

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

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APOLLO GUIDANCE AND NAVIGATION PROGRAM

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R-567

GUIDANCE SYSTEM OPERATIONS PLAN
FOR MANNED LM EARTH ORBITAL AND
LUNAR MISSIONS USING
PROGRAM LUMINARY 1C (LM131 REV. 1)

SECTION 2 DATA LINKS
(Rev. 8)

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MIT

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R-567

GUIDANCE SYSTEM OPERATIONS PLAN
FOR MANNED LM EARTH ORBITAL AND
LUNAR MISSIONS USING
PROGRAM LUMINARY 1C (Rev. 130)

SECTION 2 DATA LINKS

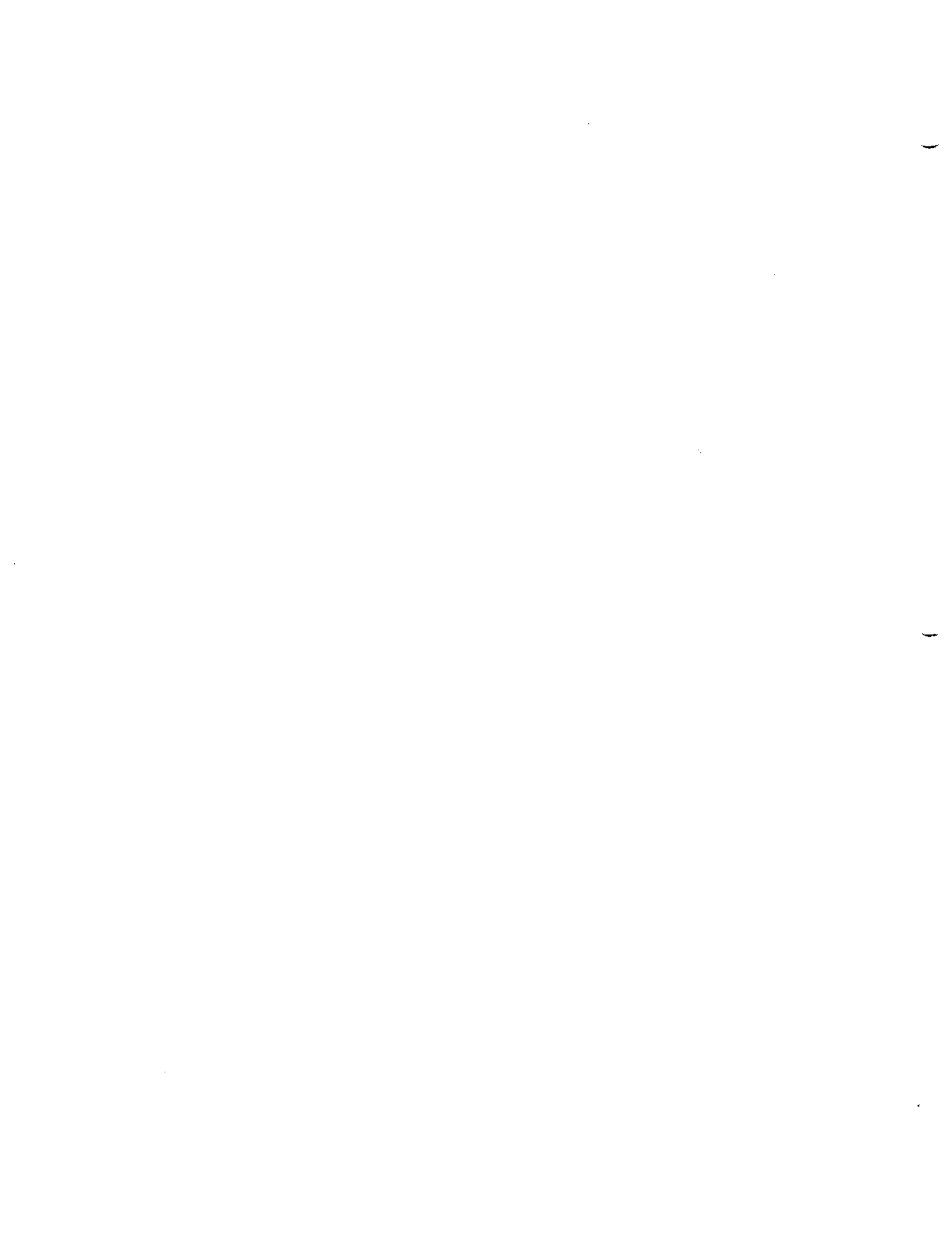
(Rev. 7)

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REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY

Section #2 Title: Data Links (Rev. 1)

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

	Rev. 1
PCR-(PCN)	Description of Change
PCR-105	Delete P-46, LM-CSM separation monitor
PCR-106	Delete P-11, Predicted Launch Time (DT)
PCR-138	Delete P-10, Predicted Launch Time (CFP)
PCR - 163	Change format of Lambert Target Updates
PCR - 207.2	Update GSOP, Sec. 2, for typing errors, scaling changes, extra detail and description.
PCR - 230	Addition of 4 parameters to the Ascent/Descent Downlist.
PCR - 243	Additional detail, description, and typing corrections.
PCR - 417.2	Deletion of ENDSAFE.
PCR-468.2	Changed R32 to P76, Target Delta V
PCR-470	Added P68, Confirm Lunar Landing
PCN-494*	Added landing site vector (X, Y, Z) to Ascent/Descent list.
PCN-532*	Correct error in documentation
PCN-554*	Delete GUIDANCE THRUST CMD and CMDSTODECA from Orbital Maneuvers downlist.

Because of the numerous changes required by PCR #207.2 in Revision 1, there will be no PCR/PCN reference information at the bottom of any page which changed as a result of PCR #207.2 only.

Additional UPLINK information resulted in the following new sections:

2.1.5	Use of the Contiguous Block Update VERB.
2.1.5.1	LGC CSM/LM State Vector Update.
2.1.5.2	LGC Desired REFSMMAT Update.
2.1.5.3	LGC External DELTA V Update.
2.1.5.4	LGC Lambert Target Update.
2.1.6	Use of the Scatter Update VERB.
2.1.6.1	LGC Landing Site Update.

*Indicates an MIT Program Change Notice (PCN)

Date: December 1968

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATION PLAN

GSOP # R-567 Title: For Manned LM Earth Orbital and Lunar
Missions Using Program LUMINARY

Section # 2 Title: Data Links (Rev. 2)

This publication, a complete new revision (Rev. 2), incorporates the
NASA/MSC approved changes listed below.

PCR/PCN	Description of Change
265	Assure time homogeneous set of LR Data
589	LR Raw Data Downlist
615	Allows running of R04 during P47
616	Downlink Jet Control Torque
644	Section 2 Correction
264	Add TALIGN to Coast and Align List

Date: March 1969

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATION PLAN

GSOP # R-567 Title: For Manned LM Earth Orbital and Lunar Missions
Using Program LUMINARY

Section # 2 Title: Data Links (Rev. 3)

This publication, a complete new revision (Rev. 3), contains no new PCR or PCN changes.

Date: June 1969

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-567 Title: For Manned LM Earth Orbital and Lunar
Missions Using Program LUMINARY 1A (Rev. 099)

Section #2 Title: Data Links (Rev. 4)

This publication, a complete new revision (Rev. 4), incorporates revisions and additions as indicated below.

<u>PCR-(PCN)</u>	<u>Description of Change</u>
PCR-259	Omit Zone 1 from Descent Logic
PCR-260	Preferred Orientation During LM Aborts
PCR-267	Time homogeneous RR downlink data from P20, P22
PCR-271	Downlink Change
PCR-647	Replace Lambert with "A" steer in P40, P41, and P42
PCR-670	Simplification of Landing Programs
PCR-700	Improve the Rate of Descent Mode (P66) Performance
PCR-719	Speed up P21
PCR-722	Improve performance of RR designate procedure on Lunar Surface
PCR-740	Display TLAND in P52, option 4
PCN-765*	New Propulsion System Constants
PCR-824	Update GSOP, Sec. 2, for typing errors and extra detail and description.

Because of the numerous changes required by PCR#824 in Revision 4, there will be no PCR/PCN reference information at the bottom of any page which changed as a result of PCR#824 only.

* Indicates an MIT Program Change Notice (PCN).

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-567 Title: For Manned LM Earth Orbital and Lunar Missions
Using Program LUMINARY 1B (Rev. 116)

Section #2 Title: Data Links (Rev. 5)

This publication, a complete new revision (Rev. 5), incorporates revisions and additions as indicated below.

<u>PCR-LNY</u>	<u>Description of Change</u>
PCR 277	A fixed DUMPCNT.
PCR 279	Variable insertion computation with capability to abort at any time.
PCR 284	VGTIGs on C/A downlist.
PCR 802.2	Save alarm data after "error reset".
PCR 816	Modify R03 to permit astronaut setting of 1° deadband.
PCR 823	Delete P31 (Lambert aim point guidance program).
PCR 827	Add ZDOTD to Ascent/Descent downlist.
PCR 839	R12 and LR reposition routine improvements.
PCR 841	PGNCS derived vehicle attitude rates on FDAI error needles.
PCR 844	Deletion of P38/P78 and P39/P79.
LNY 89*	State vector integration in P00, P27.
LNY 90*	Response to V97 in P63.

* Anomaly.

Date: October 1969

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

GSOP #R-567 Title: For Manned LM Earth Orbital and Lunar
Missions Using Program LUMINARY 1B (Rev. 116)

Section #2 Title: Data Links (Rev. 6)

This publication is a revision to the previous issue of this document, Rev. 5, dated August 1969 and incorporates the NASA/MSC approved PCRs, described below.

<u>PCR-(PCN)</u>	<u>Description of Change</u>
PCR 702	Add COAS Calibration Option to R52.
PCR 780	Provide pure RR Range, Range Rate, and Time Tag during P20, P22 and P25.
PCR 791. 2	Do not allow a proceed response to a V21, V22, or V23.
PCR 798. 2	Reset GLOKFAIL in R00.
PCR 805	Don't allow V66 on the surface.
PCR 812. 2	Resetting and setting of the External Delta V Flag.
PCR 814	Reduce keystrokes required to check and approve LR data.
PCR 838	Prevent RCS jet firings on lunar surface.
PCR 845	Do not turn on R29 during P70/P71.
PCR 847	Eliminate possible lock-out of pitch-over from P12, P70 and P71.
PCR 854	Provide a flexible method for crew to modify RLS.
PCR 855	Begin reading LR Velocity as soon as Velocity Data Good appears.

Date: November 1969

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions
Using Program LUMINARY 1C (Rev. 130)

Section No. 2 Title: Data Links (Rev. 7)

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

<u>PCR-(PCN)</u>	<u>Description of Change</u>
PCR 863.2	Make P76 set NODO flag
PCR 893.	Abort targeting flagbit
PCR 285	Remove check of auto throttle discrete

DATE: March 1970

REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

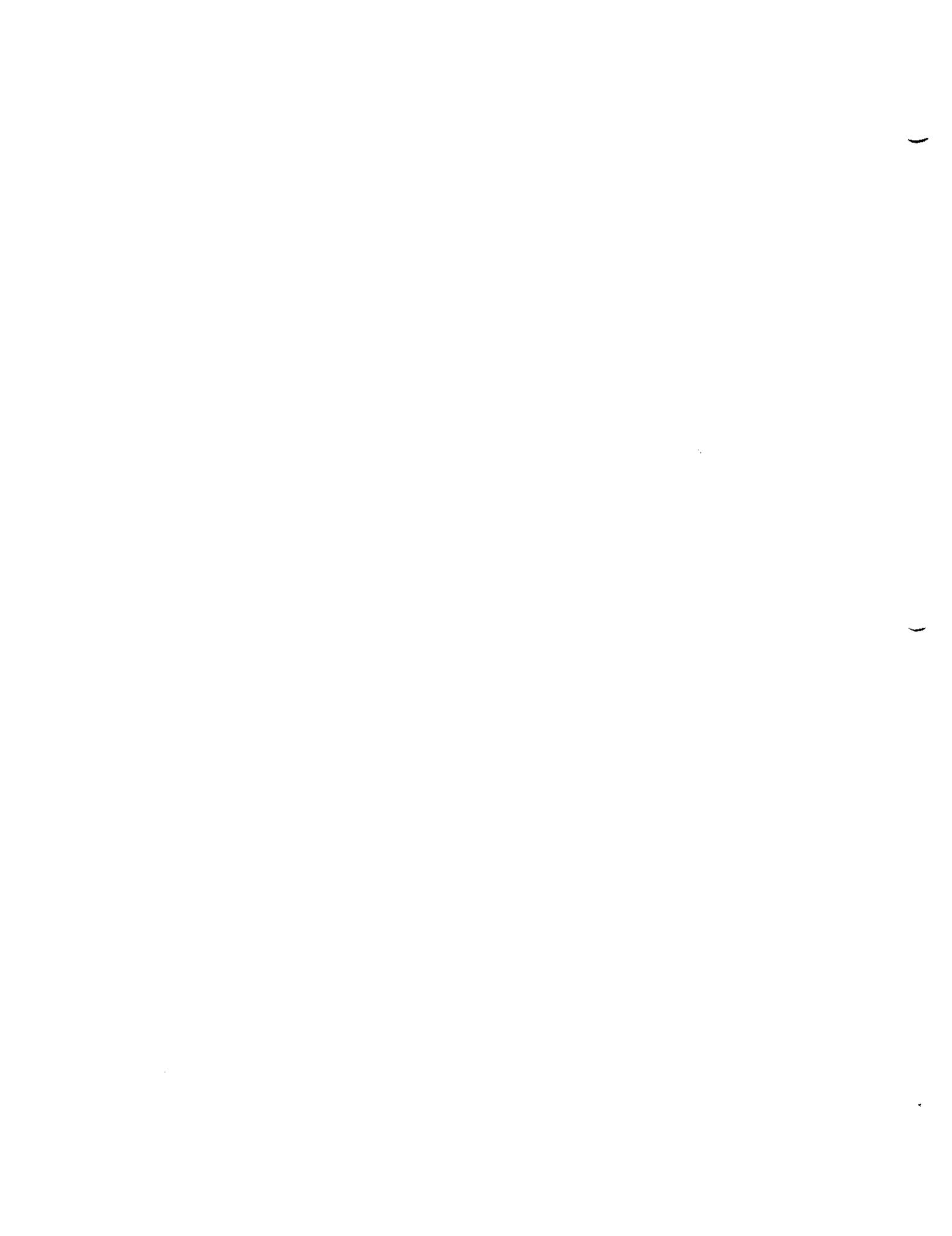
GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar
Missions Using Program LUMINARY 1C
(LM131, Revision 1)

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

Revision 8 is published as change pages to Section 2 LUMINARY GSOP. Substitution of these pages for those in Revision 7 makes Section 2 the control document for the re-release of Program LUMINARY 1C (LM131, Revision 1). The following NASA/MSC approved changes are included in Revision 8:

<u>PCR (PCN*)</u>	<u>TITLE</u>	<u>PAGES AFFECTED</u>
942	LR Update Cutoff	61
988	AUTO P66	22, 34, 48, 60, 105

NOTE: A solid bar, |, in the margin indicates a change in specification authorized by the PCR (PCN*) listed at the bottom of the page.



Guidance System Operations Plan for Manned
LM Earth Orbital and Lunar Missions Using
Program LUMINARY 1C
Section 2 Data Links (Revision 7)

TABLE OF CONTENTS

Paragraph	Title	Page
2.	PGNCS Data Links	2-1
2. 1	Digital Uplink to LGC (P27)	2-3
2. 1. 1	LM Liftoff Time Increment	2-6
2. 1. 2	LM Contiguous Block Update	2-8
2. 1. 3	LM Scatter Update	2-11
2. 1. 4	LGC Octal Clock Increment	2-13
2. 1. 5	Use of the Contiguous Block Update VERB	2-13
2. 1. 6	Use of the Scatter Update VERB	2-17
2. 1. 7	Absolute Addresses for UPDATE Program	2-18a
2. 2	LGC Digital Downlink	2-19
2. 2. 1	Erasable Memory Dump Downlist	2-20
2. 2. 2	Downlists:	2-21
	Orbital Maneuvers - Contents	2-25
	Orbital Maneuvers - Descriptions	2-28
	Coast and Align - Contents	2-89
	Coast and Align - Descriptions	2-92
	Rendezvous and Prethrust - Contents	2-95
	Rendezvous and Prethrust - Descriptions	2-98
	Descent and Ascent - Contents	2-101
	Descent and Ascent - Descriptions	2-104
	Lunar Surface Align - Contents	2-107
	Lunar Surface Align - Descriptions	2-110
	AGS Initialization and Update - Contents	2-111
	AGS Initialization and Update - Descriptions	2-114
	Mnemonics	2-117

2. PGNCS Data Links

The Guidance System Operations Plan is published as six separate volumes (sections) as follows:

Section 1	Pre-Launch
Section 2	Data Links
Section 3	Digital Autopilots
Section 4	Operational Modes
Section 5	Guidance Equations
Section 6	Control Data

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

This volume constitutes a control document to govern the structure of Uplink and Downlink Programs in LUMINARY. Revisions to this plan which reflect changes in the above control items require approval from NASA.

The material of Section 2 of this GSOP is arranged:

- 2.1 Digital Uplink to LGC (P27)
- 2.2 LGC Digital Downlink



2.1 Digital Uplink to LGC (P27)

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

1. LIFTOFF TIME INCREMENT: Provides ground capability via VERB 70 to increment or decrement the LGC 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 via VERB 71 to update from 1 to 18 consecutive E memory registers in the same EBANK.
3. SCATTER UPDATE: Provides ground capability via VERB 72 to update from 1 to 9 nonconsecutive E memory registers in the same or different EBANK's.
4. OCTAL CLOCK INCREMENT: Provides ground capability via VERB 73 to increment or decrement the LGC clock with a double precision octal time value, scaled centiseconds / 2^{28} .

All information received by the LGC 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 LGC 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 LGC (1 C \bar{C} C). The leading "1" bit causes an interrupt within the LGC after all 16 bits have been shifted from the uplink receiver.

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

TABLE 2-1

<u>Character</u>	<u>Uplink Word</u>
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.

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 major mode number of program interrupted by P27, i.e., 0 for program 00 and -0 for fresh start; program 27 is inhibited from interrupting any other programs.
4. COMPNUMB - Contains 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 LGC receives 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 0000 0000 0000

(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.

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.

*"ERROR RESET" must be sent via uplink to set BIT 4 of FLAGWRD7 to zero. DSKY "ERROR RESET" does not affect this bit.

This program may be entered only from P00 or Fresh Start for the LM.

If the LGC 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 LM 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 LGC is in Program 27.

If P27 is entered, the LGC 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 centi-seconds scaled 2^{-28} . A negative time value 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 registers is correct, it should transmit "VERB33ENTER" to signal P27 to process the update data. For the Verb 70 update, P27 inverts BIT3 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 integra-

tion 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 LGC 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 LGC clock without causing overflow, P27 proceeds to increment TEPHEM and decrement the LGC 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 Coast and Align downlist, 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 LGC 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 Coast and Align downlist, 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 ≤ 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 UP-COUNT 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 LGC 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 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) and the octal identifier has been entered, transmission of VERB33ENTER will be ignored by P27.

2.1.2 LM 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 UPWERB 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 E's represent ENTER's):

```
  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 parameter(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. A A A A is the first E memory address (ECADR) of the update data block to be processed. Bits 1-8 indicate the relative address (0 - 377₈) 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 ≤ 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 LGC 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 of section 2.1.2.1 for format).

If an index value < 3 or > 24 octal is erroneously keyed-in and 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 that the numerical value is 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 re-transmit 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 section 2.1.1.2.

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 LM 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 is placed in UPCOUNT. Following P27 verification, the ground station performs this update exactly as described for the VERB71 update. 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. $3 \leq II \leq 24$ 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 A's represent the ECADR's. (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 EBANK's.
3. All X X X X X's are in octal and scaled the same as the internal LGC 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 section 2.1.1.2.

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 the Uplink Activity light, transfer to the previous program and the Coast and Align 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 LGC 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 data 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 registers that are used for the orbital integration routine 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. LGC CSM/LM STATE VECTOR UPDATE
2. LGC DESIRED REFSMMAT UPDATE
3. LGC REFSMMAT UPDATE
4. LGC EXTERNAL DELTA V 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 LGC 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:

$$\begin{array}{l} 1 = \text{CSM} \\ -1 = \text{LM} \end{array} \left. \vphantom{\begin{array}{l} 1 = \text{CSM} \\ -1 = \text{LM} \end{array}} \right\} \text{earth-centered}$$
$$\begin{array}{l} 2 = \text{CSM} \\ -2 = \text{LM} \end{array} \left. \vphantom{\begin{array}{l} 2 = \text{CSM} \\ -2 = \text{LM} \end{array}} \right\} \text{moon-centered}$$

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 LGC will not perform a state vector update. In the other numeric cases a valid state vector update will be performed (earth-center).

The position and velocity components should be in reference coordinates scaled as follows:

	<u>earth-centered</u>	<u>moon-centered</u>
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 LGC clock zero. The identifier is scaled 2^{-14} . Time is scaled centiseconds/ 2^{28} .

The LGC 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:

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 "1's complement" of the 2 words is used (all 1's are replaced by 0's, and all 0's are replaced 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 characters with their corresponding binary and uplink words.

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

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
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
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 LGC clock zero) ENTER
21 ₈	XXXXX	(least sig. part of time from LGC clock zero) ENTER

2.1.5.2 LGC DESIRED REFSMMAT UPDATE

XSMD - XSMD + 17 is a 3 × 3 double precision matrix which represents the Reference to Stable Member Desired Transformation. Scaled 2⁻¹.

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

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
1	24 ₈	(index value) ENTER
2	(AAAA)*	(ECADR, XSMD) ENTER

* Refer to Paragraph 2.1.7 to obtain the absolute address (ECADR) for this UPDATE.

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
3	XXXXXX	(most sig. part of Row 1 Col. 1) ENTER
4	XXXXXX	(least sig. part of Row 1 Col. 1) ENTER
5	XXXXXX	(most sig. part of Row 1 Col. 2) ENTER
6	XXXXXX	(least sig. part of Row 1 Col. 2) ENTER
7	XXXXXX	(most sig. part of Row 1 Col. 3) ENTER
10 ₈	XXXXXX	(least sig. part of Row 1 Col. 3) ENTER
11 ₈	XXXXXX	(most sig. part of Row 2 Col. 1) ENTER
12 ₈	XXXXXX	(least sig. part of Row 2 Col. 1) ENTER
13 ₈	XXXXXX	(most sig. part of Row 2 Col. 2) ENTER
14 ₈	XXXXXX	(least sig. part of Row 2 Col. 2) ENTER
15 ₈	XXXXXX	(most sig. part of Row 2 Col. 3) ENTER
16 ₈	XXXXXX	(least sig. part of Row 2 Col. 3) ENTER
17 ₈	XXXXXX	(most sig. part of Row 3 Col. 1) ENTER
20 ₈	XXXXXX	(least sig. part of Row 3 Col. 1) ENTER
21 ₈	XXXXXX	(most sig. part of Row 3 Col. 2) ENTER
22 ₈	XXXXXX	(least sig. part of Row 3 Col. 2) ENTER
23 ₈	XXXXXX	(most sig. part of Row 3 Col. 3) ENTER
24 ₈	XXXXXX	(least sig. part of Row 3 Col. 3) ENTER

2.1.5.3 LGC REFSMMAT UPDATE

REFSMMAT - REFSMMAT + 17D is a 3 x 3 double precision matrix used to convert from reference coordinates to stable member coordinates. The elements of the matrix are scaled, units/2¹.

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

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
1	24 ₈	(index value) ENTER
2	(AAAA)*	(ECADR, REFSMMAT) ENTER
3	XXXXXX	(most sig. part of Row 1 Col. 1) ENTER
4	XXXXXX	(least sig. part of Row 1 Col. 1) ENTER
5	XXXXXX	(most sig. part of Row 1 Col. 2) ENTER
6	XXXXXX	(least sig. part of Row 1 Col. 2) ENTER
7	XXXXXX	(most sig. part of Row 1 Col. 3) ENTER
10 ₈	XXXXXX	(least sig. part of Row 1 Col. 3) ENTER
11 ₈	XXXXXX	(most sig. part of Row 2 Col. 1) ENTER
12 ₈	XXXXXX	(least sig. part of Row 2 Col. 1) ENTER
13 ₈	XXXXXX	(most sig. part of Row 2 Col. 2) ENTER
14 ₈	XXXXXX	(least sig. part of Row 2 Col. 2) ENTER
15 ₈	XXXXXX	(most sig. part of Row 2 Col. 3) ENTER

* Refer to Paragraph 2.1.7 to obtain the absolute address (ECADR) for this UPDATE.

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
16 ₈	XXXXXX	(least sig. part of Row 2 Col. 3) ENTER
17 ₈	XXXXXX	(most sig. part of Row 3 Col. 1) ENTER
20 ₈	XXXXXX	(least sig. part of Row 3 Col. 1) ENTER
21 ₈	XXXXXX	(most sig. part of Row 3 Col. 2) ENTER
22 ₈	XXXXXX	(least sig. part of Row 3 Col. 2) ENTER
23 ₈	XXXXXX	(most sig. part of Row 3 Col. 3) ENTER
24 ₈	XXXXXX	(least sig. part of Row 3 Col. 3) ENTER

2. 1. 5. 4 LGC EXTERNAL DELTA V UPDATE

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

1. DELVSLV_{x, y, z} (meters/centisecond)/2⁷
2. TIG centiseconds/2²⁸

DELVSLV_{x, y, z} must be in a local vertical system at an origin which corresponds to the LM state (earth-centered or moon-centered) at TIG.

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

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
1	12 ₈	(index value) ENTER
2	(AAAA)*	(ECADR, DELVSLV) ENTER
3	XXXXXX	(most sig. part of DELVSLV _x) ENTER
4	XXXXXX	(least sig. part of DELVSLV _x) ENTER
5	XXXXXX	(most sig. part of DELVSLV _y) ENTER
6	XXXXXX	(least sig. part of DELVSLV _y) ENTER
7	XXXXXX	(most sig. part of DELVSLV _z) ENTER
10 ₈	XXXXXX	(least sig. part of DELVSLV _z) ENTER
11 ₈	XXXXXX	(most sig. part of TIG) ENTER
12 ₈	XXXXXX	(least sig. part of TIG) ENTER

2. 1. 6 Use of the Scatter Update VERB

VERB 72, defined in section 2. 1. 3, can be used to perform the LANDING SITE UPDATE. It is assumed that the ground station has transmitted VERB72ENTER 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. 3. 3.

* Refer to Paragraph 2. 1. 7 to obtain the absolute address (ECADR) for this UPDATE.

2.1.6.1 LGC LANDING SITE UPDATE

This data consists of the Landing Site Vector (X, Y, Z) in moon-fixed coordinates and the nominal time of landing referenced to the computer clock. The scale factors are as follows:

1. $RLS_{x,y,z}$ meters/ 2^{27}
2. TLAND centiseconds/ 2^{28}

The LGC LANDING SITE UPDATE may be sent in the following sequence:

<u>Octal Identifier</u>	<u>Data Value</u>	<u>Data Definition</u>
1	21_8	(index value) ENTER
2	(AAAA)*	(ECADR, RLS) ENTER
3	XXXXX	(most sig. part of RLS_x) ENTER
4	(AAAA)*	(ECADR, RLS +1) ENTER
5	XXXXX	(least sig. part of RLS_x) ENTER
6	(AAAA)*	(ECADR, RLS +2) ENTER
7	XXXXX	(most sig. part of RLS_y) ENTER
10_8	(AAAA)*	(ECADR, RLS +3) ENTER
11_8	XXXXX	(least sig. part of RLS_y) ENTER
12_8	(AAAA)*	(ECADR, RLS +4) ENTER
13_8	XXXXX	(most sig. part of RLS_z) ENTER
14_8	(AAAA)*	(ECADR, RLS +5) ENTER
15_8	XXXXX	(least sig. part of RLS_z) ENTER
16_8	(AAAA)*	(ECADR, TLAND) ENTER
17_8	XXXXX	(most sig. part of TLAND) ENTER
20_8	(AAAA)*	(ECADR, TLAND +1) ENTER
21_8	XXXXX	(least sig. part of TLAND) ENTER

* Refer to Paragraph 2.1.7 to obtain the absolute address (ECADR) for this UPDATE.

2.1.7 Absolute Addresses for UPDATE Program

ABSOLUTE ADDRESSES FOR UPDATE PROGRAM

THIS SECTION PROVIDES ECADRS FOR SECTION 2 OF LUMINARY IC GSOP

<u>ECADR</u> -----	<u>MNEMONIC</u> -----
01501	ECADR UPSVFLAG
03606	ECADR XSMD
01733	ECADR REFSMMAT
03433	ECADR DELVSLV
02022	ECADR RLS
02023	ECADR RLS +1
02024	ECADR RLS +2
02025	ECADR RLS +3
02026	ECADR RLS +4
02027	ECADR RLS +5
02400	ECADR TLAND
02401	ECADR TLAND +1

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2.2 LGC Digital Downlink

The downlink format is controlled by an LGC program. This program is entered on an interrupt caused by an "endpulse" from the telemetry system. The program loads into channels 34 and 35, the contents of the next two 16-bit LGC registers that are to be transmitted. 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 LGC register (15 bits of data followed by an odd parity bit). The final 16 bits are the contents of another 16-bit LGC 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 LGC register transmitted.

Thus, the contents of the two LGC registers are arranged for transmission on channels 34 and 35 as shown in the following table.

		Channel 34																																	
Reg. #1	X Word Order Code	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		15 ₁	14 ₁	13 ₁	12 ₁	11 ₁	10 ₁	9 ₁	8 ₁	7 ₁	6 ₁	5 ₁	4 ₁	3 ₁	2 ₁	1 ₁	P ₁											}	word						
		Channel 35																																	
Reg. #2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X
		15 ₂	14 ₂	13 ₂	12 ₂	11 ₂	10 ₂	9 ₂	8 ₂	7 ₂	6 ₂	5 ₂	4 ₂	3 ₂	2 ₂	1 ₂	P ₂																		
		Channel 34																																	
Reg. #1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		15 ₁	14 ₁	13 ₁	12 ₁	11 ₁	10 ₁	9 ₁											}	repeat															

Table Showing LGC 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 list.) 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 contents of the standard lists and the programs in which they are transmitted are described in section 2.2.2.

The standard LGC downlink lists contain 100 downlink words (200 LGC registers). The LGC digital downlink is transmitted at a rate of 50 words per second. Therefore, transmission of one standard list requires two seconds.

2.2.1 Erasable Memory Dump

Upon reception of a Verb 74 Enter from the keyboard or the uplink, the computer will interrupt the dump or downlist being transmitted and start transmitting an erasable memory dump. The first word of the erasable memory dump is an ID word: 01776_8 and the same pattern of sync bits as for the standard downlist. 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 words of the bank currently being dumped. 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 downlink lists. The "packed indicator" identifies the erasable bank and the pass through that bank as follows:

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

Bits 11-9 - gives EBANK number
Bits 8-1 - 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 group (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. 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, the current downlist will be started at the ID word. Since programs continue to run during the transmission of the erasable memory dump, some of the registers transmitted may have different contents on different passes through the erasable.

2.2.2 Downlists

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

- A. The Orbital Maneuvers List is transmitted during:
 - P40 DPS Thrust
 - P41 RCS Thrust
 - P42 APS Thrust
 - P47 Thrust Monitor

- B. The Coast and Align List is transmitted during:
 - P00 LGC Idling
 - P06 LGC Power Down
 - P51 IMU Orientation Determination
 - P52 IMU Realignment

- C. The Rendezvous and Prethrust List is transmitted during:
 - P20 Rendezvous Navigation
 - P21 Ground Track Determination
 - P25 Preferred Tracking Attitude
 - P30 External ΔV Maneuver Guidance

 - P32 Coelliptic Sequence Initiation (CSI)
 - P33 Constant Differential Altitude (CDH)
 - P34 Transfer Phase Initiation (TPI)
 - P35 Transfer Phase Midcourse (TPM)

 - P72 CSM CSI Targeting
 - P73 CSM CDH Targeting
 - P74 CSM TPI Targeting
 - P75 CSM TPM Targeting
 - P76 Target DELTA V

- D. The Descent and Ascent List is transmitted during:
 - P12 Powered Ascent Guidance
 - P63 Braking Phase Guidance
 - P64 Approach Phase Guidance

 - P66 Rate of Descent (ROD) Landing Phase Guidance

 - P68 Confirm Lunar Landing
 - P70 DPS Abort Guidance
 - P71 APS Abort Guidance
- E. The Lunar Surface Align List is transmitted during:
 - P22 RR Lunar Surface Navigation
 - P57 Lunar Surface Alignment
- F. The AGS Initialization and Update List is transmitted during:
 - P27 LGC Update
 - R47 AGS Initialization

The list switching is accomplished as follows: The DOWNLINK program, at the beginning of a pass, uses the ID word to trigger selection of the appropriate list for that pass. Whenever a new program is entered, it sets up a request for its list by placing the appropriate value in the DNLSTCOD register which the DOWNLINK will pick up as the ID. When, at the beginning of the next pass, the DOWNLINK reads this register, the appropriate list is then initiated (i. e., the list is not switched in the middle of a pass). 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.

When a computer hardware restart occurs, the downlist whose code is in the DNLSTCOD register will be transmitted beginning with the first word; a fresh start places the code for the Coast and Align list into DNLSTCOD. This occurs when either a downlist or an erasable dump is interrupted.

Since certain data on the 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 that 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 LUMINARY downlists have the following "snapshots":

Orbital Maneuvers List	words 2-8, 52-58
Coast and Align List	words 2-8, 52-58
Rendezvous and Prethrust List	words 2-8, 9-13, 52-58
Descent and Ascent List	words 2-13, 52-58
Lunar Surface Align List	words 2-8, 9-13, 52-58
AGS Initialization and Update List	words 52-58

During the Rendezvous and Prethrust List one of the parameters selected to be monitored has the same erasable locations as other quantities which are also calculated during the Rendezvous and Prethrust List. This time-sharing is described. Therefore, each change in an erasable monitored by the downlists is accounted for. Before a parameter is calculated during a downlist the erasable location may contain a quantity from a program on another downlist.

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I Orbital Maneuvers

Word Number	Contents		Comments	
	First Register	Second Register		
1.	I.D. (77774 ₈)	Sync (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)	Reference Coordinates	
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.	TF	TF		
				(Time of Flight to Conic Target Aim Vector)
10.	RTARG X	RTARG X		Reference Coordinates
11.	RTARG Y	RTARG Y		
12.	RTARG Z	RTARG Z		
13.	Elevation Angle	Elevation Angle		
14.	Time of Event	Time of Event		
15.	REFSMMAT (R ₁ C ₁)	REFSMMAT (R ₁ C ₁)	REFSMMAT = 3 × 3 Matrix R = row C = column	
16.	REFSMMAT (R ₁ C ₂)	REFSMMAT (R ₁ C ₂)		
17.	REFSMMAT (R ₁ C ₃)	REFSMMAT (R ₁ C ₃)		
18.	REFSMMAT (R ₂ C ₁)	REFSMMAT (R ₂ C ₁)		
19.	REFSMMAT (R ₂ C ₂)	REFSMMAT (R ₂ C ₂)		
20.	REFSMMAT (R ₂ C ₃)	REFSMMAT (R ₂ C ₃)		
21.	CSI Time	CSI Time		
22.	CSI Δ V X	CSI Δ V X	Reference Coordinates (DELVEET1)	
23.	CSI Δ V Y	CSI Δ V Y		
24.	CSI Δ V Z	CSI Δ V Z		
25.	VG TIG X	VG TIG X	Reference Coordinates	
26.	VG TIG Y	VG TIG Y		
27.	VG TIG Z	VG TIG Z		
28.	LR Vel Z	LR Alt	Raw Data	
29.	TPF Time	TPF Time		
30.	REDO COUNTER	Final CDU X (THETAD)		
31.	Final CDU Y (THETAD + 1)	Final CDU Z (THETAD + 2)		
32.	* RSBBQ	RSBBQ + 1		

*Indicates two single precision words that are not distinguished otherwise.

Word Number	Contents		Comments
	First Register	Second Register	
33.	Actual Body Rate X	Actual Body Rate Y	} OMEGAP, Q&R In Body Axes
34.	Actual Body Rate Z	Garbage	
35.	CDU XD	CDU YD	} RCS DAP Internal CDU's Desired
36.	CDU ZD	Garbage	
37.	Actual CDU X	Actual CDU Y	
38.	Actual CDU Z	RR TRUNNION CDU	
39.	Flagword 0	Flagword 1	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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)	} Reference Coord- inates
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.	Desired Body Rate X	Desired Body Rate Y	
60.	Desired Body Rate Z	Garbage	
61.	* CADRFLSH	CADRFLSH + 1	
62.	* CADRFLSH + 2	FAILREG	
63.	* FAILREG+1	FAILREG+2	
64.	RADMODES	DAPBOOLS	
65.	POSTORKU	NEGORKU	
66.	POSTORKV	NEGORKV	
67.	Spare	Spare	

Word Number	Contents		Comments
	First Register	Second Register	
68.	CDH Time	CDH Time	
69.	CDH Delta V _x	CDH Delta V _x	DELVEET 2 in Reference Coordinates
70.	CDH Delta V _y	CDH Delta V _y	
71.	CDH Delta V _z	CDH Delta V _z	
72.	TPI Time	TPI Time	
73.	TPI Delta V _x	TPI Delta V _x	DELVEET 3 in Reference Coordinates
74.	TPI Delta V _y	TPI Delta V _y	
75.	TPI Delta V _z	TPI Delta V _z	
76.	R R Range	R R Range Rate	Raw Data
77.	L R Vel X	L R Vel Y	
78.	L R Vel Z	L R Alt	
79.	CDH Delta Altitude	CDH Delta Altitude	
80.	LM Mass	CSM Mass	
81.	IMODES 30	IMODES 33	
82.	TIG	TIG	
83.	Actual Body Rate X	Actual Body Rate Y	OMEGAP OMEGAQ OMEGAR Body Axes
84.	Actual Body Rate Z	Garbage	
85.	CDU XD	CDU YD	RCS DAP Internal CDU's Desired
86.	CDU ZD	Garbage	
87.	Actual CDU X	Actual CDU Y	
88.	Actual CDU Z	RR TRUNNION CDU	
89.	Moment Offset Q	Moment Offset R	
90.	POSTORK P	NEGORK P	
91.	Channel 11	Channel 12	
92.	Channel 13	Channel 14	
93.	Channel 30	Channel 31	
94.	Channel 32	Channel 33	
95.	PIPTIME 1	PIPTIME 1	
96.	DELV X	DELV X	Stable Member Coordinates
97.	DELV Y	DELV Y	
98.	DELV Z	DELV Z	
99.	Spare	Spare	
100.	TGO	TGO	

I Orbital Maneuver List

<u>Word Number</u>	<u>Contents</u>
1a	I. D. word for this list. Will contain 77774_8 .
1b	Sync bits. Will contain 77340_8 .
2-8	<p>CSM STATE VECTOR and TIME. The LGC's latest calculated state vector for the CSM in reference coordinates. The coordinates may be either earth-centered or moon-centered; a zero in bit 12 of flagword 8 (CMOONFLG) indicates earth-centered, a one indicates moon-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 state vector scaled centiseconds/2^{28}, referenced to the computer clock. The scaling for position, velocity and time is the same whether earth-centered or moon-centered. The CSM state vector and time are set in the following:</p> <ul style="list-style-type: none">P00 - every four time stepsP20, P22 - every mark and every Incorp if CSM correctedP76 - after operationAverage G - at completionP27 - uplink of state vector <p>V66</p>
9	<p>T_F LAMBERT(DELLT4 - The desired transfer time). The time from TIG until the target (RTARG) is reached, scaled centiseconds/2^{28}. During a burn, the time from present state vector time until intercept. It is used as an input to the INITVEL subroutine and calculated by each user of this subroutine.</p>
10-12	<p>RTARG. The aim point vector X, Y, Z in either earth-centered or lunar-centered coordinates. Scaled meters/2^{29}. The origin of the coordinate system is the same as that of the LM state vector at TIG and TIG -30 sec. Bit 11 of flagword 8 (LMOONFLG) indicates whether the LM state vector is earth or moon-centered. RTARG is initially calculated in P34/P74, P35/P75, and updated in the Initial Velocity Subroutine.</p>

Word NumberContents

- 13 ELEVATION ANGLE. The angle between the horizontal plane defined by the active vehicle's position at TPI and the line of sight from the active to the passive vehicle. The angle is measured in a counter-clockwise rotation from the plane in 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. Used to compute TPI Time by P33/P73 and P34/P74. Input to P32/P72. Input to P34/P74 or computed by P34/P74. Scaled degrees/360.
- 14 TIME OF EVENT. Contains the image of TIME2, TIME1 at the time of the last significant event. Loaded in burn programs with time of ignition and time of engine cutoff as they occur. Loaded with abort initiation time in P70 and P71. Scaled centiseconds/ 2^{28} .
- 15-20 REFSMMAT. Six elements of REFSMMAT, in the order R_1C_1 , R_1C_2 , R_1C_3 , R_2C_1 , R_2C_2 , R_2C_3 . REFSMMAT is the 3×3 matrix used to convert from reference to 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.
- Calculated at the end of P51, prior to IMU coarse align in P52 for alignment options 1, 2 and 4, and in P57 for alignment techniques 1 and 4. Each row is a half-unit vector.
- 21 CSI TIME. The time of ignition for the CSI maneuver. Used in P32/P72 calculations; may also be calculated in P32/P72. Input by V25N11. Scaled centiseconds/ 2^{28} , referenced to computer clock.
- 22-24 CSI DELTA Vs (X, Y, Z). The required delta velocity for the CSI maneuver. Used to calculate delta velocity in local vertical coordinates. Calculated during each iteration of CSI/A sub-routine in P32/P72 and after display of ΔV_{LV} at CSI, regardless of whether display is overwritten. In reference coordinates. Earth or moon-centered depending upon whether bit 12 of flagword 8 (CMOONFLG) is zero or one, respectively. Scaled (meters/centisecond)/ 2^7 .

Word NumberContents

- 25-27 VGTIGs (X, Y, Z). Velocity-to-be-gained at ignition. For external $-\Delta V$ type burns this is the input ΔV rotated through half the calculated central angle expected to be covered by the burn. Calculated once at the beginning of each of P40, P41, and P42. In reference coordinates, scaled (meters/centisecond)/ 2^7 . VGPREV (X, Y, Z) appears in the same locations once Average G has been turned on (TIG -30 seconds). This is the velocity-to-be-gained used by steering in P40 and P42, and for display in P41. VGPREV is updated every 2 seconds during the burn. In reference coordinates. Scaled (meters/centisecond)/ 2^7 .
- 28 Same as word 78 of this list.
- 29 TPF TIME. Time of rendezvous of active and passive vehicles. Time to which the passive vehicle is extrapolated to compute the target vector. Computed once per pass through P34, and P74, and passed on to P35, and P75. Dependent on TIG and CENTANG. Scaled centiseconds/ 2^{28} .
- 30a REDO COUNTER. Counter for hardware restarts. Set to zero by keyboard freshstart (Verb 36). Incremented once per hardware restart by restart program (GO PROG). Scaled 2^{-14} .
- 30b, 31 FINAL DESIRED CDUs (X, Y, Z). The target attitude (desired outer, inner and middle gimbal angles) for all coasting flight automatic maneuvers and for the ISS coarse align loop. Also, used in the FDAI attitude error display checkout routine (V43). Computed as inputs to the coasting flight automatic attitude maneuver routine (KALCMANU) and prior to or during R60. Also computed whenever a coarse alignment is to be made. The astronaut can load these quantities directly via N22. The extended verbs V41N20, V43, V49, will request a load of these angles. These registers are unsigned 15-bit fractions. The quantities are scaled degrees/360.
- 32a RSBBQ. Loaded with the setting of the BBANK and Superbank when a hardware restart occurs.
- 32b RSBBQ + 1. Loaded with the setting of the Q-register when a hardware restart occurs.

<u>Word Number</u>	<u>Contents</u>
33, 34a	CURRENT BODY RATES (X, Y, Z). Estimated current rates about body axis. Calculated at the beginning of every DAP cycle every 0.1 sec. Zeroed at DAP start-up. Scaled (degrees/sec)/45. Expected range of ± 10 degrees/sec but ± 45 degrees/sec is possible.
34b	Garbage. This is the same erasable location as the one described for word 89a of this list.
35, 36a	DAP INTERNAL DESIRED CDUs (X, Y, Z). Outer, inner and middle intermediate desired gimbal angles. Steering commands to DAP. Generated during a burn by guidance equations or during an automatic maneuver. Calculated every 2 secs during a PGNCS controlled burn (i. e., P40, P42). Updated every 0.1 sec by the DAP (using DELCDUs) during an automatic maneuver (KALCMANU) and also during powered flight. These registers are unsigned 15-bit fractions. Scaled degrees/360.
36b	Garbage. The increment subtracted from CDUXD each .1 second by the DAP. An unsigned 15-bit fraction scaled degrees/360.
37, 38a	ACTUAL CDUs (X, Y, Z). The current outer, inner and middle IMU gimbal angles. Automatically updated by the hardware when the IMU is on. These registers are unsigned 15-bit fractions. Scaled degrees/360.
38b	ACTUAL RR TRUNNION CDU. RR trunnion angle CDU counter. Defines the RR antenna position (along with shaft angle). Updated from RR CDUs as trunnion angle changes. This register is an unsigned 15-bit fraction. Scaled degrees/360.
39-44	TWELVE FLAGWORDS. (0, 1, ... 11). Bit assignments are as follows:

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
0	15	NEED2FLG. A 1 means display DAP rates on FDAI needles. A 0 means needles will have either mode 1 or mode 2 attitude error displays. Set 1 by V60. Set 0 when V61 or V62 selected. Also set 0 when R60 selected.
0	14	JSWITCH. Bit set to 1 to indicate that extrapolation of W-matrix is being carried out in orbital integration routine. Bit set to 0 to indicate that the state vector extrapolation is being carried out in orbital integration routine. Bit would remain 0 until bit 1 of flagword 3 becomes 1.

Word NumberContents39-44
(Cont'd)Flagword BitMeaning

- | | | |
|---|----|--|
| 0 | 13 | MIDFLAG. Set to 1 in orbital integration when magnitude of conic position vector is greater than the constant RME when earth is primary body and RMM when moon is primary body and set to 0 when magnitude is less than these constants. In LUMINARY, these constants are set to POSMAX; therefore MIDFLAG should never be set to 1. If MIDFLAG were set to 1, integration would attempt to include secondary body and solar perturbations to the orbit. Since position vectors of the moon and sun are needed, and these are not available in LUMINARY, integration would be invalid and possibly disastrous. |
| 0 | 12 | MOONFLAG. Set as follows in orbital integration when integrating the stored CSM and LM state vectors: 1 indicates lunar orbit, 0 indicates earth orbit. Also set to 0 or 1 in integration when switching coordinate centers but this can't be done in LUMINARY because logic is engaged by MIDFLAG = 1. Also set to 0 (earth-orbit) or 1 (lunar-orbit) in P21, R31, INITVEL, P32 thru P35, P72 thru P75 when specifying a state vector to integrate and in P27, P76 when using integration subroutines to store modified state vectors for systems use. |
| 0 | 11 | 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. |
| 0 | 10 | FSPASFLG. Bit is set to 1 during P22 at the point in the designate routine (R21) when the line of sight is not in mode 2 coverage (the Predesignate routine is necessary). A 1 indicates the first pass through the Predesignate routine. Bit is reset to 0 when the line of sight is inside mode 2 coverage; another line of sight computation is done before continuous designation starts. A 0 indicates that it is not the first pass through the Predesignate routine. |

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
0	9	P25FLAG. A 1 means P25 is operating. A 0 means P25 is not operating. Set to 1 at the beginning of P25. Set to 0 by P63, V56, Terminate Tracking, or by selection of P00.
0	8	IMUSE. Set to 1 by P51 and R02. Reset to 0 by P00, P06, IMU performance tests, Extended Verb 56 (if tracking was operating), and all new program selections unless either RNDVZFLG or P25FLAG is 1. Bit is examined by R47 and by the T4RUPT turn-on sequence to determine whether to do IMU CDU Zero. If the bit is 1, CDU Zero is bypassed. The effect of this is that CDU Zero is not done in AGS initialization or after a restart if IMUSE is 1.
0	7	RNDVZFLG. A 1 means P20 or P22 is operating. A 0 means P20 or P22 is not operating. Set to 1 at the beginning of P20 or P22. Set to 0 by V56, Terminate Tracking, or by selection of P00. Set to 0 by the ISS Service Routines in T4RUPT if a change in the ISS operate discrete is detected. Set to 0 by P06-Standby Program, P12, and P63.
0	6	RRNBSW. A 1 means RR target is in nav-base coordinates. A 0 means RR target is in stable-member coordinates. Set to 1 by V41 RR Coarse Align. Set to 0 by LPS20.1 (subroutine of P20/P22). Set to 0 by Stable Member Designate Subroutine (used by R21 and R24 in P20/P22).
0	5	LOKONSW. A 1 means radar lock-on is desired in RR Designate. A 0 means radar lock-on is not desired in RR Designate. Set to 1 by R21 RR Designate Routine of P20/P22. Set to 1 by V41 RR Coarse Align if the Lockon Option is selected. Set 0 by R26. Set 0 by V41 RR Coarse Align if the Continuous Designate Option is selected.
0	4	NEEDLFLG. Set to 1 by Verb 62 or R60 and reset to 0 by Verb 61 (or a fresh start). Used to control the information presented on the FDAI attitude error needles by the LM DAP. If bit is 1, the "total attitude error" is displayed, defined as THETAD-CDU (THETAD is the Noun 22 cells) rotated into pilot axes (P, Q, R). The crew may use this display as a "fly to" indicator when performing manual maneuvers to the attitude specified by the gimbal angles in Noun 22. If the bit is 0, the "autopilot following error" is displayed. This is the same error which is used in controlling the firing of the RCS jets and is provided as a monitor of the LM DAP.

Word NumberContents39-44
(Cont'd)Flagword Bit
0 3Meaning

FREEFLAG. Used as a temporary flag to control the internal logic of the following subroutines:

R54 - Used as a counter to control two passes through CHKSB which computes the star data check error. Set to 1 for first pass, set to 0 for second pass. Also used to indicate the response of the astronaut to the star data check display V06N05. Set to 1 if the astronaut performed PROCEED, V33E. Set to 0 if the astronaut performed RECYCLE, V32E.

R51 - Bit interrogated after R54 in P52. If bit is 1, gyro torquing (R55) is accomplished. If bit is 0, gyro torquing is bypassed and V50N25 R1 = 00014 is displayed.

P57 - GRAVITY VECTOR DETERMINATION routine is used to indicate astronaut response to error display. Bit is set to 0 if the astronaut performed PROCEED, and set to 1 if the astronaut performed RECYCLE.

P51 - Bit interrogated after R54. If bit is 1, the new REFSMMAT is computed and stored and the REFSMMAT flag is set. If bit is 0, P51 is started again and V50N25 R1 = 00015 is displayed.

LSPOS - Used as a counter to control two passes through POSITB. Bit is 0 for first pass, 1 for second pass.

0 2 R10FLAG. Bit set to 1 during ascent (in P12, P70, and P71) to indicate that R10 only outputs data to altitude and altitude rate meters. Bit reset to 0 (initially and during descent) to indicate that R10 outputs data to the Forward and Lateral velocity cross-pointers, in addition to the altitude and altitude rate meters. Bit is checked in R10 (Landing Analog Displays) in order to determine the type of output to display.

0 1 P66PROFL. Set to 1 when P66 is entered for the first time (in R13) as a directive to continue P66 horizontal nulling. It is reset to 0 when the astronaut proceeds on a flashing V06 N60 after touchdown, the 0 specifying a stop to P66 horizontal nulling. It is tested in P66 after horizontal commands have been calculated, but before commands are issued.

1 15 NJETSFLG. Used for thrust determination in P41. Set in R03 (entered via V48) as follows: set to 1 if bit 11 of DAPDATR1 is 0, indicating that 2-jet X translation is specified; set to 0 if bit 11 of DAPDATR1 is 1, indicating 4-jet X translation.

 Revised AddedGSOP # R-567 PCR # 988 Rev. 8 Date 3/70

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
1	14	DIDFLAG. Bit is set to 1 in R10 to indicate that R10 has performed initialization sequence on the first pass, and inertial data is available for displays on subsequent passes thru R10. Bit is reset to 0 in R10, FRESH START, and RESTART to force R10 to perform initialization sequence if the mode select switch is set at PGNCNS. Bit will remain at 0 when inertial data displays are not desired. Bit is examined when the mode select switch is set at PGNCNS, indicating that the astronaut requests inertial data displays.
1	13	ERADFLAG. Used in lat-long subroutine. For the earth, a 1 means compute Fischer ellipsoid radius; a 0 means use fixed radius. For the moon, a 1 means use fixed radius; a 0 means use R_{LS} (lunar land site radius) for lunar radius. Set to 0 or 1 by routines that use lat-long subroutine.
1	12	RODFLAG. Bit is set to 1 on the first pass thru P66 to designate continuation of algorithm without reinitialization. A 1 indicates that the rate-of-descent mode is in progress. Bit is reset to 0 during a restart, to insure reinitialization of P66 algorithm. If in P66, a 0 indicates that there has been a restart. Bit is set to 1 to check for restarts and fresh start. Bit is set to 1 only when the vertical guidance (landing phase) is in effect, the SCSMODE is in attitude hold, and the ROD switch has been activated.
1	11	Not used.
1	10	R61FLAG. Bit is set to 1 by UPFLAG at the start of R61, to indicate that R61 is in operation. Bit is reset to 0 by DOWNFLAG at the start of R65, to indicate that R65 is in operation. Bit is tested during R61, R65 to determine exit from these routines.
1	9	Not used.
1	8	VEHUPFLG. A 1 means CSM state vector to be corrected by Navigation. A 0 means LM state vector to be corrected by Navigation. Set to 0 at the beginning of P20. Set to 0 by V80 Update LM. Set to 1 by V81 Update CSM. Set to 1 at the beginning of P22.

2-35

 Revised
 Added
GSOP # R-567PCR # 285Rev. 7Date Nov. 1969

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
1	7	UPDATFLG. A 1 means updating of the state vector by Navigation is allowed. A 0 means updating of the state vector by Navigation is not allowed. Set to 1 at the beginning of P20 or P22. Set to 0 by V37 selection of a program other than P20 or P22. Set to 1 by V37 selection of P20 or P22 if either is already operating. Set to 0 by V56 Terminate Tracking. Also set 0 by V34E response to a P20 display (except V06N49). Set to 1 by Rendezvous Targeting Programs (P32, P33, P34, P35 and P72 thru P75) during the loading of input data and set to 0 by these programs when starting the targeting computations.
1	6	NOUPFLAG. A 1 means neither the CSM nor the LM state vector may be updated by Navigation. A 0 means either state vector may be updated (see bit 8 of this flagword). Set to 1 by V95 Inhibit State Vector Updating. Set to 0 by V80 Update LM V81 Update CSM.
1	5	TRACKFLG. A 1 means tracking of CSM allowed. A 0 means tracking of CSM not allowed. Set to 1 at the beginning of P20 or P22. Set to 0 by V37 selection of a program other than P20 or P22. Set to 0 (if 1) by V56 Terminate Tracking. Also set 0 by V34E response to a P20 display (except V06N49). Set to 1 by V37 selection of P20, P22, or P25, unless one of these is already running. Set to 1 by all of the rendezvous targeting programs (P32, P33, P34, P35, and P72 thru P76) at the beginning of the targeting program. Set to 0 by the IMU mode switching routines when the IMU is put in the coarse align mode.
1	4	Not used.
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. This bit is equivalent to the switch f_3 of Section 5.5 of this GSOP.

Word NumberContents39-44
(Cont'd)FlagwordBitMeaning

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. 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 P-34 or P74, the Pre-TPM Maneuver Program P-35 or P75, and the Lambert Aim-Point Maneuver Pre-Thrust Computation Routine. This bit is equivalent to the switch f_1 in Section 5.5 of this GSOP.

1

1

Not used.

2

15

DRIFTFLG. Set to 1 to enable free-flight gyro drift compensation and set to 0 to disable compensation. Set to 0 if IMU caged and prior to the IMU being coarse aligned and when Average-G program is started. Set 0 for pulse torquing option of P52. Set to 1 after IMU coarse alignment and upon termination of Average -G.

2

14

SRCHOPTN. A 1 means R24 RR Automatic Search Routine used to lock on to CSM. A 0 means R24 not used to lock on. Set to 0 at beginning of P20 or P22. Set to 1 at beginning of R24. Set to 0 (if 1) in P20 or P22 before going to R22 RR Data Read Routine.

2

13

ACMODFLG. A 1 means Manual Radar Acquisition Mode (R23) used to lock-on. A 0 means Manual Radar Acquisition Mode (R23) not used to lock-on. Set to 0 at beginning of P20 or P22. Set to 1 upon return from R23 to P20 or P22 with lock-on achieved. Set to 0 (if 1) in P20 or P22 before going to R22 RR Data Read Routine.

Word Number

Contents

39 - 44
(Cont'd)

Flagword

Bit

Meaning

- 2 12 LOSCMFLG. A 1 means line-of-sight being computed during Radar Designate. A 0 means line-of-sight not being computed. Set to 0 when RR data good discrete (indicating lock-on) is received by the Radar Designate Routine. Set to 1 at the start of R21 RR Designate Routine. Set to 0 at the end of R21 when lock-on has been achieved. Set to 0 by V41N72 Designate, R24 Search Routine, and at the beginning of P20 or P22. Set to 1 by R29 when a new line-of-sight is being computed.

- 2 11 STEERSW. Bit is set to 1 in SERVICER (P40 or P42) to indicate that cross-product steering computations are to be performed and the result loaded into communication cells with the DAP (if the MODE SELECT SWITCH is in AUTO). Bit is set to 0 when time-to-go (for a closed-loop guided burn, including predicted thrust decay) first drops below 4 seconds, or if bit 7 of FLAGWRD7 = 0 and the output of the accelerometers is below about 0.12 m/sec (CSM-docked), 0.36 m/sec (DPS), or 3.08 m/sec (APS) (for the 2-second interval). Bit is set to 1 if the accelerometer output goes above these thresholds (if bit 7 FLAGWRD7 = 0). If bit is 0, only the required velocity is updated (no derivation of time-to-go or steering commands are performed). Bit is set to 1 in SERVICER (P12, P63 thru P66) but it is not looked at in P12, P66, and P70/P71. Set 0 in SERVICER in P12 and descent programs.

- 2 10 Not used.

- 2 9 IMPULSW. Bit set to 1 when a countdown to initiate engine (DPS or APS) cutoff is required (i. e. the value of time-to-go is known and is not to be updated further). The bit is set to 0 unconditionally at the start of S40.13 (entered about 5 seconds before nominal ignition, and comprising the "short burn test and time-to-go predictor" routine), and is then set to 1 if it is concluded that the predicted burn duration is to be less than 6 seconds. (For DPS burns, a thrust level of approximately 10% is used.) The bit is set to 1 when time-to-go (for "long" burns) is less than 4 seconds; it is reset to 0 after being sensed (when the action to perform the engine cutoff has been initiated, so as to avoid double initiation).

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
2	8	XDELVFLG. Set to 1 if an External Delta V burn is to be performed. Set to 0 if a Lambert burn is required. Set to 1 in P30 before N42 display. Set 1 by P72 and P73. For P34, P35, P74, and P75 - set to 0 in subroutine S34/35.2. For P32/P72 and P33/P73 set to 1 in subroutine ADVANCE.
2	7	ETPIFLAG. A 1 means elevation angle supplied for P34, P74-compute TPI. A 0 means no elevation angle supplied for P34, P74-compute ELEV. Set to 0 initially in P34, P74. After ELEV has been input (V06N55), the bit is set to 1 if the ELEV input is non-zero.
2	6	FINALFLG. A 1 means last pass through rendezvous program computation. A 0 means interim pass through rendezvous program computation. Set to 0 by subroutine SELECTMU which is called at the start of P32 thru P35, and P72 thru P75 to perform initialization. Bit is set to 1 by P30. Set to 1 by subroutine VN1645 (which is called to perform calculations and display Noun 45 data) upon receipt of proceed to Noun 45 if FINALFLG not already set.
2	5	AVFLAG. Set to 1 if LM is active vehicle, set to 0 if CSM is active vehicle. Set to 1 in subroutine AVFLAGA which is called at the start of P32, P33, P34 and P35 to indicate that the LM is the active vehicle. Set to 1 in subroutine S40.9 and program P42. Set to 0 in subroutine AVFLAGP which is called at the start of P72, P73, P74 and P75.
2	4	PFRATFLG. Set to 1 if an IMU orientation matrix has been stored for the preferred IMU alignment option. Set to 1 in P40, P41, and P42 after computation of the "preferred IMU orientation" for engine ignition. Bit is reset to 0 in P52 after completion of coarse align and gyro torque coarse align, and at the end of re-align routine R51.
2	3	CALCMAN3. Set to 1 by the attitude maneuver routine (KALCMANU) to indicate that no gimbal lock avoidance (in going from the initial to final spacecraft attitude) is required. Since the checks for intermediate gimbal lock as well as the gimbal lock

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
2 (Cont'd)	3	avoidance feature have been removed, the bit should be 1 after the first maneuver computation and remain so (the final middle gimbal angle, THETAD+2 is checked and must be less than about 70° for the maneuver to be carried out).
2	2	CALCMAN2. A 1 means perform maneuver starting procedure (in KALCMANU). A 0 means bypass starting procedure. Set to 1 at the end of a large attitude calculation of maneuver parameters and reset after some computations concerning initial conditions for generation of the commands have been completed. 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. Set to 1 by R47, P76, P06, and P00 integration to inhibit selection of any new program except P00. Attempted selection of a new program other than P00 when the bit is 1 results in a program alarm (code 1520). Reset to 0 by P00, P76 and R47 when they are completed and by P06 when recovering from standby. Reset 0 by POODOO routine.
3	15	POOHFLAG. Set to 1 in STATINIT 1 as P00 integration is started to bypass backwards integration and perform check for 4 time-step criterion while P00 integration loop is going. Set to 0 in V37 logic.
3	14	GLOKFAIL. Set to 1 when CALCGA detects gimbal lock (alarm 401 occurs at the same time bit is set). Tested in IMU performance tests; if 1, PIPA test is done and GLOKFAIL is reset to 0. Also reset in R00.
3	13	REFSMFLG. Set to 1 if a meaningful REFSMMAT, reference to stable member matrix, is available, i.e. the alignment of the IMU is known in inertial (reference coordinate) space. Set to 1 after computation of REFSMMAT in the IMU orientation determination routine P51. Reset to 0 in the coarse align routine R50 and set to 1 on completion of R50 and on completion of gyro torque coarse align, after desired orientation is stored in REFSMMAT. Reset to 0 in gravity vector determination routine in P57. Reset to 0 in coarse align routine IMUCOARS. Set to 1 after desired orientation is stored in REFSMMAT after alignment is completed in P57.

<u>Word Number</u>		<u>Contents</u>
39-44 (Cont'd)		
<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
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	NOR29FLG. Bit is set to 1 by FRESH START, and when the Servicer routine terminates. A 1 indicates that R29 is not allowed. Bit is reset to 0 by P12 Ascent Guidance. A 0 indicates that R29 is allowed. Bit is tested during the RR read cycle of R29 and during software restart (V37). Bit is tested by R04 and R77 to determine if another program/routine is using the radar.
3	10	VFLAG. Used in automatic star selection routine (R56) during IMU alignment program (P52). Set to 1 to indicate that a pair of stars are not in the AOT field-of-view. Set to 0 if pair of stars found. Initially set to 1 at beginning of R56 and is used temporarily for program control purposes.
3	9	Bit used for two distinct functions, hence assigned two separate mnemonics. R04FLAG. Set to 1 by Verb 63 entry to indicate R04 is running and set to 0 at the end of R04. Set to 0 by Verb 78 entry to indicate R77 is running, rather than R04, since the two routines use much of the same coding. Set to 0 in R00 (V37). Set to 0 in the beginning of P20/P22 in order that alarm 521 be sent if the radar cannot be read. Set to 1 by R65 before reading RR and set to 0 by R65 after reading RR. The bit is checked in the RADAREAD routine (which is used by R04 and P20/P22) if the radar cannot be read; if the bit is 1 (R04 is running), alarm 521 will not be sent. READRFLG. Bit is set to 1 by R29 when RR lock-on has been achieved and the RR read cycle is starting. A 1 indicates that R29 is reading RR data. Bit is reset to 0 by R29 when exiting the RR read cycle because of a bad reading or the RR not in LGC mode. Bit is reset to 0 by software restart (V37), FRESH START, and hardware restart. A 0 indicates that R29 is not reading RR data. Bit is tested by the RR read cycle of R29 to determine if radar read is allowed.

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
3	8	PRECIFLG. Set to 1 in the integration routine on calls to CSMPREC, LEMPREC, INTEGRVS, and in P00 when integrating LM. Set to 0 when completing integration and in P00 when integrating CSM. PRECIFLG = 0 engages integral time step logic in integration when major mode is 00.
3	7	CULTFLAG. A 1 means star occulted. A 0 means star not occulted. Used in automatic star selection routine (R56) during the IMU alignment program (P52). Set to 1 to indicate that the particular star being checked lies too close to the computed position of the Sun, Earth, or Moon.
3	6	ORBWFLAG. Not used. Bit is not set to 1 in LUMINARY.
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 after V96 if QUITFLAG is 1. Set 0 by POODOO routine. Set to 1 if W-matrix integration overflows. Set to 1 for periodic integration in P00 (LM and CSM) and to 0 if P00 integration not to be done (QUITFLAG = 1). Set to 1 in P22 and P20 for integration to mark time and to cause permanent integration on initial operation of P20 and P22.
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 and INTEGRVS.
3	2	D60R9FLG. Used by orbital integration for W-Matrix integration; if bit is 1, 9×9 matrix is integrated; if bit is 0, 6×6 matrix is integrated. Set to 0 or 1 by P00 periodic integration, P20, P22 and Average-G to coasting flight.
3	1	DIMOFFLAG. Used by orbital integration for W-Matrix integration: if bit is 1, W-Matrix to be integrated; if bit is 0, no W-Matrix integration to be done. Set to 0 or 1 by P00 periodic integration, P20, P22 and Average-G to coasting flight.

<u>Word Number</u>		<u>Contents</u>
39-44 (Cont'd)		
<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
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 ("pinball").
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 is 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.
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).

Word NumberContents39-44
(Cont'd)Flagword BitMeaning

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 <u>not</u> 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 14 or bit 13 of this word = 1. Bit reset to 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).
4	2	Not used.
4	1	XDSPFLAG. Set to 1 to indicate that a mark display status exists. This will lock out normal displays.
5	15	DSKYFLAG. A 1 means displays sent to DSKY. A 0 means no displays sent to DSKY. Set to 1 (if 0) by subroutine of the Keyrupt routine. Subroutine of T4RUPT program branches according to DSKYFLAG setting.
5	14	Not used.
5	13	SNUFFER. Bit is set to 1 to inhibit RCS control about the U and V axes during unstaged powered flight. Set to 0 by Verb 75. Set to 1 by Verb 65.
5	12	NOTHROTL. Bit set to 0 in P40 to indicate that the burn will last longer than 95 seconds at approximately 10% thrust and that the engine should be throttled to maximum in the number of centiseconds after ignition indicated by the contents of ZOOM-TIME. Bit set to 1 unconditionally in S40.13 (time-to-go predictor) and then reset to 0 if the predicted burn duration at 10% thrust is greater than 95 seconds. Bit set to 0 in P63.

<u>Word Number</u>		<u>Contents</u>
39-44 (Cont'd)		
<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
5	11	R77FLAG. Bit is set to 1 at the start of R77 (in response to V78), if R77 operation is permissible. Bit is reset to 0 at the end of R77 (in response to V79), and by FRESH START (V36). Also set 0 by V37/ software restarts or hardware restart. Bit is checked in the RADAREAD routine: if bit is a 1 (R77 in operation), no checks are made for data fails. Bit is checked in RADSAMP (Radar Sampling Loop): if bit is a 1, the portion of coding particular to R04 is bypassed. Bit is checked at entry to both R04 and R77: if either is selected while the bit is set to 1, an operator error will be indicated. Bit is checked at entry to V40N72, V41N72, and V59: if any one of these extended verbs is called while the bit is set to 1, an operator error will be indicated.
5	10	RNGSCFLG. A 1 means a change has occurred in the RR range scale discrete while reading the range. A 0 means no change has occurred. Set to 0 at the beginning of each RR Read sequence in R22 RR Data Read Routine. Set to 1 by the Radar Interrupt Processor if the range scale discrete changes while reading the range.
5	9	DMENFLG. Set to 1 if the dimension of the W-Matrix is 9 for measurement incorporation. Set to 0 if the dimension of the W-Matrix is 6 for measurement incorporation. Set to 1 by the Rendezvous Navigation Routine.
5	8	ZOOMFLAG. Set 1 at throttle up to indicate throttle up and to start guidance. Reset 0 at TIG-5 to prepare for throttle up. Tested at start of landing guidance equations: if 0 do N63 display only; if 1 do landing guidance.
5	7	ENGONFLG. Bit set to 1 just after the DPS or APS engine is turned on (bit 13 of channel 11 set to 1 and bit 14 of channel set to 0), and reset to 0 when the engine is turned off (bit 14 set 1 and bit 13 set to 0 in channel 11). This happens in P12, P40, P42, P70, and P71. Bit is set to 1 in P63 and reset to 0 in P68. Bit is used when a restart occurs to determine the proper setting for the channel bits. Engine is turned off following ENTER response to V97.

Word NumberContents39-44
(Cont'd)Flagword Bit
5 6Meaning

5	6	3AXISFLG. A 1 means maneuver specified by three gimbal angles (Noun 22). A 0 means maneuver specified by two vectors. Set to 1 prior to entering R60 if the attitude maneuver to be made is specified by three angles (Noun 22). If it is 0, the attitude is specified by two vectors, the body fix vector (SCAXIS) and the direction in which this is to be pointed (POINTVSM). Another routine, VECPOINT, is used to compute the corresponding desired gimbal angles (Noun 22). Reset to 0 before exit from R60. Most calls to R60 require a VECPOINT solution (bit = 0). V49 (R62) uses the three gimbal angle option (bit = 1).
5	5	AORBSFLG. A 1 means P-Axis couples 7, 15 and 8, 16 used. A 0 means P-Axis couples 4, 12 and 3, 11 used.
5	4	NORRMON. Set to 1 if the gimbal monitor function of the RR Monitor Routine, R25, is disabled; set to 0 if enabled. Set to 0 at the beginning of P20/P22. Set to 1 at the beginning of RR Manual Acquisition Routine (R23); set to 0 when exiting R23. Set 1 by R26. Set to 1 by V41 RR Coarse Align if the No Lockon Option is chosen. Set to 0 by V44 Terminate Coarse Align Continuous Designate. Set 0 by hardware/software restart or V37.
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.

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
5	2	MGLVFLAG. A 1 means local vertical coordinates computed. A 0 means middle gimbal angle computed. Set to 0 by subroutine SETMGA after computation of the middle gimbal angle. Set to 1 by subroutine GET.LVC after computation of local vertical coordinates.
5	1	RENDWFLG. Set to 1 to indicate that the W-Matrix is valid and should not be re-diagonalized in navigation (P20 or P22), set to 0 to indicate W-Matrix is invalid. Set to 1 in P20 or P22, after initializing the W-Matrix when state vector correction is being done and RENDWFLG is initially set to 0. Set to 0 when integration of the W-Matrix overflows. Set to 0 by V93. Bit is reset to 0 by V67 if new W-Matrix initialization values have been loaded by V67. Set to 0 when state vectors are uplinked by P27, Set 0 in P12. Used in P00 periodic state vector update, powered flight to coasting flight transition routine (AVETOMID) and P20 or P22 to determine if W-Matrix should be integrated to maintain synchronization of state vectors and W-Matrix.
6	15	S32.1F1. Used in P32, P72 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 $ \Delta V_{CSI} > 1000$ ft/sec and subsequent test of bit in case $ \Delta V_{CSI} > 1000$ ft/sec will terminate iterative loop.
6	14	S32.1F2. Controls first step size of iterative loop to establish two points for Newton-Raphson iteration in P32, P72. Set to 1 at start of each iterative loop. Set to 0 after first step.
6	13, 12	S32.1F3A and S32.1F3B. 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 in P32, P72. 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.
6	11	Not used.

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
6	10	GMBDRVSW. Bit used in "TRIMGIMB", a subroutine called by R03 (entered via Verb 48) to indicate that the trim gimbal has been driven to the correct position in either pitch or roll (depending on which gets finished first). Bit is unconditionally set to 0 at start of "TRIMGIMB" and is checked at the conclusion of the roll drive task and the pitch drive task; if the bit is 0 (indicating that the other task has not been completed yet) it is set to 1 and the current task ended; if it is already 1 (indicating that the other task has already finished) a return to routine 03 is initiated (via a NOVAC job call) and the task ended.
6	9	Not used.
6	8	MUNFLAG. Bit is set to 1 at entry to P12 and P63. Bit is reset to 0 at the termination of SERVICER. Bit is checked by R25: if both AVEGFLAG and MUNFLAG are set to 1, R25 exists without checking RR gimbal angles. Bit is checked by SERVIDLE (the routine executed if a P00D00 abort occurs while SERVICER is running): if bit is set to 1, restart group 2 is left alone; otherwise it is inactivated. Bit is checked by READACCS: if bit is set to 1, R09 is initiated; otherwise it is bypassed. Bit is checked by NORMLIZE (which is called by PREREAD to initialize state vectors for SERVICER): if bit is set to 1, MUNRVG is initialized; otherwise CALCRVG is initialized. Bit is checked by SERVICER: if bit is set to 1 (either P12, P63, P64, P66, P70 or P71 running), the average-g routine MUNRVG is called; otherwise (either P40, P41, P42 or P47 running) the average-g routine CALCRVG is called. Bit is checked by BURNBABY (Master Ignition routine): if bit is set to 1, CSMPREC is called prior to calling R41; otherwise it is omitted. Bit is reset to 0 by V37.

 Revised AddedGSOP # R-567 PCR # 988 Rev. 8 Date 3/70

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
6	7	Not used.
6	6	REDFLAG. Bit is set to 1 by "proceed" response to V06N64 in P64 to enable landing site redesignation capability. Bit is reset to 0 at the start of P66 to prohibit landing site redesignation capability, and at the start of P63, P64 as initialization. Set 0 in P64 if TREDES = 0. Bit is tested by P64 display routine to determine whether to flash V06N64, and by redesignation logic to determine whether to allow redesignations.
6	5	Not used.
6	4	Not used.
6	3	NTARGFLG. A 1 means astronaut did overwrite delta velocity. A 0 means astronaut did not overwrite delta velocity. Set to 0 in subroutine S34/35.5 (used by P34, P35, P74, and P75) initially before displaying Noun 81. If the values for Noun 81 are changed by the astronaut, NTARGFLG is set 1 after a PROCEED response, and the new target vector is computed based on the loaded Delta V (LV).
6	2	AUXFLAG. Bit is set to 1 by SERVICER whenever the delta-V monitor is bypassed. When the delta-V monitor detects that the bit is a 1, the monitor knows that it must be on the first pass; the monitor then bypasses further activity and resets the bit to 0. A 0 indicates that the delta-V monitor is on the second or later pass and can perform its normal functions. The bit is used only by the delta-V monitor as a one-pass delay mechanism.
6	1	ATTFLAG. Bit is set to 1 by REFMF routine during the Lunar Surface Alignment Program P57 if the REFSMMAT flag is set 1 and the Post Lunar Landing Program P68, after LM Y and Z axis vectors are calculated in moon-fixed coordinates and stored in YNBSAV and ZNBSAV. Bit is reset to 0 by a FRESH START. If align technique 0 or 1 is selected, alarm 701 will be displayed if bit is zero and REFSMMAT is not available. If align technique 2 or 3 is selected, the INITALGN flag is clear and the alignment continues. Bit is tested with each P57 alignment.

 Revised AddedGSOP # R-567PCR # 285Rev. 7Date Nov. 1969

Word NumberContents39-44
(Cont'd)Flagword BitMeaning

7	15	ITSWICH. A 1 means a solution of TPI time has not yet been reached. A 0 means a solution for TPI time has been reached. Bit is reset to 0 in P34, P74 if the TPI time is given and the elevation angle is to be computed. Bit is set to 1 in P33, P34, P73, and P74 when the elevation angle is given and TPI time 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.
7	14	MANUFLAG. Not used. Bit is not set to 1 in LUMINARY.
7	13	IGNFLAG. Set to 1 in P12, P40, P41, P42 and P63 when nominal ignition time has arrived. If bit is 1 when a "proceed" response is received to the V99 display, engine ignition is performed immediately. Set to 0 5 seconds before scheduled ignition time or 5 seconds before next attempt at engine ignition if the astronaut has keyed in "enter" to the V97 engine fail display. In the latter case P70 and P71 treat IGNFLAG in the same manner as the above five programs. Also set to 0 at time engine (DPS or APS) has been turned on.
7	12	ASTNFLAG. Bit set to 1 in P12, P40, P42, and P63 when crew authorization for ignition (a "proceed" to the V99 display) is received. If bit 13 of this word is 1, engine ignition is performed promptly. Bit is set to 0 at the same time that bit 13 is set to 0. The treatment of this bit for P70 and P71 following an "enter" to a V97 display, is the same as for P12.
7	11	SWANDISP. Bit is set to 1 in the Master Ignition Routine at P63IGN and P12IGN portions of the program to enable Landing Analog Displays (R10). The mode select switch must be set to the PGNCs position in order to display. Bit is reset to 0 at the termination of SERVICER or on landing confirmation to suppress the Landing Analog Displays. R10 can be executed at the rate of four times per second, but data will not be displayed while the bit is 0. The bit is examined immediately upon entrance to the R10 routine.

Word NumberContents39-44
(Cont'd)FlagwordBitMeaning

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 one of the targeting programs (P34 or P74), or results from one of the maneuver programs (P35 or P75) 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 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.

Word Number
39-44
(Cont'd)

Contents

Flagword Bit

Meaning

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 both 1 and to 0 during the course of the computations of each standard internal iteration in the Pre-CSI Maneuver Program P32 or P72. Set to 0 by the Pre-CDH Maneuver Program P33 or P73. Set to 1 by the Pre-TPI Maneuver Program P34 or P74. The bit is equivalent to the inverse of the switch f_6 of Section 5.5 of this GSOP.
7	8	V67FLAG. Set to 0 whenever an extended verb V67 is taken. This verb displays the RMS position, velocity, and bias errors from the W-Matrix using a V06N99. If the astronaut then changes these values, the bit is set to 1. The bit is tested in the V67CALL routine: a 1 means compute new initial W-Matrix values for either rendezvous or lunar surface navigation; a 0 means do not compute these values.
7	7	IDLEFLAG. Bit set to 1 as part of a fresh start, and used if 0 to permit the Delta-V monitor computations to be performed by the Average-G loop. Bit is always set to 0 when engine is turned on in P12 and P63 (or in P70 and P71 if the astronaut has attempted to relight the engine following an engine failure). In P40 and P42 the bit is set to 0 at engine ignition if and only if bit 9 of flagword 2 is 0 (i. e. burn interval \geq 6 secs). The bit is set to a 1 in the following instances: 1) Whenever V37 is used to select a new program, 2) In P12, P40, P42, P70, and P71 when TGO is less than 4 seconds (i. e. when a waitlist task is set up to turn off the engine), and 3) when engine fail has been determined (i. e. when V97 appears on the DSKY). In addition the bit is set to 0 if an engine failure is detected and the astronaut keys in a "proceed" to the V97. The bit is set to 1 also if a "POODOO" type of abort occurs while Average-G is running.
7	6	V37FLAG. Set to 1 by PREREAD (Average-G initialization) to indicate that Average-G is running. Bit is examined by R00 (Program Change Routine) to detect Average-G activity and to wait for Average-G termination if it is on. Reset to 0 by AVGEND after termination of Average-G.

<u>Word Number</u>		<u>Contents</u>
39-44 (Cont'd)		
<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
7	5	AVEGFLAG. Set to 1 by PREREAD (Average-G initialization) to indicate that Average-G is desired. Bit is examined by READACCS (PIPA Read Routine, cycling at 2-second intervals) to determine whether to continue Average-G cycle. Reset to 0 by R00 (Program Change Routine) to indicate that Average-G should terminate.
7	4	UPLOCKFL. Set to 1 if a failure of the C \bar{C} C 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	V82EMFLG. A 1 indicates moon vicinity. A 0 indicates earth vicinity. Set 1 or 0 by R30 according to whether state vectors are moon-centered 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.
7	1	TFFSW. Set to 1 in CALCTPER, cleared in CALCTFF. When 1, indicates that present or last computation was Time to Perigee for Noun 32. When 0, indicates that present or last computation was Time to Free Fall for Noun 44. In R30, Time to Perigee is computed if perigee altitude is at least 300,000 feet above the earth launch pad (Earth sphere) or at least 35,000 feet above the lunar landing site (Moon sphere). Otherwise TFF is computed.
8	15	RPQFLAG. Internal flag in integration to indicate if primary body to secondary body position vector (RPQ) was computed; 1 indicates RPQ not computed.
8	14	Not used.
8	13	NEWIFLG. Internal flag in integration. Used to engage 4 time step only on the first step of P00 integration; 1 means first step, 0 means not first step.
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.

Word NumberContents39-44
(Cont'd)FlagwordBitMeaning

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	FLUNDISP. Bit is set to 1 by R40 (Engine-fail routine) to suppress guidance displays that P12, P63 thru P66, P70, and P71 issue in order to avoid conflict with V97 or V99. Bit is reset to 0 by TIG-0 to allow guidance displays to be presented by the guidance equations. The bit is examined by P12, P63 thru P66, P70, and P71 prior to issuing a display.
8	9	Not used.
8	8	SURFFLAG. Bit is set to 1 by P68. Bit is reset to 0 by P12 when engine thrust is detected. Bit is not altered by FRESH START. Bit is checked by LEMCONIC, LEMPREC, and INTEGRV (when integrating LM) integration routines; if set, these routines call the Planetary Inertial Orientation subroutine to obtain the LM state vector. Bit is checked by R31; if bit is set to 1, R31 obtains LM state vectors by calling LEMPREC rather than by calling a conic integration routine. Bit is checked by V67 to determine whether the W-matrix is being initialized for P20 or P22. Bit is checked by P20 and P22 in common coding areas to determine if P20 or P22 is running. Bit is checked by the AOTMARK routine to determine whether the mark taken is an in-flight or a surface mark. Bit is checked by the P00 integration routine; if the bit is set to 1, the LM state vectors are not updated. Bit is checked by SERVICER; if the bit is set to 1, the LM mass is not altered by MASSMON. Bit is checked by the LASTBIAS and NBDONLY routines (IMU compensation routines for free-fall and lunar surface operation): if the bit is set to 1, these routines include acceleration-sensitive drift corrections; whereas, if the bit is reset to 0, only non-acceleration-sensitive drift corrections are made. In addition, NBDONLY zeroes the pipas (after reading them) if the bit is set to 1. P21 checks SURFFLAG to determine whether LM is on surface. Bit is checked in V66 to see if LM is on lunar surface.

Word Number

Contents

39-44
(Cont'd)

Flagword

Bit

Meaning

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, 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

Word NumberContents39-44
(Cont'd)Flagword Bit
8 5
(Cont'd)Meaning

8	5	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_g in Section 5.5 of this GSOP.
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 $1^{\circ} 47.5'$ or greater than $178^{\circ} 12.5'$. 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 never tested or set either way outside the conic routines.
8	3	Not used.
8	2	INITALGN. Bit is set to 1 by P57 alignment to indicate that an initial alignment, technique 0, is being performed. The program will then branch to the selected alignment technique, unless the selected technique is 0. Bit is reset to 0 after completion of the initial alignment to indicate that the final, selected technique, alignment is to be performed. Bit is reset to 0 if ATTFLAG is at 0. Bit is tested after each initial alignment if the alignment technique is 1, 2, or 3.
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	Not used.
9	14	FLVR. Bit is set to 1 in P70, P71 initialization before throttling up the engine, and in P12 during initialization. A 1 indicates that the vertical rise command overrides the computed guidance command. Bit is reset to 0 when either the vertical rate is greater than 40 fps or the altitude is greater than 25 K ft. A 0 indicates that computed guidance commands may be used. Bit is tested in Ascent Guidance Equations to determine whether vertical rise is required.

39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
9	13	P7071FLG. Set 1 near the beginning of P70 and P71 to indicate that the ascent guidance equations are operating in abort mode (i. e. explicit targeting and no R29). Pad-loaded 0. Tested as follows: near the beginning of Ascent Guidance Equations, if 1 compute needed ZDOTD; in middle of Ascent Guidance Equations, if 1 compute estimated pericyynthion radius (RP), in tipover segment of Ascent Guidance Equations, if 1 do not activate R29.
9	12	FLPC. Bit is set to 1 in Ascent Guidance Equations when Time-to-go is less than 10 seconds. A 1 indicates that the pitch rate parameter is nulled, thereby releasing altitude control. Bit is assumed to be 0 in padload. A 0 indicates that the pitch rate parameter is a function of altitude and altitude rate. Bit is tested in guidance parameter computations.
9	11	FLPI. Bit is set to 1 in P12 initialization (pre-launch computation) to use Ascent Guidance Equations as a subroutine. A 1 indicates that program sequence will return to P12. Bit is reset to 0 immediately upon return from Ascent Guidance Equations. A 0 indicates that normal Ascent Guidance operation will be continued (call FINDCDUW). Bit is tested in Ascent Guidance Equations before call to FINDCDUW.
9	10	FLRCS. Bit is set to 1 when an engine cuts off while guidance is under control of Ascent Guidance Equations. A 1 indicates that the thrust-magnitude filter will be bypassed, and that the Ascent Guidance Equations will only be used to generate \underline{V}_{GB} . Bit is assumed to be 0 in padload. Bit is reset to 0 in P70, P71 initialization. A 0 indicates that the thrust-magnitude filter will be used (if ΔV is large enough), and that the normal mode of the guidance equations will be used. Bit is tested at the beginning of thrust-magnitude filter, and early in Ascent Guidance Equations.
9	9	LETABORT. Bit is set to 1 in P63 after ignition, permitting the calling of the abort programs P70 and P71. Bit is reset to 0 during P68, prohibiting any subsequent call to P70 or P71. Bit is also reset to 0 after a TERMINATE or PROCEED response to the V16N85 display following injection, and at the beginning of P71. Bit is tested at the beginning of P70, P71.
9	8	FLAP. This bit is examined by P71 in order to determine if it has been preceded by the P70 abort program. If P71 finds it set the abort will proceed using target initialization set up by P70. If P71 finds it reset then either P70 did not precede P71 or else the P70 target initialization had not been completed by the time P71 was selected. In this case, P71 performs the target initialization itself. P70 sets the bit to 1 when all target initialization is complete. P71 also sets the bit to 1 if it is required to do its own initialization but this has no real function.

39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
9	7	ABTTGFLG. The bit is normally a 0 (reset 0 by V37). In P70 and P71, if the J_1, K_1 parameters are being used for Abort Targeting, the bit will remain a 0. If the J_2, K_2 parameters are to be used, the bit will be set to 1. The bit will then be reset to 0 by the next V37.
9	6	ROTFLAG. Bit is set to 1 by UPFLAG shortly after P70 or P71 is selected by pushbutton action or through DSKY entry. A 1 indicates that P70, P71 will force vehicle rotation in the preferred direction ("over-the-top" automatic attitude maneuver). If the LM altitude is less than 25K feet at the time of altitude check, the bit is reset to 0 when HDOT is greater than 40 fps (up). If the LM altitude is more than 25K feet at the time of altitude check, the bit is reset to 0 when the LM x-axis is within 90° of the desired LM x-axis, or the present LM x-axis is within 30° of the local vertical (up). A 0 indicates that P70, P71 will not force vehicle rotation in the preferred direction (vehicle rotation completed or the conditions stated above have been satisfied). The bit is used for branching during ABORT and/or ABORT STAGE ascent guidance.
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. P00 state vector integration is not performed if the bit is 1. Reset to 0 in P00 if it was found to be 1. Normal integration processes resume as soon as a new program is selected via V37.
9	4	Not used.
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.
10	15	Not used.
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.

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
10	13	APSFLAG. Bit is set to 1 by the astronaut in R03 (V48). Bit is set to 1 when entering P68 (touchdown) or P71 (APS abort). Bit also set 1 by P42. A 1 indicates that LM has staged or that it is on the lunar surface. Bit is reset to 0 before launch or by the astronaut in R03 (V48). A 0 indicates that the descent stage is attached and that the LM is not on the lunar surface. Bit is the only indicator of stage and is not changed by FRESH START. Bit is used in the autopilot and in burn programs.
10	12	Not used.
10	11	Not used.
10	10	Not used.
10	9	Not used.
10	8	Not used.
10	7	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 untouched by hardware restarts thus retaining INTSTALL for restartable programs.
10	6	Not used.
10	5	Not used.
10	4	Not used.
10	3	Not used.
10	2	Not used.
10	1	Not used.
11		Flagword 11 is used to control the operation of R12, the Descent State Vector Update routine. Therefore, its contents are only used during the programs P63 thru P66. During all other programs, bit 15 is set, bits 14 thru 1 are reset, and the contents of flagword 11 should be 40000 ₈ . The exception, bit 8, which can be set and reset by the extended verb 57 and reset by extended verb 58, is normally switched during R12. Flagword 11 is initialized to 40000 ₈ by R00, R11 (when an abort is requested), and by a fresh start. Also set to 40000 ₈ whenever a POODOO abort occurs when Average-G is running.

Word Number

Contents

39-44
(Cont'd)

Flagword Bit

Meaning

11	15	LRBYPASS. Bit is reset to 0 by P63 to permit R12 operation. R09, the "R10, R11, R12 service monitor", checks LRBYPASS and when it is 0, R12 is entered. When the bit is set to 1, R09 bypasses R12. This bit is set to 1 by R00 (V37) or by an abort (R11), insuring that R12 will be off when either P12, P70, or P71 is called.
11	14	Not used.
11	13	Not used.
11	12	VXINH. If the Z velocity component fails to pass the data reasonability test, the bit is set to 1 and the X velocity component is not updated with landing radar data. If the next velocity sample to pass the reasonability test is not an X component, the bit is reset to 0 and the data is accepted; X component data will be rejected, and then the bit will be reset to 0. This process prevents updating with questionable data caused by cross lobe lock-up on the X component.
11	11	PSTHIGAT. Bit is initially reset to 0. Bit is set to 1 when the criteria for repositioning the landing radar antenna are first met, and indicates that the antenna should be either repositioning or in position 2. Bit remains set for the duration of the landing.
11	10	NOLRREAD. Bit is set to 1 when PSTHIGAT is set to 1, to prevent reading the landing radar while the antenna is repositioning. Bit is reset to 0 after the antenna achieves position 2 and allows further readings. If the antenna does not achieve position 2, and the astronaut chooses to proceed without R12 (i. e. V34E response to flashing V05N09 alarm 00523), bit will remain set to 1 and therefore inhibit landing radar reading.
11	9	XORFLG. Bit is set to 1 when the LM estimated altitude first falls below 30K feet. At this point, R12 inhibits X axis override in the digital autopilot. Bit remains set to 1 for the duration of the landing. Its purpose is to prevent R12 from inhibiting X axis override.

Revised

Added

GSOP # R-567

PCR # 988

Rev. 8

Date 3/70

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
11	8	LRINH. This bit is initially reset to 0 by R00 allowing the landing radar data to be read and tested but not incorporated into the state vector. The bit may be set to 1 via extended verb 57, permitting landing radar data incorporation into the state vector. It is reset to 0 via extended verb 58 and also R12 (when LM altitude below 50 feet) inhibiting landing radar data incorporation. Bit may be reset to 0 after it has been set to 1 in V57.
11	7	VELDATA. Bit is set to 1 by the landing radar velocity read routine after a valid reading has been made. A 1 indicates that a landing radar velocity reading has been made and that the data is available. Bit is reset to 0 by R12 after the data is used. Bit has a limited value on the downlink because it is set and reset at least once during a two second interval;and, due to the fact that the downlink reads this bit at the same point during each pass, it may read exactly the same (either always set or always reset) on each pass.
11	6	LPOS2FLG. Set 1 in SETPOS2 to inform that position 2 transformation is being used. Reset 0 in fresh start and V37 logic. Also set 0 for abort or abort stage.
11	5	READVEL. Bit is set to 1 when the LM inertial velocity estimate drops below 6K feet per second. When the bit is set to 1, it permits R12 to read the landing radar velocity components, and process the data. This bit remains set to 1 during the entire landing.
11	4	RNGEDATA. Bit is set to 1 by the landing radar altitude read routine after a valid reading has been made. A 1 indicates that a landing radar altitude reading has been made and that the data is available. Bit is reset to 0 by R12 after the data is used. Bit has a limited value on the downlink because it is set and reset at least once during a two second interval;and, due to the fact that the downlink reads this bit at the same point during each pass, it may read exactly the same (either always set or always reset) on each pass.

 Revised Added GSOP # R-567 PCR # 942 Rev. 8 Date 3/70

Word NumberContents39-44
(Cont'd)

<u>Flagword</u>	<u>Bit</u>	<u>Meaning</u>
11	3	NO511FLG. A 1 means do not test LR antenna position in R12. Set 1 by V33 response to a flashing V05N09, alarm code=523. If bit is 1, R12 won't test for 511 alarm.
11	2	VFLSHFLG. Bit is set to 1 when two or more of the last four landing radar velocity readings (including the current reading) have failed the landing radar velocity data reasonability test. When bit is set to 1, the landing radar velocity fail light will be flashed by R09. Bit is reset to 0 when a velocity reading passes the reasonability test.
11	1	HFLSHFLG. Bit is set to 1 when two or more of the last four landing radar altitude readings (including the current reading) have failed the landing radar altitude data reasonability test. When bit is set to 1, the landing radar altitude fail light will be flashed by R09. Bit is reset to 0 when an altitude reading passes the reasonability test.

45-49, 50a

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

Bit Assignments

<u>DSPTAB Register</u>	<u>Downlink Word No.</u>	<u>Bit 11</u>	<u>Bits 10-6</u>	<u>Bits 5-1</u>
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

Word Number
45-49, 50a
(Cont'd)

Contents

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.

The five bit codes associated with the digits are as follows:

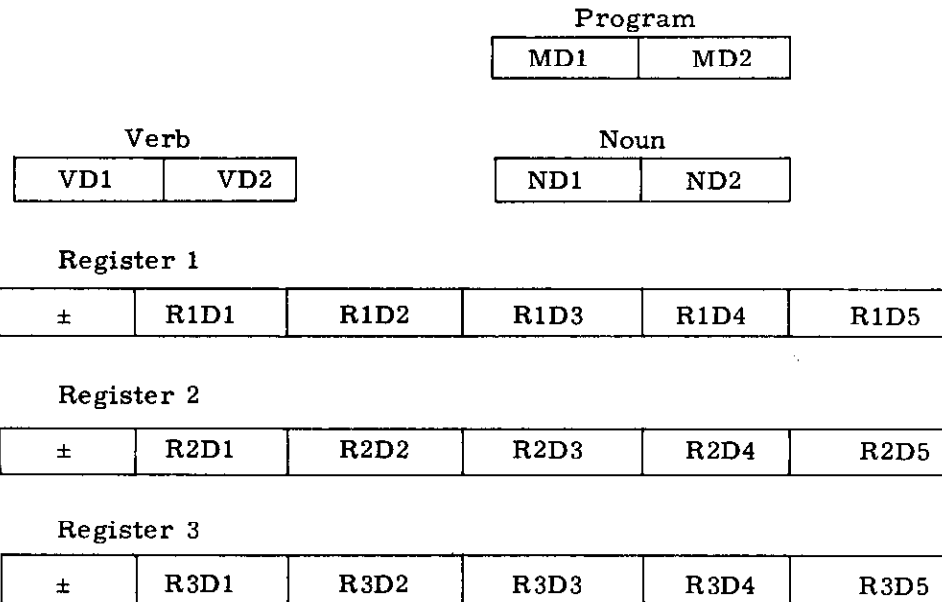
	MSB			LSB		
0	1	0	1	0	1	
1	0	0	0	1	1	
2	1	1	0	0	1	
3	1	1	0	1	1	
4	0	1	1	1	1	
5	1	1	1	1	0	
6	1	1	1	0	0	
7	1	0	0	1	1	
8	1	1	1	0	1	
9	1	1	1	1	1	
Blank	0	0	0	0	0	

Word Number

Contents

45-49, 50a
(Cont'd)

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



50b

DSPTAB+11D. This register drives relays for display lights. The bit assignments are:

<u>Bit</u>	<u>Assignment</u>
1	
2	
3	Landing Radar Velocity Fail
4	No Attitude
5	Landing Radar Altitude Fail
6	Gimbal Lock
7	
8	Tracker
9	Program Caution

If bits 15 through 12 of DSPTAB+11D are 1000, the last 11 bits indicate the state to which the LGC 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.

Word NumberContents

- 51 TIME2, TIME1. Double precision word indicating ground elapsed time. Used for all timing while LGC is on. Zeroed at liftoff (by crew procedure), increment by one bit per centisecond. May be updated by V55 (R33), V25N36, V70(P27), or V73(P27). Scaled centiseconds/ 2^{28} .
- 52-58 LM STATE VECTOR and TIME. The LGC's latest calculated state vector for the LM in reference coordinates. The coordinates may be either earth-centered or moon-centered; a zero in bit 11 of flagword 8 (LMOONFLG) indicates earth-centered, a one indicates moon-centered. Words 52-54 contain the position components X, Y, Z scaled meters/ 2^{29} . Words 55-57 contain the velocity components X, Y, Z scaled (meters/centisecond)/ 2^7 . Word 58 contains the time associated with the state vector scaled centiseconds/ 2^{28} , referenced to the computer clock. The scaling for position, velocity and time is the same whether earth-centered or moon-centered. These parameters are calculated whenever the LM state vector is permanently extrapolated or changed as follows:
- SERVICER on - every 2 seconds
 - P00 - every 10 min. to CSM state vector time
 - P20 - every mark and every Incorp if LM corrected
 - P27 - state vector update
 - P57 - If P57 is used to compute the LM landing site position by keying in "enter" to the display of checklist code 14 then only time and position are updated.
- 59-60a DESIRED BODY RATES (X, Y, Z). Desired automatic maneuver rates about body axes as given to the DAP. Calculated at the beginning of an automatic coasting flight maneuver (KALCMANU) and zeroed at the end. Recomputed every 2 seconds in powered flight when steering (FINDCDUW) is enabled. Scaled (radians/sec)/ $(\pi/4)$. Range is ± 10 degrees/sec.
- 60b Garbage. The first half of the first element of a 3×3 direction cosine matrix (double-precision) relating a desired set of S/C axes to stable member axes. Used by the VECPOINT routine and by the coasting flight attitude maneuver routine (KALCMANU). Scaled 2^{-1} . Also contains ECDUW, the contents of the EBANK at the time user called FINDCDUW.
- 61, 62a CADRFLSHs. A set of three single-precision erasable memory cells used to retain return address information from the display interface routine. CADRFLSH contains the FCADR of the last priority display request, CADRFLSH+1 the FCADR of the last mark/extended verb display, and CADRFLSH+2 contains the FCADR for the last normal display. Octal quantities.

Word Number

62b, 63

Contents

FAILREG's, a set of three single-precision cells used to retain alarm pattern code information. They are all reset to 0 by a fresh start. FAILREG and FAILREG+1 are also reset to 0 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.

64a

RADMODES. A flagword associated with radar modes. A fresh start sets bits 7 and 2 to 1, sets bit 6 to the value of bit 6 of channel 33, and sets all other bits to 0.

BitMeaning

- 15 Continuous Designate. A 1 means that commands are issued by the LGC to the Rendezvous Radar without checking to see if lock-on is achieved. A 0 indicates that the LGC checks for lock-on when designating the antenna. Set to 1 by selection of the continuous designate option of Verb 41, RR Coarse Align, and RR Automatic Search Routine (R24). Set 0 by Verb 56 (Terminate Tracking), Verb 37 selection of P00, Verb 44 (Terminate RR Coarse Align), by answering the display (V16 N80) of R24, and by RR Monitor Routine (R25) if the RR mode changes from LGC to manual or off, i. e., if the RR auto mode discrete (Bit 2 of channel 33) changes from 0 to 1. Also set 0 at the start of P20, P22, and P12.
- 14 Remode. A 1 means that a change in the antenna mode has been requested or is in progress. A 0 indicates that no remode is requested. Set to 1 when the Radar Designate Routines (R21, R24, Verb 41) determine that a designate may be performed after a remode has been done, and by R21 when on the lunar surface (in P22). Set to 0 by the remode subroutine at the end of remoding and by Verb 56 or a Verb 37 request for another program and by R25 when the RR auto-mode discrete changes from 0 to 1. Set to 1 by R29 before it calls the remode routine.
- 13 RR CDU Zero. A 1 means that the RR CDUs are being zeroed. A 0 means that they are not being zeroed. A 1 inhibits an RR CDU fail from lighting the tracker fail light. Set to 1 by R25 when the RR auto-mode discrete changes from off/manual to on, and by Verb 40 with Noun 72. Set to 0 by the RR zero subroutine at the end of the CDU zero, by Verb 56 or a Verb 37 request for another program and by a change in the RR auto-mode discrete from 0 to 1.

Word Number64a
(Cont'd)BitContentsMeaning

- 12 RR Antenna Mode. A zero means the antenna is in Mode I, a 1 indicates Mode II. The bit is set to the appropriate value by the RR turn-on sequence in R25 after an RR CDU zero, by the remode subroutine at the conclusion of a remode, and by a Verb 37 request for a new program.
- 11 Monitor Reposition. A 1 means that an RR reposition is taking place. A 0 means that no reposition is taking place. A 1 inhibits further checking of the antenna gimbal limits by R25. When a designate is possible and about to begin, a 1 in this bit delays the designate until the reposition is completed. If this bit is set to 1 during a designate operation, the designate is terminated with an error return (503 alarm). Set to 1 by the RR Monitor Routine (R25) when it detects the antenna gimbal angles outside the limits for the present mode. Set to 0 by the Reposition Routine at the end of the reposition, by Verb 56 or a Verb 37 request for another program and by R25 when the RR auto-mode discrete changes from on to off/manual. Set to 1 at the start of antenna prepositioning in R29, set to 0 at the end of antenna prepositioning in R29.
- 10 Designate. A 1 means that an RR designate has been requested or is in progress. A 0 indicates that a designate has not been requested nor is one in progress. Set to 1 at the start of a designate by R21, R24 or Verb 41. Set to 0 by Verb 44, by R21 when the designate is completed, by R24 when the V16 N80 display is answered, and by Verb 56. Set to 0 by SERVICER if R29 is not allowed. Set to 0 by R29 when lock-on is achieved in R29. Set to 0 by R29 before calling the remode routine. Set to 1 at the beginning of R29 if previously 0. Set to 0 by a Verb 37 request for a program if R29 had been requested. Also set 0 at the start of P20, P22 and P12.
- 9 Landing Radar Altitude Scale. A 1 means that the landing radar altitude reading is on the high scale. A 0 means low scale. Set to the value in channel 33 bit 9 by R04 and R77 and each time the LR altitude is read.

Word Number64a
(Cont'd)ContentsBitMeaning

- 8 Landing Radar Velocity Data Fail. A 1 means that landing radar velocity data could not be read successfully. Set to the value in channel 33 bit 8 each time landing radar velocity data is read. Set to 0 by pressing the error reset button on the DSKY and by a lamp test.
- 7 No RR CDU Fail. A 1 means that an RR CDU fail has not occurred. A 0 means one has occurred. Set to the value in channel 30 bit 7 whenever the RR CDU fail discrete changes. Set to 1 by an IMU turn-on sequence. Set to 1 by a fresh start or a hardware restart.
- 6 Landing Radar Position. A 1 indicates LR position 2. A 0 indicates position 1. Set to 1 by Verb59. Set to value of bit 6 of channel 33 at start of R04/R77. Also set 1 by R12.
- 5 Landing Radar Altitude Data Fail. A 1 means that LR altitude data could not be read successfully. Set to the value in channel 33 bit 5 each time LR altitude data is read. Set to 0 by pressing the error reset button on the DSKY and by a lamp test.
- 4 RR Data Fail. A 1 means that RR data could not be read successfully. Set to the value in channel 33 bit 4 each time RR data is read. Set to 0 by pressing the error reset button on the DSKY, and by a lamp test.
- 3 RR Range Scale. A 1 indicates the RR range reading is on the high scale. A 0 indicates low scale. Set to the value in channel 33 bit 3 by R22 prior to reading RR range, and also set by R22 when a scale change is detected. Set to value of bit 3 of channel 33 at start of R04/R77.
- 2 RR Auto Mode. A 1 means the RR is not in the auto mode; i. e., the RR auto mode discrete is not present. A 0 means the RR is in the auto mode. Set to the appropriate value by R25 when a change occurs in the RR auto mode discrete (channel 33 bit 2). Set to 1 by an IMU turn-on sequence. Set to 1 by a fresh start or hardware restart.
- 1 RR Turn-On. A 1 indicates that an RR turn-on sequence (zero the RR CDUs and establish the antenna mode) is in progress. A 0 means that no RR turn-on sequence is in progress. Set to 1 by R25 when the RR auto mode discrete changes from off/manual to auto. Set to 0 at the termination of the turn-on sequence.

<u>Word Number</u>	<u>Contents</u>
64b	DAPBOOLS. A flagword associated with the DAP. A fresh start sets DAPBOOLS to 21322 ₈ .

<u>Bit</u>	<u>Name</u>	<u>1 Meaning</u>	<u>0 Meaning</u>
15	PULSES	Minimum impulse command mode.	Not in minimum impulse command mode.
14	USEQRJTS	Gimbal unusable. Use jets only.	Gimbal may be used.
13	CSMDOCKD	CSM-DOCKED (Use backup DAP)	CSM not docked.
12	OURRCBIT	Still in rate command.	Not in rate command.
11	ACC4OR2X	4-Jet X-Axis translation requested.	2-Jet X-Axis translation requested.
10	AORBTRAN	B-System for X-translation.	A-System for X-translation.
9	LPDPHASE (XOVINHIB)	In LPD Phase (X-Axis override locked out).	Not in LPD Phase.
8	DRIFTBIT	Assume zero offset. Drifting Flight.	Offset acceleration likely (DPS, APS).
7	RHCSCALE	Normal RHC scaling requested.	Fine RHC scaling requested.
6	ULLAGER	Internal Ullage request.	No internal ullage request.
5-4	DBSL2FLG DBSELECT	These bits used together to indicate astronaut-chosen deadband (5°, 1° or 0.3°).	
3	ACCSOKAY	Computed accelerations probably correct.	Computed accelerations probably incorrect.
2-1	AUTORATE2 AUTORATE1	These bits are used together to indicate astronaut-chosen KALCMANU maneuver rates.	

Word NumberContents

- 64b
(Cont'd) Bits 13, 11, 10, 7, 5, 4, 2, 1 are changed only in R03. Bit 15 is set by V76, cleared by V77; also cleared by P63, P70 and P71. Bit 12 is under internal DAP control. Bit 3 is set by 1/ACCs, cleared by fresh start and restart.
- 65a POSTORKU. Running sum of positive torque commands about control axis U (RCS on-time multiplied by the number of jets used). POSTORKU will, in time, overflow and subsequently increase once more from zero (overflow does not go into sign bit). The scaling is such as to preclude more than one overflow per downlink cycle (2 sec) thus making the change from one reading to the next unambiguous. Calculated every 0.1 sec when DAP is running. Scaled jetseconds/32 (1 jetsecond is defined as 1 jet firing for 1 second).
- 65b NEGORKU. Running sum (always positive) of negative torque about control axis U. Calculated every 0.1 second when DAP is running. Scaled jetseconds/32.
- 66a POSTORKV. Running sum of positive torque about control axis V. Calculated every 0.1 second when DAP is running. Scaled jetseconds/32.
- 66b NEGORKV. Running sum (always positive) of negative torque about control axis V. Calculated every 0.1 second when DAP is running. Scaled jetseconds/32.
- 67 Spare. The first half of each spare contains 00000_g. The second half is ARUPT (the contents of the accumulator when the telemetry interrupt was recognized).
- 68 CDH TIME. The time of ignition of the CDH maneuver. Used in CDHMVR subroutine. Calculated each iteration of CSI/A subroutine in P32/P72. Input to P33/P73. Scaled centiseconds/ 2^{28} , referenced to computer clock.
- 69-71 DELTA VELOCITY (X, Y, Z) at CDH. In reference coordinates. Used to calculate ΔV_{CDH} in local vertical coordinates. Calculated each iteration of CDHMVR subroutine (once in P33/P73, possibly numerous times in P32/P72). Also calculated after the local-vertical velocity is displayed in P33/P73 (regardless of whether or not overwrite occurs). Earth-centered if CMOONFLG is zero, moon-centered if CMOONFLG is one. Scaled (meters/centisecond)/ 2^7 .

Word NumberContents

- 72 TPI TIME. Time of TPI ignition. Ultimately passed on to burn program. Also used as input to orbital integration. Computed by P33/P73, may be recomputed by P34/P74. Input to P32/P72. Scaled centiseconds/ 2^{28} .
- 73-75 DELTA VELOCITY (X, Y, Z) for TPI MANEUVER. In reference coordinates. Delta velocity required at TPI Time of Ignition or at TPM Time of ignition. Rotated to local vertical and line-of-sight coordinate systems and displayed to astronaut via V06 N81 and V06 N59, respectively. Computed once per program pass by P34/P74 and P35/P75. Updated during burn programs by RASTEER1 for Lambert targeted burns. Scaled(meters/centisecond)/ 2^7 .
- 76a RR RANGE (Raw Data). Treated as a 15-bit integer which is multiplied by either 9.38 for the low scale or by 75.04 for the high scale to convert to units of feet. A 1 in bit 3 of RADMODES indicates high scale. See page 2-98 for more complete description.
- 76b RR RANGE RATE (Raw Data). Treated as a 15-bit integer. To convert to units of feet per second the following computation is done:
$$(15\text{-bit integer} - 17000) \times (-0.6278).$$
A negative quantity indicates closing. See page 2-98 for more complete description.
- 77, 78a LR VELOCITIES (Raw Data). Landing radar beam velocities (X, Y, Z). The data readout from the Landing Radar High Speed Counter into LGC input counter 46_g. Always contain the last values which were read, i. e., these registers are never initialized. Each component read once per second during R77. Each component read once per four seconds during LR option of R04. Scaled $(15\text{-bit integer} - 12288.2) \times K$ ft/sec where $K = -0.6440$ for V_x , $K = 1.212$ for V_y , and $K = 0.8668$ for V_z .
- 78b LR RANGE (Raw Data). Landing radar slant range. The data readout from the LR High Speed Counter into LGC input counter 46_g. Always contains the last value read, i. e., this register is never initialized. Read once per second in R77. Read once every 4 sec during LR option of R04. A 15-bit integer which is multiplied by either 5.395 on the high scale or 1.079 on the low scale to convert to units of feet. A 1 in bit 9 of RADMODES indicates high scale.

Word NumberContents

- 79 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 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} .
- 80a LM MASS. Current mass of the LM. First part of Noun 47. A buffered quantity that is determined by MASS (and CSMMASS when desired). Pad-loaded. Can also be loaded by crew via R03 (Verb 48 - DAP Data Load); R03 then determines MASS on the basis of LEMMASS (and CSMMASS when docked). The 1/ACCS Routine, which is called every 2 seconds during powered flight, determines LEMMASS from MASS (MASS is decremented as a function of acceleration). Scaled kilograms/ 2^{16} .
- 80b CSM MASS. Current mass of the CSM. Used in the computation of the RCS and GTS control authorities when the LM is docked to the CSM. Second half of Noun 47. Pad-loaded. Can also be loaded by crew via R03 (Verb 48 - DAP Data Load). Scaled kilograms/ 2^{16} .
- 81a IMODES30. A flagword which monitors IMU conditions. Set to 37411₈ by a fresh start. A restart sets bits 14, 13, 12, 11, 10 to 1, sets bits 15, 8, 7, 6, 2 to 0 and preserves bits 9, 5, 4, 3, 1. Updated every 0.48 second by T4RUPT program.

<u>Bit</u>	<u>Meaning</u>
15	Value of bit 15 of channel 30. A 0 indicates stable member temperature within design limits.
14	Value of bit 14 of channel 30. A 0 indicates ISS has been turned on or commanded to be turned on. Bit is set 1 by a fresh start or a restart.
13	Value of bit 13 of channel 30. A 0 indicates an IMU fail indication has been produced. If this bit becomes 0 while bit 4 of this word is also 0, bit 1 of channel 11 (ISS warning) is set 1.

Word Number

Contents

81a
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
12	Value of bit 12 of channel 30. A 0 indicates an IMU CDU fail indication has been produced. If this bit becomes 0 while bit 3 of this word is also 0, bit 1 of channel 11 (ISS warning) is set 1.
11	Value of bit 11 of channel 30. A 0 indicates an IMU cage command has been generated by the crew.
10	Value of bit 13 of channel 33. A 0 indicates a PIPA fail indication has been produced. This bit has the same value as bit 13 of IMODES33. Set 1 if an error reset key code is received (DSKY or uplink). If this bit becomes 0 while bit 1 of this word is also 0, bit 1 of channel 11 (ISS warning) is set 1.
9	Value of bit 9 of channel 30. A 0 indicates IMU turned on and operating with no malfunctions. If bit becomes 1 while IMUSE (bit 8 of flagword 0) is 1, alarm 0214 _g will be generated.
8	Used to control sequencing of IMU turn-on. Set 1 if bit 7 of this word is 1 and reset zero 0.48 second later, before the IMU turn-on sequencing is started. Used to achieve a 0.48-second wait before acting on IMU turn-on information.
7	Used to control sequencing of IMU turn-on, set 1 based on values of bits 14, 9 and 2 of this word. Reset zero 0.48 second later. Can be set 1 if ISS initialization requested since last fresh start, IMU turn-off, or turn-on delay complete.
6	A 1 indicates that IMU initialization is being carried out. Set 1 during turn-on sequence, if a cage command is received, or if IMU zeroing is done in T4RUPT. Set 0 about 10.56 seconds after cage command removed, 10.56 seconds after start of zeroing in T4RUPT, or about 100 seconds after start of turn-on sequence. If bit is 1, verb 37 input will not be processed (alarm 1520 _g will be generated). If bit is 1, an error exit will be forced from the internal IMU routines.

Word NumberContents81a
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
5	Set to 1 to inhibit the generation of alarm 0212 ₈ if a PIPA fail signal occurs. Not used unless bit 1 of this word is 1. Set 1 during IMU turn-on sequence and reset 0 about 4 seconds after bit 6 is reset 0. (If bit 10 of this word is 0, an alarm will be generated when Average-G is stopped regardless of the value of bit 5.)
4	Set to 1 to inhibit generation of an ISS warning based on receipt of an IMU fail signal. Reset 0 when bit 6 is set 0. Set 1 when IMU coarse align started and set 0 about 5.12 seconds after mode change to fine align. Set 1 for 10.56 seconds when IMU CDU zero commanded.
3	Set to 1 to inhibit generation of an ISS warning based on receipt of an IMU fail signal. Set 1 when bit 6 of this word is set 1 and set 0 when bit 6 is set 0. Also set 1 for 10.56 seconds when IMU CDU zero is commanded separate from T4RUPT package (by V40N20 or prelaunch or IMU tests).
2	Set to 1 to indicate failure of the IMU turn-on delay sequence (alarm 0207 ₈ will also be generated).
1	Set to 1 to inhibit generation of an ISS warning based on receipt of a PIPA fail signal. Bit set 1 when bit 6 of this word is set 1. Bit set 0 when Average-G started and set 1 when Average-G ends.

81b IMODES33. A flagword which monitors various channel 32, channel 33 and IMU conditions. Also monitors Verb 35 "lamp test". Set to 16040₈ by a fresh start. Set to 16000₈ + the contents of bit 6 by a restart. An error reset key code sets bits 13, 12, and 11 to 1 and does not affect other bits. Updated every 0.48 second by T4RUPT program except for bit 14 which is updated every 0.12 second.

<u>Bit</u>	<u>Meaning</u>
15	Not used.
14	Value of bit 14 of channel 32. A 0 indicates Proceed Key depressed. A change from a 1 to a 0 will cause a job to be established that has the same program logic effect as Verb 33. 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
81b
(Cont'd)

Contents

<u>Bit</u>	<u>Meaning</u>
13	Value of bit 13 of channel 33. A 0 indicates a PIPA fail signal. This bit has the same value as bit 10 of IMODES30.
12	Value of bit 12 of channel 33. A 0 indicates downlink end pulse rate greater than 100 pps. If this bit changes from 1 to 0, alarm 1105 _g is generated.
11	Value of bit 11 of channel 33. A 0 indicates uplink rate greater than 6.4K pps. If this bit changes from 1 to 0, alarm 1106 _g is generated.
10-9	Not used.
8	Set to 1 when R10 routine is initialized during the powered descent trajectory. A 1 in this bit causes the display inertial data discrete to be sent to the RR CDUs (bit 8 set in channel 12) and the RR error counter to be enabled (bit 2 set in channel 12). A 0 in this bit causes the display inertial data discrete to be removed from the RR CDUs and the RR error counter to be disabled if R10 was terminated during the descent trajectory. However, if R10 was terminated and/or restarted while in ascent bits 2 and 8 of channel 12 are left unchanged.
7	A switch employed in R10 for alternate computations of altitude rate and altitude (bit 2 of channel 14 tells which is which). A 0 forces a program branch to compute and display altitude rate; bit is then set to 1 to compute and display altitude on next pass thru R10. Bit then set 0, etc.
6	Set to 1 to indicate that IMU should not be used for vehicle attitude information. Bit checked every 0.1 second by autopilot. Bit set 1 the same time as bit 6 of IMODES30 and also when bit 4 of IMODES30 is set 1 (for IMU zeroing external to T4RUPT and for IMU coarse align). Bit set 0 if IMU fine align routine is performed. Bit set 1 if IMU turned off.

Word Number

Contents

81b
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
5	Set to 1 in IMU zeroing routine external to T4RUPT (by V40N20 or prelaunch or IMU tests). Remains set to 1 for an interval of about 10.56 seconds while zeroing taking place. Bit 6 of this word is set to 1 at the same time as bit 5.
4-2	Not used.
1	Set to 1 when Verb 35 "lamp test" received. Reset to 0 about 5 seconds later. A 1 inhibits resetting of lights to 0 in T4RUPT during lamp test.
82	TIG. Targeted time of ignition. Calculated during pre-burn programs (P30s, P70s). Updated in P12, P40, P41, P42 or P63 by MIDTOAVE routine if integration cannot be completed in time (1703 alarm). After ignition TIG is set to time of engine cutoff (PIPTIME + TGO). See also pg. 2-106 for use on Descent/Ascent List. Scaled centiseconds / 2^{28} .
83-88	Repeat of words 33-38 of this list.
89	Y, Z MOMENT OFFSETS. Calculated angular acceleration about Y and Z body axes due to the fact that the main engine is not exactly aligned with the center of gravity. During powered flight these are calculated every 0.1 second at the beginning of the DAP cycle; otherwise these are zeroed in every DAP cycle. Also zeroed at discrete times, such as fresh start and engine off. Scaled (degrees/second ²)/90. Expected range is ± 35 degrees/second ² .

<u>Word Number</u>	<u>Contents</u>																		
90a	POSTORKP. Running sum of positive torque about control axis P. Calculated every 0.1 second when DAP is running. Scaled jetseconds/32.																		
90b	NEGTORKP. Running sum (always positive) of negative torque about control axis P. Calculated every 0.1 second when DAP is running. Scaled jetseconds/32.																		
91a	CHANNEL 11. Output channel. Bits are used to control engine on/off and for display parameter quantities. Set 0 by a fresh start. A restart zeroes all output channels by hardware means. The program associated with restart or processing of a V37 program change preserves the value of bits 14, 13 and 1 and sets remaining bits to 0. A restart then sets bit 13 to 1 if ENGONFLG (bit 7 of flagword 5) is 1 and sets bit 14 to 1 if ENGONFLG is 0.																		
	<table border="1"> <thead> <tr> <th><u>Bit</u></th> <th><u>Meaning</u></th> </tr> </thead> <tbody> <tr> <td>15</td> <td>Not used.</td> </tr> <tr> <td>14-13</td> <td>Engine on-off. A 1 in bit 14 and a 0 in bit 13 turns off the descent (ascent) engine. A 0 in bit 14 and a 1 in bit 13 turns on the descent (ascent) engine. All other combinations are ignored.</td> </tr> <tr> <td>12-11</td> <td>Not used.</td> </tr> <tr> <td>10</td> <td>Caution Reset signal (for display system lights). A 1 indicates an Error Reset Key code (uplink or DSKY) has been received.</td> </tr> <tr> <td>9</td> <td>Used in hybrid simulation only.</td> </tr> <tr> <td>8</td> <td>Not used.</td> </tr> <tr> <td>7</td> <td>Operator Error Light. Set to 0 when an Error Reset Key code (uplink or DSKY) is received. Set to 1 if various procedures (mainly DSKY, such as illegal noun/verb combinations) are not performed properly.</td> </tr> <tr> <td>6</td> <td>Flash verb and noun lights. Set 1 to indicate that an operator action is required.</td> </tr> </tbody> </table>	<u>Bit</u>	<u>Meaning</u>	15	Not used.	14-13	Engine on-off. A 1 in bit 14 and a 0 in bit 13 turns off the descent (ascent) engine. A 0 in bit 14 and a 1 in bit 13 turns on the descent (ascent) engine. All other combinations are ignored.	12-11	Not used.	10	Caution Reset signal (for display system lights). A 1 indicates an Error Reset Key code (uplink or DSKY) has been received.	9	Used in hybrid simulation only.	8	Not used.	7	Operator Error Light. Set to 0 when an Error Reset Key code (uplink or DSKY) is received. Set to 1 if various procedures (mainly DSKY, such as illegal noun/verb combinations) are not performed properly.	6	Flash verb and noun lights. Set 1 to indicate that an operator action is required.
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6	Flash verb and noun lights. Set 1 to indicate that an operator action is required.																		

Bit

Meaning

- 5 Key Release light. Set 1 if program desires to use display system but external (DSKY or uplink) use of it is being made. Also would be set to 1 if an internal or externally initiated monitor display (e. g. verb 16) had been started and then some DSKY button (except error reset) 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, or at the end of a V37 request) when display system is released by the internal program.
- 4 Temperature Caution light. A 0 indicates stable member temperature within design limits.
- 3 Uplink Activity light. A 1 indicates an uplink interrupt has been received. Reset 0 when an error reset key code is received, a key release key code is received, or at the end of P27 (based on receipt of a "proceed" or "terminate" response).
- 2 Computer Activity light. A 0 indicates no active "jobs" are to be performed. Normally 0 during P00 except during the periodic state vector update or gyro compensation. Bit is not set 1 if a "task" is performed, but retains its previous value.
- 1 ISS Warning light. A 1 indicates an IMU fail indication or an IMU CDU fail indication or a PIPA fail indication has been received. Setting of this bit may be inhibited (see bits 4, 3, and 1 of IMODES30).

91b

CHANNEL 12. Output channel. Bits are used for control of the rendezvous radar and IMU CDUs. Set 0 by a fresh start. A re-start preserves bits 14, 12, 11, 10, 9, 6, 5, 4 and sets remaining bits to 0. Set 0 by a hardware restart.

Word NumberContents91b
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
15	ISS turn-on delay complete. Set 1 at end of 90 second ISS turn-on delay and reset 0 about 10.24 seconds later.
14	Rendezvous radar enable. A 1 in this bit enables rendezvous radar range and angle trackers to acquire target (lock on). Set 1 when rendezvous radar antenna is within 0.5° of target.
13	Landing radar position command. If this bit is set 1 and the antenna position switch is in LGC position, the LR antenna will move to position 2 (Hover). Removing the discrete will not return the antenna to position 1.
12*	Minus roll gimbal trim. A 1 in this bit will cause the descent engine to rotate positively about the +Z axis causing the vehicle to rotate negatively about the +Z axis if the engine is thrusting.
11*	Plus roll gimbal trim. A 1 in this bit will cause the descent engine to rotate negatively about the +Z axis causing the vehicle to rotate positively about the +Z axis if the engine is thrusting.
10*	Minus pitch gimbal trim. A 1 in this bit will cause the descent engine to rotate positively about the +Y axis causing the vehicle to rotate negatively about the +Y axis if the engine is thrusting.
9*	Plus pitch gimbal trim. A 1 in this bit will cause the descent engine to rotate negatively about the +Y axis causing the vehicle to rotate positively about the +Y axis if the engine is thrusting.
8	Display inertial data. A 1 in this bit commands the rendezvous radar CDU DACs to switch to the forward and lateral velocity meters during landing.
7	Not used.

*These bits will issue commands of opposite polarity to the names. (Missile vs gimbal polarity problem).

Word Number

Contents

91b
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
6	Enable IMU CDU error counters. Set to 1 during coarse align of IMU, and in order to permit output of error information to the FDAI attitude error needles (bit is set to 0 on initialization pass, then set to 1; the third pass is the first one with output to needles).
5	Zero IMU CDUs. A 1 in this bit permits the IMU CDUs to be zeroed. Bit set 1 at the same time as bit 4 of this channel when bit 6 of IMODES30 is set 1 (IMU initialization) and reset 0 about 10.24 seconds before bit 6 of IMODES30 is reset 0.
4	Enable IMU coarse align. Set 1 to specify IMU coarse align. Also set 1 if middle gimbal angle exceeds 85°.
3	Not used.
2	Enable rendezvous radar error counter. A 1 in this bit during designate causes error counter to be loaded with appropriate rate commands to drive antenna. If display inertial data bit (bit 8 of this channel) is 1, a 1 enables error counter for driving inertial velocity display meter.
1	Zero rendezvous radar CDUs. A 1 in this bit zeroes the CDUs.

92a

CHANNEL 13. Output channel. Bits are used for various purposes. Set 0 by a fresh start. A restart or V37 sets bit 12 to 1, preserves bits 15-13 and 7-5 and sets remaining bits to 0. Set 0 by a hardware restart.

<u>Bit</u>	<u>Meaning</u>
15	When this bit is set 1, an internal computer clock (TIME6) may be counted down at a 1600 pps rate. This clock is used to control jet on-times. Bit is reset to 0 by auto-pilot when no timed firings are being commanded.
14	Used in association with program interrupt #10. Should always appear as 0.
13	Used in association with program interrupt #10. Should always appear as 0.

Word NumberContents92a
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
12	Used in association with program interrupt #10. Should always appear as 0.
11	Enable standby. Set 1 at end of P06 to enable the "PRO" button to put the computer into a period of low power operation.
10	Test DSKY lights. Set 0 if an error reset keycode received. Set 1 (for about 5 seconds) if a V35 input received.
9	Start "read" of rotational hand controller. A 1 in this bit (together with a 1 in bit 8) starts a sequence which allows all the hand controller angles to be read into the counters. Bit reset 0 when hand controllers are read. Should not be set more than 30 times/sec.
8	Rotational hand controller counter enable. A 1 in this bit allows the hand controller counters to receive inputs.
7	Telemetry word order code bit. Will have a value of 1 (0 for words 1 and 51 only) when channel is telemetered.
6	Block inputs to uplink register. Not set by program.
5	Not used.
4	Radar activity. A 1 in this bit starts a sequence which reads the rendezvous radar or landing radar parameter selected by bits 3-1. Bit set 0 when sequence is finished, and a radar rupt is generated by the hardware.
3-1	These three bits select the radar parameter to be read as follows:

<u>Bit</u>	<u>3</u>	<u>2</u>	<u>1</u>	
	0	0	0	-
	0	0	1	RR range
	0	1	0	RR range rate
	0	1	1	-
	1	0	0	LR X velocity
	1	0	1	LR Y velocity
	1	1	0	LR Z velocity
	1	1	1	LR range

Word NumberContents

92b

CHANNEL 14. Output channel. Bits are used for control of computer counter registers. Set 0 by a fresh start. A restart or V37 preserves bit 6 and sets remaining bits to 0. Caging command zeroes bits 15-6. Set 0 by a hardware restart.

<u>Bit</u>	<u>Meaning</u>
15	A 1 in this bit causes output pulses from register used to drive X-axis IMU CDU error counter. (IMU X-axis coarse align mode or error needles for yaw axis in FDAI mode).
14	A 1 in this bit causes output pulses from register used to drive Y-axis IMU CDU error counter. (IMU Y-axis coarse align mode or error needles for pitch axis in FDAI mode).
13	A 1 in this bit causes output pulses from register used to drive Z-axis IMU CDU error counter. (IMU Z-axis coarse align mode or error needles for roll axis in FDAI mode).
12	A 1 in this bit causes output pulses from register used to drive rendezvous radar trunnion or lateral horizontal velocity meter depending on the mode of operation. Reset 0 after counter register reduced to 0 (3200 pps).
11	A 1 in this bit causes output pulses from register used to drive radar shaft or forward velocity meter depending on the mode of operation. Reset 0 after counter register reduced to 0 (3200 pps).
10	A 1 in this bit generates gyro torquing pulses. Set 1 when pulse torquing of gyros performed (for IMU compensation or for pulse torquing in P52 or P57 following acceptance of V06N93 display and for ENTR to 00013 ₈ checklist). Also set 1 in P57 following coarse alignment after the N22 display. Reset 0 when required number of pulses have been produced.
9	A 1 in this bit indicates negative gyro torquing required (otherwise, torquing is positive). Reset 0 after completion of routine.
8-7	These bits indicate the axis for gyro compensation (in the sequence Y, Z, X for inner, middle, outer). Program resets to 00 ₂ when finished. 00 ₂ No axis 01 ₂ X-axis 10 ₂ Y-axis 11 ₂ Z-axis

Word Number92b
(Cont'd)Contents

<u>Bit</u>	<u>Meaning</u>
6	A 1 in this bit enables gyro torquing power supply. Set 1 at beginning of routine to generate gyro torquing pulses; remains 1 unless a fresh start done or a caging command.
5	Not used.
4	Thrust drive activity. A 1 in this bit causes output pulses from the register used to throttle the engine. Bit reset 0 after counter register reduced to 0 (3200 pps).
3	Altitude meter activity. A 1 in this bit causes the contents of the altitude counter to be shifted out serially to either the altitude rate meter or the altitude meter depending on the setting of bit 2. Bit reset 0 after shifting is completed.
2	Altitude rate select. A 1 in this bit causes the contents of the altitude counter register to be shifted out to the altitude rate meter. If this bit is 0 the contents will be shifted out to the altitude meter when bit 3 is set 1. This bit should alternately be set 1 and 0 for smooth meter driving.
1	Not used.

93a

CHANNEL 30. Input channel. Bits are used for various purposes.

<u>Bit</u>	<u>Meaning</u>
15	A 0 indicates stable member temperature within design limits.
14	A 0 indicates ISS has been turned on or commanded to be turned on.
13	A 0 indicates an IMU fail indication has been produced.
12	A 0 indicates an IMU CDU fail indication has been produced.
11	A 0 indicates an IMU cage command has been generated by the crew.
10	A 0 indicates G&N system is in control of S/C.
9	A 0 indicates IMU turned on and operating with no malfunctions.
8	Not used.
7	A 0 indicates a rendezvous radar CDU fail indication has been produced.

Word NumberContents93a
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
6	A 0 indicates a display of inertial data signal has been produced.
5	A 0 indicates an auto throttle control signal has been produced.
4	A 0 indicates an abort stage signal has been produced (abort with ascent stage).
3	A 0 indicates an engine armed signal has been produced.
2	A 0 indicates a stage verify signal has been produced (descent stage attached).
1	A 0 indicates an abort signal has been produced (abort with descent stage).

93b

CHANNEL 31. Inputs from crew control devices, used by DAP.

<u>Bit</u>	<u>Meaning</u>
15	A 0 indicates an attitude control out of detent signal has been produced (from attitude control assembly).
14	A 0 indicates auto stabilization mode has been selected.
13	A 0 indicates attitude hold mode has been selected.
12	A 0 indicates translation in -Z direction has been commanded.
11	A 0 indicates translation in +Z direction has been commanded.
10	A 0 indicates translation in -Y direction has been commanded.
9	A 0 indicates translation in +Y direction has been commanded.
8	A 0 indicates translation in -X direction has been commanded.
7	A 0 indicates translation in +X direction has been commanded.
6	A 0 indicates rotation in negative roll direction (minimum impulse), or a negative azimuth direction has been commanded.

Word NumberContents93b
(Cont'd)BitMeaning

5	A 0 indicates rotation in positive roll direction (minimum impulse), or a positive azimuth direction has been commanded.
4	A 0 indicates rotation in negative yaw direction (minimum impulse) has been commanded.
3	A 0 indicates rotation in positive yaw direction (minimum impulse) has been commanded.
2	A 0 indicates rotation in negative pitch direction (minimum impulse) has been commanded, or a negative elevation direction has been commanded.
1	A 0 indicates rotation in positive pitch direction (minimum impulse) has been commanded, or a positive elevation direction has been commanded.

94a

CHANNEL 32. Input channel. Additional crew input to DAP, etc.

BitMeaning

15	Not used.
14	A 0 indicates "proceed key" is depressed.
13	Not used.
12	Not used.
11	Not used.
10	A 0 indicates an apparent gimbal fail signal has been produced.
9	A 0 indicates a gimbal off signal has been produced.
8	A 0 indicates a thruster 10&11 fail signal has been produced.
7	A 0 indicates a thruster 9&12 fail signal has been produced.
6	A 0 indicates a thruster 13&15 fail signal has been produced.
5	A 0 indicates a thruster 14&16 fail signal has been produced.
4	A 0 indicates a thruster 6&7 fail signal has been produced.

Word NumberContents94a
(Cont'd)

<u>Bit</u>	<u>Meaning</u>
3	A 0 indicates a thruster 1&3 fail signal has been produced.
2	A 0 indicates a thruster 5&8 fail signal has been produced.
1	A 0 indicates a thruster 2&4 fail signal has been produced.

94b

CHANNEL 33. Input channel. Bits are used for hardware status and command information. Bits 15-11 are "flip-flop" bits (reset by a channel "write" command). They are reset in the T4RUPT loop every 0.48 second. They are also reset by a restart.

<u>Bit</u>	<u>Meaning</u>
15	A 0 indicates the LGC oscillator has stopped.
14	A 0 indicates repeated presence of the following alarms: restart, counter fail, voltage fail (standby mode), and scaler double alarm. An alarm test will also turn it on.
13	A 0 indicates one of the following: no pulses have arrived from a PIPA during a 312.5 μ sec. period; both a + and a - pulse occurred simultaneously; only + (-) pulses occurred for a period greater than 1.28 seconds.
12	A 0 indicates downlink end pulses occurred at a rate greater than 100 pps.
11	A 0 indicates uplink rate is greater than 6.4K pps.
10	This bit is always 1 since the block uplink signal is wired in accept position.
9	A 0 indicates a landing radar range low scale signal has been produced.
8	A 0 indicates a landing velocity data good signal has been produced.
7	A 0 indicates a landing radar position #2 signal has been produced.
6	A 0 indicates a landing radar position #1 signal has been produced.
5	A 0 indicates a landing radar range data good signal has been produced.

<u>Word Number</u>	<u>Contents</u>	
94b (Cont'd)	<u>Bit</u>	<u>Meaning</u>
	4	A 0 indicates a rendezvous radar data good signal has been produced.
	3	A 0 indicates a rendezvous radar range low scale signal has been produced.
	2	A 0 indicates a rendezvous radar power on auto signal has been produced.
	1	Not used.
95		PIPTIME1. The time at which the accelerometers were read (associated with words 96-98, but since the group is not a snapshot quantity, their values as transmitted may not be valid simultaneously). When the PIPAs are read, the time is stored in PIPTIME1; when the state vector is updated, the contents of PIPTIME1 is stored in PIPTIME. Scaled centiseconds/ 2^{28} , referenced to computer clock.
96-98		DELVs (X, Y, Z). The accumulated PIPA counts when the servicer is running. At the start of each 2-second cycle the PIPAs are zeroed and the contents of the PIPAs are loaded into DELVs. In stable member coordinates. Scaled (centimeters/second)/ 2^{14} .
99		Spare. See page 2-70 for definition.
100		TGO. Calculated time to engine cutoff. Calculated every 2 seconds during P40, P42 (after burn starts). Also calculated 5 seconds before ignition in P40, P42. Scaled centiseconds/ 2^{28} .

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II Coast/Align

Word Number	Contents		Comments
	First Register	Second Register	
1.	I. D. (77777 ₈)	Sync (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)	Reference Coordinates
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.	K Factor	K Factor	
10.	TALIGN	TALIGN	
11.	POSTORK U	NEGTOPK U	
12.	POSTORK V	NEGTOPK V	
13.	RR Range	RR Range Rate	Raw Data
14.	Time of Event	Time of Event	
15.	REFSMMAT (R ₁ C ₁)	REFSMMAT (R ₁ C ₁)	REFSMMAT= 3 × 3 matrix R = row C = column
16.	REFSMMAT (R ₁ C ₂)	REFSMMAT (R ₁ C ₂)	
17.	REFSMMAT (R ₁ C ₃)	REFSMMAT (R ₁ C ₃)	
18.	REFSMMAT (R ₂ C ₁)	REFSMMAT (R ₂ C ₁)	
19.	REFSMMAT (R ₂ C ₂)	REFSMMAT (R ₂ C ₂)	
20.	REFSMMAT (R ₂ C ₃)	REFSMMAT (R ₂ C ₃)	
21.	AOT CODE	Garbage	
22.	Landing Site Vector X comp.	Landing Site Vector X comp.	} Moon-fixed Coordinates
23.	Landing Site Vector Y comp.	Landing Site Vector Y comp.	
24.	Landing Site Vector Z comp.	Landing Site Vector Z comp.	
25.	LR VEL X	LR VEL Y	Raw Data
26.	LR VEL Z	LR Range	} Reference Coordinates
27.	VG TIG X	VG TIG X	
28.	VG TIG Y	VG TIG Y	
29.	VG TIG Z	VG TIG Z	
30.	REDO Counter	Final CDU X (THETAD)	
31.	Final CDU Y (THETAD + 1)	Final CDU Z (THETAD + 2)	
32.	* RSBBQ	RSBBQ + 1	} Body Axes
33.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	
34.	Actual Body Rate Z (OMEGAR)	Garbage	

Word Number	Contents		Comments
	First Register	Second Register	
35.	CDU XD	CDU YD	} Internal CDUs Desired
36.	CDU ZD	Garbage	
37.	Actual CDU X	Actual CDU Y	
38.	Actual CDU Z	RR TRUNNION CDU	
39.	Flagword 0	Flagword 1	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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)	} Reference Coordinates
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.	Desired Body Rate X (OMEGAPD)	Desired Body Rate Y (OMEGAQD)	} Body Axes
60.	Desired Body Rate Z (OMEGARD)	Garbage	
61.	* CADRFLSH	CADRFLSH + 1	
62.	* CADRFLSH + 2	FAILREG	
63.	* FAILREG + 1	FAILREG + 2	
64.	RADMODES	DAPBOOLS	
65.	OGC	OGC	
66.	IGC	IGC	
67.	MGC	MGC	
68.	STAR I. D. 1	STAR I. D. 2	

Word Number	Contents		Comments
	First Register	Second Register	
69.	VECTOR 1X	VECTOR 1X	associated with STAR ID1 stable member coord.
70.	VECTOR 1Y	VECTOR 1Y	
71.	VECTOR 1Z	VECTOR 1Z	
72.	VECTOR 2X	VECTOR 2X	associated with Star ID2 stable member coordinates.
73.	VECTOR 2Y	VECTOR 2Y	
74.	VECTOR 2Z	VECTOR 2Z	
75.	LR VEL X	LR VEL Y	Raw data
76.	LR VEL Z	LR RANGE	
77.	RR SHAFT CDU	Actual PIPA X	
78.	Actual PIPA Y	Actual PIPA Z	
79.	RR Trunnion Error Counter	RR Shaft Error Counter	
80.	LM MASS	CSM MASS	
81.	IMODES 30	IMODES 33	
82.	TIG	TIG	
83.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	Body Axes
84.	Actual Body Rate Z (OMEGAR)	Garbage	
85.	CDU XD	CDU YD	Internal CDUs desired
86.	CDU ZD	Garbage	
87.	Actual CDU X	Actual CDU Y	
88.	Actual CDU Z	RR TRUNNION CDU	
89.	Moment Offset Q	Moment Offset R	
90.	POSTORK P	NEGORK P	
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	

II COAST AND ALIGN LIST

<u>Word Number</u>	<u>Contents</u>
1a	I. D. word for this list. Will contain 77777_8 .
1b	Sync bits. Will contain 77340_8 .
2-8	Same as words 2-8 on Orbital Maneuvers List.
9	K-FACTOR. The ground elapsed time of the zero reference time of the Abort Guidance System (AGS). It is set only by the AGS Initialization Routine (R47). Calculated on the first use of R47 and on subsequent calls to R47 if requested by the astronaut. Scaled centiseconds/ 2^{28} .
10	TALIGN. Time to which a landing site or LM state vector is referenced for the landing site and nominal IMU alignment orientations during P52 and P57. Scaled centiseconds/ 2^{28} , referenced to computer clock.
11-12	Same as words 65-66 on Orbital Maneuvers List.
13	Same as word 76 on Orbital Maneuvers List.
14-20	Same as words 14-20 on Orbital Maneuvers List.
21a	AOT CODE. Bits 6-1 contain the octal identification number of the celestial body being sighted. Bits 9-7 contain the Detent Code as follows: 0 Optical System Calibration Code Valid Only in R52 1 is AOT Position 1 (left forward) AZ = -60° EL = 45° 2 is AOT Position 2 (forward) AZ = 0° EL = 45° 3 is AOT Position 3 (right forward) AZ = 60° EL = 45° 4 is AOT Position 4 (right rear) AZ = 120° EL = 45° 5 is AOT Position 5 (rear) AZ = 180° EL = 45° 6 is AOT Position 6 (left rear) AZ = -120° EL = 45° 7 Crew Optical Alignment Sight AOT CODE is the erasable storage for Display Nouns 70 and 71 in the routines AOTMARK (R53), Auto Optics Positioning (R52), and Star Acquisition (R59). AOTCODE is always equal to the data keyed in by the astronaut under Nouns 70 and 71 except during R59 where the detent code in bits 9-7 is computed to reflect the azimuth position code in R3 under the display V06 N79.

Word Number

Contents

21b	Garbage. Contains the sine of the Y CDU angle, or the sine of Y CDU desired or the sine of an LR antenna angle. Scaled 2^{-1} .
22-24	Same as words 23-25 on Descent/Ascent List.
25-26	Same as words 77-78 on Orbital Maneuvers List.
27-29	Same as words 25-27 on Orbital Maneuvers List.
30-64	Same as words 30-64 on Orbital Maneuvers List.

Word NumberContents

- 65-67 OGC, IGC, MGC. The X, Y, and Z gyro torquing angles computed in CALCGTA in P52, P57; counted down as gyros are torqued. During coarse align in CALCGA in P52, P57 the desired gimbal angles. Scaled degrees/360.
- 68 STAR IDs. 68a contains the star I. D. for the sighting vector in words 69-71. 68b contains the star I. D. for the sighting vector in words 72-74. Set during PICAPAR and after astronaut changes star number. These I. D. s will be the LGC catalogue number (Refer to Control Data section of this GSOP) multiplied by six. Scaled 2^{-14} .
- 69-71 STAR SIGHTING VECTOR 1(STARSAV1). During P52, P51 and Technique 2 of P57 STARSAV1 contains the 1st optics sighting vector. During Technique 0 of P57 it contains the Y spacecraft axis and the gravity vector during techniques 1 and 3. In stable member coordinates. Scaled 2^{-1} .
- 72-74 STAR SIGHTING VECTOR 2(STARSAV2). During P52, P51 and Techniques 2 and 3 of P57 STARSAV2 contains the 2nd optics sighting vector and contains the 1st sighting vector temporarily during sighting on the 2nd body. During P57 techniques 0 and 1, STARSAV2 contains the Z spacecraft axis. In stable member coordinates. Scaled 2^{-1} .
- 75-76 Repeat of words 25-26 of this list.
- 77a ACTUAL RR SHAFT CDU. RR shaft angle CDU counter. Defines RR antenna position (along with trunnion angle). Updated from RR CDUs as shaft angle changes. This register is an unsigned 15-bit fraction. The quantity is scaled degrees/360.
- 77b, 78 ACTUAL PIPAS (X, Y, Z). Velocity increments along the IMU Stable Member X, Y, and Z axes. Data is valid commencing at approximately 15 seconds after ISS Turn-on. Automatic increments when ISS is on. Zeroed every 2 seconds during powered flight. Zeroed after coarse alignment in P51, P52, and P57. Zeroed by NBDONLY (after reading) if SURFFLAG is set 1. In stable member coordinates. Scaled (centimeters/second)/ 2^{14} .
- 79 Repeat of word 29 of this list.
- 80-94 Same as words 80-94 on Orbital Maneuvers List.
- 95-100 Same as words 45-50 on Orbital Maneuvers List.

III Rendezvous/Prethrust

Word Number	Contents		Comments
	First Register	Second Register	
1.	I. D. (77775 ₈)	Sync (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.	RR Range (Raw Data)	RR Range Rate (Raw Data)	} at Marktime
10.	CDU Y (Vehicle)	CDU Z (Vehicle)	
11.	CDU X (Vehicle)	Number of Marks	
12.	RR TRUNNION CDU	RR SHAFT CDU	
13.	MARKTIME	MARKTIME	
14.	T _F	T _F	(Time of Flight to Conic Target aim Vector)
15.	RTARG X	RTARG X	} Reference Coor- dinates
16.	RTARG Y	RTARG Y	
17.	RTARG Z	RTARG Z	
18.	P-30 DELVSLV X	P-30 DELVSLV X	} Local vertical coordinates
19.	P-30 DELVSLV Y	P-30 DELVSLV Y	
20.	P-30 DELVSLV Z	P-30 DELVSLV Z	
21.	CSI Time	CSI Time	
22.	CSI ΔVX	CSI ΔVX	} DELVEET 1 reference coordinates
23.	CSI ΔVY	CSI ΔVY	
24.	CSI ΔVZ	CSI ΔVZ	
25.	Spare	Spare	
26.	TPF Time	TPF Time	
27.	Delta Beta	Delta Beta	
28.	Delta Theta	Delta Theta	
29.	RR Trunnion Error Counter	RR Shaft Error Counter	
30.	REDO COUNTER	Final CDU X (THETAD)	
31.	Final CDU Y (THETAD + 1)	Final CDU Z (THETAD + 2)	
32. *	RSBBQ	RSBBQ + 1	

Word Number	Contents		Comments
	First Register	Second Register	
33.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	Body Axes
34.	Actual Body Rate Z (OMEGAR)	Garbage	
35.	CDU XD	CDU YD	Internal CDUs Desired
36.	CDU ZD	Garbage	
37.	Actual CDU X	Actual CDU Y	
38.	Actual CDU Z	RR TRUNNION CDU	
39.	Flagword 0	Flagword 1	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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)	Reference Coordinates
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.	Desired Body Rate X (OMEGAPD)	Desired Body Rate Y (OMEGAQD)	
60.	Desired Body Rate Z (OMEGARD)	Garbage	
61. *	CADRFLSH	CADRFLSH + 1	
62. *	CADRFLSH + 2	FAILREG	
63. *	FAILREG + 1	FAILREG + 2	

Word Number	Contents		Comments
	First Register	Second Register	
64.	RADMODES	DAPBOOLS	
65.	POSTORK U	NEGORK U	
66.	POSTORK V	NEGORK V	
67.	Spare	Spare	
68.	CDH Time	CDH Time	
69.	CDH Delta V _x	CDH Delta V _x	DELVEET 2 Reference Coordinates
70.	CDH Delta V _y	CDH Delta V _y	
71.	CDH Delta V _z	CDH Delta V _z	
72.	TPI Time	TPI Time	
73.	TPI Delta V _x	TPI Delta V _x	DELVEET 3 Reference Coordinates
74.	TPI Delta V _y	TPI Delta V _y	
75.	TPI Delta V _z	TPI Delta V _z	
76.	Elevation Angle	Elevation Angle	
77.	RR SHAFT CDU	Actual PIPA X	
78.	Actual PIPA Y	Actual PIPA Z	
79.	RR Trunnion Error Counter	RR Shaft Error Counter	
80.	LM Mass	CSM Mass	
81.	IMODES 30	IMODES 33	
82.	TIG	TIG	
83.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	Body Axes
84.	Actual Body Rate Z (OMEGAR)	Garbage	
85.	CDU XD	CDU YD	Internal CDUs Desired
86.	CDU ZD	Garbage	
87.	Actual CDU X	Actual CDU Y	
88.	Actual CDU Z	RR TRUNNION CDU	
89.	Moment Offset Q	Moment Offset R	
90.	POSTORK P	NEGORK P	
91.	Channel 11	Channel 12	
92.	Channel 13	Channel 14	
93.	Channel 30	Channel 31	
94.	Channel 32	Channel 33	
95.	Spare	Spare	
96.	Central Angle	Central Angle	
97.	CDH APSIS	Garbage	
98.	CDH DELTA Altitude	CDH DELTA Altitude	
99.	TPF ΔV Magnitude	TPF ΔV Magnitude (DELV TPF)	
100.	Spare	Spare	

III Rendezvous and Prethrust List

<u>Word Number</u>	<u>Contents</u>
1a	I. D. word for this list. Will contain 77775_8 .
1b	Sync bits. Will contain 77340_8 .
2-8	Same as words 2-8 on Orbital Maneuvers List.
9a	<p>* RR RANGE (Raw data). The RR range reading as it is transmitted from the radar interface. Varies from 0 to 400 nmi. Each time a mark is taken in P20, P22, the reading is stored in this register. Frequency is as follows:</p> <ol style="list-style-type: none">1. About once per minute in P20 if the No Update Flag is set 0 and the Update Flag is set 1.2. About every 15 seconds in P20 if the No Update Flag is set 0 and the Update Flag is set 0.3. About every 45 seconds in P20 if the No Update Flag is set 1 (whether the Update Flag is set or not).4. About every 15 seconds in P22 if the No Update Flag is set 0 and the Update Flag is set 1.5. About every 4 seconds in P22 if the No Update Flag is set 1. <p>At Marktime (MKTIME). RR Range is a 15-bit integer which is multiplied by either 9.38 for the low scale or by 75.04 for the high scale to convert to units of feet. A 1 in bit 3 of RADMODES indicates high scale.</p>
9b	<p>* RR RANGE RATE (Raw data). At MARKTIME (MKTIME). Treated as a 15-bit integer. To convert to units of feet per second the following computation is done: (15-bit integer minus 17000) \times (-0.6278). A negative quantity indicates closing. Read when RR Range is read.</p>
10, 11a	<p>* CDUs (Y, Z, X). At Marktime (MKTIME). The IMU CDU counter readings (inner, middle and outer gimbals). Used to define stable member to nav-base coordinate transformation during state vector correction in Rendezvous Navigation. Read when RR Range is read except not read in R04. These are unsigned 15-bit fractions scaled degrees/360.</p>

*RR downlink data from P20, P22 are time homogeneous.

Word NumberContents

- 11b NUMBER OF MARKS. The number of RR marks used to correct the state vector during rendezvous navigation. Used for display to the astronaut. An integer which ranges from 0 to N (the number of marks taken in a sequence). Incremented by 1 each time a state vector correction is done in P20 or P22 (UPDATFLG must be set to allow state vector corrections). Set to 0 when:
1. P20 or P22 is selected as a new program.
 2. The W-Matrix is re-initialized.
 3. A thrust program is completed.
 4. P76 is selected.
 5. R24 END (goes to beginning of P20/P22).
- Scaled 2^{-14} .
- 12 * RR TRUNNION and SHAFT CDUs. At Marktime (MKTIME). RR trunnion and shaft angles used to define RR antenna position; 12a is trunnion, 12b is shaft. Read from the RR CDU counters when RR Range is read except not read in R04. Also read once every 6 seconds during R24 RR Automatic Search Routine in P20 or P22. Read once during Verb 41 RR Coarse Align. Also read once per second during Verb 85 RR Angle Display. These are unsigned 15-bit fractions scaled degrees/360.
- 13 * MARKTIME (mnemonic is MKTIME). Time of RR Mark (Range, Range-rate, CDUs, trunnion and shaft readings). The LM and CSM state vectors are integrated to this time in order to perform the state vector correction. The time is read from the Time 2, Time 1 counter. Read when RR Range Rate is read except not read in R04. Scaled centiseconds/ 2^{28} .
- 14-17 Same as words 9-12 on Orbital Maneuvers List.
- 18-20 DELVSLVs (X, Y, Z). For P30: input delta-V for an external delta-V burn. DSKY or uplink input once per burn. Noun 81, In local vertical coordinates. Scaled (meters/centisecond)/ 2^7 .
- 21-24 Same as words 21-24 on Orbital Maneuvers List.
- 25 Spare. See page 2-70 for definition.
- 26 Same as word 29 on Orbital Maneuvers List.
- 27-28 RR SHAFT and TRUNNION BIASES. The estimate of the RR angle biases; 27 is shaft, 28 is trunnion. Computed by the Rendezvous Navigation Program. Initially pad-loaded to 0. They can oscillate in sign and magnitude with a maximum magnitude of about 20 milliradians. Calculated during state vector correction in P20 four times per mark (Range, Range-Rate, Trunnion and

Word NumberContents

27-28 (Cont'd)	Shaft incorporations). Marks are taken about once a minute in P20, so four calculations are made about once a minute when UPDATFLG is set. They are not calculated if the No Update Flag is set. Scaled radians/ 2^5 if in earth sphere of influence. Scaled radians/ 2^3 if in lunar sphere of influence. A 0 in bit 11 of flagword 8 (LMOONFLG) indicates earth sphere, a 1 indicates lunar sphere. These words are updated only in P20, hence they are useful only on the Rendezvous and Prethrust List.
29	RR TRUNNION and SHAFT ERROR COUNTERS. Rendezvous Radar error counter commands; 29a is trunnion, 29b is shaft. They are placed in the RR error counters and specify the rate at which the RR antenna is driven. Values range from +384 to -384 and vary according to the angular error between the present and desired RR positions. Calculated every 0.5 second in the Radar Designate Routine (DODES) whenever the LGC is driving the RR antenna which occurs when: <ol style="list-style-type: none">1. The RR monitor (R25) detects the antenna out of mode limits.2. V41 N72 (RR Coarse Align) is operated.3. R21 (RR designate) is operated in P20/P22.4. R24 (RR Automatic Search) is operated in P20/P22. A magnitude of 384 corresponds to a rate command of about 10 degrees/second. The exact rate depends on the characteristics of the motors in the RR gyros. 29a and 29b are each scaled 2^{-14} .
30-75	Same as words 30-75 on Orbital Maneuvers List.
76	Same as word 13 on Orbital Maneuvers List.
77-79	Same as words 77-79 on Coast and Align List.
80-94	Same as words 80-94 on Orbital Maneuvers List.
95	Spare. See page 2-70 for definition.
96	CENTRAL ANGLE from IGNITION to INTERCEPT. Central angle covered by the passive vehicle from ignition time to intercept time. Used in P32/P72 as flag for program control purposes. Astronaut input by V25 N55 during P34/P74. Used as input to TIME THETA routine to calculate time of transfer. Scaled degrees/360.
97	CDH APSIS. The number of apsidal crossings (apogee or perigee) until the CDH time. The register will contain 00001 to indicate CDH ignition will occur at first crossing, etc. Input by astronaut by V25 N55. In P34/P35 and P74/P75, 0 means use conic integration and no target offsets; not 0 means use precision integration and the number of offsets contained in this register. Scaled 2^{-14} .
98	Same as word 79 on Orbital Maneuvers List.
99	TPF ΔV MAGNITUDE. Magnitude of the delta velocity vector at Intercept. Calculated each P34/P74 or P35/P75 cycle. Scaled (meters/centisecond)/ 2^7 .
100	Spare. See page 2-70 for definition.

IV Descent/Ascent

Word Number	Contents		Comments
	First Register	Second Register	
1.	I.D. (77773 _g)	Sync (77340 _g)	
2.	LR CDU X	LR CDU Y	
3.	LR CDU Z	Garbage	
4.	VSELECT	Garbage	Landing Radar Velocity Selector
5.	LR VEL TIME	LR VEL TIME	
6.	LR VEL	LR VEL	LR velocity component
7.	L R RANGE TIME	L R RANGE TIME	
8.	LR RANGE	L R RANGE	
9.	RR RANGE (RAW)	RR RANGE RATE (RAW)	At MARKTIME
10.	CDU Y (vehicle)	CDU Z (vehicle)	} CDUs for RR at Marktime when R29 running or CDUs for L.R Range Reading for R12 at LR Range Time.
11.	CDU X (vehicle)	Number of Marks	
12.	RR Trunnion CDU	RR Shaft CDU	
13.	MARKTIME	MARKTIME	
14.	Time of Event	Time of Event	
15.	Desired Thrust Axis Orientation X	Desired Thrust Axis Orientation X	} stable member coordinates
16.	Desired Thrust Axis Orientation Y	Desired Thrust Axis Orientation Y	
17.	Desired Thrust Axis Orientation Z	Desired Thrust Axis Orientation Z	
18.	VG VEC X	VG VEC X	} velocity-to-be- gained in stable member coordinates
19.	VG VEC Y	VG VEC Y	
20.	VG VEC Z	VG VEC Z	
21.	TTF/8	TTF/8	
22.	DELTA H	DELTA H	
23.	Landing Site Vector X comp.	Landing Site Vector X comp.	} moon fixed coordinates
24.	Landing Site Vector Y comp.	Landing Site Vector Y comp.	
25.	Landing Site Vector Z comp.	Landing Site Vector Z comp.	
26.	ZDOTD	ZDOTD	
27.	Delta Beta	Delta Beta	
28.	Delta Theta	Delta Theta	
29.	RR Trunnion Error Counter	RR Shaft Error Counter	
30.	REDO Counter	Final Desired CDU X (THETAD)	
31.	Final Desired CDU Y (THETAD+1)	Final Desired CDU Z (THETAD+2)	
32.	* RSBBQ	RSBBQ + 1	

Word Number	Contents		Comments
	First Register	Second Register	
33.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	} body axes
34.	Actual Body Rate Z (OMEGAR)	Garbage	
35.	CDU XD	CDU YD	} Internal CDUs Desired
36.	CDU ZD	Garbage	
37.	Actual CDU X	Actual CDU Y	
38.	Actual CDU Z	RR Trunnion CDU	
39.	Flagword 0	Flagword 1	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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)	} Reference Coordinates
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.	Desired Body Rate X (OMEGAPD)	Desired Body Rate Y (OMEGAQD)	
60.	Desired Body Rate Z (OMEGARD)	Garbage	
61. *	CADRFLSH	CADRFLSH + 1	
62. *	CADRFLSH + 2	FAILREG	
63. *	FAILREG + 1	FAILREG + 2	
64.	RADMODES	DAPBOOLS	
65.	POSTORK U	NEG TORK U	
66.	POSTORK V	NEG TORK V	

Word Number	Contents		Comments
	First Register	Second Register	
67.	LM State Vector (R_x)	LM State Vector (R_x)	} Guidance Coordinates
68.	LM State Vector (R_y)	LM State Vector (R_y)	
69.	LM State Vector (R_z)	LM State Vector (R_z)	
70.	LM State Vector (V_x)	LM State Vector (V_x)	
71.	LM State Vector (V_y)	LM State Vector (V_y)	
72.	LM State Vector (V_z)	LM State Vector (V_z)	
73.	Position of Landing Site X	Position of Landing Site X	} stable member coordinates
74.	Position of Landing Site Y	Position of Landing Site Y	
75.	Position of Landing Site Z	Position of Landing Site Z	
76.	Computed Vehicle Thrust Acceleration	Computed Vehicle Thrust Acceleration	
77.	T-Land	T-Land	
78.	Guidance Thrust CMD	Garbage	
79.	RR Trunnion Error Counter	RR Shaft Error Counter	
80.	LM Mass	CSM Mass	
81.	IMODES 30	IMODES 33	
82.	TIG	TIG	
83.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	} body axes
84.	Actual Body Rate Z (OMEGAR)	Garbage	
85.	CDU XD	CDU YD	} Internal CDUs Desired
86.	CDU ZD	Garbage	
87.	Actual CDU X	Actual CDU Y	
88.	Actual CDU Z	RR Trunnion CDU	
89.	Moment Offset Q	Moment Offset R	
90.	POSTORK P	NEGORK P	
91.	Channel 11	Channel 12	
92.	Channel 13	Channel 14	
93.	Channel 30	Channel 31	
94.	Channel 32	Channel 33	
95.	PIPTIME 1	PIPTIME 1	
96.	DELV X	DELV X	} stable member coordinates
97.	DELV Y	DELV Y	
98.	DELV Z	DELV Z	
99.	CMDS to DECA	Garbage	
100.	TTOGO	TTOGO	

IV DESCENT/ASCENT LIST

<u>Word Number</u>	<u>Contents</u>
1a	I.D. word for this list. Will contain 77773_8 .
1b	Sync bits. Will contain 77340_8 .
2, 3a	LR CDUs (X, Y, Z). CDU readings at LR VEL TIME (word 5 of this list). Read once every 2 seconds during LR velocity updates. These registers are unsigned 15-bit fractions. The quantities are scaled degrees/360.
3b	Garbage. Same erasable location as first half of word 5 of this list.
4a	VSELECT. Indicates LR velocity (X, Y, or Z) which has been read. Changes after a different velocity component has been read. An integer. 2 indicates X, 1 indicates Y, 0 indicates Z.
4b	Garbage. Same erasable location as first half of word 6 of this list.
5	LR VEL TIME. Time of velocity reading. Scaled centiseconds/ 2^{28} .
6	LR VELOCITY. Velocity along one of the antenna axes (as indicated by VSELECT). Each is the sum of five readings. A different component is read every 2 seconds during LR velocity updates. Scaled (ft/sec)/($K \times 2^{28}$) where $K = -0.6440$ for X, $K = 1.212$ for Y, and $K = 0.8668$ for Z. Divide by 5 for average of readings.
7	LR RANGE TIME. Time of CDUs for LR Range Reading when R12 running or time of RR mark when R29 running. Scaled centiseconds/ 2^{28} , referenced to computer clock.
8.	LR RANGE (d.p.). Landing radar slant range. Scaled ft/(1.079×2^{28}). Always low scale. Calculated every 2 seconds during altitude updates.
9	Same as word 9 on Rendezvous and Prethrust List.
10, 11a	CDUY, CDUZ, CDUX. The Y, Z, and X CDUs for RR at Marktime when R29 running or the Y, Z and X CDUs for LR Range Reading for R12 at LR Range Time. 15-bit fractions scaled degrees/360.
11b	NUMBER OF MARKS. Either 0 or 1. A 0 means the list (words 9-13 of this list) is in transition and should not be used. A 1 means the list is usable. Scaled 2^{-14} .
12	RR TRUNNION and SHAFT. For RR at Marktime when R29 running or for LR Range Reading for R12 at LR Range Time. 15-bit fractions scaled degrees/360.
13	Same as word 7 of this list.
14	Same as word 14 on Orbital Maneuvers List.

Word NumberContents

- 15-17 DESIRED THRUST AXIS ORIENTATION. Defines the desired thrust axis orientation (X, Y, Z) in stable member coordinates. Input command for FINDCDUW. Calculated once every 2 seconds during powered flight. The magnitude of the vector is variable.
- 18-20 VG VEC (X, Y, Z). A stable member vector that indicates current velocity error. Scaled (meters/centisecond)/2⁷. Calculated every 2 sec. during P12 (after ignition), P70 and P71. Good for ascent and aborts, not good for descent.
- 21 TTF/8. Landing guidance time to go, negative in sign. The computed time to achievement of the target conditions currently being aimed for. Used in the guidance equations and as a basis for guidance phase switching. Calculated once every 2 seconds during P63 (after full throttle), and P64. Scaled centiseconds/2¹⁷.
- 22 DELTAH. LR Altitude minus LGC altitude. Scaled meters/2²⁴. Calculated every 2 seconds during altitude updates.
- 23-25 LANDING SITE VECTOR(X, Y, Z). Landing site in moon-fixed coordinates. "LAND" is initialized from this vector (RLS) at the start of P63. RLS is recomputed after landing by P68 and is computed by P57 if the landing site determination option is selected. Otherwise except perhaps by uplink, it does not change. Scaled meters/2²⁷.
- 26 ZDOTD. The desired down-range velocity at injection. Garbage until P12 selection or until P70 or P71 selection. In P12 it is a constant (Loaded by astronaut via DSKY). In P70/P71 it is recomputed every 2 seconds. Scaled (meters/centisecond)/2⁷.
- 27-29 Same as words 27-29 on Rendezvous and Prethrust List.
- 30-66 Same as words 30-66 on Orbital Maneuvers List.
- 67-72 LM STATE VECTOR in GUIDANCE COORDINATES. Words 67-69 contain the position vector (X, Y, Z) scaled meters/2²⁴. Words 70-72 contain the velocity vector (X, Y, Z) scaled (meters/centisecond)/2¹⁰. Calculated once every 2 sec. during P63 (after full throttle) and P64. Not good during ascent and aborts. See Section 5 of this GSOP for definition of guidance coordinates.
- 73-75 POSITION OF LANDING SITE (LAND). Position vector (X, Y, Z) of current landing site in stable member coordinates. Updated for lunar rotation once every 2 seconds during P63 (after full throttle) and P64. May be changed by astronaut redesignation during P64, and also by selection of N69. Scaled meters/2²⁴.

Word NumberContents

- 76 COMPUTED VEHICLE THRUST ACCELERATION. Estimate of current vehicle acceleration based on a weighted average of all the preceding PIPA readings. This is computed by making a raw estimate based on the last 4 PIPA readings, and averaging with the previous value updated by 2 sec. of mass decrease. The weighting factors are 1, 3/2, 7/4, 15/8, 15/16, 15/32, 15/64 etc. An input parameter to the ascent guidance equations. Calculated every 2 seconds if the ΔV reading from the PIPAs is greater than $1.1 \times 2 \text{ sec} \times g_{\text{lunar}}$. Range is from 3 to 6 meters/second², generally increasing with time. Scaled (meters/centisecond²)/2⁻⁹.
- 77 TLAND. Nominal time of landing. Used in conversion of RLS to platform coordinates and in computing the first guess at ignition time for the ignition algorithm. Pad loaded, possibly changed by uplink and P52, option 4. Scaled centiseconds/2²⁸, referenced to computer clock.
- 78a GUIDANCE THRUST COMMAND (FC). The magnitude of the desired DPS thrust computed by the Lunar Landing Guidance Equations. It does not apply to Ascent or Aborts. Calculated once every 2 seconds during landing. Scaled lbs/(2.817 x 2¹⁴).
- 78b Garbage. This erasable location contains RDOTV and ITC TR, neither of which is calculated during Descent/Ascent.
- 79 Same as word 29 on Coast and Align List.
- 80-81 Same as words 80-81 on Orbital Maneuvers List.
- 82 TIG. The time of ignition until thrust, then time of engine cutoff (time of ignition + TGO). Can be loaded by astronaut during P12. After P63 ignition TIG is set to clock at ignition (for use in P70/P71 logic). Meaningless after ignition during ascent. Scaled centiseconds/2²⁸, referenced to computer clock.
- 83-98 Same as words 83-98 on Orbital Maneuvers List.
- 99a PSEUDO55. Filled with exactly what goes into Counter 55_g whenever Counter 55_g is filled by the landing throttle program (once every 2 seconds during landing). Scaled lbs/(2.817 x 2¹⁴).
- 99b Garbage. Same erasable location as word 78a on this list.
- 100 TTOGO. During ascent or descent, the time to go until ignition. After ignition, during ascent, the time to go until engine cutoff. Scaled centiseconds/2²⁸.

V. Lunar Surface Align

Word Number	Contents		Comments
	First Register	Second Register	
1.	I. D. (77772 ₈)	Sync (77340 ₈)	
2.	CSM State Vector (Rx)	CSM State Vector (Rx)	} Reference Coordinates
3.	CSM State Vector (Ry)	CSM State Vector (Ry)	
4.	CSM State Vector (Rz)	CSM State Vector (Rz)	
5.	CSM State Vector (Vx)	CSM State Vector (Vx)	
6.	CSM State Vector (Vy)	CSM State Vector (Vy)	
7.	CSM State Vector (Vz)	CSM State Vector (Vz)	
8.	CSM State Vector Time	CSM State Vector Time	
9.	RR RANGE (RAW)	RR RANGE RATE (RAW)	} at Mark Time
10.	CDU Y (Vehicle)	CDU Z (Vehicle)	
11.	CDU X (Vehicle)	Number of Marks	
12.	RR TRUNNION CDU	RR SHAFT CDU	
13.	MARKTIME	MARKTIME	
14.	TALIGN	TALIGN	
15.	REFSMMAT (R ₁ C ₁)	REFSMMAT (R ₁ C ₁)	
16.	REFSMMAT (R ₁ C ₂)	REFSMMAT (R ₁ C ₂)	
17.	REFSMMAT (R ₁ C ₃)	REFSMMAT (R ₁ C ₃)	REFSMMAT
18.	REFSMMAT (R ₂ C ₁)	REFSMMAT (R ₂ C ₁)	3 x 3
19.	REFSMMAT (R ₂ C ₂)	REFSMMAT (R ₂ C ₂)	Matrix
20.	REFSMMAT (R ₂ C ₃)	REFSMMAT (R ₂ C ₃)	R = row, C = Column
21.	Y NAV Base Vector (1st comp)	Y NAV Base Vector (1st comp)	
22.	Y NAV Base Vector (2nd comp)	Y NAV Base Vector (2nd comp)	} with respect to lunar - fixed coordinate system
23.	Y NAV Base Vector (3rd comp)	Y NAV Base Vector (3rd comp)	
24.	Z NAV Base Vector (1st comp)	Z NAV Base Vector (1st comp)	
25.	Z NAV Base Vector (2nd comp)	Z NAV Base Vector (2nd comp)	
26.	Z NAV Base Vector (3rd comp)	Z NAV Base Vector (3rd comp)	
27.	DELTA BETA	DELTA BETA	
28.	DELTA THETA	DELTA THETA	
29.	RR Trunnion Error Counter	RR Shaft Error Counter	
30.	REDO COUNTER	Final Desired CDUX (THETAD)	
31.	Final Desired CDU Y (THETAD+1)	Final Desired CDU Z (THETAD+2)	
32.	* RSBBQ	RSBBQ +1	
33.	Actual Body Rate X (OMEGAP)	Actual body rate Y (OMEGAQ)	} body axes
34.	Actual body rate Z (OMEGAR)	GARBAGE	
35.	CDUXD	CDUYD	} Internal CDUs Desired
36.	CDUZD	Garbage	
37.	Actual CDUX	Actual CDUY	
38.	Actual CDUZ	RR TRUNNION CDU	
39.	Flagword 0	Flagword 1	

Word Number	Contents		Comments
	First Register	Second Register	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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 (Rx)	LM State Vector (Rx)	
53.	LM State Vector (Ry)	LM State Vector (Ry)	
54.	LM State Vector (Rz)	LM State Vector (Rz)	reference coordinates
55.	LM State Vector (Vx)	LM State Vector (Vx)	
56.	LM State Vector (Vy)	LM State Vector (Vy)	
57.	LM State Vector (Vz)	LM State Vector (Vz)	
58.	LM State Vector TIME	LM State Vector TIME	
59.	Desired body rate X (OMEGAPD)	Desired body rate Y (OMEGAQD)	
60.	Desired body rate Z(OMEGARD)	Garbage	
61.	* CADRFLSH	CADRFLSH+1	
62.	* CADRFLSH +2	FAILREG	
63.	* FAILREG+1	FAILREG+2	
64.	RADMODES	DAPBOOLS	
65.	OGC	OGC	
66.	IGC	IGC	
67.	MGC	MGC	
68.	STAR ID 1	STAR ID 2	
69.	VECTOR 1 X	VECTOR 1 X	} For STAR ID 1
70.	VECTOR 1 Y	VECTOR 1 Y	
71.	VECTOR 1 Z	VECTOR 1 Z	
72.	VECTOR 2 X	VECTOR 2 X	} Stable Member Coordinates
73.	VECTOR 2 Y	VECTOR 2 Y	
74.	VECTOR 2 Z	VECTOR 2 Z	} For STAR ID 2
75.	GRAVITY VECTOR X	GRAVITY VECTOR X	
76.	GRAVITY VECTOR Y	GRAVITY VECTOR Y	} body axes
77.	GRAVITY VECTOR Z	GRAVITY VECTOR Z	
78.	K FACTOR	K FACTOR	

Word Number	Contents		Comments
	First Register	Second Register	
79.	RR Trunnion Error Counter	RR Shaft Error Counter	
80.	LM MASS	CSM Mass	
81.	IMODES 30	IMODES 33	
82.	TIG	TIG	
83.	Actual body rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	
84.	Actual body rate Z (OMEGAR)	GARBAGE	
85.	CDUXD	CDUYD	} Internal CDUs Desired
86.	CDUZD	GARBAGE	
87.	Actual CDUX	Actual CDUY	
88.	Actual CDUZ	RR TRUNNION CDU	
89.	Moment OFFSET Q	Moment OFFSET R	
90.	POSTORK P	NEGTORK P	
91.	CHANNEL 11	CHANNEL 12	
92.	CHANNEL 13	CHANNEL 14	
93.	CHANNEL 30	CHANNEL 31	
94.	CHANNEL 32	CHANNEL 33	
95.	PIPTIME 1	PIPTIME 1	
96.	DELVX	DELVX	} Stable Member Coordinates
97.	DELVY	DELVY	
98.	DELVZ	DELVZ	
99.	SPARE	SPARE	
100.	SPARE	SPARE	

V LUNAR SURFACE ALIGN LIST

<u>Word Number</u>	<u>Contents</u>
1a	I. D. word for this list. Will contain 77772_8 .
1b	Sync bits. Will contain 77340_8 .
2-8	Same as words 2-8 on Orbital Maneuvers List.
9-13	Same as words 9-13 on Rendezvous and Prethrust List.
14	TALIGN. Time to which a landing site or LM state vector is referenced for the landing site and nominal IMU alignment orientations during P52 and P57. Scaled centiseconds/ 2^{28} , referenced to computer clock.
15-20	Same as words 15-20 on Orbital Maneuvers List.
21-23	Y NAV BASE VECTOR (X, Y, Z). Orientation of Y component of navigation base with respect to lunar-fixed coordinate system. Computed initially by P68. Computed with each P57 alignment if REFSMFLG (Bit 13 of flagword 3) is set 1. Unit vector. Scaled 2^{-1} .
24-26	Z NAV BASE VECTOR (X, Y, Z). Orientation of Z component of navigation base with respect to lunar-fixed coordinate system. Computed initially by P68. Computed with each P57 alignment if REFSMFLG (Bit 13 of flagword 3) is set 1. Unit vector. Scaled 2^{-1} .
27-29	Same as words 27-29 on Rendezvous and Prethrust List.
30-64	Same as words 30-64 on Orbital Maneuvers List.
65-74	Same as words 65-74 on Coast and Align List.
75-77	GRAVITY VECTOR. Defines direction of gravity with respect to body axes. Initially computed by P68. Recomputed with each technique 1 & 3 alignment in P57. Unit vector. Scaled 2^{-1} .
78	Same as word 9 on Coast and Align List.
79	Same as word 79 on Coast and Align List.
80-98	Same as words 80-98 on Orbital Maneuvers List.
99-100	Spares. See page 2-70 for definition.

VI AGS Initialization/Update

Word Number	Contents		Comment
	First Register	Second Register	
1.	I. D. (77776 ₈)	Sync (77340 ₈)	
2.	LM X POS	Garbage	} stable member coordinates
3.	LM Y POS	Garbage	
4.	LM Z POS	Garbage	
5.	LM Epoch Time (MSB)	Garbage	
6.	LM X VEL	Garbage	} stable member coordinates
7.	LM Y VEL	Garbage	
8.	LM Z VEL	Garbage	
9.	LM Epoch Time (LSB)	Garbage	
10.	CSM X POS	Garbage	} stable member coordinates
11.	CSM Y POS	Garbage	
12.	CSM Z POS	Garbage	
13.	CSM Epoch Time (MSB)	Garbage	
14.	CSM X VEL	Garbage	} stable member coordinates
15.	CSM Y VEL	Garbage	
16.	CSM Z VEL	Garbage	
17.	CSM Epoch Time (LSB)	Garbage	
18.	COMPNUMB	UPOLDMOD	
19.	UPVERB	UPCOUNT	
20.	* UPBUFF	UPBUFF + 1D	
21.	* UPBUFF + 2D	UPBUFF + 3D	
22.	* UPBUFF + 4D	UPBUFF + 5D	
23.	* UPBUFF + 6D	UPBUFF + 7D	
24.	* UPBUFF + 8D	UPBUFF + 9D	
25.	* UPBUFF + 10D	UPBUFF + 11D	
26.	* UPBUFF + 12D	UPBUFF + 13D	
27.	* UPBUFF + 14D	UPBUFF + 15D	
28.	* UPBUFF + 16D	UPBUFF + 17D	
29.	* UPBUFF + 18D	UPBUFF + 19D	
30.	REDO COUNTER	FINAL CDU X (THETAD)	
31.	FINAL CDU Y (THETAD + 1)	FINAL CDU Z (THETAD + 2)	
32.	* RSBBQ	RSBBQ + 1	
33.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	} body axes
34.	Actual Body Rate Z (OMEGAR)	Garbage	

Word Number	Contents		Comments
	First Register	Second Register	
35.	CDU XD	CDU YD	} Internal CDUs Desired
36.	CDU ZD	Garbage	
37.	Actual CDU X	Actual CDU Y	
38.	Actual CDU Z	RR Trunnion CDU	
39.	Flagword 0	Flagword 1	
40.	Flagword 2	Flagword 3	
41.	Flagword 4	Flagword 5	
42.	Flagword 6	Flagword 7	
43.	Flagword 8	Flagword 9	
44.	Flagword 10	Flagword 11	
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)	} Reference Coordinates
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.	Desired Body Rate X (OMEGAPD)	Desired Body Rate Y (OMEGAQD)	} Body Axes
60.	Desired Body Rate Z (OMEGARD)	Garbage	
61.	* CADRFLSH	CADRFLSH + 1	
62.	* CADRFLSH + 2	FAILREG	
63.	* FAILREG + 1	FAILREG + 2	
64.	RADMODES	DAPBOOLS	
65.	POSTORK U	NEGORK U	
66.	POSTORK V	NEGORK V	
67.	Spare	Spare	
68.	Spare	Spare	
69.	K FACTOR	K FACTOR	
70.	* UPBUFF	UPBUFF + 1	
71.	* UPBUFF + 2	UPBUFF + 3	

Word Number	Contents		Comments
	First Register	Second Register	
72.	* UPBUFF + 4.	UPBUFF + 5	
73.	* UPBUFF + 6.	UPBUFF + 7	
74.	* UPBUFF + 8D	UPBUFF + 9D	
75.	* UPBUFF + 10D	UPBUFF + 11D	
76.	* UPBUFF + 12D	UPBUFF + 13D	
77.	* UPBUFF + 14D	UPBUFF + 15D	
78.	* UPBUFF + 16D	UPBUFF + 17D	
79.	* UPBUFF + 18D	UPBUFF + 19D	
80.	LM MASS	CSM MASS	
81.	IMODES 30	IMODES 33	
82.	Spare	Spare	
83.	Actual Body Rate X (OMEGAP)	Actual Body Rate Y (OMEGAQ)	} Body Axes
84.	Actual Body Rate Z (OMEGAR)	Garbage	
85.	CDU XD	CDU YD	} Internal CDUs Desired
86.	CDU ZD	Garbage	
87.	Actual CDU X	Actual CDU Y	
88.	Actual CDU Z	RR Trunnion CDU	
89.	Moment Offset Q	Moment Offset R	
90.	POSTORK P	NEG TORK P	
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	

VI AGS Initialization/Update List

<u>Word Number</u>	<u>Contents</u>		
1a	I. D. word for this list. Will contain 77776_8 .		
1b	Sync bits. Will contain 77340_8 .		
2-17	STATE VECTORS FOR AGS INITIALIZATION. The state vectors of the LM and CSM for transmission to the AGS during AGS initialization (R47). Filled every time R47 is called. The position components are scaled $\text{ft}/2^{25}$ for earth-orbital and $\text{ft}/2^{23}$ for moon-orbital. The velocity components are scaled $(\text{ft}/\text{sec})/2^{15}$ for earth orbital and $(\text{ft}/\text{sec})/2^{13}$ for moon-orbital. The epoch times are scaled $\text{sec}/2^{18}$. These are all two's complement quantities in stable member coordinates. The position and velocity components are rounded. The order is as follows:		
2a	LM X Position	2b	LM X Velocity
3a	LM Y Position	3b	LM Y Velocity
4a	LM Z Position	4b	LM Z Velocity
5a	LM Epoch Time (Most Significant Bits)	5b	LM Epoch Time (Least Significant Bits)
6a	LM X Velocity	6b	LM Y Position
7a	LM Y Velocity	7b	LM Z Position
8a	LM Z Velocity	8b	CSM X Position
9a	LM Epoch Time (Least Significant Bits)	9b	Garbage (Temporary used in R30, R31 and R36)
10a	CSM X Position	10b	CSM X Velocity
11a	CSM Y Position	11b	CSM Y Velocity
12a	CSM Z Position	12b	CSM Z Velocity
13a	CSM Epoch Time (Most Significant Bits)	13b	CSM Epoch Time (Least Significant Bits)
14a	CSM X Velocity	14b	CSM Y Position
15a	CSM Y Velocity	15b	CSM Z Position
16a	CSM Z Velocity	16b	CSM Epoch Time (Most Significant Bits)
17a	CSM Epoch Time (Least Significant Bits)	17b	Garbage (Temporary used in R30, R31 and R36)
18a	COMPNUMB. The octal equivalent of the number of components the update program expects to receive. For a Verb 71 or Verb 72 update COMPNUMB will be set equal to the index value. Scaled 2^{-14} .		
18b	UPOLDMOD. The number of the LGC program interrupted by the update program (P27). Will contain 0 or -0. Scaled 2^{-14} .		

Word NumberContents

19a	UPVERB. The least significant digit of the update verb used to initiate the last LGC update. Scaled 2^{-14} .
19b	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. Scaled 2^{-14} .
20-29	UPBUFFs. These 20 registers, UPBUFF through UPBUFF+19D, contain the uplinked octal parameters in the same order they were transmitted. In the event the update has less than twenty quantities, the remaining registers will contain garbage.
30-66	Same as words 30-66 on Orbital Maneuvers List.
67-68	Spares. See page 2-70 for definition.
69	Same as word 9 on Coast and Align List.
70-79	Repeat of words 20-29 of this list.
80-81	Same as words 80-81 on Orbital Maneuvers List.
82	Spare. See page 2-70 for definition.
83-94	Same as words 83-94 on Orbital Maneuvers List.
95-100	Same as words 45-50 on Orbital Maneuvers List.

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ORBITAL MANEUVERS LIST -- Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	36	CDUZD	70	DELVEET2 +2
2	R-OTHER	37	CDUX	71	DELVEET2 +4
3	R-OTHER +2		(2nd reg is CDUY)	72	TTPI
4	R-OTHER +4	38	CDUZ	73	DELVEET3
5	V-OTHER		(2nd reg is CDUT)	74	DELVEET3 +2
6	V-OTHER +2	39	STATE	75	DELVEET3 +4
7	V-OTHER +4	40	STATE +2	76	DNRRANGE
8	T-OTHER	41	STATE +4		(2nd reg is DNRRDOT)
9	DELLT4	42	STATE +6	77	DNLRVELX
10	RTARG	43	STATE +8		(2nd reg is DNLRVELY)
11	RTARG +2	44	STATE +10D	78	DNLRVELZ
12	RTARG +4	45	DSPTAB		(2nd reg is DNLRALT)
13	ELEV	46	DSPTAB +2	79	DIFFALT
14	TEVENT	47	DSPTAB +4	80	LEMMASS
15	REFSMMAT	48	DSPTAB +6		(2nd reg is CSMMASS)
16	REFSMMAT +2	49	DSPTAB +8	81	IMODES30
17	REFSMMAT +4	50	DSPTAB +10D		(2nd reg is IMODES33)
18	REFSMMAT +6	51	TIME2	82	TIG
19	REFSMMAT +8	52	RN	83	OMEGAP
20	REFSMMAT +10D	53	RN +2		(2nd reg is OMEGAQ)
21	TCSI	54	RN +4	84	OMEGAR
22	DELVEET1	55	VN	85	CDUXD
23	DELVEET1 +2	56	VN +2		(2nd reg is CDUYD)
24	DELVEET1 +4	57	VN +4	86	CDUZD
25	VG TIG	58	PIPTIME	87	CDUX
26	VG TIG +2	59	OMEGAPD		(2nd reg is CDUY)
27	VG TIG +4		(2nd reg is OMEGAQD)	88	CDUZ
28	DNLRVELZ	60	OMEGARD		(2nd reg is CDUT)
	(2nd reg is DNLRALT)	61	CADRFLSH	89	ALPHAQ
29	TPASS4	62	CADRFLSH +2		(2nd reg is ALPHAR)
30	REDOCTR		(2nd reg is FAILREG)	90	POSTORKP
	(2nd reg is THETAD)	63	FAILREG +1		(2nd reg is NEGORKP)
31	THETAD +1	64	RADMODES	91	Channels 11, 12
	(2nd reg is THETAD +2)		(2nd reg is DAPBOOLS)	92	Channels 13, 14
32	RSBBQ	65	POSTORKU	93	Channels 30, 31
	(2nd reg is RSBBQ +1)		(2nd reg is NEGORKU)	94	Channels 32, 33
33	OMEGAP	66	POSTORKV	95	PIPTIME1
	(2nd reg is OMEGAQ)		(2nd reg is NEGORKV)	96	DELV
34	OMEGAR	67	SPARE	97	DELV +2
35	CDUXD	68	TCDH	98	DELV +4
	(2nd reg is CDUYD)	69	DELVEET2	99	SPARE
				100	TGO

COAST AND ALIGN LIST - Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	35	CDUXD	71	STARSAV1 +4
2	R-OTHER		(2nd reg is CDUYD)	72	STARSAV2
3	R-OTHER +2	36	CDUZD	73	STARSAV2 +2
4	R-OTHER +4	37	CDUX	74	STARSAV2 +4
5	V-OTHER		(2nd reg is CDUY)	75	DNLRLVELX
6	V-OTHER +2	38	CDUZ		(2nd reg is DNLRLVELY)
7	V-OTHER +4		(2nd reg is CDUT)	76	DNLRLVELZ
8	T-OTHER	39	STATE		(2nd reg is DNLRLALT)
9	AGSK	40	STATE +2	77	CDUS
10	TALIGN	41	STATE +4		(2nd reg is PIPAX)
11	POSTORKU	42	STATE +6	78	PIPAY
	(2nd reg is NEGORKU)	43	STATE +8		(2nd reg is PIPAZ)
12	POSTORKV	44	STATE +10D	79	LASTYCMD
	(2nd reg is NEGORKV)	45	DSPTAB		(2nd reg is LASTXCMD)
13	DNRRANGE	46	DSPTAB +2	80	LEMMASS
	(2nd reg is DNRRDOT)	47	DSPTAB +4		(2nd reg is CSMMASS)
14	TEVENT	48	DSPTAB +6	81	IMODES30
15	REFSMMAT	49	DSPTAB +8		(2nd reg is IMODES33)
16	REFSMMAT +2	50	DSPTAB +10D	82	TIG
17	REFSMMAT +4	51	TIME2	83	OMEGAP
18	REFSMMAT +6	52	RN		(2nd reg is OMEGAQ)
19	REFSMMAT +8	53	RN +2	84	OMEGAR
20	REFSMMAT +10D	54	RN +4	85	CDUXD
21	AOTCODE	55	VN		(2nd reg is CDUYD)
22	RLS	56	VN +2	86	CDUZD
23	RLS +2	57	VN +4	87	CDUX
24	RLS +4	58	PIPTIME		(2nd reg is CDUY)
25	DNLRLVELX	59	OMEGAPD	88	CDUZ
	(2nd reg is DNLRLVELY)		(2nd reg is OMEGAQD)		(2nd reg is CDUT)
26	DNLRLVELZ	60	OMEGARD	89	ALPHAQ
	(2nd reg is DNLRLALT)	61	CADRFLSH		(2nd reg is ALPHAR)
27	VTIG	62	CADRFLSH +2	90	POSTORKP
28	VTIG +2		(2nd reg is FAILREG)		(2nd reg is NEGORKP)
29	VTIG +4	63	FAILREG +1	91	Channels 11, 12
		64	RADMODES	92	Channels 13, 14
30	REDOCTR		(2nd reg is DAPBOOLS)	93	Channels 30, 31
	(2nd reg is THETAD)	65	OGC	94	Channels 32, 33
31	THETAD +1	66	IGC	95	DSPTAB
	(2nd reg is THETAD +2)	67	MGC	96	DSPTAB +2
32	RSBBQ	68	BESTI	97	DSPTAB +4
	(2nd reg is RSBBQ +1)		(2nd reg is BESTJ)	98	DSPTAB +6
33	OMEGAP	69	STARSAV1	99	DSPTAB +8
	(2nd reg is OMEGAQ)	70	STARSAV1 +2	100	DSPTAB +10D
34	OMEGAR				

RENDEZVOUS AND PRETHRUST LIST - Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	35	CDUXD	70	DELVEET2 +2
2	R-OTHER		(2nd reg is CDUYD)	71	DELVEET2 +4
3	R-OTHER +2	36	CDUZD	72	TTPI
4	R-OTHER +4	37	CDUX	73	DELVEET3
5	V-OTHER		(2nd reg is CDUY)	74	DELVEET3 +2
6	V-OTHER +2	38	CDUZ	75	DELVEET3 +4
7	V-OTHER +4		(2nd reg is CDUT)	76	ELEV
8	T-OTHER	39	STATE	77	CDUS
9	RANGRDOT	40	STATE +2		(2nd reg is PIPAX)
	(2nd reg is RANGRIDOT +1)	41	STATE +4	78	PIPAY
10	AIG	42	STATE +6		(2nd reg is PIPAZ)
	(2nd reg is AMG)	43	STATE +8	79	LASTYCMD
11	AOG	44	STATE +10D		(2nd reg is LASTXCMD)
	(2nd reg is TRKMKCNT)	45	DSPTAB	80	LEMMASS
12	TANGNB	46	DSPTAB +2		(2nd reg is CSMMASS)
	(2nd reg is TANGNB +1)	47	DSPTAB +4	81	IMODES30
13	MKTIME	48	DSPTAB +6		(2nd reg is IMODES33)
14	DELLT4	49	DSPTAB +8	82	TIG
15	RTARG	50	DSPTAB +10D	83	OMEGAP
16	RTARG +2	51	TIME2		(2nd reg is OMEGAQ)
17	RTARG +4	52	RN	84	OMEGAR
18	DELVSLV	53	RN +2	85	CDUXD
19	DELVSLV +2	54	RN +4		(2nd reg is CDUYD)
20	DELVSLV +4	55	VN	86	CDUZD
21	TCSI	56	VN +2	87	CDUX
22	DELVEET1	57	VN +4		(2nd reg is CDUY)
23	DELVEET1 +2	58	PIPTIME	88	CDUZ
24	DELVEET1 +4	59	OMEGAPD		(2nd reg is CDUT)
25	SPARE		(2nd reg is OMEGAQD)	89	ALPHAQ
26	TPASS4	60	OMEGARD		(2nd reg is ALPHAR)
27	X789	61	CADRFLSH	90	POSTORKP
28	X789 +2	62	CADRFLSH +2		(2nd reg is NEGORKP)
29	LASTYCMD		(2nd reg is FAILREG)	91	Channels 11, 12
	(2nd reg is LASTXCMD)	63	FAILREG +1	92	Channels 13, 14
30	REDOCTR	64	RADMODES	93	Channels 30, 31
	(2nd reg is THETAD)		(2nd reg is DAPBOOLS)	94	Channels 32, 33
31	THETAD +1	65	POSTORKU	95	SPARE
	(2nd reg is THETAD +2)		(2nd reg is NEGORKU)	96	CENTANG
32	RSBBQ	66	POSTORKV	97	NN
	(2nd reg is RSBBQ +1)		(2nd reg is NEGORKV)	98	DIFFALT
33	OMEGAP	67	SPARE	99	DELVTPF
	(2nd reg is OMEGAQ)	68	TCDH	100	SPARE
34	OMEGAR	69	DELVEET2		

DESCENT/ASCENT LIST - Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	34	OMEGAR	68	RGU +2
2	LRXCDUDL (2nd reg is LRYCDUDL)	35	CDUXD (2nd reg is CDUYD)	69	RGU +4
3	LRZCDUDL	36	CDUZD	70	VGU
4	VSELECT	37	CDUX (2nd reg is CDUY)	71	VGU +2
5	LRVTIMDL			72	VGU +4
6	VMEAS	38	CDUZ (2nd reg is CDUT)	73	LAND
7	MKTIME			74	LAND +2
8	HMEAS	39	STATE	75	LAND +4
9	RM (2nd reg is RM+1)	40	STATE +2	76	AT
		41	STATE +4	77	TLAND
10	AIG (2nd reg is AMG)	42	STATE +6	78	FC
		43	STATE +8	79	LASTYCMD (2nd reg is LASTXCMD)
11	AOG (2nd reg is TRKMKCNT)	44	STATE +10D	80	LEMMASS (2nd reg is CSMMASS)
		45	DSPTAB		
12	TANGNB (2nd reg is TANGNB+1)	46	DSPTAB +2	81	IMODES30 (2nd reg is IMODES33)
		47	DSPTAB +4		
13	MKTIME	48	DSPTAB +6	82	TIG
14	TEVENT	49	DSPTAB +8	83	OMEGAP (2nd reg is OMEGAQ)
15	UNFC/2	50	DSPTAB +10D		
16	UNFC/2 +2	51	TIME2	84	OMEGAR
17	UNFC/2 +4	52	RN	85	CDUXD (2nd reg is CDUYD)
18	VGVECT	53	RN +2		
19	VGVECT +2	54	RN +4	86	CDUZD
20	VGVECT +4	55	VN	87	CDUX (2nd reg is CDUY)
21	TTF/8	56	VN +2		
22	DELTAH	57	VN +4	88	CDUZ (2nd reg is CDUT)
23	RLS	58	PIPTIME		
24	RLS +2	59	OMEGAPD (2nd reg is OMEGAQD)	89	ALPHAQ (2nd reg is ALPHAR)
25	RLS +4				
26	ZDOTD	60	OMEGARD	90	POSTORKP (2nd reg is NEGORKP)
27	X789	61	CADRFLSH		
28	X789 +2	62	CADRFLSH +2 (2nd reg is FAILREG)	91	Channels 11, 12
29	LASTYCMD (2nd reg is LASTXCMD)			92	Channels 13, 14
		63	FAILREG +1	93	Channels 30, 31
30	REDOCTR (2nd reg is THETAD)	64	RADMODES (2nd reg is DAPBOOLS)	94	Channels 32, 33
				95	PIPTIME1
31	THETAD +1 (2nd reg is THETAD +2)	65	POSTORKU (2nd reg is NEGORKU)	96	DELV
				97	DELV +2
32	RSBBQ (2nd reg is RSBBQ +1)	66	POSTORKV (2nd reg is NEGORKV)	98	DELV +4
				99	PSEUDO55
33	OMEGAP (2nd reg is OMEGAQ)	67	RGU	100	TTOGO

LUNAR SURFACE ALIGN LIST - Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	34	OMEGAR	69	STARSAV1
2	R-OTHER	35	CDUXD	70	STARSAV1 +2
3	R-OTHER +2		(2nd reg is CDUYD)	71	STARSAV1 +4
4	R-OTHER +4	36	CDUZD	72	STARSAV2
5	V-OTHER	37	CDUX	73	STARSAV2 +2
6	V-OTHER +2		(2nd reg is CDUY)	74	STARSAV2 +4
7	V-OTHER +4	38	CDUZ	75	GSAV
8	T-OTHER		(2nd reg is CDUT)	76	GSAV +2
9	RANGRDOT	39	STATE	77	GSAV +4
	(2nd reg is RANGRDOT +1)	40	STATE +2	78	AGSK
10	AIG	41	STATE +4	79	LASTYCMD
	(2nd reg is AMG)	42	STATE +6		(2nd reg is LASTXCMD)
11	AOG	43	STATE +8	80	LEMMASS
	(2nd reg is TRKMKCNT)	44	STATE +10D		(2nd reg is CSMMASS)
12	TANGNB	45	DSPTAB	81	IMODES30
	(2nd reg is TANGNB +1)	46	DSPTAB +2		(2nd reg is IMODES33)
13	MKTIME	47	DSPTAB +4	82	TIG
14	TALIGN	48	DSPTAB +6	83	OMEGAP
15	REFSMMAT	49	DSPTAB +8		(2nd reg is OMEGAQ)
16	REFSMMAT +2	50	DSPTAB +10D	84	OMEGAR
17	REFSMMAT +4	51	TIME2	85	CDUXD
18	REFSMMAT +6	52	RN		(2nd reg is CDUYD)
19	REFSMMAT +8	53	RN +2	86	CDUZD
20	REFSMMAT +10D	54	RN +4	87	CDUX
21	YNBSAV	55	VN		(2nd reg is CDUY)
22	YNBSAV +2	56	VN +2	88	CDUZ
23	YNBSAV +4	57	VN +4		(2nd reg is CDUT)
24	ZNBSAV	58	PIPTIME	89	ALPHAQ
25	ZNBSAV +2	59	OMEGAPD		(2nd reg is ALPHAR)
26	ZNBSAV +4		(2nd reg is OMEGAQD)	90	POSTORKP
27	X789	60	OMEGARD		(2nd reg is NEGTOCKP)
28	X789 +2	61	CADRFLSH	91	Channels 11, 12
29	LASTYCMD	62	CADRFLSH +2	92	Channels 13, 14
	(2nd reg is LASTXCMD)		(2nd reg is FAILREG)	93	Channels 30, 31
30	REDOCTR	63	FAILREG +1	94	Channels 32, 33
	(2nd reg is THETAD)	64	RADMODES	95	PIPTIME1
31	THETAD +1		(2nd reg is DAPBOOLS)	96	DELV
	(2nd reg is THETAD +2)	65	OGC	97	DELV +2
32	RSBBQ	66	IGC	98	DELV +4
	(2nd reg is RSBBQ +1)	67	MGC	99	SPARE
33	OMEGAP	68	BESTI	100	SPARE
	(2nd reg is OMEGAQ)		(2nd reg is BESTJ)		

AGS INITIALIZATION/UPDATE LIST - Mnemonics

For each word the mnemonic of the first register is given. The second register is always the register adjacent to the first.

1	I.D. and Sync	35	CDUXD	68	SPARE
2	AGSBUFF		(2nd reg is CDUYD)	69	AGSK
3	AGSBUFF +2	36	CDUZD	70	UPBUFF
4	AGSBUFF +4	37	CDUX	71	UPBUFF +2
5	AGSBUFF +12D		(2nd reg is CDUY)	72	UPBUFF +4
6	AGSBUFF +1	38	CDUZ	73	UPBUFF +6
7	AGSBUFF +3		(2nd reg is CDUT)	74	UPBUFF +8
8	AGSBUFF +5	39	STATE	75	UPBUFF +10D
9	AGSBUFF +13D	40	STATE +2	76	UPFUBB +12D
10	AGSBUFF +6	41	STATE +4	77	UPBUFF +14D
11	AGSBUFF +8	42	STATE +6	78	UPBUFF +16D
12	AGSBUFF +10D	43	STATE +8	79	UPBUFF +18D
13	AGSBUFF +12D	44	STATE +10D	80	LEMMASS
14	AGSBUFF +7	45	DSPTAB		(2nd reg is CSMMASS)
15	AGSBUFF +9	46	DSPTAB +2	81	IMODES30
16	AGSBUFF +11D	47	DSPTAB +4		(2nd reg is IMODES33)
17	AGSBUFF +13D	48	DSPTAB +6	82	SPARE
18	COMPNUMB	49	DSPTAB +8	83	OMEGAP
	(2nd reg is UPOLDMOD)	50	DSPTAB +10D		(2nd reg is OMEGAQ)
19	UPVERB	51	TIME2	84	OMEGAR
	(2nd reg is UPCOUNT)	52	RN	85	CDUXD
20	UPBUFF	53	RN +2		(2nd reg is CDUYD)
21	UPBUFF +2	54	RN +4	86	CDUZD
22	UPBUFF +4	55	VN	87	CDUX
23	UPBUFF +6	56	VN +2		(2nd reg is CDUY)
24	UPBUFF +8	57	VN +4	88	CDUZ
25	UPBUFF +10D	58	PIPTIME		(2nd reg is CDUT)
26	UPBUFF +12D	59	OMEGAPD	89	ALPHAQ
27	UPBUFF +14D		(2nd reg is OMEGAQD)		(2nd reg is ALPHAR)
28	UPBUFF +16D	60	OMEGARD	90	POSTORKP
29	UPBUFF +18D	61	CADRFLSH		(2nd reg is NEGORKP)
30	REDOCTR	62	CADRFLSH +2	91	Channels 11, 12
	(2nd reg is THETAD)		(2nd reg is FAILREG)	92	Channels 13, 14
31	THETAD +1	63	FAILREG +1	93	Channels 30, 31
	(2nd reg is THETAD +2)	64	RADMODES	94	Channels 32, 33
32	RSBBQ		(2nd reg is DAPBOOLS)	95	DSPTAB
	(2nd reg is RSBBQ +1)	65	POSTORKU	96	DSPTAB +2
33	OMEGAP		(2nd reg is NEGORKU)	97	DSPTAB +4
	(2nd reg is OMEGAQ)	66	POSTORKV	98	DSPTAB +6
34	OMEGAR		(2nd reg is NEGORKV)	99	DSPTAB +8
		67	SPARE	100	DSPTAB +10D

Internal Distribution List

R-567

Luminary 1C
Section 2 (rev. 7)

Group 23A	<u>S. MacDougall</u>	<u>IL7-205</u>	<u>15</u>
	Gustafson	Philliou	
	Kachmar	Pickford	
	Klumpp	Pippenger	
	Kriegsman	Pu	
	Levine (4)	Reber	
	Muller	Robertson	
	Group 23B	<u>J. Flaherty</u>	<u>IL7-238A</u>
Barnert		Kirven	
Berman		McCoy	
Eyles		Millard	
Finkelstein		Moore	
Gilson			
Group 23B	<u>J. Kaloostian</u>	<u>IL7-221L</u>	<u>5</u>
	Bernikowich	Volante	
	Dunbar	White	
	Ostaneck		
Group 23B	<u>D. Lutkevich</u>	<u>IL7-228</u>	<u>40</u>
	Allen	Hubbard	
	Babicki	Klawnsnik	
	Beck	Maher	
	Danforth	Nayer	
	Daniel	Pope	
	DeCain	Reed(20)	
	Entes	Seiler	
	Fisher		
	Flaherty	Sprague	
	Glendenning	Williams	
	Good	Wolff	

Group 23P	<u>A. Tucholke</u> Battin	<u>IL7-203</u>	<u>1</u>
Group 23B	<u>C. Taylor</u> Densmore Hamilton Rosenberg	<u>IL7-221L</u> Rye Stoppelman	<u>5</u>
Group 33	<u>J. Hargrove</u> Drane Glick	<u>IL7-111</u> Johnson (23P) Mimno	<u>4</u>
Group 23H	<u>B. Lynn</u> Cook Kossuth	<u>IL7-234A</u> O'Connor	<u>3</u>
Group 23C	<u>T. Carlton</u> Bairnsfather Fraser Goss Jones Kalan Keene	<u>IL11-102</u> Penchuk Pope Schlundt Stengel Widnal Work	<u>12</u>
Group 23D	<u>S. Prangley</u> Nevins	<u>IL7-209</u>	<u>1</u>
Group 23P	<u>J. Sutherland</u> Greene	<u>IL7-266</u> Stubbs	<u>2</u>
Group 23D	<u>F. McGann</u> Davis Dimock Drake Dunbar Johnson Kiburz Metzinger	<u>IL7-332</u> Olsson Schroeder Schulte Sewall Siarniche Walsh Woolsey	<u>14</u>

Group 23P	<u>C. Mitaris</u> Cherry Copps	<u>IL7-213</u> Larson	<u>3</u>
Group 23S	<u>P. Amsler</u> Adams Aiyawar Day Felleman Johnston	<u>IL7-240</u> McOuat Petrillo Strunce Werner White	<u>10</u>
Group 23T	<u>J. Grinnel</u> Edmonds Goodwin Grace Kido Laats Lawrence	<u>IL7-140</u> Lones McKern Megna Sarda Sheridan	<u>11</u>
Group 23N	<u>G. Grover</u> Blanchard Johnson Ogletree	<u>IL11-202</u> Parr Tanner	<u>5</u>
Group 23P	<u>A. Rubin</u> Hoag	<u>IL7-252</u> Larson	<u>2</u>
Group 23P	<u>E. Johnson</u> Ragan	<u>IL7-248</u> Stameris	<u>2</u>
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	<u>MIT/IL Library</u>		<u>6</u>

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