



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# *SUBCOURSE OUTLINE AND HANDOUT*

## *FLIGHT CONTROL ORIENTATION AND INDOCTRINATION*

### *APOLLO COMMAND NETWORK*

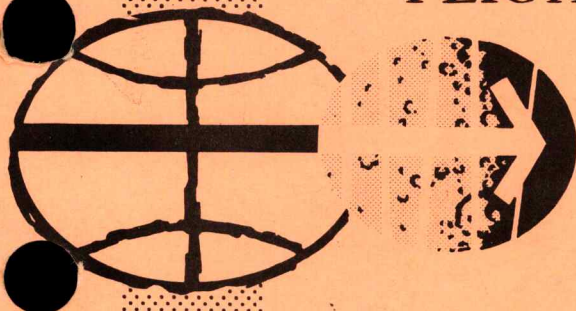
*MAY 5, 1969*

*PREPARED BY*

*FLIGHT CONTROL DIVISION*

MANNED SPACECRAFT CENTER  
HOUSTON, TEXAS

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IS NOT TO BE USED FOR ENGINEERING APPLICATIONS.



FLIGHT CONTROL DIVISION

Subcourse Outline

COURSE: Flight Control Orientation and Indoctrination

SUBCOURSE: Apollo Command Network

METHOD OF  
INSTRUCTION: Conference

TIME ALLOTTED: 3 Hours

PREREQUISITES: None

BRING TO CLASS: Pencil or Pen

STUDENT REFERENCES: Handout Material

INSTRUCTOR  
REFERENCES: PHO TR170A, PHO TR231, Data Acquisition Plan,  
CCATS Program Requirements

TRAINING AIDS: Transparency projector, chalk, chalkboard

CONDUCT OF CLASS: Minor deviations from the time schedule listed in  
this outline may be made if necessary. Emphasis  
will be directed toward insuring student understanding.  
Order of presentation will be adhered to by instructor.

Writer

A. C. Hughes

Contractor Approval

D. V. Swift

Requesting Organization  
Approval

FED

FCQS Approval

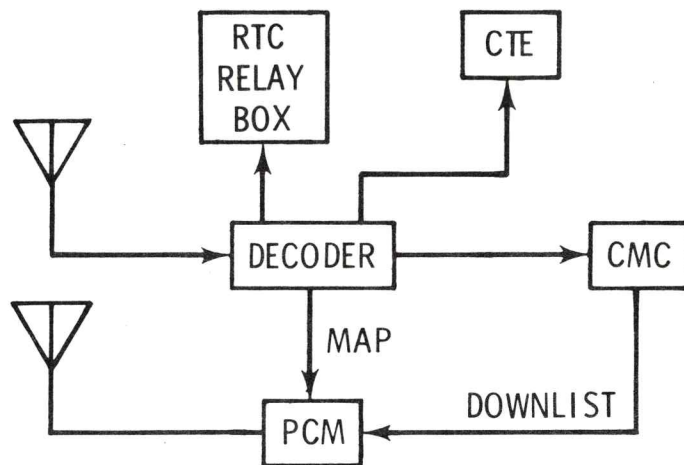
John H. Cress

May, 1969

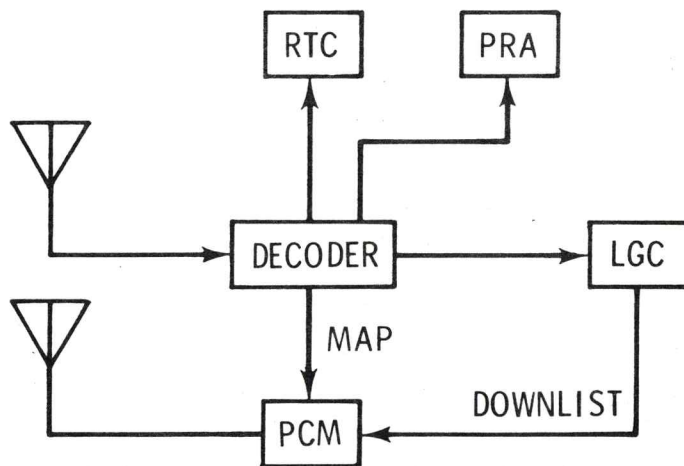
TOPIC	DESCRIPTION	TIME PERIOD
Objectives	As a result of attending the subcourse, the attendee should be: (1) Familiar with the command network and the functions of the network equipments. (2) Familiar with the basic operational concepts concerning command facilities. (3) Familiar with the general capabilities of the command network and related equipments. (4) Familiar with the acronyms, terms, and expressions used by MSC documentation and personnel.	
A.Network	°A review of spacecraft command categories and formats °A discussion of the overall network related to command and the general operational concepts. °A discussion of the network stations hardware. °A discussion of the network stations command software.	1st hour
B.MCC	°A discussion of the MCC command related hardware	2nd hour
	°A discussion of MCC command software °A description of flight controller command panels and operational functions performed with the use of these panels.	3rd hour



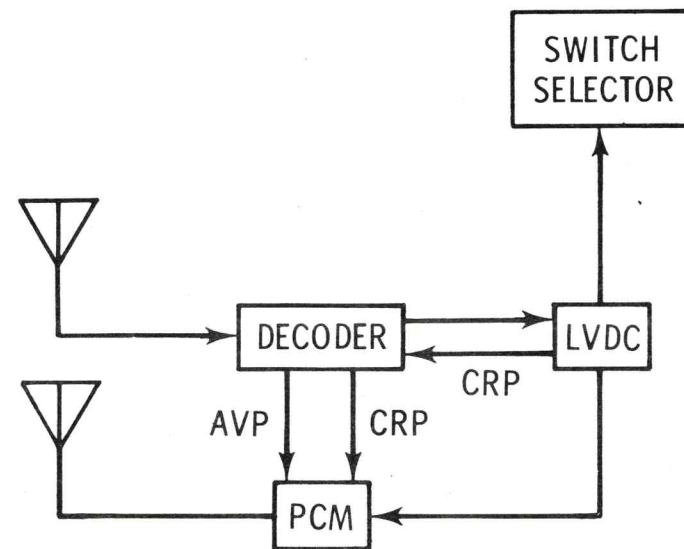
# COMMAND MODULE



# LUNAR MODULE



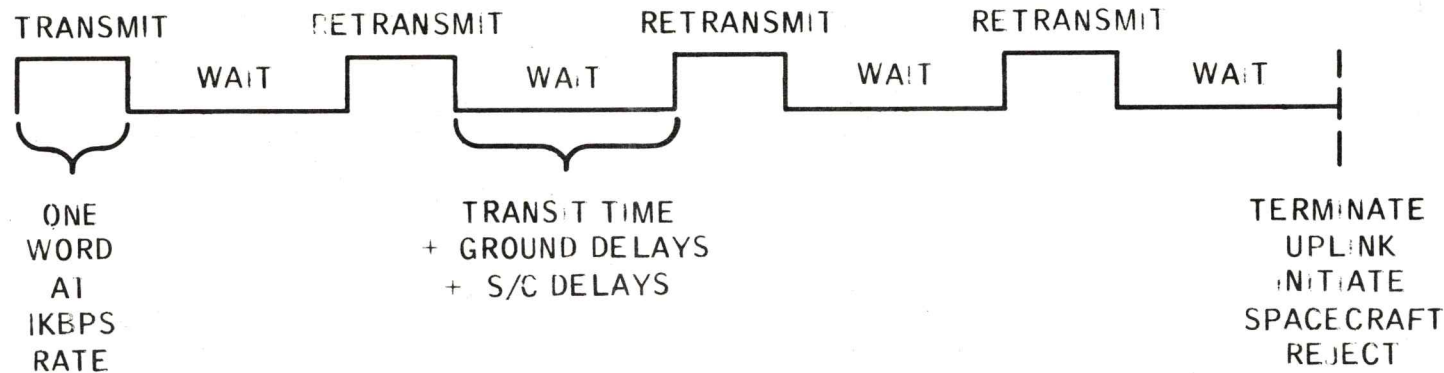
# INSTRUMENT UNIT



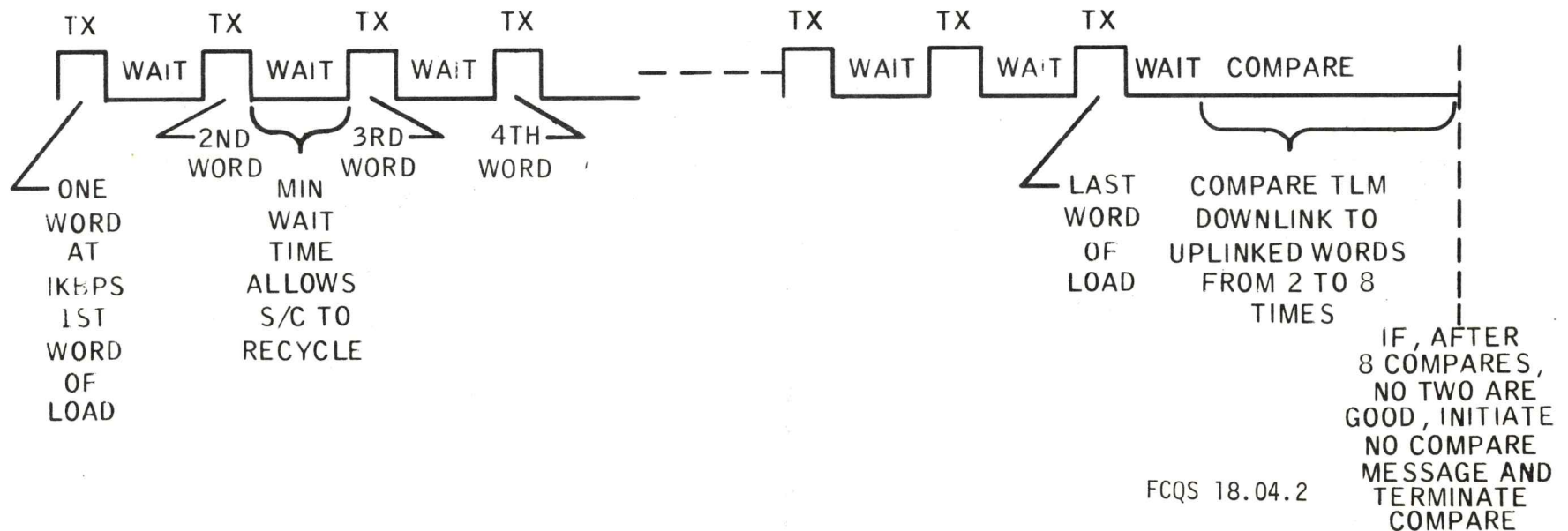


# UPLINK SEQUENCES

## REAL TIME COMMANDS AND SLV LOAD UPLINK SEQUENCE

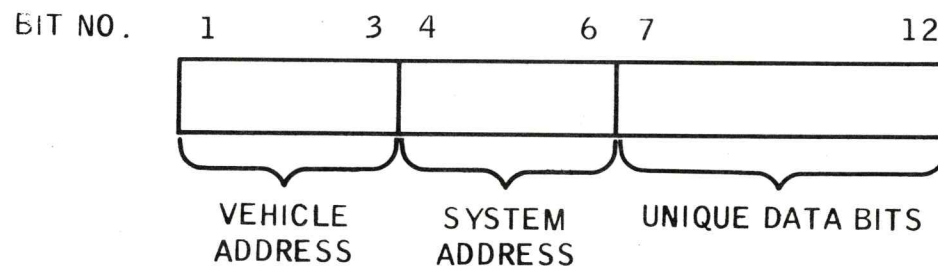


## CSM/LM LOAD UPLINK SEQUENCE

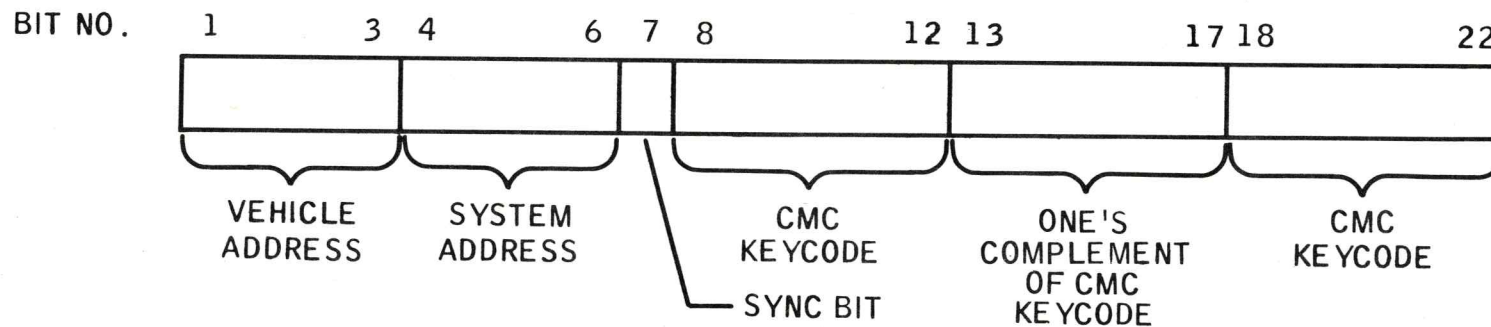


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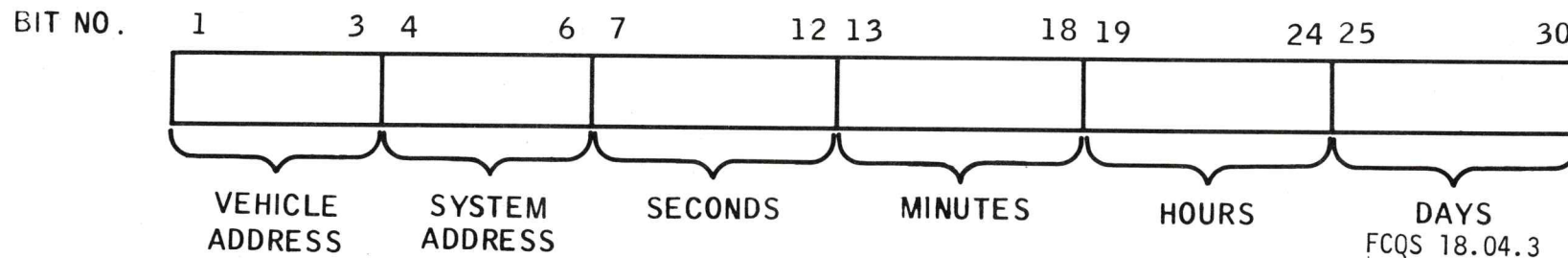
### CSM RTC FORMAT



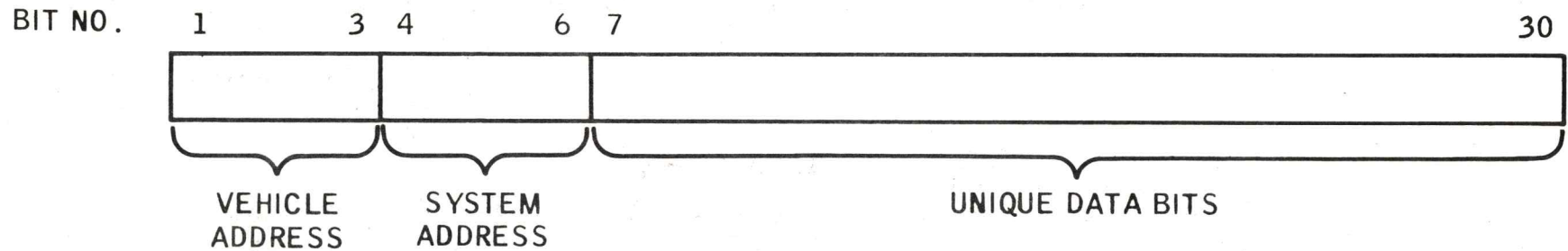
### CMC WORD FORMAT



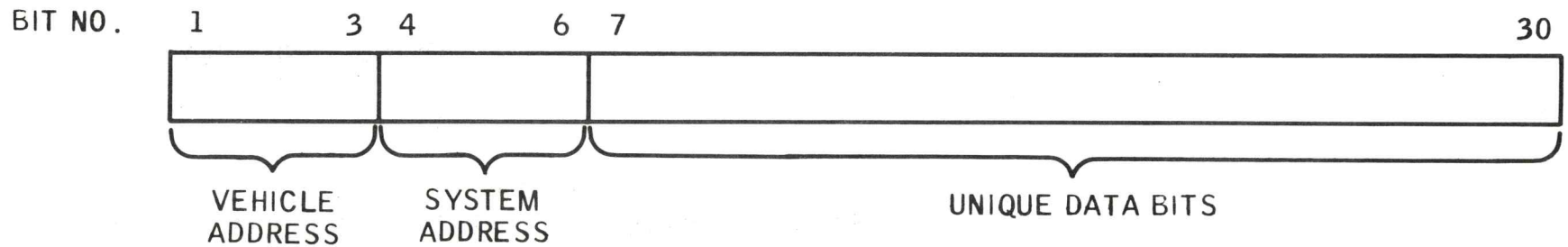
### CSM CTE WORD



CSM TEST WORD "A"



CSM TEST WORD "B"

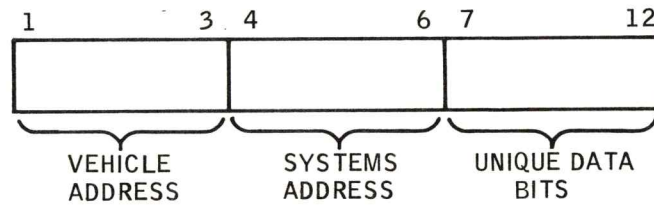


FCQS 18.04.4

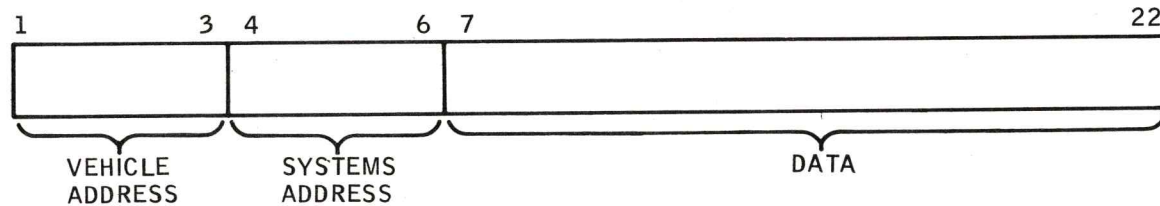


## LM COMMAND WORD FORMATS

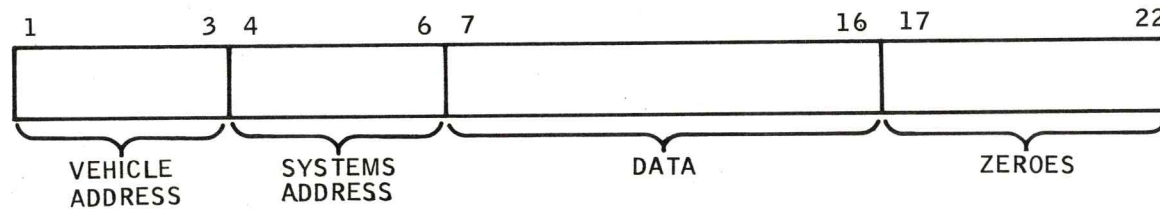
### LM RTC FORMAT



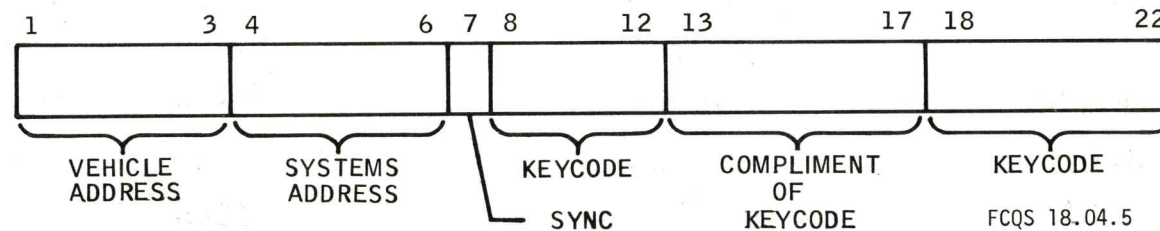
### LM DCA TEST WORDS 1, 2, AND 3



### LM PROGRAM READER ASSEMBLY (PRA) WORD



### LM GUIDANCE COMPUTER WORDS



V33E

[illegible]

V33E

V72E  
IIE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE  
AAAAE  
DDDDDE

V33E

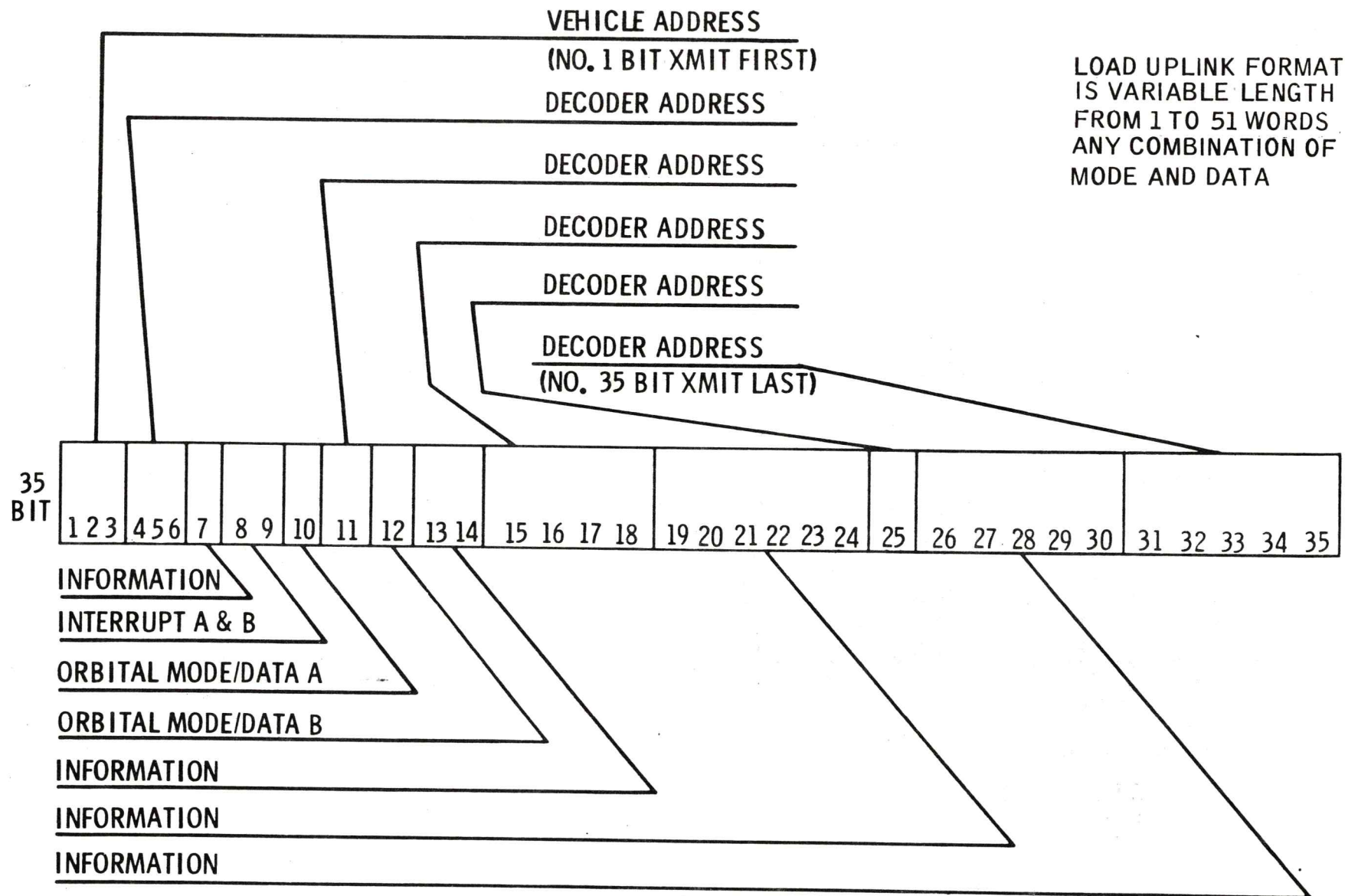
V73E  
DDDDDE  
DDDDDE

V33E

## CSM/LM LOAD UPLINK FORMATS

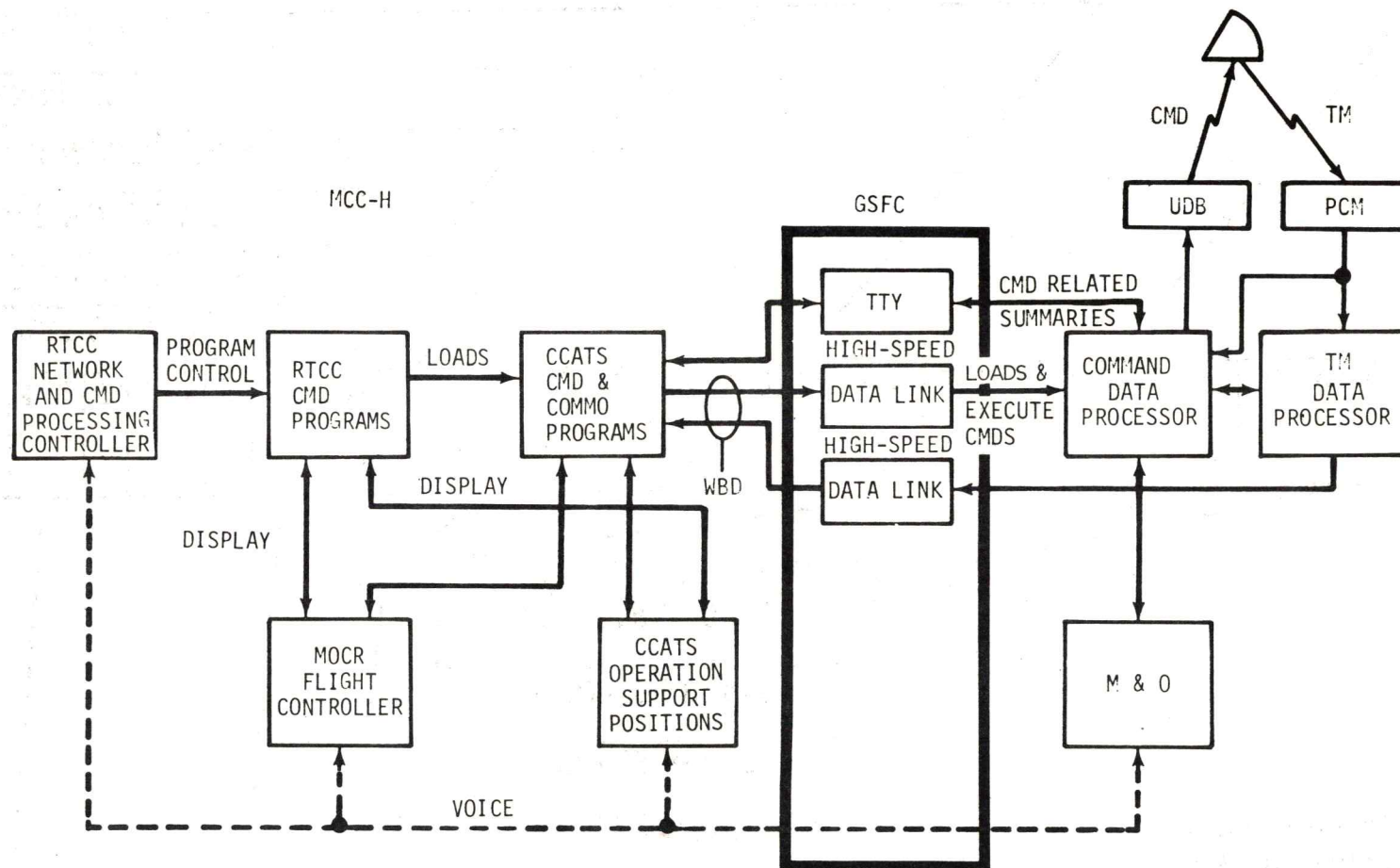
FCQS 18.04.6

# SLV COMMAND WORD FORMAT



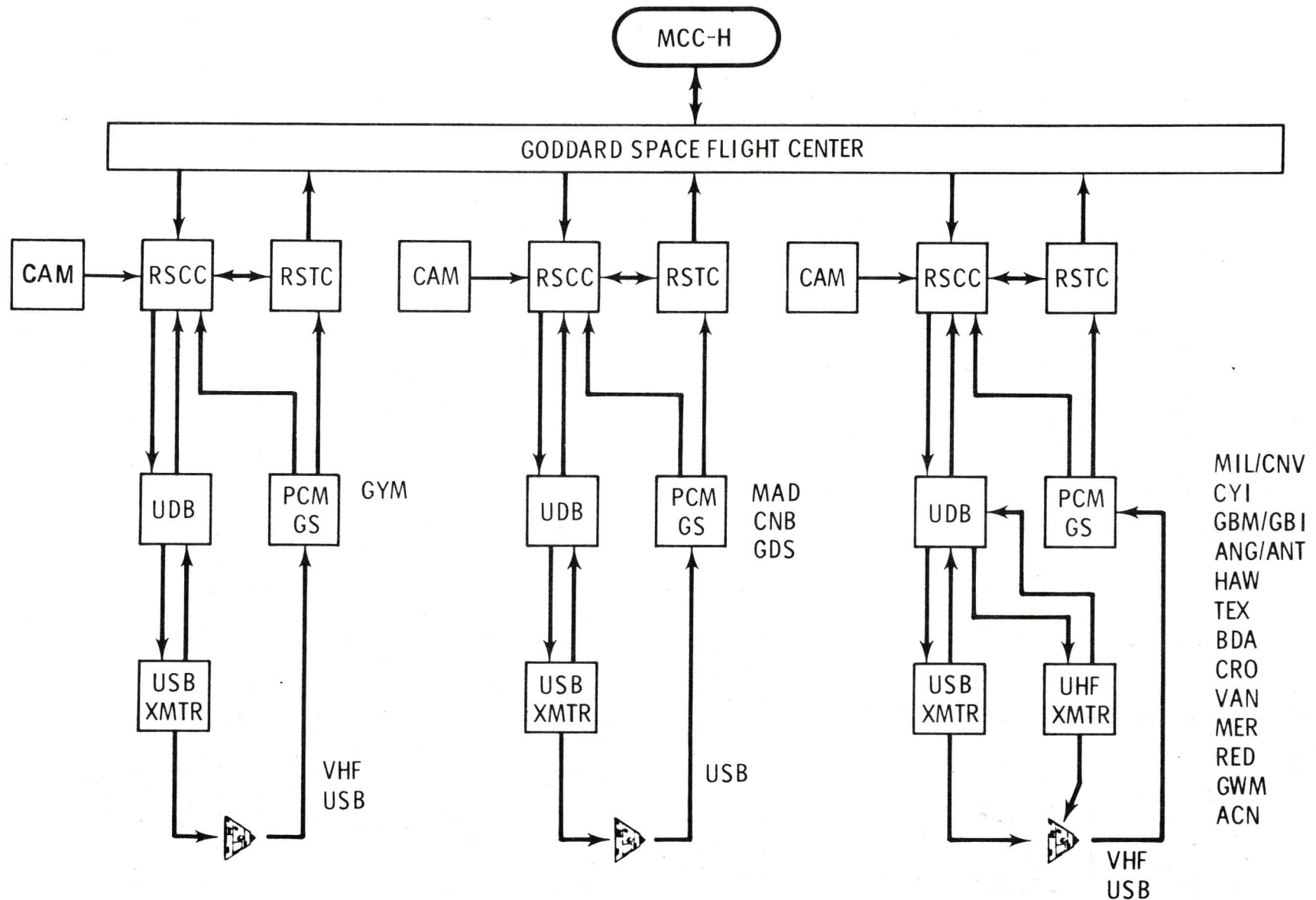


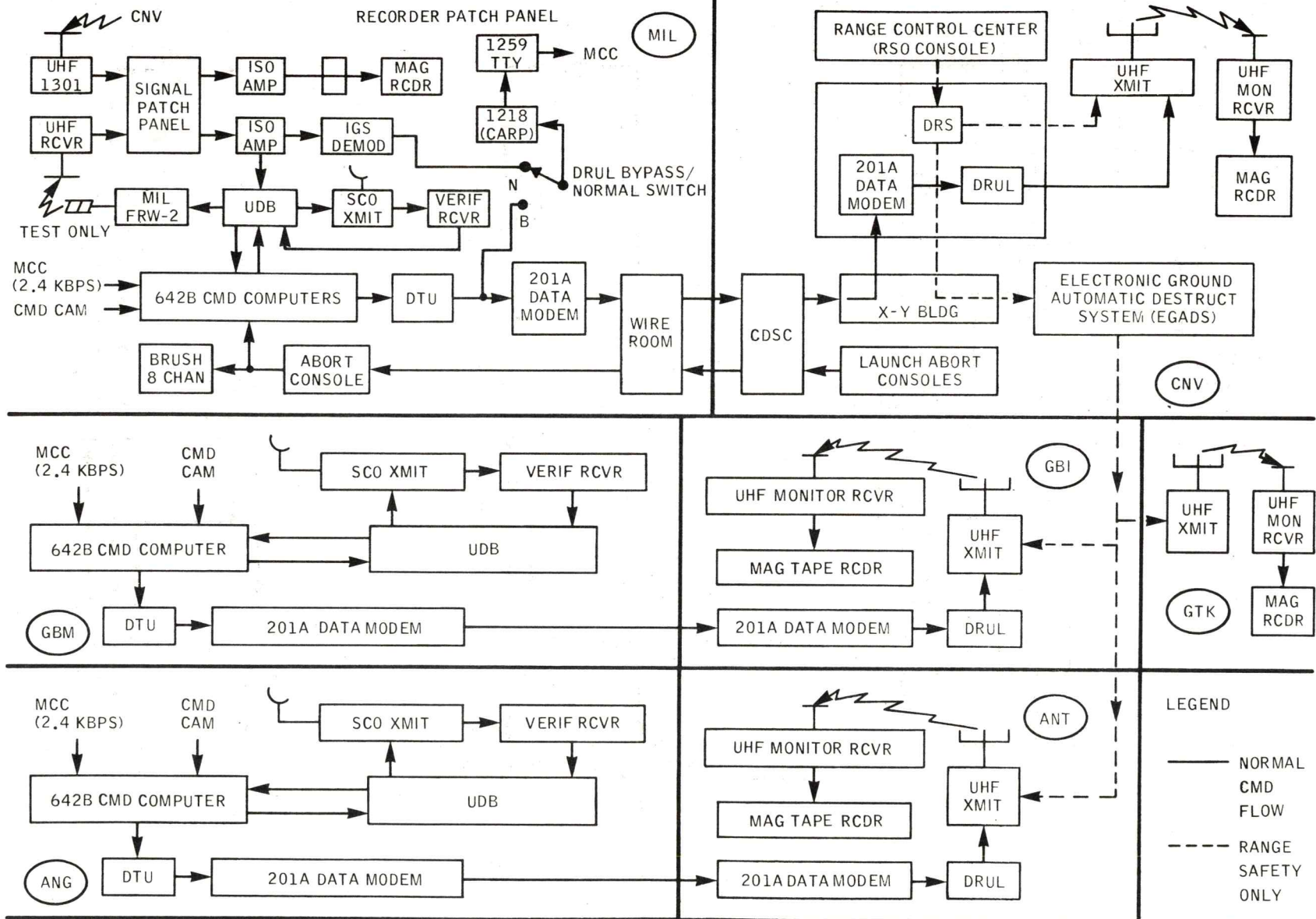
# COMMAND OPERATIONAL INTERFACES



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# MSFN STATIONS COMMAND UPLINK AND VERIFICATION DATA FLOW DIAGRAM





DRUL COMMAND INTERFACE

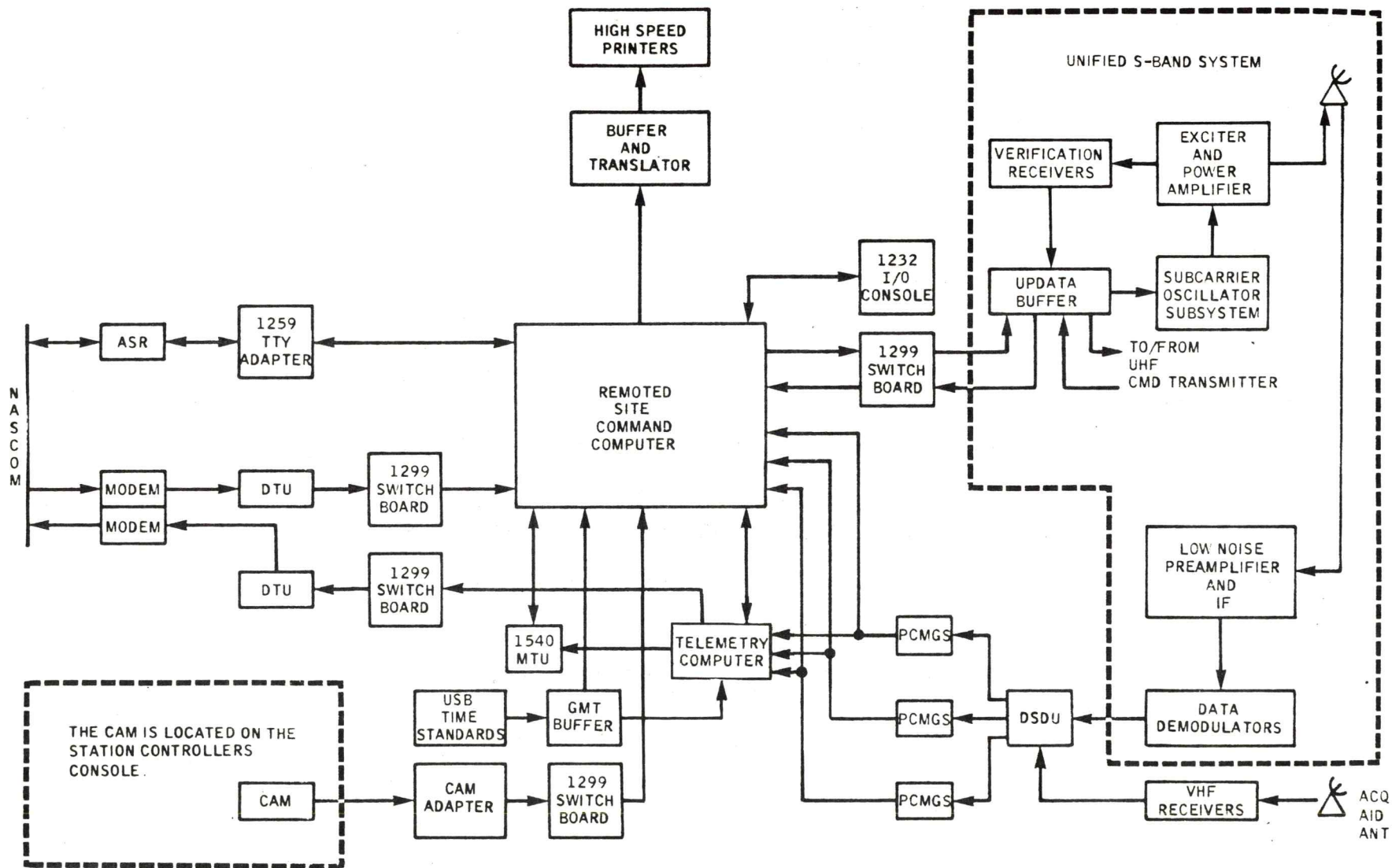
FCQS 18.04.10



## REMOTED SITE STATION CONTROLLER

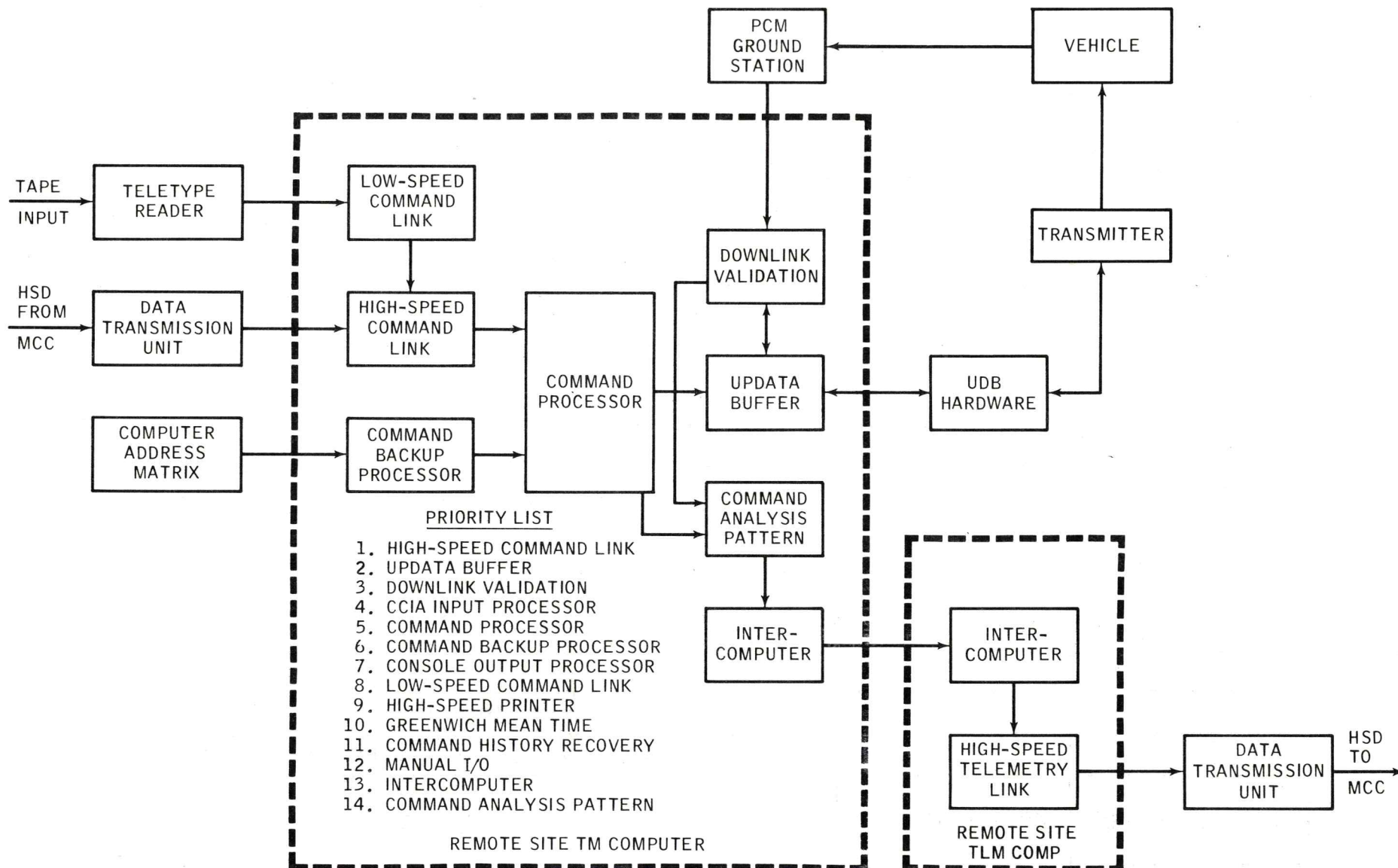
- PROVIDES BACKUP COMMAND EXECUTE FOR MCC
- COORDINATE LOADING THE RSCC WITH CCATS  
COMMAND LOAD CONTROLLER
- CONTROLS COMMAND SYSTEM MODE SELECTIONS
- MARKS COMMAND HISTORY END OF FILE

FCQS 18.04.11



MSFN STATION COMMAND SYSTEM FUNCTIONAL BLOCK DIAGRAM

FCQS 18.04.12



SIMPLIFIED RSCC DATA FLOW



SUMMARY OF VALIDATION AND VERIFICATION MESSAGES  
FROM MSFN TO MCC CCATS

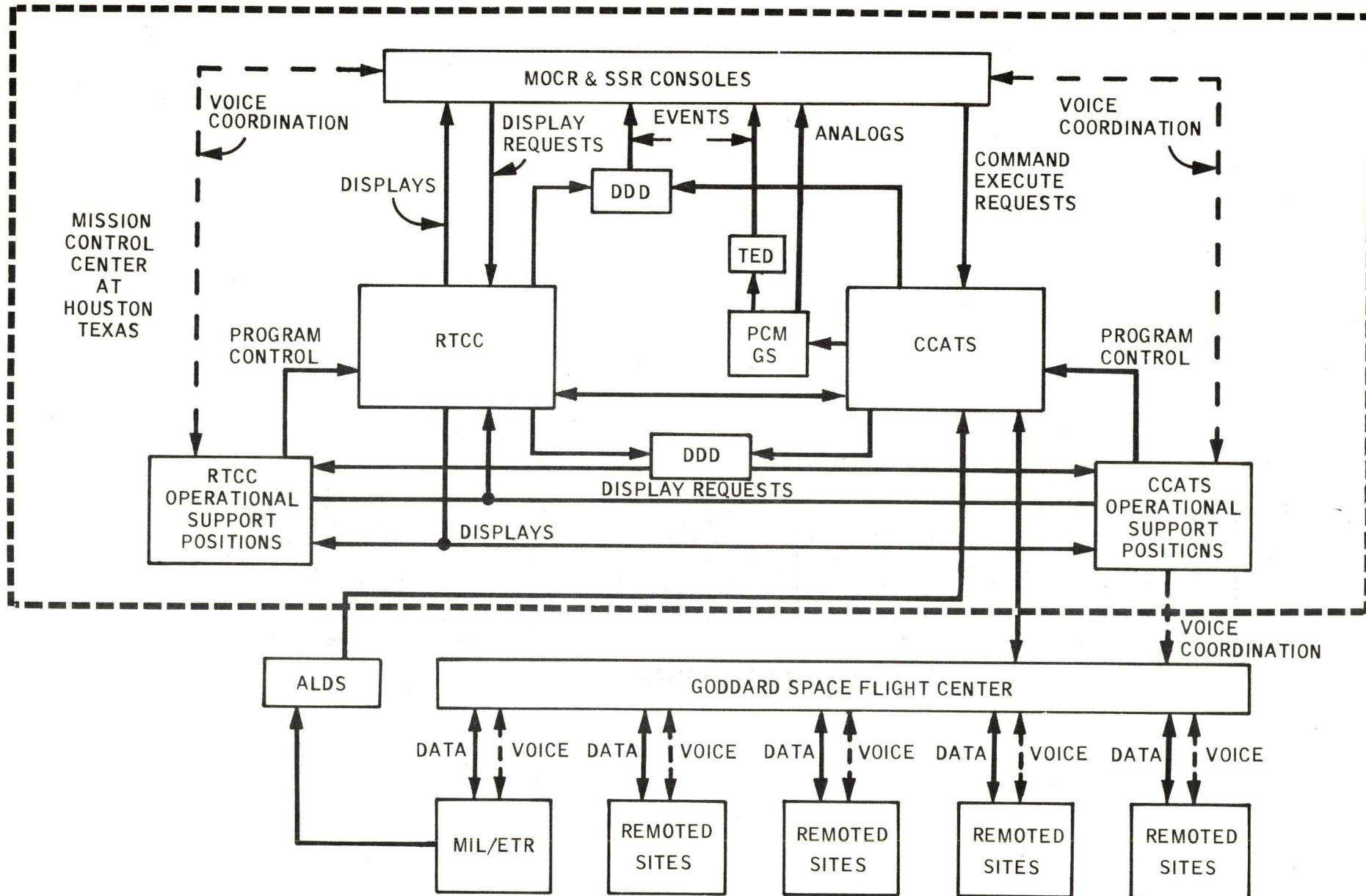
MESSAGE	HIGH-SPEED CAP	LOW-SPEED TTY
INVENTORY SUMMARY PR VALIDATION	X	
INVENTORY SUMMARY MESSAGE		X
LOAD CLEAR PR VALIDATION	X	
LOAD CLEAR ACCOMPLISHED MESSAGE	X	X
ONSITE LOAD CLEAR ACCOMPLISHED MESSAGE	X	X
ECR VALIDATION MESSAGE	X	
ECR VERIFICATION MESSAGE	X	
LOAD VALIDATION MESSAGE	X	X
GROUND REJECT/SPACECRAFT REJECT MESSAGE	X	
SITE STATUS REPORT (CARRIER STATUS)	X	
COMMAND TERMINATE PR VALIDATION	X	
COMMAND TERMINATE PR ACCOMPLISHED MESSAGE	X	
COMMAND HISTORY PR VALIDATION	X	
COMMAND HISTORY MESSAGE		X
BUFFER COMPARE PR VALIDATION	X	
COMPARISON ERROR MESSAGES	X	
TM FORMAT PR VALIDATION	X	
LINE-BY-LINE ECR VALIDATION	X	

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The timing diagram displays the detected RF output as a series of pulses at the bottom. Above it, the decoded bit stream is shown, with vertical lines marking the boundaries between bits. The bit stream is organized into groups corresponding to the letters VA, SA, S, K, and K-bar. Each group contains four bits. The final group, labeled SUB-BIT ONES, contains five bits.

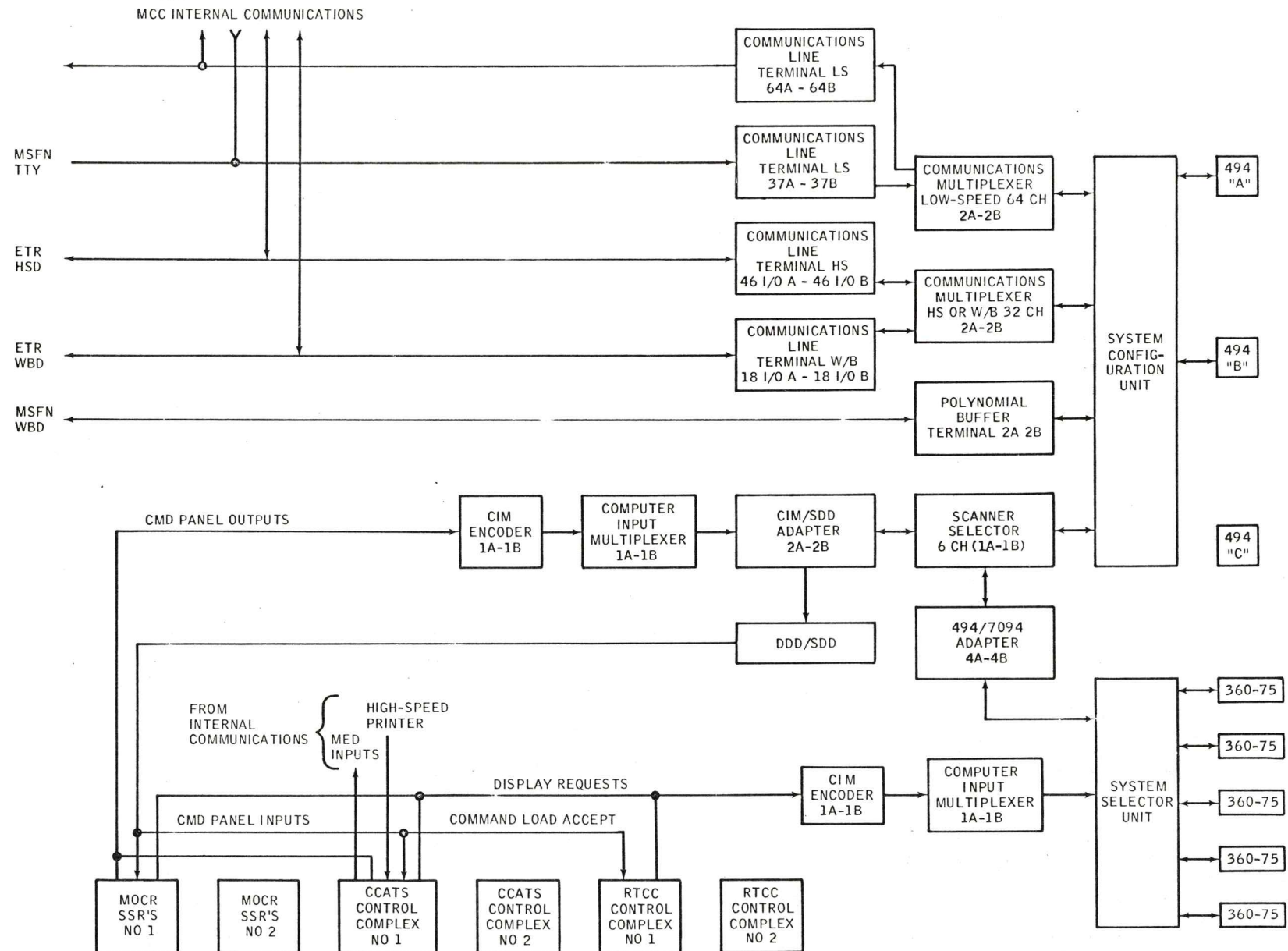
Letter	Bit 1	Bit 2	Bit 3	Bit 4	Binary Value
V	1	0	1	0	0011
A	1	0	1	0	1100
S	1	1	1	1	1010
S	1	1	1	1	1010
K	0	0	0	0	0101
K	0	0	0	0	0101
$\bar{K}$	1	1	1	1	1010
$\bar{K}$	1	1	1	1	1010
$\bar{K}$	1	1	1	1	1010
$\bar{K}$	1	1	1	1	1010
Sub-bit Ones	0	0	0	0	0101

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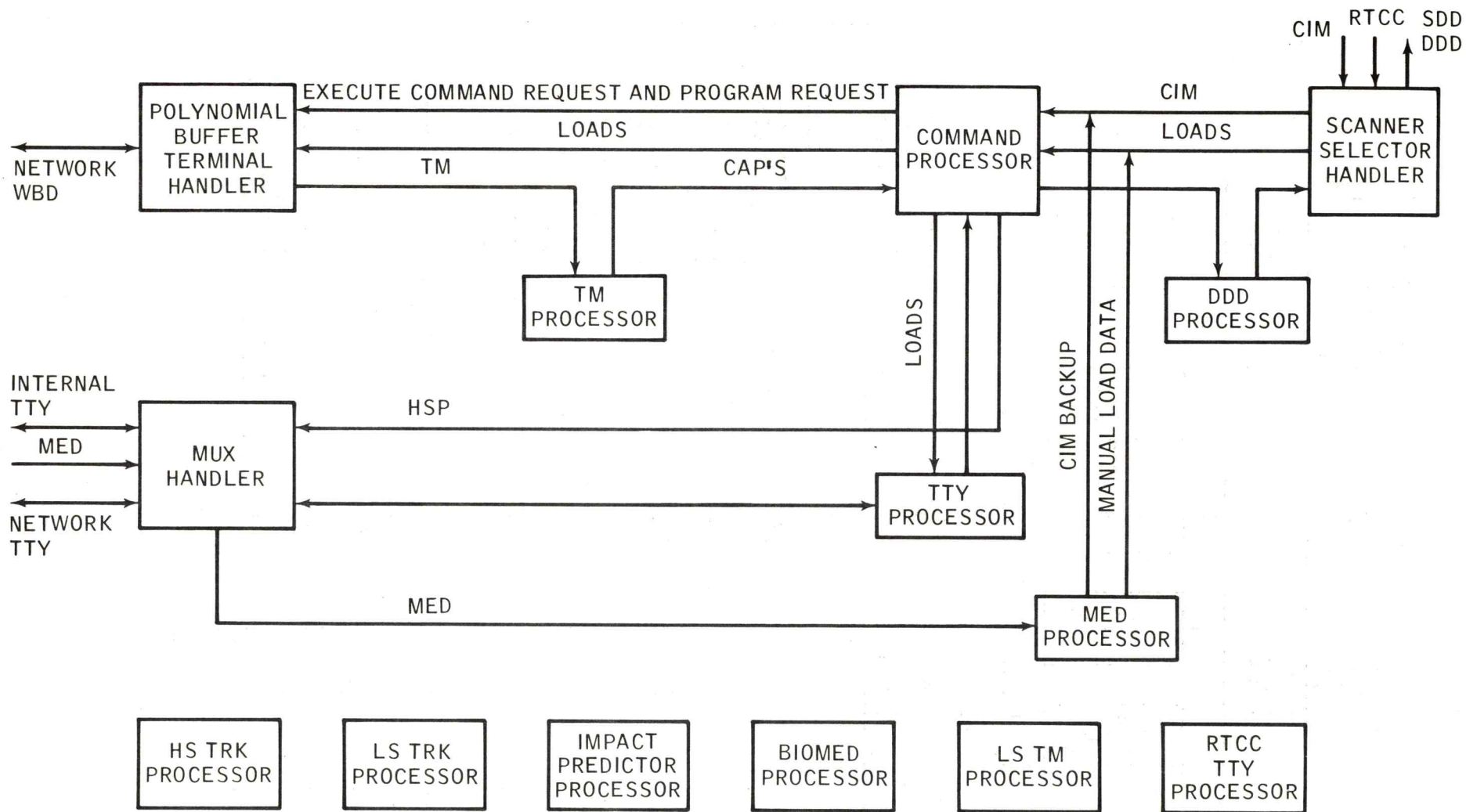


MCC-H COMMAND UPLINK AND VERIFICATION DATA FLOW DIAGRAM

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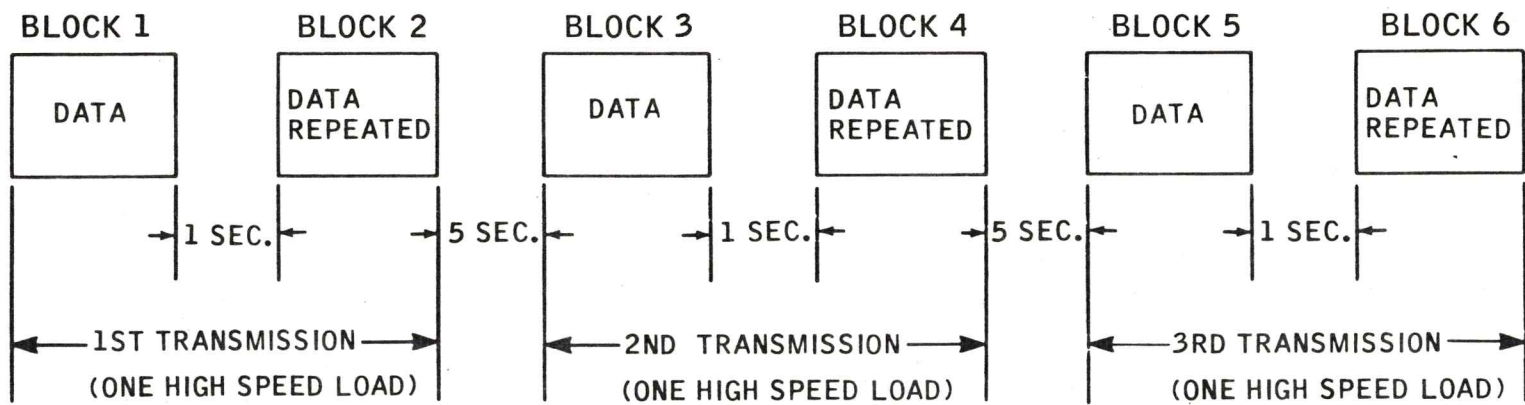




CCATS SOFTWARE  
COMMAND FUNCTIONS

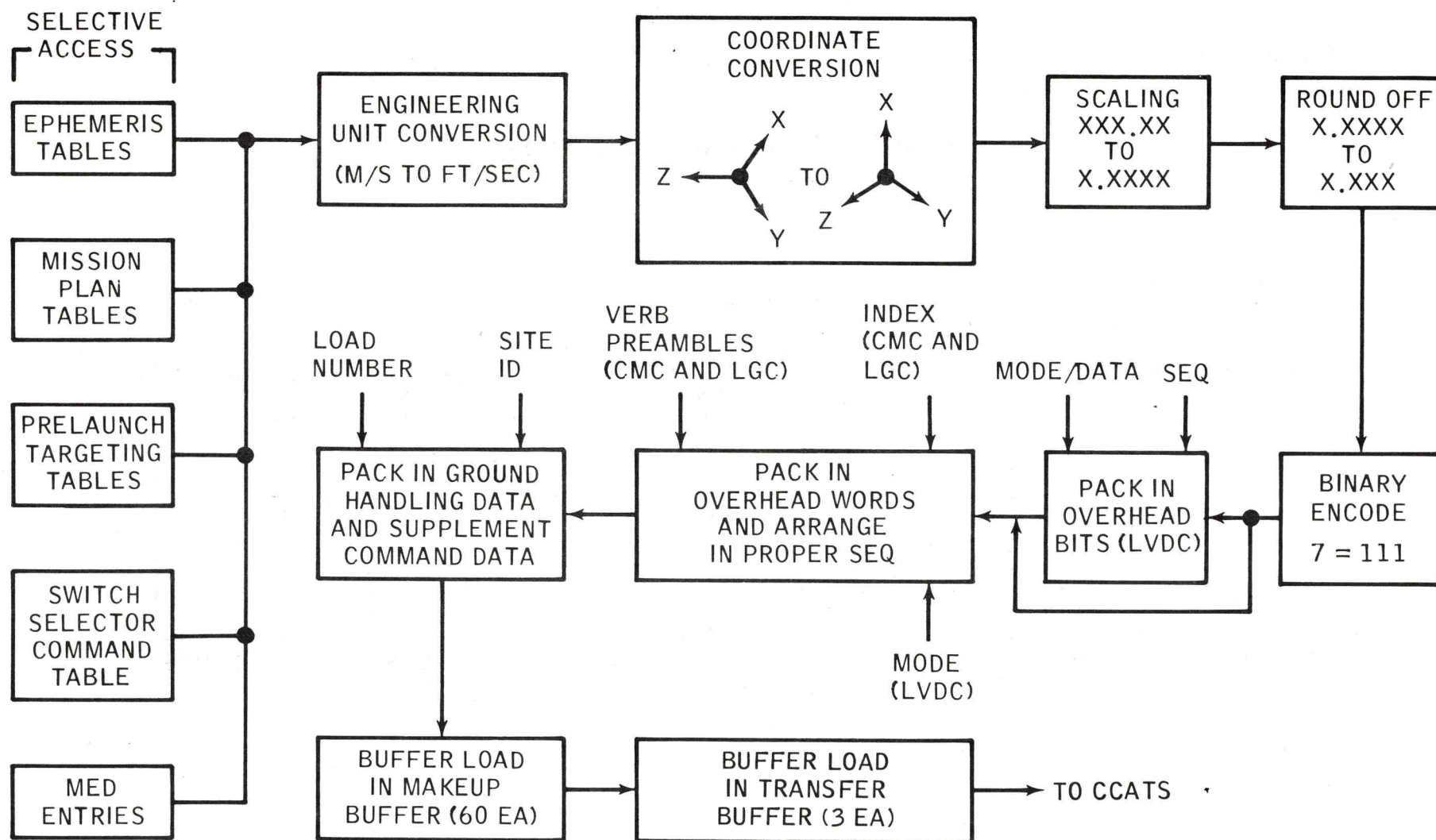
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ONE LOAD SEQUENCE

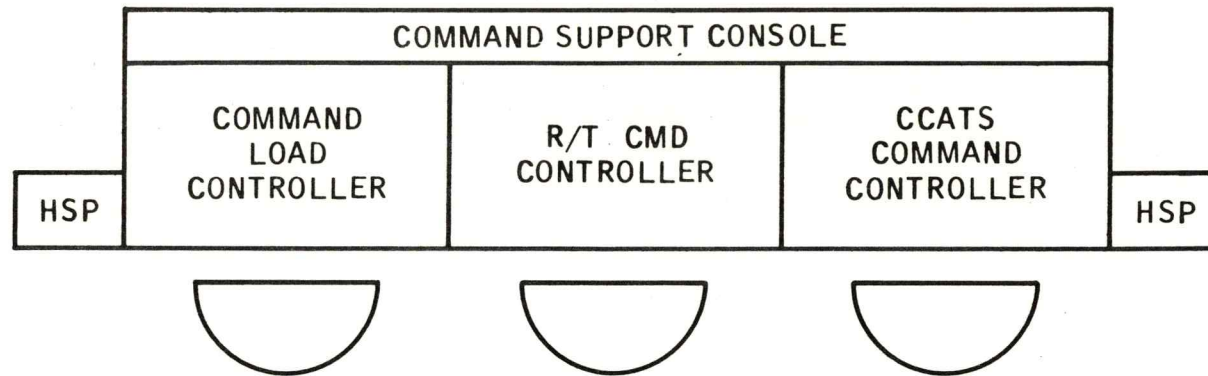
### HIGH-SPEED TRANSMISSION SEQUENCE



RTCC COMMAND LOAD GENERATION  
FUNCTIONAL SOFTWARE DIAGRAM

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## CCATS AREA FLIGHT SUPPORT PERSONNEL



### CLC

CONTROLS LOADING OF REMOTED  
SITES COMMAND COMPUTER

MAINTAINS UPDATED LOAD  
STATUS OF ALL RSCC'S

VERIFIES MED GENERATED  
LOADS

MAINTAINS MISSION HISTORICAL  
COMMAND DATA

### RTC

COORDINATES SPECIFIC  
CMD PLANS WITH FC'S

PERFORMS CONSOLE/SITE  
SELECT

MAINTAINS REMOTED SITE  
STATUS

COORDINATES THE HANDOVER

RESPONSIBLE FOR ISOLATION  
OF COMMAND SYSTEM  
PROBLEMS

### CCC

CONDUCTS MCC CMD SYSTEM  
CHECKOUT

MONITOR MCC COMMAND DATA  
FLOW AND INITIATES CORRECTIVE  
ACTION WHEN NECESSARY

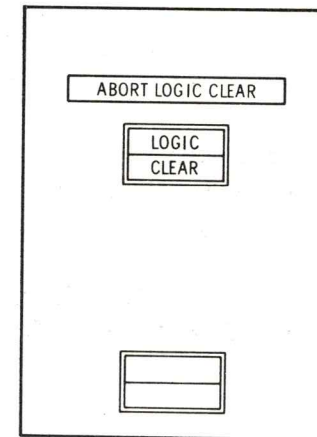
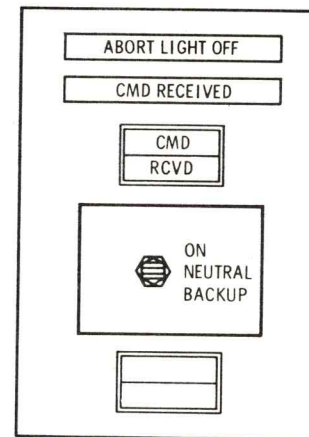
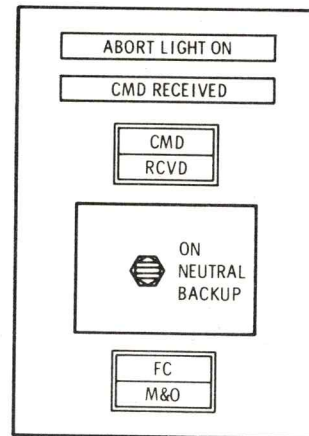
ASSISTS RTC IN TROUBLE  
ISOLATION

GENERATES SPECIAL OR BACKUP  
LOADS VIA MED OR TTY

BACKUP TO FC'S IF THEIR CMD  
PANELS FAIL

BACKUP TO VARIOUS CCATS  
MODULES VIA MED

FLIGHT DIRECTOR CONSOLE



UNIQUE PRIORITY CMD PANELS

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# COMMAND PANELS

DIGITAL READOUT MODULE			

RTC INIT	VERB INIT	LOAD INIT	LINE/LINE INIT	COMPARE INIT	CMD TERMINATE
0	1	2	3	4	SITE VAL RSCC INVAL
5	6	7	8	9	S/C REJ GND REJ

ALL ZEROS	ERROR RESET	CLEAR	+	-	V
0	1	2	3	4	N
5	6	7	8	9	E

ENABLE DISABLE	LD MODE RTC MODE	UHF USB	SITE SEL CARRIER ON	FC M&O	MAP O/R
DATA REJ TM REJ				VEH 1 VEH 2	VEH 3 LM VEH 4 CSM
DSM SELECT CLEAR	VERIFY CLEAR		CCATS TST	VEH 5 VEH 6	VEH 7 SLV VEH 8

RTC	RTC	RTC	RTC	RTC	RTC
RTC	RTC	RTC	RTC	RTC	RTC
RTC	RTC	RTC	RTC	RTC	RTC



# MANUAL VERIFICATION OF CMC OR LGC COMMANDS

AM 2097 CMC DSKY AND STATE BUFF MONITOR 0267

	01 XXXXX	
PG XX	02 XXXXX	
VB XX NO XX FL X	03 XXXXX	
R1 (±) XXXXX	04 XXXXX	
R2 (±) XXXXX	05 XXXXX	
P3 (±) XXXXX	06 XXXXX	
	07 XXXXX	STA XXX
	10 XXXXX	UP ACT X
COMP ACT X	11 XXXXX	UP VB XX
UPL ENBL X	12 XXXXX	ST CNTR XX
CMC WARNX	13 XXXXX	K FAIL X
PG ALARM X	14 XXXXX	VERIFY X
IN LENBL X	15 XXXXX	
CMD INH X	16 XXXXX	
	17 XXXXX	
NO ATT X	20 XXXXX	
	21 XXXXX	
CMC L/O XXX:XX:XX.XX	22 XXXXX	
CMC GET XXX:XX:XX	23 XXXXX	
Δ T XXX:XX:XX.XX	24 XXXXX	
GET RTCC XXX:XX:XX		
GMT RTCC XXX:XX:XX		

ALL ZEROS	ERROR RESET	CLEAR	+	-	V
0	1	2	3	4	N
5	6	7	8	9	E

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EXAMPLE TTY HISTORY PRINTOUT

CSM TYPE 1

HAW000A  
SS DSVL  
DE PHAW  
20/1200Z

COMMAND HIST CSM 1

0701 VI 013:00:00 013:00:00 MCC UHF

CMC ENTER 43740760 0 013:00:01 013:00:01 MCC UHF

0701 LI 013:00:10 013:00:12 MCC UHF

0701 CM N 013:00:14 013:00:24

0701 LL 013:00:30 013:00:31 MCC UHF

0701 CM C 013:00:33 013:00:43

BIT RAT LO 4665 M 013:10:00 MCC 000 UHF

BIT RAT HI 4664 4671 M 013:15:05 MCC 003 UHF

CTE 4400003440 M 01:14:00:00 014:00:00 MCC UHF

TEST B 4032777775 M 014:20:10 MCC UHF

20/1205Z OCT PHAW

#

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## EXAMPLE TTY HISTORY PRINTOUT

CSM TYPE 2

MILO00A  
SS DSCT  
DE GMIL  
20/1200Z

COMMAND HIST CSM 2

0701 VI

43613504 43476034 43437014

013:10:00 013:10:00 MCC UHF

CMC ENTER 43740760 0 013:10:05 013:10:05 MCC UHF

0701 LI

43437014 43476034 43476034 43476034 43476034 43740760

43437014 43476034 43476034 43476034 43476034 43740760

013:20:00 013:20:02 MCC UHF

0701 CM

01 37777 37777 36777 36777 36777 36777 36777 36777 36777

N 013:20:04 013:20:14

0701 LL

43603700 43417404 43740760

43436014 43476034 43476034 43476034 43476034 43740760

013:20:40 013:20:42 MCC UHF

0701 CM

C 013:20:44 013:20:54

ABT LTA ON 4601 M 013:30:00 MCC 006 UHF

R/T PCM ON 4632 4637 M 013:35:00 MCC 000 USB

TEST A 4032000002 M 013:40:00 MCC UHF

CTE 4467677240 M 01:23:59:59 023:59:59 MCC UHF

20/1206Z OCT GMIL

#

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EXAMPLE TTY HISTORY PRINTOUT

LM TYPE 1

HSK000A  
SS DSCT  
DE AHSK  
22/1400Z

COMMAND HIST LM 1

2402 VI 014:00:00 014:00:00 MCC UHF  
LGC ENTER 31740760 0 014:01:00 014:01:00 MCC UHF  
2402 LI 014:02:00 014:02:02 MCC UHF  
2402 CM N 014:02:04 014:02:14  
2402 LL 014:05:00 014:05:01 MCC UHF  
2402 CM C 014:05:03 014:05:13  
ASC EN ARM 3402 M 014:10:00 MCC 000 UHF  
DEC A INHB 35040000 M 014:11:00 MCC UHF  
PRA 3600 FWDSCH M 014:12:00 000 CAM UHF  
22/1403Z OCT AHSK

#

EXAMPLE TTY HISTORY PRINTOUT

LM TYPE 2

GYM000A  
SS DSVL  
DE GGYM  
22/1500Z

COMMAND HIST LM 2

PRA 3600 REVSCH M 016:00:00 000 CAM UHF

DEC 3 INHB 35100000 M 016:10:00 CAM UHF

C-BAND OFF 3452 N 016:20:00 MCC 007 UHF

2402 VI

31613504 31476034 31437014

016:30:00 016:30:01 MCC UHF

LGC ENTER 31740760 0 016:30:10 016:30:10 MCC UHF

2402 LI

31437014 31476034 31476034 31476034 31476034 31740760

3143

31437014 31476034 31476034 31476034 31476034 31740760

016:40:00 016:40:02 MCC UHF

2402 CM

02 37777 37777 36777 36777 36777 36777 36777 36777 36777

N 016:40:04 016:40:14

2402 LL

31603700 31427210 31740760

31437014 31476034 31476034 31476034 31476034 31740760

016:50:00 016:50:01 MCC UHF

2402 CM

C 016:50:03 016:50:13

22/1503Z OCT GGYM

#

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EXAMPLE TTY HISTORY PRINTOUT

S-IVB TYPE 1

BDA000A  
SS DSCT  
DE GBDA  
25/1600Z

COMMAND HIST S-IV 1

S 017:00:00 753 533 235 356 A C 624 MCC	LOX VNT OP
S 017:00:00 753 053 167 456 A C 043	
S 017:00:00 753 033 235 356 A C 024	
S 017:10:00 753 573 325 156 A - 666 MC	EXEC MAN A
SEQ BIT ERROR - MODE 1 067 110	
S 017:20:00 753 513 636 356 A C 614 MCC	4101
S 017:20:00 753 013 177 456 A C 003	
S 017:30:00 753 513 137 556 0 0 602 MCC	SEQ 1 INHIB
S 017:40:00 753 533 235 356 A C 624 MCC	LOX VNT CL
S 017:40:00 753 053 067 565 A C 041	
S 017:40:00 753 053 026 356 - C 054	
S 017:40:00 753 533 235 356 A C 624	
S 017:40:00 753 053 167 456 A C 043	
S 017:40:00 757 053 606 356 A - 154	
OM DATA ERROR R DATA 1 066 111	
25/1603Z OCT GBDA	

#

# EXAMPLE TTY HISTORY PRINTOUT

S-IVB TYPE 2

CR0000A  
SS DSVL  
DE ACRO  
26/1300Z

COMMAND HIST S-IV 2

S 017:00:00 753 553 526 556 A C 652 MCC

ALT SEQ 1

S 017:01:00 753 553 626 356 A - 654 MCC

ALT SEQ 2

SEQ BIT ERROR - MODE 1 055 122

S 017:01:00 753 553 626 356 A - 654

SEQ BIT ERROR - MODE 1 055 122

S 017:01:00 753 553 626 356 A C 654

S 017:10:00 757 533 514 556 A C 732 MCC

H GAIN

S 017:20:00 753 513 736 156 A C 616 MCC

4201

S 017:20:00 753 013 137 556 A - 002

SEQ BIT ERROR - DATA 1 003 174

S 017:20:00 753 013 137 556 A C 002

26/1303Z OCT ACRO

#

FCQS 18.04.30

GLOSSARY

### AVP--Address Verification Pulse

Part of the SLV telemetry downlink. Detection of a valid AVP indicates the onboard command decoder has successfully decoded the 14-bit decoder address included in every command word to the SLV. The remote site command computer strips these pulses from the telemetry downlink during the map waiting period following each SLV uplink word. A detection of four 1's, within a 60 ms period during the SLV map waiting period constitutes a valid AVP. An indication of this event is recorded for command history.

### Buffer Compare

An uplink verification process used for CM and LM computer loads. No reference to maps is made. All words are uplinked with minimum spacing. When all words in the load have been transmitted, the RSCC waits a specified amount of time (Buffer Compare delay) to insure the state buffer contains the uplinked load. It then begins to collect state buffer data. One set of state buffer words contain the entire load. The computer collects up to 8 sets of state buffer words comparing each set to the retained uplink load data. When two favorable comparisons are made, the buffer compare is terminated. If no two comparisons are favorable out of a possible 8, the buffer compare process is terminated. Whenever the buffer compare is terminated, it results in two CAPS being transmitted to MCC conveying the results of the comparison process.

### Buffer Compare Delay

Following uplink of a load for which a buffer compare is required, a delay will occur before collecting state buffer words. This delay insures that the downlink state buffer data is for the load that was previously uplinked. The delay is variable from 0 to 7 seconds. The minimum setting is dependant on range to the vehicle and buffering delays incurred in the telemetry scheme.

### CAM--Computer Address Matrix

There are two CAM's at each remote site. One is associated with the RSCC and the other is related to the remote site telemetry computer. The command CAM may be used to select modes of operation for the RSCC and if MODE I is selected, it may be used to request an uplink.



## CAP--Command Analysis Pattern

Part of the high speed telemetry output from the remote site telemetry computer to CCATS at MCC. The 40-bit pattern occupies 5 successive 8-bit word slots in the high speed format. The 40 bits include 14 bits of polynomial coding. The contents of each CAP is determined by the remote site command computer and is transferred to the telemetry computer via the inter-computer channel. The telemetry computer will output each CAP three times in successive telemetry blocks. The types of information conveyed by the CAP are as follows:

- A. acceptance or rejection by the RSCC of loads, ECR's, or PR's.
- B. verification by spacecraft that an uplinked word was received and decoded correctly.
- C. Status concerning results of an automatic or manual buffer compare made following uplink of a CMC or LGC load.
- D. Ground/spacecraft reject of an uplinked command.
- E. Site/carrier status information (UHF/USB ON-OFF; LD ENABLE-DISABLE; MODE 1 or 2; FC or M&O MODE)
- F. accomplishment of load clear
- G. accomplishment of command terminate

## CCATS--Command, Communications and Telemetry System

CCATS is a computer complex hubbed by 3 Univac computers. The computers are present by Univac 494 general purpose digital computers with a very large input/output peripheral complement. One of these computers will handle all of the required traffic for two missions simultaneously on one mission and one simulation. Another 494 serves as a dynamic standby. The CCATS complex handles all of the digital information flowing to or from the Mission Control Center. It serves as an input/output processor for MCC. In addition to input/output (communications processing), it serves very specific functions related to the MCC's capability to uplink digital data to the spacecrafts. It provides some degree of control over all of the remote sites' command computers. It maintains status tabulations of all RSCC's. It responds to manual inputs requesting an uplink and causes the appropriate RSCC to uplink the commands. It relays command loads from the Real Time computer complex to the appropriate RSCC's. In short, it controls a world wide network of command related equipments to fulfill the Mission Control Center's command requirements.



### CEF-Computer Execute Function

A message generated by CCATS in response to a manual input. CEF relates to all high speed data inputs to the RSCC except loads. The term CEF is found in the Remote Site documentation where CCATS documentation uses the terms Execute Command Requests (ECR) and Program Requests (PR) to refer to the same data.

### Command Spacing

The command spacing is the amount of time, in milliseconds, which must follow the last sub bit of a command word uplinked before the first sub bit of the following word may be uplinked. This time is variable from 50 MS to 300 MS. The minimum setting is dependant on spacecraft equipment delays (circuit recovery time).

### CTE Bias

The RSCC may add a delay time to the computed GET prior to uplink of the CTE word. This time delay is added to compensate for the transmission time delays. The time is variable from 0 to 3 seconds.

### CRP-Computer Reset Pulse

Part of the SLV telemetry downlink. Sometimes referred to as MAP. Generated by the LVDC when it accepts a command word from the onboard command decoder. Detection of a valid CRP by the remote site command computer indicates successful completion of the uplink attempt for the previous word. Detection of four CRP bits, set to logical 1's, within a 60 MS period during the SLV map waiting period constitutes a valid CRP. A valid CRP will terminate the retransmit sequence and will be included in the command history.

### Data Bit Error

An error characterized by the transmission of the code for a data bit one instead of the code for a data bit zero (or vice versa). It is highly unlikely that this type of error could occur any place but the remote site command computer. A data bit error cannot be detected by the onboard equipments but can be detected during the uplink process by the remote site command computer. During the RF loop check, the remote site command computer accepts the demodulated verification receiver output, (a monitor of transmitted command) decodes the subbits, and checks the resulting data bits against the retained data bits which originally generated the outputted command. Detection of a data bit error results in immediate termination of the uplink process and an immediate ground reject. The early termination of the uplink sequence will result in an incomplete word being received by the spacecraft. The incomplete word will be rejected by the spacecraft.

## Downlink Validation Word

See MAP

## ECR-Execute Command Request

A message generated by CCATS in response to a manual input (usually by a flight controller). This type of message requests the RSCC to uplink a real-time command, a group of real-time commands, a load, or a correction for a previously transmitted load.

## FC/M&O Mode-Flight Control Maintenance and Operations

May refer to an RSCC mode or a CCATS mode. When used to refer to the RSCC, the mode selection is accomplished by use of the command CAM. The M&O mode enables the 1232 input/output console. The FC mode disables certain 1232 input/output console functions. If the term FC/M&O mode is used to refer to the CCATS mode, mode selections are accomplished by use of a push-button on the commando's console or by use of the manual entry device on the CCATS COMMAND CONTROLLER's console. There is a FC/M&O mode indicator at all of the MOCR flight controller positions having command panels. In the FC mode command uplinks may be initiated from the MOCR positions with command panels. In the M&O mode, the flight controllers cannot initiate a request for an uplink.

## GCA-Generalized Core Area

This is an RSCC term referring to a portion of main memory allocated to storage of command loads. The area will accommodate a maximum of 60 permanent loads of maximum anticipated length. One of these loads may be flagged as a temporary load rendering it unavailable for uplink. The RSCC will reject loads with the same type and sequence number as a load residing in memory but it will accept loads with the same type number but different sequence numbers. Any load stored in the generalized core area will remain there until cleared by remote site or CCATS operational personnel.

## Key Codes

A 5-bit character code used to interface the CMC with its DSKY. The same codes are used to interface the LGC with its DSKY. All commands from the network to either of these computers will be in the form of these keycodes. The keycodes are as follows:

0 - 10000	6 - 00110	ENTER - 11100
1 - 00001	7 - 00111	ERROR RESET - 10010
2 - 00010	8 - 01000	CLEAR - 11110
3 - 00011	9 - 01001	+
4 - 00100	VERB - 10001	11010
5 - 00101	NOUN - 11111	-
		11011
		KEY RELEASE-11001



All command loads are formatted into keycodes at CCATS prior to transmission to the remote site for storage. A complete set of keycodes are part of the remote site command computer program and are treated as real time commands by the computer.

#### Load Enable/Disable

A mode of the RSCC. When the load enable function is active (load enable mode or simply load mode) loads from CCATS are checked by the RSCC and if found valid, are placed in the generalized core area. When the load enable function is inactive (load disable) a load from CCATS is checked by the RSCC and if found valid, placed in the generalized core area and flagged as a temporary load. Until the temporary flag is removed, the load may not be uplinked. Only one load may be flagged as temporary. When the load enable mode is entered with a temporary load in memory, the temporary flag is then removed. Load enable/disable is selected by the CAM.

#### Load Record

A log (in main memory) maintained by CCATS. It lists all loads validly loaded at each site (by site).

#### MAP

Message acceptance pattern. More correctly known as the Downlink validity word. An 8-bit telemetry word from the CSM and LM (only 4 bits are used). Generated by the onboard command decoder. Five different patterns are used by the CSM and four different patterns are used by the LM. This telemetry word is stripped from the telemetry downlink during the MAP waiting period following each CSM or LM uplink word which is subject to the MAP method of verification. An example of message acceptance patterns follows; 1010XXXX indicates the onboard command decoder is powered but has not received an acceptable command word. 0101XXXX indicates the onboard decoder has received and accepted a command word. Detection of the latter pattern will terminate the uplink retransmission sequence. The term "MAP" is sometimes used in lieu of CRP.

#### MAP Method

An uplink verification process used by the remote site command computer. The computer strips downlink validity words from the CSM or LM telemetry or computer reset pulses from the IU telemetry. This TM decommutation

occurs during the MAP waiting time after transmission of the uplinked command word. If the decommutated TM indicates the word has been accepted by the spacecraft, it terminates the uplink sequence. If TM does not verify the uplink, the computer will retransmit the command and wait for a MAP. The number of retransmissions is variable from 0 to 7. The detection of a map during the waiting period following any one of the retransmissions will terminate the transmission sequence. The map method of verification is optionally used on all SLV commands, CSM and LM RTC's and CSM CTE words. These commands may also be transmitted with the map override method of verification.

#### MAP Override

An option provided the flight controller where he may initiate an uplink of any command normally requiring MAP verification but when this option is exercised, the remote site command computer will make no reference to MAPs and will uplink all words of the command with minimum spacing. As soon as the command has been outputted, the computer will assume verification.

#### MAP Waiting Period

A period of time in which the RSCC will look for maps (CRP's) downlinked from a vehicle in response to a command word uplinked. The time period begins following uplink of the last subbit of the command word. This period is variable from 50 MS to 4 seconds. The minimum time setting is dependant on range to the vehicle.

#### Mode I/II

Refers to operation of the RSCC. May be selected by the command CAM on the station controller's console. (Remote site) The most significant effect selection of the modes have is to control the source of execute command requests. In mode I, only remote site requests for uplink will be honored. This mode is used on a backup basis. Mode I uplinks may be initiated by use of the command CAM. In mode II, only high speed ECR's will be accepted by the RSCC. This is the normal mode of operation.

#### Polynomial Encoding

An error protection scheme used in ground communications by the MSFN. All command related information exchanged between CCATS and the remote site command computer is protected by this encoding scheme. Also known as the Base-Chaudhuri error encoding scheme.



### PR-Program Request

A message generated by CCATS in response to a manual input from the program request module. (Command Load Controller and Telemetry Instrumentation Controller (CCATS)) The message is routed to a remote site command computer and requests the RSCC to accomplish some task that does not involve uplinking data to the spacecraft. RSCC functions which are requested by PR's include:

- A. Command History Summary Request
- B. Load Inventory Summary Request
- C. Load Clear Request

The term CEF (computer execute function) collects the terms ECR (execute command request) and PR.

### Priority Command

A priority command is a real time command designated priority so that it will receive special treatment during the uplink process. When a priority command is uplinked, it is not subject to the retransmission setting. It will be transmitted continuously, waiting for a map after each transmission, until the proper map is received or until the command transmission is terminated. The command transmission may be terminated by reception of a PR from CCATS (command terminate). Even though the transmission sequence is not subject to the retransmission setting, if the command is transmitted a number of times equal to this setting and no ground reject has been generated and no map has been received, the RSCC will generate a spacecraft reject CAP which when received by CCATS will result in a spacecraft reject light on the command panel of the flight controller that requested the uplink. The RSCC transmission sequence will continue until the command is verified or terminated.

### Priority ECR

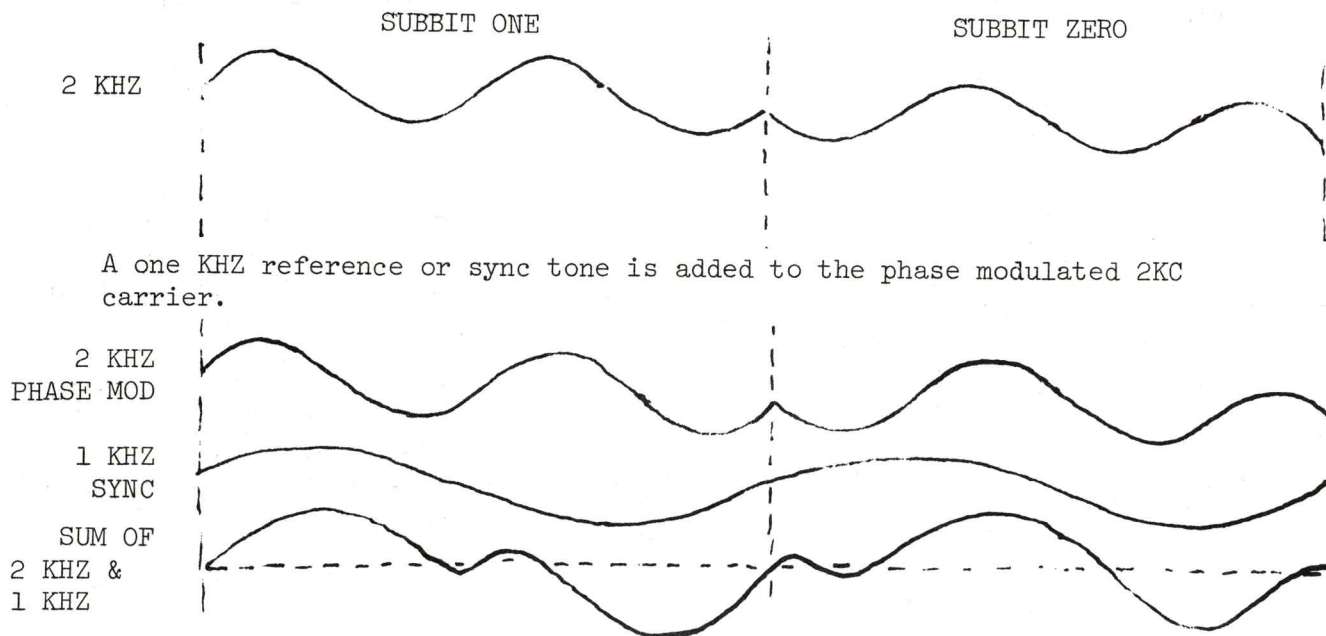
A priority ECR is an ECR generated by CCATS and designated priority so that it will receive special handling when being output from CCATS. Priority ECR's are output continuously at 250 MS intervals from CCATS until it is validated (receipt of a validation CAP from the RSCC). This contrasts with non-priority ECR's which are output only one time. Priority ECR's identify priority commands to be uplinked by the RSCC. The commands are subject to the uplink sequence described under "priority commands". Priority ECR's are generated in response to manual inputs from special command panels on the Flight Director's, Flight Dynamics officer's, and Booster Systems engineer's consoles. Each panel is associated with two discrete locations in a table of 20 maintained by CCATS. This table defines the hierarchy for manual inputs requesting priority ECR's. (A priority ECR will interrupt another priority ECR of lesser priority) Any priority ECR will interrupt the transmission of a load being transmitted from CCATS. A priority ECR will not interrupt a non-priority ECR because these ECR's are only transmitted one time. However, the RSCC



will interrupt the transmission of a multiple word non-priority command in favor of a priority command (at the end of the word being uplinked). The command panels capable of initiating a priority ECR are referred to as toggle command panels. A priority ECR is sometimes referred to as a unique priority ECR.

### PSK - Phase Shift Key Modulation

A modulation technique used in project Apollo for uplink commands. The subbits to be transmitted are used to phase modulate a 2KHZ sine wave so that a subbit one is represented by 2 cycles of the sine wave and a subbit zero is represented by 2 cycles of the same signal but opposite



The composite waveform is used to modulate the 70KHZ subcarrier in the USB system. The modulated subcarrier then modulates the S-Band carrier. The transmitted command is PSK/PM/PM.

### RF-Loop Check

A check performed by the RSCC during the uplink process. The outputted command is retained for subsequent checks. The transmitted command is monitored by the verification receiver and returned to the RSCC via the updata buffer. The monitored command is checked for proper subbit codes against the stored codes. The decoded command is then checked against the original command. The outputs of this check are subbit errors and data bit errors (if any). The presence (or absence) of these errors are used as logical inputs for:

controlling the uplink sequence  
generating verification caps  
generating S/C reject caps  
generating ground reject caps

#### RSCC-Remote Site Command Computer

The univac computer at all remote sites. It is a modified 642B otherwise known as univac 1230. The general purpose digital computer has a main memory capacity of 32,608 addressable 30-bit words. The RSCC provides storage for all commands awaiting uplink. When requested, the RSCC will take the identified command from storage, prefix it with the appropriate addresses and otherwise format it properly. It will then subbit encode the command and control the uplink. It attempts to verify each uplink by using the telemetry downlink. It is in constant communications with CCATS and relays status information dating to uplinks, equipments, or modes of operation. In short, it is the remote site's command control system.

#### RTCC-Real Time Computer Complex

The RTCC is a large scale computer complex. It presently uses 5 IBM 360/75 computers. One of these computers serves all of MCC's computational requirements for one mission or simulation. Another serves as a dynamic standby. If two missions are running simultaneously, four computers are operating. The fifth computer is off-line. The RTCC provides the display and control system with the dynamic data for most of the displays used at MCC. It also uses tracking and telemetry data from the network to compute trajectory data. This trajectory data is used for many guidance and navigational functions and sometimes serve as primary source when relayed to the spacecraft. The RTCC is capable of generating a number of command loads. The purpose of these loads vary considerably. A typical purpose would be to define required parameters for maneuvering the spacecraft. A somewhat less dramatic purpose would be to correct the spacecraft's ephemeris (ephemeris is a table of predicted position and velocity at given times). In summary, the RTCC provides MCC the capability of generating command loads automatically.

#### SLV Decoder Address

All SLV command words are formatted with a fixed 14-bit decoder address. The bit structure is as follows:

Bit number	4	5	6	11	15	16	17	18	25	31	32	33	34	35
value	1	0	1	0	1	0	1	1	1	1	0	1	1	1

## Subbit Code

A Command encoding scheme used by Project Apollo to insure that no invalid commands are accepted by the spacecraft. An example follows: Each logical 1 to be uplinked is replaced with the discrete 5-bit pattern, i.e.; 10101. Each logical 0 is replaced with the complement of that pattern.

1 = 10101

0 = 01010

Only these two patterns would be accepted by the onboard equipment. The loss or gain of a subbit during transmission would generate a pattern which would not be acceptable by the onboard equipment. Additional protection is afforded by using one subbit code for the vehicle address and a different subbit code for the remainder of the command word.

## Subbit Error -

An error formed by dropping or adding a subbit so that the resulting code is invalid. Usually occurs in the transmitting media. This type of error is detected during the RF loop check performed by the remote site command computer. The error is detected by comparing the input to the computer from the verification receiver (a monitor of the transmitted command) and stored subbit codes from memory. This type of error will not cause termination of the uplink sequence nor a ground reject unless the retransmit sequence has been completed and no map has been received. Note that the subbit error may have been caused by the verification receiver and if that is the case, the erroneous code would not have been transmitted. This type of error will be detected by the onboard decoder and will result in the rejection of the entire word.

## Systems Addresses

All CSM and LM command words are prefixed with a three-data bit code denoting the vehicle system to which the command will ultimately be routed. The codes are as follows:

<u>Data Bits</u>	<u>CSM</u>	<u>LM</u>
000	Test Messages	spare
001	Spare	LGC word
010	Spare	spare
011	CMC words	Decoder B or RTC's
100	CTE word	Decoder A
101	RTC (Salvo Reset)	Test Messages
110	RTC (Internal Relay)	Program Reader Assembly
111	RTC (External Relay)	spare



These codes are prefixed to the data during the formatting process in the RSCC just prior to the uplink.

#### Unique Priority Commands

Those commands identified by priority ECR's.

#### VAL-Validation CAP

A class of command analysis patterns. When the RSCC receives data (or requests) from CCATS, it generates a VAL CAP to indicate its acceptance or rejection of the data or request. The RSCC may reject the request or data on the basis of checks made which identify transmission errors. It may also reject a request in the event the request processing would conflict with RSCC activities already in process. For example: if it receives a request for uplink while another uplink is in process, it will reject the request and generate a VAL CAP to inform MCC. This type VAL CAP is sometimes called a NON VAL CAP. The different types of VAL CAPS are listed below:

1. Load validation or non validation
2. RTC Execute command request, validation or non validation
3. Load Execute command request validation or non validation
4. Program Request validation or non validation.

#### Vehicle Addresses

All command words are prefixed with a three-data bit code denoting the vehicle to which the command is directed. The codes are as follows:

- 000 - spare
- 001 - spare
- 010 - spare
- 011 - LM
- 100 - CSM
- 101 - spare
- 110 - spare
- 111 - SIVB/IU

The codes are prefixed to the data during the formatting process in the RSCC just prior to the uplink.

#### VER-Verification CAP

A class of command analysis patterns. When the RSCC receives, accepts, and processes a request from CCATS, the RSCC generates a VER CAP to

inform MCC of the completion of the process. For example: the RSCC receives a request for uplink, it accepts the request and generates a VAL CAP (see VAL), it then processes the request and performs the uplink. In the uplink process, it makes use of the telemetry downlink to assure itself of a satisfactory uplink. When the uplink is completely finished and verified, it generates a VER CAP to inform MCC of the successful completion of the uplink. The VER CAP may also inform MCC of the unsuccessful completion of an uplink. If that is the case, information relating to WHY the uplink was unsuccessful is included. In summary, the VER CAP relates the end results of the request received by the RSCC. Different types of verifications are listed below:

1. Execute command request for an RTC - S/C VER
2. Execute command request for an RTC - ground reject
3. Execute command request for an RTC - S/C reject
4. Execute command request for a LOAD - S/C VER
5. Execute command request for a LOAD - ground reject
6. Execute command request for a LOAD - S/C reject
7. Comparison error words 1 and 2
8. Load clear accomplished
9. Command terminate accomplished



## ABBREVIATIONS

ACN	USB station at Ascension
ACRO	TTY routing indicator for Carnarvon, Australia
AFD	Assistant Flight Director
ALDS	Apollo launch data system
ANG	USB station at Antigua
AOS	Acquire on signal
APS	Ascent propulsion system of the lunar module
ASR	Automatic send-receive TTY machine
AVP	Address verification pulse in the SIVB/IU telemetry downlink
BDA	Bermuda
BSE	Booster systems engineer
CAM	Computer address matrix
CAP	Command analysis pattern
CAPCOM	Capsule communicator
CC	Computer command (operating position in the RTCC)
CCATS	Communications, command and telemetry system
CCC	CCATS Command controller
CC̄C	True-Compliment-True Keycode uplink format also written as K̄K̄K̄
CIM	Computer input multiplexer
CLAM	Command load acceptance message
CLC	Command load controller, an operating position in CCATS
CLT	Communications line terminal
C/M	Communications multiplexer
CNB	USB Station at Canberra, Australia
CNU	CSM navigation update
CNV	Cape Canaveral (Kennedy)
CRO	MSFN Station at Carnarvon, Australia
CRP	Computer reset pulse
CS	Centiseconds
CSCC	Command Support Control Console (CCATS)
CSM	Command Service Module
CTE	Central Timing Equipment
CTI	CSM time increment update
CYI	Grand Canary Island
DCS	Digital display drivers
DPS	Descent propulsion system (Lunar module)
DRUL	Down range uplink
DSKY	Display Keyboard
DSPTAB	Display tabulation
DTU	Data transmission unit
D/TV	Digital to television
EMU	Erasable memory update
ET	English translation

FC	Flight Control
FD	Flight Director
FDO	Flight Dynamics Officer
FIDO	Flight Dynamics Officer
GBM	USB Station at Grand Bahama Island
GDS	USB Station at Goldstone, California
GET	Ground elapsed time
GMT	Greenwich Mean time
GNC	Guidance, Navigation and Control
GOSS	Ground operational support system
GSFC	Goddard Space Flight Center
GUIDO	Guidance Officer
GWM	Guam
GYM	Guaymas, Mexico
HAW	Hawaii
HBR	High bit rate
HMAS	TTY routing indicator denoting CCATS command program
H/O, HO	Handover
HS	High Speed
HSD	High Speed Data
HSP	High Speed printer
ID	Identification
IMU	Inertial measurement unit
INV	Inventory
I/O	Input-output
JPL	Jet Propulsion Laboratories
KKK	True-compliment-true Keycode uplink format
LBR	Low bit rate
LGC	LM guidance computer
LM	Lunar Module
LMP	LM Mission programmer
L/O, LO	Liftoff
LTU	Liftoff time update
LVDC	Launch Vehicle digital computer
MAD	USB station at Madrid, Spain
MAP	Message acceptance pattern
MCC	Mission Control Center
MER	Mercury-Apollo support ship
MIL	USB station at the Merritt Island Launch area
M&O	Maintenance and Operations
MOCR	Mission operations control room
Modem	Modulator-demodulator
MP	Mission Phase
MSC	Manned Spacecraft Center

MSFN	Manned Space Flight Network
MTU	Magnetic tape unit
NASCOM	NASA Communications network
OID	Octal Identification
P	Parity
PBI	Pushbutton indicator
PBT	Polynomial buffer terminal
PCM	Pulse code modulation
PCMGs	Pulse code modulation ground station
PSK	Phase shift keyed
PTA	Pitch trim angle
RED	Redstone-Apollo support ship
REFSMMAT	Reference stable member matrix
RJT	Reject
RO	Read only TTY machine
RS, R/S	Remote or remoted site
RSCC	Remote site command computer
R/T	Real Time
RTC	Real time command
RTCC	Real time computer complex
SA	Systems address
S/C	Spacecraft
SCO	Subcarrier oscillator
SDD	Subchannel data distributor
SIU	Sequence initiate update
SLV	Saturn Launch Vehicle
SNU	SIVB Navigation update
SPS	Service Propulsion system
SS	Switch selector
SSU	Switch selector update
STBUF	State buffer
STCNTR	State counter
TB4	Time base four
TBU	Time base update
TEX	MSFN Site at Corpus Christi, Texas
TM	Telemetry
TTY	Teletype
TV	Television
UDB	Update buffer
UHF	Ultra high frequency
USB	Unified "S" Band

VA	Vehicle address
VAL	Validation
VAN	Vanguard-Apollo Support ship
VB	Verb
VER	Verify, verification
VHF	Very high frequency
WBD	Wide Band Data
XMIT	Transmit
XMTR	Transmitter
YTA	Yaw Trim Angle



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OUTLINE  
AND  
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