MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

MIT CHARLES STARK DRAPER LABORATORY

CAMBRIDGE MASSACHUSETTS 02139

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R-577

GUIDANCE SYSTEM OPERATIONS PLAN FOR MANNED CM EARTH ORBITAL AND LUNAR MISSIONS USING PROGRAM COLOSSUS 3

SECTION 2 DATA LINKS

(Rev. 15)

NOVEMBER 1971

MIT CHARLES STARK DRAPER LABORATORY

CAMBRIDGE, MASSACHUSETTS, 02139

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R-577

GUIDANCE SYSTEM OPERATIONS PLAN
FOR MANNED CM EARTH ORBITAL AND
LUNAR MISSIONS USING
PROGRAM COLOSSUS

SECTION 2 DATA LINKS

REVISION 15

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REVISION INDEX COVER SHEET

GUIDANCE SYSTEM OPERATIONS PLAN

GSOP # R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS

Section #2 Title: Data Links (Revision 1)

This publication, a complete new revision (Rev. 1), incorporates revisions and additions as indicated below:

Revision 1

PCR-(PCN)	Description of Change
PCR-154	Update GSOP, Section 2, for typing errors, scaling changes, extra detail and description.
PCR-157	Lambert target updates conform to verb 71 format.
PCR-172(MIT-101)*	Change word-order of Entry/Update list.
PCR-174(MIT-108)*	LANDMARK I.D. added to P22 downlist.
PCR-422(MIT-146)*	Words 20 and 33 of the Entry/Update list were interchanged. Word 100 of the same list is now GAMMA (EI) and Range for Initialization.
PCN-417*	Use of ENDSAFE terminated.

Because of the numerous changes required by PCR #154 in Revision 1, there will be no PCR/PCN reference information at the bottom of any page which changed as a result of PCR #154 only.

Additional UPLINK information resulted in the following new sections:

2.1.5	Use of the Contiguous Block Update Verb.
2.1.5.1	CMC CSM/LM State Vector Update.
2.1.5.2	CMC Desired REFSMMAT Update.
2.1.5.3	CMC External DELTA V Update.
2.1.5.4	CMC Retrofire External DELTA V Update.
2.1.5.5	CMC Entry Update.
2.1.5.6	CMC Lambert Target Update.
2.1.5.7	CMC Lambert Return to Earth Update.

*Indicates an MIT Program Change Notice (PCN)

Date: November 1968

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP # R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 1 (Rev 237)

Section # 2 Title: Data Links (Revision 2)

This publication, a complete new revision (Rev 2), is expanded in many places over the previous one (Rev 1, dated June 1968). Only changes in specifications, resulting from the PCR/PCN information listed below, will be indicated by a solid-black line at the edge of the page along with the appropriate reference number at the bottom of the page. Any editorial changes will be marked by a vertical series of black dots at the page's edge.

PCR/PCN	Description of Change
PCR 439.1*	Deleted logic in P52 to check status of preferred orientation flag. It is not required now in the Preferred REFSMMAT Update.
PCR 237	Update GSOP, Section 2 Rev 1, for typing errors, scaling changes additions and revisions.
PCN 585*	Scaling in word 27b (Rend/Pre) should be changed to, "multiply by 18.52".
	FAILREG +2 may also contain a first digit of 1 or 5.
	Delete word "RESTART", IMODES 30, bit 7.

* Indicates an MIT Program Change Notice (PCN).

Note: PCR 207.1 was complied with in Revision 2 but was not indicated in the list above.

Date: March 1969

REVISION INDEX COVER SHEET

GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2 - COMANCHE (Rev 44 & 45)

Section #2 Title: Data Links (Revision 3)

This publication, a complete new revision (Rev. 3), is expanded in many places over the previous one (Rev. 2, dated November 1968). Only changes in specifications, resulting from the PCR/PCN information listed below, will be indicated by a solid black line at the edge of the page along with the appropriate reference number at the bottom of the page.** Any editorial changes will be marked by a vertical series of black dots at the page's edge.

PCR/PCN	Description of Change
PCR 250	Put $\dot{M}$ into erasable.
PCR 256	Eliminates R35 and fixed memory lunar landmarks.
PCR 266	Makes CSI/CDH data available on downlinks and corrects downlink addresses for R30 data.
PCR 269**	Changes to Section 2 COLOSSUS GSOP (Rev. 2).
PCR 606	Eliminates R60FLAG.
PCN 627.1*	Eliminates NTARGFLG.
PCR 656	Uprated TVC DAP.
PCN 662*	Deletes V67FLAG.
PCN 667*	Creates flagbit, AMOONFLG.
PCN 678*	Creates flagbit, V96ONFLG.
PCN 685*	Creates flagbit, NODOP01.
PCN 689*	Creates flagbit, SKIPVHF.
PCR 690	Creates flagbit, SLOWFLG.
PCR 691	Creates flagbit, RETROFLG.
PCN 693*	Creates flagbit, P21FLAG.
PCR 711	Issue SIV-B cutoff.
PCR 735	Place P11 on Powered List. Replace DELTAR with PACTOFF, YACTOFF on Coast and Align List.
PCN 746*	Entry Roll Error on Downlist.

* Indicates an MIT Program Change Notice (PCN).

** NOTE: Due to its magnitude, PCR 269 will not be written as a reference number at the bottom of a page when the change pertains only to PCR 269.

Date: June 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP # R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2 (MANCHE 45, Rev. 2)

Section #2 Title: Data Links (Revision 4)

This complete, new revision (Rev. 4), updates the previous publication (Rev. 3, dated March 1969) and incorporates the NASA/MSC approved change listed below.

PCR and PCN changes are indicated by denoting the applicable number at the bottom of the page and by marking the location of the change with a solid black line at the edge of the page. Editorial corrections (not covered by PCR) are denoted by a vertical series of black dots.

PCR	DESCRIPTION OF CHANGE
276*	Changes to COLOSSUS 2 (COMANCHE, Rev. 45) Section 2, Rev. 3.

Date: June 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP # R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2A (COMANCHE, Rev. 55)

Section # 2 Title: Data Links (Revision 5)

This publication, Rev. 5, is a supplement to the previous issue Rev. 4, dated June 1969, and incorporates PCR #275 described below. The supplementary pages are printed on tinted stock and marked 2A. When these tinted pages are included the document is a valid COLOSSUS 2A (COMANCHE, Rev. 55) configuration.

PCR	DESCRIPTION OF CHANGE
275	Change RCS selected rate from 4°/sec. to 2°/sec.

Date: July 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2C (Comanche, Rev. 67)

Section #2 Title: Data Links (Revision 6)

This publication, a complete new revision (Rev. 6) incorporates revisions as indicated below:

PCR/PCN	DESCRIPTION OF CHANGE
PCR 278	Fixed DUMPCNT
PCR 815	Digital Autopilot Barbecue Mode Routine
PCN 833*	SWTOVER Check
PCR 787	Make N63 Count during P61.
PCR 802.1	Save Alarm Data after "Error Reset"
PCR 785	Reverse V50N18 Logic in P20

NOTE: PCR 268.1, which should have been reflected in Rev. 5, was inadvertently overlooked at that time. It was processed in Rev. 6 (page 2-42)

*Indicates an MIT Program Change Notice (PCN).

Date: September 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2C (Comanche, Rev. 67)

Section #2 Title: Data Links (Revision 7)

This publication, a complete new revision (Rev. 7) incorporates revisions as indicated below:

PCR/PCN	DESCRIPTION OF CHANGE
PCR 791.1	Do not allow Proceed response to V21, V22, V23
PCR 798.1	Reset GLOKFAIL in R00
PCR 801.1	Make BAILOUT alarms 3xxxx, POODOO alarms 2xxxx
PCR 810	Yaw DAP CDU sampling
PCR 832.1	Remove restriction of R05 only in P00
PCN 835*	Change Recycle point on N63 in P61
PCR 812.1	Resetting and setting of XDELVFLG

*Indicates an MIT Program Change Notice (PCN).

Date: November 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2D (COMANCHE, Rev. 72)

Section No. 2 Title: Data Links (Rev. 8)

This publication, a complete new revision (Rev. 8) incorporates revisions as indicated below:

PCR/PCN	DESCRIPTION OF CHANGE
PCR 863.1	Make P76 set NODO flag
PCR 963	In R52 delete program alarm 407 and drive trunnion to 50° if desired trunnion > 50°
PCR 966	Clearing Preferred Orientation Flag
PCN 965 *	Define POOFLAG
PCR 961	SIVB-TB6 E-Memory Routine

* Indicates an MIT Program Change Notice (PCN).

Date: December 1969

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577	Title:	For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2D (MANCHE72, Rev. 3)
Section No. 2	Title:	Data Links (Rev. 9)

Attached are change-pages for, and a supplement page to, Section 2 Data Links of R-577 Guidance System Operations Plan for Manned CM Earth Orbital and Lunar Missions using Program COLOSSUS 2D.

The substitution of the white change-pages and the addition of the supplemental page in Rev. 8 (November 1969) will update this document to a COLOSSUS 2D (MANCHE72, Rev. 3) configuration.

PCR/PCN	DESCRIPTION OF CHANGE
PCR 984	Avoid Coarse Align During Saturn
PCN 992*	T6JOB OPCODE Correction

*Indicates an MIT Program Change Notice (PCN)

Date: March 1970

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2E

Section No. 2 Title: Data Links (Revision 10)

This publication, a complete new revision, incorporates the NASA/MSC approved changes, listed below.

PCR (PCN*)	TITLE
292	Add Time Display to V79
295	AK's on Powered Downlist
868	P23 Changes§
869	Rate Aided Optics Drive
916	Delete P17 and P77
917	Delete P31
921	N38 and N06 on Downlist
956	Time of Longitude
973	Move T6JOB to Fixed Memory
978	Check OPTMODES Bit 3 when V37 Requested
985	Delete P38, P39 and P78, P79
987	Rate-Aided Optics (P24)
991.1	Sum Uplink Data
993	P23 Auto Maneuver Change
994*	Elimination of Bit 1 of OPTMODES
1002*	GSOP Section 2 Rev 10 Editorial Changes

§ Additional material added in Revision 12.

Date: June 1970

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2E

Section No. 2 Title: Data Links (Revision 11)

Revision 11 incorporates the following NASA/MSC approved changes and becomes the control document for COLOSSUS 2E (Revision 108).

PCR (PCN*)	TITLE
302.1	Channel 77
315.1	Channel 77
995*	Check ENGONFLG, not SPS ENG ON outbit
1034	Deletion of Time of Longitude (P29)
1046*	Change Time to Perform IMUCDU Zero
1053*	GSOP Section 2 Rev 11 Editorial Changes

Date: October 1970

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2E

Section No. 2 Title: Data Links (Revision 12)

Revision 12 incorporates the following NASA/MSC approved changes and becomes the control document for COLOSSUS 2E (Rev. 108).

PCR (PCN*)	TITLE
857	Save 300 Performance Test Words
1041*	Add AVEGFLAG Check in Implementation of PCR 984
1102*	Section 2 Revision 12 GSOP Changes

Date: December 1970

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 2E

Section No. 2 Title: Data Links (Revision 13)

Revision 13 is published as change pages to Section 2, Revision 12. With the pages substituted it becomes the control document for COLOSSUS 2E. The following NASA/MSC approved changes are included in this revision.

PCR (PCN*)	TITLE
1131*	GSOP Editorial Changes

Date: February 1971

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 3

Section No. 2 Title: Data Links (Revision 14)

Revision 14 incorporates the following NASA/MSC approved changes and becomes the control document for COLOSSUS 3 (ARTEMIS Rev 72).

PCR (PCN*)	TITLE
318	Software Workaround for State Failures of Channel 31, bits 15, 14, 13
320	TLI Initiate/Cutoff Program
325	New Target - ΔV Program
326	R61 Maneuver Recomputation
328	P34 Elevation Angle Initialization to +000.00
331.1	Section 2 GSOP Additions
875*	Delete Certain Alarm Codes; Change Flagbit Definition
877*	New Impulsive Burn Logic
878*	New CSMMASS Update Logic
880*	Define VNFLAG
910*	Change Location of Flagbit REINTFLG
946*	Delete MGLVFLAG
948*	Delete Use of SAVECFLG in P23
1018*	Changes to Alarm Codes and Flagwords
1019*	Do Not Specify N20 with V40
1049	CSM Automatic Rendezvous Sequence (MINKEY)
1051	Universal Pointing
1054	Time of Longitude (P29)
1057*	GSOP Section 2 Flagword Description Changes
1063	P22 Mark Reject

PCR (PCN*)	TITLE
1069.1	Delete Rendezvous and Orbit Navigation Tests for Earth Orbit
1076	Input Bit Protection for Channel 33 Bits 4 and 5 AGC Control of Optics
1081*	Coding Change to Fix Anomaly COM 44 (Disabled DACs in S40.6)
1084*	Eliminate V37 Lockout During Optics Zero
1090*	3AXISFLG Resetting
1094*	Flag Resetting in POODOO Abort
1118	Change to Downlink Lists
1135*	Change GSOP Description of REINTFLG
1139*	R61 10° Test (P20 Option 0 and 1)
1142*	GSOP Sect. 2 Rev. 14 Changes

Date: September 1971

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-577 Title: For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 3.

Section No. 2 Title: Data Links (Revision 15)

Revision 15 does not reflect a change in the COLOSSUS 3 program. Rather, it contains technical and editorial changes which improve the quality of the document. Additional material has been added for several PCRs which were incompletely implemented in Revision 14. These changes are indicated by a solid bar in the margin. Other changes are indicated by a series of dots in the margin.

FOREWORD

SECTION 2, REVISION 15

The Guidance System Operations Plan (GSOP) for Program COLOSSUS is published in six sections as separate volumes:

1. Prelaunch
2. Data Links
3. Digital Autopilots
4. Operational Modes
5. Guidance Equations
7. Erasable Memory Programs

With this issue, Section 2 is revised from the previous issue of COLOSSUS GSOP (Revision 14, February 1971 for COLOSSUS 3).

Technical writing for this section was performed by Joseph Klawsnik.

The GSOP specifies an earth-orbital capability for all programs except P31 and aimpoint transfer between P34 and P40/41, and between P35 and P40/41. This capability has been provided; however, verification testing shall not be accomplished for earth-orbital rendezvous and earth-orbit navigation with P22.

This volume constitutes a control document to govern the structure of Uplink and Downlink programs in COLOSSUS 3. Revisions constituting changes to the COLOSSUS Program require NASA approval.

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SECTION 2

DATA LINKS

2.0 Introduction

This volume, Section 2 of the Guidance System Operations Plan for Manned CM Earth Orbital and Lunar Missions using Program COLOSSUS describes the GNCS Data Links: Digital Uplink to CMC (P27) and CM Digital Downlink for use on these missions.

The material of Section 2 of this GSOP is arranged:

2.1 Digital Uplink to CMC (P27)

By means of the CMC UPLINK, ground control can insert data or issue instructions to the CMC in the same manner that these functions are normally performed by the spacecraft crew in using the DSKY keyboard. The CMC is programmed to accept the following UPLINK inputs:

1. LIFTOFF TIME INCREMENT: Provides ground capability to increment or decrement the CMC clock, LM and CSM state vector times and TEPHEM (time) with a double precision octal time value, scaled centiseconds/2^{28}.

2. CONTIGUOUS BLOCK UPDATE: Provides ground capability to update from 1 to 18 consecutive E memory registers in the same EBANK.

3. SCATTER UPDATE: Provides ground capability to update from 1 to 9 non-consecutive E memory registers in the same or different EBANKs.

4. OCTAL CLOCK INCREMENT: Provides ground capability to increment or decrement the CMC clock with a double precision octal time value scaled centiseconds/2^{28}.

All information received by the CMC from the uplink is in the form of keyboard characters. Each character is assigned an identifying code number called its character code. Each character code transmitted to the CMC is sent as a triply redundant uplink word preceded by a leading "1" bit. Thus, if C is the 5-bit character code, then the 16 bit uplink word has the form:

$$1\ C\ \bar{C}\ C$$

where $\bar{C}$ denotes the bit-by-bit complement of C. (Table 2-1 defines all the legal input keycodes.) To these 16 bits of information the ground adds a 3-bit code specifying the system aboard the spacecraft which is to be the final recipient of the data and a 3-bit code indicating the spacecraft which should receive the information. The 22 total bits are sub-bit encoded (replacing each bit with a 5-bit code for transmission). If the message is received and successfully decoded, the on-board receiver will send back an 8-bit "message accepted pulse" to the ground and shift the original 16 bits of the uplink word to the CMC ($1\ C\ \bar{C}\ C$). The leading "1" bit causes an interrupt within the CMC after all 16 bits have been shifted from the uplink receiver. During ground testing the count of UPRUPTS and the sum of the $C\bar{C}C$ codes entering the AGC are accumulated in erasable registers, permitting a count and sum-check on data transmitted UPLINK to the AGC. This feature will not be used in flight because the summing of uplink data is disabled.

Any ground command sequence normally transmitted via the uplink may be duplicated by the astronaut via the keyboard. All reference to uplink words used in

TABLE 2-1

Character	Uplink Word
0	1 10000 01111 10000
1	1 00001 11110 00001
2	1 00010 11101 00010
3	1 00011 11100 00011
4	1 00100 11011 00100
5	1 00101 11010 00101
6	1 00110 11001 00110
7	1 00111 11000 00111
8	1 01000 10111 01000
9	1 01001 10110 01001
VERB	1 10001 01110 10001
NOUN	1 11111 00000 11111
ENTER	1 11100 00011 11100
ERROR RESET	1 10010 01101 10010
CLEAR	1 11110 00001 11110
KEY RELEASE	1 11001 00110 11001
+	1 11010 00101 11010
-	1 11011 00100 11011

NOTE: It is good operational procedure to end every uplink message with a KEY RELEASE.

this section are in the form transmitted from the uplink receiver to the CMC. Therefore, they do not contain the vehicle or subsystem addresses added by the ground facilities.

During update program (P27) execution, the following registers may be monitored via the P27 Downlink List:

1. UPBUFF - Contains all input data, including index value, ECADR value(s) and update parameters. There are 20 (decimal) UPBUFF registers numbered sequentially from UPBUFF + 0 to UPBUFF + 19D where the D indicates decimal notation.

2. UPVERB - Contains second digit of update verb being used, e.g., "0" for Verb 70, "1" for Verb 71, etc.

3. UPOLDMOD - Contains value of program interrupted by P27, e.g., 00, 02, or 20 for programs 00, 02, or 20; program 27 is inhibited from interrupting any other programs.*

4. COMPNUMB - Contains octal value of number of components to be processed by P27. Once set, it remains fixed during complete update operation.

5. UPCOUNT - Used for indexing UPBUFF. The contents of this register may vary from one (1) to the value contained in COMPNUMB. This register always contains the octal identifier of the parameter that is being loaded.

If the CMC received an improperly coded word from the uplink receiver during the load (i.e., not "1 C$\bar{C}$C") it sets BIT 4 of FLAGWRD7 to "one", which is transmitted via Downlink to the ground station. When this occurs, the ground station should correct the transmission by sending the following uplink word:

1 00000 00000 00000

(which clears the INLINK register) and follow this by transmitting "ERROR RESET" (which will set BIT 4 of FLAGWRD7 to zero).** If "CLEAR" is transmitted immediately following "ERROR RESET", the ground station then may begin the corrected transmission with the first word of the 5 octal digits that was being sent when the alarm condition occurred. The "CLEAR" button is used after the "ERROR RESET" to blank the data display register (R1). The ground station should then continue the update by using UPCOUNT to indicate the specific parameter being processed and resume the update function by re-transmitting the parameter beginning with the first octal character.

---

* It is possible to update when program lights are blanked by a FRESH START (MODREG is 77777_8).

** "ERROR RESET" must be sent via uplink to set BIT4 of FLAGWRD7 to zero. DSKY "ERROR RESET" has no effect.

If the ground wishes to continue loading without transmitting the "CLEAR" code it must determine which character was in error when failure occurred, and resume uplink transmission from the point of failure. This may be determined by monitoring the display in R1 as well as the contents of UPCOUNT.

This program may be entered only from P00, P02, or P20 Option 1, 2, or 5 for the CM. If the CMC is not in one of the programs indicated above when any update VERB is sent uplink, the "Operator Error" lamp will be illuminated, the uplink activity light will be turned "OFF" and the computer will ignore the request, via the specified update VERB, to transfer control to P27.

2.1.1 CM LIFTOFF TIME INCREMENT

To initiate a double precision LIFTOFF octal time increment the ground station transmits "VERB70ENTER".

2.1.1.1 Program 27 Verification

The ground station should then await confirmation via Downlink that the CMC is in Program 27.

If P27 is entered, the CMC puts the old program number in UPOLDMOD, sets UPCOUNT to "one", selects the P27 Downlink List for Downlink transmission and flashes V21N01 which requests a data load for UPBUFF + 0.

If P27 is entered for a Verb 70 update, 0 is placed in UPVERB and 2 is placed in COMPNUMB. Following P27 verification and confirmation of UPVERB and COMPNUMB sent via Downlink, the ground station should transmit the double precision octal time XXXXX ENTER XXXXX ENTER, where time is in centiseconds scaled 2^{-28}. A negative time value (decrement) should be transmitted in one's complement form. It should be noted that UPCOUNT is incremented by 1 after the ENTER following the most significant part of the double precision time. P27 uses the contents of UPCOUNT to calculate the next UPBUFF location for the V21N01.

2.1.1.2 Data Verification and Termination

After the final ENTER associated with the last update has been transmitted, P27 flashes V21N02 which is a request to the ground station to verify all the update data and to perform one of the following functions:

1. Accept all the update data entered
2. Modify some or all of the update data
3. Reject all of the update data

2.1.1.2.1 Accept All the Update Data Entered

If the ground station verifies that the content of the UPBUFF register is correct, it should transmit "VERB33ENTER" to signal P27 to process the update data. For the Verb 70 update, P27 inverts BIT 3 of FLAGWRD7 and determines if the State Vector data is being used by the orbital integration routine. If so, further P27 instruction executions are delayed (P27 dormant) until the integration routine is complete. A display of "27" in the program lights, along with a ground verification that BIT3 of FLAGWRD7 has been inverted and that the operator error light is "OFF", should indicate to the operator that the completion of P27 is temporarily being delayed.

After P27 is re-activated or if it initially finds that the integration routine is not in use, it will inhibit other routines from using State Vector data and complete the data verification requirements for the specific update Verb in use. (For each Verb, see appropriate verification section.)

2.1.1.2.1.1 Verb 70 Double Precision Time Verification

Program 27 verifies that the double precision octal time can be subtracted from the CMC clock without causing overflow. (For this operation two of the UPBUFF registers, UPBUFF + 18D and 19D, are used as temporary buffers for TIME2 and TIME1.) If the double precision input time can be subtracted from the CMC clock without causing overflow, P27 proceeds to increment TEPHEM and decrement the CMC clock, the CSM State Vector time, and the LM State Vector time. Program 27 will then turn the uplink activity light "OFF", replace the downlink list code in DNLSTCOD with the code for the previous program, release the State Vector data for other routines, and reinstate the previous program.

If, on the other hand, an overflow would occur, P27 will leave the CMC clock intact and turn the operator error light "ON". It will then turn the uplink activity light "OFF", replace the downlink list code in DNLSTCOD with the code for the previous program, release the State Vector data, and reinstate the previous program.

2.1.1.2.2 Modify Some or All of the Update Data

If during the verification time some of the UPBUFF registers are found to be in error, the ground station may make corrections by either of the following methods:

a. Individual parameters in UPBUFF + 0 to UPBUFF + 19D may be changed by sending a two digit octal identifier followed by the ENTER code. For example, if input word 2 (UPBUFF+1) required change, the ground station would transmit "02ENTER". This causes P27 to display the UPBUFF+1 address in R3 and flash V21N01, requesting a new octal data load from the ground. After transmission of the data and its ENTER code, P27 repeats the V21N02 flash to request data acceptance, modification or rejection (section 2.1.1.2). NOTE: If the octal identifier is $\leq$ 0 or $>$ COMPNUMB, P27 will continue the V21N02 flash and completely disregard the value just entered. It should also be noted that the contents of UPCOUNT is never changed during line by line correction.

b. If several parameters are to be modified, the ground station may change each separately as in step "a" above, or it may choose to terminate and re-initiate the load. To terminate the load the ground must transmit "VERB34ENTER" which will cause the CMC to return to the program it was in before the update was initiated. (P27 turns the uplink activity light "OFF", and switches to the previous Downlink list before returning control to the other program.) To resume its update the ground station would re-transmit the update VERB followed by the complete update load.

2.1.1.2.3. Reject All the Update Data

Update data may be rejected at any time by terminating a load. This is accomplished with the VERB34ENTER sequence described in part "b" of section 2.1.1.2.2.

2.1.1.2.4 Effects and Use of "VERB33ENTER"

1. During data loads and prior to the V21N02 flash, transmission of VERB33ENTER will be ignored by P27.

2. During V21N02 flashing, transmission of VERB33ENTER will initiate the procedure described in section 2.1.1.2.1.

3. If line by line correction is initiated (section 2.1.1.2.2), transmission of VERB33ENTER after the octal identifier has been entered will be ignored by P27.

2.1.2 CM Contiguous Block Update

To initiate a contiguous E-memory update the ground station should transmit "VERB71ENTER".

Before sending the update data the ground station should perform Program 27 verification as defined in the first three paragraphs of section 2.1.1.1. If P27 is entered, 1 is placed in UPVERB and in UPCOUNT.

The verb 71 data format is defined in section 2.1.2.1 below and the data load requirements are described in section 2.1.2.2.

2.1.2.1 VERB71 Data Entry Format

The VERB71 update data format is as follows (all Es represent ENTERs):

```
I I E
A A A A E
X X X X X E
X X X X X E
    .
    .
    .
X X X X X E
```

where:

1. $3 \leq$ II $\leq$ 24 octal. This is the index value used by P27 to process the update data. The index value represents the total number of numeric quantities to be loaded, including the index value itself, the starting address (ECADR) and the update parameters(s). The minimum value of 3 is for a single update parameter load. A maximum value of 24 octal is allowed since the UPBUFF capacity is a 20 (decimal) register buffer for P27. This value represents a maximum of 18 update parameters in addition to the index count and the starting E memory address.

2. AAAA is the first E memory address (ECADR) of the update block to be processed. Bits 1-8 indicate the relative address ($0\text{-}377_8$) within the selected EBANK and bits 9-11 identify the desired EBANK (0-7). Also, for one data load operation, all update parameters must ultimately be stored in the same EBANK. Therefore, the starting address and the length of the block must be chosen so that the complete load is contained in the same EBANK; i.e., (bits 8 - 1 of AAAA) + II-3 must be $\leq$ 377 octal.

3. X X X X X is octal data which is to be loaded. This data is stored in sequential order in UPBUFF+2 and following, up to UPBUFF+19D. Scaling of the data must be the same as that of the internal CMC registers.

2.1.2.2 Data Load Requirements by Ground Station

Following Program 27 verification (V21N01 flashes with the UPBUFF+0 address displayed in R3) the ground station should enter the update data in the manner described below.

2.1.2.2.1 Index Value

The index value I I should be entered as an octal number and visually verified (displayed in R1) prior to transmitting the ENTER code. This value should be within the specified limits (see part 1 section 2.1.2.1 for format).

If an index value < 3 or > 24 octal is erroneously keyed-in followed by the ENTER code, P27 will reject the value and will continue to flash V21N01 until the ground station enters an index value within the specified limits. (Entry of a legal value is indicated when the UPBUFF+1 address value is displayed in R3 and UPCOUNT contains a 2).

If a legal index value is keyed-in but is found to be in error (displayed in R1) before the ENTER code is transmitted, the operator may correct his error by depressing the "CLEAR" key and re-transmitting the new index value followed by the ENTER code. A legally entered value is stored in UPBUFF+0 and COMPNUMB. UPCOUNT is incremented by 1, the next UPBUFF location is computed and V21N01 continues to flash indicating a request for an ECADR load.

If, however, the ground station operator loads a legal index value followed by the ENTER code and then discovers the numeric value to be incorrect (UPBUFF+0 display), then the only means of recovery is to terminate the load (VERB34ENTER) and re-initiate the update VERB. This procedure is necessary since invalid index values cannot be changed if entered in COMPNUMB and will therefore result in an incorrect update if it is not immediately modified.

2.1.2.2.2 E Memory Address Value

The second octal data word to be entered must be the first E memory address (ECADR) of the update data block.

The ENTER code following the ECADR causes P27 to store this value in UPBUFF+1, increment UPCOUNT by 1, compute the next UPBUFF location and continue the V21N01 flash which requests an update data load.

2.1.2.2.3 Update Data

The update parameters which will be stored in sequential E memory locations beginning with a legitimate E memory address (ECADR), as defined in part 2 of section 2.1.2.1, may be loaded in two separate ways.

1. Each octal value may be individually entered and visually verified (address of data is displayed in R3 and data is displayed in R1) prior to transmitting the ENTER code.

   If data is in error the operator may depress the "CLEAR" key and retransmit the correct octal value followed by the ENTER code. This code causes P27 to store the data in the UPBUFF address specified in R3. If more data follows, UPCOUNT is incremented by 1, the next UPBUFF location is computed and V21N01 continues to flash.

   This method of input allows the ground station to make immediate corrections if data errors are detected and to visually verify that each data word is loaded into its specified E memory location.

2. The second method of input is to transmit all the octal update data as quickly as possible and then perform a visual verification of all the data in the UPBUFF registers as specified in section 2.1.1.2.

2.1.2.3 VERB71 Contiguous Block Update Verification

The last ENTER of the update sequence causes P27 to flash V21N02. This is a request to the ground station to accept, modify or completely reject the data load as specified in 2.1.1.2 sections.

VERB33ENTER also causes P27 to check the validity of the ECADR value stored in UPBUFF+1 (this value must meet the requirements specified in part 2 of section 2.1.2.1). If the ECADR value is illegal, P27 rejects all input data, replaces Program 27 with the previous program value, turns the uplink activity light "OFF", turns the operator error light "ON" and switches to the Downlink list for the previous program.

A valid ECADR causes P27 to transfer all the update data from the UPBUFF registers into the specified E memory registers, replace program 27 with the previous program value, turn the uplink activity light "OFF", switch to the Downlink list for the previous program and release the State Vector data.

2.1.3 CM Scatter Update

To initiate an E memory update in non-contiguous E memory locations the ground station should transmit "VERB72ENTER".

Before sending the update data the ground station should perform Program 27 verification as defined in the first two paragraphs of section 2.1.1.1.

If P27 is entered for a VERB72 update, a 2 is placed in UPVERB and a 1 in UPCOUNT. Following P27 verification the ground station performs this update exactly as described for the VERB71 updates. The differences in these two update verbs are noted in the following section.

2.1.3.1 VERB72 Data Entry Format

The VERB72 update format is defined as follows:

I I E
A A A A E
X X X X X E
A A A A E
X X X X X E
.
.
.
A A A A E
X X X X X E

where:

1. 3 ≤ I I ≤ 24 octal. The difference between this index value and the VERB71 index value is that this value must always be odd. This is due to the fact that each update parameter must have its specified E memory address. Thus, the index count includes itself and up to 9 pairs of update words. An even number index value, although accepted at this point in the procedure, will cause rejection of VERB72 data as indicated in section 2.1.3.3. Additionally, Program 27 is replaced with the previous program value, the uplink activity light is turned "OFF", the operator error light is turned "ON", the State Vector data is released and the Downlink list is switched for use by the previous program.

2. All A A A As represent the ECADRs. (Each A A A A is the ECADR of the register to be loaded with the X X X X X immediately following.) Note that update data entered via VERB72 may be loaded into different EBANKs.

3. All X X X X Xs are in octal and scaled the same as the internal CMC registers.

2.1.3.2 Data Load Requirements by Ground Station

The load requirements of VERB72 are identical to VERB71 (see sections 2.1.2.2 and 2.1.2.2.1 through 2.1.2.2.3).

2.1.3.3 VERB72 Scatter Update Verification

The last ENTER of the update sequence will cause P27 to flash V21N02. This is a request to the ground to accept, modify or completely reject the data load as specified in 2.1.1.2 sections.

VERB33ENTER causes P27 to verify that COMPNUMB is odd. If COMPNUMB is even, P27 will not transfer the data into the specified E memory registers; instead it will turn on the Operator Error Light, turn off Uplink Activity Light, transfer to previous program and downlist.

If, however, COMPNUMB is valid P27 will perform exactly as specified in the third paragraph of section 2.1.2.3.

2.1.4 CMC Octal Clock Increment

To initiate a double precision octal time increment the ground station transmits "VERB73ENTER".

The loading procedure for this update is identical to the VERB70 update defined in section 2.1.1 except that 3 is placed in UPVERB instead of 0.

If the update is acceptable, it is immediately used to increment the clock (i.e., positive double precision time is added to the clock). No delay is encountered if the orbital integration routine is in use since the CSM and LM state vector time registers and the TEPHEM register are not modified.

2.1.5 Use of the Contiguous Block Update VERB

VERB 71, defined in section 2.1.2, can be used to perform the following updates:

1. CMC CSM/LM STATE VECTOR UPDATE
2. CMC DESIRED REFSMMAT UPDATE
3. CMC REFSMMAT UPDATE
4. CMC EXTERNAL DELTA V UPDATE
5. CMC RETROFIRE EXTERNAL DELTA V UPDATE
6. CMC ENTRY UPDATE
7. CMC LANDING SITE VECTOR UPDATE

In defining each of these updates, it is assumed that the ground station has transmitted VERB71 ENTER and performed Program 27 verification as required prior to transmittal of the index value, ECADR and update parameters. It is also assumed that final verification of each update will be done as specified in section 2.1.2.3.

2.1.5.1 CMC CSM/LM STATE VECTOR UPDATE

This data consists of a single precision state vector identifier, three (3) double precision components of position, three (3) double precision components of velocity and a double precision time. The identifier (UPSVFLAG) indicates CSM or LM and whether coordinates are earth-centered or moon-centered as follows:

1 = CSM	earth-centered *	2 = CSM	moon-centered
-1 = LM		-2 = LM	

Note that the CMC, at the next permanent memory state-integration, may change the origin, based upon computed position. The position and velocity components should be in reference coordinates scaled as follows:

	earth-centered	moon-centered
Position	meters/2^{29}	meters/2^{27}
Velocity	(meters/centisecond)/2^7	(meters/centisecond)/2^5

The time associated with the state vector should be relative to CMC clock zero. The identifier is scaled units/2^{14}. Time is scaled centiseconds/2^{28}.

The CMC is a fixed point machine with the point just to the left of the most significant bit.

The scaling indicated above will be sufficient to force the 3 components of position and the 3 components of velocity and time to numbers less than one.

To form the double precision quantities ready for coding and transmission, the scaled magnitudes of time and each component of position and velocity should be expressed as two binary words as follows:

*If a quantity other than 0, -0, 2 or -2 is loaded into UPSVFLAG, the data will also be interpreted as earth-centered. A 0 or -0 will update the UPSVFLAG erasable but the CMC will not perform a state vector update. In the other numeric cases a valid state vector update will be performed (earth-center).

1st word:

0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}

2nd word:

0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}

Each X above represents a binary bit of the appropriate magnitude, the place value of which is indicated below the corresponding X. Once the magnitude of the component is accounted for in the above 28 X's, the sign must be considered.

If the component is positive, the words remain as formed; if the component is negative, the "1s complement" of the 2 words is used (all 1's are replaced by 0's and all 0's by 1's.)

The first word is then transformed into a 5 character octal word. The first character is the octal equivalent of the first three bits, the second character is the octal equivalent of the next three bits, etc. This word is referred to as the "most significant part" of data in the text below. Similarly, the second word is transformed into a 5 character octal word which is the "least significant part" of the data. Table 2-1 lists all the uplink characters with their corresponding binary format.

The CMC CSM/LM STATE VECTOR UPDATE data must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	21_8	(index value) ENTER
2	(AAAA)*	(ECADR - UPSVFLAG) ENTER
3	XXXXX	(identifier) ENTER
4	XXXXX	(most sig. part of X position) ENTER
5	XXXXX	(least sig. part of X position) ENTER
6	XXXXX	(most sig. part of Y position) ENTER
7	XXXXX	(least sig. part of Y position) ENTER
10_8	XXXXX	(most sig. part of Z position) ENTER
11_8	XXXXX	(least sig. part of Z position) ENTER

* Refer to Paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

ع

Octal Identifier	Data Value	Data Definition
12_8	XXXXX	(most sig. part of X velocity) ENTER
13_8	XXXXX	(least sig. part of X velocity) ENTER
14_8	XXXXX	(most sig. part of Y velocity) ENTER
15_8	XXXXX	(least sig. part of Y velocity) ENTER
16_8	XXXXX	(most sig. part of Z velocity) ENTER
17_8	XXXXX	(least sig. part of Z velocity) ENTER
20_8	XXXXX	(most sig. part of time from CMC clock zero) ENTER
21_8	XXXXX	(least sig. part of time from CMC clock zero) ENTER

where each "A", "X" and "ENTER" above represent an uplink word.

2.1.5.2 CMC DESIRED REFSMMAT UPDATE

XSMD - XSMD + 17 is a 3 x 3 double precision matrix which represents the Reference to Stable Member Desired Transformation.

The elements of the matrix are scaled, units/2^1.

The following relations must hold:

1. The inner product of any row with itself must equal 0.25
2. The inner product of any column with itself must equal 0.25
3. The inner product of any row with another row must equal 0
4. The inner product of any column with another column must equal 0

The CMC DESIRED REFSMMAT UPDATE must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	24_8	(index value) ENTER
2	(AAAA)*	(ECADR-XSMD) ENTER
3	XXXXX	(most sig. part of Row 1 Col. 1) ENTER
4	XXXXX	(least sig. part of Row 1 Col. 1) ENTER
5	XXXXX	(most sig. part of Row 1 Col. 2) ENTER
6	XXXXX	(least sig. part of Row 1 Col. 2) ENTER
7	XXXXX	(most sig. part of Row 1 Col. 3) ENTER
10_8	XXXXX	(least sig. part of Row 1 Col. 3) ENTER
11_8	XXXXX	(most sig. part of Row 2 Col. 1) ENTER

*Refer to Paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

Octal Identifier	Data Value	Data Definition
12_8	XXXXX	(least sig. part of Row 2 Col. 1) ENTER
13_8	XXXXX	(most sig. part of Row 2 Col. 2) ENTER
14_8	XXXXX	(least sig. part of Row 2 Col. 2) ENTER
15_8	XXXXX	(most sig. part of Row 2 Col. 3) ENTER
16_8	XXXXX	(least sig. part of Row 3 Col. 3) ENTER
17_8	XXXXX	(most sig. part of Row 3 Col. 1) ENTER
20_8	XXXXX	(least sig. part of Row 3 Col. 1) ENTER
21_8	XXXXX	(most sig. part of Row 3 Col. 2) ENTER
22_8	XXXXX	(least sig. part of Row 3 Col. 2) ENTER
23_8	XXXXX	(most isg. part of Row 3 Col. 3) ENTER
24_8	XXXXX	(least sig. part of Row 3 Col. 3) ENTER

2.1.5.3 CMC REFSMMAT UPDATE

REFSMMAT - REFSMMAT + 17D is a 3 x 3 matrix used to convert between reference coordinates and stable member coordinates. The elements of the matrix are scaled, units/2^1.

The CMC REFSMMAT UPDATE must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	24_8	(index value) ENTER
2	(AAAA)*	(ECADR - REFSMMAT) ENTER
3	XXXXX	(most sig. part of Row 1 Col. 1) ENTER
4	XXXXX	(least sig. part of Row 1 Col. 1) ENTER
5	XXXXX	(most sig. part of Row 1 Col. 2) ENTER
6	XXXXX	(least sig. part of Row 1 Col. 2) ENTER
7	XXXXX	(most sig. part of Row 1 Col. 3) ENTER
10_8	XXXXX	(least sig. part of Row 1 Col. 3) ENTER
11_8	XXXXX	(most sig. part of Row 2 Col. 1) ENTER
12_8	XXXXX	(least sig. part of Row 2 Col. 1) ENTER

* Refer to paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

Octal Identifier	Data Value	Data Definition
13_8	XXXXX	(most sig. part of Row 2 Col. 2) ENTER
14_8	XXXXX	(least sig. part of Row 2 Col. 2) ENTER
15_8	XXXXX	(most sig. part of Row 2 Col. 3) ENTER
16_8	XXXXX	(least sig. part of Row 2 Col. 3) ENTER
17_8	XXXXX	(most sig. part of Row 3 Col. 1) ENTER
20_8	XXXXX	(least sig. part of Row 3 Col. 1) ENTER
21_8	XXXXX	(most sig. part of Row 3 Col. 2) ENTER
22_8	XXXXX	(least sig. part of Row 3 Col. 2) ENTER
23_8	XXXXX	(most sig. part of Row 3 Col. 3) ENTER
24_8	XXXXX	(least sig. part of Row 3 Col. 3) ENTER

2.1.5.4 CMC EXTERNAL DELTA V UPDATE

This data consists of three velocity components in local vertical coordinates, and the time of ignition. The scale factors are .

1. $DELVSLV_{x, y, z}$ (meters/centisecond)/2^7
   $DELVSLV_{x, y, z}$ must be in a local vertical system at an origin which corresponds to the CM state (earth-centered or moon-centered) at TIG.
2. TIG centiseconds/2^{28}

The velocity components, sent from the ground must be in the local vertical system defined by the CMC-determined, CSM state vector at TIG-30. In addition, in order for an update to be accepted properly when near the sphere, the CMC must not change the sphere reference between TIG-30 and TIG.

The CMC EXTERNAL DELTA V UPDATE data must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	12_8	(index value) ENTER
2	(AAAA)*	(ECADR - DELVSLV) ENTER
3	XXXXX	(most sig. part of $DELVSLV_x$) ENTER
4	XXXXX	(least sig. part of $DELVSLV_x$) ENTER
5	XXXXX	(most sig. part of $DELVSLV_y$) ENTER
6	XXXXX	(least sig. part of $DELVSLV_y$) ENTER
7	XXXXX	(most sig. part of $DELVSLV_z$) ENTER
10_8	XXXXX	(least sig. part of $DELVSLV_z$) ENTER
11_8	XXXXX	(most sig. part of TIG) ENTER
12_8	XXXXX	(least sig. part of TIG) ENTER

* Refer to paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

2.1.5.5 CMC RETROFIRE EXTERNAL DELTA V UPDATE

This data consists of the latitude and longitude of the entry target, three velocity components in local vertical coordinates and the time of ignition. The scale factors are:

1. GEODETIC LAT(SPL) degrees/360 (North positive)
2. LNG (SPL) degrees/360 (East positive)
3. $DELVSLV_{x,y,z}$ (meters/centisecond)/2^7
4. TIG centiseconds/2^{28}

The CMC RETROFIRE EXTERNAL DELTA V UPDATE date must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	16_8	(index value) ENTER
2	(AAAA)*	(ECADR- LAT(SPL)) ENTER
3	XXXXX	(most sig. part of LAT (SPL)) ENTER
4	XXXXX	(least sig. part of LAT (SPL)) ENTER
5	XXXXX	(most sig. part of LNG (SPL)) ENTER
6	XXXXX	(least sig. part of LNG (SPL)) ENTER
7	XXXXX	(most sig. part of $DELVSLV_x$) ENTER
10_8	XXXXX	(least sig. part of $DELVSLV_x$) ENTER
11_8	XXXXX	(most sig. part of $DELVSLV_y$) ENTER
12_8	XXXXX	(least sig. part of $DELVSLV_y$) ENTER
13_8	XXXXX	(most sig. part of $DELVSLV_z$) ENTER
14_8	XXXXX	(least sig. part of $DELVSLV_z$) ENTER
15_8	XXXXX	(most sig. part of TIG) ENTER
16_8	XXXXX	(least sig. part of TIG) ENTER

2.1.5.6 CMC ENTRY UPDATE

This data consists of the latitude and longitude of the entry target. The scale factors are:

1. GEODETIC LAT(SPL) degrees/360 (North positive)
2. LNG (SPL) degrees/360 (East positive)

The CMC ENTRY UPDATE data must be sent in the following sequence:

* Refer to paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

Octal Identifier	Data Value	Data Definition
1	06_8	(index value) ENTER
2	(AAAA)*	(ECADR-LAT (SPL)) ENTER
3	XXXXX	(most sig. part of LAT (SPL)) ENTER
4	XXXXX	(least sig. part of LAT (SPL)) ENTER
5	XXXXX	(most sig. part of LNG (SPL)) ENTER
6	XXXXX	(least sig. part of LNG (SPL)) ENTER

2.1.5.7 CMC Landing Site Vector Update

This data consists of three double-precision position components X, Y, Z, defining the lunar landing site in moon-fixed coordinates, scaled meters/2^{27}.

The CMC LANDING SITE VECTOR UPDATE data must be sent in the following sequence:

Octal Identifier	Data Value	Data Definition
1	10_8	(index value) ENTER
2	(AAAA)*	(ECADR-RLS) ENTER
3	XXXXX	(most sig. part of RLS X-component) ENTER
4	XXXXX	(least sig. part of RLS X-component) ENTER
5	XXXXX	(most sig. part of RLS Y-component) ENTER
6	XXXXX	(least sig. part of RLS Y-component) ENTER
7	XXXXX	(most sig. part of RLS Z-component) ENTER
10_8	XXXXX	(least sig. part of RLS Z-component) ENTER

* Refer to paragraph 2.1.6 to obtain the absolute address (ECADR) for this UPDATE.

2.1.6. Absolute Addresses for UPDATE Program

```
ASSEMBLE REVISION 072 OF AGC PROGRAM ARTEMIS BY NASA 2021114-011
 ABSOLUTE LOCATIONS FOR UPDATES


                      ECADR            MNEMONIC
                      -----            --------
                      01501     ECADR  UPSVFLAG

                      00306     ECADR  XSMD

                      01733     ECADR  REFSMMAT

                      03404     ECADR  DELVSLV

                      03400     ECADR  LAT(SPL)


                      02025     ECADR  RLS
```

2.2 CMC Digital Downlink

The downlink format is controlled by a CMC program. This program is entered on an interrupt caused by an "endpulse" from the telemetry system. The program loads the content of the next two 16-bit CMC registers that are to be transmitted into channels 34 and 35. The loading is accomplished according to the format described in the next paragraph.

Each downlist word consists of 33 significant bits plus seven repetition bits. The first bit is a "word order code bit". The next 16 bits comprise the contents of one 16-bit CMC register (15 bits of data followed by an odd parity bit). The final 16 bits are the content of another 16-bit CMC register. Since the spacecraft downlink is organized in 8-bit segments, seven "filler bits" are transmitted to follow the 33 bits outlined above in order to use all the downlink space available. These filler bits are repetitions of the first seven bits of the first CMC register transmitted.

Thus the form in which the content of the two CMC registers is arranged for transmission as a sequence of 40 CMC downlink bits (represented by X) on channels 34 and 35 may be pictured as shown in the table below:

		Channel 34																
Reg #1	X Word Order Code	X 15_1	X 14_1	X 13_1	X 12_1	X 11_1	X 10_1	X 9_1	X 8_1	X 7_1	X 6_1	X 5_1	X 4_1	X 3_1	X 2_1	X 1_1	X P_1	word
		Channel 35																
Reg #2		X 15_2	X 14_2	X 13_2	X 12_2	X 11_2	X 10_2	X 9_2	X 8_2	X 7_2	X 6_2	X 5_2	X 4_2	X 3_2	X 2_2	X 1_2	X P_2	
		Channel 34																
Reg #1		X 15_1	X 14_1	X 13_1	X 12_1	X 11_1	X 10_1	X 9_1										repeat

Table Showing CMC Downlink Bits

The first word in any list contains the "ID" and synchronization registers and has a word order code bit of zero. (All other downlink words have word order code bits of one except word 51 on the standard downlists which has a word order code bit of zero to indicate the mid-point of the standard downlists.) The ID register marks the beginning of a list and identifies the list being transmitted. The synchronization (sync) register always contains the same sixteen bits (111 111 011 100 000 0), which are used to synchronize remote site downlink processing equipment. The content of the standard lists and the programs in which they are transmitted are described in section 2.2.2.

The standard CMC downlink lists contain 100 downlink words (200 CMC registers). The CMC digital downlink is transmitted at a rate of 50 words per second at high bit rate and 10 words at low bit rate. Therefore, transmission of the standard list requires two seconds at high bit rate and ten seconds at the low bit rate.

2.2.1 Erasable Memory Dump Downlist

Upon reception of a Verb 74 Enter from the keyboard or the uplink, the computer will interrupt the nominal downlist being transmitted and start transmitting the erasable memory dump downlist. The first word of the erasable memory dump downlist is an ID word, 01777_8 and the same pattern of synch bits as on the standard list. The word order code for this downlink word will be zero. The next 129 downlink words have word order codes of one and make up the remainder of the 130 word dump downlink list. Word 2 of this list (i.e., the word following the ID word) contains a "packed indicator" code in the first register and the contents of TIME1 in the second register. TIME1 is the least significant clock register and is described later in this section under the standard lists. The "packed indicator" identifies which erasable bank and which pass through that bank is contained in the present list as follows:

Bits 15 & 14 - zero
Bits 13 & 12 - 00 for 1st pass
01 for 2nd pass

Bits 11 thru 9 - gives EBANK number
Bits 8 thru 1 - zeros

The next 128 downlink words (256 registers) are the contents of the erasable bank indicated in the packed indicator.

After transmitting the 130 downlink word list (one ID word, one packed indicator and time word, and 128 data words), the downlink will transmit the ID word again, followed by the packed indicator, followed by the contents of the next erasable bank etc. In this way, one complete pass through erasable memory will require 20.8 seconds for high bit rate, and 104 seconds for low bit rate. The computer will make two complete passes through the complete erasable memory before returning to the standard downlist.

NOTE: After completion of the erasable dump downlist the current downlist will be started at the ID word. Since no programs are interrupted during the transmission of the erasable memory downlist, some of the registers transmitted may have different contents on different passes through the erasable.

2.2.2 Standard Downlists

For this mission there are five standard downlists, each associated with a set of programs, as follows:

A. The Powered List is transmitted during

11 Earth Orbit Insertion (EOI) Monitor
15 TLI Initiate/Cutoff Program
40 SPS Thrust
41 RCS Thrust
47 Thrust Monitor
61 Entry Preparation Program

B. The Coast and Align List is transmitted during

00 CMC Idling
01 Prelaunch Initialization
02 Gyro Compassing
03 Optical Verification of Gyro Compassing
06 CMC Power Down
07 System Test
51 IMU Orientation Determination
52 IMU Realign
53 Backup IMU Orientation Determination
54 Backup IMU Realign

C. The Rendezvous and Prethrust List is transmitted during

20 Universal Tracking
21 Ground Track Determination
23 Cislunar Midcourse Navigation
29 Time of Longitude Program
30 External ΔV Maneuver Guidance
31 Height Adjust Maneuver (HAM)
32 Co-elliptic Sequence Initiation (CSI)
33 Constant Differential Altitude (CDH)
34 Transfer Phase Initiation (TPI) Guidance
35 Transfer Phase Midcourse (TPM) Guidance
36 Plane Change Maneuver (PC)
37 Return to Earth Maneuver Guidance
72 LM CSI Targeting
73 LM CDH Targeting
74 LM Transfer Phase Initiation (TPI) Targeting
75 LM Transfer Phase Midcourse (TPM) Targeting

76 Target ΔV

77 CSM Velocity Vector Update

79 Final Rendezvous Program

D. The Entry and Update List is transmitted during

27 CMC Update

62 CM/SM Separation and Pre-entry Maneuver

63 Entry Initialization

64 Post 0.05 G Entry Mode

65 Up Control Entry Mode

66 Ballistic Entry Mode

67 Final Entry Mode

E. The P-22 List is transmitted during

22 Orbital Navigation

24 Rate-Aided Optics Tracking

The list switching is accomplished as follows: Whenever a new program is entered, it sets up a request for its list by placing the appropriate code in the register, DNLSTCOD. The downlink program will transmit the complement of this code as the ID and use the code to select the appropriate list. The complete list is then transmitted even if DNLSTCOD is changed during it. This procedure is, of course, not true for the erasable memory dump downlist (see Section 2.2.1), which completes its required number of passes irrespective of other programs. A computer "restart" (hardware), or "fresh start" will immediately cause the telemetry list to start with word #1. A "restart" (hardware) will begin the list whose code is in DNLSTCOD but a "fresh start" will always set DNLSTCOD to transmit the Coast and Align list. An erasable memory dump, if in process, will be interrupted in both cases, and regular downlist transmission resumed.

Since certain data on the standard downlink lists are only meaningful when considered in multiregister arrays and since the programs which compute these arrays are not synchronized with the downlink program, a "snapshot" is taken of these words so that changes in their values will not occur while these arrays are being transmitted to the ground. When a "snapshot" is taken several words are stored at the time the first word is transmitted. The other words in the downlist are read at the time of transmission and therefore the only time homogeneity for them is between the two registers making up a single word. The COLOSSUS downlists have the following "snapshots":

Powered List	words 2-8, 9-13, 52-58, 59-63
Coast and Align List	words 2-8, 9-13, 52-58, 59-63
Rendezvous and Prethrust List	words 2-8, 9-13, 52-58, 59-63
Entry and Update List	words 2-8, 9-13, 52-58, 59-63
P-22 List	words 2-8, 9-13, 18-24, 25-31, 32-35, 52-54, 59-63

The following is a list of CMC registers making up the various downlists. A register may contain other quantities during programs in which the CMC no longer needs to save the primary downlist quantity.

2.2.2.1 Powered List

Word Number	Contents: First Register	Second Register
1	I.D. (77774_8)	Synch Bits (77340_8)
2	CSM State Vector (R_X)	CSM State Vector (R_X)
3	CSM State Vector (R_Y)	CSM State Vector (R_Y)
4	CSM State Vector (R_Z)	CSM State Vector (R_Z)
5	CSM State Vector (V_X)	CSM State Vector (V_X)
6	CSM State Vector (V_Y)	CSM State Vector (V_Y)
7	CSM State Vector (V_Z)	CSM State Vector (V_Z)
8	CSM State Vector Time	CSM State Vector Time
9	Actual X CDU angle	Actual Y CDU angle
10	Actual Z CDU angle	Optics CDU Trunnion Angle
11	ADOTS roll or OGARATE	ADOTS roll or OGARATE
12	ADOTS pitch or OMEGA B pitch	ADOTS pitch or OMEGA B pitch
13	ADOTS yaw or OMEGA B yaw	ADOTS yaw or OMEGA B yaw
14	X attitude error	Y attitude error
15	Z attitude error	RCS flags
16	THETADX	THETADY
17	THETADZ	Garbage
18	TIG	TIG
19	T_F Lambert	T_F Lambert
20	RTARGX	RTARGX
21	RTARGY	RTARGY
22	RTARGZ	RTARGZ
23	TGO	TGO
24	PIPTIME1	PIPTIME1
25	DELVX	DELVX
26	DELVY	DELVY
27	DELVZ	DELVZ
28	PACTOFF	YACTOFF
29	PCMD	YCMD
30	CSTEER	Garbage
31	CSI and CDH ΔVX	CSI and CDH ΔVX
32	CSI and CDH ΔVY	CSI and CDH ΔVY
33	CSI and CDH ΔVZ	CSI and CDH ΔVZ
34	REFSMMAT (R_1C_1)	REFSMMAT (R_1C_1)
35	REFSMMAT (R_1C_2)	REFSMMAT (R_1C_2)
36	REFSMMAT (R_1C_3)	REFSMMAT (R_1C_3)

Contents

Word Number	First Register	Second Register
37	REFSMMAT (R_2C_1)	REFSMMAT (R_2C_1)
38	REFSMMAT (R_2C_2)	REFSMMAT (R_2C_2)
39	REFSMMAT (R_2C_3)	REFSMMAT (R_2C_3)
40	Flagword 0	Flagword 1
41	Flagword 2	Flagword 3
42	Flagword 4	Flagword 5
43	Flagword 6	Flagword 7
44	Flagword 8	Flagword 9
45	DSPTAB+0	DSPTAB+1
46	DSPTAB+2	DSPTAB+3
47	DSPTAB+4	DSPTAB+5
48	DSPTAB+6	DSPTAB+7
49	DSPTAB+8D	DSPTAB+9D
50	DSPTAB+10D	DSPTAB+11D
51	TIME 2	TIME 1
52	LM State Vector (R_X)	LM State Vector (R_X)
53	LM State Vector (R_Y)	LM State Vector (R_Y)
54	LM State Vector (R_Z)	LM State Vector (R_Z)
55	LM State Vector (V_X)	LM State Vector (V_X)
56	LM State Vector (V_Y)	LM State Vector (V_Y)
57	LM State Vector (V_Z)	LM State Vector (V_Z)
58	LM State Vector Time	LM State Vector Time
59	Actual X CDU angle	Actual Y CDU angle
60	Actual Z CDU angle	Optics CDU trunnion angle
61	ADOTS roll or OGARATE	ADOTS roll or OGARATE
62	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
63	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
64	X attitude error	Y attitude error
65	Z attitude error	RCS flags
66	THETADX	THETADY
67	THETADZ	Garbage
68	* RSBBQ	RSBBQ+1
69	Garbage	Channel 77
70	* C31FLWRD	FAILREG
71	* FAILREG+1	FAILREG+2
72	Optics Shaft	PIPAX
73	PIPAY	PIPAZ

* Indicates two single precision quantities that are not indicated otherwise.

Contents

Word Number	First Register	Second Register
74	Elevation Angle	Elevation Angle
75	Central Angle	Central Angle
76	Spare	Spare
77	Flagword 10	Flagword 11
78	TEVENT	TEVENT
79	PCMD	YCMD
80	OPTMODES	HOLDFLAG
81	LM MASS	CM MASS
82	DAPDATR1	DAPDATR2
83	ERROR X	ERROR Y
84	ERROR Z	Garbage
85	WBODY (roll) or OMEGAC (roll)	WBODY (roll) or OMEGAC (roll)
86	WBODY (pitch) or OMEGAC (pitch)	WBODY (pitch) or OMEGAC (pitch)
87	WBODY (yaw) or OMEGAC (yaw)	WBODY (yaw) or OMEGAC (yaw)
88	REDO COUNTER	Desired FINAL CDUX
89	Desired FINAL CDUY	Desired FINAL CDUZ
90	IMODES 30	IMODES 33
91	Channel 11	Channel 12
92	Channel 13	Channel 14
93	Channel 30	Channel 31
94	Channel 32	Channel 33
95	VGTIGX	VGTIGX
96	VGTIGY	VGTIGY
97	VGTIGZ	VGTIGZ
98	CDH ΔVX	CDH ΔVX
99	CDH ΔVY	CDH ΔVY
100	CDH ΔVZ	CDH ΔVZ

2.2.2.2 Powered List

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Word Number	Contents
1a	ID word for this list. It will contain 77774_8.
1b	Synch bits. It will contain 77340_8.
2-8	CSM STATE VECTOR and TIME. The CMC's latest calculated state vector for the CSM in either earth-centered or moon-centered reference coordinates. During the Orbital Integration Routine, the sphere of influence will be indicated by Flagword 8, bit 12 (CMOONFLG): zero = earth-centered; one = lunar-centered. It is important to note that the Average G routine is initialized with a state in RN, VN which can have a different origin than is indicated by CMOONFLG. Bit 2 of Flagword 0 (AMOONFLG) indicates sphere of influence for Average G state vector: 0 = earth-centered, 1 = lunar-centered. Words 2-4 contain the position components X, Y, Z, scaled meters/2^{29}. Words 5-7 contain the velocity components, X, Y, Z, scaled (meters/centisecond)/2^7. Word 8 contains the time associated with the CSM state vector in words 2-7, scaled centiseconds/2^{28}, referenced to the computer clock. These parameters are calculated whenever the CSM state vector is permanently extrapolated or changed, as follows:

P00, P20 Option 1, 2, or 5	- every four time steps
P20, P22, P23	- every mark and every Incorp if CM updated
P27	- update of state vector
Average G	- every cycle
V47	-
P20 (MINKEY), P24	- upon entry
P77	-
P23	- acquisition of landmark or horizon via POINTAXS

P20 option 0, 4 (non-MINKEY)-after initial displays have been answered

9-10a	CDUX (outer gimbal) CDUY (inner gimbal) CDUZ (middle gimbal): The actual values of the IMU CDU angles. Each register is an unsigned 15-bit fraction, scaled degrees/360, and is updated by counter interrupts. A middle gimbal angle greater than 70 degrees will light the Gimbal Lock lamp on the DSKY. When |MGA| exceeds 75° P20 automatic maneuvers are inhibited; when |MGA| exceeds 85° the ISS stabilization loop is disabled except during Average-G when the "config" bits of DAPDATR1 indicate SATURN configuration. As a result, the CDUZ register should maintain values that correspond to middle gimbal angles between -70 degrees and +70 degrees.
10b	CDUT. The optics trunnion angle CDU, scaled (degrees-19.7754)/45 (two's complement). The angle measurement varies from -19.775° to 45°, corresponding to a range of 0° to about 65° in actual trunnion.
11-13	ADOTs (if RCS DAP on) or OGARATE and OMEGABs (if TVC DAP on). ADOTs are the RCS DAP-measured vehicle body rates (i.e. the outputs from the RCS DAP rate filter), roll, pitch and yaw, about the control axes. These axes are aligned with the RCS jet quads and, consequently, are rotated, with respect to the NAV base axes, -7.25 degrees about +X. ADOTs are scaled, (degrees/second)/450. OGARATE, in word 11, is the measured roll rate.

Word Number	Contents
11-13 (cont)	obtained by back-differencing the outer gimbal angle (OGA) measurements every 0.5 second, scaled $(rev/sec)/2^{-4}$. This quantity will normallv be near zero magnitude but a roll jet failed-on could produce 2-3°/sec rates. OMEGABs in words 12 and 13, are the measured attitude rates about the pitch and yaw body axes, obtained by transforming the back-differenced CDU readings taken each DAP sample period. OMEGAYB is computed each pitch DAP pass; OMEGAZB is computed each yaw DAP pass. The first OMEGAZB value when the TVC DAP is started (or after a hardware restart) is measured over 1.5 DAP sample periods. The time sharing and scaling for OMEGABs are the same as for the OMEGACs, described in words 85-87 of this downlist. The maximum OMEGAB rate will be less than 5 deg/sec. NOTE: Even though OGARATE is computed and stored as a single precision quantity, it can be considered a double precision word in which the least significant half is always zero. This is insured by the TVC zeroing loop.
14-15a	AKs. The X, Y and Z (roll, pitch and yaw, respectively) attitude errors used to drive the FDAI display, scaled degrees/180. The roll attitude error register (AK +0) is loaded with one-quarter the "raw" value during P11 and entry programs while Entry DAP is running, to increase the scale by a factor of four. The attitude errors are about the control axes for RCS DAP and about the body axes for TVC and Entry DAP. Zeros in bits 15, 14 and 13 of DAPDATR1 and a one in bit 2 of Flagword 6 indicate that the Entry DAP is active. During RCS DAP operation the particular error quantities depend upon the display mode selected, as follows: MODE 1 (selected by V61) results in Autopilot phase-plane errors; MODE 2 (selected by V62) results in total attitude errors with respect to the angles in N22; MODE 3(selected by V63) results in total astronaut attitude errors with respect to the angles in N17. In MODE 1 the errors should generally remain less than the attitude deadband, ADB. The values are calculated every 200 ms during RCS DAP operation, whereas in TVC DAP operation, AK is updated every 0.5 second in TVC EXECUTIVE with the complement of OGAERROR, and AK 1 and AK 2 are updated every TVC DAP sample period (in PCOPY and YCOPY) with the respective values of ERRBTMP. The error needles themselves, however, are updated with AKs only every one-half second on a call from TVC EXECUTIVE. Also, with TVC DAP, AK will normally have a magnitude of less than 5 degrees but a jet failed-on could produce a diverging roll attitude.. AK1 and AK2 will normally have peak values of up to 3 degrees, converging to 0-1 degrees with time.

Word Number	Contents
15b	RCSFLAGS. A cell whose individual bits are used in monitoring the RCS DAP.

Bit	Meaning
15	Bit set to 1 during R60 or R67 auto maneuver if high rate (2 deg/sec) has been specified in R03. Bit is reset to 0 at termination of auto maneuver.
14	Bit is set to 1 if rate estimates are not good and a repeat of the rate filter initialization is required. Bit is reset to 0 if the G&N is in control and the IMU data is usable. Approximately 1 second after bit is reset to 0 the rate filter initialization is complete.
13	Bit set 1 if the rate damping has not been completed on the roll axis. Bit is reset to 0 if the rate damping on the roll axis has been completed.
12	Bit set 1 if the rate damping has not been completed on the pitch axis. Bit is reset to 0 if the rate damping has been completed on the pitch axis.
11	Bit set 1 if the rate damping has not been completed on the yaw axis. Bit reset to 0 if the rate damping has been completed on the yaw axis.
10, 9	If either or both bits have been set to 1, there has been a change in RHC roll command since the last DAP cycle. If both bits are reset to 0, it implies that no change in the RHC roll command has occurred since the last DAP cycle.
8, 7	If either or both bits have been set to 1, there has been a change in RHC yaw command since the last DAP cycle. If both bits are reset to 0, it implies that no change in the RHC yaw command has occurred since the last DAP cycle.
6, 5	If either or both bits have been set to 1, there has been a change in the RHC pitch command since the last DAP cycle. If both bits are reset to 0, it implies that no change in the RHC pitch command has occurred since the last DAP cycle.
4	Bit set 1 indicates that the AK values should be updated. Bit is reset to 0 to indicate that the NEEDLE DRIVE routine should be processed with the AK values which have been previously acquired.

Word Number	Bit	Contents — Meaning
15b (cont)	3, 2	If Bit 3, Bit 2 $= 11_2$ or 10_2, it is necessary to follow the initialization path of the NEEDLE DRIVE routine. If Bit 3, Bit 2 $= 01_2$, it is necessary to follow pass 2 of the NEEDLE DRIVE routine. If Bit 3, Bit 2 $= 00_2$, it is necessary to follow pass 3 and greater paths of the NEEDLE DRIVE routine.
	1	Bit is set 1 to indicate that the initial pass path in the T6 program should not be followed. Bit is reset to 0 if the T6 program should be initialized.

16-17a THETADX, THETADY, THETADZ. During normal RCS DAP operation, when the CMC Mode switch is in AUTO or HOLD and there are no RHC commands, these registers contain the desired current, (i.e., of this DAP cycle opposed to final) roll, pitch, and yaw CDU angles, treated as 15-bit unsigned fractions and scaled degrees/360. These quantities are used in the computation of phase plane attitude errors and are calculated as follows:

1. During automatic maneuvers they are updated every 100 milliseconds.
2. During attitude hold they are constants (the desired CDU angles to be held).
3. At the end of manual rate maneuvers, after rate damping is complete, THETADX, Y & Z are set to the current CDU angles.
4. During manual rate maneuvers and when in FREE mode the registers are not updated.

17b Garbage.

18 TIG. The time of ignition (prethrust) or time of cutoff (while thrusting). The changeover in definition for P40 occurs at ignition if an impulsive burn and at first TGOCALC (nominal TIG+2) if steering. For P15, the changeover occurs at ignition +10 seconds. This item is scaled, centiseconds/2^{28}. This parameter is

Word Number	Contents
18 (cont)	calculated by P31, P32, P33, P34, P35, P36, P72, P73, P74 and P75. P15, P30, P37, P76 and P77 all require TIG as an input, although P37 may modify TIG based on correction for burn interval. In P76/P77, TIG is loaded with targeted ignition time. If the ignition time must be slipped (alarm 1703_8), P40 or P41 loads this word with the new ignition time. After ignition for an impulsive burn, TIG is loaded with predicted cutoff time, and after the first TGO calculation (long burn) TIG is loaded with the state vector time (word 8) plus TGO. After the enter response to the flashing verb 97 (engine fail), the most significant half of TIG is set to -24_8 and the least significant half remains unchanged. †
19	DELLT4 (The desired transfer time). The time from TIG until the target (RTARG) is reached, scaled centiseconds/2^{28}. It is used as an input to the INITVEL subroutine and calculated by each user of this subroutine.
20-22	RTARG. The aimpoint vector X, Y, Z, in either earth-centered or lunar-centered coordinates and scaled meters/2^{29}. The origin of the coordinate system is the same as that of the CSM state vector at TIG. Caution must be exercised in ground/AGC communications whenever the spacecraft is operating near the "sphere-of-influence" switchover point. Bit 12, flagword 8 (CMOONFLG) indicates whether the CSM state vector is earth- or moon-centered. This parameter is calculated by P34/P74, P35/P75, and P37.
23	TGO. The time to go until engine cutoff, scaled centiseconds/2^{28}. At TIG-5 for an impulsive burn (TGO < 6) it is calculated once to represent the time from ignition to engine cutoff. If the estimated maneuver time is greater than six seconds and active steering has been initiated, TGO becomes the length of the time from the last PIPA reading to engine cutoff. During a burn in which steering is used, TGO is calculated every two seconds from the start of steering until steering is stopped.
24	PIPTIME1. The time (T2/T1) at which the PIPAs are read, scaled centiseconds/2^{28}. Integration stores the PREREAD state vector time in anticipation of reading PIPAs at that time. PIPASR stores TIME2/TIME1 every two seconds during Average G. Since this word and words 25-27 are not in a snapshot group, the possibility exists that this set of data may not be time homogeneous.

†This change accomplished in Revision 14 but PCR 325 notation omitted.

Word Number	Contents
25-27	DELVs. The sampled X, Y, & Z PIPA accumulations (velocity increments) with compensation for PIPA bias and scale factor errors. These quantities are in the stable member coordinate system and are scaled, (cm/sec)/(5.85×2^{14}). Calculation takes place every two seconds during AVE G. The variation with time and the range of values depend on the acceleration level and compensation. There is a zeroing of all low-order components and a momentary zeroing of DELVY and DELVZ prior to the loading of PIPA contents into respective high-order words (part of READACCS, or REREADAC task). If no restarts occur the momentary zeroing would not appear on the downlink. PIPA compensation follows in Servicer job (inhinted, so that all or no PIPA compensation shows up).
28	PACTOFF (pitch), YACTOFF (yaw). The SPS engine gimbal-actuator trim angle estimates in the pitch and yaw planes (used to align the engine with the vehicle cg), scaled (seconds of arc)/(85.41×2^{14}). These values are added to the DAP filter output every DAP sample period as part of the engine gimbal servo command. The variation is usually less than ± 2 degrees over the course of a burn. These are equivalent to the upper halves of the double-precision registers, PDELOFF and YDELOFF. These items are set initially by astronauts in R03. They change significantly at the CSM "one-shot" correction time, which is about 3.4 seconds after ignition. For the CSM/LM the "one-shot" occurs at TVC initialization and hence causes no change to PACTOFF or YACTOFF. Incremental changes are made every 0.5 second after the "one-shot" correction and an end-of-burn update is made following the engine shut-down command.
29	PCMD (pitch), YCMD (yaw). The pitch and yaw SPS engine gimbal-actuator position commands from the respective TVC DAPs, scaled (seconds of arc)/(85.41×2^{14}). The expected range of values is between ± 1 degree, while the maximum possible values are ± 6 degrees. They are calculated at every TVC DAP sample period: 40 ms for CSM, 80 ms for CSM/LM.
30a	CSTEER. The Cross Product Steering Constant, "c", used by P40/P41 in the equation $\Delta \underline{m} = c\underline{b}\Delta t - \Delta \underline{v}$ and certain prethrust computations. It is scaled "c"/4. The value range will be from -4 to +4 (less one bit). It is set by P40 prethrust to ECSTEER if a Lambert burn. It will be zeroed by P40 prethrust if an external ΔV burn and also by P41 prethrust.
30b	Garbage

Word Number	Contents
31-33	DELTA VELOCITY (X, Y, Z) at CSI and CDH. In Reference Coordinates. During P31, P32, P72 contains delta velocity at CSI, calculated during each iteration of CSI/A subroutine. During P33/P73 contains delta velocity at CDH loaded from words 98-100 of this list. Scaled (meters/centisecond)/2^7.
34-39	REFSMMAT. Six elements of REFSMMAT, double precision quantities, transmitted R_1C_1, R_1C_2, R_1C_3, R_2C_1, R_2C_2, and R_2C_3, each scaled 2^{-1}. REFSMMAT is the 3×3 matrix used to convert between reference coordinates and stable member coordinates. The remaining three components of REFSMMAT may be computed as follows:

$$R_3C_1 = (R_1C_2)\ (R_2C_3) - (R_1C_3)\ (R_2C_2)$$

$$R_3C_2 = (R_1C_3)\ (R_2C_1) - (R_1C_1)\ (R_2C_3)$$

$$R_3C_3 = (R_1C_1)\ (R_2C_2) - (R_1C_2)\ (R_2C_1),$$

where R = ROW and C = COLUMN.

REFSMMAT is calculated in P11, P51, P52, P53 and P54.

40-44 TEN FLAGWORDS (0, 1, . . . 9). Bit assignments are as follows:

Flagword	Bit	Meaning
0	15	Not used. Should always be 0.
0	14	JSWITCH. Bit set to 1 within orbital integration routine to indicate that extrapolation of W-matrix is being carried out in orbital integration routine (in contrast to the state vector extrapolation likewise done by the routine). Would only become 1 if bit 1 of FLAGWRD3 were 1.
0	13	MIDFLAG. Set to 1 within orbital integration routine at beginning of time step when magnitude of conic position vector is greater than the constants r_{ME} (earth-centered) or r_{MM} (moon-centered) and set to 0 if less than these constants. If MIDFLAG is set to 1 integration will include secondary body and solar perturbations to the orbit.

Flagword	Bit	Meaning
0	12	MOONFLAG. Set by orbital integration to 1 or 0 when integrating the stored CSM and LM state vectors; 1 indicates lunar orbit, 0 indicates earth orbit. Also set to 1 or 0 in integration when switching coordinate centers. MOONFLAG is also set to 1 or 0 by callers of INTEGRVS which specify the state vector to be integrated and in P27, P76, P77, V66 and V47 when using integration subroutine to permanently store state vectors.
0	11	NORFHOR. A 1 indicates far horizon. A 0 indicates near horizon. Set to 0 or 1 in P23 from astronaut input of near or far horizon. Used to determine which point of tangency equation is to be used (near or far).
0	10	ZMEASURE. A 1 indicates measurement planet and primary planet different. A 0 indicates measurement planet and primary planet the same. Set 0 in P23 when state vector sphere of influence and sighting planet measurement are in the same sphere of influence; otherwise set to 1. Used in P23 to pick up the vector difference between state vector and landmark or horizon vector.
0	9	NEEDLFLG. Bit set 1 by a verb 62 or verb 63 and set 0 by a verb 61 (or by a fresh start), used to control the information presented on the FDAI attitude error needles by the RCS DAP (it has no effect on the TVC or Entry DAP's.) If the bit is 1 and in addition the N22ORN17 bit (bit 6 of flagword 9) is 1, "total attitude error" with respect to the contents of N22 is displayed, defined as THETAD - CDU resolved into roll pitch and yaw coordinates. If the bit is 1 and in addition the N22ORN17 bit is 0, "total astronaut attitude error" with respect to the contents of N17, is displayed, defined as CPHIX - CDU resolved into roll pitch and yaw coordinates. CPHIX can be loaded with the present CDU angles by a verb 60. If the bit is 0, then, independent of other bit settings, RCS DAP phase-plane errors, ERRORX, ERRORY, and ERRORZ, which are some times called "auto-pilot following errors" are displayed. Polarity of the error is, as in the other displays, desired minus actual. The "total attitude error" and the "total astronaut attitude error" are defined as a difference between "present" attitude and

Flagword	Bit	Meaning
0 (cont)	9	an attitude specified in N22 or N17. Consequently, these attitude errors may assume large values. The phase plane attitude errors, however, are quantities used by the RCS DAP to command jet firings when the CMC MODE SWITCH is in AUTO and HOLD and thus should generally remain within the selected RCS DAP attitude deadband.
0	8	IMUSE. Bit is set to 1 to indicate that "IMU IS IN USE." It is set to 0 each time a verb 37 program change is processed (unless UTFLAG or RNDVZFLG = 1) and is set to 1 when R02 is performed for P20, P22, P24, P40, P41, P47, P52, P54, P61, P62, and R63. It is also set to 1 at the start of P51 and P53 if the IMU is on. Besides the V37 processing, bit is set to 0 for P06 and IMU turn off and when P20 terminated via V56E or V34 to R22 or R60/R61 display). If the bit is 1 and the IMU is turned off, alarm 0214_8 is generated.
0	7	RNDVZFLG. Bit set 1 to indicate that P20 option 0 or 4 (Rendezvous Navigation) has been enabled and is set to 0 for options 1, 2, 5 of P20. P20 may be dormant even if this bit is 1. It is set to 1 shortly after a proceed on last P20 input display and reset to 0 by a verb 56, IMU turn off, POODOO and by verb 37 input of P00, P22, P23, P24, or P06. It can be set 0 by a verb 34 response to the V50 N18 display in R60, if R60 was called from R61. A verb 34 response to a V06N49 display in R22 will also set the bit to 0.
0	6	R53FLAG. Bit set 1 to indicate that a request for optics marks (flashing verb 51) has been initiated for R53. R53 is used by P22, P23, P24, P51, and P52. Bit is reset 0 at the start of R52 (for use in logic that causes R53 to be initiated if optics mode not "computer control"). R53 will not be established by R52 if entered from P20.
0	5	F2RTE. A 1 means Return to Earth Targeting is operating in the time-critical mode. A 0 means Return to Earth Targeting is operating in the fuel-critical mode. In the time-critical mode the program generates a trajectory which meets the re-entry constraints and returns the space-craft in the shortest possible time. In the fuel-

Flagword	Bit	Meaning
0 (cont)	5	critical mode the program generates a trajectory which meets the re-entry constraints and minimizes the impulsive velocity change required to achieve this trajectory. Bit set 0 if the astronaut sets the desired velocity change (ΔV_D) equal to 0 or to a value less than the minimum required impulsive velocity change. Otherwise a time-critical trajectory is provided (bit set 1). Bit is set and tested in P37.
0	4	CYC61FLG. Bit set indicates KALCMANU will return to R61 following computation of maneuver time. Bit set to 1 by R61 when KALCMANU is called for the first time. Bit set to 0 by R61 before second call to KALCMANU to do maneuver. Set to 0 by STARTSB2.
0	3	FREEFLAG. Bit used for temporary program control purposes to control the internal performance of a subroutine. Used in R54(P51, P52, P53 and P54) to control performance of the star data check routine, where it is initialized to 1 and set to 0 if V32E performed for V06N05 display.
0	2	AMOONFLG. This flagbit enables the ground to determine the origin of the Average G state vector and allows burn through the sphere. Bit is set 1 in MIDTOAVE (R41) if the state vector is moon-centered at Average-G turn on and is set to 0 if earth-centered. Bit is set 0 in a Fresh Start.
0	1	P29FLAG. Set at the start of P29 and after each 10 min time increment and cleared after the first pass through the P29 logic. Used as an indicator to the P21 logic that P29 is operating. Also used as a first pass switch in P29. Cleared by V37.
1	15	NJETSFLG. Bit set 1 in routine 03 (entered via verb 48) if bits 10 and 7 of DAPDATR1 are not equal, indicating that two-jet X translation is specified (setting also made if DAP initiation is required, e.g. transition between TVC and RCS DAP or DAP start-up, so DAPDATR1 could have been changed by V21N46 means). If these bits are equal, bit is set 0, indicating 4-jet X translation. The bit (i.e. #15) is used in the computation of the burn interval required in the "time burn" test done 5 seconds before ignition in P40, and for P41 X-axis thrust. This bit is also used in P37, if an RCS burn is specified, to compute the required burn interval for determining ignition time.

Flagword	Bit	Meaning
1	14	STIKFLAG. Bit set 1 in RCS DAP computations if bits 6-1 of channel 31 (rotational hand controller inputs used for either attitude rate commands (not in free mode) or for minimum impulse commands (in free)) are not 77_8. Bit is also set 1 when $\lvert MGA \rvert$ is $>75^{\circ}$. STIKFLAG set to 1 means that the astronaut has assumed rotational control of the S/C or that $\lvert MGA \rvert > 75^{\circ}$ and P20 automatic tracking is inhibited. The bit is reset to 0 by an input of V58 and V37.
1	13	ERADFLAG. Bit set 1 to specify that a coordinate transformation should use the Fischer ellipsoid for determining earth radius, and set 0 to specify that the pad radius (6 373 338 meters) should be used. If the moon is the sphere of influence then bit set to 1 to use fixed lunar radius (1 738 090 meters) and bit set to 0 to use the magnitude of the lunar landing site (RLS) as the lunar radius. A value of 1 is set in P22, P23, P24, and P52/P54 (landing site alignment option). Bit set to 0 at start of P11, in P21, in P29, in P37, and in Entry, as well as in R30 (if done in P00 or P11).
1	12	NODOP01. Bit is set to 1 to indicate that neither selection of P01 or the summing of uplink keycodes is allowed. The bit is set to 1 near the start of P11 and is left alone by fresh start. If the bit is a 1, an attempt to select P01 will result in a POODOO abort (alarm code 21521_8). Bit is set to 0 as part of the pad load.
1	11	ENG2FLAG. SPS/RCS thrust indication for prethrust burn attitude computations. Set 1 by P41 to indicate RCS thrust levels. Cleared to 0 by P40 to indicate SPS thrust levels.
1	10	TARG1FLG. If option 0 or 4 of P20, bit is set to 1 in PIKUP20 after the initial performance of R61, and in RELINUS (restart-type entry if R61 during R60). Bit is set to 1 to indicate to R52 that tracking of the LM is required. Bit is set 0 each time a verb 37 program change is processed.
1	9	TARG2FLG. Bit set 1 at start of P22 and P24 to flag the fact (combined with bit 10 = 0) that tracking of a landmark is required by routine 52. Bit is set 0 in P23, P51, P53, and when R51 is entered (P52 or P54) (indicating, with bit 10 = 0, that tracking of a star is required).

Flagword	Bit	Meaning
1	8	VEHUPFLG. Bit set 1 to specify that CSM state vector is to be updated by rendezvous (or orbital) navigation measurements; a value of 0 means that the LM state vector is to be updated. Bit can be set to 1 by a verb 81, and to 0 by a verb 80. Bit cleared at the start of P20. Bit is set to 1 in P22 after the response to the V06 N45 display. Bit is set to 1 in P23 for a proceed response to V06N49.
1	7	UPDATFLG. Bit is set to 1 to indicate that updating of state vector in P20 (by optics or VHF marks) is allowed. Bit is set to 1 by P20 option 0 or 4. Bit is set to 0 each time a verb 37 program change is processed. Bit also set 1 at the start of programs 30, 31, 32, 33, 34, 35, 36, 72, 73, 74, and 75. (It is also reset and set during the prethrust computations to protect erasable memory.) If this bit is 0, then the performance of the optics pointing computations in R52 for P20 is omitted, and the performance of computations by R22 is suppressed. Bit is set 0 redundantly at the start of P52 and P54, also set to 0 by a V56E or a V34E on P20 display (V50N18 in R60 or V06N49 in R22). A value of 0 causes P20 state vector updating to be bypassed.
1	6	IDLEFAIL. Set to 1 in V97PJOB after a proceed response to the flashing V97. A 1 will inhibit the thrust fail routine for 2 seconds. After the 2 second delay, V97PTASK sets bit to 0; it is also set to 0 in INITSUB and for a verb 37.
1	5	TRACKFLG. Bit set to 1 to indicate that performance of P20 is allowed, i.e., in option 0 or 4 of P20 tracking and optical pointing are permitted, in option 1 or 5 tracking is permitted, and in option 2 rotation is permitted. Bit is set to 1 in programs 20, 21, 29, 30, 31, 32, 33, 34, 35, 36, 72, 73, 74, 75, 79. Also set 1 in P22 and P24 when option 1, 2 or 5 is active, and in P52 and P54 if option 2 is active. Bit is reset to 0 each time a verb 37 is processed,

Flagword	Bit	Meaning
1 (cont.)	5	as well as a V56E or a V34E on a P20 display (including V50N18 in R60 and V06N49 in R22). If this bit is zero then the computations for R22 and R52 (P20) are halted. An attempt to initiate R23 is rejected and alarm 406_8 generated unless this bit and bit 7 of Flagword 0 are both 1; although a verb 87 will be accepted. Bit also set to zero by POODOO, IMU coarse align, caging, or turnoff.
1	4	MARKFLG. Bit is set in MARKRUPT routine when mark accepted; cleared by MRKREJCT when REJECT is accepted; cleared by MKRELEAS (end of marking) and by STARTSB2 (software or hardware restart). Purpose is to indicate to the MRKREJCT routine that a mark exists which can be rejected.
1	3	SLOPESW. Set to 1 at the start of the LAMBERT routine, and reset to 0 at the end of the first pass through the internal LAMBERT iteration process (specifically, inside the ITERATOR subroutine, which calculates the increment to be added to the independent variable for use on the next pass). The bit controls the type of computation performed in the ITERATOR subroutine. If the first pass through the internal LAMBERT iteration process yields satisfactory results, however, so that additional passes are not required (which will generally only occur when a very good guess of the independent variable is input to LAMBERT, such as occasionally during powered-flight guidance computation sequencing), then ITERATOR is not called, and consequently the bit is left set to 1 when LAMBERT is exited. This bit is equivalent to the switch f_3 of Section 5. 5 of this GSOP.
1	2	GUESSW. Set to 1 to indicate to the LAMBERT routine that an initial guess of the independent variable used in the internal LAMBERT iteration process is not available, thus forcing LAMBERT to start iterating from the mid-point of the range of the independent variable. The bit is set to 0 to indicate to LAMBERT that an initial guess is available; this will in general greatly reduce the number of iterations and the computation time inside LAMBERT. The Initial Velocity Subroutine INITVEL always sets the bit to 0 internally immediately after it calls LAMBERT, whether or not

Flagword	Bit	Meaning
1 (cont.)	2	INITVEL is in its conic mode or its precision mode. The bit is also set to 1 by INITVEL, but only when INITVEL is entered via a special entrance. This special entrance is used only by the Pre-TPI Maneuver Program P34/P74 and the Pre-TPM Maneuver Program P35/P75. This bit is equivalent to the switch f_1 in Section 5.5 of this GSOP.
1	1	AVEGFLAG. Bit set 1 to permit cycling of Average-G computations to continue at a two-second rate, and reset to 0 to halt this cycling and cause initial conditions to be set for a period of free-flight operation. Bit is set 0 by the processing of a V37 input if bit 6 of FLAGWRD7 = 1 (the V37 processing is then resumed when the Average-G routine detects bit 1 of FLAGWRD1 = 0 and has completed the necessary initializations: consequently, Average-G is always terminated when a V37 input is acted upon). Bit is set 1 when Average-G is initialized.
2	15	DRIFTFLG. Bit set 1 to enable free-flight gyro drift compensation, and set to 0 in order to disable it (if bit is 1, a job is established every 81.93 seconds to perform free-flight gyro compensation). Bit is set 1 when Average-G is terminated and also in P51/P53 before taking optics marks and in P52/P54 after completion of coarse align (if performed) or of pulse torquing option. Bit is set to 0 if IMU is coarse aligned, caged, or off, when P06 is entered, and when Average-G started.

Flagword	Bit	Meaning
2	14	R21MARK. Set if option 0 or 4 of P20 is active, cleared for other options of P20, cleared by V37, V56, V54 (R23), and set on exit from R23. Bit set 1 specifies to optics marking routine that special mark processing is required, and to R22 that optics rather than backup marks are being processed.
2	13	22DSPFLG. A 1 means display ΔR and ΔV which are computed by the measurement incorporation routine for astronaut approval. A 0 means do not display. Set 1 in P22 prior to displaying the ΔR and ΔV values which are computed from the first set of mark data. Tested after the first ΔR and ΔV are computed, then cleared to 0 for the remainder of the present operation of P22.
2	12	P21FLAG. Bit set to 1 when base vectors have been saved and indicates that integration is to be performed from base vectors which were computed during previous integration. Bit set to 0 when P21 is established and on restarts. Setting the bit to 0 means that the base vectors have not been computed; integration must operate to compute base vectors for use in subsequent passes. Cleared in all software and hardware restarts.
2	11	STEERSW. In P40, a 1 indicates that cross-product steering, check for low thrust, and time-to-engine cutoff computations are to be made. A 0 indicates these computations are to be bypassed. Cleared by V37. If the burn is non-impulsive, this bit is set to 1 two seconds after SPS ignition commanded, also set to 1 for a proceed response to the flashing verb 97 engine fail display. Bit is set to 0 if the measured acceleration is less than an erasable memory constant or if time-to-go is less than four seconds. In P15, set at TLI ignition +10 seconds to enable TGO (time to SIVB shutdown) calculations. Cleared if time-to-go is less than 4 seconds.

Flagword	Bit	Meaning
2	10	SKIPVHF. Bit indicates to the VHF read routine whether a restart (also software restart: V37, POODOO, Bail-out, V56, V96) has occurred during the VHF read cycle. Bit is set to 1 if a restart has occurred. Bit is set to 0 prior to reading VHF. The bit is tested after reading VHF radar in R22.
2	9	IMPULSW. A 1 indicates that an impulsive burn (TGO ≤6 sec) is to be performed; a 0 indicates that a steering burn (TGO > 6 sec) is to be performed. Bit cleared by V37 logic; set by S40.13 (predicted burn time logic) at TIG-5 seconds if impulsive burn is required; cleared by impulsive-burn ignition logic after engine-shutdown waitlist task has been established.
2	8	XDELVFLG. An indication of targeting/guidance type: 1 for external delta-V; 0 for Lambert. Set 1 by External Delta-V Targeting Programs (P30, P31, P32, P33, P36, P72 and P73); set to 0 by Lambert targeting programs (P34, P35, P37, P74 and P75).
2	7	Bit used for two distinct functions, hence assigned two separate mnemonics. ETPIFLAG. A 1 means an elevation angle has been input to P34/P74 and that TPI time is to be computed. A 0 means that TPI time is input and an elevation angle is to be computed. Bit set to 0 on a proceed response to the initial V06N55 display in P34/74, and is then set to 1 if the elevation angle input in R2 of N55 was non-zero. Bit set to 0 on P34 final pass in MINKEY mode. FIRSTFLG. Bit set to 1 to indicate that the first pass through Lambert targeting has not yet been accomplished. Bit is set to 1 at the start of S40. 1 and set to 0 after the first pass through the Lambert computations.
2	6	FINALFLG. Bit set to 1 to indicate that the final pass through rendezvous targeting is to be performed, also used to control program performance in setting of bit 7 flagword 1 and program performance for responses to the V16N45 display. Bit is set to 0 before the first V16N45 in P31, P32, P33, P34/P74, P72, P73, P35/P75, and P36. Bit set by P37 and at PRO on V16N45.

Flagword	Bit	Meaning
2	5	AVFLAG. Bit is set to 1 at the start of P72, P73, P74 and P75 to indicate that the LM is the active vehicle. Also set to 1 by MINKEY control following CDH burn. Bit is set 0 at the start of P31, P32, P33, P34, P35 and P36 to indicate that the CSM is the active vehicle.
2	4	PFRATFLG. Bit is set to 1 to indicate to P52/P54 that a "preferred attitude" for the burn has been computed and is available. Also set by P52 after Plane Change REFSMMAT is calculated. Bit is set to 1 in P40 and P41 just before R60's V50 N18 display. Bit is set to 0 after the information is used in P52/P54 and in P40/P41 at TIG-30.
2	3	P24MKFLG. Bit is cleared upon entry to P24. It is set in MARKRUPT, every time a mark is taken, to indicate to P24 that a new mark exists that is suitable for updating the landmark coordinates. After the update, it is cleared so that the same mark will not be used again. It is also cleared in MARKRUPT after a "mark reject" so that the bad mark will not be used.
2	2	CALCMAN2. Bit set 1 at end of large attitude calculation of maneuver parameters and reset zero after some computations concerning initial conditions for generation of the commands have been completed. Bit is set whenever R67 reinitializes the rotation matrix. Bit signifies that first iteration through the command generation equations is being performed; depending on phasing of the telemetry output with respect to the guidance computations, the "1" setting may or may not be observed on the downlink.
2	1	NODOFLAG. Bit set to 1 to cause V37 input of programs (other than P00) to be rejected and alarm 1520_8 to be generated. If the TVC DAP is on when the V37 is entered, special logic disables the TVC DAP and selects P00 (no alarm) without any consideration for the status of this bit. Bit is set to 1 while the checks for periodic P00 (and P20, options 1, 2, 5) integration are being done and set to 0 after integration is complete. Bit set to 1 when P06 is entered and set to 0 after the clock is reset. Bit also set to 1 after the entry DAP is started following separation confirmation in P62. Bit is set to 1 during state vector manipulation in P76 in order to prevent selection of a new program during P76 which could cause the LM state vector update to be incomplete. Bit is set to 0 if P00 is selected or if a POODOO abort has occurred and also at the end of P76. Bit also set to 1 in P77 and set to 0 at the end of P77.

Flagword	Bit	Meaning
3	15	V50N18FL. Bit set 1 when P20 initialized to allow R60, if required. Set by any V37 except when P00 selected; also set in V58 by astronaut to allow maneuver. Tested in R61: if R60 maneuver is needed and bit is not set 1 then uplink activity light is turned on, if bit is set 1 then R60 is executed. Bit reset 0 in R61CSM.
3	14	GLOKFAIL. Bit set 1 when the CALCGA routine computes a middle gimbal angle in excess of 60°. A code 401_8 program alarm is then issued by CALCGA. GLOKFAIL is tested (and then reset to 0) by the IMU Calibration and Prelaunch Alignment Programs to determine the feasibility of requested IMU positions. This bit is also reset to 0 in R00. Flight Programs P52, P54, P62, P64 (if velocity below 27,000 fps at the .05 g point) and P66 call CALCGA.
3	13	REFSMFLG. Bit set 1 if a meaningful [REFSMMAT] (reference to stable member matrix) is available, i.e. the alignment of the IMU is known in inertial (reference coordinates) space. Bit set 1 in P11 shortly after liftoff deduced (and after [REFSMMAT] loaded). Bit is set 0 if the IMU is coarse aligned or caged, and is also set 0 for normal sequences through IMU turn-off and P06. Bit is set 0 briefly in P51 and P53 while the IMU orientation information obtained from star sightings is being loaded into [REFSMMAT], and is then set back to 1 (just before transfer to GOTOPOOH at the end of the program). In P52 or P54, bit would be set 0 if routine R50 performed coarse align, and bit is set 1 just before the checklist flash of 00015_8 to perform star acquisition: bit is not set 0 while new values being loaded into [REFSMMAT] in routine R50, so that restart protection of P51 and P53 not applicable here. If [REFSMMAT] option selected for P52 or P54, the bit is not set 1, but instead is left at 1 (since if bit is 0 when P52 or P54 selected, alarm 220_8 is generated, followed by a flashing verb 37). Bit is also set to 0 in P52/P54 if the pulse torque method of aligning is selected and set 1 when a new [REFSMMAT] is loaded.

Flagword	Bit	Meaning
3	12	LUNAFLAG. Used in lat-long subroutine. A 1 means lunar lat-long. A 0 means earth lat-long. Set to 0 or 1 by routines that call lat-long subroutine.
3	11	P22MKFLG. A 1 means the block of landmark data on the P22 downlist is valid. A 0 means not valid. Set 0 upon entry to P22. Set 1 in P22 after marking is complete. Reset to 0 upon entry to P24. Set to 1 in P24 after each mark is taken to signify that the SVMRKDAT table contains valid mark data.
3	10	VFLAG. Bit initialized to 1 at the beginning of the star selection routine (entered by P52 and P54), and reset to 0 if a pair of stars found that satisfy all criteria. If bit is still 1 at the end of the star table search, alarm 0405_8 is displayed. Cell used for program control purposes (temporarily set 1, then back to 0) within star table search program after the first pair found.
3	9	POOFLAG. Bit is used to indicate that P00 type integration (including that in P20 options 1, 2, 5) is active. The bit is set 1 when P00 type integration is established and is reset 0 in INITSUB (R00). POOFLAG is checked within the integration routine to determine if P00 type integration is being performed.
3	8	PRECIFLG. Set to 1 in the integration routine on calls to CSMPREC, LEMPREC, INTEGRVS, and during P00 type integration when integrating LM. Set to 0 when completing integration and during P00 type integration when integrating CSM. PRECIFLG = 0 engages integral time step logic in integration when POOFLAG (Flag 3, Bit 9) is set.
3	7	CULTFLAG. Bit used in automatic star selection routine (performed with P52 and P54) as an indicator (if 1) that the particular star being checked is too close to the computed positions of the earth (about 4 minutes after response to the checklist code 00015_8), sun, or moon. Bit also used in optics angle coordinate transformation routine to indicate (if bit 1 when return from the routine) that the indicated sextant trunnion angle required is in excess of 90°: this setting is used in the automatic optics positioning routine (R52) to replace normal drive of trunnion by driving to 49.7754°, as well as to generate priority alarm 0404_8 if LM not being tracked. Bit otherwise set 0 by routine.

Flagword	Bit	Meaning
3	6	ORBWFLAG. Bit set 1 if W-Matrix is considered valid for use in performing orbital navigation. Bit 1 of flagword 5 is used for the analogous function with rendezvous navigation. In P22 and P23 bit is set 1 for a valid W-Matrix and 0 for an invalid W-Matrix. Set 0 by V93E. Set 0 upon entry into P24. Set 0 in P27 after receipt of a CSM state vector update, at the start of R22 and in P22 if the reduction of the W-matrix to 6 x 6 form after completion of the mark information for a given object overflows. Set 0 in orbital integration if overflow occurs when integrating the W-Matrix. Set to 0 for V67 if new data entered in response to V06N99. Tested in AVETOMID: if bit 1 the 6 x 6 W-Matrix is integrated to PIPTIME using CSM state vector. Also tested in P00 type periodic integration (including P20 options 1, 2, 5): if 1, 6 x 6 W-Matrix is integrated to CSM state vector time (TETCSM) using CSM state vector.
3	5	STATEFLG. Set to 1 if the permanent state vector is to be updated by orbital integration. Bit is checked after completion of integration (either CSM or LM) and if it is 1 it is reset to 0 and the appropriate loading of permanent and downlink state vectors (either CSM or LM) is accomplished. Also set to 0 if a POODOO abort occurs. Set to 0 after V96 if QUITFLAG is 1. Set to 1 if W-Matrix integration overflows. Set to 1 for P00 type periodic integration (LM & CSM) and to 0 if P00 type integration not to be done (QUITFLAG = 1). Set to 1 in P22, P23 and P20 (options 0, 4) for integration to mark time and to cause permanent integration on initial operation of P20 (options 0, 4). Set to 1 upon entry into P24. Bit is also set to 0 when the integration package returns to the caller. Bit also set to 1 in POINTAXS of P23 entered before integration for the mark.
3	4	INTYPFLG. Set to 1 if conic extrapolation to be done in orbital integration, set to 0 for precision extrapolation.
3	3	VINTFLAG. Set to 1 if CSM state vector to be integrated; set to 0 if LM state vector to be integrated. Set internally in integration on calls via CSMPREC (conic), LEMPREC (conic) and by callers of INTEGRV.
3	2	D6OR9FLG. Used by orbital integration for W-Matrix integration. A 1 means 9 × 9 W-Matrix is integrated for P22. A 0 means 6 × 6 W-Matrix is integrated for P20, P23.

Flagword	Bit	Meaning
3	1	DIM0FLAG. Used by orbital integration for W-Matrix integration. A 1 means W-Matrix to be integrated. A 0 means no W-Matrix integration to be done.
4	15	MRKIDFLG. Set to 1 if a mark/extended verb display is waiting for a response: it signifies that a display of this type is in the "ENDIDLE" routine of the DSKY package.
4	14	PRIODFLG. Set to 1 if a priority display is waiting for a response. It signifies that a display of this type is in the "ENDIDLE" routine of the DSKY package.
4	13	NRMIDFLG. Set to 1 if a normal display (most of the displays in the program are in this category) is waiting for a response: it signifies that a display of this type is in the "ENDIDLE" routine of the DSKY package.
4	12	PDSPFLAG. Set to 1 to indicate a priority display status exists. This will lock out mark displays and normal displays.
4	11	MWAITFLG. Bit included in logic assignments to permit function similar to bit 10 to be applied to mark/extended verb displays. Bit set to 1 if a mark / extended verb display is waiting to be initiated. Set to 1 if a priority display is presently on the DSKY. Bit is used in case a priority display has been generated after an extended verb has passed the lockout check, but before corresponding extended verb display.

Flagword	Bit	Meaning
4	10	NWAITFLG. Set to 1 if a normal display is waiting to be initiated (e.g. program attempts to initiate a normal display when an extended verb or mark display is occupying the DSKY). Helps give DSKY sequence of crew-initiated display, crew-initiated monitor display, priority display, interrupted mark/extended verb display, interrupted normal display, and waiting normal display.
4	9	MRKNVFLG. Set to 1 if a mark/extended verb display attempt found the display system busy (due to crew or uplink use for a display, including an externally initiated monitor display). Bit reset after appropriate display initiated (following key release response).
4	8	NRMNVFLG. Set to 1 if a normal display attempt found the display system busy (cf. bit 9).
4	7	PRONVFLG. Set to 1 if a priority display attempt found the display system busy (cf. bit 9).
4	6	PINBRFLG. Set to 1 if it is concluded that "interference" with the internally generated display has taken place (e.g. an enter verb was used but the associated noun was not that requested by the program when the internally generated display was produced), or if a termination for an extended verb/mark routine is performed with bit 13 or 14 of this word = 1. Bit reset 0 upon successful conclusion of a priority or normal display after having been used to bypass internal checks that otherwise would cause a program abort.
4	5	MRUPTFLG. Set to 1 if a mark/extended verb display or display attempt has been interrupted by a priority display.
4	4	NRUPTFLG. Set to 1 if a normal display or display attempt has been interrupted by a priority display or by a mark/extended verb display.
4	3	MKOVFLAG. Set to 1 briefly if a mark/extended verb display is to interrupt a normal display (used to control internal program branching, whereupon it is reset to 0).

Flagword	Bit	Meaning
4	2	VNFLAG. Set in entrance to display routines VNFLASH, VNFLASHR. Cleared by response to VNFLASH, VNFLASHR displays. Purpose is to distinguish between VNFLASH and other (e.g. GOFLASH) type displays.
4	1	XDSPFLAG. Set to 1 to indicate that a mark display status exists. This will lock out normal displays.
5	15	DSKYFLAG. Bit set 1 when any keycode input is received from either DSKY, and not subsequently reset 0 (barring another fresh start). If bit is 0, display of quantities on DSKY lights is suppressed, leaving all DSKY lights blank. Bit is not set to 1 by an uplink input.
5	14	RETROFLG. Bit is set 1 if P37 determines that the premaneuver orbit is retrograde with respect to the earth. Bit is set 0 if P37 determines that the premaneuver orbit is not retrograde. P37 tests RETROFLG prior to displaying ΔV_{LV}.
5	13	SLOWFLG. Bit is set 1 in P37 during Trans-Earth Coast if the astronaut inputs a negative desired velocity change (V06N60), which will result in a trajectory slow-down. Bit is set 0 in P37 if such a request has not been made. The bit is tested by P37 when it is computing a conic return trajectory.
5	12	V59FLAG. Bit set 1 in R57 in conjunction with initiation of a V59 display. Bit set to indicate calibration mark for P23. Reset 0 if a proceed or enter response is received. If a mark is made a special display job is set up to display the calibration data at MARKDISP in R57 using a V06N87. After display of V06N87, V59FLAG is reset to prevent display from recurring.
5	11	INCORFLG. Bit set 1 in R22 (performed for P20) and P22 to indicate that computation pertinent to the first incorporation of observation data from a certain optics mark is being made. After this data has been incorporated in the state vector, bit is set 0 and a second incorporation is made. In R22 for VHF ranging, only one measurement incorporation is made for which this bit is set to 1 to enable magnitude checks leading to a possible V06N49 display.
5	10	NEWTFLAG. Set temporarily in P29 to indicate new iteration of longitude calculation. Cleared in R00.

Flagword	Bit	Meaning
5	9	DMENFLG. Bit set 0 at the start of processing of optics mark data from a given object in P22 to indicate that $\underline{R}_L$, W_6, W_7, W_8 have not been computed yet; bit set 1 after computation of these items. Bit is set to 1 in P22 if the W matrix is to be considered 9×9 for measurement incorporations. Bit set to 0 at the start of R22 (P20) and P23 since both P20 and P23 use 6×6.
5	8	COMPUTER. Bit is not used. (Bit set 1 as part of a fresh start and not subsequently changed, hence should remain at 1.)
5	7	ENGONFLG. Bit set 1 just before the SPS engine is turned on (Bit 13 of channel 11 set 1), and reset to 0 just before the engine is turned off (bit 13 of channel 11 set 0). Used in the event of a hardware restart to determine the proper setting for the engine-on channel bit (bit 13 of channel 11); if set 1 engine should be on. Used also by V37, P40 and TVC.
5	6	3AXISFLG. Bit set 1 prior to entering R60 if the attitude maneuver to be made is specified by 3 angles. If it is zero, VECPOINT is performed to compute the required angles from information on the spacecraft axis to be pointed and the direction in which it is to be pointed. Bit set 1 for uses of attitude maneuver routine based on input of V49 for R62. Bit set to 1 in P23 when 3 axis maneuver with shaft angle constrained to 180 degrees is desired. Bit set 1 for options 4 and 5 of P20. Bit set 0 for options 0 and 1 of P20. Set 0 in P23 if VECPOINT maneuver is desired. Also set 0 by V89 and P40/41 (S40. 2, 3) before call to R60.
5	5	GRRBKFLG. Set 1 when a V75E is executed, to serve as a backup liftoff signal. Bit tested before and after gyrocompassing during each half second cycle of P02 and if bit is 1 or bit 5 of channel 30 is 0 (the prime liftoff signal input) then P11 is started. Same two bits also checked for control purposes by V43.
5	4	Not used.

Flagword	Bit	Meaning
5	3	SOLNSW. Set to 1 by the LAMBERT routine if the routine could not accurately solve the problem with which it was called (i.e. if sufficient convergence was not achieved to the specified transfer time, or if the subtended true anomaly difference between the two input position vectors was less than about 1/2 minute of arc). Reset to 0 by LAMBERT if a successful LAMBERT solution was obtained. Set to 1 by the TIME-RADIUS Routine if this routine was called with an orbit having an eccentricity less than about 0.000004, and reset to 0 if the eccentricity was greater than this value (regardless of what the specified terminal radius is, and regardless of whether this radius could be reached conically from the input state vector). Thus, for the TIME-RADIUS Routine, the resetting of this bit to 0 does not necessarily imply a successful TIME-RADIUS solution. This bit is never tested by any of the mission programs. This bit is equivalent to the switches f_5 and f_9 of Section 5.5 of this GSOP. These two switches are represented by the same bit in the AGC.
5	2	Not used.
5	1	RENDWFLG. Bit set 1 if W-Matrix is considered valid for use in performing rendezvous navigation (using P20). Bit 6 of FLAGWRD3 is used for the analogous function for P22 or P23. This bit is set to 1 in R22 after processing of a set of mark information has been started. Set 0 upon entry into P24. Set 0 by orbital integration if W-Matrix integration overflows. Set 0 by P27 on state vector update. Set 0 by P22, P23. Bit also set 0 by a verb 93. Tested in AVETOMID: if bit is 1 W-Matrix is integrated to PIPTIME using pre-thrust state vector. Also tested in P00 type periodic integration, if bit is 1 the W-Matrix is integrated to CSM state vector time using the LM state vector (unless bit 8 of flagword 8 = 1) and is updated when Average-G is terminated.
6	15	DAPBIT1. Bit used with bit 14 to indicate current status of DAP.

Flagword	Bit	Meaning
6	14	DAPBIT2. Bit used with bit 15 to indicate current status of DAP. Used to implement lockout of V48E input if TVC DAP is running, and to cause restart of RCS, TVC, or Saturn DAP as appropriate if a restart is encountered. Bits are set to 00_2 if a V46E is received (with bits not 10_2) and bits 14-13 of DAPDATR1 (loaded by R03) are 0, signifying that no DAP is desired, and are also set to 00_2 in P62 shortly after response to checklist code 00041_8. Bits are set to 01_2 when the RCS DAP is started (after TVC shutdown or after V46E, bits not 10_2, and bits 14-13 of DAPDATR1 unequal) or when RCS DAP computations resumed following a period of TVC DAP operation. Bits set to 00_2 at ignition; set to 10_2 0.4 seconds later (for TVC DAP indication). Bits set to 11_2 when Saturn Stick Function is called by V46E to indicate Saturn Stick control of T5. A V46 entry during TVC operation does not affect these bits.
6	13	Bit used for two distinct functions, hence assigned two separate mnemonics. ENTRYDSP. Set 1 in P62 after N61 responded to, and actuates the entry current display nouns when the entry exit code sequence is used (set 0 to suppress display). Set 0 in P65 before flashing display N69 is activated. Set 1 in P65 after N69 is responded to with a PROCEED. Bit also set to 1 at the start of P66 or P67. STRULLSW. A 1 indicates steering and time to engine cutoff computations should be permitted (STEERSW set 1) 2 seconds after ignition. When 0 STEERSW not touched. Cleared to 0 for the V97E response (R40) if re-ignition is for impulsive burn. Set 1 at ignition if non-impulsive burn (steering to be done). Cleared to 0 at ignition for impulsive burn.
6	12	CMDAPARM. Bit set to 1 to "arm" the entry DAP (to allow "entry firings and calculations"). Bit is set to 1 in P62 shortly after bit 11 of this word becomes 1 (within 1/2 second), having previously been set 0 in P62 shortly before start of 00041_8 checklist display. If bit is 0, entry DAP computations are halted after computation of vehicle body rates.

Flagword	Bit	Meaning
6	11	GAMDIFSW. Bit set to 1 to permit initialization of entry DAP computations to proceed (see bit 12 of this word), and to permit an entry DAP quantity to be computed as the first difference of the present and previous values of a cell. Bit set to 0 in P62 shortly before start of 00041_8 checklist display, and set to 1 within 2 seconds (the first Average-G cycle following).
6	10	GONEPAST. Bit initialized to 1 near the start of P63 to prevent lateral control before D >.05g. Switch set 0 when .05g sensed (c.f. INRLSW) and subsequently set to 1 if in P67 bit 8 (GONEBY) of FLAGWRD7 is sensed as 1 (hence is a "latched" version of this bit 8). If in P67 and bit is 1, no lateral control computations are done, and the desired lift is set to maximum down (provided that g-limiter constraints are not violated).
6	9	RELVELSW. Bit initialized to 0 near the start of P63 and subsequently set to 1 if bit 8 of this word is 1 and the output of the Average-G equations indicates a velocity magnitude of less than about 12883.1ft/s (causes, if 1, "earth-relative velocity" to be used for entry targeting and computations).
6	8	Bit used for two distinct functions, hence assigned two separate mnemonics. KNOWNFLG. Bit is set to 1 in P22 if the landmark is considered to be known and set to 0 if unknown. If CMOONFLG = 1 (moon-centered), bit is set to 0 after response to the N70 display but is immediately set to 1 if octal digit #1 of R2 in N70 = 1. Bit is set to 0 after the N71 display, but is immediately set to 1 if octal digit #1 of N71 = 1. EGSW. Bit initialized to 0 near the start of P63 and subsequently set to 1 when P67 is started (the "final phase" of the entry computations). Used by TARGETNG for range prediction.
6	7	NOSWITCH. Set 0 after start of P63. Set 1 during P65 if D> 140 ft/s/s, and prevents lateral reversal of roll command on that steering cycle.

Flagword	Bit	Meaning
6	6	HIND. Bit initialized to 0 near the start of P63 and subsequently set to 1 when some entry iteration calculations are to be performed.
6	5	INRLSW. Bit initialized to 0 near the start of P63 and subsequently set to 1 the first time the sensed drag is 0.05g or more (a "latched" version of bit 3 of this word).
6	4	LATSW. Bit set to 1 in P62 shortly before start of 00041_8 checklist display, and also near the start of P63. Bit is set 0 by entry guidance computations to enforce a roll "over the top" by the entry DAP (which resets the bit to 1). For orbital cases, velocity is expected to be less than 27,000 ft/s and bit not expected to be set 0 since computations not entered.
6	3	.05GSW. Bit initialized to 0 in P61 and in P62 shortly before start of 0041_8 checklist display, and also near the start of P63. Bit is set to 0 or 1 each pass through TARGETNG depending on whether the sensed drag is less than or greater than .05g. Bit used in entry DAP to control nature of computations which are performed. Bit is set 1 by fresh start.
6	2	CM/DSTBY. Bit set to 1 to indicate that entry DAP not to be in "standby" (i.e. that it is "activated"). Bit initialized to 1 in P62 shortly before start of 00041_8 checklist display, and reset to 0 in P67 after response to the V16N67 display when velocity has become less than 1000 ft/s. When entry DAP senses that bit is 0, channels 5 and 6 are set 0 and the 0.1-second cycling of the computations is terminated.
6	1	GYMDIFSW. Bit initialized to 0 in P62 shortly before start of 00041_8 checklist display, and subsequently set 1 in entry DAP if this bit is 0 and bit 2 of this word is 1 and bit 6 of IMODES33, is 0. A value of 1 means that CDU differences and body rates can be computed (and therefore computations continued subject to other bits, such as bit 12 of this word). Bit is reset to 0 if bit 6 of IMODES33 is 1, and also in P67 after response to the V16N67 display (see bit 2 of this word).
7	15	TERMIFLG. Bit set to 1 to terminate performance of R52 used by P22, P23, P24, and P52. Bit is set to 0 at the start of R52, and is set to 1 after receipt of the marks in R53 and after the response to the N71 display in P51 through P54.

Flagword	Bit	Meaning
7	14	ITSWICH. A 1 means a solution for TPI time has not yet been reached. A 0 means a solution for TPI time has been reached. Set to 1 at the beginning of P34 and P74, and then immediately set to 0 only if the TPI time is given and the elevation angle is to be computed. Bit is tested at SWCHCLR: if 1 it is immediately set to 0 and control is transferred to INTLOOP where the final solution for TPI time is reached; if 0, then either the TPI time or the elevation angle is displayed depending on the setting of ETPIFLAG . ITSWICH also tested at TESTY: if 1 the program looking for a solution for TPI time; if 0 the computed elevation angle is stored. Bit also set to 1 in P33 and P73 to cause iteration for TPI time information.
7	13	IGNFLAG. Cleared by V37 logic - viz. for P40. Set 1 by TIG-0 to indicate that nominal ignition time has arrived. Note, if TIG-0 finds ASTNFLAG set 1 (crew has OK'd ignition) then ignition is immediate; otherwise ignition waits for receipt of the PROCEED response to the TIG-5 flashing V99 (please enable engine) display. Set 1 (redundantly) by the ENTER response to the flashing V97 (perform engine fail procedure) display. Note, since IGNFLAG is set 1, not cleared, by the "recycle for re-ignition" V97 ENTER response, ignition will be immediate upon receipt of the PROCEED response to the subsequent flashing V99 display.
7	12	ASTNFLAG. Cleared by V37 logic - viz. for P40. Set 1 by the PROCEED response to the TIG-5 flashing V99 (please enable engine) display. Note, if V99P logic finds IGNFLAG

Flagword	Bit	Meaning
7 (cont)	12	set 1 (nominal ignition time has passed) then ignition is set up immediately, otherwise ignition waits for TIG-0. Cleared also by the ENTER response to the flashing V97 (perform engine fail procedure) display, forcing re-ignition delay until receipt of the PROCEED response to the subsequent flashing V99 display.
7	11	TIMRFLAG. Bit set to 1 to permit a self-perpetuating wait-list task to continue, which loads time-to-go with the difference between TIME2, TIME1 and T_{ig}. The time-to-go cell is displayed automatically by the program for nouns 35, 40, 45, 80, and 95 (the "time" generally is from nominal ignition or predicted cutoff).
7	10	NORMSW. Set to 1 to specify to the LAMBERT routine that it is to use the unit normal vector (to the conic transfer plane) which is provided by the calling program; reset to 0 if LAMBERT is to calculate its own unit normal vector (by crossing the initial and final position vectors of the transfer). Set to 1 by the Initial Velocity Routine, INITVEL (the only routine which calls LAMBERT) whenever INITVEL is called with a (true or offset) target vector which lies inside "the cone"; reset to 0 by INITVEL whenever INITVEL is called with a (true or offset) target vector which lies outside "the cone". ("The cone" is a mathematically - defined cone whose vertex is the origin of coordinates, whose axis is the 180° transfer direction, and whose semi-cone angle is specified to INITVEL.) The semi-cone angle is set to 15° by P34, P35, P74 and P75, because active vehicle transfer angles between 165° and 195° are normally avoided in the targeting procedure. However, if a transfer angle falling within this $180^{\circ} \pm 15^{\circ}$ sector is intentionally selected by any one of the above targeting programs, or by the results from any one of the above maneuver programs during an intercept trajectory targeted for more than 180°, the Lambert Aim Point Maneuver Prethrust Routine increases the semi-cone angle to 45° so that active vehicle transfer angle will not change from inside to outside the cone angle during the powered maneuver. Such a condition is undesirable since the intercept trajectory would be retargeted during the powered maneuver. Likewise, if the initial transfer central angle falls outside the 15° semi-cone angle, the semi-cone angle is decreased to 10° to reduce the possibility of a transfer angle changing from outside to inside the cone during a powered maneuver. NORMSW is set to 0 by P37 because the semi-cone angle

Flagword	Bit	Meaning
7 (cont)	10	should be set to 10° for this program. NORMSW should generally remain 0, unless transfers between 165° and 195° are intended. NORMSW is equivalent to the switch f_2 of section 5.5, and to the switch S_R of section 5.3.3 of this GSOP.
7	9	RVSW. Set to 1 to indicate to the TIME-THETA and TIME-RADIUS Routines that the only desired output is the time required to transfer through the specified transfer angle or to the specified radius respectively, and set to 0 to indicate that the state vector at the terminal point is desired in addition to the transfer time. Set to 1 during the Pre-TPI Maneuver Programs, P34 and P74. Also set to 1 by the Plane Change Targeting Program (P36). Set to 0 by the Pre-CDH programs, P33 and P73, and by P29. Set both 0 and 1 by the Return to Earth Maneuver Program P37 and by P31, P32, P72. The bit is equivalent to the inverse of the switch f_6 of Section 5.5 of this GSOP.
7	8	GONEBY. Bit set 0 each time through the entry "targeting" routine (entered every 2 seconds after Average-G is performed, starting about 2 seconds after the beginning of P63 and ending after a response to the V16N67 display in P67 (velocity below 1000ft/s)). Bit is then set 1 again if it is concluded that the vehicle has passed (i.e. overshot) the target. Bit is used to determine the sign (minus if bit 0, otherwise plus) of the R3 display for noun 64 and the R1 display for noun 67, and is also used to determine if bit 10 of flagword 6 should be set: mechanization permits a new sign to be determined each computing interval.
7	7	Not used.
7	6	V37FLAG. Bit set 1 at the same time that bit 1 of FLAGWRD1 is set 1, i.e. when Average-G is "started", and set 0 when the Average-G state vector has been loaded into the orbital integration state vector cells (at the conclusion of the last Average-G cycle, which found bit 1 FLAGWRD1 equal to 0 as a result of V37 action). Consequently, bit would be expected to be set to 0 within about 2 seconds of the time that bit 1 of FLAGWRD1 is set 0.

Flagword	Bit	Meaning
7	5	Not used.
7	4	UPLOCKFL. Set to 1 if failure of the $\overline{c}cc$ data check is detected in processing an input from the uplink receiver. The bit can be reset by sending an error reset code via the uplink (the DSKY error reset key does not reset the bit). While the bit is 1, all uplink information except an error reset code is rejected by the program.
7	3	VERIFLAG. Bit whose value is complemented when the final proceed entry is received in P27, indicating that the uplink information is to be used.
7	2	ATTCHFLG. Bit set 1 if bits 14-13 of DAPDATR1 are 10_2 when R03 is performed or when the RCS DAP is started (e.g. as a result of V46E or after TVC DAP completion). The bit being 1 means that LM is attached (otherwise, bit is set 0); bit not otherwise sensed in program.
7	1	TFFSW. Bit set 1 if perigee time is to be calculated, and set 0 if TFF (to a specified interface altitude) is to be computed. When R30 is performed via V82E (every 2 seconds if Average-G is on and on a single-shot basis otherwise) bit is set 1 if perigee altitude at least 300,000 ft above pad radius for earth coordinates or 35,000 ft above lunar landing site for moon coordinates and then is set 0 for calculation of TFF. Hence bit would generally be observed as 0.
8	15	RPQFLAG. Internal flag in integration to indicate if primary body to secondary body position vector (RPQ) was computed; a 0 indicates RPQ was computed, a 1 indicates RPQ was not computed. RPQ is computed only when MID-FLAG is set 1.
8	14	NEWLMFLG. Bit is cleared upon entry to P24. It is set after a landmark-coordinate update in P24 so that the shaft and trunnion rate computation will be delayed one R52 cycle in order to avoid a false rate. It is cleared after the delay is effected.
8	13	NEWIFLG. Internal flag in integration. Used to engage 4 time step only on the first step of P00 type integration; 1 means first step, 0 means not first step.

Flagword	Bit	Meaning
8	12	CMOONFLG. Indicates origin of "permanent" CSM State Vector; 1 means lunar-centered, 0 means earth-centered. Always set to 0 or 1 depending on MOONFLAG when permanently updating the CSM state vector.
8	11	LMOONFLG. Indicates origin of "permanent" LM State Vector; 1 means lunar-centered, 0 means earth-centered. Always set to 0 or 1 depending on MOONFLAG when permanently updating the LM state vector.
8	10	ADVTRK. A 1 means use auto optics to drive optics to a LMK on advanced ground track. A 0 means use auto optics to drive to star, LM or landmark. Set 1 when entering auto optics for advanced orbit. Set 0 when entering auto optics via R52. Tested in each computational cycle of auto optics.
8	9	UTFLAG. A 1 indicates that option 1, 2 or 5 of P20 has been selected. Bit is set to 1 by P20 for options 1, 2 or 5. Set to 0 by P20 options 0, 4 and by P00, V56, P06, POODOO and IMU turn off. Also set to 0 by a verb 34 response to the V50N18 display in R60, if R60 was called from R61.
8	8	SURFFLAG. Indicates whether LM is on lunar surface. Set and reset manually with extended verbs 44 and 45 respectively. Tested in P00 type periodic integration and if set, LM state vector is not integrated. Also tested in orbital integration and if set, the planetary inertial orientation routine is used to transform RLS to reference coordinate system. Lunar velocity is also computed in reference coordinate system.
8	7	INFINFLG. Set to 1 in the conic TIME-THETA Routine to indicate that the routine was called with a hyperbolic initial state vector and a true anomaly transfer angle which was so large as to require a transfer past the hyperbolic asymptote of the conic, which is physically impossible. Set to 0 in TIME-THETA if a valid physical solution is obtained. Set to 1 in the conic TIME-RADIUS Routine to indicate that the routine was called with a hyperbolic initial state vector, a desired final radius,

Flagword	Bit	Meaning
8 (cont)	7	and a desired sign of the radial velocity of the final radius (to indicate whether trajectory is to be inbound or outbound here) which would require a transfer past the hyperbolic asymptote of the conic. For example, a spacecraft which is inbound can never return inbound to a radius which is greater than its current radius, and likewise a spacecraft which is outbound can never return outbound to a radius which is less than its current radius. Set to 0 in TIME-RADIUS if a valid physical solution is obtained. Set to 1 during any one (or several) of the internal LAMBERT iterations if the intermediate solution arrived at on this particular internal iteration required a transfer past a hyperbolic asymptote. The LAMBERT routine senses such a situation on the succeeding iteration and adjusts various parameters in an attempt to obtain a valid solution. Set to 0 in LAMBERT if the preceding internal iteration yielded a physically realizable transfer. The bit is never tested or set either way outside the conic subroutines. The bit is equivalent to the switch f_7 of Section 5.5 of this GSOP.
8	6	ORDERSW. Never set to 1. Set to 0 as part of a fresh start. Used to control the type of computation performed in the ITERATOR routine (part of the conic subroutines). This bit is equivalent to the switch f_4 of Section 5.5 of this GSOP.
8	5	APSESW. Set to 1 by the TIME-RADIUS routine to indicate that the routine solved for the time required to reach pericenter (or apocenter) rather than the desired radius, because the desired radius input to the routine was less than the pericenter radius (or was greater than the apocenter radius, respectively). Set to 0 by the TIME-RADIUS routine to indicate that the routine attempted to solve for the time required to reach the desired radius, since the desired radius input was greater than pericenter radius and less than apocenter radius. (Such a solution will be reached unless INFINFLG is set to 1). This bit is equivalent to the switch f_8 in Section 5.5 of this GSOP.

Flagword	Bit	Meaning
8	4	COGAFLAG. Set to 1 by the TIME-THETA routine and the TIME-RADIUS routine if either of these routines was called with an initial state vector having a flight-path-angle (measured from local vertical) less than 1° 47.5' or greater than 178° 12.5'. Set to 0 in each of these routines if either was called with an initial state vector having a flight-path-angle between these two extremes. The bit is not tested or set either way outside the conic routines.
8	3	V96ONFLG. Bit is set to 1 when V96 is selected and, as a result, P00 integration has been inhibited. Bit is set 0 when P00 is reselected and indicates that integration is proceeding normally.
8	2	R67FLAG. When set, bit indicates that R67 (Automatic Rotation Routine) is active. Bit set to 1 when R67 is initiated or restarted. Set to 0 in R67 if TRACKFLG (Flag 1 bit 5) is 0. Set to 0 in V56 and R00.
8	1	360SW. Used to indicate the type of computation to be performed by the Universal Variable Routine (a subroutine called by the LAMBERT, TIME-THETA, and TIME-RADIUS routines). The bit is not of interest outside these three conic routines and in fact is neither tested nor set either way outside the Universal Variable Routine itself. The bit is equivalent to the switch f_w of Fig. 5.10-4 of Section 5.5 of this GSOP.
9	15	SWTOVER. A 1 indicates switchover has occurred. A 0 indicates switchover has not yet occurred. The switchover referred to here is the optional V46 switchover (by the astronaut) from the CSM/LM high-bandwidth TVC DAP mode to the low-bandwidth mode.
9	14	P24FLAG. Bit is set to 1 upon entry to P24 to enable the rate-aided optics capability in R52 and the special mark processing in MARKRUPT. Bit is cleared in V37.

Flagword	Bit	Meaning
9	13	V82EMFLG. A 1 indicates moon vicinity. A 0 indicates earth vicinity. Set 1 or 0 by R30 according to whether state vectors are moon-or earth-centered. Bit tested by SR30.1 when called by R30 to compute PERIGEE, APOGEE radius and PERIGEE, APOGEE height above launch pad or lunar landing site.
9	12	MAXDBFLG. Bit is set to the value of bit 4 of DAPDATR1 in R03. Used by routines GOTOPOOH and R00 (verb 37) and by FIXDB.
9	11	V94FLAG. A 1 indicates Extended Verb 94 is allowed. A 0 indicates Extended Verb 94 not allowed. Set 1 before P23 enters R52 so astronaut may re-maneuver spacecraft LLOS before marking. Set 0 after mark so spacecraft does not re-maneuver after that time. Tested at VERB94.
9	10	SAVECFLG. Cleared by P23 initialization if REFSMFLG = 1; set after a navigation mark is taken (before N71 display). Controls program flow following computation of star vector; if clear use star vector to compute 3 axis maneuver; if set use star vector for mark processing.
9	9	VHFRFLAG. A 1 allows R22 to accept range data. A 0 stops acceptance of range data. Set 1 by Verb 87. Set 0 by Verb 88. Set 1 by R00 (verb 37) when MINKEY is initiated and reset in R00 only when a non-MINKEY program change is made. Tested each time a mark is processed by R22.
9	8	SOURCFLG. A 1 indicates source of input data is VHF radar. A 0 indicates source is optics mark. Set 1 when a VHF radar mark is processed. Set 0 when an optics mark is processed. Tested each time a mark is processed by R22.
9	7	R22CAFLG. A 1 indicates that an optics mark is being processed. Set and cleared in R22. When bit is set, a mark reject prevents mark incorporation into the state vector.

Flagword	Bit	Meaning
9	6	N22ORN17. Bit set 1 means use the angles stored in N22 to compute the "total attitude error" for display on FDAI error needles. Bit set 0 means use the angles stored in N17. Set 1 by Verb 62. Set 0 by Verb 63. Set 0 by fresh start. During normal RCS DAP operation if bit 9 of flagword 0 is set (i.e. display "total attitude errors") the bit N22ORN17 is checked every other pass thru Phase 1 of the RCS DAP.
9	5	QUITFLAG. Set to 1 by extended Verb 96 (which then exits to P00) to indicate that integration should be discontinued. Bit is examined by integration routines which exit if the bit is 1. Reset to 0 in P00 if it was found to be 1. Periodic P00 integration is disabled until a new program (other than P27) is selected.
9	4	R31FLAG. Bit set 1 at V83PERF in response to V83 or P79 to indicate R31 is selected for operation. Bit set 0 at V85PERF to indicate R34 is selected for operation. Tested in R31/R34 to determine formulation of angle RTHETA: if R31FLAG is 1 then angle Theta is computed as the angle between X-body axis and the local horizontal; if R31FLAG is 0 then angle Phi is computed as the angle between SXT LOS and local horizontal.
9	3	MID1FLAG. Bit set 1 to indicate that MIDTOAV1 called integration.
9	2	MIDAVFLG. Bit set 1 to indicate that integration was called by MIDTOAV1 or MIDTOAV2 (R41). Bit set 1 engages R41 logic.
9	1	AVEMIDSW. Set to 1 to indicate that synchronization of state vectors and W-Matrix is in progress in the transition from powered flight to coasting flight and that the powered flight state vector should not be overwritten until the synchronization is completed.

Word Number	Contents
45-50a	DSPTABs. The eleven registers, DSPTAB through DSPTAB+10D, indicate the status of the DSKY displays. If bits 15 through 12 are 0001, the next 11 bits will indicate the actual status of the DSKY displays; if bits 15 though 12 are 1110, the next 11 bits indicate the "ones" complement of the status to which the CMC will command the DSKY display. Bits 11-1 of DSPTAB+0 through DSPTAB+10D are decoded as follows:

DSPTAB Register	Downlink Word Number	Bit Assignments		
		Bit 11	Bits 10-6	Bits 5-1
DSPTAB+0	45a	-R3S	R3D4	R3D5
DSPTAB+1	45b	+R3S	R3D2	R3D3
DSPTAB+2	46a		R2D5	R3D1
DSPTAB+3	46b	-R2S	R2D3	R2D4
DSPTAB+4	47a	+R2S	R2D1	R2D2
DSPTAB+5	47b	-R1S	R1D4	R1D5
DSPTAB+6	48a	+R1S	R1D2	R1D3
DSPTAB+7	48b			R1D1
DSPTAB+8D	49a		ND1	ND2
DSPTAB+9D	49b		VD1	VD2
DSPTAB+10D	50a		MD1	MD2

R3D1 stands for digit one of the third register and VD1 stands for the first digit of the verb display, etc. For the right character of a pair, bit 5 is the MSB with bit 1 the LSB. For the left character of a pair, the MSB is bit 10 with bit 6 the LSB. Bit 11 of some of the DSPTABs contains discrete information, a one indicating that the discrete is on. For example, a one in bit 11 of DSPTAB+1 indicates that R3 has a plus sign. If the sign bits associated with a given register are both zeros, then the content of that particular register is octal; if either of the bits is set, the register content is decimal data.

Word Number	Contents
45-50a (cont)	The five bit codes associated with the digits are as follows:

	MSB				LSB
0	1	0	1	0	1
1	0	0	0	1	1
2	1	1	0	0	1
3	1	1	0	1	1
4	0	1	1	1	1
5	1	1	1	1	0
6	1	1	1	0	0
7	1	0	0	1	1
8	1	1	1	0	1
9	1	1	1	1	1
Blank	0	0	0	0	0

The following is a diagram of the DSKY face showing positions of the different digits:

Program

MD1	MD2

Verb

VD1	VD2

Noun

ND1	ND2

Register 1

±	R1D1	R1D2	R1D3	R1D4	R1D5

Register 2

±	R2D1	R2D2	R2D3	R2D4	R2D5

Register 3

±	R3D1	R3D2	R3D3	R3D4	R3D5

Word Number	Contents
50b	DSPTAB+11D. This register drives relays for display lights. The bit assignments are:

Bit	Assignment
1	
2	
3	
4	No Attitude
5	
6	Gimbal Lock
7	
8	Tracker
9	Program Caution
10	
11	

If bits 15 through 12 of DSPTAB+11D are 1000, the last 11 bits indicate the state to which the CMC will command the relays; if bits 15 through 12 are 0000, the last 11 bits indicate the actual state of the relays. A one indicates that the discrete is on. A verb 36 fresh start preserves bits 6 and 4, while a restart preserves bits 9, 6 and 4. All other bits are zeroed. An error reset code preserves bits 6 and 4.

51 TIME2, TIME1. A double precision word indicating ground elapsed time. Used for all timing while the CMC is on. Zeroed at liftoff and incremented by one bit per centisecond. It may be updated by verb 55, verb 73 (P27) or verb 70 (P27). Scaled centiseconds/2^{28}.

52-58 LM STATE VECTOR AND TIME. The CMC's latest calculated state vector for the LM in either earth-centered or moon-centered reference coordinates. A zero in bit 11 of flagword 8 (LMOONFLG) indicates earth-centered whereas a one indicates moon-centered. Words 52-54 contain the position coordinates, X, Y, and Z, scaled meters/2^{29}. Words 55-57 contain the velocity components, X, Y, and Z, scaled (meters/centisecond)/2^{7}. Word 58 contains the time associated with the LM state vector in words 52-57, scaled centiseconds/2^{28}. These parameters are calculated whenever the LM state vector is permanently extrapolated or changed, as follows:

P00 and P20 - every 10 mins. to CM state vector time.
Option 1, 2 or 5.

P20 - upon entry (MINKEY) or after initial displays (non-MINKEY options 0, 4), then extrapolated for each mark; updated by each Incorp if LM update option.

P27 - update of state vector.

P76 and V66

Termination of Average-G.

Word Number	Contents
59-67	Repeat of words 9-17.
68a	RSBBQ. When a hardware "restart" occurs, this register is loaded with the setting of the BBANK portion of the calling address + 1 and also Superbank information which is in channel 7.
68b	RSBBQ+1. Loaded with the setting of the Q-register when a hardware restart occurs.
69a	Garbage. The register will contain all zeros.
69b	Channel 77. A computer output channel, the invididual bits of which are used to indicate the source of a hardware restart and/or AGC warning. The channel is initialized to 0 by a V36E (request fresh start). The channel will be zeroed by the final V33E on a P27 state vector uplink and also by a crew or ground V21N10E77EE. Should a hardware restart occur, one of the bits in the channel would be set to 1 indicating the source. If multiple restarts occur, more than one bit could possibly be left set afterwards (i. e., if they were different types). Many restarts of the same type would leave just one bit set with the software REDOCTR indicating the number. The bit definitions are:

BIT	RESTART (and/or AGC warning) CAUSE
15-10	Spare
9	Scalar double freq.
8	Scalar fail
7	Counter fail
6	Voltage fail
5	Nightwatchman
4	Ruptlock
3	TC Trap
2	E-memory parity fail
1	E or F-memory parity fail

Note that a restart due to oscillator fail is not shown in this channel.

70a	C31FLWRD. A single-precision erasable memory cell used to determine if the channel representations of the CMC mode switch, SC control switch, optics mode switch, or optics zero switch are to be used or if back-up indicators are to be used. The erasable is of the form AXXDX, where:

Word Number	Contents

70a (cont.)

A Value	
0 or 4	Bits 13, 14, 15 of channel 31 are valid
1	G&N Control FREE
2	G&N Control ATTITUDE HOLD
3	G&N Control AUTO
5	SCS Control FREE
6	SCS Control ATTITUDE HOLD
7	SCS Control AUTO

D Value	
0 or 4	Bits 4 and 5 of channel 33 are valid
1 or 5	Optics Mode CMC
2 or 6	Optics Mode ZERO
3 or 7	Optics Mode MANUAL

70b, 71 FAILREG's. A set of three single-precision cells used to retain alarm pattern code information. They are all reset to zero by a Fresh Start. FAILREG and FAILREG+1 are also reset to zero by use of the "ERROR RESET" keycode. FAILREG contains the first alarm code received after the "ERROR RESET", FAILREG+1 contains the second , and FAILREG+2 will always contain the most recent alarm code. Octal quantities.

72a SHAFT. The optics CDU shaft angle.This register is an unsigned 15-bit fraction scaled, degrees/360. The angle varies $\pm 180^{\circ}$.

72b, 73 PIPA's. The accumulation of output pulses from the X, Y, and Z accelerometers (a measure of the velocity changes), scaled (centimeters/second)/(5.85×2^{14}). These registers are zeroed by PIPUSE (called by LASTBIAS which is called by PREREAD at the start of AVEG). They are then read and zeroed every two seconds by READACCS (or REREADAC) throughout AVEG.

74 ELEVATION ANGLE. The angle between the local horizontal plane of the active vehicle and the line of sight vector to the passive vehicle at TPI. The scaling is degrees/360. This parameter is an input (N55) to P34/P74 (preset to 0); also to P32/P72 and P31 (preset to 208.3°). Also set to 0 on final pass through P34 (elevation option) in MINKEY. The angle is measured in a counter clockwise rotation from the forward-direction path of the active vehicle (determined by the positive direction of the active vehicle's velocity vector) to the active-passive line of sight vector. See Fig. 4.2-3 of Section 5.

Word Number	Contents
75	CENTRAL ANGLE. The angle traversed by the passive vehicle between TPI time and intercept time scaled degrees/360. This item can be inputted via the DSKY and it is used in computing the time of flight. It is an input to P32/P72, P34/P74 and P31 and is initially set to 130°.
76	SPARE. See word 37 program 22 list.
77	TWO FLAGWORDS (10, 11). Bit assignments are as follows:

Flagword	Bit	Meaning
10	15	PCMANFLG. When set, indicates P20 to exit after plane change maneuver and P79 maneuver. Set by MINKEY controller after plane change burn. Set by P79. Cleared by controller after the tracking maneuver which follows the P36 plane change burn. Cleared by P79 upon termination. Cleared when new program selected via V37.
10	14	INTFLAG. A 1 indicates that some program or routine has called INTSTALL and is presumably in the process of integrating. Other programs calling INTSTALL will wait until this bit is reset to 0. A 0 indicates that no program or routine is currently using integration. Set 1 by INTSTALL. † Set 0 by INTWAKE. A hardware or software restart sets this bit to 0.
10	13	REINTFLG. A 1 indicates that the routine currently using INTSTALL is to be restarted. A 0 indicates that no restartable integration is in progress. Programs which have restart points during integration set this bit to 1. INTWAKE sets this bit to 0. Bit is also set to 0 by POODOO.
10	12	REJCTFLG. When set, R22 is to ignore optics mark currently being processed. Set by MARK REJECT interrupt and by V86. Cleared in R22 after mark data processing.
10	11	HDSUPFLG. A 1 indicates "heads-up" tracking attitude. This flag is not altered by a Fresh Start. Set or cleared by ground or crew action.
10	10	BURNFLAG. When set, indicates that the CSM performed a burn. Cleared at start of P40 and P41. Set by P40 and P41 if there has been any thrusting by the CSM. Set in MINKEY controller prior to selection of P36 if ΔV is zero.

† This change accomplished in Rev 14, however, PCN 1135 notation omitted.

Flagword	Bit	Meaning
10	9	RANGFLAG. Bit set to indicate range $<$ 327.67 n.mi. Set or cleared in R61 depending on range.
10	8	P35FLAG. A 1 indicates MCC targeting has been completed. Set after final computation cycle of P35/75. Cleared in R22 after W-matrix initialization.
10	7	AUTOSEQ. When set, indicates automatic sequence operating. Set in R00 when MINKEY is selected. Cleared in V56, POODOO, R00 logic after MINKEY is terminated, and V37 program selection if a non-MINKEY program is requested. Set temporarily in V37 selection of all rendezvous targeting programs for purpose of P20 initialization and subsequently cleared on ENTER response to V50N25FL (R1 = 17). Set to 1 at PRO response to V50N25FL (R1 = 17). It can be set 0 by a verb 34 response to the V50 N18 display in R60, if R60 was called from R61. A verb 34 response to a V06N49 display in R22 will also set the bit to 0.
10	6	Not used.
10	5	MANEUFLG. When set, indicates no mark has been processed since the last final computation cycle of a targeting program. Set after final computation cycle of all rendezvous targeting programs except P36. Set on PROCEED response to V50N25FL (R1 = 17) if RENDWFLG = 0. Cleared after mark incorporation in R22.
10	4	PTV93FLG. A 1 indicates W-matrix initialization to be performed after the next burn. Set on PROCEED response to V50N25FL (R1 = 17) if RENDWFLG is 0. Also set in AUTOW logic of R22 if age of W-matrix and other criteria indicate W-matrix initialization is desired after next burn. Cleared in R22 after W-matrix initialization.
10	3	TPIMNFLG. Set to indicate that TPI targeting has been completed. Cleared at start of P34/74; set after final pass of P34/74, P35/75.
10	2	FULTKFLG. When set, indicates only one type of marking (optics or VHF) is being performed for targeting. Set or cleared by crew option in V57.
10	1	PCFLAG. Set to indicate P36 plane change targeting. Set in P36. Cleared by P31, 32/72, 33/73, 34/74, 35/75. Cleared on PROCEED response to V50N25FL (R1 = 17). Cleared by P52 if pulse torquing is done.

Flagword	Bit	Meaning
11	15	S32.1F1. Used in P31,P32/P72. Used to terminate iteration if ΔV_{CSI} exceeds 1000 ft/sec twice during the iteration. Set to 0 at start of each iterative loop. Set to 1 if $\lvert\Delta V_{CSI}\rvert > 1000$ ft/sec and subsequent test of bit in case $\lvert\Delta V_{CSI}\rvert > 1000$ ft/sec will terminate iterative loop.
11	14	S32.1F2. Used in P31,P32/P72. Controls first step size of iterative loop to establish two points for Newton-Raphson iteration. Set to 1 at start of each iterative loop. Set to θ after first step.
11	13 and 12	S32.1F3A and S32.1F3B. Used in P31,P32/P72. Control setting of alarm codes during first iterative loop and control the 50 ft/sec steps utilized to establish the starting point of the second iterative loop. Bits set (0, 1) at start of first iterative loop to allow setting of the alarm codes. Set (0, 0) at start of second iterative loop until after first 50 ft/sec step is taken, when set (1, 1). Set (1, 0) after the angular error undergoes a sign change.
11	11	Not used.
11	10	Not used.
11	9	Not used.
11	8	AZIMFLAG. A 1 indicates 3-axis maneuver desired in R61. Bit set to 1 by MINKEY and by P20 when option 4 or 5 is selected. Cleared by P20 for other options and by V89 before maneuver is calculated.
11	7	HAFLAG. Set to indicate P31 Height Adjustment targeting. Set and subsequently cleared in P31.
11	6	CSISFLAG. A 1 indicates multiple CSI targeting. Cleared in first MINKEY CSI targeting, set in succeeding MINKEY CSI targeting. Cleared after V06N37FL display in P32.
11	5	Not used.
11	4	Not used.
11	3	Not used.
11	2	Not used.
11	1	Not used.

Word Number	Contents
78	TEVENT. The time of liftoff (P11, clock zeroing), the time at which S4B Injection Sequence (P15) starts, the time of S4B cutoff command, or time of any SPS ignition or shutdown (P40), whichever occurs last. It is scaled centiseconds/2^{28} and referenced to the computer clock.
79	Repeat of word 29 of this downlist.

Word Number	Contents
80a	OPTMODES, a cell whose individual bits are used to control the performance of optics functions within the T4RUPT package. Set to 00130_8 (bits 7, 5, 4 = 1) as part of a fresh start; a restart preserves the present values of the bits 5, 4, while setting bit 7 to 1 and zeroing the remaining bits (15-8, 6, 3-1). Word is updated once every 0.48 seconds, about 0.24 seconds before the interrupt that updates IMODES30 & IMODES33.

Bit	Meaning
15-11	Not assigned, hence expected to remain 0.
10	Bit set 1 to indicate that zeroing of optics completed since last fresh start or restart (both of which set the bit 0). If an attempt is made to drive the optics and this bit is found to be zero, alarm 0120_8 is generated (but computation proceeds).
9	Not assigned, hence expected to remain 0.
8	Not assigned, hence expected to remain 0.
7	Last sampled value of channel 30 bit 7 (0 if an optics CDU fail indication has been generated by the optics CDU hardware). If bit 2 of this word is 0, a Tracker alarm (bit 8 of DSPTAB+11) is generated if this bit has a 1 to 0 transition. Bit set 1 by a fresh start or restart.
6	Not assigned, hence expected to remain 0.
5	Last sampled value of channel 33 bit 5 or its backup as indicated by C31FLWRD (0 if optics mode switch set to computer control).
4	Last sampled value of channel 33 bit 4 or its backup as indicated by C31FLWRD (0 if optics mode switch set to zero optics). If bits 5-4 = 11_2, this means that optics mode switch set to manual mode.
3	Bit set 1 when optics mode switch changed from manual or computer control mode to zero optics mode, to indicate that zeroing of the optics is in progress.

Word Number		Contents
(cont) 80a	Bit	Meaning
	(cont) 3	If bit is 1, then a switch out of zero optics mode will cause alarm 0116_8 to be generated (if switched to manual, a "grace period" of about 5.3 seconds is provided before the optics-zeroing time counter is reset, during which time a switch back to optics zeroing can be made). Bit remains 1 for about 16.2 seconds, and is then reset to 0 (at same time that bit 10 of this word is set 1, and bit 2 of this word set 0).
	2	Bit set 1 to inhibit generation of Tracker alarm (bit 8 of DSPTAB+11) if bit 7 of this word goes from 1 to 0. Bit set and reset at the same time as bit 3.
	1	This bit is not used.

80b

HOLDFLAG. A multiple purpose switch which is used for establishing the control reference of the autopilot. It has the following three states:

State	Meaning
(+)	Sample the CDU angles and store in THETADX, THETADY, and THETADZ before resuming attitude hold and resetting HOLDFLAG to (+0).
(+0)	Remain in attitude hold about previously established reference angles, THETADX, THETADY and THETADZ. Set to this state by RCS DAP when $\lvert MGA \rvert > 75^{o}$.
(-)	Enable automatic steering.

81a

LEMMASS. The current mass of the LM vehicle, scaled kilograms/2^{16}. This is a pad load erasable and is not changed in normal use. The astronaut can change it, however, as part of the normal DAPDATA LOAD (R03, V48).

Word Number	Contents
81b	CSMMASS. The current weight of the CSM vehicle, scaled kilograms/2^{16}. It is a pad load erasable which can be altered by the astronaut in R03 (V48). It is changed automatically every 2 seconds during P40 by S40.8 if thrust is OK. This change consists of decrementing the parameter by 200 times the value of the pad-loaded quantity EMDOT, which represents the value of the SPS mass-flow rate in kg/cs.
82	DAPDATR1, DAPDATR2. Information concerning the RCS-CSM DAP interfaces:

DAPDATR1 is packed with 5 octal digits of information as follows:

Bits	15-13	12-10	9-7	6-4	3-1
	CONFIG	XTAC	XTBD	DB	RATE

(1) CONFIG: Configuration
- 0 No DAP or ENTRY DAP
- 1 CSM
- 2 CSM/LM
- 3 CSM/SIVB
- 6 CSM/LM ASCENT STAGE ONLY

(2) XTAC: X-translation using Quads AC
- 0 No AC
- 1 Use AC

(3) XTBD: X-translation using Quads BD
- 0 No BD
- 1 Use BD

(4) DB: Deadband
- 0 ±0.5 degree
- 1 ±5.0 degrees

(5) RATE: Response to RHC, Automatic maneuvers
- 0 0.05 degree/second
- 1 0.2 degree/ second
- 2 0.5 degree/second
- 3 2.0 degrees/second

DAPDATR2 is packed with 5 octal digits of information as follows:

Bits	15-13	12-10	9-7	6-4	3-1
	AC-Roll	Quad A	Quad B	Quad C	Quad D

Word Number	Contents
82 (cont)	(1) AC-Roll: Roll jet selection 0 Use BD Roll 1 Use AC Roll (2) A, B, C, D Quad fails 0 Quad Failed 1 Quad OK
83-84a	ERRORX, ERRORY, ERRORZ. The RCS DAP phase plane (roll, pitch, yaw) attitude errors scaled degrees/180. During steady state operation the magnitude of ERRORX, Y, and Z should be less than the attitude deadband, ADB. When the CMC mode switch is in AUTO or HOLD, a magnitude greater than the ADB which exists for long intervals without diminishing at the rate as specified in DAPDATR1 would be an indication of bad RCS DAP performance. The RCS control axes, with which these errors are concerned, are rotated, with respect to the body axes, by -7.25 degrees about the +X axis. The error values are calculated: 1. During RCS DAP operation with CMC MODE switch in AUTO or HOLD, every 100 millisecs. 2. During RCS DAP operation with CMC MODE switch in FREE - not updated.
84b	Garbage.
85-87	WBODYs or OMEGACs (when TVC DAP is on). WBODYs are the desired angular body rates (roll, pitch, yaw) about the control axes when RCS DAP is on, scaled (degrees/second)/450. The RCS DAP control axes are rotated w.r.t. body axes by -7.25 degrees about +X. OMEGACs are body axis rate commands in roll, pitch and yaw generated by cross-product steering (Roll is ignored by TVC). Bits 15 and 14 of Flagword 6, indicate which parameter is being sent. Bits 15, 14 and 13 of DAPDATR1 indicate the correct scaling for OMEGAC.

Word Number	Contents		
85-87 (cont)	Bits 15, 14 Flagword 6	Bits 15, 14, 13 DAPDATR1	
	01	XXX	WBODYs
	10	001	OMEGACs for CSM alone scaled (rev/sec)/ 12.5.
	10	010 110	OMEGACs for CSM/LM DAP. Scaled (rev/sec)/ 6.25.

88a — REDO COUNTER. Counter for hardware restarts. Set to zero by a keyboard fresh start (VERB 36). Incremented once per hardware restart by the restart program (GOPROG) and scaled 2^{-14}.

88b, 89 — THETAD's. The final desired CDU angles, (X, Y, Z) treated as 15-bit unsigned quantities and scaled, degrees/ 360. THETAD+2 should not be in gimbal lock or near it. These items should not be confused with THETADX, Y, and Z.

90a — IMODES30, a cell whose individual bits are used to control the monitoring of IMU functions associated with channel 30 (and in a few cases channel 33). Set to 37411_8 for a fresh start; a restart sets the word to 37000_8 plus the present contents of bits 9, 5, 4, 3, 1 (zeroing bit 15, 8, 7, 6 and 2). Word is updated once every 0.48 seconds based upon the channel sampling controlled by the T4RUPT computations. Discussion below ignores settings performed by verb 35 ("lamp test").

Bit	Meaning
15	Last sampled value of channel 30 bit 15 (0 if IMU temperature within limits). If bit changes, bit 4

Word Number		Bit	Contents Meaning
(cont) 90a	(cont)	15	(Temperature caution) of channel 11 is set to agree with this bit. Bit set 0 for a fresh start or restart.
		14	Last sampled value of channel 30 bit 14 (0 if ISS has been turned on or commanded to be turned on). Bit is used in the control of IMU monitoring logic; set to 1 for a fresh start and restart.
		13	Last sampled value of channel 30 bit 13 (0 if an IMU fail indication produced). Set 1 for a fresh start or restart; if bit becomes 0 while bit 4 of this word is also zero, then channel 11 bit 1 (ISS Warning) is set 1.
		12	Last sampled value of channel 30 bit 12 (0 if an IMU CDU fail indication produced). Set 1 for a fresh start or restart; if bit becomes 0 while bit 3 of this word is also zero, then channel 11 bit 1 (ISS Warning) is set 1.
		11	Last sampled value of channel 30 bit 11 (0 if an IMU cage command produced by crew). Set 1 for a fresh start or restart.
		10	Last sampled value of channel 33 bit 13 (0 if a PIPA fail indication produced), having same value as bit 13 of IMODES33. Bit is set 1 for a fresh start or restart, and if an error reset key code is received via DSKY or uplink. If bit becomes 0 while bit 1 of this word is also zero, then channel 11 bit 1 (ISS Warning) is set 1.
		9	Last sampled value of channel 30 bit 9 (0 if IMU turned on and operating with no malfunctions). Set 1 for a fresh start. Alarm 0214_8 is generated if bit goes from 0 to 1 while bit 8 (IMUSE) of Flagword 0 is 1.
		8	Bit used to control the IMU turn-on sequencing. It is set 1 if bit 7 of this word is sensed as 1, and is reset (with bit 7) to zero 0.48 secs later, before starting the IMU turn-on sequencing. Used to achieve a wait of 0.48 secs before acting on the IMU turn-on information. Set 0 by fresh start or restart.

Word Number	Bit	Contents: Meaning
90a (cont)	7	Bit used to control the IMU turn-on sequencing. It is set to 1 based on logic using bits 14, 9, and 2 of this word, and is reset to zero (with bit 8 of this word) 0.48 secs later. Also set 0 by a fresh start or restart. Hence can be set to 1 if ISS initialization requested (bit 14 or bit 9 of this word changing) since last fresh start, turn-off of IMU (change in bit 9 of this word), or turn-on delay complete (change in bit 14 of this word).
	6	Bit set 1 to indicate that IMU initialization is being carried out. Set 1 during turn-on sequence, if a cage command (bit 11 of this word) is received, or if IMU zeroing in T4RUPT is done. Set 0 by a fresh start or restart, about 8.22 seconds after removal of cage command, about 8.22 seconds after start of zeroing in T4RUPT (when bits 8-7 set 0), or about 97.90 seconds after start of turn-on sequence (when bits 8-7 set 0 marks the "start" of sequence). If bit is 1, no verb 37 input is processed and alarm pattern 1520_8 is generated. If bit is 1, an error exit from the internal IMU routines is forced (coarse align, fine align, or gyro torquing).
	5	Bit set 1 to inhibit the generation of program alarm 0212_8 if a PIPA fail signal (bit 13 of channel 33) is produced. Set 0 as part of a fresh start, and value retained if a restart. Bit not used unless bit 1 of this word is 1. Bit set to 1 during IMU turn-on sequence (when bit 6 is set 1), and reset 0 about 4.0 seconds after bit 6 is reset 0 (alarm generated when Average-G is stopped, if bit 10 of this word is 0, regardless of the value of this bit 5).
	4	Bit set 1 to inhibit generation of an ISS warning based on receipt of an IMU fail signal. Set 1 as part of a fresh start, and value retained if a restart. Bit reset to 0 when bit 6 is set 0 (having been set 1 when bit 6 set 1). Bit also set 1 when coarse align of IMU is started, and is set 0 about 5.12 seconds after mode change to fine align is done. Also set to 1 for 8.22 seconds when IMU CDU zero commanded outside of T4RUPT package.

Word Number	Bit	Contents Meaning
90a (cont)	3	Bit set 1 to inhibit generation of an ISS warning based on receipt of an IMU CDU fail signal. Bit set 0 as part of a fresh start, and value retained if a restart. Bit set 1 when bit 6 of this word set 1, and is set 0 (at end of IMU zeroing sequence) when bit 6 set 0. Bit also set 1 (at the same time as bit 4) for 8.22 seconds when IMU CDU zero is commanded separate from T4RUPT package (via V40E).
	2	Bit set 1 to indicate failure of the turn-on delay sequence for IMU turn-on (alarm 0207_8 is also generated). Zeroed by fresh start or restart.
	1	Bit set 1 to inhibit generation of an ISS warning based on receipt of a PIPA fail signal (bit 13 of channel 33). Bit set 1 as part of a fresh start, and value retained if a restart. Bit also set 1 when bit 6 of this word is set 1 (but is not subsequently reset in the T4RUPT logic, cf. bit 5 of this word).

90b

IMODES33, a cell whose individual bits are used to control the monitoring of functions associated with channel 33 (and other items). Set to 16000_8 as part of a fresh start; a restart sets it to 16000_8 + the present contents of bit 6 (other bits set 0); and an error reset key code sets bits 13-11 to 1 (leaving other bits alone). Word is updated once every 0.48 seconds. Discussion below ignores settings performed by verb 35 ("lamp test") except for bit 1.

Bit	Meaning
15	Not assigned, hence expected to remain 0.
14	Last sampled value of channel 32 bit 14 (0 if a Proceed command is given using the old "standby" button). A transition from 1 to 0 causes a job to be established that has same program logic effect as V33 E (from a mission program standpoint). Contrary to the other bits of this word, this bit is updated once every 0.12 seconds. It should be noted that in the case of a response to a V21, V22, and V23, the logic for a Proceed is not the same as for a V33E.

Word Number	Bit	Contents: Meaning
90b (cont)	13	Last sampled value of channel 33 bit 13 (0 if an accelerometer fail signal, or PIPA fail, produced by hardware). Same quantity loaded into bit 10 of IMODES30 (for program logic control convenience). Fresh start and restart bit set to 1.
	12	Last sampled value of channel 33 bit 12 (0 if a telemetry end pulse rejected because downlink rate too fast). When a 1 to 0 transition is sensed, alarm pattern 1105_8 is generated. Fresh start and restart set bit to 1.
	11	Last sampled value of channel 33 bit 11 (0 if an uplink bit rejected because uplink rate too fast). When a 1 to 0 transition is sensed, alarm pattern 1106_8 is generated. Fresh start and restart sets bit to 1.
	10-7	Not assigned, hence expected to remain 0.
	6	Bit set to 1 to indicate that IMU use for vehicle attitude information should not be attempted. Bit 1 the same time as bit 6 of IMODES30 is set1, and also when bit 4 of IMODES30 is set1 (for IMU zeroing external to T4RUPT and for IMU coarse align). Bit set 0 if IMU fine align routine is performed. Set 1 if IMU turned off.
	5	Bit set 1 in IMU zeroing routine external to T4RUPT while zeroing is taking place (for an interval of about 8.22 seconds, at the same time as bit 6 of this word is set in the routine). This routine is entered via V40E. †
	4-3	Not assigned, hence expected to remain 0.
	2	Not assigned, hence expected to remain 0.
	1	Bit set to 1 when a verb 35 ("lamp test") is received, and reset to 0 about 5 seconds later. Used to inhibit resetting of lights to 0 in T4RUPT package while the lamp test is being performed.

† This change accomplished in Revision 14 but PCN 1019 notation omitted.

Word Number	Contents
91-94	Channels 11, 12, 13, 14, 30, 31, 32, and 33. Bit assignments are as follows:

Word 91a, Channel 11. A computer output channel whose individual bits are used for display parameter quantities and engine on/off control. A fresh start sets all bits to 0. Processing of a verb 37 and a software restart both set bits 7-3 to 0. V37 also sets bits 10 and 9 to 0. A hardware restart sets all bits to 0 unless bit 7 of flagword 5 = 1 in which case, bit 13 of this word will be set to 1.

Bit	Meaning
15-14	Not assigned.
13	SPS Engine on (set 1 in P40 to turn on SPS engine, set 0 to turn it off). Also set 0 if caging command received.
12-11	Not assigned.
10	Caution Reset signal (for display system lights). Set to 1 when an error reset key code (from uplink or DSKY) is received.
9	Test connector Outbit. Set 1 in accelerometer reading subroutine ("READACCS", entered about 2 seconds after Average-G is "started" and each two seconds thereafter until bit 1 of Flagword 1 = 0) and set 0 when Average-G is terminated (shortly after bit 6 of Flagword 7 is set 0).
8	Not assigned.
7	Operator error light. (FLASH) Set 0 when an error reset key code (from uplink or DSKY) is received; set 1 if various procedural items (most of which are related to the DSKY, such as illegal noun/verb combinations) are not performed properly.
6	Flash verb and noun lights. Bit is set when an operator action is required (by program means, as a clue to the operator that a response is needed). See discussion of Flagword 4.
5	Key Release light. (FLASH) Set 1 if program desires to use display system but external (DSKY or uplink) use of it is being made. Also would be set 1 if an internal or

Word Number		Bit	Contents
(cont)	91-94		Meaning
	(cont)	5	externally initiated monitor display had been started and then some DSKY button was depressed. It is lit if a request for operator response has been initiated and crew does not respond directly to it, but instead displays something else. Set 0 by key release keyboard input, and upon other instances (such as processing of an extended verb) when display system is released by the internal program.
		4	Temperature Caution light. See bit 15 of IMODES30.
		3	Uplink activity light. Set when an uplink interrupt is received; reset when an error reset key code is received, a key release key code, or at the termination of P27 (based on receipt of a proceed or terminate response). Bit is also set to 1 in R61 if an R60 maneuver is desired, but the maneuver is inhibited. Set by P15 and, after 10 seconds, reset.
		2	Computer activity light. Set 0 if no active Jobs are to be performed. During P00 probably will be 0 except during the periodic state vector update or gyro drift compensation. It will also be set to one intermittently during P00 if the RCS DAP is active. Bit is not set 1 if a Task is performed, but instead left at its previous value.
		1	ISS Warning light. See bits 13, 12, and 10 of IMODES30.

Word 91b, Channel 12. A computer output channel whose individual bits are used for control of optics/TVC and IMU hardware, and for control of the ISS. A fresh start zeroes all bits and then sets bits 6 and 4 to 1 if bits 6 and 4 of DSPTAB+11 are both 1. A hardware restart sets all bits to zero. A verb 37 clears bits 2, 3, 8, 10, 11, 13, and 14. A software restart does not change this channel, IMU caging zeros bits 8, 6, 5, 4, and 2.

Bit	Meaning
15	ISS turn-on delay complete. Reset to 0 7.90 seconds after being set 1 at end of 90 second ISS turn-on delay.
14	S4B Cutoff command. Bit set in P15. Bit also set in P40 at time of SPS cutoff for backup of S4B cutoff.
13	S4B Injection Sequence Start. Set by P15 and, after 10 seconds, reset.
12	Not assigned.

Word Number		Contents
(Cont.) 91-94	Bit	Meaning
	11	Disengage optics Digital-to Analog Converter. Bit set in TVC DAP preparations (S40. 6) at the start of the gimbal drive test or trim to avoid driving the optics system with TVC commands if optics had been left in the computer control mode. Set to 0 when the TVC DAP is terminated.
	10	Zero Optics. Not set by the program.
	9	S4B Takeover Enable. Set to 1 following a V46E with bits 14-13 of DAPDATR1 = 1 (for Saturn attitude control using RHC). Bit also set to 1 if bit 10 of Channel 30 is sensed as 0 in P11, meaning the Saturn control given to CMC.
	8	TVC Enable. Set to 1 in P40 shortly after the response to checklist 0204_8 code, in order to connect the output of the "optics" CDU digital-to-analog converters to the SPS gimbal servo amplifiers. Bit set 0 about 2.5 seconds after engine cutoff command (bit 13 of channel 11 set 0) in the following cases: normal cutoff, an enter or terminate response to a flashing V99N40 initiated at nominal ignition-5 seconds, an enter or terminate response to a flashing V97 initiated by thrust fail routine. Set to 1 in T4RUPT when optics mode is changed to manual and computer-driving of the optics is requested (OPTIND = 0 or 1). This enables the optics DAC to operate in a "rate" mode, a non-zero rate being applied only during P24. Set to 0, if present value is 1, when leaving the manual mode or when terminating computer control of optics (OPTIND = -0 or -1).
	7	Not assigned.
	6	Enable IMU error counters. Set 1 during coarse align of IMU, and in order to permit output of error information to the FDAI attitude error needles (bit is set 0 on initialization pass, then set 1; the third pass is the first one with output to needles).
	5	Zero IMU CDU's. Set to 1 to zero IMU CDU's. Set and reset in T4RUPT or V40E.

Word Number		Contents
(cont) 91-94	Bit	Meaning
	4	Enable coarse align of IMU. Set 1 to specify coarse align of IMU (cf. bit 6), and also if middle gimbal angle (i.e. CDUZ) exceeds 85^{o}, except during Average-G when the "config" window of DAPDATR1 indicates Saturn configuration.
	3	Not used (assigned to "star trackers on").
	2	Enable Optics CDU Error Counters. Set to 0 at start of SPS gimbal trim subroutine, then set 1 about 0.06 seconds after TVC Enable (bit 8 of this channel) set 1, for TVC control; and set 0 at the same time TVC Enable is zeroed, (approximately 2.5 seconds after SPS engine shutdown). In OPTMON routine (entered every 0.48 sec) it is set to 0, then set to 1 about 0.06 sec later, whenever optics mode is changed to manual or CMC and computer driving of the optics is requested (OPTIND = 0 or 1). Set to 0, if present value is 1, when optics mode is changed to zero or when terminating computer control of optics (OPTIND = -0 or -1).
	1	Zero Optics CDU's. Set 1 for about 0.2 seconds at the end of the optics zeroing sequence (cf. OPTMODES). Not needed for TVC purposes, of course, since these CDU's are optics inputs and TVC merely takes advantage of the digital-to-analog outputs assigned to "optics".

Word 92a, Channel 13. A computer output channel whose outputs are used for miscellaneous purposes. Set to 0 by a fresh start or hardware restart. Processing of a verb 37 first clears bits 8 and 9 in DUMMYAD and then clears bits 10 and 11 in STARTSB2, retaining the value of the remaining bits. A software restart clears bits 11 and 10 to zero and retains the value of the other bits.

Bit	Meaning
15	Bit set 1 to permit an internal computer clock (TIME6) to be counted down at a 1600 pps rate. This clock is used for control of jet on-times in RCS DAP and the TVC roll DAP, but is not used for the entry DAP. When clock has counted down, bit is reset to 0, and the desired program interrupt action initiated.
14	Reset input trap circuit 32 , concerned with bits 10-1 of channel 32. Bit not set in program.

Word Number		Contents
(cont) 91-94	Bit	Meaning
	13	Reset input trap circuit 31B, concerned with bits 12-7 of channel 31. Bit not set in program.
	12	Reset input trap circuit 31A, concerned with bits 6-1 of channel 31. Bit not set in program.
	11	Enable Standby. Set to 1 in P06 after the clock has been read and reset to 0 by powering up the computer after the standby operation.
	10	Test DSKY lights. Set 0 by an error reset keycode input; set 1 for about 5 seconds if a verb 35 input is received.
	9	Not assigned.
	8	Not used (assigned to "BMAG output enable").
	7	Telemetry word order code bit. When channel is telemetered, should have a value of 1(bit 0 only for words 1 and 51).
	6	Block inputs to uplink cell. Not set by program.
	5	Not used (connects an alternate input to uplink cell).
	4	Range Unit activity.
	3	Range Unit Select a.
	2	Range Unit Select b.
	1	Range Unit Select c.
	Note:	Bits 1 through 4 are assigned control functions for sampling of the VHF Range link to establish quantity fed to cell 0046_8 (RNRAD). These bits must contain the quantity, 1001_2 in order to obtain this control.

Word 92b, Channel 14. A computer output channel whose outputs are used for control of computer counter cells. Set 0 by a fresh start or hardware restart. Processing of a verb 37 or software restart does not change this channel setting. An IMU cage command zeros bit 15-6.

Bit	Meaning
15	Bit set to 1 to cause output pulses from cell used to drive X-axis IMU CDU error counter (IMU X-axis coarse align or error needle for roll axis). Bit reset to 0 after counter cell reduced to 0 (3200 pps): bit 6 of channel 12 must be set to load error counter.

Word Number	Bit	Contents Meaning
(cont) 91-94	14	Same as bit 15, but for Y-axis (pitch).
	13	Same as bit 15, but for Z-axis (yaw).
	12	Bit set to 1 to cause output pulses from cell used to drive optics trunnion or TVC yaw axis. Bit reset to 0 after counter cell reduced to 0 (3200 pps): bit 2 of channel 12 must be set to load error counter.
	11	Same as bit 12, but for optics shaft or TVC pitch axis.
	10	Bit set 1 to generate gyro torquing pulses, and reset to 0 when required number produced. Is set when pulse torquing of gyros performed (for IMU compensation or for pulse torquing in P52 or P54 following acceptance of V06N93 display). Bit also set to 1 in GYCRS (pulse torque coarse aligning in P52/P54).
	9	Bit set 1 to indicate negative gyro torquing required. (otherwise, torquing is positive). Bit reset to 0 after completion of routine.
	8-7	Bits used to specify axis for gyro compensation (sequence is Y, Z, X for inner, middle, outer). Program resets to 00_2 when done. 00_2 No axis 01_2 X-axis 10_2 Y-axis 11_2 Z-axis
	6	Bit set 1 (at beginning of routine to generate gyro torquing pulses) to enable gyro torquing power supply, and left at 1 (unless a fresh start done or a caging command).
	5	Not used (assigned to entry monitoring function).
	4-2	Not assigned.
	1	Not used (assigned to "outlink activity").

Word 93a, Channel 30. A computer input channel for miscellaneous functions.

Bit	Meaning
15	Bit sensed as 0 if stable member temperature within design limits (see bit 15 of IMODES30).
14	Bit sensed as 0 if ISS has been turned on or commanded to be turned on (see bit 14 of IMODES30).

Word Number		Contents
(cont) 91-94	Bit	Meaning
	13	Bit sensed as 0 if an IMU fail indication produced (see bit 13 of IMODES30).
	12	Bit sensed as 0 if an IMU CDU fail indication produced (see bit 12 of IMODES30).
	11	Bit sensed as 0 if an IMU cage command generated by the crew (see bit 11 of IMODES30).
	10	Bit sensed as 0 if control of Saturn given to computer.
	9	Bit sensed as 0 if IMU turned on and operating with no malfunctions (see bit 9 of IMODES30).
	8	Not assigned.
	7	Bit sensed as 0 if an optics CDU fail indication produced (see bit 7 of OPTMODES).
	6	Bit sensed as 0 if guidance reference release signal produced: bit not sensed by program.
	5	Bit sensed as 0 if liftoff signal produced (used to cause termination of P02 and initiation of P11, a function that can alternatively be initiated by V75E).
	4	Bit sensed as 0 if S4B separation/abort signal produced: bit not sensed by program.
	3	Bit sensed as 0 when preparations for use of the SPS engine ("SPS ready") is complete. This bit is not sensed by the flight program.
	2	Bit sensed as 0 if CM/SM separation signal produced: bit not sensed by program.
	1	Bit sensed as 0 if "ullage thrust present" (from Saturn): bit not sensed by program.

Word 93b Channel 31. A computer input from crew control devices, used by RCS DAP.

Bit	Meaning
15	Bit sensed as 0 if computer in control of spacecraft ("G&N autopilot control"). Bit also becomes 1 if IMU turned off, SCS spacecraft control, or translation hand controller twisted in clockwise direction.

Word Number		Contents
(cont) 91-94	Bit	Meaning
	14	Bit sensed as 0 if "Free" mode selected.
	13	Bit sensed as 0 if "Hold" mode selected. If bits 14-13 are 11_2, this indicates that "Automatic" mode selected.
	12	Bit sensed as 0 if translation in -Z direction commanded.
	11	Bit sensed as 0 if translation in +Z direction commanded.
	10	Bit sensed as 0 if translation in -Y direction commanded.
	9	Bit sensed as 0 if translation in +Y direction commanded.
	8	Bit sensed as 0 if translation in -X direction commanded.
	7	Bit sensed as 0 if translation in +X direction commanded.
	6	Bit sensed as 0 if rotation in negative roll direction commanded.
	5	Bit sensed as 0 if rotation in positive roll direction commanded.
	4	Bit sensed as 0 if rotation in negative yaw direction commanded.
	3	Bit sensed as 0 if rotation in positive yaw direction commanded.
	2	Bit sensed as 0 if rotation in negative pitch direction commanded.
	1	Bit sensed as 0 if rotation in positive pitch direction commanded.

Word 94a, Channel 32. A computer input channel for additional crew input to RCS DAP, etc.

Bit	Meaning
15	Not assigned.
14	Bit sensed as 0 if "proceed key" (formerly standby button) is depressed (see bit 14 of IMODES33).
13-12	Not assigned.
11	Bit sensed as 0 if spacecraft switch set to indicate that LM attached: bit not used by program (cf. bit 2 of Flagword 7).
10-7	Not assigned.

Word Number		Contents
(cont) 91-94	Bit	Meaning
	6	Bit sensed as 0 if negative roll commanded by minimum impulse controller.
	5	Bit sensed as 0 if positive roll commanded by minimum impulse controller.
	4	Bit sensed as 0 if negative yaw commanded by minimum impulse controller.
	3	Bit sensed as 0 if positive yaw commanded by minimum impulse controller.
	2	Bit sensed as 0 if negative pitch commanded by minimum impulse controller.
	1	Bit sensed as 0 if positive pitch commanded by minimum impulse controller.

Word 94b, Channel 33. A computer input channel for hardware status and command information. Bits 15-11 are flip-flop bits (which are reset by a channel "write" command) that are also reset when a restart is encountered.

Bit	Meaning
15	Bit sensed as 0 if the computer oscillator has stopped.
14	Bit sensed as 0 if a computer warning is produced. If bits 15-14 = 10_2, it is concluded that a restart loop exists and a fresh start is done.
13	Bit sensed as 0 if an accelerometer fail indication produced (PIPA fail). See bit 13 of IMODES33.
12	Bit sensed as 0 if a telemetry end pulse rejected (downlink interrupt rate excessive). See bit 12 of IMODES33.
11	Bit sensed as 0 if an uplink input bit is rejected, indicating an excessive uplink rate. See bit 11 of IMODES33.

Word Number	Contents	
(cont) 91-94	**Bit**	**Meaning**
	10	Bit sensed as 0 if spacecraft switches set by crew so as to inhibit uplink inputs from being loaded into erasable memory (and subsequently generating an uplink interrupt). The bit reads a binary 1 when the "accept uplink" signal is present at the interface.
	9-8	Not assigned.
	7	Not used (assigned to "star present").
	6	Not used (assigned to "star tracker on").
	5	Bit sensed as 0 if computer control of optics is set. See bit 5 of OPTMODES.
	4	Bit sensed as 0 if zero optics mode is set. See bit 4 of OPTMODES. If bits 5-4 are both 1, the manual mode is selected.
	3	Not assigned.
	2	Bit sensed as zero if the Range Unit data is good.
	1	Not assigned.

95-97 VGTIGs: The predicted velocity (X, Y, Z) to be gained at TIG in reference coordinates, scaled (meters/centisecond)/2^7. During Lambert burns, the DELVEET3s from pre-thrust targeting are picked up and stored in VGTIG. External ΔV burns compute and store a rotated VG. It is calculated in burn programs: S40.1 computes (X-DELV) or copies (LAMBERT) as part of pre-thrust computations.

During P15 these words contain the following:

95 - garbage
96 - VNOW (R3 of N95) scaled (m/cs)/2^7
97 - VGTLI (R2 of N95) scaled (m/cs)/2^7

98-100 DELTA VELOCITY (X, Y, Z) at CDH. Vector velocity change computed (P31, P32/P72 and P33/P73) for CDH burn. Vector is in reference coordinates, scaled (meters/centisecond)/2^7. Transformed to local vertical coordinates for display in N82 (P32/P72). Vector becomes invalid after R41 completed.

2.2.2.3 Coast and Align List

Contents

Word Number	First Register	Second Register	
1	I.D. (77777_8)	Synch Bits (77340_8)	
2	CSM State Vector (R_X)	CSM State Vector (R_X)	
3	CSM State Vector (R_Y)	CSM State Vector (R_Y)	
4	CSM State Vector (R_Z)	CSM State Vector (R_Z)	
5	CSM State Vector (V_X)	CSM State Vector (V_X)	
6	CSM State Vector (V_Y)	CSM State Vector (V_Y)	
7	CSM State Vector (V_Z)	CSM State Vector (V_Z)	
8	CSM State Vector Time	CSM State Vector Time	
9	Actual X CDU angle	Actual Y CDU angle	
10	Actual Z CDU angle	Optics CDU trunnion angle	
11	ADOTS roll or OGARATE	ADOTS roll or OGARATE	
12	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch	
13	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw	
14	X Attitude error	Y attitude error	
15	Z attitude error	RCS flags	
16	THETADX	THETADY	
17	THETADZ	Garbage	
18	TIG	TIG	
19	STARID1	STARID2	
20	MARKTIME1	MARKTIME 1	
21	Y CDU angle	Optics shaft angle	for last MARKTIME1
22	Z CDU angle	Optics trunnion angle	
23	X CDU angle	Garbage	
24	MARKTIME2	MARKTIME2	
25	Y CDU angle	Optics Shaft angle	for last MARKTIME2
26	Z CDU angle	Optics trunnion angle	
27	X CDU angle	Garbage	
28	Apogee	Apogee	
29	Perigee	Perigee	
30	PACTOFF	YACTOFF	
31	VGTIGX	VGTIGX	
32	VGTIGY	VGTIGY	
33	VGTIGZ	VGTIGZ	
34	REFSMMAT (R_1C_1)	REFSMMAT (R_1C_1)	
35	REFSMMAT (R_1C_2)	REFSMMAT (R_1C_2)	
36	REFSMMAT (R_1C_3)	REFSMMAT (R_1C_3)	

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Contents

Word Number	First Register	Second Register
37.	REFSMMAT (R_2C_1)	REFSMMAT (R_2C_1)
38	REFSMMAT (R_2C_2)	REFSMMAT (R_2C_2)
39	REFSMMAT (R_2C_3)	REFSMMAT (R_2C_3)
40	Flagword 0	Flagword 1
41	Flagword 2	Flagword 3
42	Flagword 4	Flagword 5
43	Flagword 6	Flagword 7
44	Flagword 8	Flagword 9
45	DSPTAB+0	DSPTAB+1
46	DSPTAB+2	DSPTAB+3
47	DSPTAB+4	DSPTAB+5
48	DSPTAB+6	DSPTAB+7
49	DSPTAB+8D	DSPTAB+9D
50	DSPTAB+10D	DSPTAB+11D
51	TIME 2	TIME 1
52	LM State Vector (R_X)	LM State Vector (R_X)
53	LM State Vector (R_Y)	LM State Vector (R_Y)
54	LM State Vector (R_Z)	LM State Vector (R_Z)
55	LM State Vector (V_X)	LM State Vector (V_X)
56	LM State Vector (V_Y)	LM State Vector (V_Y)
57	LM State Vector (V_Z)	LM State Vector (V_Z)
58	LM State Vector Time	LM State Vector Time
59	Actual X CDU angle	Actual Y CDU angle
60	Actual Z CDU angle	Optics CDU trunnion angle
61	ADOTS roll or OGARATE	ADOTS roll or OGARATE
62	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
63	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
64	OPTION1	OPTION2
65	TET	TET
66	THETADX	THETADY
67	THETADZ	Garbage
68	* RSBBQ	RSBBQ+1
69	Garbage	Channel 77
70	* C31FLWRD	FAILREG
71	* FAILREG+1	FAILREG+2
72	Optics shaft	PIPAX
73	PIPAY	PIPAZ

* Indicates two single precision quantities that are not indicated otherwise.

Contents

Word Number	First Register	Second Register
74	OGC	OGC
75	IGC	IGC
76	MGC	MGC
77	Flagword 10	Flagword 11
78	TEVENT	TEVENT
79	LAUNCH AZIMUTH	LAUNCH AZIMUTH
80	OPTMODES	HOLDFLAG
81	LM MASS	CM MASS
82	DAPDATR1	DAPDATR2
83	ERROR X	ERROR Y
84	ERROR Z	Garbage
85	WBODY (roll) or OMEGAC (roll)	WBODY (roll) or OMEGAC (roll)
86	WBODY (pitch) or OMEGAC (pitch)	WBODY (pitch) or OMEGAC (pitch)
87	WBODY (yaw) or OMEGAC (yaw)	WBODY (yaw) or OMEGAC (yaw)
88	REDO COUNTER	Desired FINAL CDU X
89	Desired FINAL CDU Y	Desired FINAL CDU Z
90	IMODES 30	IMODES 33
91	Channel 11	Channel 12
92	Channel 13	Channel 14
93	Channel 30	Channel 31
94	Channel 32	Channel 33
95	DSPTAB+0	DSPTAB+1
96	DSPTAB+2	DSPTAB+3
97	DSPTAB+4	DSPTAB+5
98	DSPTAB+6	DSPTAB+7
99	DSPTAB+8D	DSPTAB+9D
100	DSPTAB+10D	DSPTAB+11D

2.2.2.4 Coast and Align List

Word Number	Contents
1a	I.D. word for this list. It will contain 77777_8.
1b	Synch bits, 77340_8.
2-18	Same as words 2-18 on the Powered List.
19	STAR ID1, 2. The star I.D.'s associated with the sighting vectors in words 21-23 and 25-27. Each star I.D. will be the octal equivalent of the CMC star catalogue number multiplied by six. Each register is scaled (star number $\times$ 6)/2^{14}. Example: Star — Cat. Number — Downlink Star I.D. Alpha Tauri — 11_8 — 66_8
20	MARKTIME1. The time of the mark (TIME2, TIME1) associated with the data described in words 21-23a, scaled centiseconds/2^{28}.
21-23a	SIGHTING DATA SET1. These five registers contain, in the following order: YCDU angle, optics shaft angle, ZCDU angle, optics trunnion angle and XCDU angle. This data is valid at MARKTIME1 and is associated with the star indexed by BESTI (word 19a). XCDU, YCDU, ZCDU and the optics shaft angle are treated as unsigned 15-bit fractions, scaled degrees/360. The optics trunnion angle is scaled (degrees-19.7754)/45. The bias, 19.7754, is programmed-in.
23b	Garbage.
24	MARKTIME2. The time of the mark (TIME2, TIME1) associated with the data described in words 25-27a, scaled centiseconds/2^{28}.
25-27a	SIGHTING DATA SET 2. Same as words 21-23a of this list except that this set is associated with MARKTIME2 and Star ID2 indexed by BESTJ (word 19b).
27b	Garbage.
28	APOGEE. The altitude of the apogee above a reference radius (pad radius - earth, landing site - moon), scaled meters/2^{29}. Calculated in R30 only.

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Word Number	Contents
29	PERIGEE. The altitude of the perigee above a reference radius (pad radius - earth, landing site - moon) scaled meters/2^{29}. Calculated in R30 only.
30	Same as Word 28 of the Powered List.
31-33	Same as words 95 - 97 of the Powered List.
34-63	Same as words 34 - 63 of the Powered List.
64a	OPTION1. The option code which is displayed in R1 in conjunction with a flashing V04 N06 to request the astronaut to load into R2 the option he desires.
64b	OPTION2. The astronaut-selected option which was loaded into R2 as a result of the displayed OPTION1 code.

The OPTION1 and OPTION2 codes, scaled in octal, are as follows:

OPTION1 Code	Purpose	OPTION2 Code (Astronaut Input)	
00001 (during P52, P54)	Specify IMU Orientation	1=Preferred 3=REFSMMAT	2=Nominal 4=Landing site
† 00002 (during P21 & P29)	Specify Vehicle	1=This Vehicle	2=Other Vehicle
00004	Specify State of Tracking	1=Partial	0=Full
00007 (during P37)	Specify Propulsion System	1=SPS	2=RCS
00024 (during P20)	Specify Tracking Option	0=Rendezvous, VECPOINT 1=Celestial body, VECPOINT 2=Rotation 4=Rendezvous, 3-axis 5=Celestial body, 3-axis	

Word Number	Contents
65	TET. The time of state vector being integrated or the time to which the last state vector was integrated. It is stepped by half-time-step increments (plus or minus) whenever integration is being done. It is scaled, centiseconds/2^{28}.
66-73	Same as words 66-73 of the Powered List.
74-76	OGC, IGC, MGC. During R55, the X, Y, and Z gyro torquing angles. During coarse align, in P52 and P54, the desired gimbal angles (outer, inner & middle), scaled degrees/360.
77	Same as word 77 of the Powered List.
78	Same as word 78 of the Powered List.
79	LAUNCHAZ: The clockwise angle from true north to the IMU stable member X axis, measured in the local horizontal plane and scaled degrees/360. The expected angles will range from $+72^{\circ}$ to $+108^{\circ}$ (approx.). The item is pad loaded and may be re-loaded during P02, gyrocompassing program, via Verb 78E.
80-94	Same as words 80-94 of the Powered List.
95-100	Same as words 45-50 of the Powered List.

† This change accomplished in Revision 14 but PCR 1054 notation omitted.

2.2.2.5 Rendezvous and Prethrust List

Contents

Word Number	First Register	Second Register
1	I.D. (77775_8)	Synch Bits (77340_8)
2	CSM State Vector (R_X)	CSM State Vector (R_X)
3	CSM State Vector (R_Y)	CSM State Vector (R_Y)
4	CSM State Vector (R_Z)	CSM State Vector (R_Z)
5	CSM State Vector (V_X)	CSM State Vector (V_X)
6	CSM State Vector (V_Y)	CSM State Vector (V_Y)
7	CSM State Vector (V_Z)	CSM State Vector (V_Z)
8	CSM State Vector Time	CSM State Vector Time
9	Actual X CDU angle	Actual Y CDU angle
10	Actual Z CDU angle	Optics CDU trunnion angle
11	ADOTS roll or OGARATE	ADOTS roll or OGARATE
12	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
13	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
14	X attitude error	Y attitude error
15	Z attitude error	RCS flags
16	THETADX	THETADY
17	THETADZ	Garbage
18	TIG	TIG
19	T_F Lambert	T_F Lambert
20	RTARGX	RTARGX
21	RTARGY	RTARGY
22	RTARGZ	RTARGZ
23	VHF TIME	VHF TIME
24	MARK TIME	MARK TIME
25	Y CDU angle	Optics shaft angle
26	Z CDU angle	Optics trunnion angle
27	X CDU angle	VHF Range
28	VHF MARKS	OPTIC MARKS
29	TPI TIME	TPI TIME
30	ECSTEER	Garbage
31	DELVTPF (Magnitude)	DELVTPF (Magnitude)
32	CDH TIME	CDH TIME
33	CSI TIME	CSI TIME
34	TPF Time	TPF Time
35	DELVSLV X	DELVSLV X
36	DELVSLV Y	DELVSLV Y
37	DELVSLV Z	DELVSLV Z

ß

Contents

Word Number	First Register	Second Register
38	Range	Range
39	Range Rate	Range Rate
40	Flagword 0	Flagword 1
41	Flagword 2	Flagword 3
42	Flagword 4	Flagword 5
43	Flagword 6	Flagword 7
44	Flagword 8	Flagword 9
45	DSPTAB+0	DSPTAB+1
46	DSPTAB+2	DSPTAB+3
47	DSPTAB+4	DSPTAB+5
48	DSPTAB+6	DSPTAB+7
49	DSPTAB+8D	DSPTAB+9D
50	DSPTAB+10D	DSPTAB+11D
51	TIME 2	TIME 1
52	LM State Vector (R_X)	LM State Vector (R_X)
53	LM State Vector (R_Y)	LM State Vector (R_Y)
54	LM State Vector (R_Z)	LM State Vector (R_Z)
55	LM State Vector (V_X)	LM State Vector (V_X)
56	LM State Vector (V_Y)	LM State Vector (V_Y)
57	LM State Vector (V_Z)	LM State Vector (V_Z)
58	LM State Vector Time	LM State Vector Time
59	Actual X CDU angle	Actual Y CDU angle
60	Actual Z CDU angle	Optics CDU trunnion angle
61	ADOTS roll or OGARATE	ADOTS roll or OGARATE
62	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
63	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
64	OPTION1	OPTION2
65	TET	TET
66	THETADX	THETADY
67	THETADZ	Garbage
68	* RSBBQ	RSBBQ+1
69	Garbage	Channel 77
70	* C31FLWRD	FAILREG
71	* FAILREG+1	FAILREG+2
72	Optics shaft	PIPAX
73	PIPAY	PIPAZ
74	CDH Delta Altitude	CDH Delta Altitude
75	Central Angle	Central Angle

* Indicates two single precision quantities that are not indicated otherwise.

	Contents	
Word Number	First Register	Second Register
76	Spare	Spare
77	DELVEET3 X	DELVEET3 X
78	DELVEET3 Y	DELVEET3 Y
79	DELVEET3 Z	DELVEET3 Z
80	OPTMODES	HOLDFLAG
81	LM MASS	CM MASS
82	DAPDATR1	DAPDATR2
83	ERROR X	ERROR Y
84	ERROR Z	Garbage
85	WBODY (roll) or OMEGAC (roll)	WBODY (roll) or OMEGAC (roll)
86	WBODY (pitch) or OMEGAC (pitch)	WBODY (pitch) or OMEGAC (pitch)
87	WBODY (yaw) or OMEGAC (yaw)	WBODY (yaw) or OMEGAC (yaw)
88	REDO COUNTER	Desired FINAL CDU X
89	Desired FINAL CDU Y	Desired FINAL CDU Z
90	IMODES 30	IMODES 33
91	Channel 11	Channel 12
92	Channel 13	Channel 14
93	Channel 30	Channel 31
94	Channel 32	Channel 33
95	RTHETA	RTHETA
96	GEODETIC LAT	GEODETIC LAT
97	LONG	LONG
98	V PRED	V PRED
99	GAMMA(EI)	GAMMA(EI)
100	Flagword 10	Flagword 11

2.2.2.6 Rendezvous and Prethrust List

Word Number	Contents
1a	I.D. word for this list. It will contain 77775_8.
1b	Synch bits, 77340_8.
2-22	Same as words 2-22 on Powered List.
23	VHF TIME. The time (TIME2, TIME1) of the last VHF Range mark, scaled centiseconds/2^{28}. This item is calculated each time the VHF Range is read. It is also used to determine if one minute has elapsed since the last mark was processed and to integrate the state vector to the mark-time.
24	OPTICS MARKTIME. The time of mark (TIME2, TIME1) associated with the data described in words 25-27a, scaled centiseconds/2^{28}.
25-27a	SIGHTING DATA. These five registers contain, in the following order: YCDU angle, optics shaft angle, ZCDU angle, optics trunnion angle and XCDU angle. This data is valid at the time an optics mark is taken on the LM vehicle during rendezvous tracking (P20). XCDU, YCDU, ZCDU and optics shaft angle are unsigned 15-bit fractions, scaled degrees/360. The trunnion angle is a 14-bit signed fraction scaled, (degrees -19.7754)/45 (two's complement). The bias, 19.7754, is programmed-in.
27b	VHF RANGE. (Raw Data). The range from the CSM to the LM as measured by the VHF range link, using the Rendezvous Tracking Data Processing Routine. This quantity is a 15-bit integer with the least significant bit equal to 0.01 nmi. (multiply by 18.52 to obtain meters). Whenever the VHF Range Flag is found to be set, the routine (R22) reads the range value if at least 60 seconds have expired since the time of last reading. If so, the t_{VHF} is updated to the present time and a VHF range reading made. It is assumed, for practical purposes, that the range data is acquired at this present t_{VHF} but there actually is a very small time delay.
28a	VHF MARKS. The number of VHF ranging marks incorporated into the state vector since the initialization of P20, scaled 2^{-14}. This item is used in the N45 display (two most significant digits of R1) and has a range in that display of 0 to 99 (modulo 100). VHFCNT is incremented each time a VHF ranging mark is incorporated (approx. 1/min if P20 is operating, VHF ranging is on and RANGFLAG, VHFRFLAG, UPDATFLG and TRACKFLG are set). Set to 0 by Fresh Start, P37, and when the W-matrix is re-initialized.

Word Number	Contents
28b	OPTIC MARKS. The number of optic marks incorporated into the state vector since the initialization of P20, scaled 2^{-14}. This item is used in the N45 display (two least significant digits of R1) and has a range in that display of 0 to 99 (modulo 100). TRKMKCNT is incremented each time an optics mark is incorporated. The frequency depends upon the astronaut because marking is a manual operation. Set to 0 as in word 28a.
29	TPI TIME. The time of ignition for the Rendezvous programs, scaled centiseconds/2^{28}. It is an input to P31, P32, P34, P72 and P74. It can be updated by P34 or P74 if elevation angle is provided.
30a	ECSTEER. A pad-load erasable which may be used by P40 to set CSTEER, the constant "c" in the cross-product steering equation: $\Delta \underline{m} = c\underline{b}\Delta t - \Delta \underline{v}$, and in certain prethrust computations for P40/41. It is scaled as a 14-bit fraction/4. P34 and P35 will set ECSTEER = 1. 0. P37 will set ECSTEER = 0. 5. Values for "C" from -4. 0 to +4. 0 (less 1 bit) can be handled. The MIT standard is 1. 0, except for P37 where 0. 5 is used. Once set up prior to a burn, ECSTEER should be constant throughout the burn and post-burn sequences. ECSTEER is also set to 1 by P31, P32, P33 and P36. Although this setting is not functional, it would destroy any previously uplinked value.
30b	Garbage.
31	DELVTPF. The difference between the absolute velocities of the passive and active vehicles at intercept time [ABVAL (VPASS4 - VTPRIME)], scaled (meters/centisecond)/2^7. This quantity is calculated by P34 and P74.
32	CDH Time. The time of ignition of the CDH maneuver. Used to initialize state vector for CDHMVR subroutine. Calculated each iteration of CSI/A subroutine in P31, P32 and P72. Scaled centiseconds/2^{28}, referenced to computer clock.

Word Number	Contents
33	CSI Time. The time of ignition for the CSI maneuver. Used in P31, P32 and P72 calculations. Input by astronaut by V25N11. Scaled centiseconds/2^{28}, referenced to computer clock. During multiple CSI sequences in MINKEY, the MINKEY controller updates this cell to the time of the next CSI maneuver.
34	TPF Time. The time of intercept for the various rendezvous programs, scaled centiseconds/2^{28}. It is one of the variables used in the determination of the required delta velocity for a rendezvous maneuver. It is calculated in P34/P74 and inputted to the midcourse programs, P35/P75.
35-37	P30 DELV's. An impulsive Delta V in the local vertical coordinates of the active vehicle at the time of ignition specified by the astronaut (V06N81) or uplink and scaled (meters/centisecond)/2^7. The local vertical coordinate system may be either earth-centered or moon-centered. There is no flagbit to indicate the origin point. The P30 ΔV vector is rotated into a basic reference coordinate system for use by P40 or P41.
38	RANGE. This parameter is involved in two areas, R31/R34 and R36. In either category it is scaled, meters/2^{29}. In R31/R34, RANGE is the magnitude of the difference between the two vehicles' (CSM-LM), radius vectors. In R36, RANGE represents the out-of-plane position for the CSM and is computed as $Y = \underline{r}_C \cdot \{\mathrm{UNIT}(\underline{V}_L \times \underline{r}_L)\}$. This item is calculated in P79 or whenever R31, R34 or R36 is selected by the astronaut via V83, V85, or V90. The displayed value can range from 000.00 nmi. to 999.99 nmi. Once the routine is selected, RANGE is recomputed in R31/R34 until program termination ("PROCEED"); in R36 it is necessary to "RECYCLE" in order to have the value recomputed. The update rate in R31 and R34 is a function of what other jobs are running.
39	RRATE. This parameter is involved in two areas, R31/R34 and R36. It is scaled (meters/centisecond)/2^7. In R31/R34 it is defined as the range rate between the two vehicles (CSM-LM) and is computed as $\dot{R} = (\underline{V}_L - \underline{V}_C) \cdot \{\mathrm{UNIT}(\underline{R}_L - \underline{R}_C)\}$. A negative quantity indicates closing. In R36, RRATE represents velocity for CSM in the sense of $\dot{Y} = \underline{V}_C \cdot \{\mathrm{UNIT}(\underline{V}_L \times \underline{r}_L)\}$. This item is calculated in P79 or whenever R31, R34, or R36 is selected by the astronaut using verbs V83, V85, or V90. The displayed value can range from 0000.0 fps to 9999.9 fps. It is recomputed

Word Number	Contents
	in R31/R34 until program termination ("PROCEED"). In R36 it is necessary to RECYCLE in order to update the value, which is valid for an astronaut-selected time. The update rate in R31 and R34 is a function of what other jobs are running.
40-63	Same as words 40-63 of the Powered List.
64, 65	Same as words 64, 65 of the Coast and Align List.
66-73	Same as words 66-73 of the Powered List.
74	CDH Delta Altitude. The altitude between the active and passive vehicle orbits at CDH time. Used for display and other CDHMVR calculations. Calculated each iteration of CDHMVR subroutine; once in P33/P73, numerous times possible in P31, P32/P72. Earth- or moon-centered altitude depending upon whether bit 12 of flagword 8 (CMOONFLG) is zero or one, respectively. Scaled meters/2^{29}.
75, 76	Same as words 75 and 76 of Powered List.
77-79	DELVEET3s. The impulsive DELTA V (X, Y, Z) calculated via the Lambert routine, scaled (meters/centisecond)/2^7. These quantities are based on the offset-target vector, time of ignition, and transfer time. The reference coordinates may be either moon- or earth-centered. The system in use is indicated by the contents of erasable register, RTX2. If RTX2 = 0, the system is earth-centered but, if RTX2 = 2, the system is moon-centered.
80-94	Same as words 80-94 of the Powered List.
95	Word 95 serves two areas, RTHETA in R31/R34 and RRATE2 in R36. RTHETA. In R31/R34 it is the angle from the local horizontal plane to either the CSM X-body axis (Noun 54 flashing) or to the SXT line of sight (Noun 53 flashing). The scaling is in degrees/360. This item is calculated in P79 or whenever R31 or R34 is selected by the astronaut via V83 or V85. It is computed in R31/R34 until program termination ("PROCEED"). The update rate is a function of what other jobs are running. RRATE2. Same as word 39 for R36 except velocity is for LM.
96	LAT (SPL). The latitude of the landing site (earth), scaled degrees/360. It is used only for DSKY display and is calculated and displayed at the end of both the conic phase and also the precision phase of the Return to Earth program. The range of values is from -90° to $+90^{\circ}$. A negative value indicates south of the equator, whereas a positive one denotes north of the equator.

Word Number	Contents
97	LNG (SPL). The longitude of the landing site (earth), scaled degrees/360. The range of values is from -180° to +180°. A negative quantity indicates west of Greenwich, whereas a positive one denotes east of Greenwich. This item is used for DSKY display only and is calculated and displayed at the end of both the conic phase and the precision phase of the Return to Earth program.
98	VPRED. The predicted velocity magnitude at an entry altitude of 400,000 ft above the Fischer Ellipsoid, scaled (meters/centisecond)/2^7. The range of values is from +75 meters/centisecond to +115 meters/centisecond. This item is used for DSKY display only and is calculated and displayed at the end of both the conic phase and the precision phase of the Return to Earth program.
99	GAMMAEI. The flight path angle between the inertial velocity vector and the local horizontal at the entry interface altitude of 400,000 ft. above the Fischer Ellipsoid, scaled degrees/360. The range of values runs from -1° to -7° and is used for display only. A negative value indicates that the flight path is below the horizontal plane. This item is calculated and displayed at the end of both the conic and precision phases of the Return to Earth program.
100	Same as word 77 of the Powered List.

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2.2.2.7 Entry and Update List

Contents

Word Number	First Register	Second Register
1	I.D. (77776_8)	Synch Bits (77340_8)
2	CSM State Vector (R_X)	CSM State Vector (R_X)
3	CSM State Vector (R_Y)	CSM State Vector (R_Y)
4	CSM State Vector (R_Z)	CSM State Vector (R_Z)
5	CSM State Vector (V_X)	CSM State Vector (V_X)
6	CSM State Vector (V_Y)	CSM State Vector (V_Y)
7	CSM State Vector (V_Z)	CSM State Vector (V_Z)
8	CSM State Vector Time	CSM State Vector Time
9	Actual X CDU angle	Actual Y CDU angle
10	Actual Z CDU angle	Optics CDU trunnion angle
11	ADOTS roll or OGARATE	ADOTS roll or OGARATE
12	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
13	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
14	X attitude error	Y attitude error
15	Z attitude error	RCS flags
16	THETADX	THETADY
17	THETADZ	Garbage
18	ENTRY DAP MODE	PREL (roll rate)
19	QREL (pitch rate)	RREL (yaw rate)
20	L/D1	L/D1
21	* UPBUFF	UPBUFF+1
22	* UPBUFF+2	UPBUFF+3
23	* UPBUFF+4	UPBUFF+5
24	* UPBUFF+6	UPBUFF+7
25	* UPBUFF+8D	UPBUFF+9D
26	* UPBUFF+10D	UPBUFF+11D
27	* UPBUFF+12D	UPBUFF+13D
28	* UPBUFF+14D	UPBUFF+15D
29	* UPBUFF+16D	UPBUFF+17D
30	* UPBUFF+18D	UPBUFF+19D
31	COMPNUMB	UPOLDMOD
32	UPVERB	UPCOUNT
33	Roll error	Roll angle
34	LATANG	LATANG
35	RDOT	RDOT
36	THETAH	THETAH
37	LAT (SPL)	LAT (SPL)
38	LONG (SPL)	LONG (SPL)

* Indicates two single precision quantities that are not indicated otherwise.

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Contents

Word Number	First Register	Second Register
39	ALPHA	BETA
40	Flagword 0	Flagword 1
41	Flagword 2	Flagword 3
42	Flagword 4	Flagword 5
43	Flagword 6	Flagword 7
44	Flagword 8	Flagword 9
45	DSPTAB+0	DSPTAB+1
46	DSPTAB+2	DSPTAB+3
47	DSPTAB+4	DSPTAB+5
48	DSPTAB+6	DSPTAB+7
49	DSPTAB+8D	DSPTAB+9D
50	DSPTAB+10D	DSPTAB+11D
51	TIME 2	TIME 1
52	PIPTIME1	PIPTIME1
53	DELVX	DELVX
54	DELVY	DELVY
55	DELVZ	DELVZ
56	TTE (EMS)	TTE (EMS)
57	VIO	VIO
58	VPRED (EI)	VPRED (EI)
59	Actual X CDU angle	Actual Y CDU angle
60	Actual Z CDU angle	Optics CDU trunnion angle
61	ADOTS roll or OGARATE	ADOTS roll or OGARATE
62	ADOTS pitch or OMEGA B pitch	ADOTS pitch or OMEGA B pitch
63	ADOTS yaw or OMEGA B yaw	ADOTS yaw or OMEGA B yaw
64	OPTION1	OPTION2
65	TET	TET
66	ERROR X	ERROR Y
67	ERROR Z	THETADX
68	THETADY	THETADZ
69	ENTRY DAP MODE	PREL (roll rate)
70	QREL (pitch rate)	RREL (yaw rate)
71	UPBUFF	UPBUFF+1
72	UPBUFF+2	UPBUFF+3
73	UPBUFF+4	UPBUFF+5
74	UPBUFF+6	UPBUFF+7
75	UPBUFF+8D	UPBUFF+9D

Contents

Word Number		First Register	Second Register
76		UPBUFF+10D	UPBUFF+11D
77		UPBUFF+12D	UPBUFF+13D
78		UPBUFF+14D	UPBUFF+15D
79		UPBUFF+16D	UPBUFF+17D
80		UPBUFF+18D	UPBUFF+19D
81		LM MASS	CM MASS
82		DAPDATR1	DAPDATR2
83		Roll Angle	Roll Command
84		OPTMODES	HOLDFLAG
85		WBODY (roll) or OMEGAC (roll)	WBODY (roll) or OMEGAC (roll)
86		WBODY (pitch) or OMEGAC (pitch)	WBODY (pitch) or OMEGAC (pitch)
87		WBODY (yaw) or OMEGAC (yaw)	WBODY (yaw) or OMEGAC (yaw)
88		REDO COUNTER	Desired Final CDU X
89		Desired FINAL CDU Y	Desired FINAL CDU Z
90		IMODES 30	IMODES 33
91		Channel 11	Channel 12
92		Channel 13	Channel 14
93		Channel 30	Channel 31
94		Channel 32	Channel 33
95	*	RSBBQ	RSBBQ+1
96		Garbage	Channel 77
97	*	C31FLWRD	FAILREG
98	*	FAILREG+1	FAILREG+2
99		Flagword 10	Flagword 11
100		GAMMA (EI)	Range for Initialization

* Indicates two single precision quantities that are not indicated otherwise.

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2.2.2.8 Entry and Update List

Word Number	Contents
1a	I. D. word for this list. It will contain 77776_8.
1b	Synch bits. It will contain 77340_8.
2-17	Same as words 2-17 on the Powered List.
18a	ENTRY DAP MODE. A 4-position switch specifying branching in ENTRY DAP, scaled 2^{-14}. Set to "-1" (77776_8) if entry equations sense drag in excess of 0.05 g. Set to "-0" (77777_8) if the ALFA angle (pitch attitude) magnitude is greater than 135°. Set to "+1" (00001_8) if the ALFA angle magnitude is in the range 45°-135°. Set to "+0" (00000_8) if the ALFA angle is less than 45°. The expected value sequence would be, $+1 \rightarrow +0 \rightarrow -1$. The value, -0, is not generally expected. This item is calculated each 0.1 second after the DAP is turned on in P62. Flagword 6, bits 12 and 2, indicates an active DAP.
18b, 19	PREL, QREL, RREL. The single-precision roll, pitch and yaw rates, components of the CM angular velocity vector along the body X, Y, and Z axes and scaled (degrees/sec)/1800. All are corrected for $\dot{\gamma}_E$ if $\dot{\gamma}_E > \dot{\gamma}_E$ min. The expected range of values would be: PREL $\pm 20^\circ$/sec, QREL $\pm 4^\circ$/sec, RREL $\approx \pm 17^\circ$/sec. These quantities are calculated each 0.1 sec after the DAP is turned on in P62. The functioning is indicated by non-zero values in both bit 1 and bit 2 of flagword 6.
20	L/D1. The commanded value of lift-to-drag ratio used in Reentry Steering to provide Roll Command, scaled 2^0. It is computed whenever lateral logic is exercised, normally each 2 seconds after the initiation of P64 until the velocity becomes less than 1000 ft/sec in P67. The value range should be equal to, or less than, 1.0. It is omitted in P66. LAD is pad loaded.

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C

Word Number	Contents
21-30	UPBUFF's. These twenty registers, UPBUFF through UPBUFF +19D, contain the uplinked octal components in the transmitted order. If the update is composed of less than twenty quantities, the remaining registers will contain garbage.
31a	COMPNUMB. The total number (octal) of components the update program expects to receive. For a Verb 71 or a Verb 72 update, COMPNUMB will be set equal to the index value.
31b	UPOLDMOD. This is the number of the CMC program which was interrupted by P27, the update program. It will indicate program 0, 2, 20, or Fresh Start (-0_8).
32a	UPVERB. The least significant digit of the verb number which was selected to initiate a desired CMC update.
32b	UPCOUNT. The octal identifier of the next quantity that the update program expects to receive. As each quantity goes into UPBUFF, UPCOUNT will be incremented by one, until it is equal to COMPNUMB. It will not change during a line-by-line correction of the data load.
33a	ROLL ERROR. The CM roll attitude error in body axes generated by the DAP and displayed on the FDAI needle, scaled degrees/360. The error is integrated each 0.1 sec between 2-second DAP updates. This quantity is the same as the item, AK, except for the scale factor, and is active only after the DAP is turned on in P62. A one in bit 12 of flagword 6 indicates such activity.
33b	ROLL ANGLE. The roll attitude angle used by ENTRY DAP, scaled degrees/180. It is the first Euler rotation of the CM body triad about the negative relative velocity vector -$\underline{UVA}$, along which $\underline{UBX}$ points. The value ranges ± 180°, is calculated after the DAP is turned on in P62 and is updated each 0.1 second during its operating period. Operation is indicated by a non-zero in bit 12 of flagword 6.
34	LATANG. The lateral range expressed as an angle, scaled radians/4. It will range at less than 200 nmi and is calculated each 2 seconds after the initiation of P63 until the end of P67.

Word Number	Contents
35	RDOT. Altitude rate. The radial component of velocity (negative if descending), scaled (feet/sec)/(2 × 25766.1973). This is a scalar component calculated in earth-centered reference coordinates. If bit 9, flagword 6 (RELVELSW) is zero, the velocity used is inertial. If bit 9, flagword 6 is a one, a velocity relative to air mass is used. The expected range of values runs from less than -7000 ft/sec to +1000 ft/sec and is calculated each 2 seconds after P63 until the end of P67.
36	THETAH. The range between the present position and the estimated landing site, expressed as an angle and scaled, degrees/360. The expected value is less than 180°. It is calculated each 2 seconds after P63 until the end of P67. It is used in P61 for computing EMS display but is not on the Powered Flight downlist, however.
37	LAT(SPL). The geodetic latitude of the entry target, scaled degrees/360. A positive quantity denotes North while a negative quantity indicates South. This parameter is pad loaded or DSKY loaded when P61 or P62 is in progress. It is also computed in P37 (Return to Earth) and displayed.
38	LONG(SPL). The longitude of the entry target scaled, degrees/360. A positive quantity indicates East while a negative quantity denotes West. This parameter is pad loaded or DSKY loaded when P61 or P62 is in progress. It is also computed in P37 (Return to Earth) and displayed.
39a	ALPHA. The pitch attitude angle, used by ENTRY DAP and scaled, degrees/180. It is the third rotation of the CM body triad in the Euler sequence R, β, α, and is about $\underline{\text{UBY}}$. The value range is $\pm 180^{\circ}$ and is calculated each 0.1 second after the DAP is turned on in P62. Operation of such is indicated by a non-zero value in bit 12, flagword 6. (Bits 1 and 2 are also non-zero.)
39b	BETA. The yaw attitude angle, used by ENTRY DAP and scaled degrees/180. It is the second rotation of the CM body triad in the Euler sequence R, β, α, and is about $\underline{\text{UBZ}}$. The range is $\pm 90^{\circ}$ and is calculated each 0.1 second after the DAP is turned on in P62. This state is indicated by a non-zero value in bit 12, flagword 6. (Bits 1 and 2, flagword 6, will also be non-zero.)

Word Number	Contents
40-51	Same as words 40-51 of the Powered List.
52	PIPTIME1. The time (T2/T1) at which the PIPAs are read, scaled centiseconds/2^{28}. Integration stores the PREREAD state vector time in anticipation of reading PIPAs at that time. PIPASR stores TIME2/TIME1 every two seconds during Average g.
53-55	DELVs. The sampled X, Y, & Z PIPA accumulations (velocity increments) with compensation for PIPA bias and scale factor errors. These quantities are in the stable member coordinate system and are scaled, (cm/sec)/(5.85×2^{14}). Calculation takes place every two seconds during AVE G. The variation with time and the range of values depend on the acceleration level and compensation. There is a zeroing of all low-order components and a momentary zeroing of DELVY and DELVZ prior to the loading of PIPA contents into respective high-order words (part of READACCS, or REREADAC task). If no restarts occur the momentary zeroing would not appear on the downlink. PIPA compensation follows in Servicer job (inhinted, so that all or no PIPA compensation shows up).
56	TTE(EMS). The time required to traverse the conic path from the present position to the specified EMS altitude above the Fischer ellipsoid, expressed as a negative number, counting down and scaled, centiseconds/2^{28}. The value is calculated in P61. It will be decremented every two seconds thru P63 and displayed via N63. (See Note 1).
57	VIO. The predicted entry velocity at the EMS altitude above the Fischer radius along a conic path from the present position, scaled (meters/centisecond)/2^{7}. The value will be approximately 38,000 ft/s and be calculated in P61. (See Note 1).
58	VPRED(EI). The predicted entry velocity at 400K feet above the Fischer radius along a conic path from the present position, scaled (meters/centisecond)/2^{7}. The value will be approximately 38K ft/s and be calculated in P61. (See Note 1).

(Note 1: If the Recycle option (V32E) of N63 in P61 is exercised, this quantity is recalculated using the current state vector. However, only the result of the final calculation will appear on the ENTRY and UPDATE list).

Word Number	Contents
59-63	Same as words 59-63 on the Powered List.
64-65	Same as words 64-65 on the Coast and Align List.
66-67a	Same as words 83, 84a on the Powered List.
67b-68	Same as words 16, 17a on the Powered List.
69-70	Repeat of words 18-19 of this list.
71-80	Repeat of words 21-30 of this list.
81-82	Same as words 81-82 on the Powered List.
83a	Same as word 33b of this list.
83b	ROLL COMMAND. The most significant half of roll attitude command issued by Entry Guidance equations and used by the Entry DAP, scaled degrees/360. The angle is defined as a rotation about the negative relative velocity vector, $-\underline{V}_{REL}$. The value will range ± 180° and is initially set in P62, based on HEADSUP, and holds until the drag exceeds 0.05 g. The quantity will be changed each 2 seconds after P64 until P67.
84	Same as word 80 on the Powered List.
85-94	Same as words 85-94 on the Powered List.
95-98	Same as words 68-71 on the Powered List.
99	Same as word 77 on the Powered List.
100a	GAMMA(EI). The conic flight path angle between the inertial velocity and the local horizontal at the entry interface altitude of 400,000 ft above the Fischer ellipsoid, scaled degrees/360. A minus quantity indicates that the flight path is below the horizontal plane. This item is calculated in P61. (See Note 1).
100b	RANGE for INITIALIZATION. The predicted range angle from the EMS altitude above Fischer radius to target along conic from present position, scaled degrees/360. This value is calculated in P61. (See Note 1).

REENTRY and DAP SHARING of DOWNLIST REGISTERS

Words 11-13 ADOT, ...+5	=	XPIPBUF YPIPBUF ZPIPBUF	PIPA Buffers for TM during ENTRY. PIPs filed here every 0.5 second.
		XOLDBUF YOLDBUF ZOLDBUF	Contain PIPA value previously in PIPBUF.
		Scaled (centimeters/second)/(5.85×2^{14}).	
Word 16a THETADX	=	QAXERR, Pitch attitude error. Scaled degrees/180.	

Word 16b THETADY = RAXERR, Yaw attitude error. Scaled degrees/180.

Word 17a THETADZ = Q7, high order register

Word 17b Garbage = Q7, low order register

$\left.\right\}$ Minimum drag for UPCONTROL, scaled $(ft/sec^2)/805$.

Word 21a UPBUFF = CMTMTIME, Time at which body-rate list was last initialized. Scaled centiseconds/ 2^{14}.

Word 21b UPBUFF +1 = SW/NDX, Combined switch and index associated with FDAI display and TM. See COLOSSUS GSOP Section 3. Scaled 2^{-14}.

Words 22a-29a UPBUFF +2, ... +16D = Body rates in the sequence, PREL, QREL, RREL, PREL, QREL, RREL, etc. Scaled (degrees/sec)/1800.

Words 29b, 30a UPBUFF +17D, ...+18D = V1, initial velocity for UPCONTROL. Scaled (ft/sec)/(2 × 25766. 1973).

Word 30b UPBUFF +19D = A0 (high order register) initial drag for UPCONTROL. Scaled $(ft/sec^2)/805.0$.

Word 56 TTE, ...+1 = During P64 through P67: L/DCALC, onboard estimate of L/D ratio. Scaled 2^0 (max. value of 1.0). Exception: garbage if .05GSW = 0 (bit 3 of Flagword 6). This will occur in P66 if a ballistic trajectory is flown.

Word 57 VIO, ...+1 = LEWD, UPCONTROL reference, L/D. Scaled 2^0 (max. value of 1.0).

Word 58 VPRED, ...+1 = VL, exit velocity for UPCONTROL. Scaled (ft/sec)/ (2 × 25766. 1973).

Word 66a ERRORX = VDT/180, preselected drifting rate used by Roll DAP (0 = DAP in dead zone). Scaled (deg/sec)/90.

Word 66b ERRORY = —VT/180E, minus roll rate used by the Roll DAP update cycle. Scaled (-deg/sec)/90.

Word 67a ERRORZ = LCX/360, the roll error (prior to reflection, if any) used by two second Roll DAP update cycle. Scaled deg/360. The value in this cell is used to initialize Roll Error (word 33a); however, Roll Error is updated each 0.1 second.

Words 85-87 WBODY, ...+5

= ASKEP, Kepler range angle.
ASP1, final phase range angle.
ASPUP, Up-range angle.
ASPDWN, range angle down to PULL-UP.
ASP3 (double-precision) gamma correction range angle.
All scaled, deg/360.

Words 88b, 89 THETAD, ...+2

= RDOTREF (double-precision), reference RDOT for UPCONTROL. VREF (high-order register only), reference velocity for UPCONTROL. Both scaled (ft/sec)/(2 × 25766.1973).

Word 100 GAMMAEI, ...+1

First Time Sharing = GAMMAL (double-precision), flight-path angle at VL. Scaled 2^0 radians.

Second Time Sharing = PREDANG (single-precision), predicted range angle, final phase. Scaled, revolutions/2^{-3}, where a revolution is 21600 n. m.
JJ (single-precision), index in final phase, table look-up. Scaled 2^{-14}.

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2.2.2.9 Program 22 List

Contents

Word Number	First Register	Second Register
1	I.D. (77773_8)	Synch bits (77340_8)
2	CSM State Vector (R_X)	CSM State Vector (R_X)
3	CSM State Vector (R_Y)	CSM State Vector (R_Y)
4	CSM State Vector (R_Z)	CSM State Vector (R_Z)
5	CSM State Vector (V_X)	CSM State Vector (V_X)
6	CSM State Vector (V_Y)	CSM State Vector (V_Y)
7	CSM State Vector (V_Z)	CSM State Vector (V_Z)
8	CSM State Vector Time	CSM State Vector Time
9	Actual X CDU angle	Actual Y CDU angle
10	Actual Z CDU angle	Optics CDU trunnion angle
11	ADOTS roll or OGARATE	ADOTS roll or OGARATE
12	ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
13	ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
14	X attitude error	Y attitude error
15	Z attitude error	RCS flags
16	THETADX	THETADY
17	THETADZ	Garbage
18	MARKTIME for first mark	MARKTIME for first mark
19	INNER GIMBAL ANGLE	SHAFT ANGLE
20	MIDDLE GIMBAL ANGLE	TRUNNION ANGLE
21	OUTER GIMBAL ANGLE	Most significant part of MARKTIME for second mark
22	Least significant part of MARK-TIME for second mark	INNER GIMBAL ANGLE
23	SHAFT ANGLE	MIDDLE GIMBAL ANGLE
24	TRUNNION ANGLE	OUTER GIMBAL ANGLE
25	MARKTIME for third mark	MARKTIME for third mark
26	INNER GIMBAL ANGLE	SHAFT ANGLE
27	MIDDLE GIMBAL ANGLE	TRUNNION ANGLE
28	OUTER GIMBAL ANGLE	Most significant part of MARKTIME for fourth mark
29	Least significant part of MARK-TIME for fourth mark	INNER GIMBAL ANGLE
30	SHAFT ANGLE	MIDDLE GIMBAL ANGLE
31	TRUNNION ANGLE	OUTER GIMBAL ANGLE
32	MARKTIME for fifth mark	MARKTIME for fifth mark
33	INNER GIMBAL ANGLE	SHAFT ANGLE
34	MIDDLE GIMBAL ANGLE	TRUNNION ANGLE

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Contents

Word Number		First Register	Second Register
35		OUTER GIMBAL ANGLE	Garbage
36		LANDMARK	Garbage
37		Spare	Spare
38		Spare	Spare
39		Spare	Spare
40		Flagword 0	Flagword 1
41		Flagword 2	Flagword 3
42		Flagword 4	Flagword 5
43		Flagword 6	Flagword 7
44		Flagword 8	Flagword 9
45		DSPTAB+0	DSPTAB+1
46		DSPTAB+2	DSPTAB+3
47		DSPTAB+4	DSPTAB+5
48		DSPTAB+6	DSPTAB+7
49		DSPTAB+8D	DSPTAB+9D
50		DSPTAB+10D	DSPTAB+11D
51		TIME 2	TIME 1
52		LANDMARK LATITUDE	LANDMARK LATITUDE
53		LANDMARK LONGITUDE	LANDMARK LONGITUDE
54		LANDMARK ALTITUDE	LANDMARK ALTITUDE
55		Spare	Spare
56		Spare	Spare
57		Spare	Spare
58		Spare	Spare
59		Actual X CDU angle	Actual Y CDU angle
60		Actual Z CDU angle	Optics CDU trunnion angle
61		ADOTS roll or OGARATE	ADOTS roll or OGARATE
62		ADOTS pitch or Omega B pitch	ADOTS pitch or Omega B pitch
63		ADOTS yaw or Omega B yaw	ADOTS yaw or Omega B yaw
64		OPTION1	OPTION2
65		TET	TET
66		THETADX	THETADY
67		THETADZ	Garbage
68	*	RSBBQ	RSBBQ+1
69		Garbage	Channel 77
70	*	C31FLWRD	FAILREG
71	*	FAILREG+1	FAILREG+2
72		Optics Shaft	PIPAX

* Indicates two single precision quantities that are not indicated otherwise.

Contents

Word Number	First Register	Second Register
73	PIPAY	PIPAZ
74	Number of Marks	Garbage
75	Flagword 10	Flagword 11
76	Landing Site Vector X comp.	Landing Site Vector X comp.
77	Landing Site Vector Y comp.	Landing Site Vector Y comp.
78	Landing Site Vector Z comp.	Landing Site Vector Z comp.
79	Spare	Spare
80	OPTMODES	HOLDFLAG
81	LM MASS	CM MASS
82	DAPDATR1	DAPDATR2
83	ERROR X	ERROR Y
84	ERROR Z	Garbage
85	WBODY (roll) or OMEGAC (roll)	WBODY (roll) or OMEGAC (roll)
86	WBODY (pitch) or OMEGAC (pitch)	WBODY (pitch) or OMEGAC (pitch)
87	WBODY (yaw) or OMEGAC (yaw)	WBODY (yaw) or OMEGAC (yaw)
88	REDO COUNTER	Desired FINAL CDU X
89	Desired FINAL CDU Y	Desired FINAL CDU Z
90	IMODES 30	IMODES 33
91	Channel 11	Channel 12
92	Channel 13	Channel 14
93	Channel 30	Channel 31
94	Channel 32	Channel 33
95	Spare	Spare
96	Spare	Spare
97	Spare	Spare
98	Spare	Spare
99	Spare	Spare
100	Spare	Spare

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2.2.2.10 Program 22 List

Word Number	Contents
1a	I.D. word for this list, 77773_8.
1b	Synch bits, 77340_8.
2-17	Same as words 2-17 on the Powered List.
18-35a	LANDING SITE MARK DATA. These thirty-five registers contain the mark data which is being used to update the CSM state vector in P22 and the landmark position coordinates in P22 and P24. Each mark, of which five in P22 and an unlimited number in P24 are allowed, consists of six parameters stored in seven registers. These quantities, listed in the correct transmitted order, are:

Time since epoch (double precision) scaled centiseconds/2^{28}.

Inner gimbal angle (CDUY)
Optics Shaft angle
Middle gimbal angle (CDUZ)

15-bit unsigned fractions, scaled degrees/360.

Optics Trunnion angle, scaled (degrees-19.7754)/45 (two's complement). The bias, 19.7754, is programmed-in.

Outer gimbal angle (CDUX). A 15-bit unsigned fraction, scaled degrees/360.

SVMRKDAT through SVMRKDAT +34 are set to zero upon entry to P24. They are set with mark data immediately after each individual mark in P22 and P24. P22MKFLG (bit 11 flagword 3) is cleared upon entry to P22, P24. It is set to 1 in P22 after all marks have been taken and in P24 after every individual mark to signify that SVMRKDAT (words 18-35a) contains the latest mark information. If CMOONFLG bit 12, flagword 8, is a zero, the coordinate system is earth centered. A one in this bit position would indicate a moon-centered coordinate system. In P24, if more than five marks are taken, they are stored in a cyclic manner, i.e., the sixth mark is stored in SVMRKDAT through SVMRKDAT +6, the seventh mark is stored in SVMRKDAT +7 through SVMRKDAT +13, etc. A "mark reject" in P22 and P24 will cause the time registers of the latest mark to be complemented. In P22, the next mark after a rejected mark is written over the rejected mark while in P24 the next location is used.

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Word Number	Contents
35b	Garbage.
36a	LANDMARK ID contains the R2 entry by the astronaut after a V05N70 or V05N71 action. It contains five octal digits, ABCDE, which describe the landmark as follows: A = 1 if landmark is known. A = 2 if landmark is unknown. B = index of offset designator. C = not used. DE = 00 for a landmark whose coordinates are not stored in the CMC memory. = 01 for the landing site. The offset indicator, B, is set to zero at the start of P22. The astronaut may change all items after a V05N70 or V05N71. It is used by P22 after each of these displays to extract the information described above. P24 does not touch LANDMARK ID.
36b	Garbage.
37-39	SPARES. The first half of each spare contains 00000_8. The second half is ARUPT (the contents of the accumulator when the telemetry interrupt was recognized).
40-51	Same as words 40 - 51 on the Powered List.
52	LANDMARK LATITUDE is the latitude of the landmark which P22 is updating, scaled degrees/360. It may be either earth-centered or moon-centered. If, upon entry of P22, CMOONFLG (Flagword 8, bit 12) equals zero, the coordinate system is earth-centered. Conversely, the coordinate system will be moon-centered if CMOONFLG equals one. It does not change within P22. The landmark may be either known or unknown. If known, it may be either entered by the astronaut, or obtained from the item, RLS (lunar landing site). The range of values is $-.25$ revolutions $\leq$ LAT $\leq .25$ revolutions. The latitude is computed for known landmarks only at the start of P22. At the completion of P22, the latitude is computed for all landmarks and contains the updated value. Item LANDLAT occupies the same locations as LAT and is identical in meaning. LANDLAT is the item used by noun 89 to display landmark latitude. The foregoing description applies to P24 with the exception that the landmark must be known and LANDMARK LATITUDE is only obtained from astronaut input. Also, it changes whenever a mark is used to compute new landmark coordinates.

Word Number	Contents
53	LANDMARK LONGITUDE is the longitude of the landmark which P22 is updating, scaled degrees/360. The range of values is -.5 revolutions $\leq$ LONG $\leq$ .5 revolutions. It may be either earth-centered or moon-centered. If, upon entry of P22, CMOONFLG (Flagword 8, bit 12) equals zero, the coordinate system is earth-centered. Conversely, the coordinate system will be moon-centered if CMOONFLG equals one. The longitude is computed for known landmarks only at the start of P22. At the completion of P22, the longitude is computed for all landmarks and contains the updated value. The foregoing description applies to P24 with the exception that the landmark must be known and LANDMARK LONGITUDE is only obtained from astronaut input. Also, it changes whenever a mark is used to compute new landmark coordinates.
54	LANDMARK ALTITUDE is the altitude of the landmark above the Fischer Ellipsoid for earth orbit and above the mean lunar radius for moon orbit, scaled meters/2^{29}. Tested values have varied between +2000 to -2000 meters. It may be either earth-centered or moon-centered. If, upon entry of P22, CMOONFLG (Flagword 8, bit 12) equals zero, the coordinate system is earth-centered. Conversely, the coordinate system will be moon-centered if CMOONFLG equals one. The altitude is computed for known landmarks only at the start of P22. At the completion of P22, the altitude is computed for all landmarks and contains the updated value. The foregoing description applies to P24 with the exception that the landmark must be known and LANDMARK ALTITUDE is only obtained from astronaut input. Also, it changes whenever a mark is used to compute new landmark coordinates.
55-58	SPARES. Same description as word 37 of this list.
59-63	Same as words 59-63 on the Powered List.
64, 65	Same as words 64, 65 on the Coast and Align List.
66-73	Same as words 66-73 on the Powered List.
74a	The number of valid Landing site marks, from one to five in P22 and any number in P24, which are stored in the SVMRKDAT table, scaled 2^{-14}. This item is computed by R53 and left in 8NN. In P22 and P24, this quantity is initialized to 0 and incremented by one immediately after every mark. In P24, if a mark is rejected, the counter will not be decremented, while in P22, it will be decremented.

Word Number	Contents
74b	Garbage.
75	Same as word 77 of the Powered List.
76-78	LUNAR LANDING SITE POSITION VECTOR (X, Y, Z) measured in moon-fixed coordinates from the center of the moon to the surface of the moon at the landing site, scaled meters/2^{27}. It is used in lunar orbits only and must be selected by the astronaut using nouns 70 or 71. If selected by the astronaut, it is used at the start of P22 to compute the initial landmark vector ($\underline{R}_L$) and then updated at the end of P22 as a result of data computed from the results of astronaut-acquired sighting marks.
79	SPARE. Same description as word 37 of this list.
80-94	Same as words 80-94 of the Powered List.
95-100	SPARES. Same description as word 37 of this list.

POWERED LIST – Mnemonics

Word Number		Word Number		Word Number	
1a	Identification (77774_8)	30b	garbage	75	CENTANG
1b	Sync bits (77340_8)	31-33	DELVEET1	76	SPARE
2-4	RN	34-39	REFSMMAT	77	STATE +10D
5-7	VN	40-44	STATE	78	TEVENT
8	PIPTIME	45-50	DSPTAB	79a	PCMD
9a	CDUX	51a	TIME2	79b	YCMD
9b	CDUY	51b	TIME1	80a	OPTMODES
10a	CDUZ	52-54	R-OTHER	80b	HOLDFLAG
10b	CDUT	55-57	V-OTHER	81a	LEMMASS
11-13	ADOT	58	T-OTHER	81b	CSMMASS
14a	AK	59a	CDUX	82a	DAPDATR1
14b	AK1	59b	CDUY	82b	DAPDATR2
15a	AK2	60a	CDUZ	83a	ERRORX
15b	RCSFLAGS	60b	CDUT	83b	ERRORY
16a	THETADX	61-63	ADOT	84a	ERRORZ
16b	THETADY	64a	AK	84b	garbage
17a	THETADZ	64b	AK1	85-87	WBODY
17b	garbage	65a	AK2	88a	REDOCTR
18	TIG	65b	RCSFLAGS	88b-89b	THETAD
19	DELLT4	66a	THETADX	90a	IMODES30
20-22	RTARG	66b	THETADY	90b	IMODES33
23	TGO	67a	THETADZ	91a	CHAN11
24	PIPTIME1	67b	garbage	91b	CHAN12
25-27	DELV	68	RSBBQ	92a	CHAN13
28a	PACTOFF	69a	garbage	92b	CHAN14
28b	YACTOFF	69b	CHAN77	93a	CHAN30
29a	PCMD	70a	C31FLWRD	93b	CHAN31
29b	YCMD	70b-71b	FAILREG	94a	CHAN32
30a	CSTEER	72a	CDUS	94b	CHAN33
		72b	PIPAX	95-97	VGTIG
		73a	PIPAY	98-100	DELVEET2
		73b	PIPAZ		
		74	ELEV		

COAST and ALIGN LIST -- Mnemonics

Word Number		Word Number		Word Number	
1a	Identification (77777_8)	31-33	VGTIG	74	OGC
		34-39	REFSMMAT	75	IGC
1b	Sync bits (77340_8)	40-44	STATE	76	MGC
		45-50	DSPTAB	77	STATE +10D
2-4	RN	51a	TIME2	78	TEVENT
5-7	VN	51b	TIME1	79	LAUNCHAZ
8	PIPTIME	52-54	R-OTHER	80a	OPTMODES
9a	CDUX	55-57	V-OTHER	80b	HOLDFLAG
9b	CDUY	58	T-OTHER	81a	LEMMASS
10a	CDUZ	59a	CDUX	81b	CSMMASS
10b	CDUT	59b	CDUY	82a	DAPDATR1
11-13	ADOT	60a	CDUZ	82b	DAPDATR2
14a	AK	60b	CDUT	83a	ERRORX
14b	AK1	61-63	ADOT	83b	ERRORY
15a	AK2	64a	OPTION1	84a	ERRORZ
15b	RCSFLAGS	64b	OPTION2	84b	garbage
16a	THETADX	65	TET	85-87	WBODY
16b	THETADY	66a	THETADX	88a	REDOCTR
17a	THETADZ	66b	THETADY	88b-89b	THETAD
17b	garbage	67a	THETADZ	90a	IMODES30
18	TIG	67b	garbage	90b	IMODES33
19a	BESTI	68	RSBBQ	91a	CHAN11
19b	BESTJ	69a	garbage	91b	CHAN12
20-23a	MARKDOWN	69b	CHAN77	92a	CHAN13
23b	garbage	70a	C31FLWRD	92b	CHAN14
24-27a	MARK2DWN	70b-71b	FAILREG	93a	CHAN30
27b	garbage	72a	CDUS	93b	CHAN31
28	HAPOX	72b	PIPAX	94a	CHAN32
29	HPERX	73a	PIPAY	94b	CHAN33
30a	PACTOFF	73b	PIPAZ	95-100	DSPTAB
30b	YACTOFF				

RENDEZVOUS and PRETHRUST LIST – Mnemonics

Word Number		Word Number		Word Number	
1a	Identification (77775_8)	33	TCSI	75	CENTANG
1b	Sync bits (77340_8)	34	TPASS4	76	SPARE
2-4	RN	35-37	DELVSLV	77-79	DELVEET3
5-7	VN	38	RANGE	80a	OPTMODES
8	PIPTIME	39	RRATE	80b	HOLDFLAG
9a	CDUX	40-44	STATE	81a	LEMMASS
9b	CDUY	45-50	DSPTAB	81b	CSMMASS
10a	CDUZ	51a	TIME2	82a	DAPDATR1
10b	CDUT	51b	TIME1	82b	DAPDATR2
11-13	ADOT	52-54	R-OTHER	83a	ERRORX
14a	AK	55-57	V-OTHER	83b	ERRORY
14b	AK1	58	T-OTHER	84a	ERRORZ
15a	AK2	59a	CDUX	84b	garbage
15b	RCSFLAGS	59b	CDUY	85-87	WBODY
16a	THETADX	60a	CDUZ	88a	REDOCTR
16b	THETADY	60b	CDUT	88b-89b	THETAD
17a	THETADZ	61-63	ADOT	90a	IMODES30
17b	garbage	64a	OPTION1	90b	IMODES33
18	TIG	64b	OPTION2	91a	CHAN11
19	DELLT4	65	TET	91b	CHAN12
20-22	RTARG	66a	THETADX	92a	CHAN13
23	VHFTIME	66b	THETADY	92b	CHAN14
24-27a	MARKDOWN	67a	THETADZ	93a	CHAN30
27b	RM	67b	garbage	93b	CHAN31
28a	VHFCNT	68	RSBBQ	94a	CHAN32
28b	TRKMKCNT	69a	garbage	94b	CHAN33
29	TTPI	69b	CHAN77	95	RTHETA
30a	ECSTEER	70a	C31FLWRD	96	LAT(SPL)
30b	garbage	70b-71b	FAILREG	97	LNG(SPL)
31	DELVTPF	72a	CDUS	98	VPRED
32	TCDH	72b	PIPAX	99	GAMMAEI
		73a	PIPAY	100	STATE +10D
		73b	PIPAZ		
		74	DIFFALT		

ENTRY and UPDATE LIST – Mnemonics

Word Number		Word Number		Word Number	
1a	Identification	33b	ROLLTM	68b	THETADZ
	(77776_8)	34	LATANG	69a	CMDAPMOD
1b	Sync bits	35	RDOT	69b	PREL
	(77340_8)	36	THETAH	70a	QREL
2-4	RN	37	LAT(SPL)	70b	RREL
5-7	VN	38	LNG(SPL)	71-80	UPBUFF
8	PIPTIME	39a	ALFA/180	81a	LEMMASS
9a	CDUX	39b	BETA/180	81b	CSMMASS
9b	CDUY	40-44	STATE	82a	DAPDATR1
10a	CDUZ	45-50	DSPTAB	82b	DAPDATR2
10b	CDUT	51a	TIME2	83a	ROLLTM
11-13	ADOT	51b	TIME1	83b	ROLLC
14a	AK	52	PIPTIME1	84a	OPTMODES
14b	AK1	53-55	DELV	84b	HOLDFLAG
15a	AK2	56	TTE	85-87	WBODY
15b	RCSFLAGS	57	VIO	88a	REDOCTR
16a	THETADX	58	VPRED	88b-89b	THETAD
16b	THETADY	59a	CDUX	90a	IMODES30
17a	THETADZ	59b	CDUY	90b	IMODES33
17b	garbage	60a	CDUZ	91a	CHAN11
18a	CMDAPMOD	60b	CDUT	91b	CHAN12
18b	PREL	61-63	ADOT	92a	CHAN13
19a	QREL	64a	OPTION1	92b	CHAN14
19b	RREL	64b	OPTION2	93a	CHAN30
20	L/D1	65	TET	93b	CHAN31
21-30	UPBUFF	66a	ERRORX	94a	CHAN32
31a	COMPNUMB	66b	ERRORY	94b	CHAN33
31b	UPOLDMOD	67a	ERRORZ	95	RSBBQ
32a	UPVERB	67b	THETADX	96a	garbage
32b	UPCOUNT	68a	THETADY	96b	CHAN77
33a	PAXERR1			97a	C31FLWRD
				97b-98b	FAILREG
				99	STATE +10D
				100	GAMMAEI

PROGRAM 22 LIST – Mnemonics

Word Number	
1a	Identification (77773_8)
1b	Sync bits (77340_8)
2-4	RN
5-7	VN
8	PIPTIME
9a	CDUX
9b	CDUY
10a	CDUZ
10b	CDUT
11-13	ADOT
14a	AK
14b	AK1
15a	AK2
15b	RCSFLAGS
16a	THETADX
16b	THETADY
17a	THETADZ
17b	garbage
18-35a	SVMRKDAT
35b	garbage
36a	LANDMARK
36b	garbage
37-39	SPARE
40-44	STATE
45-50	DSPTAB

Word Number	
51a	TIME2
51b	TIME1
52	LAT
53	LONG
54	ALT
55-58	SPARE
59a	CDUX
59b	CDUY
60a	CDUZ
60b	CDUT
61-63	ADOT
64a	OPTION1
64b	OPTION2
65	TET
66a	THETADX
66b	THETADY
67a	THETADZ
67b	garbage
68	RSBBQ
69a	garbage
69b	CHAN77
70a	C31FLWRD
70b-71b	FAILREG
72a	CDUS
72b	PIPAX
73a	PIPAY
73b	PIPAZ
74a	8NN

Word Number	
74b	garbage
75	STATE +10D
76-78	RLS
79	SPARE
80a	OPTMODES
80b	HOLDFLAG
81a	LEMMASS
81b	CSMMASS
82a	DAPDATR1
82b	DAPDATR2
83a	ERRORX
83b	ERRORY
84a	ERRORZ
84b	garbage
85-87	WBODY
88a	REDOCTR
88b-89b	THETAD
90a	IMODES30
90b	IMODES33
91a	CHAN11
91b	CHAN12
92a	CHAN13
92b	CHAN14
93a	CHAN30
93b	CHAN31
94a	CHAN32
94b	CHAN33
95-100	SPARE

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ALPHABETICAL LISTING OF FLAG BITS AND LOCATIONS

The following table is taken directly from the current program listing.

FLAGWORD	BIT AND FLAG
.05GSW	BIT 3 FLAG 6
22DSPFLG	BIT 13 FLAG 2
360SW	BIT 1 FLAG 8
3AXISFLG	BIT 6 FLAG 5
ADVTRK	BIT 10 FLAG 8
AMOONFLG	BIT 2 FLAG 0
APSESW	BIT 5 FLAG 8
ASTNFLAG	BIT 12 FLAG 7
ATTCHFLG	BIT 2 FLAG 7
AUTOSEQ	BIT 7 FLAG 10
AVEGFLAG	BIT 1 FLAG 1
AVEMIDSW	BIT 1 FLAG 9
AVFLAG	BIT 5 FLAG 2
AZIMFLAG	BIT 8 FLAG 11
BURNFLAG	BIT 10 FLAG 10
CALCMAN2	BIT 2 FLAG 2
CMDAPARM	BIT 12 FLAG 6
CMOONFLG	BIT 12 FLAG 8
CM/DSTBY	BIT 2 FLAG 6
COGAFLAG	BIT 4 FLAG 8
COMPUTER	BIT 8 FLAG 5
CSISFLAG	BIT 6 FLAG 11
CULTFLAG	BIT 7 FLAG 3
CYC61FLG	BIT 4 FLAG 0
D6OR9FLG	BIT 2 FLAG 3
DAPBIT1	BIT 15 FLAG 6
DAPBIT2	BIT 14 FLAG 6
DIMOFLAG	BIT 1 FLAG 3
DMENFLG	BIT 9 FLAG 5
DRIFTFLG	BIT 15 FLAG 2
DSKYFLAG	BIT 15 FLAG 5
EGSW	BIT 8 FLAG 6
ENG2FLAG	BIT 11 FLAG 1
ENGONFLG	BIT 7 FLAG 5
ENTRYDSP	BIT 13 FLAG 6
ERADFLAG	BIT 13 FLAG 1
ETPIFLAG	BIT 7 FLAG 2
F2RTE	BIT 5 FLAG 0
FINALFLG	BIT 6 FLAG 2
FIRSTFLG	BIT 7 FLAG 2
FREEFLAG	BIT 3 FLAG 0
FULTKFLG	BIT 2 FLAG 10
GAMDIFSW	BIT 11 FLAG 6
GLOKFAIL	BIT 14 FLAG 3
GONEBY	BIT 8 FLAG 7
GONEPAST	BIT 10 FLAG 6
GRRBKFLG	BIT 5 FLAG 5
GUESSW	BIT 2 FLAG 1
GYMDIFSW	BIT 1 FLAG 6
HAFLAG	BIT 7 FLAG 11
HDSUPFLG	BIT 11 FLAG 10
HIND	BIT 6 FLAG 6
IDLEFAIL	BIT 6 FLAG 1
IGNFLAG	BIT 13 FLAG 7
IMPULSW	BIT 9 FLAG 2
IMUSE	BIT 8 FLAG 0
INCORFLG	BIT 11 FLAG 5
INFINFLG	BIT 7 FLAG 8
INRLSW	BIT 5 FLAG 6
INTFLAG	BIT 14 FLAG 10
INTYPFLG	BIT 4 FLAG 3
ITSWICH	BIT 14 FLAG 7
JSWITCH	BIT 14 FLAG 0
KNOWNFLG	BIT 3 FLAG 6
LATSW	BIT 4 FLAG 6
LMOONFLG	BIT 11 FLAG 8
LUNAFLAG	BIT 12 FLAG 3
MANEUFLG	BIT 5 FLAG 10
MARKFLG	BIT 4 FLAG 1
MAXDBFLG	BIT 12 FLAG 9
MID1FLAG	BIT 3 FLAG 9
MIDAVFLG	BIT 2 FLAG 9
MIDFLAG	BIT 13 FLAG 0
MKOVFLAG	BIT 3 FLAG 4
MOONFLAG	BIT 12 FLAG 0
MRKIDFLG	BIT 15 FLAG 4
MRKNVFLG	BIT 9 FLAG 4
MRUPTFLG	BIT 5 FLAG 4
MWAITFLG	BIT 11 FLAG 4
N22ORN17	BIT 6 FLAG 9
NEEDLFLG	BIT 9 FLAG 0
NEWIFLG	BIT 13 FLAG 8
NEWLMFLG	BIT 14 FLAG 8
NEWTFLAG	BIT 10 FLAG 5
NJETSFLG	BIT 15 FLAG 1
NODOFLAG	BIT 1 FLAG 2
NODOP01	BIT 12 FLAG 1
NORFHOR	BIT 11 FLAG 0
NORMSW	BIT 10 FLAG 7
NOSWITCH	BIT 7 FLAG 6
NRMIDFLG	BIT 13 FLAG 4
NRMNVFLG	BIT 8 FLAG 4
NRUPTFLG	BIT 4 FLAG 4
NWAITFLG	BIT 10 FLAG 4
ORBWFLAG	BIT 6 FLAG 3
ORDERSW	BIT 6 FLAG 8
P21FLAG	BIT 12 FLAG 2
P22MKFLG	BIT 11 FLAG 3
P24FLAG	BIT 14 FLAG 9
P24MKFLG	BIT 3 FLAG 2
P29FLAG	BIT 1 FLAG 0

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ALPHABETICAL LISTING OF FLAG BITS AND LOCATIONS (cont.)

FLAGWORD	BIT AND FLAG
P35FLAG	BIT 8 FLAG 10
PCFLAG	BIT 1 FLAG 10
PCMANFLG	BIT 15 FLAG 10
PDSPFLAG	BIT 12 FLAG 4
PFRATFLG	BIT 4 FLAG 2
PINBRFLG	BIT 6 FLAG 6
POOFLAG	BIT 9 FLAG 3
PRECIFLG	BIT 8 FLAG 3
PRIODFLG	BIT 14 FLAG 4
PRONVFLG	BIT 7 FLAG 4
PTV93FLG	BIT 4 FLAG 10
QUITFLAG	BIT 5 FLAG 9
R21MARK	BIT 14 FLAG 2
R22CAFLG	BIT 7 FLAG 9
R31FLAG	BIT 4 FLAG 9
R53FLAG	BIT 6 FLAG 0
R67FLAG	BIT 2 FLAG 8
RANGFLAG	BIT 9 FLAG 10
REFSMFLG	BIT 13 FLAG 3
REINTFLG	BIT 13 FLAG 10
REJCTFLG	BIT 12 FLAG 10
RELVELSW	BIT 9 FLAG 6
RENDWFLG	BIT 1 FLAG 5
RETROFLG	BIT 14 FLAG 5
RNDVZFLG	BIT 7 FLAG 0
RPQFLAG	BIT 15 FLAG 8
RVSW	BIT 9 FLAG 7
S32.1F1	BIT 15 FLAG 11
S32.1F2	BIT 14 FLAG 11
S32.1F3A	BIT 13 FLAG 11
S32.1F3B	BIT 12 FLAG 11
SAVECFLG	BIT 10 FLAG 9
SKIPVHF	BIT 10 FLAG 2
SLOPESW	BIT 3 FLAG 1
SLOWFLG	BIT 13 FLAG 5
SOLNSW	BIT 3 FLAG 5
SOURCFLG	BIT 8 FLAG 9
STATEFLG	BIT 5 FLAG 3
STEERSW	BIT 11 FLAG 2
STIKFLAG	BIT 14 FLAG 1
STRULLSW	BIT 13 FLAG 6
SURFFLAG	BIT 8 FLAG 8
SWTOVER	BIT 15 FLAG 9
TARG1FLG	BIT 10 FLAG 1
TARG2FLG	BIT 9 FLAG 1
TERMIFLG	BIT 15 FLAG 7
TFFSW	BIT 1 FLAG 7
TIMRFLAG	BIT 11 FLAG 7
TPIMNFLG	BIT 3 FLAG 10
TRACKFLG	BIT 5 FLAG 1
UPDATFLG	BIT 7 FLAG 1
UPLOCKFL	BIT 4 FLAG 7
UTFLAG	BIT 9 FLAG 8
V37FLAG	BIT 6 FLAG 7
V50N18FL	BIT 15 FLAG 3
V59FLAG	BIT 12 FLAG 5
V82EMFLG	BIT 13 FLAG 9
V94FLAG	BIT 11 FLAG 9
V96ONFLG	BIT 3 FLAG 8
VEHUPFLG	BIT 8 FLAG 1
VERIFLAG	BIT 3 FLAG 7
VFLAG	BIT 10 FLAG 3
VHFRFLAG	BIT 9 FLAG 9
VINTFLAG	BIT 3 FLAG 3
VNFLAG	BIT 2 FLAG 4
XDELVFLG	BIT 8 FLAG 2
XDSPFLAG	BIT 1 FLAG 4
ZMEASURE	BIT 10 FLAG 0

EFFECTS OF FRESH START (V36) AND HARDWARE RESTART ON FLAGWORDS AND CHANNEL BITS APPEARING ON DOWNLISTS

Flagword	Downlist Word	Fresh Start (V36)					Hardware Restart				
		15-13	12-10	9 8 7	6 5 4	3 2 1	15-13	12-10	9 8 7	6 5 4	3 2 1
0	40	000	000	000	000	000	UUU	UUU	UUU	UU0	UUU
1	40	000	U00	000	000	000	UUU	UUU	UUU	UC0	UUU
2	41	000	000	000	000	000	C0U	0U1	UUU	UUU	UUU
3	41	00U	000	000	000	000	UUC	UUU	UUU	UUU	UUU
4	42	000	000	000	000	000	000	000	000	000	000
5	42	000	000	010	000	000	UUU	UUU	UUU	UUU	UUU
6	43	000	000	000	000	100	UUU	UUU	UUU	UUU	UUU
7	43	000	000	000	000	000	UUU	UUU	UUU	UUU	UUU
8	44	000	UU0	0U0	000	000	UUU	UUU	UUU	UUU	UUU
9	44	000	000	000	000	000	UUU	UUU	UUU	UUU	UUU
10	(varies)	000	0U0	000	000	000	U0U	UUU	UUU	UUU	UUU
11	(varies)	000	000	000	000	000	UUU	UUU	UUU	UUU	UUU

Channel	Downlist Word	Fresh Start (V36)					Hardware Restart				
11	91	000	000	000	000	000	00+	000	000	000	00U
12	91	000	000	000	*0*	000	000	000	000	*0*	000
13	92	000	000	000	000	000	000	000	000	000	000
14	92	000	000	000	000	000	000	000	000	000	000
30	93	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU
31	93	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU
32	94	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU	UUU
33	94	UUU	UUU	UUU	UUU	UUU	111	11U	UUU	UUU	UUU
77	(varies)	000	000	000	000	000	RRR	RRR	RRR	RRR	RRR

KEY:
- 0 - Bit set to 0
- 1 - Bit set to 1
- U - Bit unchanged
- * - If IMU was in Coarse Align, set bits 4 and 6, otherwise reset to 0
- + - Set to 1 if ENGONFLG is on, otherwise reset to 0
- C - Bit set to 0 if IMU was in Coarse Align otherwise unchanged.
- R - Set 1 if this bit indicates cause of restart, otherwise unchanged

BLANK

COLOSSUS 3

R-577

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