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1100 SEVENTEENTH STREET, N.W. WASHINGTON, D.C. 20036

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TITLE- Apollo Command System-Ground Network Data Flow

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DATE- June 20, 1968

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AUTHOR(S)- J. E. Johnson

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ABSTRACT

This memorandum describes the data flow through the ground network associated with the operation of the Apollo command system for Apollo missions AS-205 and subsequent. The major processes associated with commanding are: (1) loading of a remote site command computer with a valid command, (2) uplinking of the command from the remote site to the CSM, LM, or S-IVB/IU, and (3) verifying that the space vehicle accepted the correct command. These processes are described in the text, and shown in detail in flow carts in an appendix. The different types of commands available for use with the CSM, LM, and S-IVB/IU are itemized in appendices.

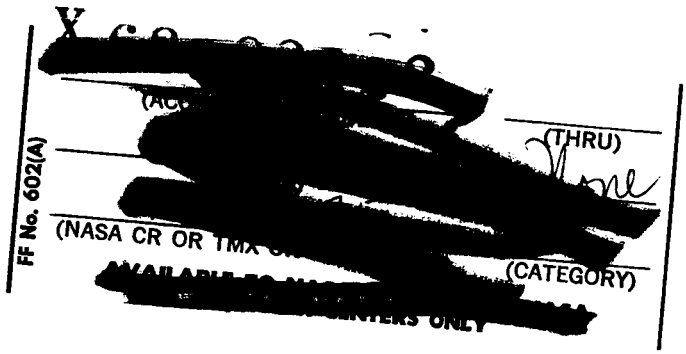

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TABLE OF CONTENTS

List of Figures and Tables

List of Figures and Tables (Cont'd)

List of Figures and Tables (Cont'd)

BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Apollo Command System-Ground Network Data Flow - Case 900

DATE: June 20, 1968

FROM: J. E. Johnson

TM -68-2034-8

TECHNICAL MEMORANDUM

This memorandum describes the ground data flow associated with the operation of the Apollo Command System. The system described is known as the Universal Command System, and will be operational for Apollo missions AS-205 and subsequent. The Universal Command System will be used with a fully remoted Manned Space Flight Network (MSFN). The fully remoted configuration does not have remote site flight controller command capability or displays.

The Universal Command System differs in two major respects from the system that has been in use: in remote site command storage and in command verification procedures. Up to 60 space vehicle computer update commands of any type can be stored in permanent storage at each remote site, nominally up to 20 each for the CSM, LM, and the Instrument Unit (IU) of the Saturn Launch Vehicle (SLV). The new system, which will be accompanied by an increase in remote site core storage size, is more flexible and has greater capacity than the previous one. Verification of uplinked data to the CSM and LM will now be done automatically by the remote site computer by making a bit-by-bit comparison of the data that left the command computer with the received data returned via telemetry. The verification process was previously performed visually by the flight controllers.

This is one of a series of memoranda describing commanding for Apollo missions. Other memoranda describe space vehicle command data flow (Reference 1), analyze error protection (References 2 and 3), and review command performance during past Apollo flights (Reference 4).

The text of this memorandum describes the operation of the ground portion of the system. Appendix A consists of flow charts describing the system in more detail, including back-up and control flow paths. Appendix B shows the message formats associated with a typical update - a Command Module Computer (CMC) navigation update. Appendix C shows functional schematics of the major ground components in the command system. Appendices D-G list the different commands available for the CSM, LM and SLV.

TYPES OF COMMANDS

There are two major types of commands - Real-Time Commands (RTC's) and Command Loads. Real-Time Commands are used to initiate spacecraft events, such as turning equipment on and off or switching modes. These commands are determined pre-mission and normally stored pre-mission in computer memory at remote sites. An RTC is called up during the mission via an Execute Command Request (ECR) message sent from MCC to the site specifying the number of the RTC to be uplinked. Command Loads are used to alter space vehicle computer memory during the course of a mission. They are generated in mission-time by the Real-Time Computer Complex (RTCC) at MCC, and transmitted to one or more specifically selected remote MSFN sites via digital data lines in advance of the pass of the space vehicle over that site. A load is also called up via an ECR message from MCC when it is desired to transmit it to the space vehicle.

In addition to the Real-Time Commands and Command Loads, there are Central Timing Equipment (CTE) updates to the CSM, and Test Message Commands to both the CSM and LM. Both of these are initiated via ECR's from MCC. Test message formats are stored at the remote sites pre-mission. CTE updates are used to advance or retard the CSM clock, and are calculated automatically at the remote site based on ground elapsed time and CSM telemetry giving the on-board CTE reading. These two latter types of commands are not discussed in the text of this memorandum, but further details are given in Appendices F and G.

REAL-TIME COMMAND DATA FLOW (CSM and LM)

Real-Time Command data flow is summarized in Figure 1 and described in detail in flow chart form in Appendix A. Real-Time Commands are formatted in advance of a mission as part of the Remote Site Command Computer (RSCC) program tape for that mission. All sites are loaded with identical real-time commands.

If, during the course of a mission, a flight controller in the Mission Operations Control Room (MOCR) at MCC wishes to cause an RTC to be transmitted to the space vehicle, he pushes the appropriate push-buttons on the command panels of his console. This causes the Communications, Command, and Telemetry System (CCATS) at MCC to generate an Execute Command Request. This ECR is addressed to the site to be used to uplink the RTC. The number of the RTC to be

uplinked is contained in the ECR. Transmission of the ECR takes place over a 50.0 kbps* wide-band data (WBD) circuit to the Goddard Space Flight Center (GSFC), and over a 2.4 kbps high-speed data (HSD) circuit from GSFC to the remote site (RS). The ECR is processed in the Remote Site Command Computer (RSCC) at the selected site. If it is determined to be a valid request (as determined from decoding error checking bits and other check information included in the message), a "Command Analysis Pattern Validation" (CAP VAL) message is generated by the RSCC. The CAP VAL is sent to the Remote Site Telemetry Computer (RSTC), and returned to MCC along with telemetry data via an HSD telemetry circuit to GSFC and a WBD circuit to MCC. Some RTC's are designed as "priority" commands. ECR's for priority commands are sent out from MCC once every 250 ms. until a CAP VAL has been received from the addressed site or until transmission is manually terminated. Only the first valid ECR will trigger a CAP VAL from the RSCC. This CAP VAL is transmitted three times in three successive telemetry frames (one second per frame). For missions in which only one HSD telemetry line is used (missions with a single spacecraft), the CAP VAL's will appear twice on one line and once on the other, and will be spaced one-half second apart.

If the ECR is validated, the RSCC removes the 6-bit RTC from memory and adds a 3-bit vehicle address and a 3-bit system address. These 12 bits are then sub-bit encoded, a process that substitutes a five bit code for each information bit. The RSCC then performs internal checks on the resulting bit stream and transfers it to the Up-Data Buffer (UDB) for uplinking. The UDB routes the command to either a UHF or a USB transmitter based on flight controller choice as specified in the ECR. The bit stream phase-shift key (PSK) modulates a 2 kHz signal, which is summed with a coherent 1 kHz signal. For USB transmission, the composite signal frequency modulates a 70 kHz command subcarrier, which in turn phase modulates the USB carrier. For UHF transmission, the composite signal frequency modulates the UHF carrier directly. The uplink data rate is 1 kbps for the sub-bits, or 200 "information" bits per second.

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*The WBD circuit currently operates at 40.8 kbps, but is being increased to 50.0 kbps for Apollo missions subsequent to 205.

The r.f. output is sampled by a monitor receiver (sometimes called a verification receiver), which demodulates the transmitted signal and returns the 1 and 2 kc composite to the UDB. The UDB converts the composite into a digital bit stream, and sends it to the RSCC, which compares it with what was sent out.

The spacecraft decoder examines the command it has received, and if the vehicle and system addresses are correct and the sub-bits all represent pre-stored patterns for valid "1's" and "0's", the command is shifted out and the appropriate RTC function relay is activated. Also, a Message Acceptance Pulse (MAP) is generated. This MAP lasts 55 ms. if the CSM or LM telemetry is operating in the high bit rate mode (51.2 kbps), or 250 ms. if the CSM telemetry is operating in the low bit rate mode (1.6 kbps). No MAP's are used with LM low bit rate telemetry. (There is at present no requirement for real-time commands for lunar mission LM's). The telemetry commutator samples the MAP signal every 20 ms. in the high rate mode and every 100 ms. in the low rate mode. Thus, at least two, and sometimes three, MAP's are returned to the ground for each RTC.

The spacecraft telemetry bit stream is routed to the RSCC, which looks for a MAP. Only one MAP is required for verification. A MAP waiting interval is preset in the RSCC. The start of this waiting interval is a function of slant range, and can be varied (pre-pass) to allow for changing propagation times.

If a MAP is found in the MAP waiting interval, a "CAP Verification" (CAP VER) is generated and returned to MCC in the same way the CAP VAL was returned. If no MAP is found, the entire uplink process is repeated up to a maximum preselected number of times (generally 3). In the case of priority RTC's, uplinking will be continued until the command is verified, or until terminated under orders from MCC. If no successful uplink is accomplished after the preselected number of attempts, the RSCC will generate a "ground reject" or a "spacecraft reject" in lieu of the CAP VER. A ground reject will result from either the detection of an internal RSCC error or an error via the r.f. monitor receiver loop without the presence of a MAP from the spacecraft. If no ground errors are detected, absence of a MAP will trigger a spacecraft reject.

In addition to MAP's, an indication of the occurrence of the RTC-commanded event is often telemetered to the ground. This data is processed in the RSTC and returned to MCC over the same line(s) carrying the CAP VER. Both types of data are made available to the flight controller who initiated the command.

A list of typical Real-Time Commands for a dual spacecraft mission (AS-503/CSM 103/LM 3) is given in Appendix D.

COMMAND LOAD DATA FLOW (CSM and LM)

Command load data flow is summarized in Figure 3 and described in detail in flow chart form in Appendix A. Command loads are used to update the contents of spacecraft computer memory and are generated during the course of a mission and transmitted to the appropriate remote site(s) pre-pass. Normally two sites, a prime site and a back-up site, will receive each command load.

Command loads are generated by the Real-Time Computer Complex (RTCC) at MCC. A flight controller who wishes to generate a command load notifies the RTCC Computer Command Controller by voice of his request, and supplies the necessary input data. The Computer Command Controller provides the instructions to the RTCC for generating the load. After the load is generated, it is reviewed by the flight controller via a digital-to-television display. If satisfactory, the command load is transferred to CCATS and on to the selected remote site(s) via the same WBD and HSD circuits referred to above in the discussion of Real-Time Command data flow. The load is validated by the RSCC, and a CAP VAL is returned three times via telemetry data lines to MCC. Each load is sent twice, separated by one second. Then a 5 second waiting period for a CAP VAL begins. If no CAP VAL is received by the end of this interval, a second group of two loads is transmitted. Again there is a 5 second waiting interval followed, if necessary, by a third group of two loads and another 5 second wait. If there is still no CAP VAL, transmission is terminated and the CCATS Command Load Controller is alerted. It is not necessary for the RSCC to receive one completely valid load. Segments of a load that are valid are retained, and if subsequent loads permit validation of the missing segments, the entire load will be validated and a CAP VAL generated.

An additional back-up is provided by teletype transmission of the load to the selected site(s). Two iterations of the octal load are sent, along with an English translation. These three components are transmitted together, and are not automatically repeated. If the high speed data is validated, the teletype load is not used.

Uplinking of command load data, plus "verb", "noun", and other special symbols is performed using a 22 bit word for each character or symbol. The character itself is "keycoded" into a sequence of 5 bits. This means that 5 bits are required to transmit a 3 bit octal digit. As with RTC's, a 3 bit vehicle address and 3 bit system address start off each word. The next bit is always a logical one. The 5 bit keycode (K) comes next, followed by its complement ($\overline{K}$), and a repeat of its true form (K). This format is shown in Figure 2. A list of legal keycodes is shown in Table 1. The 22 bit word is then sub-bit encoded into 110 bits and uplinked in the same fashion as an RTC. It will take 110 ms. to uplink each keycode word. A present delay (normally 50 ms.) is introduced before the start of uplinking of the next word in the sequence.

If it is desired to uplink a load previously placed in memory at the RSCC, the flight controller at MCC pushes the appropriate push-buttons on his command panels. This causes an ECR to be generated in CCATS similar to that generated to initiate an RTC uplink. The ECR is validated in the same way as an RTC. This ECR, however, causes only an initial "Verb preamble" to be uplinked. This consists of a "Verb" symbol followed by two octal digits (VXX) and is used to tell the spacecraft computer the nature of the data to follow and to give instructions on how to process it. The verb preamble is held in temporary storage in the spacecraft computer and not acted on until the ground verifies that it is correct. This 3 keycode word sequency requires 430 ms. for transmission. The r.f. output is monitored as before.

Verification of the correct receipt of the verb preamble is accomplished by observing a list of spacecraft computer words telemetered to the ground. MAP's are also telemetered, but are not used for command load verification as they are for RTC's. The verb preamble will appear twice in a telemetered list of 200 15-bit words read out once every two seconds when operating in a high bit rate telemetry mode, and once every 10 seconds when in a low bit rate mode. (There is no LGC readout in the low bit rate mode.) The high bit rate mode will usually be selected when commanding. These CMC or LGC words are processed in the RSTC (the RSCC also

receives the data, but does not process it), and transmitted to MCC via a 2.4 kbps HSD line and the 50.0 kbps WBD line. The data is processed at MCC and presented for visual verification to the flight controller. Note that verification of this sequence is a manual function performed at MCC, whereas verification of an RTC is an automatic function performed at the remote site.

When the flight controller verifies the verb preamble as being correct, he initiates another ECR to cause an "Enter" (E) keycode to be uplinked. As before, this will result in a CAP VAL to MCC, and the uplinking of a 110 sub-bit word containing the keycode. Correct receipt of this keycode will generate an "interrupt" to the spacecraft computer, causing it to condition itself for the actual data content of the load to follow. It also alters the downlink telemetry list, permitting verification by MCC of the successful entry of the instructions.

Uplinking of the data content of the load requires another ECR from MCC to the remote site. The load may vary in length from 3 to 20 spacecraft computer words. Each CMC and LGC word is 15 bits long, requiring 5 keycode words to fill it (the CMC and LGC will supply fill if less than 5 keycodes are uplinked). Each CMC or LGC word uplinked must be followed by an enter keycode, although it is not necessary to wait for verification of the data before this enter is sent. The entire data portion of the load is sent in "salvo" fashion, waiting only the 50 ms. waiting period between keycode words to permit the spacecraft decoder to be cleared of the previous word. It thus takes about 1 sec. to uplink one computer word (5 data keycodes plus an enter at 110 + 50 ms. each), or about 20 sec. to uplink the 120 keycodes required for the maximum length load. (If a longer length update is necessary, it is broken down into two or more sets of separate command loads). The spacecraft computer places the load in buffer storage pending receipt of a "Final Enter" (see below).

Verification of the data content of the load, as distinct from the verb preamble and the final enter, is performed automatically at the remote site. The data words are read into "UPBUFF" locations in the erasable memory of the CMC or LGC. The contents of these locations are read out twice every 2 or 10 seconds as part of the downlink telemetry word list. The RSCC waits a preset length of time after completion of the last keycode uplink, and then performs a bit-by-bit comparison of the telemetered CMC or LGC UPBUFF words with what it sent out to the UDB. This is termed a "buffer compare" routine. It is necessary to get two

correct comparisons of each 15 bit word in the UPBUFF list in not more than 8 sets of data (8 sec.) to establish verification. As soon as verification is established, a CAP COMPARE is generated and returned to MCC. If the entire load cannot be verified, the numbers of the lines failing the comparison are returned to MCC in lieu of the CAP COMPARE. If verification cannot be established, MCC will instruct the remote site to transmit a keycode to clear the load from memory and reinitiate the uplink process, or, if three or fewer lines are in error, may instruct the remote site to retransmit only the lines in error. In the latter case, it is necessary to also uplink the address of any line to be corrected.

If any keycode words are accepted by the spacecraft decoder, but fail a KK̄K keycode check performed by the computer prior to placing them in buffer memory, this fact is signaled by setting a bit in one of the flagwords that is read out twice in every 2 or 10 sec. telemetry cycle. The input channel to the computer is then blocked from accepting any further data. The flagword is not examined at the remote site, but is returned to MCC and processed to alert the flight controller of the difficulty. Command transmission will continue from the remote site until the entire data portion of the load is uplinked, or until it is manually terminated. It will then be necessary to send "all zeros" and "error reset" keycodes to clear the block and reinitiate the load transmission.

After the UPBUFF contents are verified, flight controller action is required to instruct the computer to use the data. This takes the form of a "Final Enter", consisting of a V33 preamble (the code assigned for this purpose) and an "ENTER". Each of these 4 keycodes requires its own ECR, and normal procedure is to wait for verification of each keycode before initiating the next. When the final "ENTER" is accepted by the spacecraft computer, it will cause the contents of the UPBUFF storage locations to be placed in working memory of the spacecraft computer.

In summary, seven sequences of uplinking are required (numbered 2 through 8 in Figures 3-5), as follows:

2.	VXX preamble	(verified at MCC)
3.	E	(verified at MCC)
4.	Load data	(verified at RSCC)
5.	V	(verified at MCC)
6.	3	(verified at MCC)
7.	3	(verified at MCC)
8.	E	(verified at MCC)

Each sequence is initiated by an ECR requiring manual action on the part of a flight controller at MCC.

Back-up procedures and alternate modes of commanding are available in case of difficulty. As mentioned earlier, it is possible to load an update into the RSCC via teletype if HSD loading cannot be validated. ECR's cannot be accomplished via teletype, but can be voiced to the site, and manually inserted into the RSCC. It is also possible to use a back-up site if difficulty is encountered with the prime site.

In the event of uplink difficulty, it is possible to switch transmitters, modulators, or monitor receivers, to use the back-up site, or (for manned missions) to voice the load to the astronauts for manual entry via the spacecraft Display Select Keyboard (DSKY).

A list of presently planned command loads is given in Appendix E.

S-IVB/IU COMMAND DATA FLOW

Only one command word uplink format is used for all S-IVB/IU commands (see Figure 2). Although the commands can still be categorized as either computer updates or real-time commands, all command words go into the Launch Vehicle Digital Computer (LVDC) first. The real-time commands are then issued under LVDC control. S-IVB/IU command words are loaded in the same manner as CMC/LGC keycode computer words. The basic difference between the two is in the verification process.

As shown in Figure 2, each S-IVB/IU command word of 35 bits (175 sub-bits) contains 6 information bits in true and complement form. Keycodes are not used. The LVDC word length is 26 bits, hence 5 command words are required per computer word. Load generation, transmission, validation, and sub-bit encoding are handled in the same way as for CSM and LM loads.

An S-IVB/IU command update is initiated by a flight controller in the MOCR via an ECR specifying the number of the load to be uplinked. The ECR is transmitted and validated as before. The LVDC does not use "Verbs", "Nouns", and "Enters". One validated ECR is all that is required for uplinking of the entire load. Each command word must be verified via LVDC telemetry before the next word in uplinked. Failure to verify the word within a preset time causes an automatic retransmission of that word. If a word is not verified after a preset number of retransmissions (nominally three), uplinking is terminated and a ground or space vehicle

reject is generated using the same criteria as for the CSM and LM. If the LVDC has also counted this number of incorrect transmissions, it will discard all command words associated with that load that preceded the word in error. Unlike the CSM and LM, no "clear" and "error reset" is required from the ground. S-IVB/IU updates can vary up to 51 command words in length.

There are three telemetered quantities used for verification, (1) Adress Verification Pulses (AVP's), (2) Computer Reset Pulses (CRP's), and (3) Command Error Words (CEW's). Real-time verification is accomplished via the CRP's only. They indicate LVDC acceptance of a command word. Two CRP's are telemetered via the 72 kbps PCM S-IVB/IU link every 8.33 ms. It is necessary to detect four CRP's during a 60 ms. waiting interval to establish verification. If a command word is not verified in this time, it is retransmitted up to three times before commanding is terminated and a ground or launch vehicle reject is issued.

AVP's are analogous to MAP's used in the CSM/LM. They indicate that the decoder has accepted the word, based on correct addresses and valid sub-bit patterns. They are also telemetered twice every 8.33 ms. The RSCC also establishes verification or non-verification via AVP's using the same criteria as for CRP's. However, the result of this verification does not initiate any real-time response; it is stored on magnetic tape for command history (post-pass or post-mission analysis).

CEW's are telemetered if the LVDC rejects a command word. They provide data on the reason for rejection of the command word. The RSCC stores the following information from CEW's for command history:

1. CEW error code
2. CEW error counter
3. LVDC true information bits
4. LVDC complement information bits

ERROR PROTECTION

The error protection provided on command data flow messages is summarized in Figure 6.

The transfer of command loads from the RTCC to CCATS is protected by providing one parity bit for every 12 information bits.

Command loads and ECR's transferred from CCATS to the RSCC are protected by Bose-Chaudhuri-Hocquenghem (BCH) polynomial error detection codes (see Reference 5 for a description of these codes). The information content of the message is broken into 30 bit subblocks, and 27 BCH bits and 3 fill bits are added to make the subblock length 60 bits. The subblocks in turn are assembled into 600 bit blocks (with fill subblocks if necessary), with each block containing 33 BCH bits. This latter coding is used only on the 50.0 kbps WBD line between MCC and GSFC, whereas the subblock coding provides end-to-end protection over the entire ground network.

BCH coding is also put on the CAP's returned to MCC from the remote site, but not on the rest of the telemetry data. A CAP contains 26 information bits, and is protected by 14 BCH bits. The composite telemetry data is packed into 600 bit blocks at GSFC for WBD transmission to MCC, including 480 bits of telemetry and CAP data, and 33 BCH bits for block protection.

Additional error protection is provided by the redundant trnamisssion of all messages, and by validity checks on such items as site addresses, valid load and mission numbers, and legal keycodes.

Uplink error protection is provided by use of sub-bit encoding and (CMC and LGC only) $K\bar{K}K$ encoding. Sub-bit encoding is used on both RTC's and loads, and substitutes 5 sub-bits for a single information bit. Unique sub-bit codes are used for logical "1's" and logical "0's". A different sub-bit code is used for the vehicle address from that used for the remainder of the uplink word. Failure of the sub-bits to check will cause the uplink word to be discarded, and prevent a valid MAP transmission to the ground. The MAP itself is encoded into 4 bits (CSM) or 8 bits (LM). It is sampled 50 times a second in the high bit rate mode (the actual signal will be present only 55 ms.) and 10 times a second in the low bit rate mode (the signal will be present for 250 ms.). There are no MAP's in LM low bit rate telemetry. $K\bar{K}K$ encoding provides an end-to-end check on the uplink transmission of AGC/LGC computer loads. The true-complement coding does the same for LVDC loads.

The downlinked CMC/LGC computer words are protected by a parity bit with every 15 bit word. This parity bit is checked before a buffer compare routine is initiated.

An analysis of the protection afforded by this encoding is contained in Reference 2.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Mr. T. A. Stuart of the Flight Support Division of MSC for his assistance in providing information and reviewing this memorandum.

J. E. Johnson

2034-JEJ-dlb

Attachments

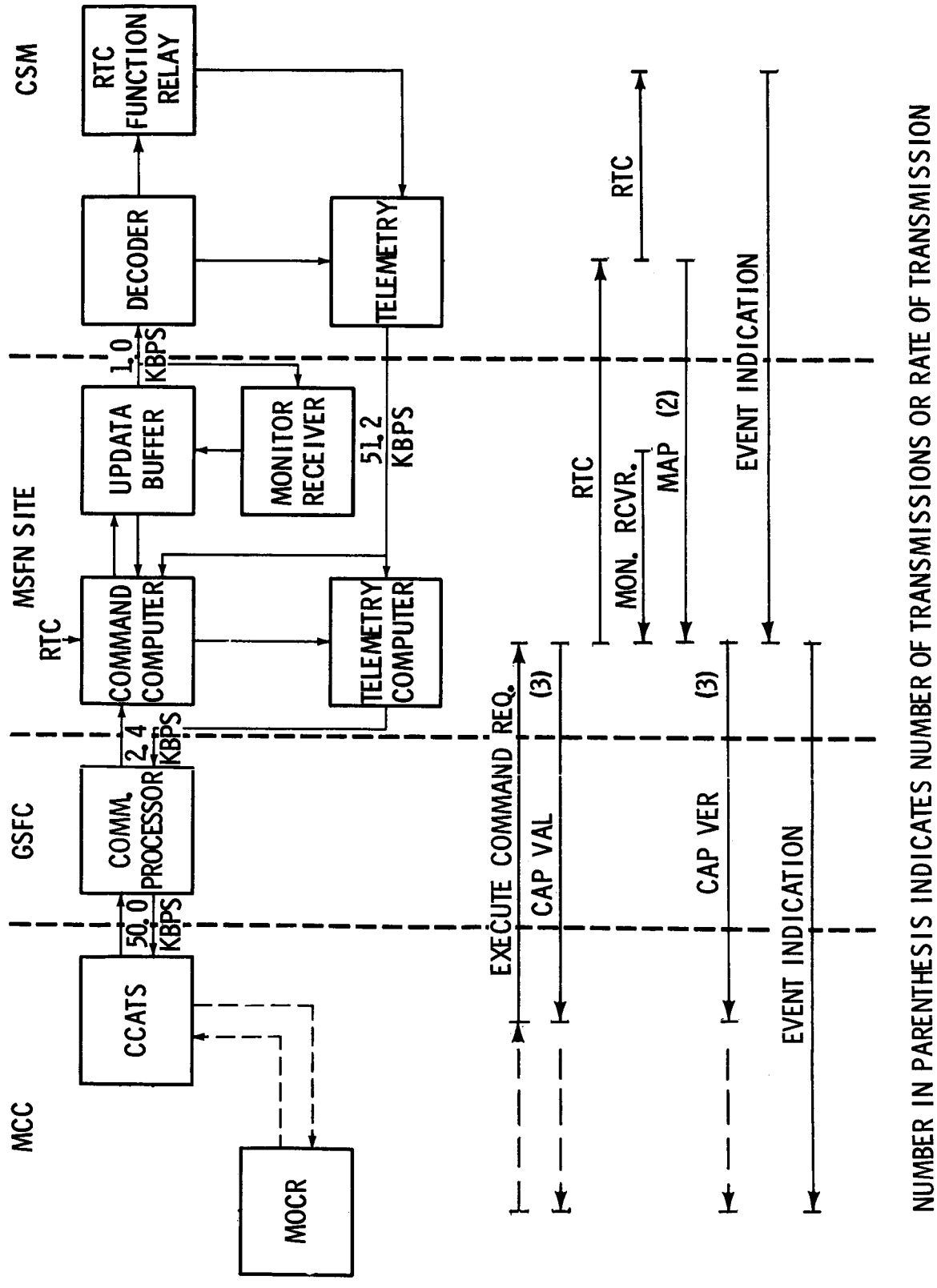
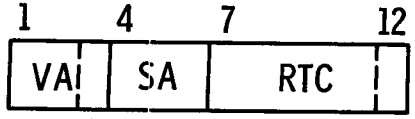


FIGURE 1 - REAL-TIME COMMAND (RTC) DATA FLOW

REAL-TIME COMMANDS
(12 BITS; 60 SUB-BITS)

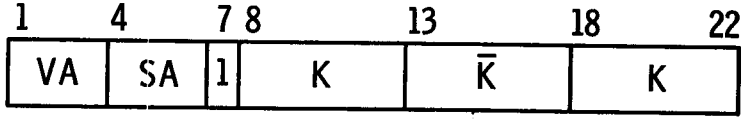


10010 = "1"
01101 = "0"

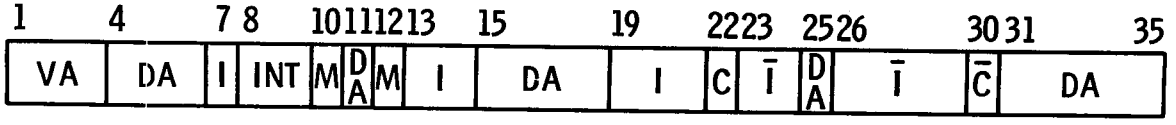
01010 = "1"
10101 = "0"

TYPICAL SUB-BIT PATTERNS

KEYCODES
(22 BITS; 110 SUB-BITS)



S-IVB/IU COMMAND WORD
(35 BITS; 175 SUB-BITS)



LEGEND - CSM/LM

VA - VEHICLE ADDRESS (3 BITS)
SA - SYSTEM ADDRESS (3 BITS)
RTC - REAL-TIME COMMAND CODE (6 BITS)
1 - LOGICAL "ONE" (1 BIT)
K - KEYCODE (5 BITS)
$\bar{K}$ - COMPLEMENT OF KEYCODE (5 BITS)

LEGEND - S-IVB/IU

VA - VEHICLE ADDRESS (3 BITS)
DA - DECODER ADDRESS (14 BITS)
INT - INTERRUPTS (2 BITS)
M - MODE DATA (2 BITS)
I - INFORMATION (6 BITS)
$\bar{I}$ - COMPLEMENT OF INFORMATION (6 BITS)
C - CONTROL BIT (1 BIT)
$\bar{C}$ - COMPLEMENT OF CONTROL BIT (1 BIT)

FIGURE 2 - UPLINK FORMATS

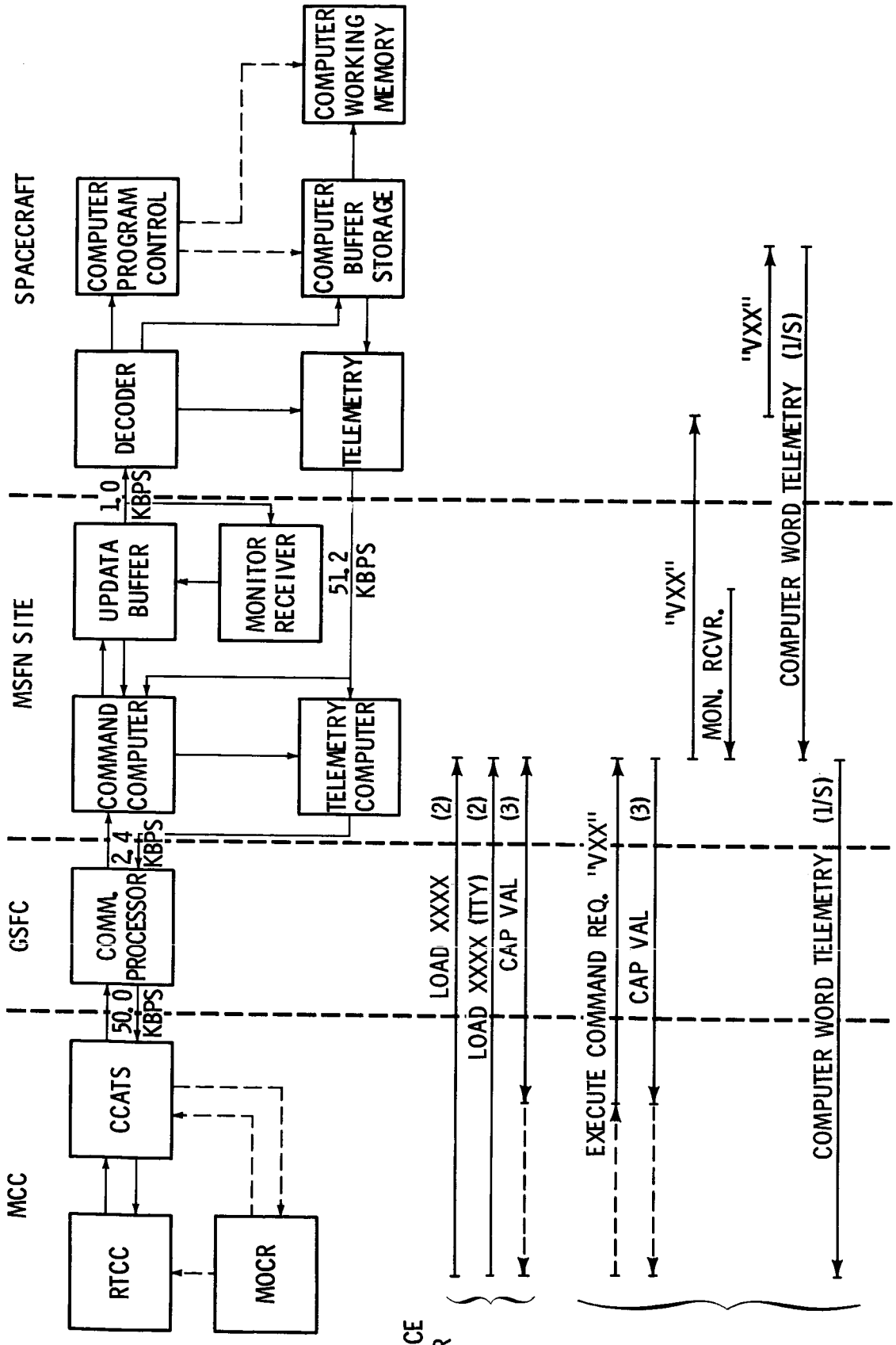


FIGURE 3 - COMMAND LOAD DATA FLOW

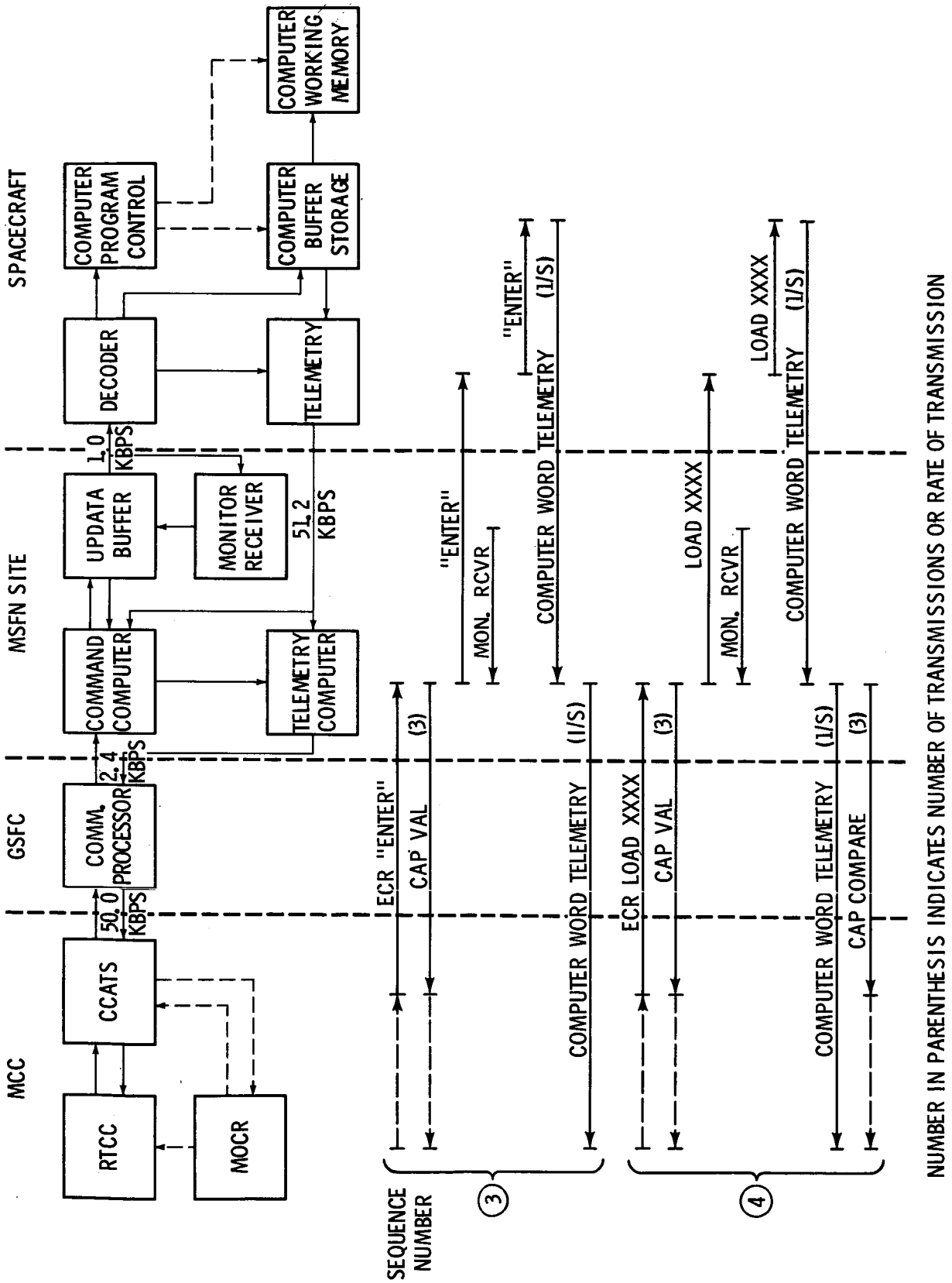


FIGURE 3 - COMMAND LOAD DATA FLOW (CONTINUED)

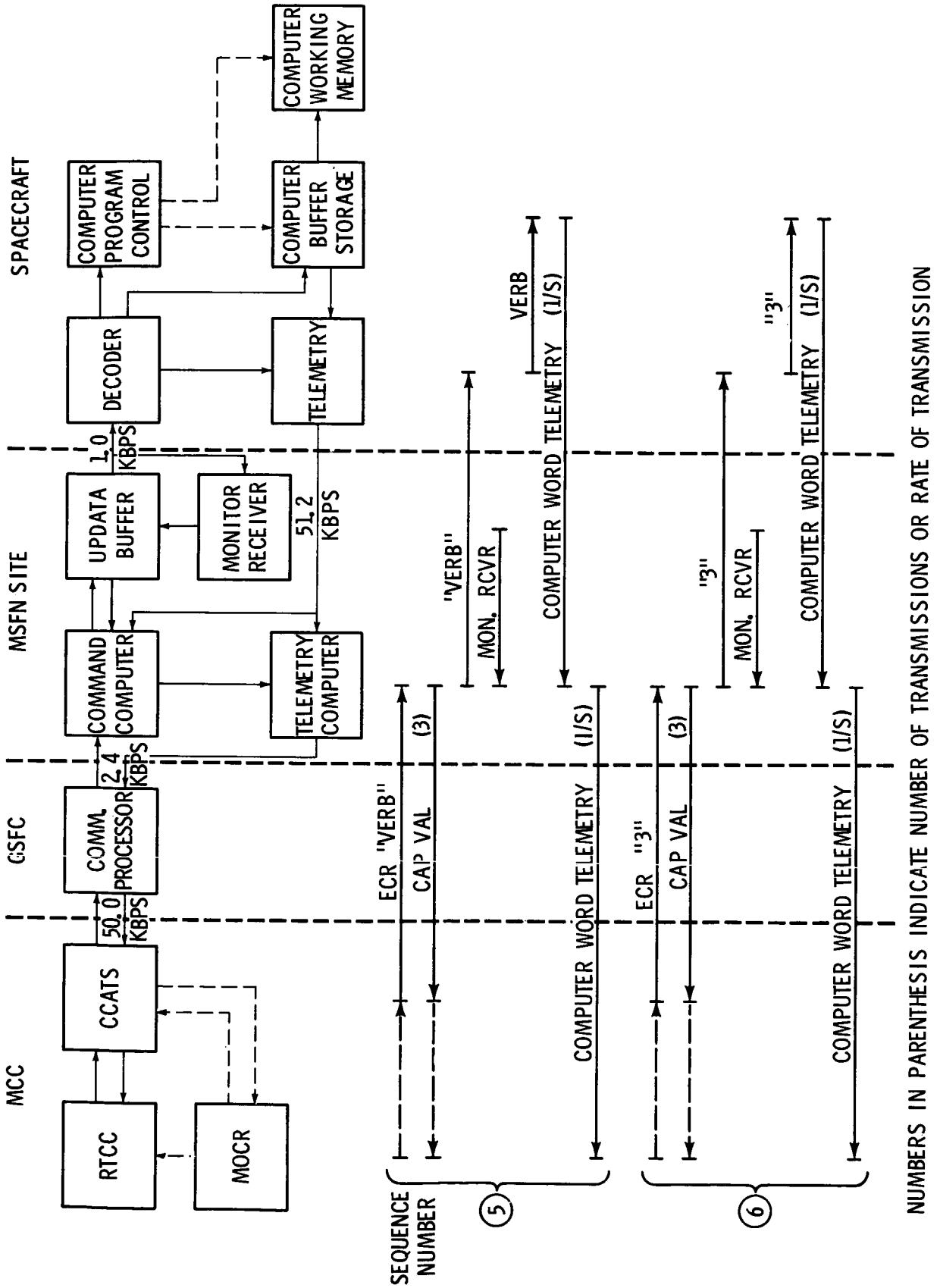
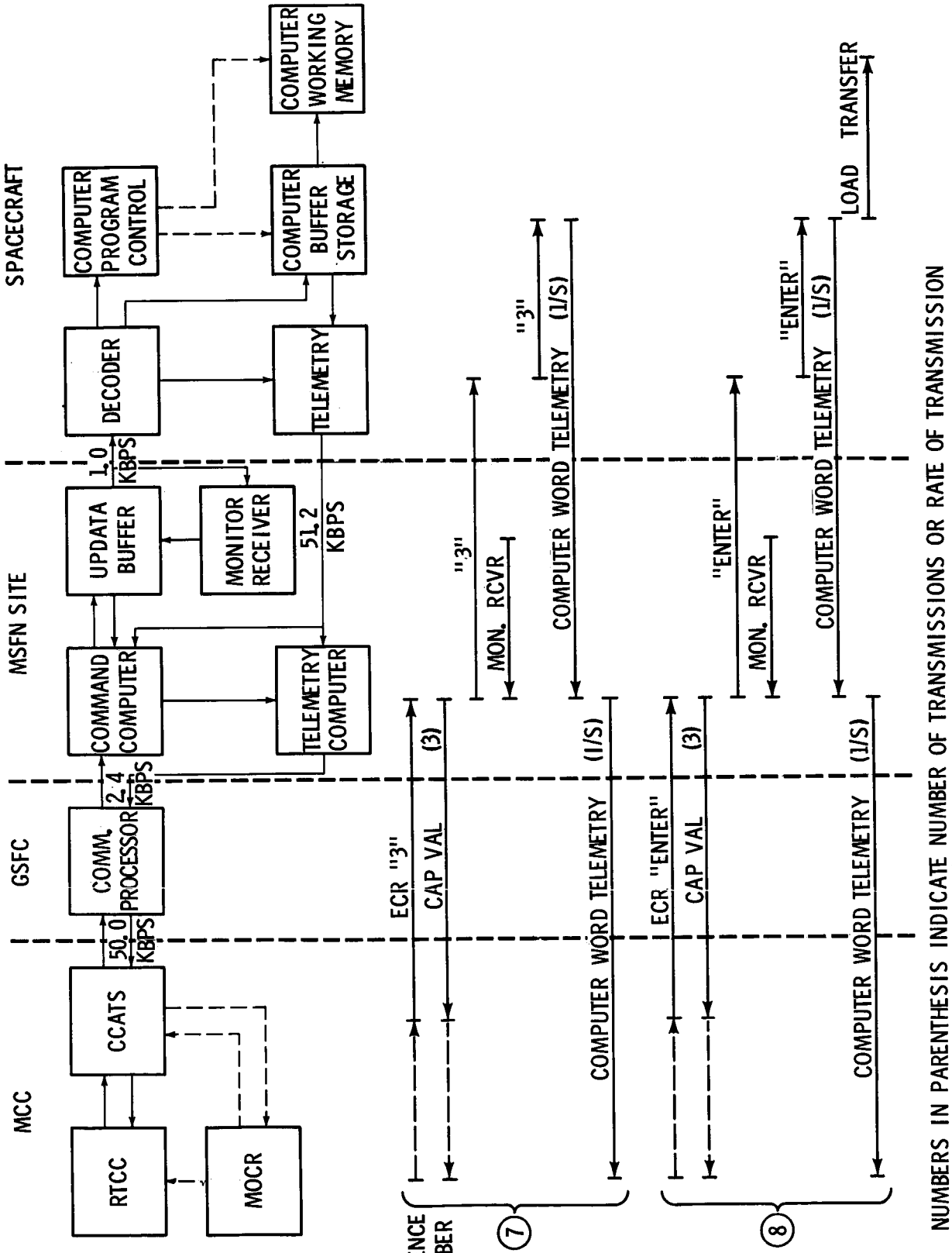


FIGURE 3 - COMMAND LOAD DATA FLOW (CONTINUED)



NUMBERS IN PARENTHESIS INDICATE NUMBER OF TRANSMISSIONS OR RATE OF TRANSMISSION

FIGURE 3 - COMMAND LOAD DATA FLOW (CONTINUED)

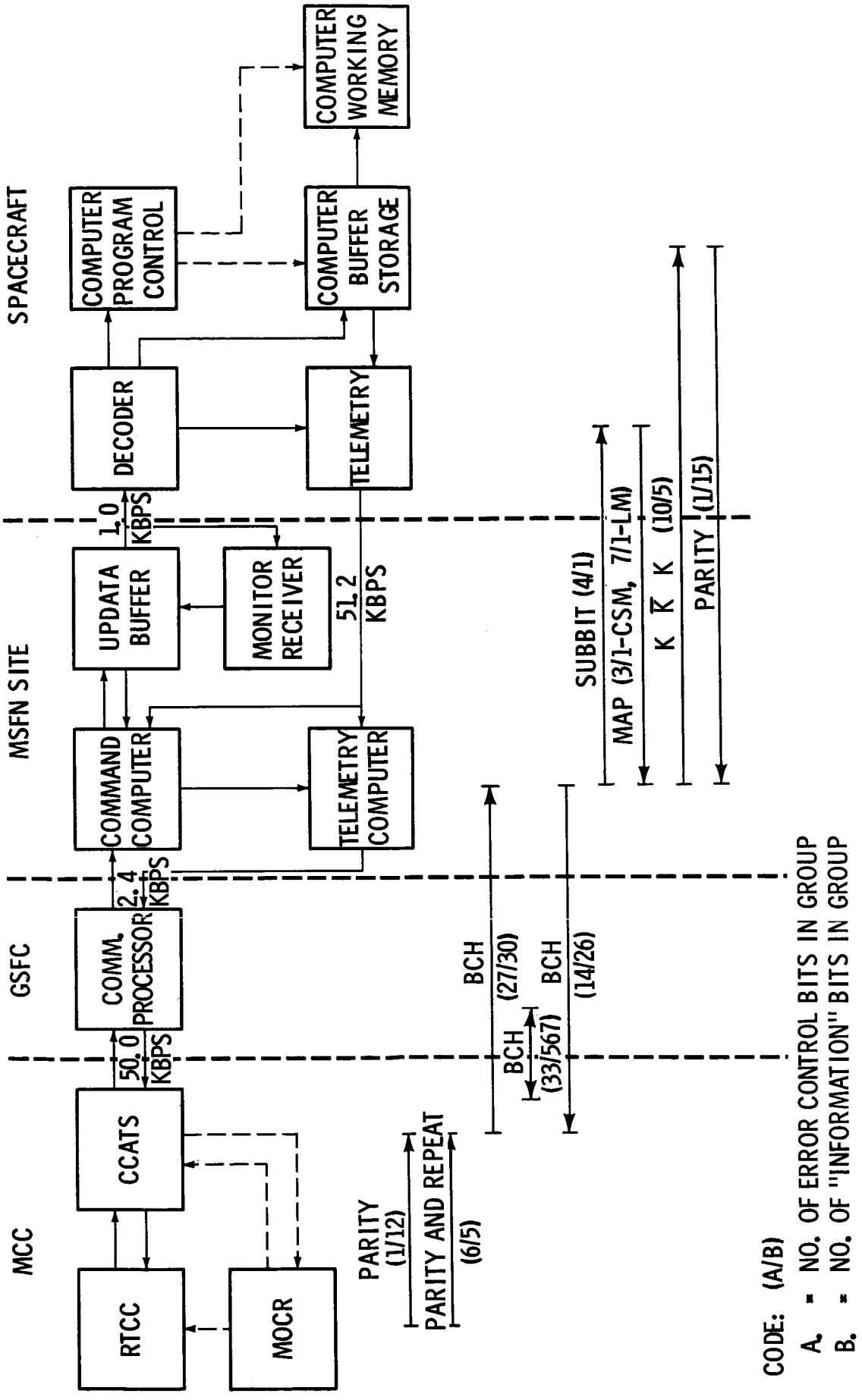


FIGURE 4 - ERROR PROTECTION

TABLE 1

CMC/LGC KEY CODE COMMAND STRUCTURE

DESCRIPTION		BIT STRUCTURE						OCTAL*
		VA	SA	P	K	$\overline{K}$	K	
VERB	V	100	011	1	10001	01110	10001	43613504
NOUN	N	100	011	1	11111	00000	11111	43770174
CLEAR		100	011	1	11110	00001	11110	43760370
ENTER	E	100	011	1	11100	00011	11100	43740760
0	0	100	011	1	10000	01111	10000	43603700
1	1	100	011	1	00001	11110	00001	43417404
2	2	100	011	1	00010	11101	00010	43427210
3	3	100	011	1	00011	11100	00011	43437014
4	4	100	011	1	00100	11011	00100	43446620
5	5	100	011	1	00101	11010	00101	43456424
6	6	100	011	1	00110	11001	00110	43466230
7	7	100	011	1	00111	11000	00111	43476034
8	8	100	011	1	01000	10111	01000	43505640
9	9	100	011	1	01001	10110	01001	43515444
+	+	100	011	1	11010	00101	11010	43721350
-	-	100	011	1	11011	00100	11011	43731154
UPLK BLK (All Zero)		100	011	1	00000	00000	00000	43400000
Error Reset		100	011	1	10010	01101	10010	43623310

* For LGC Octals, change first two characters to 31.

FROM REF. 8

TABLE 2

COMPONENTS OF DELAY

(1)	CCATS PROCESSING-OUTBOUND	56 MS.
(2)	MCC-H ⟷ GSFC WBD	23
(3)	GSFC READ-IN AND PROCESSING - OUTBOUND	25
(4)	GSFC ⟷ RS HSD VIA SATELLITE	300
(5)	RSCC READ-IN AND PROCESSING - RTC UP-LINK	355
(6)	CAP VAL FOR RTC	205
(7)	MAX LOAD STORAGE	930
(8)	CAP VAL FOR LOAD	980
(9)	RSCC PROCESSING - LOAD UP-LINK	200
(10)	RSCC ⟷ S/C AT LUNAR DISTANCE	1360
(11)	CSM/LM RTC READ-IN, DECODING, AND RELAY OPERATION	90
(12)	CMC/LGC PROCESSING FOR BUFFER STORAGE	180
(13)	KEYCODE CHARACTER SPACING	160
(14)	MAP WAITING TIME (HBR TLM)	20
(15)	(LBR TLM)	100
(16)	CMC/LGC TLM WAITING TIME (PER READ-OUT)	1000
(17)	RSCC PROCESSING - MAP VER	1000
(18)	RSCC PROCESSING - BUFFER COMPARE VER	1000
(19)	RSTC PROCESSING - CAP	800
(20)	RSTC PROCESSING - TLM DATA	1300
(21)	GSFC READ-IN AND PROCESSING - INBOUND	232
(22)	CCATS READ-IN AND PROCESSING - INBOUND	33
(23)	HUMAN DELAY	X

List of Abbreviations and Acronyms

AGC	Apollo Guidance Computer (also called CMC)
AVP	Address Verification Pulse
BCH	Bose-Chaudhuri-Hocquenghem (polynomial code)
C	Control bit (in S-IVB/IU command word)
$\overline{C}$	Complement of Control bit (in S-IVB/IU command word)
CAP	Command Analysis Pattern
CCATS	Communications, Command, and Telemetry System
CIM	Computer Input Multiplexer
CMC	Command Module Computer (also called AGC)
CP	Communications Processor (GSFC)
CRP	Computer Reset Pulse
CSM	Command Service Module
CTE	Central Timing Equipment
DA	Decoder Address (S-IVB/IU)
DCA	Digital Command Assembly
DSKY	Display Select Keyboard
DTU	Data Transmission Unit
D/TV	Digital-to-TV Converter
E	Enter (keycode)
ECR	Execute Command Request
GSFC	Goddard Space Flight Center
HBR	High Bit Rate Telemetry Mode (51.2 kbps)
HSD	High Speed Data (2.4 kbps)
HSP	High Speed Printer
I	Information bits (in S-IVB/IU command word)
$\overline{I}$	Complement of Information bits (in S-IVB/IU command word)
ID	Identification
INT	Interrupt bits (in S-IVB/IU command word)
IU	Instrument Unit
K	Keycode
$\overline{K}$	Complement of Keycode
kbps	Kilobits per second

List of Abbreviations and Acronyms

LBR	Low Bit Rate Telemetry mode (1.6 kbps)
LGC	Lunar Module Guidance Computer
LM	Lunar Module
LVDC	Launch Vehicle Digital Computer
M	Mode data bits (in S-IVB/IU command word)
MAP	Message Acceptance Pattern (or Pulse)
MCC-H	Mission Control Center - Houston
M&O	Maintenance and Operations (Personnel)
MOCR	Mission Operations Control Room
MSFN	Manned Space Flight Network
MTU	Magnetic Tape Unit
PBI	Push Button Indicator
PBT	Polynomial Buffer Terminal
PCM	Pulse Code Modulation Telemetry
POLY	Polynomial Error Detecting Code (BCH code)
RF	Radio Frequency
RO	Receive Only (teletype paper tape puncher)
RS	Remote Site
RSCC	Remote Site Command Computer
RSDP	Remote Site Data Processor (RSCC or RSTC)
RSTC	Remote Site Telemetry Computer
RTC	Real-Time Command
RTCC	Real-Time Computer Complex
SA	System Address
S-IVB	Saturn IVB Stage
SLV	Saturn Launch Vehicle
TLM	Telemetry (also TM)
TTY	Teletype
UCS	Universal Command System
UDB	Up-Data Buffer (MSFN equipment)
UDL	Up-Data Link
UHF	Ultra High Frequency
UPBUFF	Up-Data Buffer (CMC/LGC buffer storage)
USB	Unified S-Band

List of Abbreviations and Acronyms

V	Verb (keycode)
VA	Vehicle Address
VAL	Validation (remote site acceptance)
VER	Verification (space vehicle acceptance)
WBD	Wide Band Data (50.0 kpbs)

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4. Rosenblum, I. I., Command Problems on AS-202, AS-501, and AS-204 LM, Case 320, Bellcomm Memorandum for File, June 28, 1968.

5. Frey, A. H., Jr., Message Framing and Error Control, IEEE Transactions on Military Electronics, April 1965, pp. 143-147.

6. MSC, Apollo Telemetry Network, Subcourse Outline and Handout, Flight Control Orientation and Indoctrination, August 1, 1967.

7. MSC, Apollo Remote Site Data Processing Program Requirements, April 15, 1968.

8. MSC, Apollo Universal Command System Command Data Format Control Book, (with revision to March 1968), December 15, 1967.

9. MSC, Apollo Command Network, Subcourse Outline and Handout, Flight Control Orientation and Indoctrination, August 1, 1967.

Appendix A

Apollo Command System-Ground Network Flow Charts

The operation of the Apollo command system ground network is shown in flow chart form in this Appendix. The eight flow charts presented here are listed below:

Figure 1 - Command Loading-from MOCR through GSFC Outbound.

Figure 2 - Command Loading and Validation-from Remote Site Inbound through MCC-H Polynomial Buffer Terminal Inbound.

Figure 3 - Command Load Validation-from Polynomial Buffer Terminal through MOCR.

Figure 4 - Execute Command Request-from MOCR through Remote Site Validation.

Figure 5 - Command Uplinking (CSM and LM)-from RSCC to Spacecraft.

Figure 6 - Command Verification (CSM and LM)-from Spacecraft Telemetry through Remote Site Verification.

Figure 7 - Command Uplinking and Verification (S-IVB/IU)-from RSCC through Remote Site Verification.

Figure 8 - Command Verification-from RSCC through MOCR.

These flow charts show the normal command loading, uplinking, and verification logic and most of the alternate retransmission logic. Other command functions (e.g., command history, load inventory) are not shown. The nominal sequence of operation is shown by following the heavy line path. Nominal control and back-up paths are shown by dashed lines.

Message formats used for information transfers at different points in the network are presented in Appendix B, and are keyed to the flow charts by encircled capital letters. A CMC state vector update has been chosen for purposes of illustration. Functional schematics applicable to different network equipment are presented in Appendix C, and are keyed to the flow charts by lower case letters.

APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 1 OF 8
COMMAND LOADING - LOAD GENERATION AND TRANSMISSION

PRIMARY DATA FLOW PATHS - NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS - NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS
(A), (B), ... FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)
a, b, ... FUNCTIONAL SCHEMATICS (SEE APPENDIX C)

(A) MOCR FLIGHT CONTROLLER MAKES DECISION TO GENERATE COMMAND LOAD
VOICE
RTCC COMPUTER COMMAND GENERATES LOAD IN RTCC a
RTCC-MOCR D/TV DISPLAY OF LOAD TRANS - FERRED TO MOCR
(B) MOCR LOAD OK?
N: MOCR FLIGHT CONTROLLER ISSUES INSTRUC-TIONS FOR CORRECTION
VOICE
Y: RTCC ADD 1 PARITY BIT/12 INFO BITS. ADD FILL a
RTCC MANUALLY ERASE LOAD FROM RTCC MAKE-UP AND TRANSFER BUFFERS
CCATS-RTCC TRANSFER CLAM TO RTCC CONTROL CONSOLE
CCATS GENERATE COMPUTER LOAD ACCEPTANCE MESSAGE (CLAM)
RTCC-CCATS TRANSFER LOAD TO CCATS IN 36 BIT BYTES
(C) CCATS CHECK PARITY b
NG: CCATS RETRANSMIT?
Y
N: CCATS, RTCC, MOCR DECIDE ON FURTHER ACTION
G
HSP GENERATE HIGH - SPEED PRINTOUT (HSP) MESSAGE
CCATS GENERATE ENGLISH TRANSLATION MESSAGE b
CCATS ENCODE INTO KEYCODES (CSM AND LM ONLY) b
CCATS ASSEMBLE INTO 30 BIT SUBBLOCKS b
CCATS ADD 27 POLYNOMIAL (BCH) BITS AND 3 FILL BITS TO EACH SUBBLOCK b
CCATS CONVERT LOAD TO OCTAL CODE b
CCATS GENERATE OVERHEAD AND FILL SUBBLOCKS FOR PRIME SITE b
REPEAT FOR BACK-UP SITE IF ANY)
CCATS PLACE LOAD IN CCATS TRANSFER BUFFER •
(2) TO BELOW
(1) TO BELOW

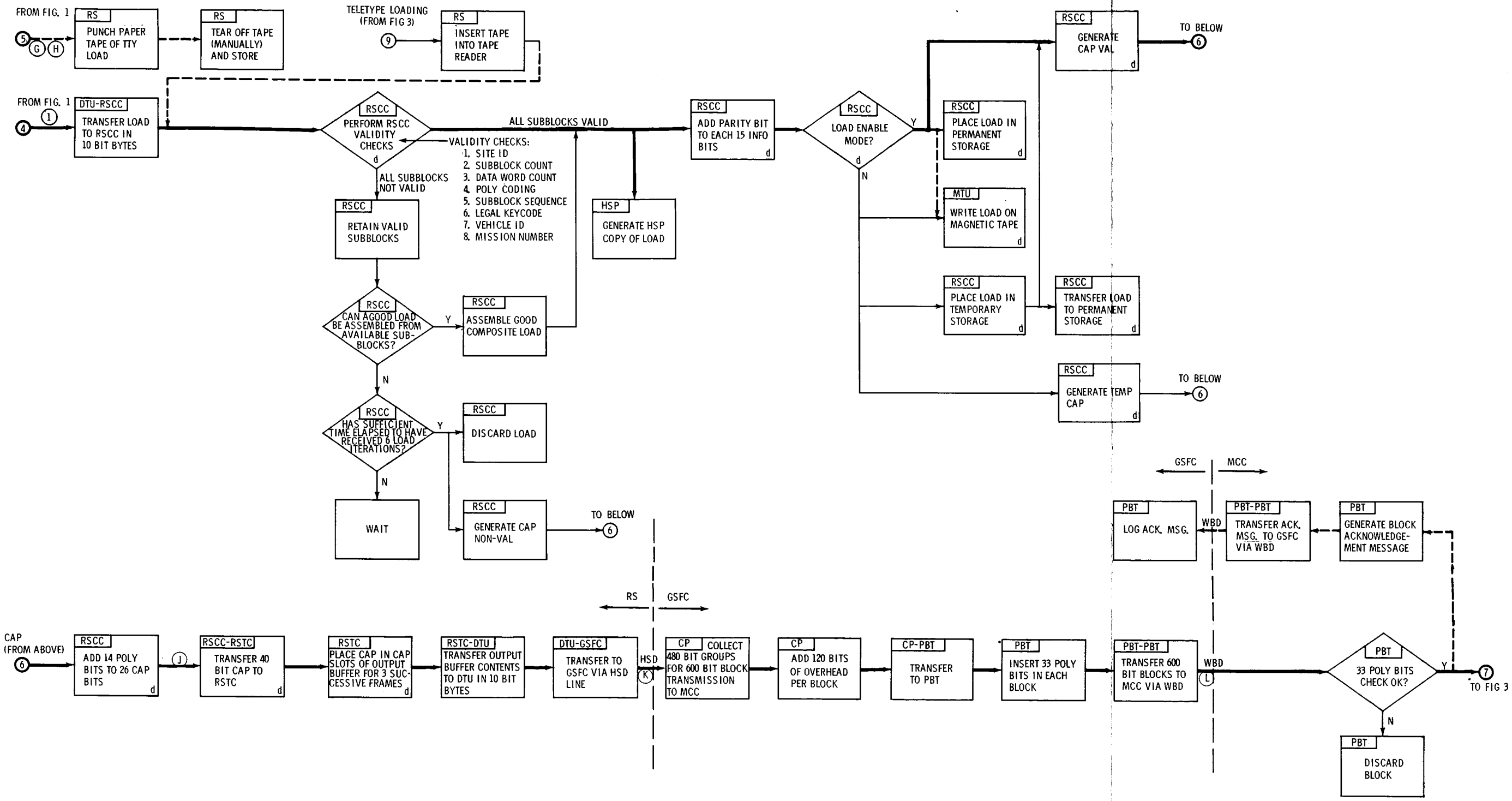
MCC | GSFC

(2) FROM ABOVE
CCATS GENERATE TELETYPE CODE FOR OCTAL LOAD (TWO ITERATIONS) PLUS TRANSLATION b
CCATS ADD HEADER INFORMATION FOR PRIME SITE b
REPEAT FOR BACK-UP SITE (IF ANY)
CCATS-GSFC TRANSFER TTY LOAD TO GSFC
TTY (G) (H)
CP SELECT TTY LINE TO RS c
CP-RS TRANSFER DATA TO RS
TTY (G) (H) (5) TO FIG 2

REATTEMPT HSD LOADING (FROM FIG 3)
(8) (1) FROM ABOVE
CCATS-PBT TRANSFER LOAD TO POLYNOMIAL BUFFER TERMINAL (PBT) IN GROUPS OF 10 SUBBLOCKS b
PBT INSERT 33 POLYNOMIAL (BCH) BITS IN EACH 600 BIT BLOCK b
PBT-GSFC TRANSFER 600 BIT BLOCK(S) TO GSFC VIA WIDE-BAND DATA
WBD (D) (E) (F)
PBT 33 POLY BITS CHECK OK? c
Y
PBT-CP TRANSFER DATA TO COMM PROCESSOR c
CP REFORMAT DATA FOR HIGH SPEED DATA (HSD) TRANSMISSION TO RS c
CP SELECT HSD LINE TO RS c
CP-RS TRANSFER DATA TO RS
HSD (I) (4) TO FIG 2
N: DISCARD BLOCK
PBT LOG ACK MSG.
WBD
PBT-PBT TRANSFER ACK. MSG. TO MCC VIA WIDE-BAND DATA
PBT GENERATE BLOCK ACKNOWLEDGE-MENT MESSAGE
CCATS WAIT ONE SEC.
CCATS IS THIS FIRST LOAD OF 2 LOAD GROUP ?
Y
N: CCATS HAS VAL BEEN RECEIVED FROM RS?
Y: PBT EXIT
N: CCATS WAIT 5 SEC.
CCATS HAVE 3 GROUPS (6 LOADS) BEEN TRANSM - ITTED?
N
Y: (3) TO FIG 3

PRIMARY DATA FLOW PATHS - NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS - NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS
(A), (B), ... FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)
a, b, ... FUNCTIONAL SCHEMATICS (SEE APPENDIX C)

APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 2 OF 8
COMMAND LOADING AND VALIDATION - REMOTE SITE TO MCC POLYNOMIAL BUFFER TERMINAL



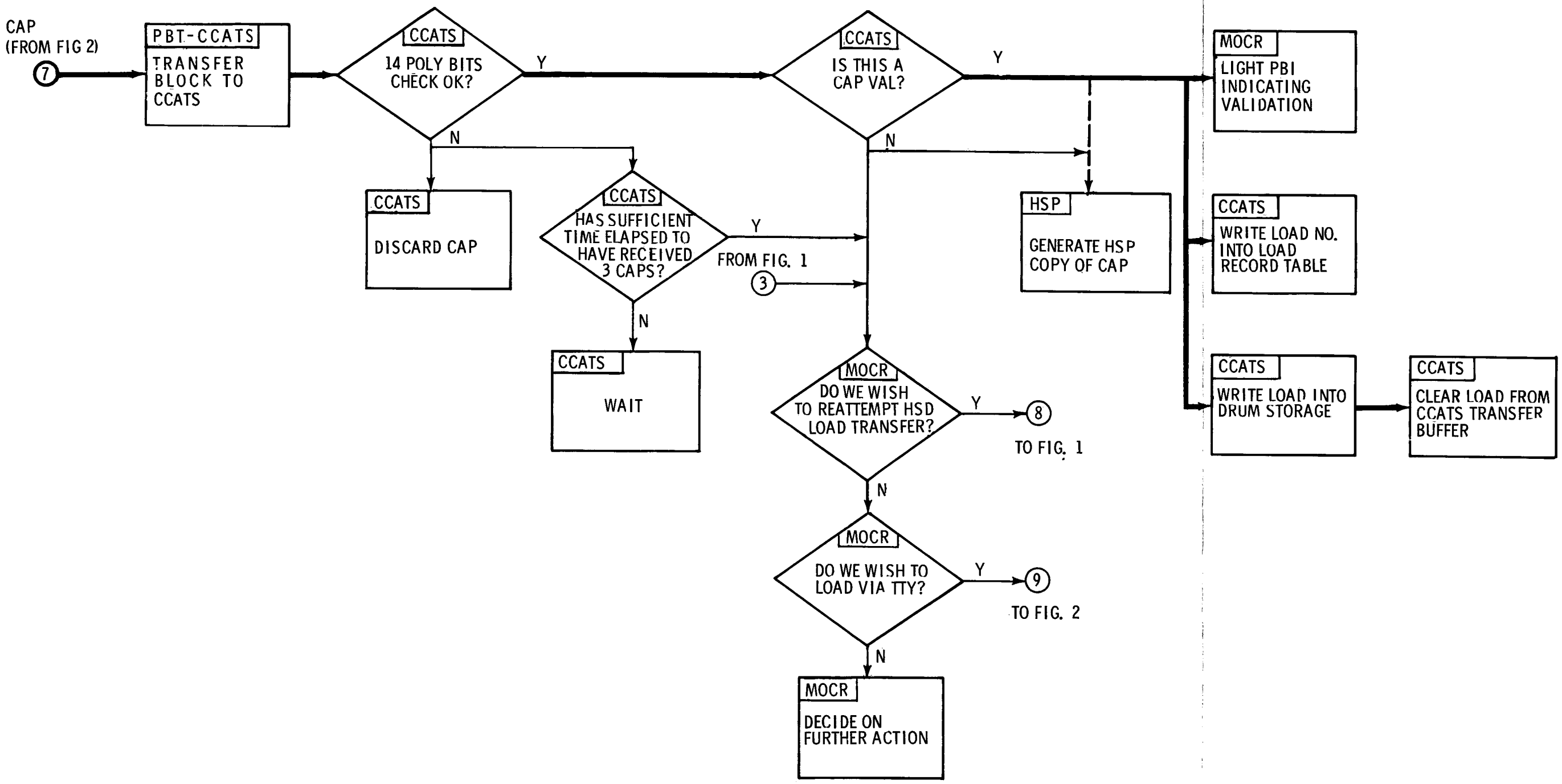
APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 3 OF 8

COMMAND LOAD VALIDATION - MCC

PRIMARY DATA FLOW PATHS - NOMINAL CASE

BACK-UP AND CONTROL DATA FLOW PATHS - NOMINAL CASE

NON-NOMINAL DATA FLOW PATHS



APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 4 OF 8
EXECUTE COMMAND REQUEST - GENERATION AND REMOTE SITE VALIDATION

PRIMARY DATA FLOW PATHS - NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS - NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS

(A) (B)... FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)
a, b,... FUNCTIONAL SCHEMATICS (SEE APPENDIX C)

FLIGHT CONTROLLER INITIATION OF NEXT STEP IN COMMAND SEQUENCE (FROM FIG 8)

(23)

MOCR FLIGHT CONTROLLER MAKES DECISION TO UPLINK COMMAND

CIM GENERATE COMPUTER INPUT MATRIX (CIM) WORDS

CCATS PERFORM ERROR CHECKS
G
NG
Y
N

MOCR RETRANSMIT?

HSP COPY

MOCR DECIDE ON FURTHER ACTION

CCATS GENERATE EXECUTE COMMAND REQUEST (ECR) MESSAGE

CCATS ADD 27 POLY BITS

(M)

CCATS ADD OVERHEAD AND FILL TO FORM 10 SUBBLOCKS

CCATS-PBT TRANSFER 600 BITS TO PBT

PBT INSERT 33 POLY BITS IN 600 BIT BLOCK

PBT-GSFC TRANSFER TO GSFC VIA WBD

WBD (D)

PBT 33 POLY BITS CHECK OK?
N
Y

(10) TO BELOW

PBT DISCARD BLOCK

MCC ← → GSFC

PBT LOG ACK. MSG.

WBD

PBT-PBT TRANSFER ACK MSG TO MCC VIA WBD

PBT GENERATE BLOCK ACKNOWLEDGEMENT MESSAGE

CCATS IS THIS A PRIORITY ECR?
N → EXIT
Y

CCATS WRITE ECR IN TRANSFER BUFFER

CCATS HAS VAL BEEN RECEIVED FROM RS?
N
Y

CCATS WAIT 250 MS.

CCATS READ OUT TRANSFER BUFFER

CCATS ERASE TRANSFER BUFFER

(10) FROM ABOVE

PBT-CP TRANSFER DATA TO COMM PROCESSOR

CP REFORMAT FOR HSD TRANSMISSION TO RS

CP SECLECT HSD LINE TO RS

CP-RS TRANSFER DATA TO RS

(I) HSD

DTU-RSCC TRANSFER ECR TO RSCC IN 10 BIT BYTES

GSFC ← → RS

RSCC PERFORM RSCC VALIDITY CHECKS
e
G
NG

RSCC DISCARD LOAD

RSCC GENERATE CAP NON-VAL

(11) TO FIG 8

RSCC IS THIS FOR CSM/LM OR FOR S-IVB/IU?
e
CSM/LM
S-IVB/IU

(12) TO FIG 7

RSCC IS THIS AN RTC OR A LOAD REQUEST?
e
RTC
LOAD

RSCC VALID REQUEST?
Y
N

(13) TO FIG. 5

RSCC DISCARD REQUEST

RSCC GENERATE CAP NON-VAL

(11) TO FIG 8

RSCC GENERATE CAP VAL

(11) TO FIG 8

RSCC VALID LOAD NO.?
e
Y
N

(14) TO FIG. 5

RSCC DISCARD REQUEST

RSCC GENERATE CAP NON-VAL

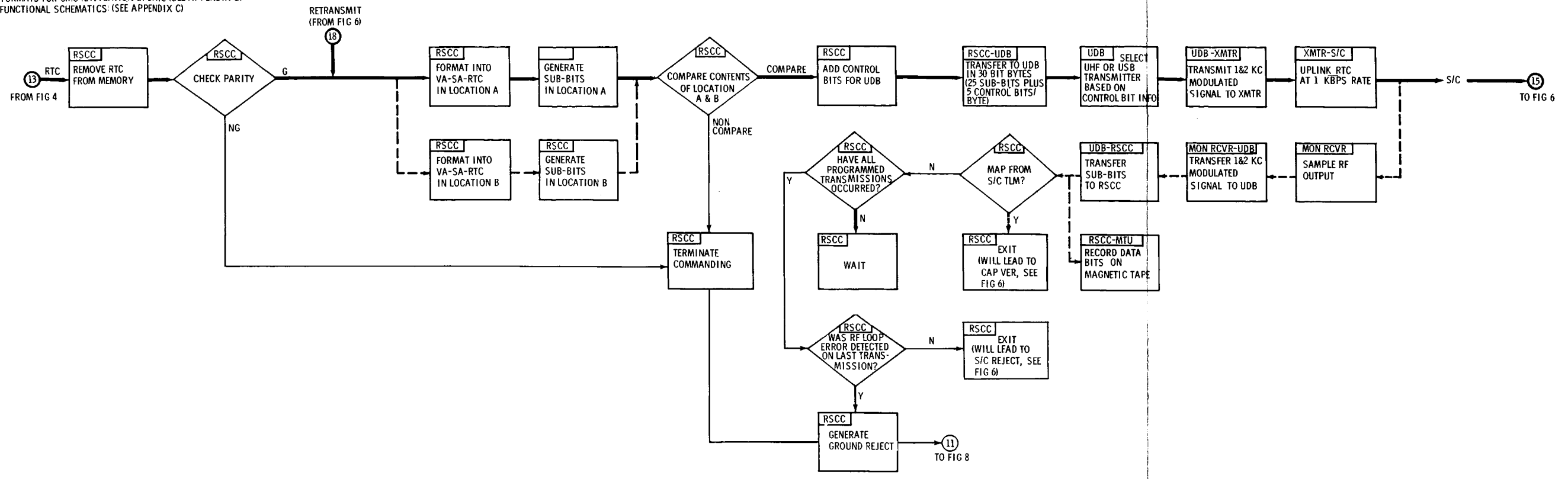
(11) TO FIG 8

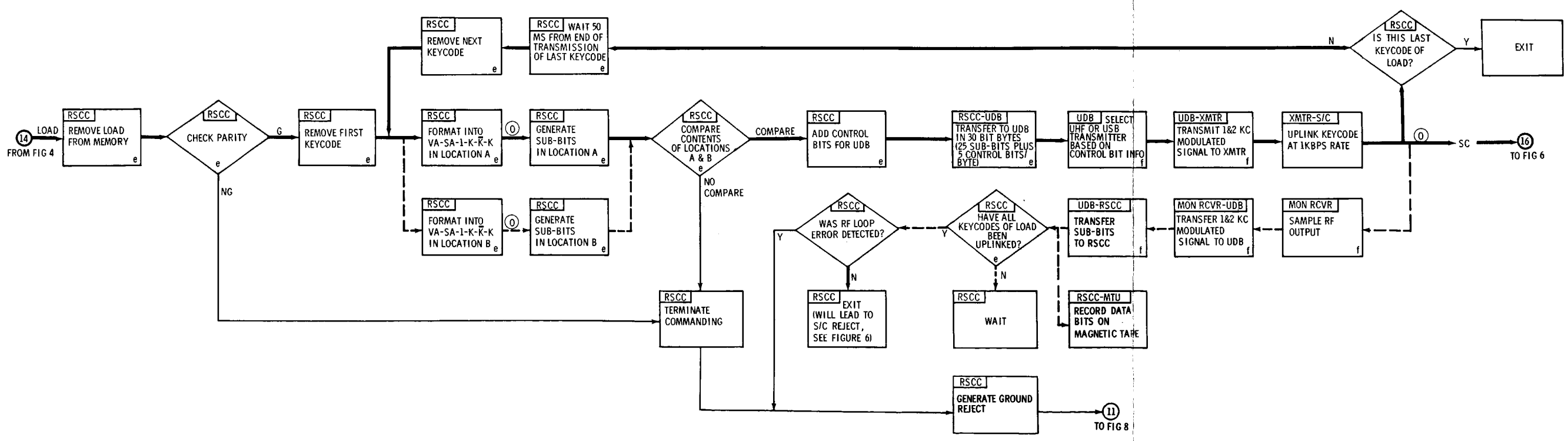
RSCC GENERATE CAP VAL
e

(11) TO FIG 8

APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 5 OF 8
COMMAND UPLINKING (CSM and LM)

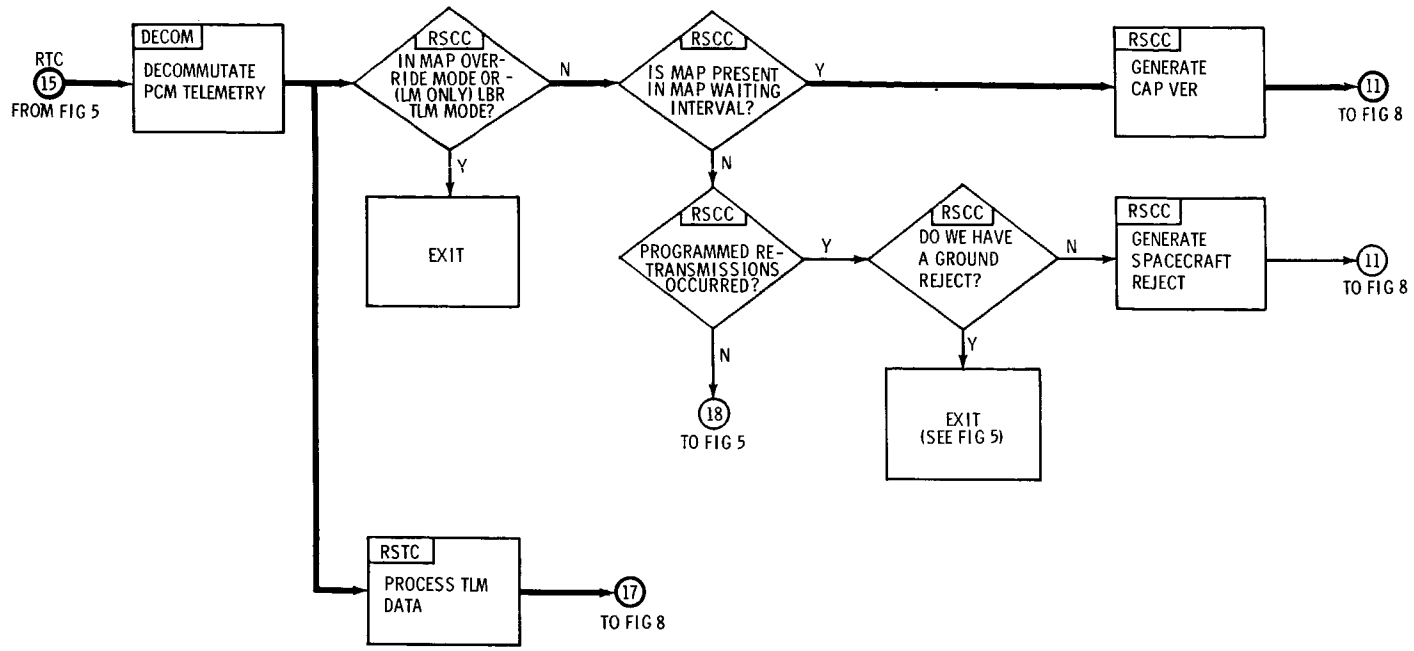
PRIMARY DATA FLOW PATHS-NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS-NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS
(A) (B)... FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)
a, b,... FUNCTIONAL SCHEMATICS (SEE APPENDIX C)





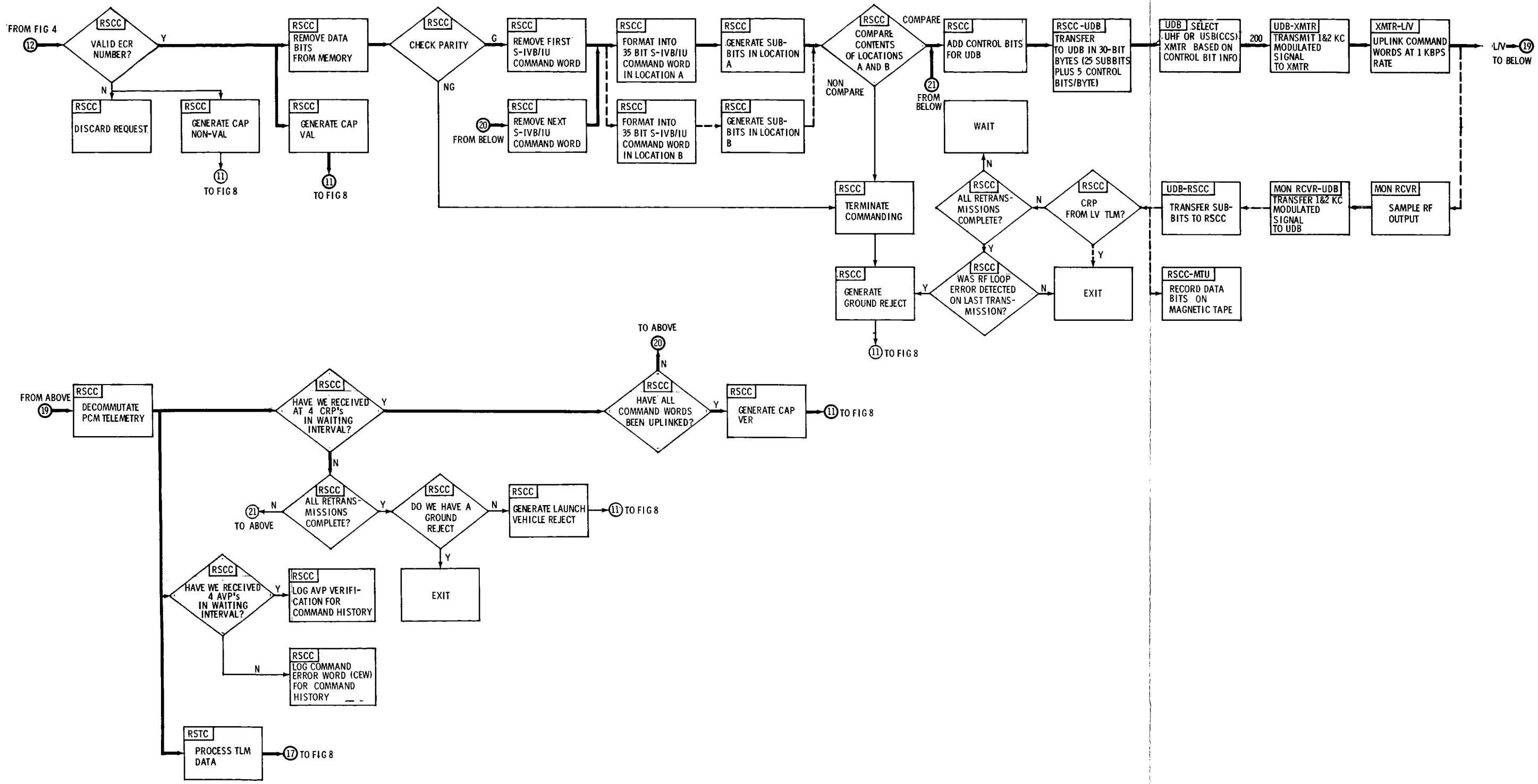
PRIMARY DATA FLOW PATHS-NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS-NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS
(A) (B)... FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)

APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 6 OF 8
REMOTE SITE COMMAND VERIFICATION (CSM and LM)



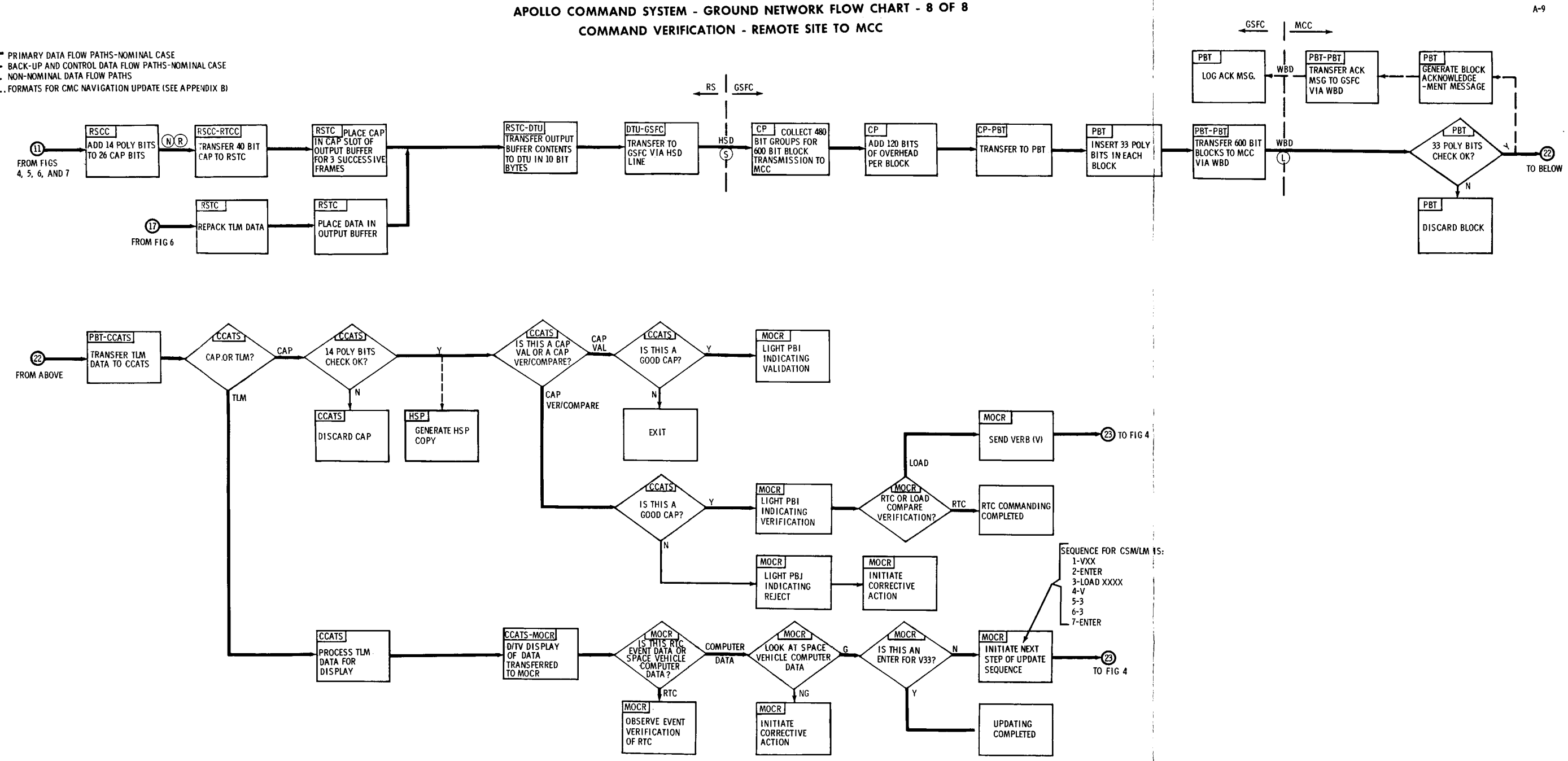
APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 7 OF 8
COMMAND UPLINKING AND REMOTE SITE COMMAND VERIFICATION (SLV)

LEGEND
- PRIMARY DATA FLOW PATHS - NOMINAL CASE
- BACK-UP AND CONTROL DATA FLOW PATHS - NOMINAL CASE
- NON-NOMINAL DATA FLOW PATHS



APOLLO COMMAND SYSTEM - GROUND NETWORK FLOW CHART - 8 OF 8
COMMAND VERIFICATION - REMOTE SITE TO MCC

PRIMARY DATA FLOW PATHS-NOMINAL CASE
BACK-UP AND CONTROL DATA FLOW PATHS-NOMINAL CASE
NON-NOMINAL DATA FLOW PATHS
(A) (B) .. FORMATS FOR CMC NAVIGATION UPDATE (SEE APPENDIX B)



Appendix B

FORMATS (CMC NAVIGATION UPDATE)

This appendix shows the message formats used to transfer information between elements of the ground network, and between the ground and the space vehicle. A CMC Navigation (State Vector) Update has been chosen as an example. The figure letters correspond to the circled upper case letters shown on the flow charts in Appendix A.

The individual formats are as follows:

AGC NAVIGATION UPDATE

X, Y, Z — THIRTY BIT WORDS DEFINING PREDICTED POSITION OF THE SPACECRAFT, REFERENCED TO THE EARTH-CENTERED INERTIAL COORDINATE SYSTEM AT THE TIME SPECIFIED BY GETSV

$\dot{X}$, $\dot{Y}$, $\dot{Z}$ — THIRTY BIT WORDS DEFINING PREDICTED VELOCITY OF THE SPACECRAFT, REFERENCED TO THE EARTH-CENTERED INERTIAL COORDINATE SYSTEM AT THE TIME SPECIFIED BY GETSV

T - TIME OF STATE VECTOR REFERENCED TO ONBOARD TIME SYSTEM

GETSV - GET OF STATE VECTOR. THIS QUANTITY FOR ENGLISH TRANSLATION MESSAGE

FIGURE A FROM REF. 9

PURPOSE:

USED BY THE AGC TO COMPUTE THE EPHEMERIS FOR THE COMMAND SERVICE MODULE.

CONTENTS:

- VELOCITY AND POSITION COMPONENTS REFERENCED TO THE EARTH CENTERED INERTIAL COORDINATE SYSTEM.
- TIME OF STATE VECTOR REFERENCED TO ONBOARD TIME SYSTEM.

AM 1560 0276

CSM NAV UPDATE TO CMC

LOAD NO. XXXX GET GEN XXX:XX:XX SITES XXX XXX

STA ID XXXXXX GMT ID XX:XX:XX:XX

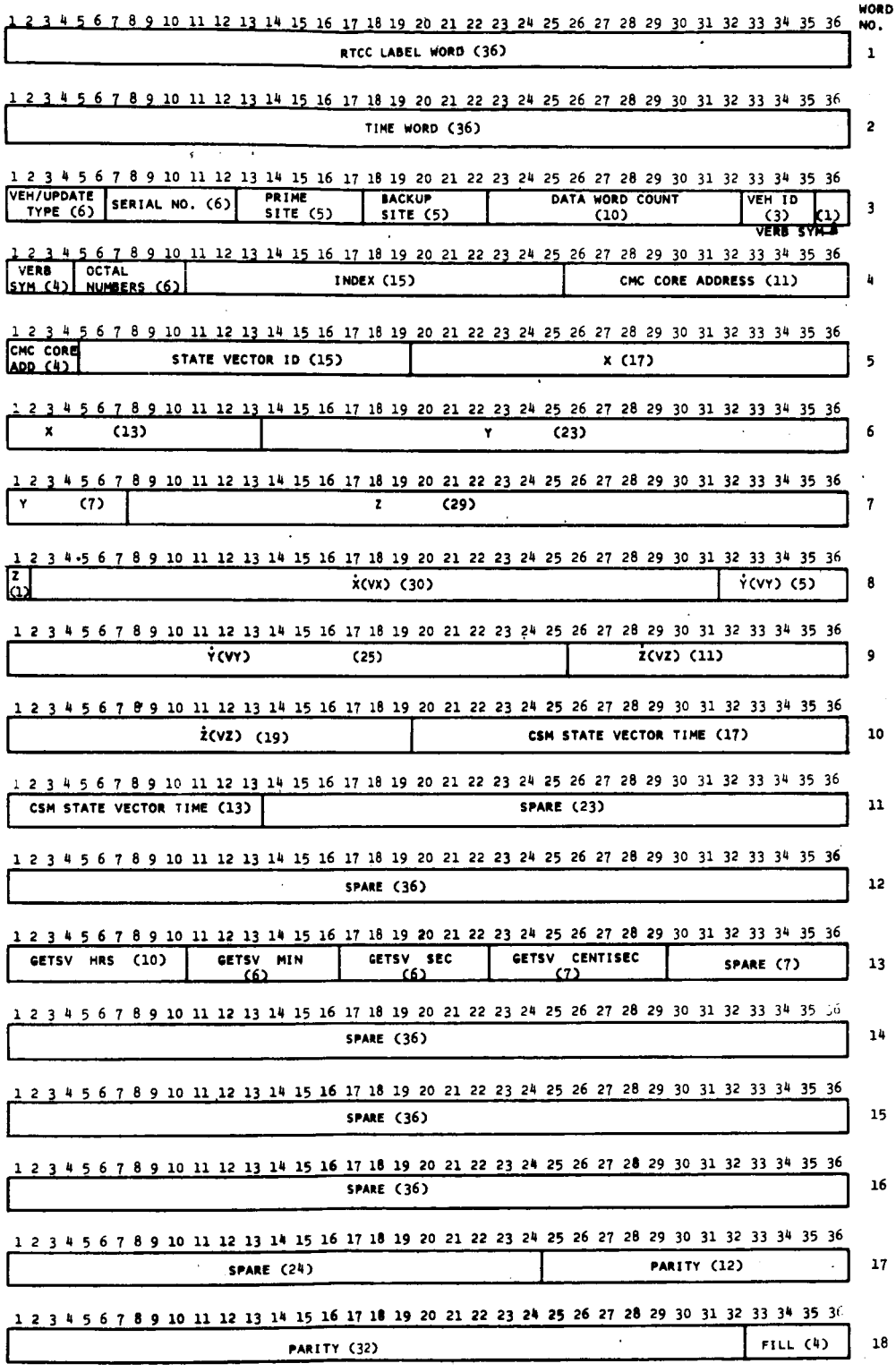
OID	FCT	DSKY V71	VECTOR
01	INDEX	XXXXX	
02	ADD	XXXXX	
03	VID	XXXXX	
04	X	XXXXX	± XXXXXXXX.XXX
05	X	XXXXX	
06	Y	XXXXX	± XXXXXXXX.XXX
07	Y	XXXXX	
10	Z	XXXXX	± XXXXXXXX.XXX
11	Z	XXXXX	
12	$\dot{X}$	XXXXX	± XXXXXXXX.XXX
13	$\dot{X}$	XXXXX	
14	$\dot{Y}$	XXXXX	± XXXXXXXX.XXX
15	$\dot{Y}$	XXXXX	
16	$\dot{Z}$	XXXXX	± XXXXXXXX.XXX
17	$\dot{Z}$	XXXXX	
20	T	XXXXX	XXX:XX:XX.XX
21	T	XXXXX	

CSM NAVIGATION UPDATE

FIGURE B
D/TV DISPLAY IN MOCR

FROM REF. 9

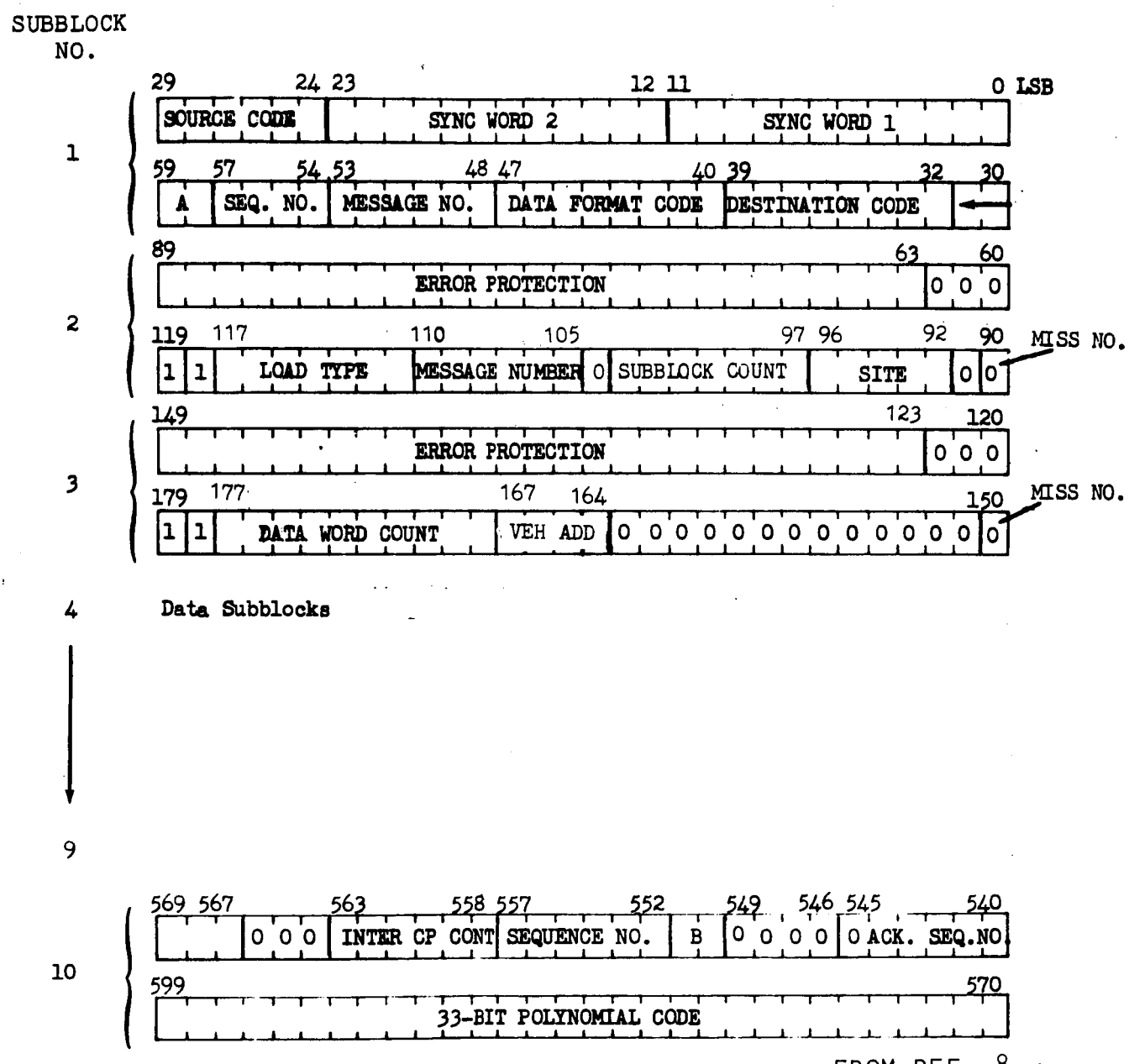
LOAD 00XX CMC CSM NAVIGATION UPDATE



MSB IS LEFTMOST BIT

FROM REF. 8

FIGURE C
RTCC TO CCATS



FROM REF. 8

FIGURE D

CCATS TO GSFC

Format For First Block of a Load

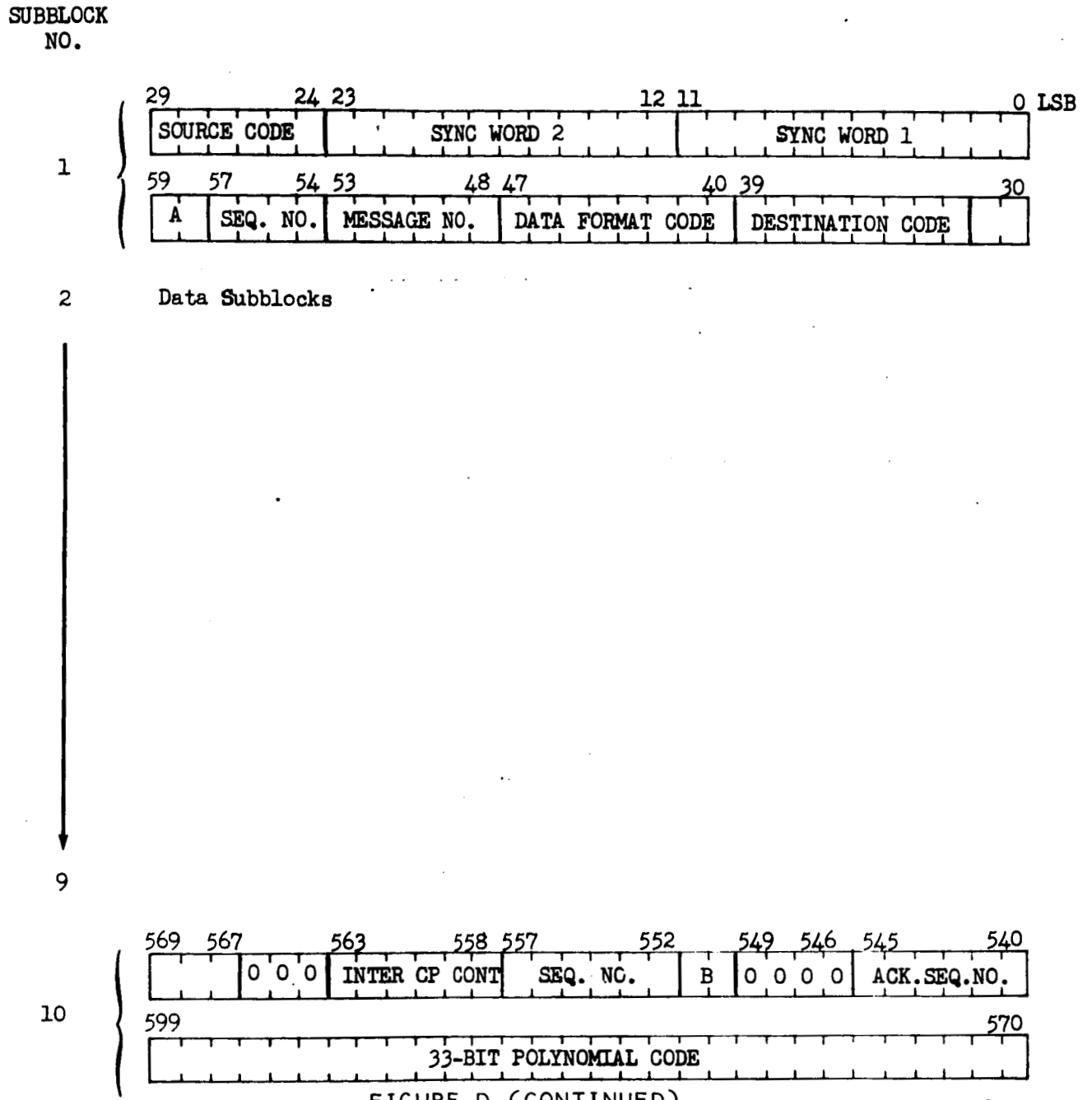


FIGURE D (CONTINUED)

FROM REF. 8

CCATS TO GSFC

Format For Second And Subsequent Blocks of a Load Requiring More Than One Block

LOAD 00XX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
1	0-11	SYNC WORD 1	12
1	12-23	SYNC WORD 2	12
1	24-31	SOURCE CODE	8
1	32-39	DESTINATION CODE	8
1	40-47	DATA FORMAT CODE	8
1	48-53	MESSAGE NUMBER	6
1	54-57	SEQUENCE NO.	4
1	58-59	STATUS A CODE	2
2	60-62	FILL	3
2	63-89	ERROR PROTECTION	27
2	90	MISSION NO.	1
2	91	SPARE	1
2	92-96	SITE ID	5
2	97-103	SUBBLOCK COUNT	7
2	104	SPARE	1
2	105-110	MSG NO.	6
2	111-117	LOAD TYPE	7
2	118	INTRODUCTION	1
2	119	INSTRUCTION	1
3	120-122	FILL	3
3	123-149	ERROR PROTECTION	27
3	150	MISSION NO.	1
3	151-163	SPARE	13
3	164-167	VEHICLE ADDRESS	4
3	168-177	DATA WORD COUNT	10
3	178	INTRODUCTION	1
3	179	INSTRUCTION	1
4	180-182	FILL	3
4	183-209	ERROR PROTECTION	27
4	210	MISSION NO.	1
4	211-215	INDEX	5
4	216-220	KEY CODE (VERB NO.)	5
4	221-225	KEY CODE (VERB NO.)	5
4	226-230	VERB SYMBOL	5
4	231-237	SEQUENCE NO. 1	7
4	238-239	INSTRUCTION	2

FROM REF. 8

FIGURE E

LOAD 00XX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU) (CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
5	240-242	FILL	3
5	243-269	ERROR PROTECTION	27
5	270	MISSION NO.	1
5	271-275	INDEX	5
5	276-280	INDEX	5
5	281-285	INDEX	5
5	286-290	INDEX	5
5	291-297	SEQUENCE NO. 2	7
5	298-299	INSTRUCTION	2
6	300-302	FILL	3
6	303-329	ERROR PROTECTION	27
6	330	MISSION NO.	1
6	331-335	CMC CORE ADDRESS	5
6	336-340	CMC CORE ADDRESS	5
6	341-345	CMC CORE ADDRESS	5
6	346-350	CMC CORE ADDRESS	5
6	351-357	SEQUENCE NO. 3	7
6	358-359	INSTRUCTION	2
7	360-362	FILL	3
7	363-389	ERROR PROTECTION	27
7	390	MISSION NO.	1
7	391-395	VECTOR ID	5
7	396-400	VECTOR ID	5
7	401-405	VECTOR ID	5
7	406-410	CMC CORE ADDRESS	5
7	411-417	SEQUENCE NO. 4	7
7	418-419	INSTRUCTION	2
8	420-422	FILL	3
8	423-449	ERROR PROTECTION	27
8	450	MISSION NO.	1
8	451-455	X (X POS)	5
8	456-460	X (X POS)	5
8	461-465	VECTOR ID	5
8	466-470	VECTOR ID	5
8	471-477	SEQUENCE NO. 5	7
8	478-479	INSTRUCTION	2

FROM REF. 8

FIGURE E (CONTINUED)

LOAD 00XX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU) (CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
9	480-482	FILL	3
9	483-509	ERROR PROTECTION	27
9	510	MISSION NO.	1
9	511-515	X (X POS)	5
9	516-520	Ẋ (X POS)	5
9	521-525	Ẍ (X POS)	5
9	526-530	X (X POS)	5
9	531-537	SEQUENCE NO. 6	7
9	538-539	INSTRUCTION	2
10	540-545	ACK. SEQUENCE NO.	6
10	546-549	FILL	4
10	550-551	STATUS B CODE	2
10	552-557	SEQUENCE NO.	6
10	558-563	INTER CP CODE	6
10	564-566	FILL	3
10	567-599	POLYNOMIAL CODE	33
11	0-11	SYNC WORD 1	12
11	12-23	SYNC WORD 2	12
11	24-31	SOURCE CODE	8
11	32-39	DESTINATION	8
11	40-47	DATA FORMAT CODE	8
11	48-53	MESSAGE NUMBER	6
11	54-57	SEQUENCE NUMBER	4
11	58-59	STATUS A CODE	2
12	60-62	FILL	3
12	63-89	ERROR PROTECTION	27
12	90	MISSION NO.	1
12	91-95	X (X POS)	5
12	96-100	X (X POS)	5
12	101-105	X (X POS)	5
12	106-110	X (X POS)	5
12	111-117	SEQUENCE NO. 7	7
12	118-119	INSTRUCTION	2
13	120-122	FILL	3
13	123-149	ERROR PROTECTION	27
13	150	MISSION NO.	1
13	151-155	Y (Y POS)	5
13	156-160	Y (Y POS)	5
13	161-165	Y (Y POS)	5
13	166-170	Y (Y POS)	5
13	171-177	SEQUENCE NO. 8	7
13	178-179	INSTRUCTION	2

FROM REF. 8

FIGURE E (CONTINUED)

LOAD OOXX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU)(CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
14	180-182	FILL	3
14	183-209	ERROR PROTECTION	27
14	210	MISSION NO.	1
14	211-215	Y (Y POS)	5
14	216-220	Y (Y POS)	5
14	221-225	Y (Y POS)	5
14	226-230	Y (Y POS)	5
14	231-237	SEQUENCE NO. 9	7
14	238-239	INSTRUCTION	2
15	240-242	FILL	3
15	243-269	ERROR PROTECTION	27
15	270	MISSION NO.	1
15	271-275	Z (Z POS)	5
15	276-280	Z (Z POS)	5
15	281-285	Y (Y POS)	5
15	286-290	Y (Y POS)	5
15	291-297	SEQUENCE NO. 10	7
15	298-299	INSTRUCTION	2
16	300-302	FILL	3
16	302-329	ERROR PROTECTION	27
16	330	MISSION NO.	1
16	331-335	Z (Z POS)	5
16	336-340	Z (Z POS)	5
16	341-345	Z (Z POS)	5
16	346-350	Z (Z POS)	5
16	351-357	SEQUENCE NO. 11	7
16	358-359	INSTRUCTION	2
17	360-362	FILL	3
17	363-389	ERROR PROTECTION	27
17	390	MISSION NO.	1
17	391-395	Z (Z POS)	5
17	396-400	Z (Z POS)	5
17	401-405	Z (Z POS)	5
17	406-410	Z (Z POS)	5
17	411-417	SEQUENCE NO. 12	7
17	418-419	INSTRUCTION	2

FROM REF. 8

FIGURE E (CONTINUED)

LOAD OOXX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU) (CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
18	420-422	FILL	3
18	423-449	ERROR PROTECTION	27
18	450	MISSION NO.	1
18	451-455	X (VX)	5
18	456-460	X (VX)	5
18	461-465	X (VX)	5
18	466-470	X (VX)	5
18	471-477	SEQUENCE NO. 13	7
18	478-479	INSTRUCTION	2
19	480-482	FILL	3
19	483-509	ERROR PROTECTION	27
19	510	MISSION NO.	1
19	511-515	X (VX)	5
19	516-520	X (VX)	5
19	521-525	X (VX)	5
19	526-530	X (VX)	5
19	531-537	SEQUENCE NO. 14	7
19	538-539	INSTRUCTION	2
20	540-545	ACK. SEQUENCE NO.	6
20	546-549	FILL	4
20	550-551	STATUS B CODE	2
20	552-557	SEQUENCE NO.	6
20	558-563	INTER CP CONT	6
20	564-566	FILL	3
20	567-599	POLYNOMIAL CODE	33
21	0-11	SYNC WORD 1	12
21	12-23	SYNC WORD 2	12
21	24-31	SOURCE CODE	8
21	32-39	DESTINATION CODE	8
21	40-47	DATA FORMAT CODE	8
21	48-53	MESSAGE NUMBER	6
21	54-57	SEQUENCE NUMBER	4
21	58-59	STATUS A CODE	2
22	60-62	FILL	3
22	63-89	ERROR PROTECTION	27
22	90	MISSION NO.	1
22	91-95	Y (VY)	5
22	96-100	Y (VY)	5
22	101-105	X (VX)	5
22	106-110	X (VX)	5
22	111-117	SEQUENCE NO. 15	7
22	118-119	INSTRUCTION	2

FROM REF. 8

FIGURE E (CONTINUED)

LOAD OOXX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU) (CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
23	120-122	FILL	3
23	123-149	ERROR PROTECTION	27
23	150	MISSION NO.	1
23	151-155	Y (VY)	5
23	156-160	Y (VY)	5
23	161-165	Y (VY)	5
23	166-170	Y (VY)	5
23	171-177	SEQUENCE NO. 16	7
23	178-179	INSTRUCTION	2
24	180-182	FILL	3
24	183-209	ERROR PROTECTION	27
24	210	MISSION NO.	1
24	211-215	Y (VY)	5
24	216-220	Y (VY)	5
24	221-225	Y (VY)	5
24	226-230	Y (VY)	5
24	231-237	SEQUENCE NO. 17	7
24	238-239	INSTRUCTION	2
25	240-242	FILL	3
25	243-269	ERROR PROTECTION	27
25	270	MISSION NO.	1
25	271-275	Z (VZ)	5
25	276-280	Z (VZ)	5
25	281-285	Z (VZ)	5
25	286-290	Z (VZ)	5
25	291-297	SEQUENCE NO. 18	7
25	298-299	INSTRUCTION	2
26	300-302	FILL	3
26	303-329	ERROR PROTECTION	27
26	330	MISSION NO.	1
26	331-335	Z (VZ)	5
26	336-340	Z (VZ)	5
26	341-345	Z (VZ)	5
26	346-350	Z (VZ)	5
26	351-357	SEQUENCE NO. 19	7
26	358-359	INSTRUCTION	2

FROM REF. 8

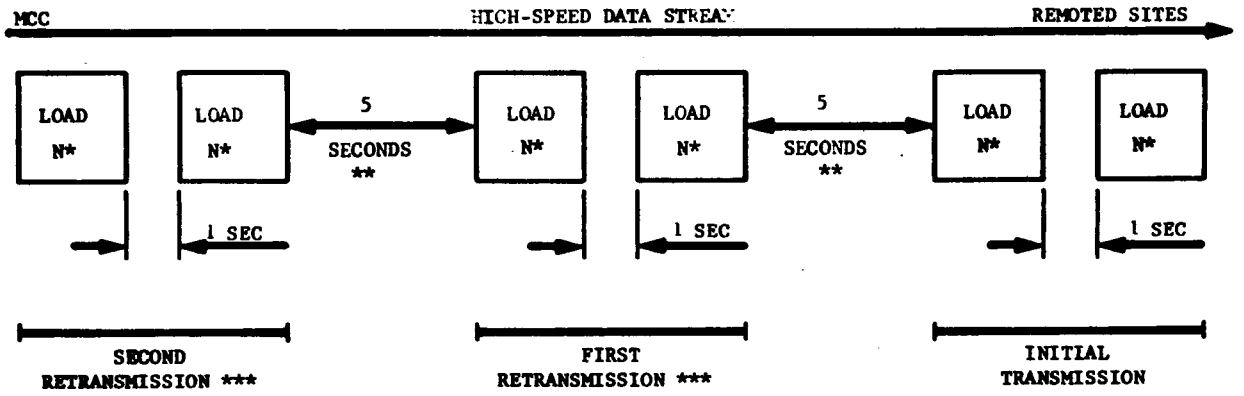
FIGURE E (CONTINUED)

LOAD OOXX CMC CSM NAVIGATION UPDATE V71 TYPE (CNU) (CONT'D)

SUBBLOCK	BITS	DESCRIPTION	NO. OF BITS
27	360-362	FILL	3
27	363-389	ERROR PROTECTION	27
27	390	MISSION NO.	1
27	391-395	CMC STATE VECTOR TIME	5
27	396-400	CMC STATE VECTOR TIME	5
27	401-405	Z (VZ)	5
27	406-410	Z (VZ)	5
27	411-417	SEQUENCE NO. 20	7
27	418-419	INSTRUCTION	2
28	420-422	FILL	3
28	423-449	ERROR PROTECTION	27
28	450	MISSION NO.	1
28	451-455	CMC STATE VECTOR TIME	5
28	456-460	CMC STATE VECTOR TIME	5
28	461-465	CMC STATE VECTOR TIME	5
28	466-470	CMC STATE VECTOR TIME	5
28	471-477	SEQUENCE NO. 21	7
28	478-479	INSTRUCTION	2
29	480-482	FILL	3
29	483-509	ERROR PROTECTION	27
29	510	MISSION NO.	1
29	511-515	CMC STATE VECTOR TIME	5
29	516-520	CMC STATE VECTOR TIME	5
29	521-525	CMC STATE VECTOR TIME	5
29	526-530	CMC STATE VECTOR TIME	5
29	531-537	SEQUENCE NO. 22	7
29	538-539	INSTRUCTION	2
30	540-545	ACK. SEQUENCE NO.	6
30	546-549	FILL	4
30	550-551	STATUS B CODE	2
30	552-557	SEQUENCE NO.	6
30	558-563	INTER CP CONT	6
30	564-566	FILL	3
30	567-599	POLYNOMIAL CODE	33

FROM REF. 8

FIGURE E (CONTINUED)



* = Load type
** = Other messages, executes, etc. may be received during this interval
*** = Occurs only if MCC does not receive an indication of successful or unsuccessful transfer of the load during the preceding 5-second period.

FROM REF. 7

FIGURE F

Flow Diagram; Command Load Transmission, MCC to Remoted Sites

500 SERIES
LOAD 00

←TELETYPE FORMAT

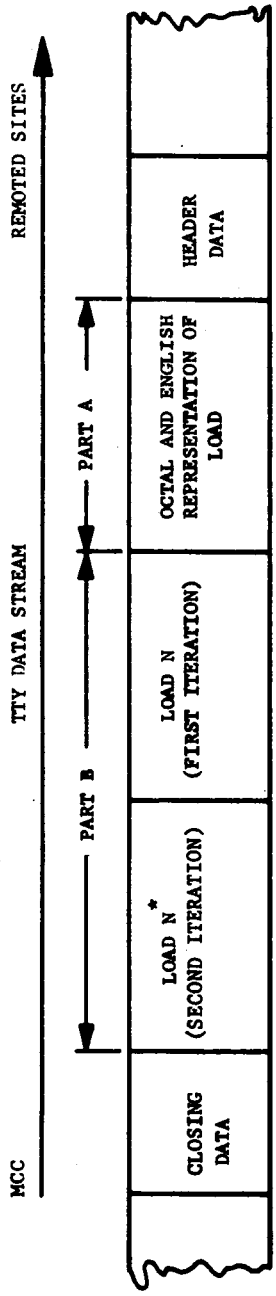
TELETYPE MESSAGE→

```
;;;;;;<<=;
HMS'001;A;;;;;;<<=;
SS=GMIL<<=;
DE=HMDC=#'002<<=;
15/0800;Z<<==;
CMC=CNU=VB='71<<=;
LN='0001/0001<<==;
GETSV='999:00:00:00<<==;
01==;I='00021/00021<<=;
02==;A='01121/01121<<=;
03=;ID='00001/00001<<=;
04==;X='14366/14366<<=;
05==;X='30370/30370<<=;
06==;Y='77151/77151<<=;
07==;Y='43125/43125<<=;
10==;Z='00702/00702<<=;
11==;Z='36743/36743<<=;
12=;VX='01703/01703<<=;
13=;VX='02632/02632<<=;
14=;VY='20416/20416<<=;
15=;VY='22301/22301<<=;
16=;VZ='65667/66567<<=;
17=;VZ='53563/53563<<=;
20==;T='00053/00053<<=;
21==;T='36200/36200<<==;
YY<<==;
60001054051600425350<<=;
61304000013503536070<<=;
00142341414636366430<<=;
00241002034725737730<<=;
00340041056766603010<<=;
00403020417405030510<<=;
00540041110567401200<<=;
00606306076270417200<<=;
00740147416476026750<<=;
01016341137363141370<<=;
01102203032644264530<<=;
01204260416346065750<<=;
01317002076745314400<<=;
01414344073433332310<<=;
01540047412037122110<<=;
01607002157067313350<<=;
01706102417745512510<<=;
02010046057213052060<<=;
02104160232662326710<<=;
02214246151017441220<<=;
02316243134510533040<<=;
02414160413045072370<<=;
02540243072627526650<<=;
02614120410103634500<<==;
60001054051600425350<<=;
61304000013503536070<<=;
00142341414636366430<<=;
00241002034725737730<<=;
00340041056766603010<<=;
00403020417405030510<<=;
00540041110567401200<<=;
00606306076270417200<<=;
00740147416476026750<<=;
01016341137363141370<<=;
01102203032644264530<<=;
01204260416346065750<<=;
01317002076745314400<<=;
01414344073433332310<<=;
01540047412037122110<<=;
01607002157067313350<<=;
01706102417745512510<<=;
02010046057213052060<<=;
02104160034142222110<<=;
02214246151017441220<<=;
02316243134510533040<<=;
02414160413045072370<<=;
02540243072627526650<<=;
02614120410103634500<<==;
HH<<==;
15/0800;Z=JUL=HMDC<<
==========;;;;;;;;;;;;;
```

```
HMS001A
SS GMIL
DE HMDC 002
15/0800Z

CMC CNU VB 71
LN 0001/0001

GETSV 999:00:00:00

01  I  00021/00021
02  A  01121/01121
03 ID  00001/00001
04  X  14366/14366
05  X  30370/30370
06  Y  77151/77151
07  Y  43125/43125
10  Z  00702/00702
11  Z  36743/36743
12 VX  01703/01703
13 VX  02632/02632
14 VY  20416/20416
15 VY  22301/22301
16 VZ  65667/66567
17 VZ  53563/53563
20  T  00053/00053
21  T  36200/36200

YY

60001054051600425350
61304000013503536070
00142341414636366430
00241002034725737730
00340041056766603010
00403020417405030510
00540041110567401200
00606306076270417200
00740147416476026750
01016341137363141370
01102203032644264530
01204260416346065750
01317002076745314400
01414344073433332310
01540047412037122110
01607002157067313350
01706102417745512510
02010046057213052060
02104160232662326710
02214246151017441220
02316243134510533040
02414160413045072370
02540243072627526650
02614120410103634500

60001054051600425350
61304000013503536070
00142341414636366430
00241002034725737730
00340041056766603010
00403020417405030510
00540041110567401200
00606306076270417200
00740147416476026750
01016341137363141370
01102203032644264530
01204260416346065750
01317002076745314400
01414344073433332310
01540047412037122110
01607002157067313350
01706102417745512510
02010046057213052060
02104160034142222110
02214246151017441220
02316243134510533040
02414160413045072370
02540243072627526650
02614120410103634500

HH

15/0800Z JUL HMDC
```

FROM REF. 8

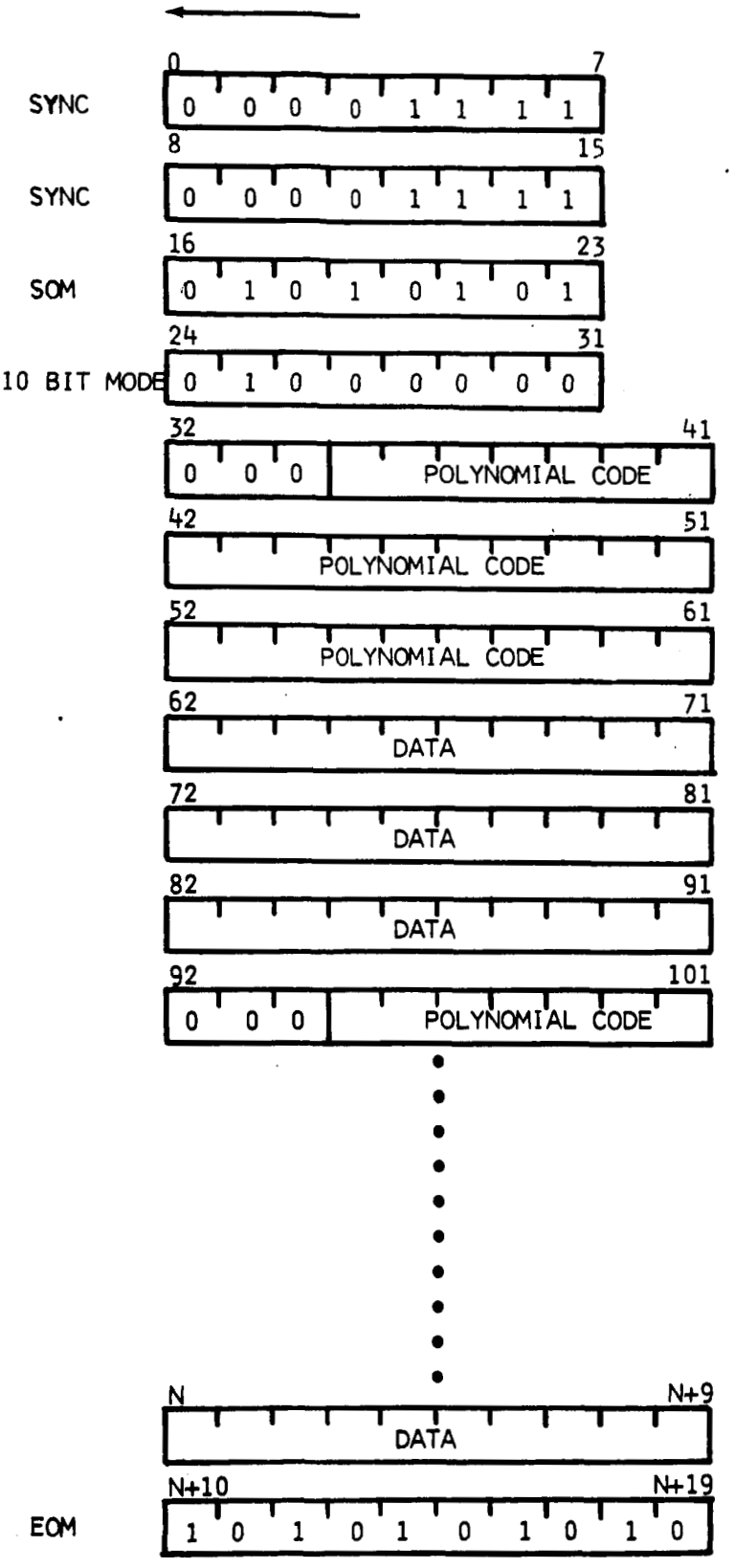
FIGURE G
CCATS TO REMOTE SITE-TTY



FROM REF. 7

FIGURE H

Figure 2.2-5 Flow Diagram; Teletype Transmission, MCC to Remoted Sites



FROM REF. 8

FIGURE I

GSFC/RS Command Data Transfer (Example For Multiple Subblock Messages)

RS RETURN SUB-BLOCK MESSAGE FORMATS SITE VALIDATION FOR MULTIPLE SUB-BLOCKS

1	2	3	4	5 — 11	12 — 17	18	19	20 — 24	25	26	27 — 40
0	0	0	0	TYPE NUMBER. FIRST TWO DIGITS OF THE LOAD NO. 00-19 CSM 20-39 LM 40-59 S-IVB 60 GMTLO 61-63 SPARE	MESSAGE NUMBER. SECOND TWO DIGITS OF THE LOAD NO. RANGE IS FROM 000001 TO 111111	0=T I=P	0=VAL 1=NVAL	SITE ID	SP 0	MIS ID 0 = 200 Series 1 = 500 Series	ERROR PROTECTION

FROM REF. 8

FIGURE J

8 bit/word
300words/frame
1 frame/second
10 seconds/data cycle

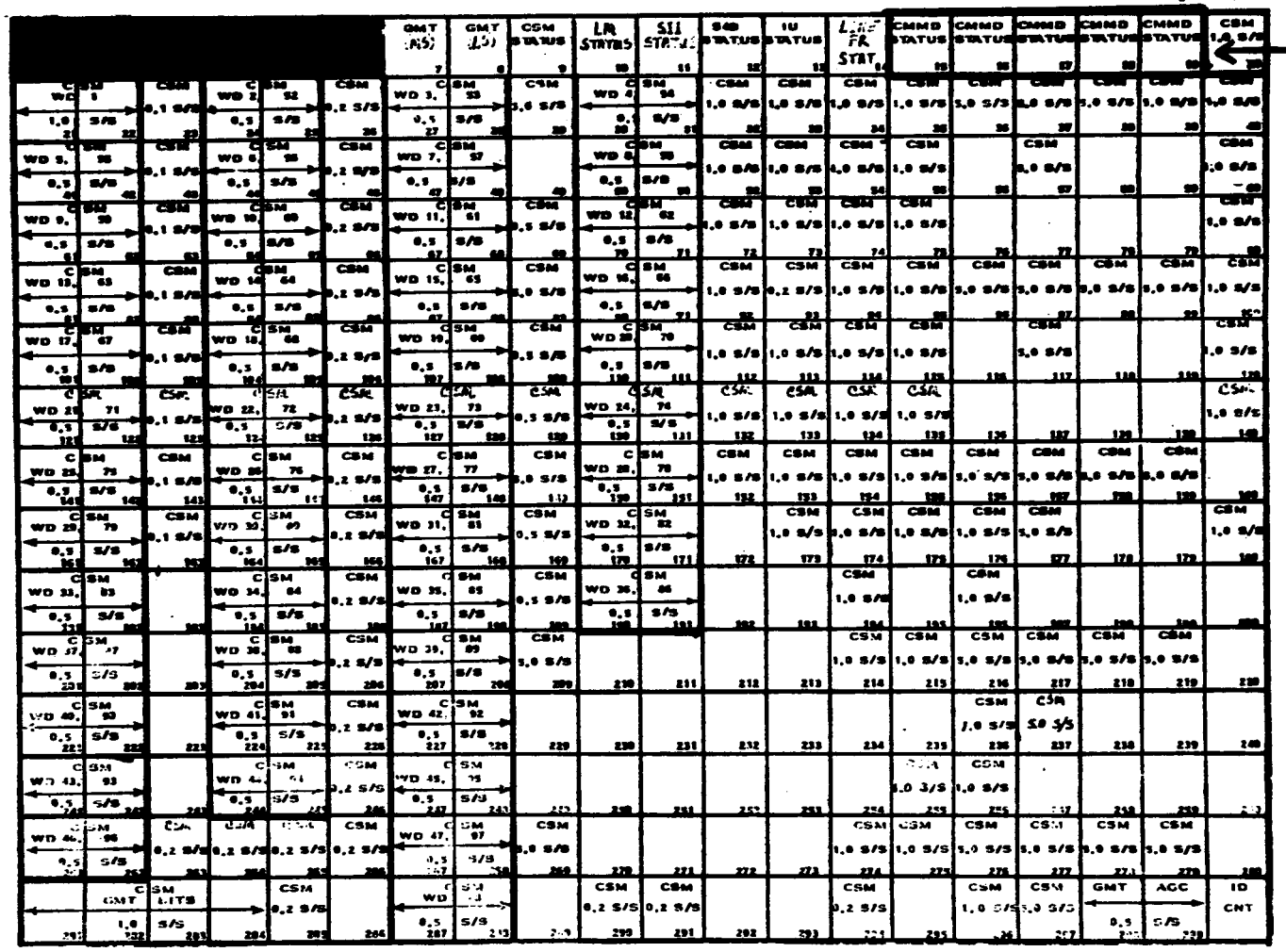
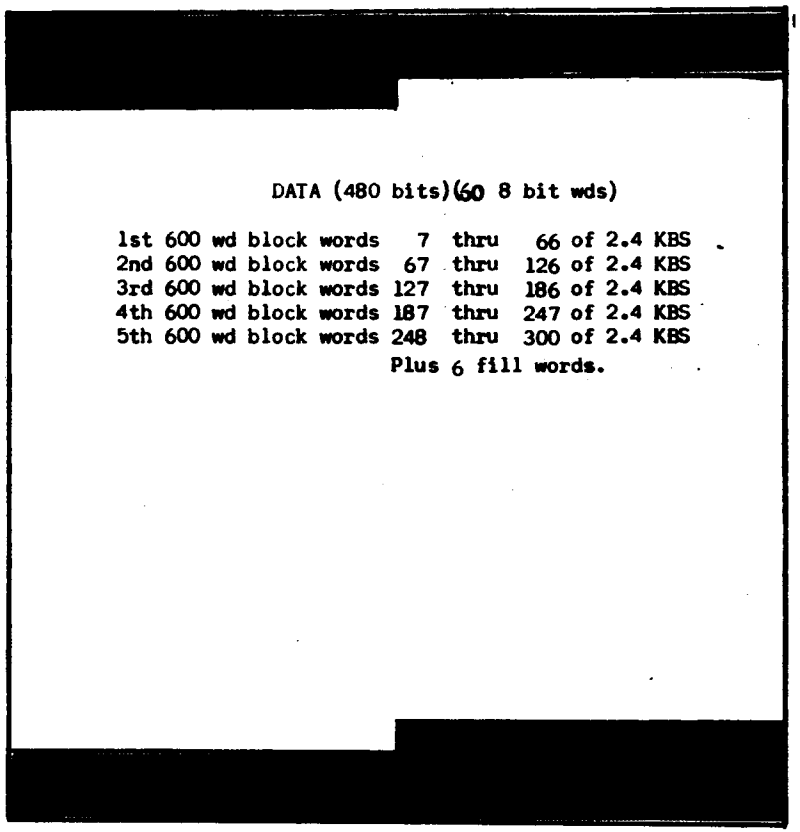


FIGURE K
REMOTE SITE TO MCC - TELEMETRY FRAME
(TYPICAL)

FROM REF. 6

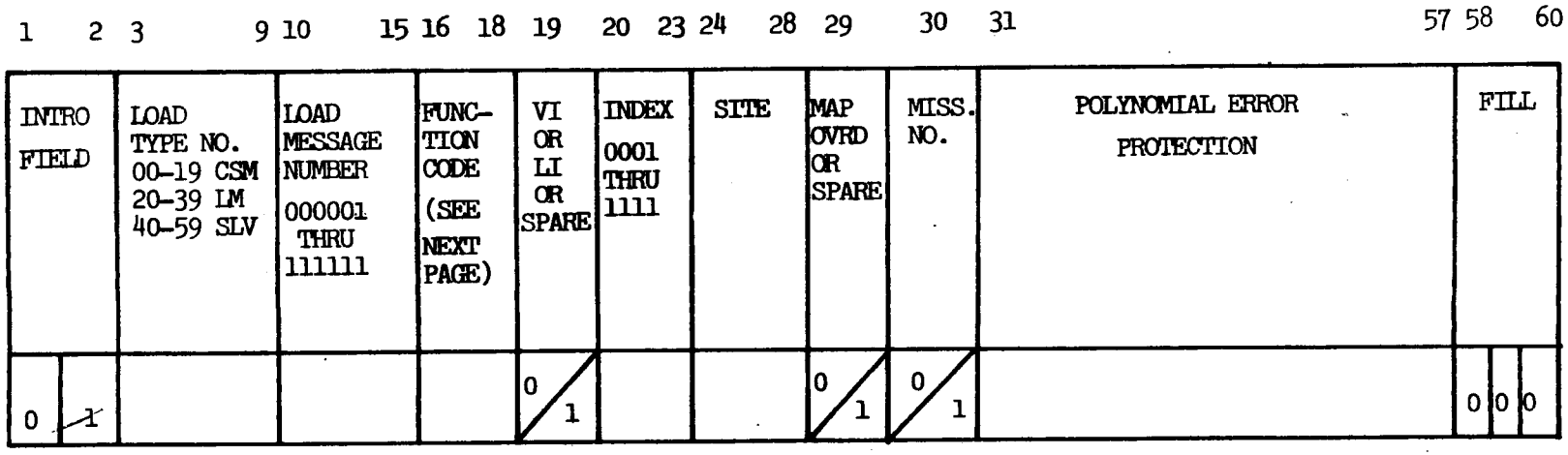
WBD FORMAT
GSFC — MCCH



600 BIT BLOCK

FIGURE L FROM REF. 6

GSFC TO CCATS - TELEMETRY DATA



FROM REF. 8

FIGURE M

CCATS TO REMOTE SITE - EXECUTE REQUEST

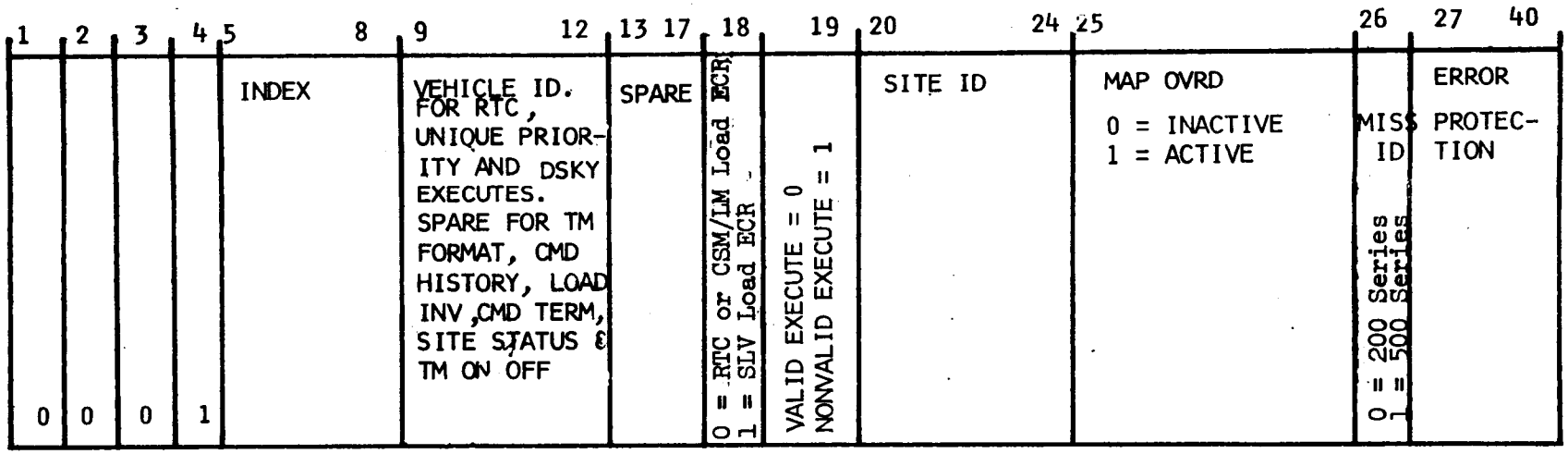
EXECUTE TYPE		LOAD TYPE (BITS 3-9)	MESSAGE NO. (BITS 10-15)	FUNCTION CODE (BITS 16-18)	(BIT 19)	MAP OVRD (BIT 29)	MISSION ID (BIT 30)
LOAD	UHF	00 - 59	01 - 63	0-0-0 = UHF	0 = VI 1 = LI	0 = Inactive 1 = Active	0 = 200 Series Mission 1 = 500 Series Mission
	USB	00 - 59	01 - 63	0-0-1 = USB	0 = VI 1 = LI	0 = Inactive 1 = Active	
LOAD CLEAR		00 - 59	01 - 63	0-1-0	SPARE	SPARE	
COMPARE		00 - 39	01 - 63	0-1-1	SPARE	SPARE	
LINE-BY-LINE	UHF	00 - 39	01 - 63	1-0-0 = UHF	SPARE	0 = Inactive 1 = Active	
	USB	00 - 39	01 - 63	1-0-1 = USB	SPARE	0 = Inactive 1 = Active	

FROM REF. 8

FIGURE M (CONTINUED)

CCATS TO REMOTE SITE - EXECUTE REQUEST

RS RETURN SUB-BLOCK MESSAGE FORMAT SITE VALIDATION FOR SINGLE SUB-BLOCKS



FROM REFERENCE 8

FIGURE N

CAP VAL

EXAMPLE FOR CMC NAVIGATION UPDATE

SEQ. NO.			KEYCODES
(2)	V 7 1	VERB	3
(3)	E	PREAMBLE	1
	I I E	INDEX	3
	A A A A E	ADDRESS	5
	X X X X X E	IDENTIFIER	6
(4)	X X X X X E . . . X X X X X E	X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$, T (14 LINES)	84
(5)	V	FINAL ENTER	1
(6)	3		1
(7)	3		1
(8)	E		1
			106

EACH ENTRY ABOVE IS A "KEYCODE" CHARACTER, FORMATTED AS FOLLOWS:

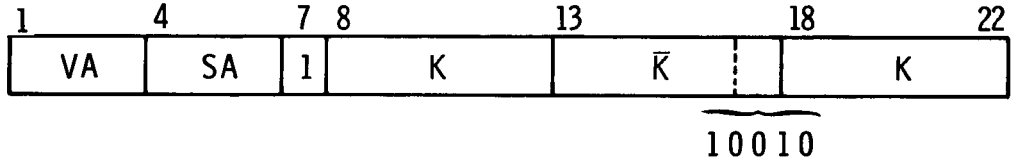
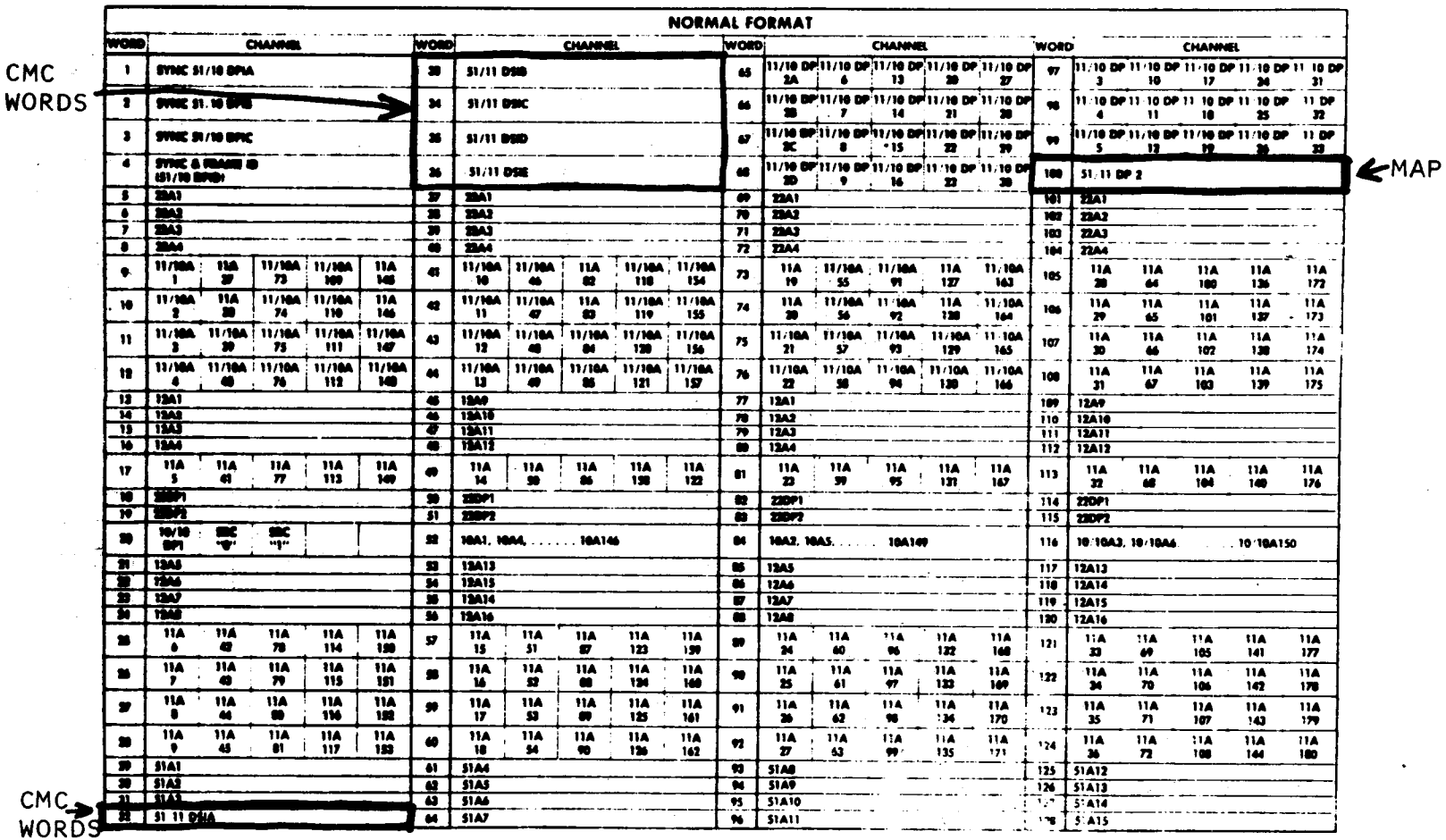


FIGURE O - LOAD UPLINK FORMAT

CSM BLOCK II HI BIT RATE PCM FORMAT



CAPABLE OF THE FOLLOWING SIGNALS-

a. ANALOGS 0-5VDC:
- 4 AT 200 S/S
- 16 AT 100 S/S
- 15 AT 50 S/S
- 180 AT 10 S/S
- 150 AT 1 S/S

b. PARALLEL DIGITAL:
- 1 - 16 BIT CHANNEL AT 200 S/S
- 1 - 8 BIT CHANNEL AT 50 S/S
- 1 - 32 BIT CHANNEL AT 10 S/S
- 1 - 24 BIT CHANNEL AT 10 S/S
- 31 - 8 BIT CHANNEL AT 10 S/S

c. DIGITAL SERIES-
- 1 - 40 BIT CHANNEL AT 50 S/S

FROM REF. 11

FIGURE P

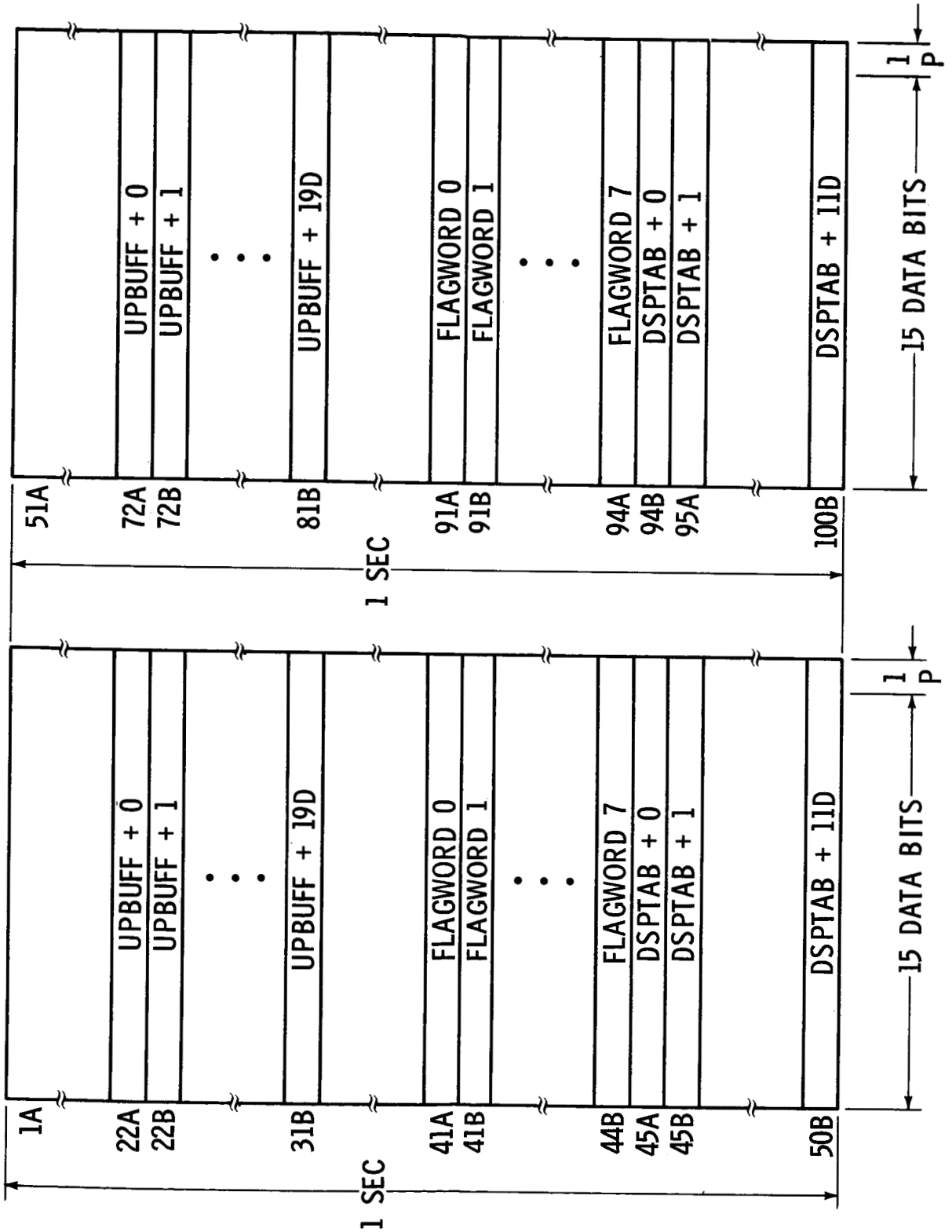
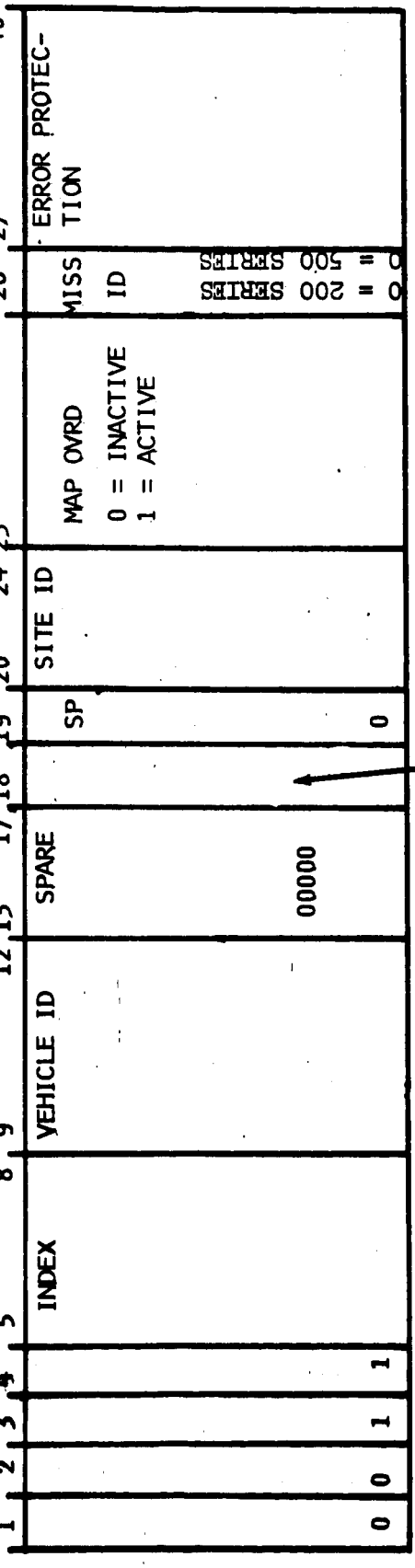


FIGURE Q - CMC/LGC ENTRY AND UPDATE LIST

RS RETURN SUB-BLOCK MESSAGE FORMAT SPACECRAFT VERIFICATION FOR EXECUTES



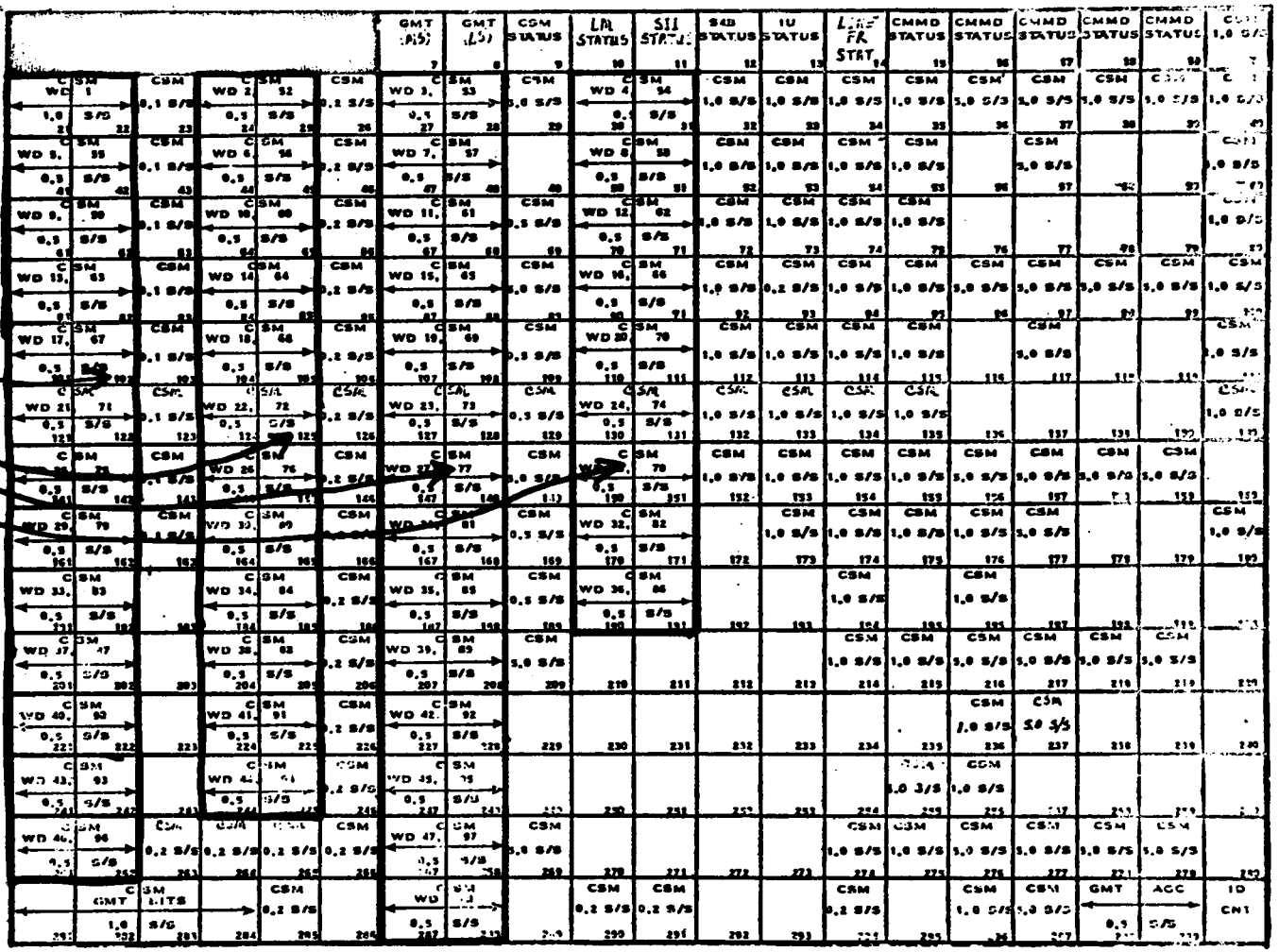
FROM REF. 8

FIGURE R

CAP COMPARE

8 bit/word
300words/frame
1 frame/second
10 seconds/data cycle

CMC WORDS



FROM REF. 11

FIGURE S

REMOTE SITE TO MCC - TELEMETRY FRAME (TYPICAL)

Appendix C

Functional Schematics

The functional schematics shown in this appendix are keyed by figure letters to the lower case letters used in the flow charts in Appendix A.

The individual figures are as follows:

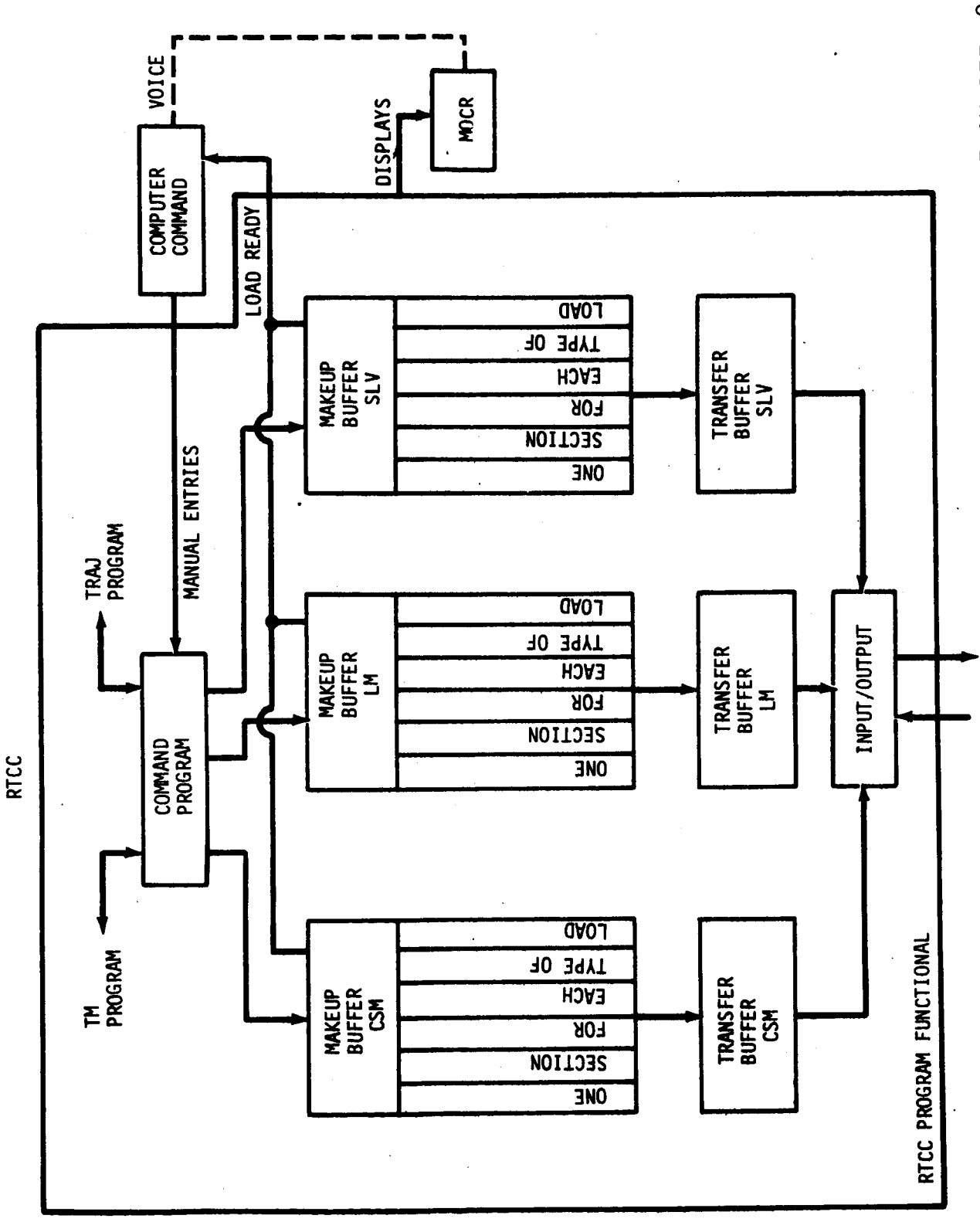

FROM REF. 9
VOICE
DISPLAYS
MOCR
COMPUTER COMMAND
LOAD READY
MANUAL ENTRIES
MAKEUP BUFFER SLV
LOAD
TYPE OF
EACH
FOR
SECTION
ONE
TRANSFER BUFFER SLV
TRAJ PROGRAM
MAKEUP BUFFER LM
TRANSFER BUFFER LM
INPUT/OUTPUT
CCATS
COMMAND PROGRAM
TM PROGRAM
MAKEUP BUFFER CSM
TRANSFER BUFFER CSM
RTCC
RTCC PROGRAM FUNCTIONAL

FIGURE a

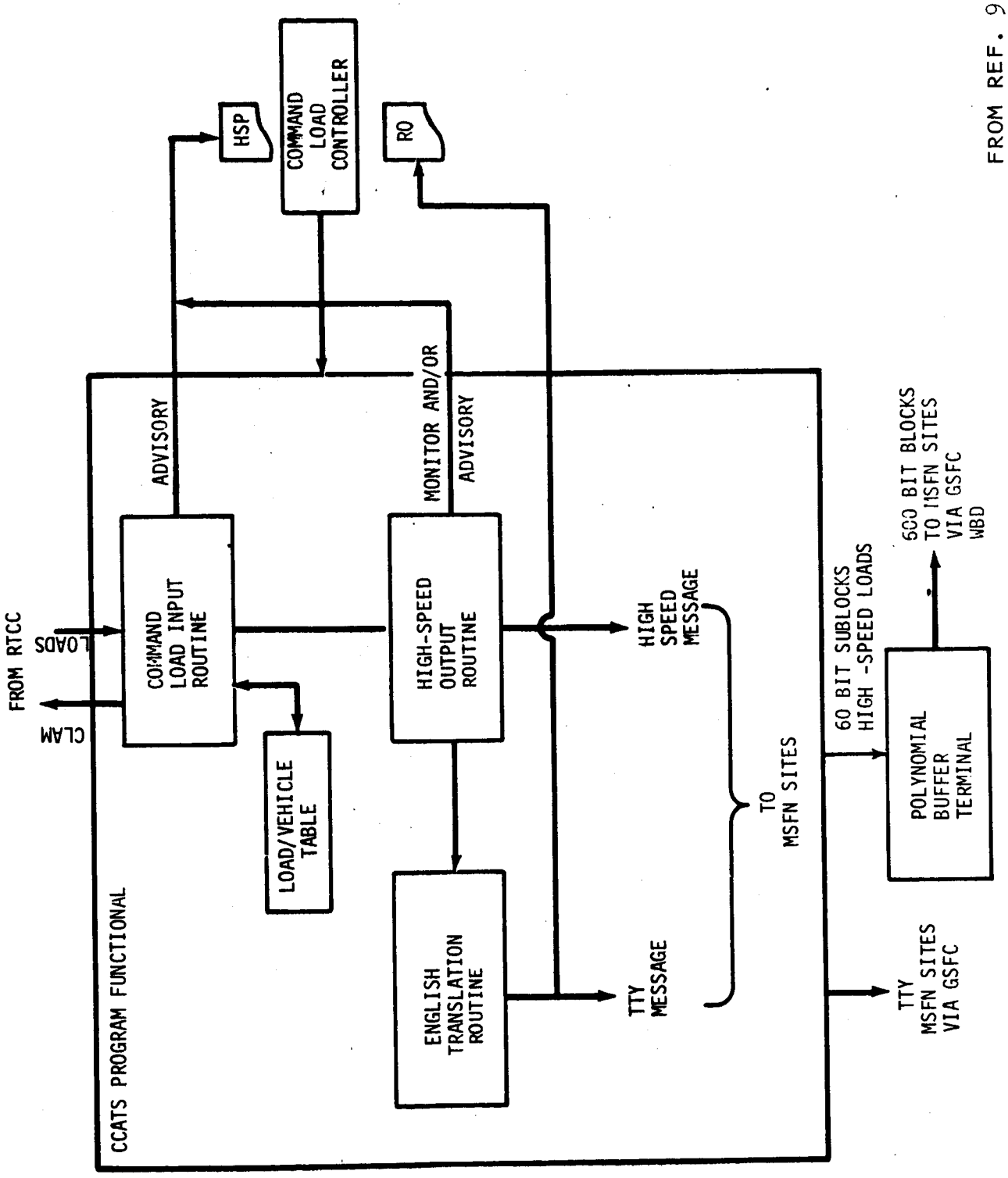

FROM REF. 9
COMMAND LOAD CONTROLLER
HSP
RO
ADVISORY
MONITOR AND/OR
ADVISORY
FROM RTCC
LOADS
CLAM
COMMAND LOAD INPUT ROUTINE
HIGH-SPEED OUTPUT ROUTINE
HIGH SPEED MESSAGE
600 BIT BLOCKS TO MSFN SITES VIA GSFC WBD
60 BIT SUBLOCKS HIGH -SPEED LOADS
LOAD/VEHICLE TABLE
TO MSFN SITES
POLYNOMIAL BUFFER TERMINAL
ENGLISH TRANSLATION ROUTINE
TTY MESSAGE
TTY MSFN SITES VIA GSFC
CCATS PROGRAM FUNCTIONAL

FIGURE b

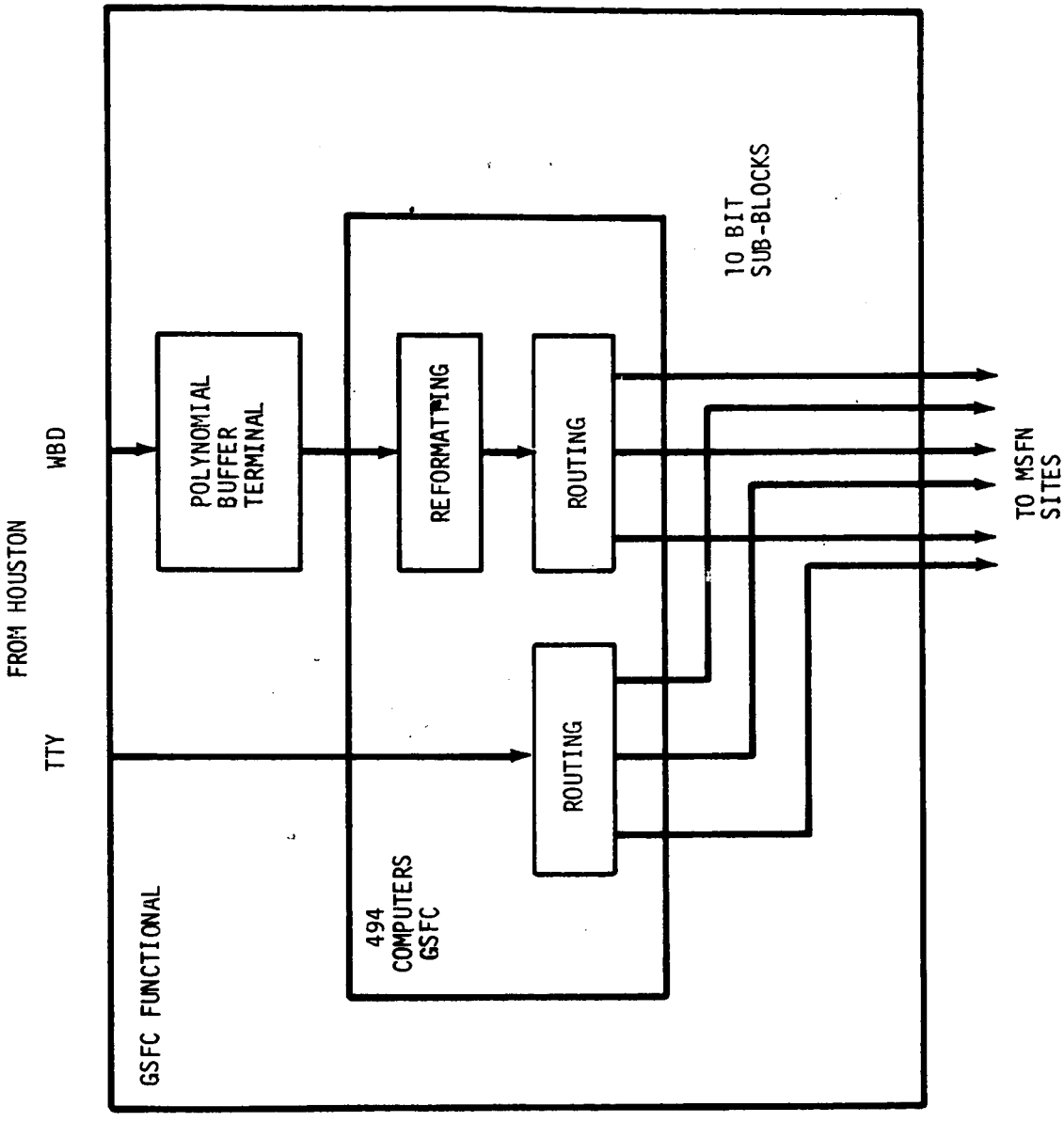
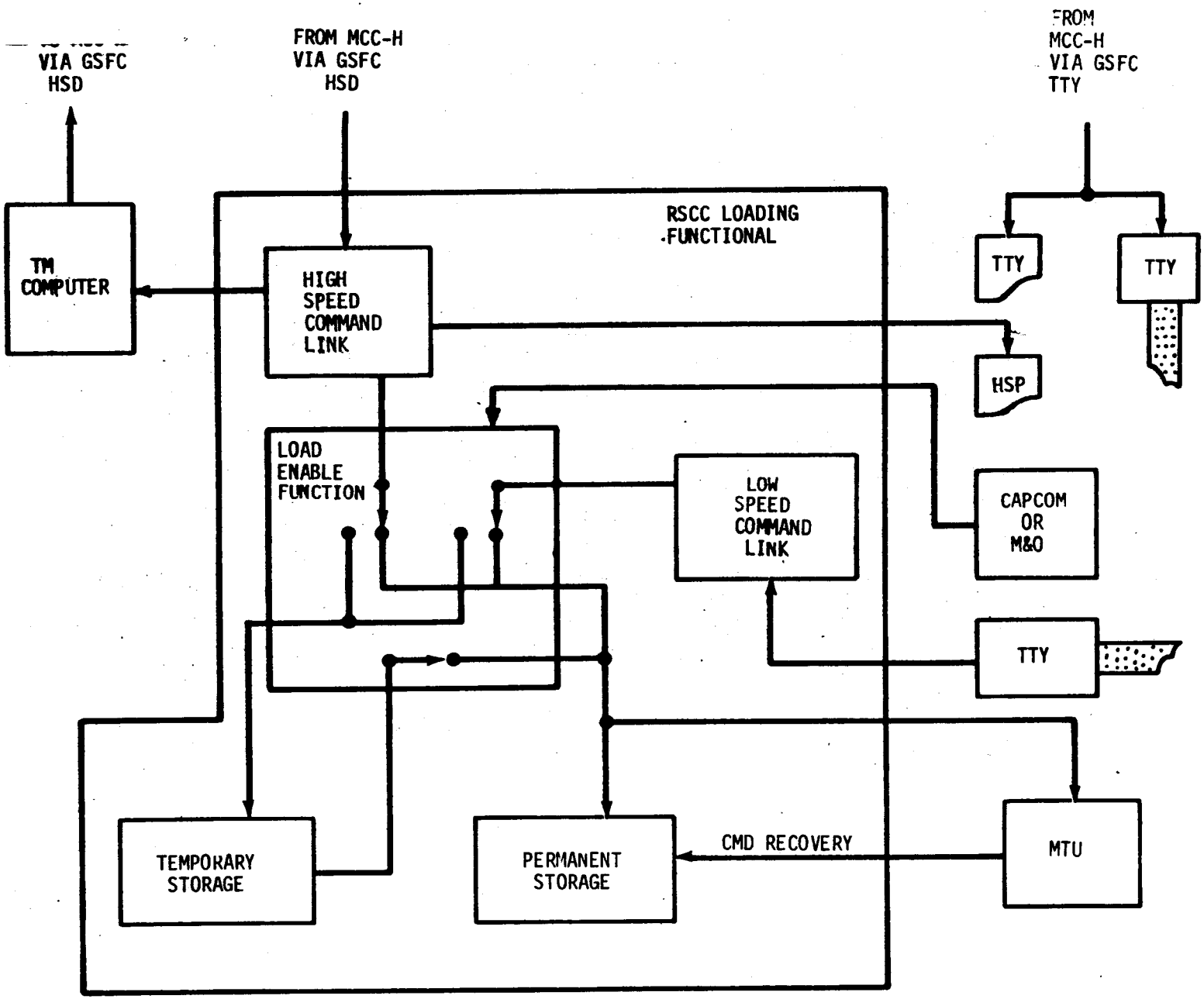

FROM HOUSTON
WBD
TTY
GSFC FUNCTIONAL
POLYNOMIAL BUFFER TERMINAL
REFORMATTING
ROUTING
ROUTING
494 COMPUTERS GSFC
10 BIT SUB-BLOCKS
TO MSFN SITES
GSFC
FROM REF. 9

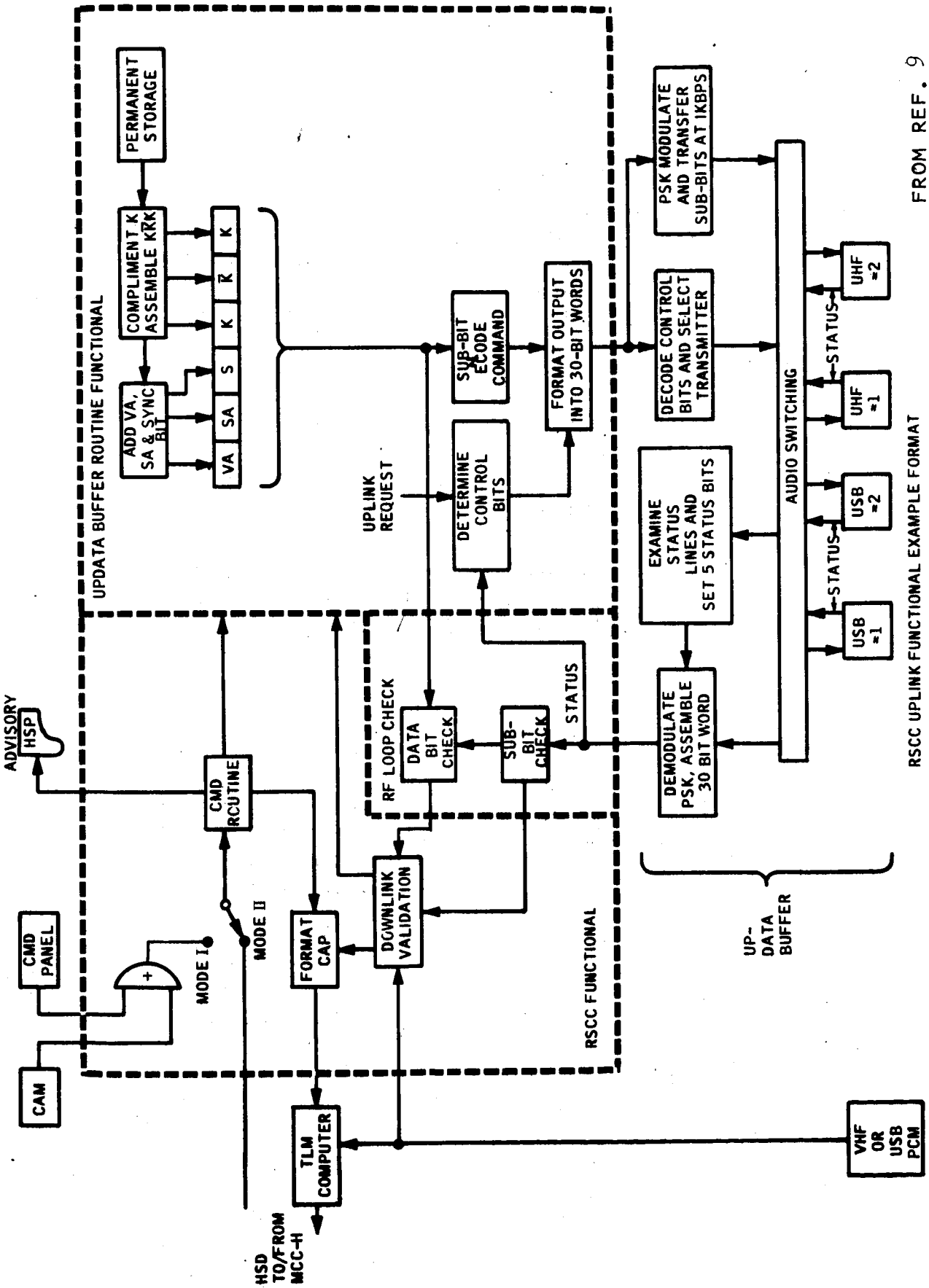
FIGURE c



FROM REF. 9

LOADING RSCC

FIGURE d



RSCC UPLINK FUNCTIONAL EXAMPLE FORMAT

FIGURE e

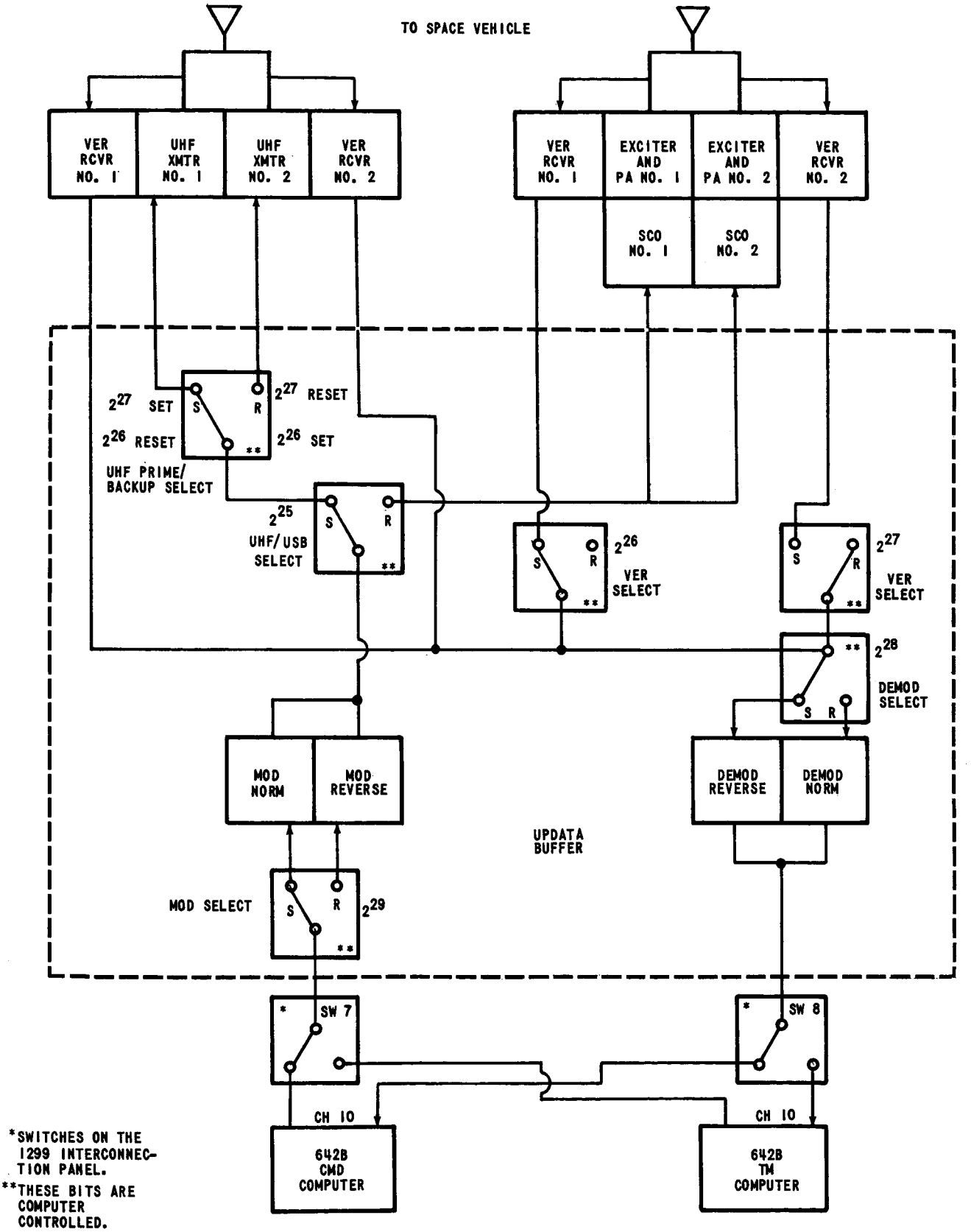


FIGURE f - UPDATA BUFFER SWITCHES UNDER PROGRAM CONTROL

Appendix D

RTC'S

This appendix lists the real-time commands available for the CSM, LM, and SLV. The LM RTC's are applicable only for LM-3, and all are associated with arming of the ascent engine. There is no present RTC capability for LM-4 and subsequent. The RTC's for the SLV are uplinked in the same 35-bit command word format as are LVDC computer updates.

TABLE D-1

CSM Block II UDL Real Time Commands (Internal Relays)

Real Time Command No.		Function
00		Abort Light (System A) Off
01		Abort Light (System A) On
02,16	Implemented Only on S/C 101 & 102	Astronaut Control (C-Band Transponder)
02,17		C-Band Power On (1-Pulse Mode)
03,12		C-Band Power Off
03,13		C-Band Power On (Double Pulse Mode)
04		Crew Alarm Off
05		Crew Alarm On
06		Abort Light (System B) Off
07		Abort Light (System B) On
10		Spare
11		Spare
14		Spare
15		Spare
20		Spare
21		Spare
22,26		Astronaut Control (S-Band Ranging)
22,27		S-Band Ranging On
23		S-Band Ranging Off
24		Spare (Not available activate UDL)
25		Spare (Not available activate UDL)
30		Spare (Not available activate UDL)
31		Spare (Not available activate UDL)
32,36		Astronaut Control (S-Bnad PCM Mode)
32,37		S-Band PCM Mode On
33,37		S-Band PCM Mode Off
34		Spare (Not available activate UDL)
35		Spare (Not available activate UDL)
40,50		Astronaut Control (S-Band Antenna)
40,51		S-Band Back-up Down Voice
41,44		S-Band Tape Off
41,45		S-Band Tape Mode
42,46		Astronaut Control (S-Band P.A. Mode)
42,47		S-Band P.A. High On
43,46		S-Band By-pass Mode
43,47		S-Band P.A. Low On
52,56		Astronaut Control (Tape Playback Mode)
52,57		Tape Playback PCM/Analog Mode
53		Tape Playback LM/PCM Mode
54		Spare
55		Spare

FROM REF. 8

TABLE D-1 (CONTINUED)

CSM Block II UDL Real Time Commands (Internal Relays)

Real Time Command No.	Function
60	Spare
61	Spare
62,66	Astronaut Control (Tape Recorder Playback/Record Selection)
62,67	Tape Recorder - Record Mode
63,66	Tape Recorder - Off Mode
63,67	Tape Recorder - Playback Mode
64,70	Astronaut Control (PCM Data Rate)
64.71	PCM Data Rate High
65	PCM Data Rate Low
72,76	Astronaut Control (Tape Transport)
72,77	Tape Recorder, Transport Forward
73,76	Tape Recorder - Power On
73,77	Tape Recorder - Transport Rewind
74	Astronaut Control (S-Band Antenna)
75	D-Omni Antenna On (Located Opposite High Gain Antenna)

Note: Complete astronaut control of the spacecraft control panel switches may be obtained by the astronaut's use of the "crew over-ride" switch located on the control panel. This action resets all UDL relays associated with the spacecraft control panel switching functions, namely, relay banks B, C, and D.

FROM REF. 8

TABLE D-2

LM-3 REAL-TIME COMMANDS

CODE (OCTAL)	COMMAND NAME
00A	Ascent Engine Pre-Arm - I
06A	Ascent Engine Pre-Arm - II
04A	Ascent Engine Arm - I
02A	Ascent Engine Arm - II
01A	Ascent Pre-Arm - I Reset
03A	Ascent Engine Arm - II Reset
05A	Ascent Engine Arm - I Reset
07A	Ascent Engine Pre-Arm - II Reset

FROM REF. 8

SLV Real Time Commands

DESCRIPTION	WORD NO.	OCTAL	BITS 10, 12-7,13,14,19-22	MODE CODE	OCTAL LOAD WORD
Terminate	1/1	753 553 027 756	11-0 100 000	040	240
Spare	1/6	753 513 037 756	11-0 000 000	000	200
	2/6	753 013 077 656	00-0 000 001	001	001
	3/6	753 013 037 756	00-0 000 000	000	000
	4/6	753 513 037 756	11-0 000 000	000	200
	5/6	753 013 077 656	00-0 000 001	001	001
	6/6	753 013 037 756	00-0 000 000	000	000
Alt. Seq. 1	1/1	757 513 516 556	11-1 001 010	112	312
Alt. Seq. 2	1/1	753 553 426 756	11-0 101 000	050	250
Alt. Seq. 3	1/1	753 553 526 556	11-0 101 010	052	252
Alt. Seq. 4	1/1	753 553 626 356	11-0 101 100	054	254
Alt. Seq. 5	1/1	753 553 726 156	11-0 101 110	056	256
Alt. Seq. 6	1/1	753 573 025 756	11-0 110 000	060	260
SS LH_2 Vent CLSD	1/6	753 533 235 356	11-0 010 100	024	224
	2/6	753 053 267 256	00-0 100 101	045	045
	3/6	753 033 434 756	00-0 011 000	030	030
	4/6	753 533 235 356	11-0 010 100	024	224
	5/6	753 053 367 056	00-0 100 111	047	047
	6/6	753 033 434 756	00-0 011 000	030	030
SS LH_2 BST CLSD OFF	1/3	753 533 235 356	11-0 010 100	024	224
	2/3	753 053 367 056	00-0 100 111	047	047
	3/3	757 033 414 756	00-1 011 000	130	130
SS LOX Vent CLSD	1/6	753 533 235 356	11-0 010 100	024	224
	2/6	753 053 067 656	00-0 100 001	041	041
	3/6	753 053 636 356	00-0 101 100	054	054
	4/6	753 533 235 356	11-0 010 100	024	224
	5/6	753 053 167 456	00-0 100 011	043	043
	6/6	757 053 606 356	00-1̄ 101 100	154	154
Execute Man A	1/1	753 563 325 156	11-0 110 110	066	266

FROM REF. 8

SLV Real Time Commands (Cont'd)

DESCRIPTION	WORD NO.	OCTAL	BITS 10,12-7,13,14,19-22	MODE CODE	OCTAL LOAD WORD
Execute Man B	1/1	753 573 424 756	11-0 111 000	070	270
Execute Man C	1/1	753 573 524 556	11-0 111 010	072	272
Resume Time Seq.	1/1	753 573 624 356	11-0 111 100	074	274
Seq. 1 Inhib.	1/1	753 513 137 556	11-0 000 010	002	202
Seq. 2 Inhib.	1/1	753 513 237 356	11-0 000 100	004	204
Seq. 3 Inhib.	1/1	753 513 337 156	11-0 000 110	006	206
Seq. 4 Inhib.	1/1	753 513 436 756	11-0 001 000	010	210
Seq. 5 Inhib.	1/1	753 513 536 556	11-0 001 010	012	212
Seq. 6 Inhib.	1/1	753 573 724 156	11-0 111 110	076	276
Seq. 7 Inhib.	1/1	757 513 017 756	11-1 000 000	100	300
Seq. 8 Inhib.	1/1	757 513 117 556	11-1 000 010	102	302
SS LOX Vent BST CLSD OFF	1/3	753 533 135 356	11-0 010 100	024	224
	2/3	753 053 067 656	00-0 100 001	041	041
	3/3	757 053 606 356	00-1 101 100	154	154
SS LH_2 Vent Open	1/3	753 533 235 356	11-0 010 100	024	224
	2/3	753 053 167 456	00-0 100 011	043	043
	3/3	757 013 217 356	00-1 000 100	104	104
SS LOX Vent Open	1/3	753 533 235 356	11-0 010 100	024	224
	2/3	753 053 167 456	00-0 100 011	043	043
	3/3	753 033 235 356	00-0 010 100	024	024
Set Roll Flag	1/1	757 513 616 356	11-1 001 100	114	314
Seq. Time Sel. Gp.A	1/1	757 513 716 156	11-1 001 110	116	316
Seq. Time Sel. Gp.B	1/1	753 523 015 756	11-1 010 000	120	320
Seq. Time Sel. Gp.C	1/1	753 533 115 556	11-1 010 010	122	322
Set Antennas Omni	1/	To be Defined			
Set Antennas L-Gain	1/	To be Defined			
Set Antennas H-Gain	1/	To be Defined			
	/				
	/				

FROM REF. 8

Appendix E

Command Updates

The different types of command updates for each vehicle are shown in Tables E-1, E-2, and E-3. Command updates to the CMC/LGC can contain a maximum of 20 spacecraft computer words each (15 bits each, or 5 keycodes plus an "enter" for each). They will be preceded by a "verb preamble", as follows:

V70 Liftoff Time Increment - Used to increment (decrement) the CMC or LGC clock, CSM or LM state vector time, or ephemeris time (TEPHEM) with a double precision octal time value in centiseconds. (This is not a CTE update).

V71 Contiguous Block Update - Used to update the contents of up to 18 consecutive words of erasable memory. The address of the first word must be supplied.

V72 Scatter Update - Used to update the contents of up to 9 non-consecutive words of erasable memory. An address must be supplied for each word of data.

V73 Octal Clock Increment - Similar to V70, except in CMC/LGC usage of data after verification.

After verification of the Vxx, an "enter" is uplinked, followed by the actual data, and the final enter (V33E) as explained in the text.

Command updates to the S-IVB/IU can contain a maximum of 10 LVDC words (26 bits per word). A maximum of 51 command words (35 bits each) are uplinked. There is no verb preamble or final enter associated with an LVDC update. RTC's are uplinked to the S-IVB/IU via Switch Selector Updates, which also enter the LVDC.

Table E-1

CSM COMMAND LOADS

Load No.	Load Type*	Description
00xx	V71	CMC CSM Navigation Update (CNU)
07xx	V73	CMC Time Increment Update (TIU)
08xx	V70	CMC Liftoff Time Update (LTU)
09xx	V71	CMC LM Navigation Update (LNU)
10xx	V71	CMC External ΔV Update
12xx	V71	CMC Reference Stable Member Matrix (REFSMMAT) Update
13xx	V71	CMC Retrofire External ΔV Entry
14xx		CMC Reentry Update
15xx		CMC Lambert Return
16xx		CMC Lambert Target
18xx	V71	CMC Erasable Memory Update (EMU A)
18xx	V72	CMC Erasable Memory Update (EMU A)
19xx	V71	CMC Erasable Memory Update (EMU B)
19xx	V72	CMC Erasable Memory Update (EMU B)

*See page E-1

Table E-2

LM COMMAND LOADS

Load No.	Load Type*		Description
20xx	V71	LGC	LM Navigation Update (LNU)
21xx	V71	LGC	CSM Navigation Update (CNU)
22xx	V71	LGC	External ΔV Update
23xx		LGC	Reference Stable Member Matrix (REFSMMAT) Update
24xx		LGC	Time Increment Update (TIU)
25xx	V70	LGC	Liftoff Time Update
27xx		LGC	Lambert Target
28xx		LGC	Ascent
29xx		LGC	Lambert Return
38xx	V71	LGC	Erasable Memory Update (EMU A)
38xx	V72	LGC	Erasable Memory Update (EMU A)
39xx	V71	LGC	Erasable Memory Update (EMU B)
39xx	V72	LGC	Erasable Memory Update (EMU B)

*See page E-1.

Table E-3

SLV COMMAND LOADS

Load No.	Description
40xx	SLV Time Base Update (TBU)
41xx	SLV Sequence Initiate Update (SIU) No. 1
42xx	SLV Sequence Initiate Update (SIU) No. 2
43xx	SLV Sequence Initiate Update (SIU) No. 3
44xx	SLV Sequence Initiate Update (SIU) No. 4
45xx	SLV Switch Selector Update (SSU) No. 1
46xx	SLV Switch Selector Update (SSU) No. 2
47xx	SLV Switch Selector Update (SSU) No. 3
48xx	SLV Switch Selector Update (SSU) No. 4
49xx	SLV Navigation Update (SNU)
50xx	SLV Sequence Initiate Update (SIU) No. 5
51xx	SLV Sequence Initiate Update (SIU) No. 6
52xx	SLV Sequence Initiate Update (SIU) No. 7
53xx	SLV Sequence Initiate Update (SIU) No. 8
55xx	SLV Prelaunch Targeting Primary Update (TGT)
56xx	SLV Prelaunch Targeting Backup Update (TGT)
57xx	Orbit Target Update
58xx	SLV General Update A
59xx	SLV General Update B

Appendix F

CTE Update

The Central Timing Equipment (CTE) update is used to update the CSM clock. It uses a 30 bit (150 subbit) uplink format shown in Figure F-1. It is calculated on-site following a CTE uplink request from MCC. Correction for propagation delay is provided via the I/O console associated with the RSCC/RSTC. The following two pages describe the CTE update and show the associated format.

CTE Update

Description

UPON RECEIPT OF A VALID CTE SYSTEM ADDRESS, THE UDL GENERATES FROM 20 TO 25 PULSES HAVING 50 MICROSECOND PULSE WIDTHS, AT A RATE OF 200 PULSES PER SECOND FOR THE PURPOSE OF RESETTING THE CTE TIME ACCUMULATOR TO 0 DAYS, 0 HOURS, 0 MINUTES AND 0 SECONDS.

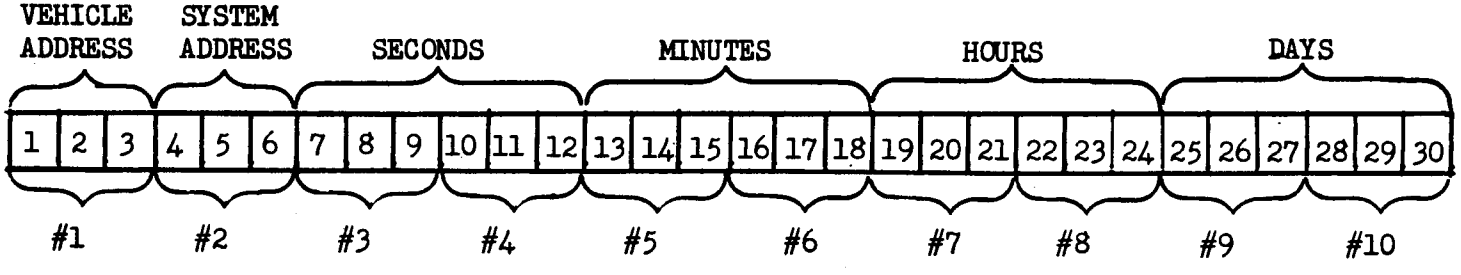
AT THE END OF THE CTE WORD, PULSES (IF REQUIRED) ARE GENERATED IN THE FOLLOWING SEQUENCE: (A) SECONDS LINE, FIRST (B) MINUTES LINE NEXT (C) HOURS LINE, NEXT AND (D) DAYS LINE, LAST. THE PULSES OCCUR AT 10 KILOPULSE PER SECOND RATE.

THE NUMBER OF PULSES GENERATED IN EACH CASE (EXCEPT FOR THE RESET PULSES) IS THE DECIMAL EQUIVALENT) A SIX-BIT BINARY NUMBER. FOR EXAMPLE, 47 PULSES ON THE SECONDS LINE WOULD BE CODED AS FOLLOWS:

BIT NO.	7	8	9	10	11	12	
BIT WEIGHT	2^0	2^1	2^2	2^3	2^4	2^5	= 47 PULSES (SECONDS)
BIT VALUE	1	1	1	1	0	1	

From Ref. 8

DESCRIPTION



FROM REFERENCE 8

NOTE: MAXIMUM ENTRY IS 13 DAYS, 23 HOURS, 59 MINUTES AND 59 SECONDS

BIT 7 IS LSB FOR SECONDS
BIT 13 IS LSB FOR MINUTES
BIT 19 IS LSB FOR HOURS
BIT 25 IS LSB FOR DAYS

FIGURE F-1 Central Timing Equipment (CTE) Word Format

Appendix G

Test Commands

This appendix lists the CSM and LM test words, and shows their uplink formats. CSM test words are 30-bits (150 subbits) long, LM test words are 22-bits (110 subbits) long. They are stored on site pre-mission, and uplinked upon receipt of an ECR from MCC.

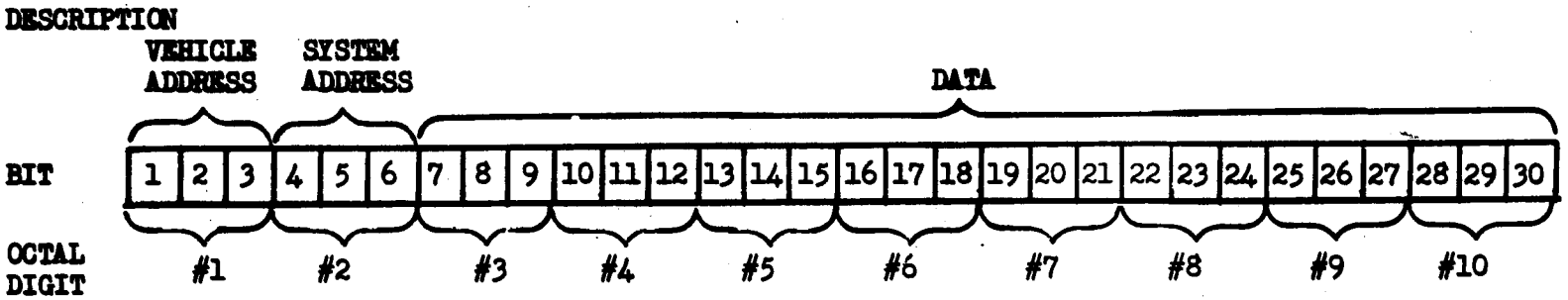
CSM Test Words

Description

UDL Test A
UDL Test B

TEST MESSAGES A AND B PROVIDE A MEANS OF EXERCISING ALL PROCESS, TRANSFER AND PROGRAM CONTROL LOGIC WITHIN THE UDL. THE RESULTS OF THESE TESTS ARE TELEMETERED BY USING UNIQUE VALIDITY SIGNALS FOR THESE TEST MESSAGES.

FROM REF. 8



SPACECRAFT FORMAT NO. 3

NOTE: BIT 1 IS TRANSMITTED FIRST

BITS 7-30 ARE UNIQUE FOR TEST WORD A AND TEST WORD B

FROM REF. 8

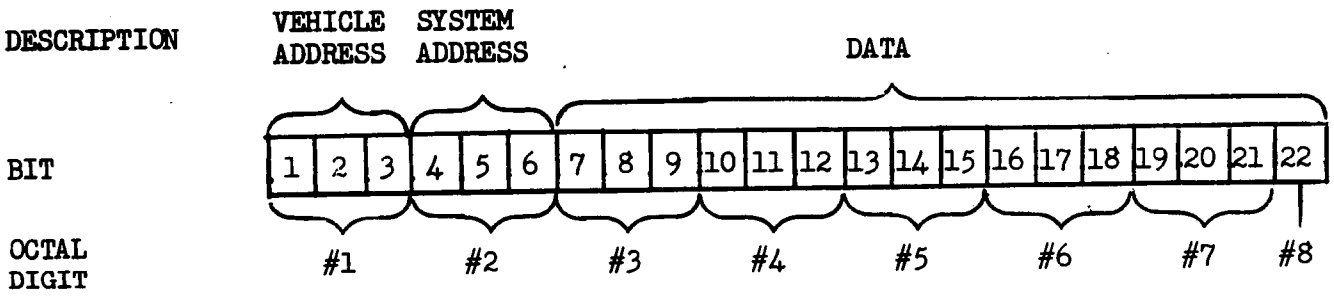
FIGURE G-1

CSM Test Words A and B Word Format

LM DCA Test Words

Description
DCA SELF TEST
DCA ENABLE
DECODER A INHIBIT
DECODER B INHIBIT

FROM REF. 8



NOTE: BIT 1 IS MSB

SPACECRAFT FORMAT NO. 7

FROM REF. 8

FIGURE G-2

LM DCA Test Words 1, 2, And 3