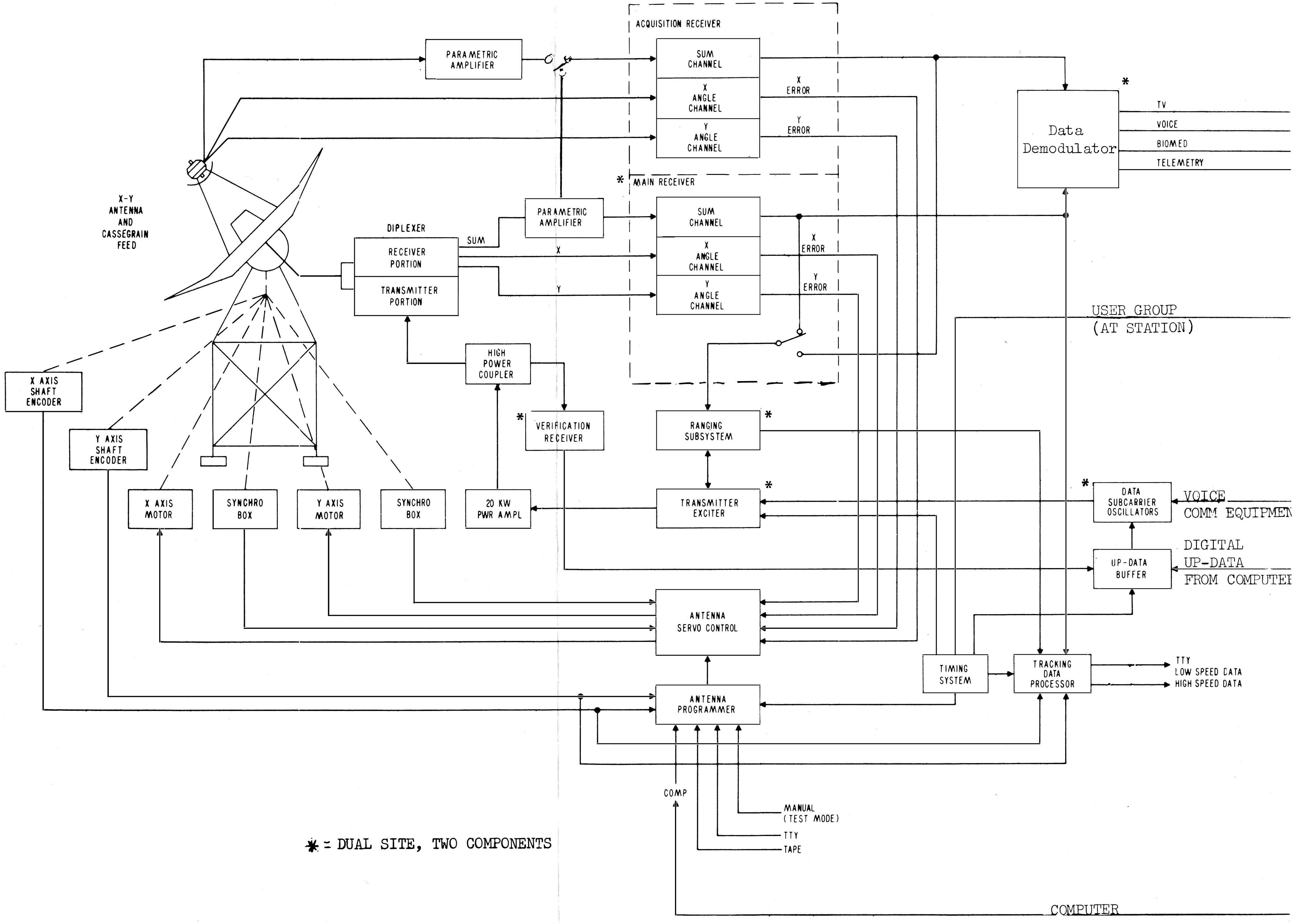


Figure 6J

servo subsystem from either a manual control, a programmer, a scan generator or tracking receivers. A specially designed airconditioning system maintains desirable ambient temperature conducive to continuous operation of the antenna's mechanical components.

6.7.10B Acquisition System

The acquisition system consist of acquisition zone selection equipment and an acquisition antenna. The system initially locates the spacecraft and accomplishes rapid, automatic, two-way carrier lock during a spacecraft pass.

The acquisition zone selection equipment is the means for offsetting normal and operation frequencies of ground transmitting and receiving equipment to compensate for doppler frequency shift caused by a component of radial velocity between the ground equipment and the spacecraft transponder.

Controls for the zone selection equipment are located on the acquisition control panel and the exciter control panel. Acquisition control panel functions relate primarily to selection and application of zone fixed bias. Exciter control functions with respect to acquisition control relate primarily to selection and application of a sweep bias.

For the 30-foot USB antennas, the acquisition is a 42-inch diameter paraboloid with a beam width of approximately 10 degrees. For the 85-foot USB antennas the acquisition antenna is a 74.5 inch diameter paraboloid with a beam width of approximately 5 degrees.

6.7.10C Control Data System

The Antenna Position Programmer (APP) provides antenna X-Y steering signals by comparing the actual position with a predetermined (command) input and providing an analog output porportional to their difference. The APP receives accurate X- and Y- axis positional information from angle encoders which derive their inputs from resolvers mounted on two axis of the antenna.

The antenna is capable of tracking in seven different modes. Three of these modes use the APP: autotrack, program, and automatic program. In the autotrack (prime) mode, the data is compared with the actual antenna position and any difference is stored in the APP for use during the next period of program operation. In the porgram mode (used for acquisition and backup), the error signals for both antenna axis are generated by the APP as a function of time and supplied to the servo system. In the automatic program mode, a summed signal (RF and program) drives the antenna.

•X- and Y- Shaft Encoders

The antenna position encoding subsystem receives two mechanical inputs representing the X-axis and Y-axis angles of the antenna.

Two precision servos on each axis repeat the X- and Y-axis inputs and position the encoders correspondingly. The real angle output is converted into bits of digital data in binary form. Binary data, representing the antenna position, is strobbed ten times per second by the APP and is used to compute antenna steering signals.

Tracking Data Processor (TDP)

Refer to Tracking Network Configuration, page

6.7.10D RF System

•Cassegrain Feed System

The Cassegrain system consists of a feed assembly positioned at the center of the main antenna reflector, a subreflector positioned near the focal point of the main antenna reflector, and a transmission filter located in the wave guide path between the transmitter and diplexer. RF energy from the waveguide is radiated from the feed assembly to the subreflector, reflects the energy to the main reflector surface, which in turn reflects the energy into space.

•Parametric Amplifier

Low-noise parametric amplifiers (paramps) are employed between the antenna feed systems and the sum channel of the receivers to provide signal amplification with minimum noise. The amplifier is of solid-state design. There are two types: cooled and uncolled. The cooled paramp improves system sensitivity by 2db over that of the uncolled paramp. All MSFN stations have one uncooled paramp connected to the main antenna and another paramp connected to the acquisition antenna. The following stations have a cooled paramp available for use with the main antenna: GDS, MAD, HSK, HAW, GWM, CRO, ACN, and the NT&TF at GSFC.

•Power Amplifier

The power amplifiers at USB ground stations consist of a klystron high-power amplifier and its associatdd power supplies, controls, protective devices, and cooling units. The klystron is a water cooled, five-cavity tube tunable over a frequency range of 2090 to 2120 MHz. It is capable of over 20-kw continuous output power with a minimum 10- MHz bandwidth. The wide bandwidth permits simultaneous amplifiaction of two signals 5 MHZ apart. When used for this dual-type transmission, however, the output at the 30-foot stations must be reduced to prevent excessive intermodulation distortion. At the 85-foot stations, there are two 20-kw power amplifiers and a high power combiner that permits transmission at full power.

The output of the klystron is coupled by rigid and flexible waveguide to the antenna feed system.

•High Power Combiner

At each of the 85-foot stations, a high power combiner is provided for dual 20-kw transmission without intermodulation distortion.

•Verification System

The verification system monitors the RF output of the power amplifier. The system comprises a verification receiver and subcarrier demodulators.

The reciever accepts and demodulates the high level phase modulated RF carrier from a directional coupler located in the feed assembly to the USB transmit antenna. The receiver output is fed to the subcarrier demodulators.

The subcarrier demodulators receive the video output of the receiver and demodulate the two subcarriers (center frequencies of 30 kHz and 70 kHz) present in the video. Each subcarrier channel output drives a dual-line driver amplifier which provides two balanced 600-ohm outputs. The 70 kHz demodulator output is applied to the updata buffer for command verification. The 30 kHz demodulator output is provided for voice verification.

6.7.10E Receiver/Exciter System

The receiver/exciter system provides phase modulation of uplink carrier with voice, CMD, and ranging signals while demodulating the spacecraft downlink. The modulated uplink signal is multiplied in frequency and used to drive the power amplifier. The downlink signal is demodulated in receiver portion to provide a broad baseband signal containing voice and telemetry information to the signal data demodulator and ranging information to the MARK 1 ranging system.

6.7.10F Uplink System

The uplink signals (ground-to-spacecraft) consist of voice, CMD data, and range code. These three types of intelligence are phase-modulated onto the S-band carrier. The basic components of the uplink system are the updata buffer, subcarrier oscillator, and exciter subsystem.

•Updata Buffer

The updata buffer interfaces the command data processor (modified 642B computer) with USB Subcarrier Oscillator (SCO) or the UHF command transmitters. It operates in simultaneous transmit and receive modes. Parallel digital data from the computer is converted to a serial Phase Shift Keyed (PSK) audio signal and applied to the selected RF equipment for transmission to space vehicles. In the receiver portion, PSK audio signals from the verification system are demodulated and reconstructed in digital format and then fed back to the computer.

°Subcarrier Oscillator

The subcarrier oscillator system consists of a mode switching amplifier, a 30 kHz VCO, a 70 kHz VCO, and a line-driving amplifier. This system frequency multiplexes voice and digital data inputs for application to the exciter. Voice input frequencies between 100 Hz and 3 kHz are applied as modulating signals to the voice subcarrier oscillator to produce an FM output with a center frequency of 30 kHz. Command data from the updata buffer is used to frequency-modulate a subcarrier oscillator of 70 kHz. The mode selection network provides subcarriers at the voltage levels required for eight different modes of operation. A backup voice mode is derived by modulating the 70 kHz subcarrier with voice.

6.7.10G Ranging System

The ranging system (ranging receiver, exciter, and digital ranging subsystem) provides data which yields the instantaneous range between the Apollo spacecraft and the ground station. The Receiver/Exciter/Ranging (RER) system permits determination of range up to 800,000 km. The digital ranging method has an accuracy of ±15 meters.

6.7.10H Signal Data Demodulation System (SDDS)

Voice and telemetry data are transmitted from the spacecraft on modulated subcarriers. Some of these subcarriers and the video ranging signals phase modulate the downlink carrier frequency. Other telemetered information including voice, data, and television signals may be frequency modulated onto a downlink carrier.

Demodulation is accomplished by the SDDS, which receives its input from either the main or the acquisition receiver via the telemetry channel receivers. The SDDS demodulates two types of signals: a 50 MHz FM carrier and a video signal (10 Hz to 1.5 MHz) derived from a PM carrier.

Both the FM carrier and the video signals may contain voice, PCM, and biomedical data modulated on subcarriers. In different transmission modes, the FM carrier input may contain spacecraft television video modulation or scientific data subcarriers while the PM baseband signal may contain voice modulation or emergency continuous wave keyed signals. The 50 MHz FM input is routed to the frequency demodulator which in turn feeds a recorder output, an isolation amplifier and filter (television channel), the voice and biomedical data demodulator, and the PCM demodulator. The video input from the USB receiver is applied to a separate voice and biomedical data subcarrier demodulator, PCM telemetry demodulator, and the emergency key demodulator (85-foot antenna stations only). Also detected in this channel is backup voice information. The telemetry subcarrier demodulators and the voice and biomedical data subcarrier demodulators of the PM and FM channels are identical.

6.7.10I Apollo Timing System

The Apollo timing system accepts inputs from a standard frequency oscillator employing an atomic reference standard and derives from the frequency standard all the time signals required by a S-band tracking facility. The system employs two identical time standards plus common time conversion and signal distribution circuits; also included is a time calibration facility employing a WWV receiver, a VLF receiver, and a LORAN-C.

6.7.11 Digital Data Formatter (DDF-13)

The DDF-13 (refer to Figure 3-D) is basically a telemetry synchronizer and data formatter. It receives the PAM/FM/FM telemetry data from subcarrier discriminators; synchronizes operation on the data with pulse rate, main frame and subframe, and generates and formats digital outputs for the RSTC.

6.7.12 Land Based C-Band Radars

The C-band tracking equipment used in the MSFN can be summarized as members of a family of high accuracy, long range, amplitude-comparison monopulse instrumentation radars. These ranging instruments provide accurate spherical coordinate information on long range, high velocity targets, such as earth orbital vehicles, as well as shorter range space vehicles, missiles, instrumented packages, and satelites. Representative of the network equipment is the FPS-16, which has served as the basic foundation for improved system such as the FPQ-6, and the TPQ-18 system. Digital data processing techniques, transistorized and integrated circuitry, parametric amplifers, etc., have been used to modify and update the early models of the FPS-16, thus producing a family of precision ranging and tracking.

Table 6-2 lists the C-band radar equipped stations which are available for support of MSFN missions. Also listed in the table are the specific types of radars employed at the stations as well as the type of antenna and maximum range (in nautical miles) of each radar system.

C-band radar determines the position of a spacecraft by measuring its range, azimuth, and elevation with respect to the ground tracking station.

The C-band radar operates in two tracking modes: beacon and skin track. In the beacon mode, a transponder aboard the spacecraft receives the transmitted radar pulse,and, after a know delay, transmits a reply pulse. In the skin track mode, RF energy reflected by the spacecraft is detected by the ground radar receiver. The maximum range limitation of the C-band radar systems restricts radar tracking to earth orbital missions and near-space phases of lunar missions.

•FPQ-6 (TPQ-18)

The FPQ-6 and the TPQ-18 systems are long range Missile Predicition Instrumentation Radars (MIPIR) and differ only in that the former is intended for fixed station operation and the latter is a transportable, van-mounted system. The diameter of the antenna associated with these radars is 29 feet, and they have a gain of 41db at a frequency range of 5400 to 900 MHz. Their peak transmitter power is 2.8 megawatts. They are located at the following MSFN sties: (FPQ-6) BDA, CRO, and PAT; (TPQ-18).

•RCA 4101 Computer

Processing of the C-band radar data at the MIPIR sites is accomplished through the use of an RCA 4101 computer. This computer is programmed to correct raw pedestal position data for most static radar errors and to provide range, azimuth, and elevation data in digital form. It processes the data in the following manner:

a. Corrects for static error (e.g., pedestal unlevel)
b. Formats the data
c. Time tags the data
d. Outputs data at required sample rates

C-BAND RADAR EQUIPPED STATIONS

Station	Station Symbol	Radar	Antenna					Range (nm)
			10-Ft. Parabolic	12-Ft. Parabolic	16-Ft. Parabolic	29-Ft. Cassegrainian Feed*	16-Ft. Cassegrainian Feed**	
Cape Kennedy	CNV	Azusa/FPS-16		X				1,000
Merritt Island	MLA	TPQ-18				X		32,000
Patrick Air Force Base	PAT	FPQ-6				X		32,000
Bermuda	BDA	FPS-16/Azusa		X				32,000
		FPQ-6				X		32,000
Carnarvon, Australia	CRO	FPQ-6				X		
Vanguard (ship T-AGM-19)	VAN	FPS-16					X	32,000

*Vertical, horizontal, left-hand circular, and right-hand circular polarization.
**Transmits left-hand circularly polarized. Receives right-hand circularly polarize

Table 6-2

°FPS-16

Another radar used in the network is the FPS-16. This is a high accuracy, long range, amplitude comparison, monopulse radar system designed for tracking opbects in orbital or suborbital flight. Several modifications to this radar have caused it to vary in its performance from site to site.

The Compact All Purpose Range Instrument (CAPRI) is a miniaturized instrumentation radar similar in performance to the FPS-16. Integrated circuits are employed, resulting in a substantial weight and volume reduction. The antenna associated with this system is normally 12 feet. Other stations which have the FPS-16 radar are BDA and CNV. The peak transmitted power for all these sites is 1.0 megawatt.

The FPS-16 at BDA uses the 4101 associated with the FPQ-6 at that station. CNV does not have any processing capability. It sends its data to the Real Time Computer Facility (RTCF) to be processed there. The data handling unit associated with the FPS-16 at BDA is the MILGO 165 D/TTY converter.

The MILGO 165 handles Low Speed Data (LSD) only. It receives digital information containing azimuth angle, elevation angel, and slant range from the FPS-16 radars. It converts the information from Gray code to a straight binary code when necessary and arranges it in the format needed for transmission over a commercial teletype line. The stations which ave this unit are: BDA, CRO, GYM, and TEX.

°T-AGM-19, C-Band Radar

The C-band radar installed on the Apollo 19 class ship Vanguard is an FPS-16, modified for shipboard use by addition of onmount rate gyros and a hydrostatic bearing compensated for horizontal thrust components. The system can provide trajectory data in realtime for space mission operational decisions and future evaluations of performance. It is amplitude comparison, monopulse radar, which is capable of manual or automatic acquisition and tracking of objects in flight or orbit. The capability exists for selecting either a single pulse output for skin tracking, or a coded pulse group output for beacon tracking, or a coded pulse group output for beacon tracking, or a coded pulse group output for beacon tracking. The transmitter operates over a range of 5.45 to 5.825 GHz at a peak power of 1 megawatt.

Network Configuration for AS-508 Mission

Systems	TRACKING			USB				TLM				DATA PROCESSING				COMM				OTHER		REMARKS
	C-band (High-Speed)	C-band (Low Speed)	USB	TV to MCC	Voice	TLM	Command	VHF Links	FM Remoting	Mag Tape Recording	Decoms	642B TLM	642B CMD	CDP	1218	High-Speed Data	TTY	Voice (SCAMA)	Voice VHF A/G	Range Safety	SPAN	
ACN			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
ANT																				X		
ARIA(4)			X		X	X		X		X							X	X	X			Note 1
ASC																						
AOCC																	X		X			
BDA	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		
CNV																				X		
CRO	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	
CYI			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	
GBI																				X		
GDS			X	X	X	X	X		X	X	X	X	X		X	X	X	X	X			
GDS-X			X		X	X	X								X							Note 2
GTK																				X		
GWM			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
GYM			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
HAW		X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
HSK			X	X	X	X	X		X	X	X	X	X		X	X	X	X				
HSK-X			X		X	X	X								X							Note 2
MAD			X	X	X	X	X		X	X	X	X	X		X	X	X	X				
MAD-X			X		X	X	X								X							Note 2
MARS				X	X	X			X													Note 2
MIL			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
MLA		X																		X		
PAT																				X		
TEX			X		X	X	X	X	X	X	X	X	X		X	X	X	X	X			
VAN	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			

Note

1. TLI and reentry
2. Post TLI coverage

Table 6-3

7.0 Spacecraft Television

Color TV cameras will be used to provide realtime television coverage. The color cameras transmit black and white pictures taken through a revolving red, green, blue filter. The MCC ground equipment converts these sequential field black and white pictures to color by means of a video disc and color encoder. A slow scan black and white camera will be carried in the LM as a backup. The slow scan TV is converted at the MSFN sites to standard 525 line video.

SPACECRAFT TELEVISION

The three 85-foot MSFN sites (HSK, MAD, GDS), the 210-foot antenna at the MARS site near Goldstone, California, and the 210-foot antenna at Parkes, Australia will be used to provide TV coverage. These sites will receive the TV video and transmit the video to MSC. At MSC the black and white video transmitted from the LM and CSM color cameras will be converted to color and will be released to the Flight Control personnel and the commercial networks.

7.1 Remote Sites

7.1.1 Goldstone

7.1.2 Goldstone Mars Site

The Mars 210-foot site can simultaneously receive and remote to the GDS 85-foot site two downlinks. The Mars site will be used much like an additional wing site except that it has no Apollo uplink capability. Support for all the CSM and LM communications modes is provided within the constraint of two downlinks.

7.1.3 Goldstone 85-Foot Site

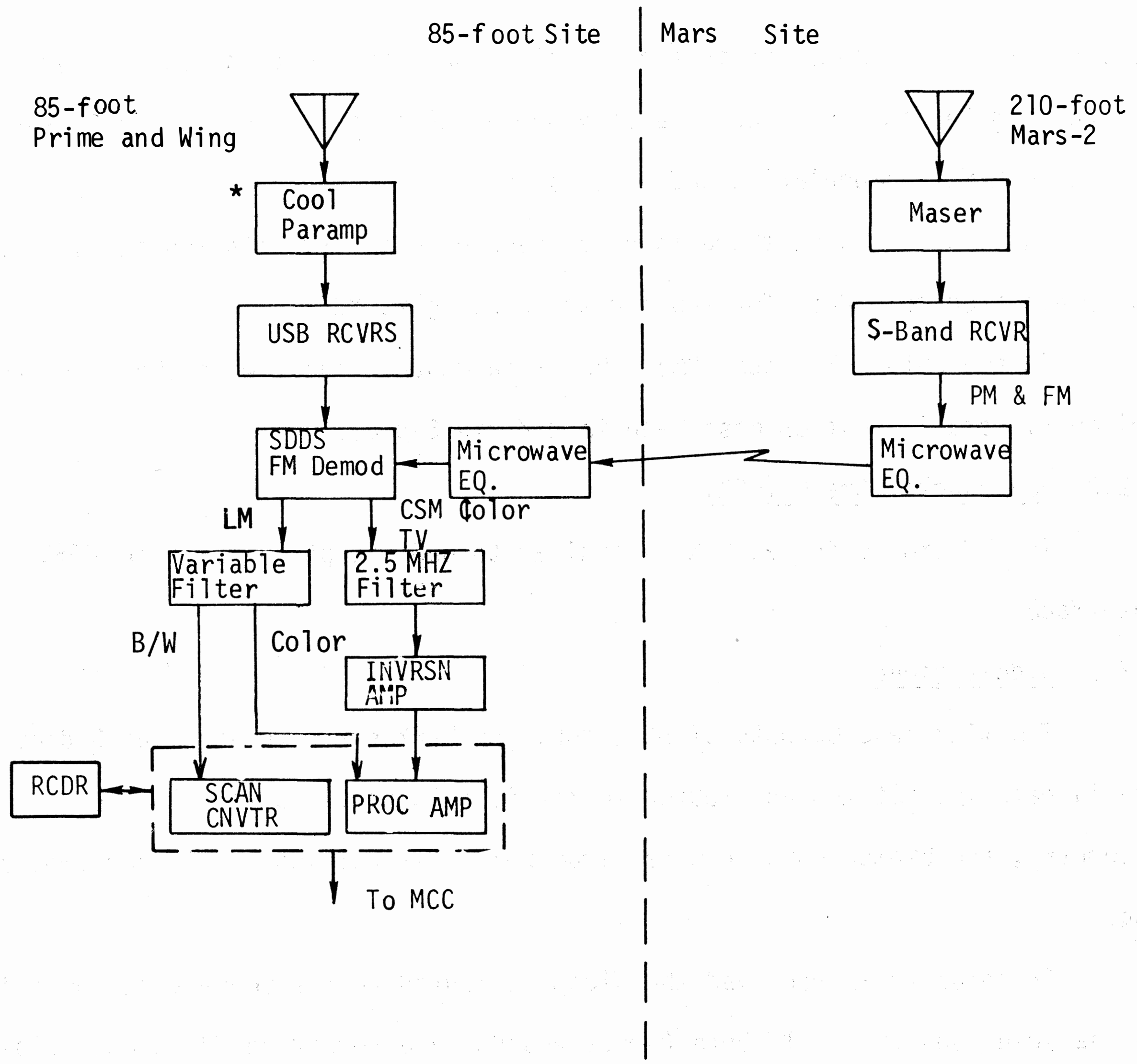
The data relayed through the Mars 210-foot site is demodulated by the Signal Data Demodulator System (SDDS). The voice and telemetry outputs of the FM and PM demodulators are processed on site in the same manner as voice or telemetry data received from the 85-foot antennas. The TV data output of the FM demodulators is routed to the Scan Converter. TV signals received from the 85-foot prime and wing sites are also routed through FM demodulators to the Scan Converter where the best source is selected for remoting to the MCC. The processing at the scan converter is dependent upon the type of TV being transmitted. The black and white slow scan is filtered and scan converted. The LM CSM TV video is low pass filtered and routed to a processing amplifier prior to interfacing with the video lines to MCC.

7.2 Australia

7.2.1 Parkes

Parkes can be used to receive and remote FM and PM communications modes. The configuration and resultant capability depends upon the type of TV being transmitted. (Refer to Figure 7A). For the first case, the black and white slow scan TV is demodulated and then up-converted on a 2.5 MHZ VCO. The data subcarriers are bandpass filtered. The two signals are remixed and remoted via a single channel microwave link to Sidney. At Sidney the voice and telemetry data is passed to HSK for demodulation and processing. The TV data is discriminated from the 2.5 MHZ carrier, scan converted and remoted to MCC.

For the LM color TV case, the output of the FM demod is applied to the microwave link. At Sidney the TV signal is low pass filtered to remove the



Goldstone Mars Site, Prime, and Wing Site Configuration for TV, Voice, TLM, and Biomed

*Wing Site (Maser) Prime (Cool Paramp)

Figure 7

data subcarriers, amplified in a processing amplifier to clean up the sync signal and remoted to MCC. The telemetry and voice data is band pass filtered and sent to HSK for demodulation and processing.

For the CSM case, there is no voice and telemetry data and the TV video is transmitted to Sidney for subsequent remoting to MCC.

In the data only mode (PM), the PM base band signal with the voice and telemetry data is sent on base band to HSK via Sydney.

7.2.2 <u>Honeysuckle Creek (HSK)</u>

The TV processing at HSK is similar to GDS except there is no MARS interface.

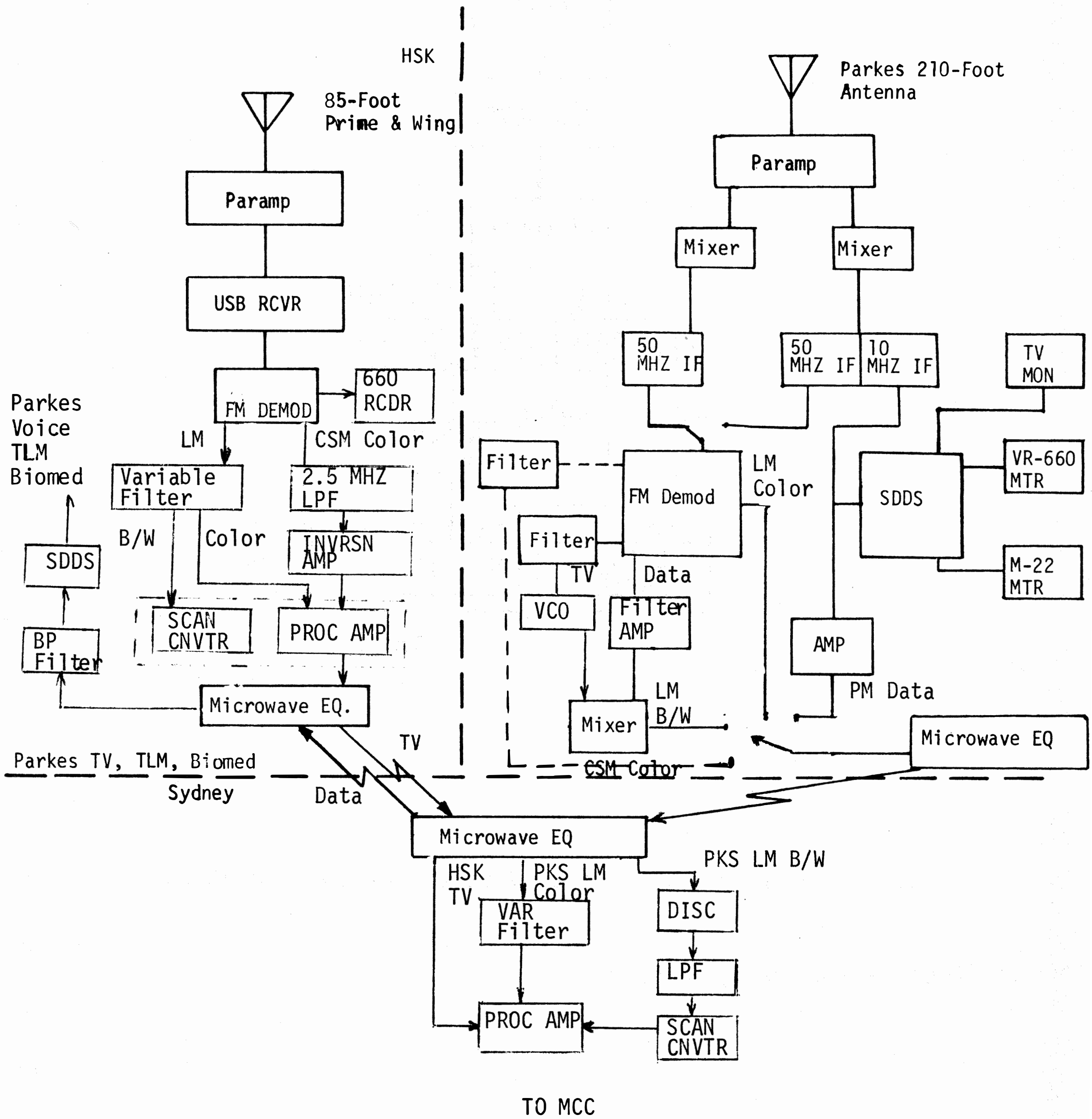
7.2.3 <u>Sydney Video</u>

The microwave outputs of HSK, NBE, and Parkes are received at Sydney. The TV data is filtered and routed to the Scan Converter area. The voice, telemetry, and biomed data received from Parkes is relayed to HSK for processing.

If color TV is received the video is routed to the porcessing amplifier in the scan converter. If both Parkes and HSK are receiving TV, Sydney video performs a best source selection. The sequential field color TV is amplified, recorded, and remoted to the MCC via microwave, land line, and satellite. Refer to Figure 7A.

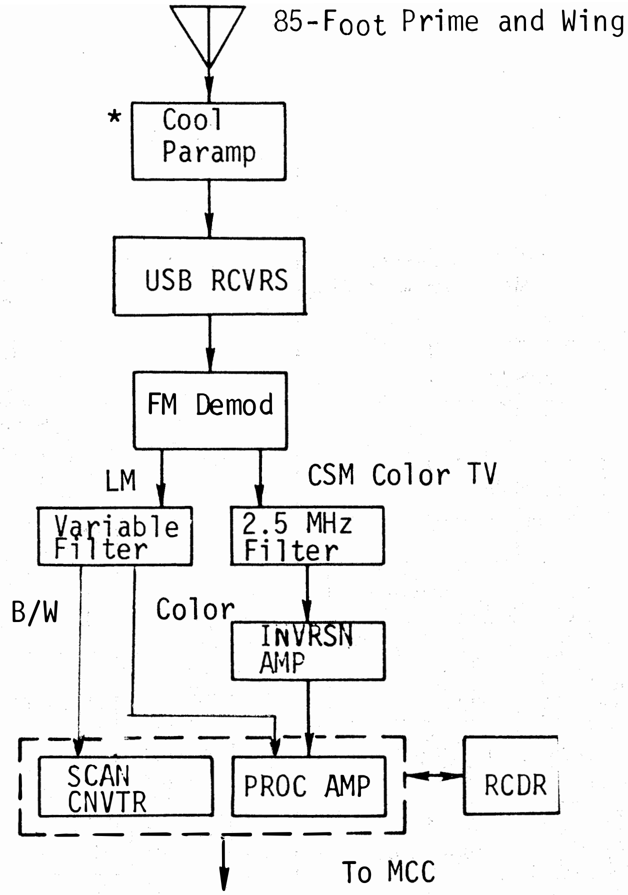
7.3 <u>Madrid (MAD)</u>

The TV processing at MAD is similar to GDS except there is no MARS interface.



PARKES/HSK/SYDNEY CONFIGURATION FOR REMOTING TV, VOICE, TLM and BIOMED

Figure 7A



Madrid Prime and Wing Site TV Data Flow Configuration

*Prime (Cool Paramp) Wing (Maser)

Figure 7B

7.4 Manned Spacecraft Center (MSC)

7.4.1 MSC TV Routing

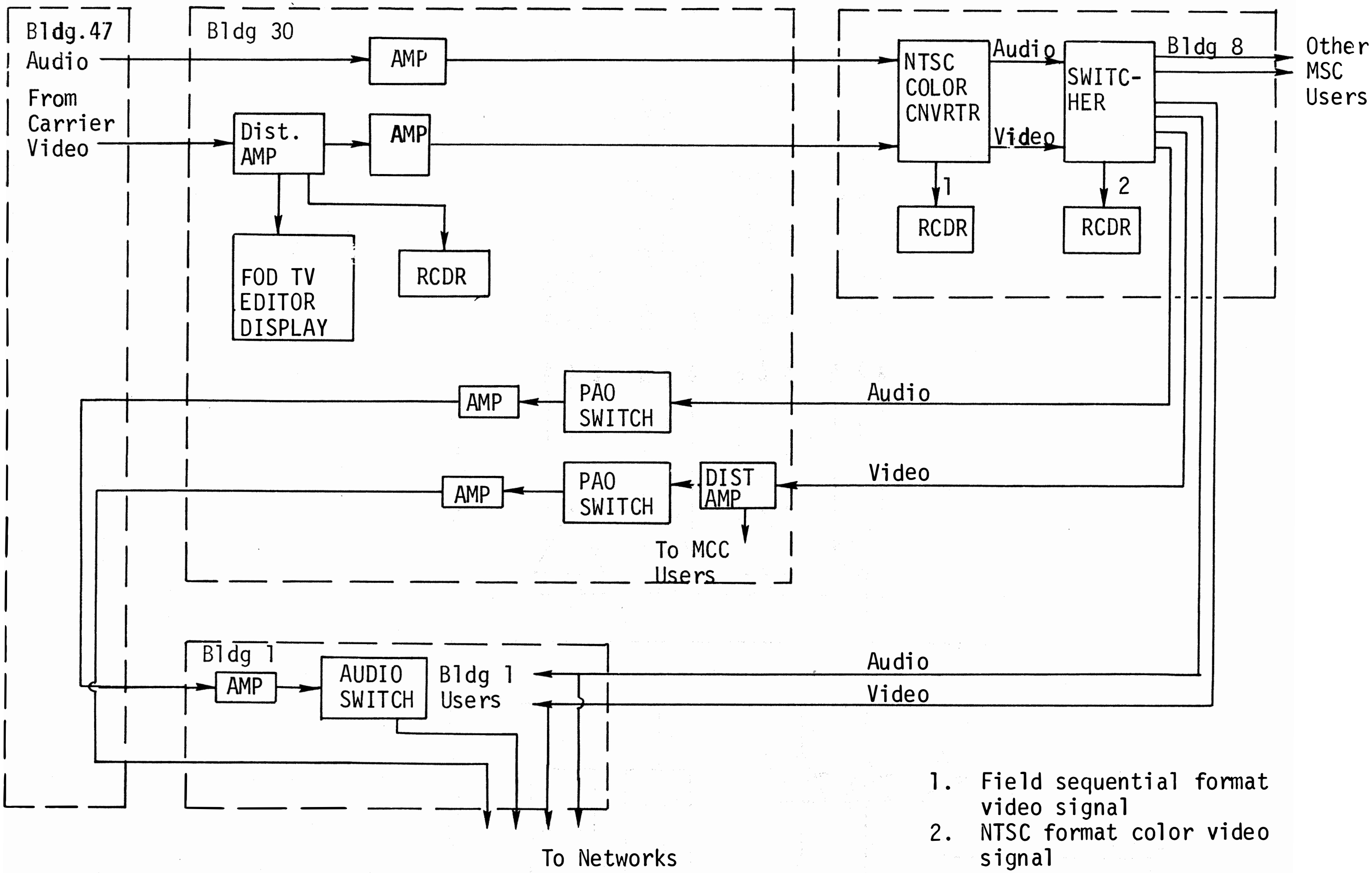
Video from the color cameras is remoted to the MCC from the remote site in black and white field sequential order via common carrier. The audio signals are taken from the normal GOSS voice lines. These audio and video signals are received at building 47 at MSC. Building 47 will route the audio and video signals to the MCC where the audio is amplified and transmitted to the color converter in building 8. The video signals entering the MCC are distributed to the FOD TV Editor Display, to a recorder, and then to the building 8 color converter. The color TV is transmitted in black and white/red, green, blue field sequential order. Six frames (two of each color) are required to make one color frame. This conversion is done by means of a disk which stores the sequential fields produced by the color wheel on the TV camera. These fields are read off the disc in parallel and into a color encoder which produces the National Television Standards Committee (NTSC) standard color TV output. The input signal to the color converter is first recorded (in building 8) along with the audio signal. It is played back on a second tape machine and any frequency or phase shift which may have occurred is removed. The output of the converter is made available to a switcher which is used to route the converted TV to several MSC users. These outputs include the MCC, the Flight Operations Directorate office in building 2, the Eidophor in building 1, the commercial TV pool in building 1, and a color recorder in building 8.

The received converted TV routed to the MCC along with the audio is distributed to several monitors within the MCC and thru a PAO switch which can be used to edit the TV released to the networks. The output of the PAO switch is routed through building 47 to building 1 where it can be released to the networks. Refer to Figure 7C.

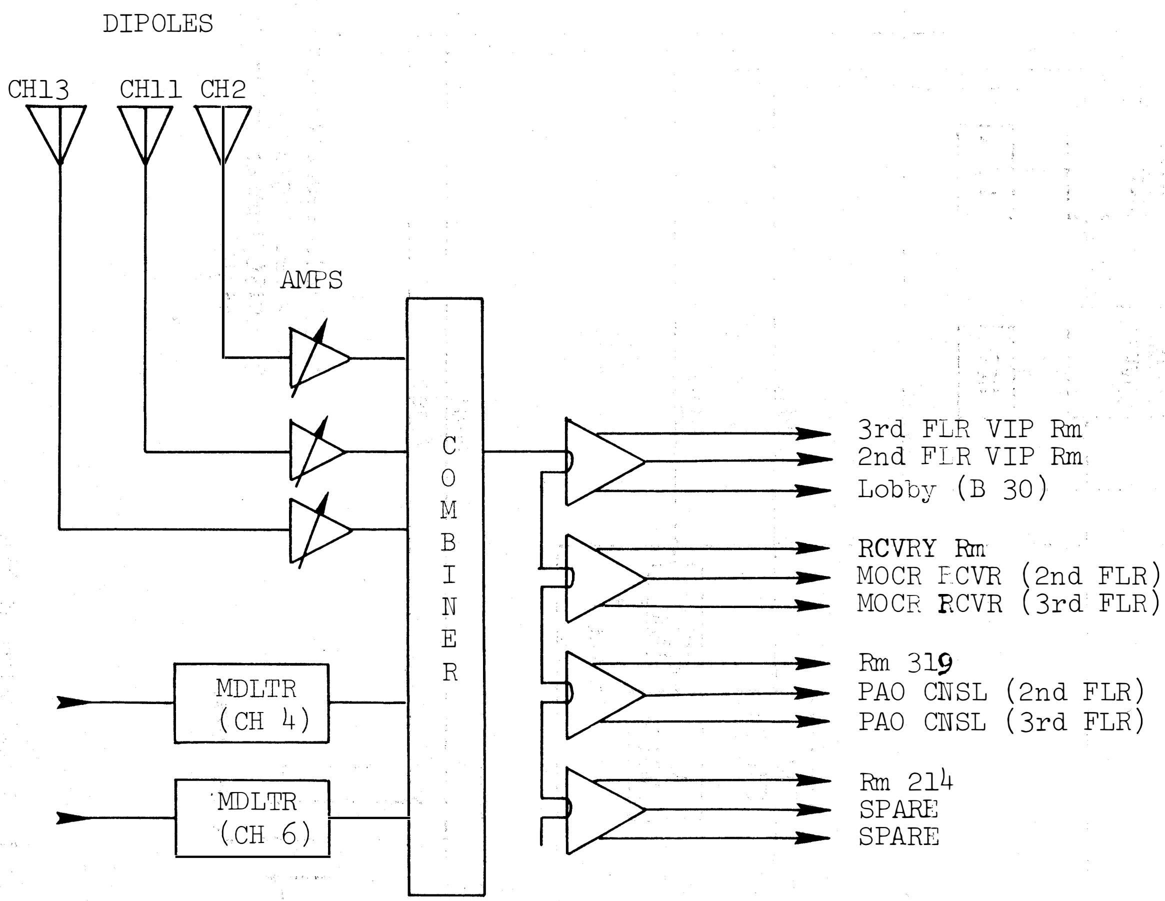
7.4.2 <u>RF Color TV Distribution System</u>

A RF color TV distribution system is being utilized to make color TV available to various users in Building 30. Three dipole antennae, one antenna for each of the three networks (ABC, CBS, NBC - local broadcast channels 2, 11, and 13), are installed on top of the MOW. These signals are amplified and routed to a combiner. There are also two inhouse inputs to the combiner which can be used for spacecraft or other TV. These inputs are routed through a channel 4 or channel 6 modulator to the combiner. The combiner enables commercial color television receivers to be used as the display device. The output of the combiner is routed through an amplifier to the receivers. Receivers are located in each VIP room, the MOCR, both PAO consoles, the building 30 lobby, the recovery room, and various other rooms. Refer to Figure 7D.

Figure 7C



Color TV Signal Flow at MSC



R.F. Type Color TV Distribution - Building 30

Figure 7D

TEST PLAN

TEST PLANS

TEST PLAN

CODE 1 of 1 1 of 2 1 of 3 1 of 4 1 of 2 (SAME STATION)

SITE	TLM-VHF	USB			CMD-UHF	C - BAND	NOTES	TLM-VHF	USB			CMD-UHF	C - BAND	NOTES	TLM-VHF	USB			CMD-UHF	C - BAND	NOTES
		TLM	TRK	CMD					TLM	TRK	CMD					TLM	TRK	CMD			
	MANDATORY							HIGHLY-DESIR							DESIRABLE						
MIL																					
MLA																					
CNV																					
PAT																					
GBM																					
GBI																					
BDA																					
GTK																					
ANG																					
ANT																					
CYI																					
ACN																					
ASC																					
MAD																					
RID																					
PRE																					
TAN																					
CRO																					
WOM																					
HSK																					
NBE																					
GWM																					
HAW																					
CAL																					
GDS																					
PIR																					
GYM																					
WHS																					
TEX																					
VAN																					
RED																					
MER																					
HTV																					
PFS																					
CIF																					
TEL IV																					

TABLE 8

TO BE SUPPLIED BY : INDIVIDUAL USER

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

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; Apollo Guidance Simulator
AIU	Abort Interface Unit
ALDS	Apollo Launch Data System
ALTDS	Apollo Launch Trajectory Data Subsystem
AM	Amplitude Modulation
ANG	Antigua (USB Site)
ANT	(Antigua (C-band Site)
AOCC	Aircraft Operations Control Center
AOS	Acquisition of Signal
APCU	Apollo Process Control Unit
APP	Antenna Position Programmer
APS	Ascent Propulsion System
A REG	A Register
ARIA	Apollo Range Instrumentation Aircraft
ASC	Ascension (C-band Site)
ASCA	Apollo Simulation Control Area
ASCATS	Apollo Simulation, Checkout, and Training System
ASR	Automatic Send/Receive
ASRS	Apollo Simulated Remote Site
AVP	Address Verification Pulse
BAPB	Biomedical Analog Patch Board
BCD	Binary Coded Decimal
BDA	Bermuda
BMDADS	Biomedical Data Analysis and Display System
CACC	Communications and Configuration Console
CAL	California
CAM	Computer Address Matrix
CAP	Command Analysis Pattern; Computer Acceptance Pulse
CAPRI	Compact All Purpose Range Instrument
CASTS	Countdown and Status Transmission System
CCATS	Communication, Command, and Telemetry System
CCC	Command Computer Controller
CCIA	Console Computer Interface Adapter
CCIT	International Telegraph Telephone Consultative Committee
CCMU	Computer Controller Multiplexer Unit
CDC	Control Data Corporation
CDCIS	Computer Display Control Interface Subsystem
CDP	Central Data Processor

CDSC	Communications 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
CMP	Computer
CNV	Cape Kennedy
CP	Central Processor; Communications Processor
CPU	Central Processing Unit
CRO	Carnarvon
CRP	Computer Reset Pulse
CRT	Cathode Ray Tube
CSCC	Command Support Control Console
CSF	Converter Slide File
CSFDD	Converter Slide File Data Distributor
CSM	Command Service Module
CTC	Cross Connect Termination Cabinet
CTE	Central Timing Equipment
CTR	Center
CTU	Central Timing Unit
CVDB	Character Vector Display Buffer
CYI	Canary Island
DAC	Digital to Analog Converter
DASF	Data Access Storage Facility
DCA	Digital Command Assembly
DCAG	Data Control and Generator
DCS	Digital Command System
DCU	Data Control Unit
DD	Data Distributor
DDD	Digital Display Driver
DDSDD	Digital Displays Subchannel Data Distributor
DEU	Data Encoder Unit
DRK	Display Request Keyboard
DRO	Digital Readout
DRUL	Down Range Uplink
DSC	Dynamic Standby Computer
DSDU	Decommutation System Distribution Unit
DSKY	Display and Keyboard
DSN	Deep Space Network

DSS	Deep Space Site
DTTU	Data Transmission and Test Unit
DTU	Data Transmission Unit
D/TV	Digital to Television
DUA	Digital Uplink Assembly
ECL	Exchange Control Logic
ECR	Execute Command Request
EKG	Electrocardiogram
ELOP	Event Light Override Panel
EOM	End of Message
EOT	End of Transmission
EPO	Earth Parking Orbit
ESO	Event Sequence Override
ETR	Eastern Test Range
ESW	Equipment Status Word
EVA	Extra Vehicular Activity
FACS	Facilities Control System
FAX	Facilities
FC	Flight Controller
FDO	Flight Dynamics Officer
FDK	Forced Display Keyboard
FM	Frequency Modulation
GACC	Ground Support Simulation Computer
GBI	Grand Bahama Island (AFETR)
GBM	Grand Bahama Island
GCA	Generalized Core Area
GCC	Ground Communications Controller
GDS	Goldstone
GMT	Greenwich Mean Time
GMTLO	Greenwich Mean Time of Liftoff
GOSS	Ground Operation Support System
GS	Ground Station
GSFC	Goddard Space Flight Center
GSSC	Ground Support Simulation Computer
GTI, GTK	Grand Turk Island
GWM	Guam; Guaymas
HAW	Hawaii
HF/SSB	High Frequency/Single Side Band
HLPC	Houston Lighting and Power Company
HOSC	Huntsville Operation Support Center
HS	High Speed
HSD	High Speed Data
HSK	Honeysuckle (Creek) USB Station Canberra)
HSOR	High Speed Output Routine

HSP	High Speed Printer
HSPB	High Speed Printer Buffer
HSTL	High Speed Telemetry Link
HTV	Huntsville
IC	Inter Computer
I/D	Identification
I/O	Input/Output
IOTS	Input/Output Transfer Switch
IP	Impact Predictor
IRIG	Interrange Instrumentation Group
ISA	Interface System Adapter
IU	Instrument Unit
JPLQ	Jet Propulsion Laboratory
IU	Instrument Unit
KSC	Kennedy Space Center
KSC/CIF	Kennedy Space Center/Central Instrumentation Facilities
KWRF	Kilowatt Radio Frequency
LAB	Laboratory Terminal
LADC	Logic and Data Converter
LCC	Launch Computer Complex
LGC	Lunar Module Guidance Computer
LIEF	Launch Information Exchange Facility
LM	Lunar Module
LOS	Loss of Signal
LSB	Lieast Significant Bit
LS	Low Speed
LSD	Low Speed Data
LVDG	Launch Vehicle Digital Computer
MAD	Madrid
MAP	Message Acceptance Pulse
MCC	Mission Control Center
MCVG	Memory Character Vector Generator
MDD	Multichannel Demultiplexer and Distributor
MED	Manual Entry Device
MER	Mercury
MET	Mission Elapse Time
MIL	(Mila (USB Site)
MILA	Merritt Island
MIPIR	Missile Predicition Instrumentation Radar
MLA	Multiplexer Line Adapter; MILA (C-band site)
M/O	Maintenance and Operations
MOC	Mission Operational Computer
MOCR	Mission Operations Control Room
MOW	Mission Operations Wing
MSB	Most Significant Bit

MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network
MSK	Manual Select Keyboard
MSS	Most Significant Syllable
MTU	Magnetic Tape Unit
MUX	Multiplexer
ANSCOM	NASA Communications
NOVVAL	Non Validated
PAM	Pulse Amplitude Modulated
PAT	Patrick AFB
PBI	Push Button Indicator
PBT	Polynomial Buffer Terminal
PCK	Phase Control Keyboard
PCM	Pulse Code Modulated
PDA	Parallel Data Adapter
PDM	Pulse Duration Modulation
PDSDD	Plotting Displays Subchannel Data Distribution
PEP	Polynomial Error Protection
PLSS	Portable Life Support System
PM	Phase Modulation
PR	Plotting Register
PRE	Pretoria
PSK	Phase Shift Keyed
RCVR	Receiver
RED	Redstone
REGEN	Regenerate
REJ	Reject
RER	Receiver/Exciter/Ranging
rf	Radio Frequency
RKV	Rose Knot Victor
R/R	Recorder/Reproducer
RS	Remote Site
RSCC	Remote Site Command Computer
RSDP	Remote Site Data Processor
RSO	Range Safety Officer
RSTC	Remote Site Telemetry Computer
RTA	Real Time Accumulators
RTC	Real Time Command
RTCC	Real Time Computer Complex
RTCF	Real Time Computer Facility
RTDL	Real Time Data Link
RTDR	Real Time Data Router
SALDS	Simulated Apollo Launch Data System
S/B	Switch Board
S/C	Spacecraft; Switching Computers

SCAMA	Switching, Conferencing, and Monitoring Arrangement
SCS	Standard Communications Subsystem
SCM	Site Configuration Message
SCO	Subcarrier Oscillator
SCU	System Configuration Unit
SDC	Shipboard Doppler Counter
SDD	Subchannel Data Distributor
SDDS	Signal Data Demodulation System
SLV	Saturn Launch Vehicle
SMC	System Monitor Console
SMCVG	Simulated Memory Character Vector Generator
SMEK	Summary Message Keyboard
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
SSU	System Selector Unit
STE	Site
STREU	Serial, Transmit, Receive, and Encoder Unit
SW	Switch
TAN	Tananarive
TDDF	Telemetry Data Distribution Frame
TDM	Time Devisor Multiplexer
TDP	Tracking Data Processor
TESAC	Telemetry Synchronizer and Serial to Parallel Converter
TEX	Corpus Christi, Texas
TICC	Telemetry Instrumentation Controllers Console
TIP	Telemetry Input Processor
TLI	Translunar Injection
TLM	Telemetry
TOB	Telemetry Output Buffer
TSP	Test Support Position
TTY	Teletype
TUT	Telemetry User Table
TV	Television
UCS	Universal Command System
UDB	Updata Buffer
UHF	Ultra High Frequency
USB	Unified S-Band
VAL	Validated
VAN	Vanguard
VCO	Voltage Controlled Oscillator

V/D	Voice/Data
VDTCF	Voice Data Terminal Control Facility
VER	Verification
VF	Voice Frequency
VFTG	Voice Frequency Telegraph
VHF	Very High Frequency
VSM	Video Switching Matrix
WB	Wide Band
WBD	Wide Band Data
WHS	Shite Sands
WOM	Woomera
WPM	Words per Minute
WWV-L	US Bureau Standards Time Station (Boulder, Colorado)

TECHNICAL MANUAL

CHANGE REQUEST SHEET

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