

February 1970

Attached are pages extracted from GSOP R-567, LUMINARY 1C, which have been updated to reflect LUMINARY 1D PCRs effected as of now. This is a preliminary publication issued for information, evaluation, and comments. Formal publication of R-567, Program LUMINARY 1D is scheduled for May 1970. The following PCRs were evaluated, and included in Sections 2, 3, 4, and 5 of GSOP as noted below:

PCR (PCR#)	TITLE	Section 2 Revision 2	Section 3 Revision 4	Section 4 Revision 4	Section 5 Revision 6
218	Format Change to Landing Site Update	*			
217	Removal of SBE Alarm in P22 and P23			**	**
214	Update Fixed Memory Map Properties		**		
218	Set "U" Vector Parallel to Landing Site Radius Vector			***	**
218	Decrease Time to Call Alarm Code 623			***	**
302.2	Channel 17	***		***	
221.2	Move AZO to Fixed Memory				**
272.2	Initiate TFI in P206			**	
274.2	Change Decimal Load Technique		*		
282	Delete R29	*	*	*	
288	LR Velocity Read Centered at PIPTIME	***		***	***
287	Delete PCR 175				*
286	LR Velocity Read	*		***	***
286	R28 in C/A, B, and R/P Lists				*
242	LR Update Cutoff	**		*	*
244	Read X-Polster Input from CDU	*			
245	Decrest Downlat	*			
270.2	Modify Gyro Torquing Routine				
278	Delete 221 Alarm	***		***	**
282	Extend Capability of Lunar Surface Star Acquisition Routine R28			**	**
283	Unit Vector Capability for R28			**	
284.2	Update Fixed Constants for 1970-1971 Ephemeris Year				**
280*	V44 BR Remode Check			**	
281.2	Sum Uplink Data	**			
288	Liftoff Check in P27	**		***	
2915	Check for AVEGON at Start of R28			***	

\* Preliminary change pages were issued January 1970.

\*\* Preliminary change pages included herein.

\*\*\* May impact this section, but information as yet unavailable.

A blank space indicates that no change is required.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
CHARLES STARK DRAPER LABORATORY  
CAMBRIDGE, MASSACHUSETTS 02139

# APOLLO

GUIDANCE, NAVIGATION  
AND CONTROL

R-567

SECTIONS 2, 3, 4, & 5  
PRELIMINARY CHANGE PAGES  
SECOND ISSUE

FEBRUARY 1970

**MIT**

CAMBRIDGE, MASSACHUSETTS, 02139

**CHARLES STARK DRAPER  
LABORATORY**

1D

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The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas.

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SECTION 2 CHANGES

## 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:

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

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.

During ground testing the count of UPRUPTS and the sum of the  $\bar{C}\bar{C}\bar{C}$  codes entering the LGC are accumulated in erasable registers, permitting a count and sum-check on data transmitted UPLINK to the LGC. This feature will not be used in flight because the summing of uplink data is disabled.

2-3

## 2.1.6 Absolute Addresses for UPDATE Program

ABSOLUTE ADDRESSES FOR UPDATE PROGRAM

THIS SECTION PROVIDES ECADRS FOR SECTION 2 OF LUMINARY <sup>1D</sup> / GOP

ECADR	MNEMONIC
01501	ECADR UPSVFLAG
03006	ECADR XSHD
01733	ECADR REFSMMAT
03433	ECADR DELVSLV
02020	ECADR RLS
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]

PRELIMINARY



Word NumberContents

1D

39-44

(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	Not used.
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.

PRELIMINARY



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## V LUNAR SURFACE ALIGN LIST

Word Number	Contents
1a	I. D. word for this list. Will contain 77772 <sub>g</sub> .
1b	Sync bits. Will contain 77340 <sub>g</sub> .
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 <sup>28</sup> , 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 <sup>-1</sup> .
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 <sup>-1</sup> .
27	Same as word 27 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. <span style="background-color: black; color: black;">XXXXXXXXXX</span> Recomputed with each technique 1 & 3 alignment in P57. Unit vector. Scaled 2 <sup>-1</sup> .
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.
28	Same as word 76 on Coast and Align List.
29	Same as word 29 on Rendezvous and Prethrust List.

The initial vector is the LM landing site with respect to the body axes, computed by P68.

PRELIMINARY

1D

SECTION 3 CHANGES

The 1/ACCS Routine

1D

Another part of the SERVICER program is the 1/ACCS routine, the primary function of which is to compute the control effectiveness of the LM DAP as a function of the vehicle mass, the unfalled jets, the configuration, and other such factors. In addition to being executed as part of the SERVICER program every 2 seconds during powered-flight mission phases, 1/ACCS is called several times during a mission when certain discrete events occur, such as restarts, fresh starts, detection of disabled jets, data load by crew (Routine 03), resetting of the attitude deadband, and the turning-off of the main engine. Also, prior to lunar lift-off, the ignition logic of the powered-ascent program (P12) loads the bias angular accelerations of the state estimator from the prior estimates given in pad-loaded erasables IGNAOSQ and IGNAOSR. This is followed by an execution of 1/ACCS that establishes the proper ascent control effectiveness.

The first thing done in 1/ACCS is a determination of the vehicle configuration on the basis of APSFLAG and CSMDOCKD. The LM mass limits and the mass-to-inertia coefficients to be used in 1/ACCS itself are selected on this basis.

Next, the mass of the LM alone is separated out as follows:

- a) For the LM-alone case, LM mass = total mass.
- b) For the CSM-docked case, LM mass = total mass - CSM mass.

The LM mass, which is displayed and loaded in Routine 03, is therefore kept updated during burns as though it were maintained directly in the SERVICER program.

There is a check on the LM mass in the 1/ACCS routine that serves to keep this critical parameter within a reasonable range despite any possible error in the initialization, in the Routine 03 load, or in SERVICER maintenance. It also results in an automatic correction of the mass when staging occurs, since the old, descent value is too high for the ascent stage alone.

The following limits on the LM mass have been implemented:

Highest descent mass 33,730 lb

Lowest descent mass = 3858 lb + HIASCENT

Highest ascent mass = HIASCENT

Lowest ascent mass = 4850 lb

HIASCENT was made a pad-loaded erasable quantity so that it can reflect the ascent fuel loading used in each particular flight. Its value for a fully loaded ascent stage is about 11,133 lb, and it is so initialized in a fresh start (to be over-written by the erasable load shortly thereafter). HIASCENT should not be less than 7265 lb, in order that the minimum descent mass will not be too low. When the LM mass is found to violate a limit, its value is changed to equal the limit (maximum or minimum); the total mass is changed correspondingly.

36,740  
PCR  
294

**ID**

SECTION 4 CHANGES



PRELIMINARY

75	CURSOR ANGLE CURSOR ALTITUDE POSITION, CELE ORGA	(L)	XXX.XX DEG XXX.XX DEG XXX.XX DEG XXXX.	851,859
80	DATA INDICATOR ORGA		XXXX. XXX.XX DEG	824
81	DELTA VZ(LV) DELTA VZ(LV) DELTA VZ(LV)	(L)	XXXX.X FFS XXXX.X FFS XXXX.X FFS	P30, P32, P 33, P34, P35, P 40, P 41, P 42, P72, P73, P74, P75
82	DELTA VZ(LV) DELTA VZ(LV) DELTA VZ(LV)	(L)	XXXX.X FFS XXXX.X FFS XXXX.X FFS	P52, P72
83	DELTA VZ(LV) DELTA VZ(LV) DELTA VZ(LV)	(L)	XXXX.X FFS XXXX.X FFS XXXX.X FFS	P47
84	DELTA VZ(LV) DELTA VZ(LV) DELTA VZ(LV)	(L)	XXXX.X FFS XXXX.X FFS XXXX.X FFS	P76
85	VZ(LV) VZ(LV) VZ(LV)		XXXX.X FFS XXXX.X FFS XXXX.X FFS	P12, P40, P41, P42, P70, P71
86	VZ(LV) VZ(LV) VZ(LV)		XXXX.X FFS XXXX.X FFS XXXX.X FFS	P40, P41, P42
87	BACKUP OPTICS LOS ELEVATION BACKUP OPTICS LOS ELEVATION	(L)	XXX.XX DEG XXX.XX DEG	852, 853, 859
88	CELESTIAL BODY NAME	(L)	X -XXXX Y -XXXX Z -XXXX	858
89	LATITUDE LONGITUDE ALTITUDE	(L)	XX.XXX DEG XX.XXX DEG XX.XX NM	P52, P57
90	RENC OUT OF PLANE PARAMETERS Y COE P31		XXX.XX NM XXX.XX FFS XXX.XX DEG	836
91	ALOC FLIGHT PATH ANGLE	(L)	XXXX. MM/10 XXX.XX DEG	P21
92	FM/OC M OCT H		XXXX. PSI XXXX.X FFS XXXX. FT	P63, P64, P65, P66
93	DELTA CYC ANGLES		X XX.XX DEG Y XX.XX DEG	P57, P55, P42

POSITION VECTOR

NDM/JLUM/RYN

104  
983

DECLASSIFIED

05

4-44-B FLAGS REFERENCED IN SECTION 4 OF R567

FLAG	PKN	IF FLAG SET	IF FLAG RESET	TESTED	REV	SET	RESET
ABORT ENBLEE FLAG		ABORT PROGRAMS ENBLEE	J1, K1 PARAMETERS TARGETING	P70, P71, ALL	P53	P70, P71	P12, P 68, P70, P 71
ABORT TARGETING FLAG		J2, K2 PARAMETERS TARGETING	J1, K1 PARAMETERS TARGETING				ROD
ACTIVE FLAG VEHICLE		LW IS ACTIVE VEHICLE	CM IS ACTIVE VEHICLE	TARGETING COMPUTATIONS	P32, P33, P34, P35	P70	P72, P73, P74, P75
APS ABORT CONTINUATION FLAG		APS ABORT AMTC	APS, ABORT AMTC OF OP'S ABORT	P71	P70		FRESH START (V36E)
APS FLAG		GRW HAS SPECIFIED THAT OPS HAS BEEN STAGED	GRW HAS SPECIFIED OPS ABORT	P12, P40, P42, P43, P70, P71, P83, P80	P42, P68, P71, P83		RO3
ASIDONALY FLAG		GRW HAS APPROVED IGNITION	GRW HAS APPROVED IGNITION	R40	P12, P40, P41, P42, P63, P12, P40, P42, P63, R40		P12, P40, P41, P42, P3, P40, P42, P3, R40
ATTITUDE FLAG		LCC HAS STREC ATTITUDE IN MULTITRAC CL-CRC	LCC HAS NOT STORED LP ATTITUDE IN MULTITRAC CO-ORO	P57	P57, P68		FRESH START (V36E)
AUX FLAG		IF TOLE FLAG SET SET SWICHER WILL EXERCISE OMMN	IF TOLE FLAG SET SWICHER = BL SKIP DYPEN ANC SET AUX FLAG	R40	M40		R40
AVERAGE G FLAG		AVERAGE G (SERVICER) (V36M)	AVERAGE G (SERVICER) NOT DESIRED	P70, P71, P25, R30, R31, R40	P70, P71, P25, R30, R31, AVERAGE G, V59		R00L, FRESH START (V36E)
CCPP E FLAG		SEW ANGLE LCC CLR	ELEM ANGLE NOT P34/P74	P34, P74	P34, P74		P34, P74
CONTINUOUS DESIGNATE FLAG		LCC CLPSPACE IN MULTICLK ON	LCC CHECKS FOR LOCK CK	V4IN72, V44	V4IN72		P20, P22, R00 R25, R24, P56, V4IN72, V44
DESIGNATE FLAG		RM DESIGUATE	RM DESIGNATE HUT	V4IN72	V4IN72		P20, P22, R00, V4IN72, V44

FLAG/LUMINARY

1D

## PRELIMINARY

UIO FLAG	REQUESTER ON IN PROGRESS	R10	M10	R10	48 FLAG/LUMINA 4212-154
DRIFT FLAG	PERFORM DATA DISPLAY INITIAL- IZATION	1 SUPT			
EXTENDED WRB ACTIVE FLAG	NO CYRO COMPEN- SATION NO EXTENDED WRB PROGRESS	405-R 30, P 31, R 76, V 85	F 76		P06, P51, P52, P57, R50, VHNZ0 P27, R03, R04, R05, R30, R 31, R 34, 44, R52, R53, R54, R55, R56, R57, R58, R59, V01, V02, V57 P34, P35, P74, P75
EXTERNAL DELTA V FLAG	EMBERT VG COMP	TVC COMPUTATIONS	P37, P32, P33, P72, P73		
FINAL FLAG	INTERIM PASS THROUGH REN- DEOUS COMP	P32, P33, P 34, P35, P72, P73, P74, P75	P30, P32, P33, P34, P35, P72, P73, P 74, P 75		P32, P33, P34, P35, P72, P73, P74, P75
FIRST PASS FLAG	<b>207</b> EMBERT EMBERT	EMBERT PASS	R20, P20, P22		R20, P20, P22
GIMBAL LOCK FLAG	GIMBAL LOCK	NOT GIMBAL LOCK			R00
H FLASH FLAG	FLASH LR R ALTITUDE FAIL LAMP	OC ACT FLASH LR ALTITUDE FAIL LAMP	R09	R12	R00 R00, R12
HIGATE FLAG	AFTER HIGATE	BEFORE HIGATE	R12	P12	R00
IDLE FLAG	NO DIV MONITOR	CONNECT DV MONITOR	R40		
IGNITION FLAG	TIC HAS ARRIVED	TIC HAS NOT ARRIVED			
IMPUULSE FLAG	MINIMUM IMPULSE BURN (EFC SET)	STEERING BURN (EFC NOT SET)	P12, P40, P42, P63, R60 R40	P12, P40, P42, P76, P71, R00, R40, FRESH START (V38C)	P12, P40, P42, P63, P70, P71, R40
IMPUSE FLAG	IMU IN USE	IMU NOT IN USE	R47	P51, P57, R02	P12, P40, P41, P42, P63, R40
INERTIAL DATA DISLAETE FLAG	4R CHUS IN USE FOR INERTIAL DATA DISPLAY	MR CDS NOT IN USE FOR INERTIAL DATA DISPLAY	R10	R10	P06, R00, R56 K10
INITIAL ALIGN FLAG	INITIAL PASS	SECOND PASS OF P57	P57	P57	P57
LANDING ANALOG DISPLAYS	LANDING ANALOG	LANDING ANALOG	R10	P12, P63	P06, R00 FLAG/LUMINA



P25 FLAG	P25 RUNNING	P25 NOT RUNNING	P25 MOD,ISS9,H611,605	P25	P63,R00,R56
QUIT FLAG	STOP INTE- GRATION	SCANTIME INTE- GRATION	PCC	V16	P00
RANGE DATA FLAG	LS ALTITUDE MEASUREMENT MADE	NO LR ALTITUDE MEASUREMENT MADE	R12	R12	R03,R12
RANGE SCALE FLAG	SCALE CHANGE DURING RW/LR REAR	NO SCALE CHANGE DURING RW/LR REAR	R12,R22	R20	R12,R22
RCS FLAG	EDIT RCS INJECTION MODE	PAIN ENGINE MODE	P12,P19,P71	P12,P7C,P71	P70,P71
READ VELOCITY FLAG	REAR LR VELOCITY DATA	GD NOT READ LR VELOCITY DATA	R12	Q12	R00
REDESIGNATION FLAG	LANDING SITE REDESIGNATION ALLIANCE	LANDING SITE REDESIGNATION PROHIBITED	P84	P84	P63,P64
REFSWAT FLAG	HEKSWAT GOOD	REFSWAT BAD	P3C,P3Z,P33,P34, P35,P51,R02,R47	P51,P52,P57	P06,P51,P52,P57, R50,W41N20
RENODE FLAG	CHANGE IN MODE REQUESTED	NO CHANGE IN ANTENNA MODE REQUESTED	R24,R25, V41N22,V44	R21	R21,R24 START FRESH START LV38E1
RENEWVDUS FLAG	EDIT P20 UK P22 RUNNING	NEITHER P20 NOR P22 RUNNING	P20,P22, R24,R25,R50,R51,R55, R56	P20+P22	P06,P12,P43,R00, R56
REND W FLAG	W MATRIX VALID	W MATRIX INVALID	NAVIGATION COMPUTATIONS	NAVIGATION COMPUTATIONS	P12,M01,W93
REPOSITION FLAG	REPOSITION IN PROGRESS	NO REPOSITION IN PROGRESS	R2C,R2L,R25, V40N72,V41N72	R25	R25, START LV38E1
ROTATION FLAG	FORCE VEHICLE ROTATION REQUESTED	OC NOT FORCE VEHICLE ROTATION	P12,P7C,P71	P70,P71	P12,P7C,P71, FRESH START LV38E1
RR ANTENNA MODE FLAG	RR IN MODE #2	RR IN MODE #1	R21	R25,W40N72	R25,W40N72
RR AUTO MODE FLAG	RR NCT IN AUTO MODE	RR IN AUTO MODE	W40N72	R25+ FRESH START LV38E1	R25

PRELIMINARY

FLAG/LUMINARY

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# PRELIMINARY

# 1D

SP  
FLAG/LUMINERY

KK CDU NLT FAILLED FLAG	NO RR CDU FAIL	KK CDU FAILED	R20,R25	R25, FRESH START (V36E)	R25
RR CDU ZERO FLAG	RR CDUS RECALIBRATED	RR CDUS NOT RECALIBRATED	R20-P22-R25	R25, V44ONTZ	R25, V44ONTZ FRESH START (V35E)
RR DATA FAIL FLAG	RR DATA FAIL	RR DATA FAIL	R25	R20	R25
RR TURN ON FLAG	RR TURN ON SEQUENCE IN PROGRESS	RR TURN ON SEQUENCE	WPNZ	R25	R25, FRESH START (V35E)
R04 FLAG	ALARM OUTLET SUPPRESSED	ALARM DISCRET ALLARM	R04,R65	R04,R65	R20-R22-R04-R65 R65
R10 FLAG	R10 CUTBOUS ONLY TIL AND F LU1 RETARD	R10 OUTPUTS TO MAIN AND FORWARD AND LATERAL CROSSPOINTERS	R10	R12+P10+P71	FRESH START (V35E)
R-12 X-AXIS OVERMODE FLAG	INHIBIT OVERMODE	DO NOT INHIBIT OVERMODE	R12	R12	R00
R61 FLAG	MUN 461 LM	RUN R65 LM	R61,R65	R61	R65
R77 FLAG	EDJIT-R77 DW (SUPPRESS) RADAR ALARMS AND TRACKER FAILS)	R77 OFF	R04-R20-R77-R59, V40RZ+V41N7Z	L77	R77, V79, FRESH START (V36E)
SEARCH FLAG	RACAN IN AUTO SEARCH OPTIC	RACAN NOT IN AUTO SEARCH OPTIC	P20P22+R24	R24	R20+P22
SNUFFER FLAG	DO NOT JETS DISABLED DURING DPS BURST	DO NOT JETS ENABLED DURING DPS BURST	04+	V45	V79, FRESH START (V35E)
STEER FLAG	SUFFICIENT THRUST	ACT SUFFICIENT THRUST	TW	R40	440
SURFACE FLAG	LPN LHM ON PULCH	LPN LHM ON MAIN	PE8 R31-R57-R63-V66	PE8	P12
TRACK FLAG	TRACKING ALLOWED	TRACKING NOT ALLOWED	P20-P22-R25-R04-R27, R40-R61-R65-R77-R59, V40RZ+V41N7Z	P70+P22+P25+P10, P12+P33+P34+P35, P72+P73+P74+P75+P76, P78	P10+P31, P57, R00, R50, 456, V41V20
ULLAGE FLAG	ULLAGE FEELSET	NO ULLAGE REJUST	04P	P40+P42+P63+R44, P71, R00, R40	F40, P42+P63, P70, P71, R00, R40
UPDATE FLAG	SW UPDATING BY 30 MARKS ALLOWED	SW UPDATING BY 30 MARKS NOT ALLOWED	R22	P10-P22-R30-P32, P33+P34+P35, P72, P73, P74, P75, P77	R10-P32, P33+P34+P35, P72, P73, P74, P75, P77

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P20/LUMINARY

# 300

# 310

# 320

# 330

# 340

1D

P20/LUMINARY

PRELIMINARY

.....  
.....  
.....  
RESET THE NO RR  
CONTIN FLAG.

.....  
.....  
.....  
RESET LCSCP FLAG.

.....  
.....  
.....  
RESET DESTONATE FLAG

.....  
.....  
.....  
RESET CONTINUOUS  
DESIGNATE FLAG

.....  
.....  
.....  
SET TRIP FLAG

.....  
.....  
.....  
DISABLE RR ERROR  
COUNTERS

.....  
.....  
.....  
MAX  
COUNT HERE.  
ERR# RR  
SEARCH  
ROUTINE  
(R24)

.....  
.....  
.....  
ZERO RR TRACKING  
MARK CCLNTR

125

04  
287

8

ID

#350

#360

#370

#380

EXTRAPOLATE LP AND  
CSM STATE VECTORS TO  
MEETING POINTS  
USING EQUATIONS

CALCULATE LCS VECTOR  
FROM LM TO CSM.

IS RANGE GREATER  
THAN ACC.NRP

Y  
N

TERMINATE DIS-  
PLAY OF RANGE  
AND RANGE RATE  
DATE (IF PRESENT)

CALCULATE RANGE  
AND RANGE RATE

IS FIRST MISS FLAG  
SET?

Y  
N

IS SURFACE FLAG  
SET?

Y  
N

THEN ON PRO-  
GRAM ALARM  
ALARM CORE  
00526

ENTER  
HERE  
FROM RA  
SEARCH ROW  
TIME (R2)

MONITOR DSKY:

OBSERVE DISPLAY  
OF PROGRAM ALARM  
00526 INDICATING  
RANGE IS GREATER  
THAN 400 NM.

(NOTE: AT THE ONROW  
THE CREW THE  
RANGE AND RANGE

PRO/LUMINARY

P20/LUMINARY

4 510

4 410

4 310

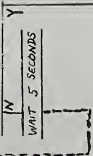
4 210

4 110

1D

RATE DISPLAY MAY BE  
RESET AT THIS TIME  
BY KEYING IN THE  
VARIABLE. IF THE  
RANGE IS INCREASING  
THE C/EW MAY TER-  
MINATE P20 BY KEY-  
ING IN V56E).

IS RANGE < 400NM?



(NOTE: 999.99 WILL BE  
DISPLAYED FOR VALUES  
GREATER THAN 999.19 NM.)

PRELIMINARY

RESET FIRST  
PASS FLAG  
WAIT 5 SEC-  
ONDS

DISPLAY ON DORT:  
V46NST  
R1 - RANGE  
R2 - RANGE RATE  
R3 - 00000

RANGE - CALCULATED  
FROM RANGE IN  
MAGNETIC UNITS TO  
NEAREST .01 NM.

RANGE RATE -  
CALCULATED FROM  
RATE BETWEEN 50  
AND 500. IN FPS  
TO NEAREST 1 FPS.

RESET FIRST PASS  
FLAG

WAIT 5 SECONDS

TEMP  
HOLD  
IND

PRELIMINARY

70"  
• ENTER HERE  
• DATA READ  
• ROUTINE (R22)  
• DESIGNATE  
• ROUTINE  
• (R21).  
•  
•  
•

15. SURFACE FLAG SET

Y

N

70"  
ENTER HERE  
DATA READ  
ROUTINE  
DESIGNATE  
R22  
SIGNATE  
ROUTINE  
R21

DC PREFERRED  
TRACKING ATT-  
TUDE ROUTINE  
(R31).  
•  
•  
•

DC PREFERRED  
INC ATTITUDE ROUTINE  
(R61).  
•  
•  
•

#490

#500

#510

#520

#530

#540  
PRO/LUMINARY

104

11

191  
P222/LUMINARY

#300

#310

#320

#330

#340

1D

P222/LUMINARY

SET FIRST PASS FLAG

DISABLE NR ERROR  
COUNTERS

NA  
ENTER HERE  
FOR NR  
SEARCH  
ROUTINE  
(R24)

TEST NR WORKING  
MARK COUNTER

UPDATE THE CUR STATE  
VECTOR TO TLUSJAC  
PRESENT TIME USING  
THE PRESENT TIME  
TIAL ORIENTATION  
SUBROUTINE AND  
UPDATE THE CUR STATE  
VECTOR TO TLUSJAC  
PRESENT TIME USING  
THE NEPLER SUBROU-  
TINE

PRELIMINARY

172  
104  
287

PRELIMINARY

PZZ/LUMINARY

1D

CALCULATE ECS VECTOR  
FROM LM TO C.S.N.

.....

IS RANGE GREATER  
THAN 400 NM? .....

Y N

.....  
TERMINATE DIS-  
PLAY OF RANGE  
AND RANGE  
DATE (IF PRESENT)

CALCULATE RANGE  
AND RANGE RATE

.....

IS FIRST PASS FLAG-

Y N

IS THE SURFACE  
FLAG SET?

Y N

STOP BY SURFACE  
PASS AND  
STORE ALARM  
CODE 00526

RESET FIRST  
PASS FLAG

WAIT 5 SEC-  
ONDS

#350

#360

#370

#380

#390

PZZ/LUMINARY



TEMP  
HOLD  
MC/N

DISPLAY ON DSKY:  
VILASCH  
R1-RANGE  
R2-RANGE RATE  
R3-0000  
R4-0000  
R5-0000  
R6-0000  
R7-0000  
R8-0000  
R9-0000  
R0-0000  
R1-0000  
R2-0000  
R3-0000  
R4-0000  
R5-0000  
R6-0000  
R7-0000  
R8-0000  
R9-0000

RANGE RATE -  
CALCULATED AND  
PRESENTED IN  
MM AND CS/M.  
IN PPS TO  
NEXTST \* 1 PPS.

RESET FIRST PASS  
FLAG  
WAIT 5 SECONDS

"A" O.  
OF FROM  
PER SEARCH  
ROUTINE (R14)

NUMBER IS  
OF RANGE AND  
RANGE RATE.

(NOTE: IF THE RANGE  
IS INCREASING, THE  
RANGE RATE WILL  
INCREASE. IF THE  
RANGE IS DECREASING,  
THE RANGE RATE WILL  
DECREASE.)

IS RANGE < 400 NM?

Y  
N  
WAIT 5 SECONDS

(NOTE: 999.99 WILL BE DIS-  
PLAYED FOR VALUES GREATER  
THAN 999.99 NM.)

PRELIMINARY

ID

P22/LUMINARY

# 900

# 410

# 420

# 430

# 440

1D

19  
P22/LUMINARY

PRELIMINARY

PG 04  
• ENK WHERE  
• FRCP IN  
• DATA HEAD  
• ROUTINE  
• (022)

IS SURFACE FLAG SET?

Y

N

DO PREPARE FOR  
TRACKING ATTITUDE  
ROUTINE (0611)?

IS TRACK FLAG SET?

Y

N

GO TO

0450

0460

0470

0480

0490

P22/LUMINARY

04

15

## RCS PROGRAM (PA-1)

## PURPOSE:

- 1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR AN RCS THROUSTING MANEUVER.
- 2) TO PREPARE THE VEHICLE MANUEVER TO THE THROUSTING ATTITUDE.

## ASSUMPTIONS:

- 1) THE TARGET SUITABLE DISPLAYS FOR MANUAL EXECUTION OF THE THROUSTING MANUEVER IN THE ATTITUDE HOLD MODE.
- 2) THE REQUIRED STEERING EQUATIONS ARE GENERATED BY THE PROPRIETARY THROUST MANUEVER WHICH EITHER RESET (MASTER) OR SET (EXT DELTA Y) THE EXTERNAL DELTA Y FLAG, FOR EXTERNAL DELTA Y STEERING. NO ISLANDING OCCURS ONCE FOR THE SPECIFIED COMPLETE, THE LOG UPDATES SO ONLY AS THE CREW INDICATES THE LOG THAT RCS THROUSTING HAS BEEN COMPLETED.
- 3) RCS STEERING CONTROL WHEN USING "MASTER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3-3-39A IN SECTION 3 OF THE RCS MANUAL. WHEN USING "EXT DELTA Y", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3-3-39A IN SECTION 3 OF THE RCS MANUAL. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN EXTERNAL LOADED VALUE (07).
- 4) WITH THE GUIDANCE CONTROL SWITCH IN POS 2 AND MODE CONTROL SWITCH IN ATTITUDE HOLD, THE PONGS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER POS 1 OR MODE CONTROL SWITCH IN POS 2. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACQUISITION EITHER 1, FOR DISPLAY ON THE FOOT, THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACQUISITION EITHER 2, FOR DISPLAY ON THE HEAD. THE STATUS OF THE PULSE FLAG, HOWEVER, IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MANUAL MODE.
- 5) THE PONGS WILL NOT BE RESPONSIBLE IF REGISTER OVERERDS OCCUR WITHIN THE LOG.
- 6) THE PONGS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FOOT:
  - PAGE 1 - ABILITY TO TRACK A COUNTER 011. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAMP'S
  - PAGE 11 - SELECTED BY EXTENDED WEAR 622. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY
- 7) PONGS-ORIGINATED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY SET FINGER OVER POS 1.
- 8) INDICATIONS OF ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF RANG WITH THE EXCEPTONS MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF THE RCS MANUAL.
- 9) THE IMU IS UNARMED MUST BE AT A VACUA ORIENTATION BEFORE 9 OF POSSET, PARA 3-2-6.
- 10) THAT THE ISS USE ON FOR A "MINIMUM OF 15" MINUTES PRIOR TO A THROUSTING MANUEVER.
- 11) THE EVENT TIMER IS SET TO COUNT TO ZERO AT T10.
- 12) THE POS 1 SWITCH MAY BE SLIPPED BEYOND THE ESTABLISHED T10 IF DESIRED BY THE CREW, OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED ON THE POS 1.
- 13) THE X - AXIS USERIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE L-W X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PONGS ATTITUDE HOLD MODE IS ACTIVE. THE CONTROLLER IS RETURNED TO ATTITUDE HOLD WHEN THE YAW RATE SIDES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.
- 14) THE X - AXIS USERIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER, IT SHOULD NOT BE EXERCISED WHEN THE LOG IS SPECIFYING A JOSHED YAW ATTITUDE, I-E-I DURING, THE ATTITUDE MANUEVER TO THE THROUSTING ATTITUDE (SEE A01).
- 15) THE LOG WAP DATA ROUTINE (W03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM.
- 16) THE LOG WILL NEITHER DESIGNATE NOR REAC THE RENDERS (R04R E08) DURING THIS PROGRAM.

PRELIMINARY

03

REV. 04/1970

1D

PA1/UP/ITERARY

03  
872

1) THE ASTRONAUT MAY OBSERVE THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM  
(A) V06 #40

- R1 - TPI
- R2 - VG
- R3 - DELTA VM

TF1 - TIME FROM DPS IGNITION IN MIN, SEC TO NEAREST SEC-MAXIMUM READING IS 59859.

Sign is - before nominal TIG, + thereafter.

VG - MAGNITUDE OF THE VELOCITY TO BE GAINED BY THRUSTING MANUEVER. IN FPS TO NEAREST +1 FPS.

DELTA VM - MEASURED DELTA V MAGNITUDE. IN FPS TO NEAREST +1 FPS-(THIS DISPLAY WILL BE 00000 UNTIL TIG-30 SECONDS AND THEN SHOULD CHANGE ONLY DUE TO PIPA BIAS UNTILL ULLAGE IS STARTED).

(13) THIS PROGRAM IS SELECTED MANUALLY BY OPSK ENTRY.

PRG#	CONT	SEC	SECOND	CREW
				SEL PROGRAM
				SELECTION
				...
				...
				KEY IN OPS PROGRAM
				(PA) 518, 418
				...
				MONITOR DSKY
				DESCRIBE DISPLAY OF
				...
				...
				DO FMU STATUS CHECK
				ROUTINE (R02)
				...
				...
				...

PRELIMINARY

03  
872

COMPUTE TIME FROM DPS IGNITION (TF1), MAGNITUDE OF VELOCITY TO BE GAINED BY THE THRUSTING MANUEVER (VG), AND MEASURED DELTA V MAGNITUDE (DELTA VM) AND STORE IN #40 FOR POSSIBLE MANUAL SELECTION.

#20

#30

ID

425  
P41/UMINARY

1177  
P58/LUMINARY

#80

#90

#100

#110

#120

#130

1D

P58/LUMINARY

PRELIMINARY

OF THE ASSUMED  
PLANET POSITION  
VECTOR

ARE THE POSITION  
AND VELOCITY COMPONENTS  
CORRECT?

CELESTIAL BODY

POSITION VECTOR:

Y=ARR  
X=Y PL  
R=Z PL

X PL - THE X COORDINATE  
OF THE LGC

POSITION VECTOR  
GET IN REFERENCE  
FIFTH PLACE (XXXXX)

Y PL - SAME AS X FOR

Y COMPONENT

Z PL - SAME AS X FOR

Z COMPONENT

WAIT FOR KEYBOARD  
ENTRY

KEY IN PROCEED

EXIT R58

TERMINATE FLASH PROM  
OR ENTER (SEE DATA)

R Y  
R Y  
D  
E E  
D STORE DATA

EXIT  
R58

04  
EDIT

04  
983

18

#59/LUMINARY

3= FEAT RIGHT EE-  
 3A= REAR RIGHT DETENT  
 3B= REAR CENTER EE-  
 3C= FRONT  
 4= REAR LEFT DETENT  
 5= REAR CENTER EE-  
 SYSTEM (NOT APPLIC-  
 ABLE ON LUMINA  
 SURFACE)

STAR CODES OF THE  
 CELESTIAL BODY TO BE  
 IDENTIFIED BY DESIGNA-  
 TIONS IN LOCAL

00= NAME  
 01/45= STAR IFCR

STAR CODE  
 46= SUN LIGHT  
 47= EARTH  
 48= MOON  
 49= PLANET

WAIT FOR KEYBOARD  
 ENTRY

STAR ACQUISITION IT  
 SPECIFY A DETENT  
 CODE.)

..Y.....N

..... KEY IN PROCEED

TERMINATE FLASH UPON  
 PROCEED OR NEW DATA

.....  
 -PRECEED  
 -NEW  
 -DATA

.....  
 -NEW  
 -DATA  
 -NEW  
 -DATA

.....  
 KEY IN VZIE  
 AND LIND DESIRED  
 DETENT IDENT  
 CODES IN SE-

03  
 982

#120

#59/LUMINARY

1D

#100

#90

#80

#70

#110

1184  
R59/LUMINARY

ID

PRELIMINARY

#130

#140

#150

#160

#170

R59/LUMINARY

DO CELESTIAL BODY  
DEFINITION ROUTINE  
(R59) FOR CELESTIAL  
BODY INTENDED TO  
BE USED.

DO CELESTIAL BODY  
ROUTINE  
(R59) FOR CELESTIAL  
BODY INTENDED TO  
BE USED.

CALCULATE STAR LGS  
COORDINATES FROM  
STARR STAR DATA

GET STAR DATA FROM THE  
CCEL TL AND LEX  
LP AZ FROM ERASABLE  
LUMINAR LEX TEL TO  
4.5 DEGREES

CALCULATE OPTICAL  
COORDINATES FOR  
PRESENTLY CELESTIAL  
AZ POSITION CODE IN  
COORDINATES.

IS THE ANGLE BETWEEN  
THE STAR LGS AND THE

03

20

74

21

Rev 1

1307

02  
REV ~~02~~

\*\*\*\* TERMINATE RR CONTINUOUS DESIGNATE

PURPOSE:

- (1) TO TERMINATE THE CONTINUOUS DESIGNATE OPTION OF W1NTZ.
- (2) TO DISABLE THE RR CCL ERRCR COUNTERS.
- (3) TO ENABLE R25.

ASSUMPTIONS:

- (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.
- (2) W44 IS EFFECTIVE ONLY IF RR CONTINUOUS DESIGNATION (W1NTZ), COURSE ALLON RR C005, OPTION Z1 IS IN PROGRESS.
- (3) THE PROCESS MAY BE SELECTED AT ANY TIME.

PROG  
CONT

LGC

GROUND

CREW  
CREW  
SELECTION

START CREW INITIATED  
TERMINATE RR CONTIN-  
UOUS DESIGNATE  
..... KEY IN 9446

IS THE CONTINUOUS  
DESIGNATE FLAG SET?

Y ..... N  
.....  
.....  
.....  
EXIT

IS THE REMODE  
FLAG SET?

Y ..... N  
.....  
.....  
.....

PRELIMINARY

#10

#20

#30

1D

VVA/LIMINARY

02  
990



1D

1308  
V44/LUMINARY

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

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WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

WAIT 1 SECOND

02

#40

#50

#60

CHANGE CONTROL NOTES

LOGIC REV 01 PER 456  
REV 02 (LUM 1D) PCN 950

V44/LUMINARY

22-1100

**1D**

SECTION 5 CHANGES



At the start of the Target Acquisition Routine in <sup>and range rate 2.2°</sup> Fig. 2.4-1 the ranging is determined between the LM and CSM by taking the vector difference between the LM and CSM position vectors propagated to that time. if the range is greater than 400 nm, a program alarm is issued since the RR is unable to <sup>exceed 900 n.m.</sup> provide the correct range information to the LGC because of the ranging technique used in the radar. insert as on left

PCR  
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Therefore, if the range is greater than 400 nm and P-22 is running, the LGC flashes range and range rate. If P-20 is running with excessive range, the ALARM light is illuminated. The astronaut may then call the range, range-rate display, if he so desires. In either case, range and range-rate are recalculated periodically, until the range is less than 400 nm.

After verifying that the range between the LM and CSM is less than 400 nm, the Preferred Tracking Attitude Routine (R-61 of Sections 4 and 5.2.4.4) is used to align the LM +Z-axis along the LOS to the CSM. This is done to insure that the RR antenna will be designated in the correct antenna angular coverage region (Mode 1 of Fig. 2.4-3) for operation with program P-20. In addition, this attitude permits the LM optical beacon to be seen by the CSM in case optical tracking is being performed. The LM optical beacon is centered with respect to the LM +Z-axis and has a beamwidth of approximately 60 degrees. In Sections 5.2.4.2.1 and 5.2.4.4 it is seen that the LM +Z-axis is continuously directed along the LOS to the CSM by use of the Fine Preferred Tracking Attitude Routine (R-65) when RR Data is being used to update the navigation equations in P-20. In addition it is seen in Section 5.2.4.2.1 that the RR data is not used to update the navigation equations if the RR is more than 30° from the LM +Z-axis. The above constraints on LM attitude not only insure that the LM optical beacon will be seen by the CSM but also insure a reliable estimate of the RR angle biases when processing RR data.

After using the Preferred Tracking Attitude Routine in Fig. 2.4-1 the LGC checks to see if the RR Auto Mode discrete is being received from the RR. This discrete signifies that the RR is on and has been placed under LGC control by a

1D

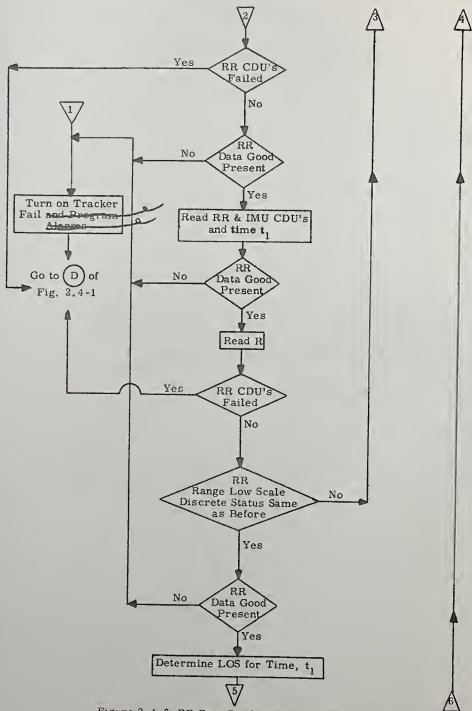
1PCR  
1979

Figure 2.4-6 RR Data Read Routine (Page 2 of 3)

5.2-55

PRELIMINARY

In this section an explanation will be given only for those logic steps in Fig. 2.4-6 associated with the use of the RR Data Read Routine during operation of the Rendezvous Navigation Program (P-20).

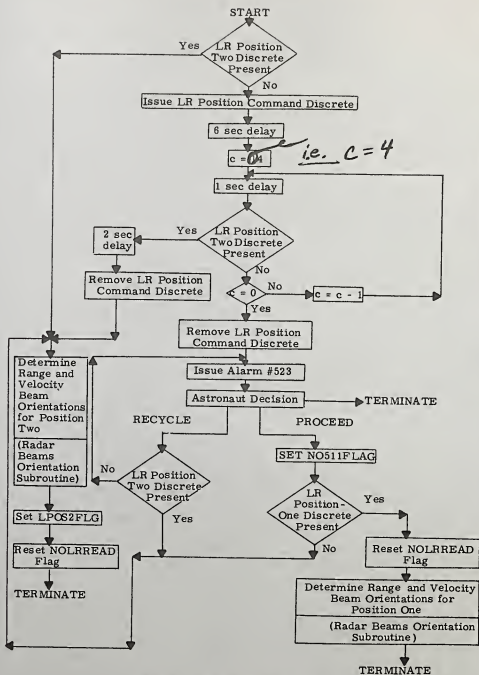
In Fig. 2.4-6, the first check made by the routine, after establishing that P-20 or P-22 is being used, is to see if the Track flag is present. This flag is removed during the preparation and execution of a LM ΔV maneuver when there is no desire to have the routine request RR data or call any other routine such as the RR Designate and Fine Preferred Tracking Attitude Routines.

If the Track flag is present, the routine next checks for issuance of the RR Track Enable discrete and reception of the RR Auto Mode discrete. The former discrete is removed and not re-issued by the RR Monitor Routine whenever the RR antenna angles exceed the limits in Fig. 2.4-3. Its absence therefore indicates a need to go back to input (B) of Fig. 2.4-1 to re-establish the preferred tracking attitude and re-designate the radar. Afterwards, a check is made to insure that RR data is not taken if the RR CDU's are being zeroed. If the RR CDU's are being zeroed and program P-20 is in operation, the Fine Preferred Tracking Attitude Routine (R-65) of Section 5.2.4.4 is called with a specified value of 2 for the quantity  $N_z$ , which indicates how many times routine R-65 is to repeat itself before returning to routine R-22.

The sequence used by the routine for reading RR data is shown in Fig. 2.4-6 where frequent checks are made on the RR Data Good discrete to insure that no RR tracking interruptions have occurred during the read-out. If this discrete is missing, the Tracker Fall and Program Alarm Lights are turned on before going to point (D) of Fig. 2.4-1 to re-designate the RR. Note in Fig. 2.4-1 that checks are also made to see if the RR CDU's have failed during the read-out and, if so, a return will also be made to point (D) of Fig. 2.4-1, except that the Tracker Fall and Program Alarm Lights are not turned on by the Data Read Routine, but are turned on by the RR Monitor Routine of Section 5.2.4.3.

1 PCR  
979

1D



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Fig. 3.4.4-4 LR Data Read Routine  
(LR Position Command Subroutine)

5.3-73

PRELIMINARY

Revised LUMINARY  
 Added GSOP # 567 . PCR # 839 Rev. 7 Date 11/69

The logic associated with the LR Position Command Subroutine is shown in Fig. 3.4.4-4. Initially, the routine checks to see if the LR Position Two discrete is being received from the LR, signifying that the antenna is already in Position Two. If the discrete is not present, the LR Position Command discrete is issued to the LR, causing its antenna to be driven to Position Two. When Position Two has been successfully obtained, it is seen that the NOLRREAD flag is reset and the unit vectors defining the orientations of the range and velocity beams for Position Two are determined. Seven seconds after the start of the routine, and each second thereafter, the routine checks to see if the LR Position Two discrete is being received, until 21 seconds have expired, at which time, an alarm is issued to the astronaut. (1)

At this point, the astronaut has three options in response to the #523 alarm. He can terminate LR updating operation in RI2 by entering V34E, which will set the NOLRREAD flag. He can try to place the antenna in Position Two with the separate antenna position control provided with the LR. Entering V32E in this case will cause checks to be made for the Position-Two discrete. Finally, the astronaut may decide to use the LR after High-Gate, even if the Position-Two discrete input has not appeared at the LGC input channel. In this case, he will key in PROCEED, which will set the N0511FLG flag. If the Position-One discrete is still present, the LR data will be used assuming the LR is still in Position One. If the Position-One discrete is not present, it will be assumed that the LR is in Position Two.

LR Velocity and Range Measurement Data. -- The velocity data obtained from the LR by the LR Data Read Subroutine are with respect to the LR antenna coordinate system of Fig. 3.4.2-2 and are in a form which is described as follows, along with the various data processing steps the LGC performs to transform the data into the Navigation Base Coordinate System.

The velocity data furnished at the LGC interface by the LR comprise three binary data words of the following form:

$$\begin{aligned} S_{XA} &= [(f_1 + f_3) / 2 + f_B] \tau_{LR} \\ S_{YA} &= [(f_1 - f_2) + f_B] \tau_{LR} \\ S_{ZA} &= [(f_3 - f_2) + f_B] \tau_{LR} \end{aligned} \quad (3.4.1)$$

where  $S_{XA}$ ,  $S_{YA}$ , and  $S_{ZA}$  correspond, respectively, to the velocity components along the  $-X_A$ ,  $+Y_A$ , and  $+Z_A$  antenna axes of Fig. 3.4.2-2. The quantities  $f_1$ ,  $f_2$ , and  $f_3$  are the beam doppler frequencies,  $f_B$  is the bias frequency used in the LR, and  $\tau_{LR}$  is the time interval used by the LR when counting the cycles of the above frequencies so as to produce the data words  $S_{XA}$ ,  $S_{YA}$ , and  $S_{ZA}$ . The time interval  $\tau_{LR}$  is 80,001 milliseconds.

PRELIMINARY



coordinates, which are either obtained from the computer's star catalog, loaded by the astronaut, or computed from ephemeris data such as for the Sun or Earth.

Once the alignment vectors have been obtained for Technique 2, it is seen in Fig. 6, 2-2 that the remaining steps in the alignment process are the same as described for Technique 0 in Section 5, 6, 2, 2, 2 except that Technique 2 also computes and stores the LM attitude in moon fixed coordinates and sets the Attitude Flag. The astronaut can repeat the final alignment if he so desires. At the bottom of page 2 of Fig. 6, 2-2, it is seen that the astronaut can repeat the final alignment by keying in a "PROCEED". If he wishes to establish a new landing site position vector as described in Section 5, 6, 2, 2, 6, he must key in an "ENTER" after the final alignment with Technique 2.

#### 5.6.2.2.4 Technique 3-IMU Alignment Using the Gravity Vector and One Celestial Body

Technique 3 is selected when the complete alignment is to be made by determining the lunar gravity vector with the IMU accelerometers and sighting on one celestial body with the AOT. As will be discussed later, this technique may be selected by the astronaut if he is only interested in determining the direction of the gravity vector. No program alarm is issued by program P-57 when selecting this technique if the Attitude flag or REFSMFLAG is not set.

In Fig. 6, 2-2 it is seen that Technique 3 initially uses the Gravity Vector Determination Routine of Section 5, 6, 3, 3 to obtain a unit vector  $\underline{u}_G$  defining the direction of lunar gravity in navigation base coordinates. The angle between this vector and any previously stored gravity vector is displayed to the astronaut so that he may judge whether there has been any tilt of the vehicle since the previous gravity vector was stored. If no previous gravity vector was stored, the angle between the present vector  $\underline{u}_G$  and the  $(M + X)$ -axis is displayed. At this point the astronaut may terminate P-57 if he is only interested in obtaining the gravity vector. However, if he is interested in making a complete IMU alignment with Technique 3, he keys in a "PROCEED".

LG's  
currently stored  
value of  $\underline{u}_L$ , the  
landing site vector,

PCR  
2-96

5.6.3.1.3 Lunar Surface Star Acquisition Subroutine

The purpose of the Lunar Surface Star Acquisition Subroutine is to assist the astronaut in locating a navigation star with the AOT when the celestial body code (or star code) has been selected by him at the beginning of the Lunar Surface Sighting Mark Routine (R-59). The subroutine is bypassed when ~~the astronaut selects the Sun, Earth, Moon, or Planet codes and there is no REFSMAT just prior to entering the subroutine.~~

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Initially, the subroutine checks to see if the star is within 30 degrees of the center of the AOT field-of-view (FOV) for any one of the six AOT viewing positions defined in Section 5.6.3.1.1. If successful, the subroutine then computes the reticle rotation angles needed to place the cursor and spiral of the AOT reticle onto the star. The parameters computed by this subroutine for display to the astronaut are the following:

N	AOT viewing position as defined in Section 5.6.3.1.1.
YROT	Reticle rotation angle in order to place the cursor on the star for viewing position N.
SROT	Reticle rotation angle in order to place the spiral on the star for viewing position N.

<u>Section No.</u>	<u>GSOP Name</u>	<u>LGC Name</u>
5.4.2.4	t ωt  $\Delta V_{TPI} (LV)$	
5.4.2.5	$\delta\tau_3$ $\delta\tau_7$ $\Delta V (LV)$	
5.4.3.1.3	J <sub>1</sub> J <sub>2</sub> K <sub>1</sub> K <sub>2</sub> θ <sub>C</sub>	J1 PARM J2 PARM K1 PARM K2 PARM THETCRIT
5.5.2	A <sub>X</sub> A <sub>Y</sub> AZ <sub>0</sub> t <sub>0</sub>  f <sub>M</sub>	
5.6.3	AZ <sub>1</sub> thru AZ <sub>6</sub> EL <sub>1</sub> thru EL <sub>6</sub> AZ EL	

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Section No.	GSOP Name	AGC Name	Units	Value	Reference (Sec. 5.8.2)	Comments (Sec. 5.8.3)
5.3.5.9	$\Delta V$ min		m/sec	3.56		26
	$A_T$ (RCS)		m/sec <sup>2</sup>	0.785		16
5.4.3.1.2	m (DPS)		lb/sec	32.62	29, 30	24
5.5.1.2	(Kepler) $\epsilon_t$		-	2 <sup>-22</sup>	12	
	(Lambert) $\epsilon_t$		-	2 <sup>-19</sup>	12	
	$\epsilon_x$ (earth)		m <sup>1/2</sup>	2 <sup>-12</sup>	12	
	$\epsilon_x$ (moon)		m <sup>1/2</sup>	2 <sup>-13</sup>	12	
	$\epsilon_c$		-	2 <sup>-23</sup>	12	
	$k_1$		-	2 <sup>-17</sup>	12	
5.5.2	$A_{Z0}$		rad	4.86315127049		
	$\omega_E$		rad/U-sec	7.292115147 x 10 <sup>-5</sup>	8	
	$B_0$		rad	4.09159633164 x 10 <sup>-1</sup>	7, 8	3
	$\Omega_0$		rad	5.859196887	7, 8	3
	$F_0$		rad	1.3216771960	7, 8	3
	$\dot{B}$		rad/U-sec	9791		3
	$\dot{\Omega}_1$		rad/U-sec	-7.19757 x 10 <sup>-14</sup>	7, 8	3
			rad/U-sec	-1.070470 x 10 <sup>-8</sup>	7, 8	3

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<u>Section No.</u>	<u>GSOP Name</u>	<u>LGC Name</u>	<u>Units</u>	<u>Value</u>	<u>Reference</u> (Sec. 5.8.2)	<u>Comments</u> (Sec. 5.8.3)
5.5.2	$\hat{F}$		rad/U-sec	$2.67240423 \times 10^{-6}$	7, 8	3
	$C_1$		-	$9.996417320 \times 10^{-1}$	7, 8	3
	$S_1$		-	$2.676579050 \times 10^{-2}$	7, 8	3
5.5.3	a		m	6,378,166	2,3,4	
	b		m	6,356,784	2,3,4	
	$\Gamma_{LP}$		m	6,378,388	11	
5.5.4	$K_1$		-	0.917455029	9,10	4
	$K_2$		-	0.035711455	9,10	4
	$K_3$		-	0.397839501	9,10	4
	$K_4$		-	0.082353949	9,10	4
	LOM <sub>O</sub>		rad	5.122570	9,10	4
	LOM <sub>R</sub>		rad/sec	$2.661689 \times 10^{-6}$	9,10	4
	A		deg	6.2160	9,10	4
	B		deg	1.2619	9,10	4
	OMEGA <sub>A</sub>		rad/sec	$2.8392078 \times 10^{-6}$	9,10	4
	OMEGA <sub>B</sub>		rad/sec	$2.2725641 \times 10^{-6}$	9,10	4
	PHASE <sub>A</sub>		rad	3.3350170	9,10	4
	PHASE <sub>B</sub>		rad	3.6779607	9,10	4

5.8.6-7

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## Internal Distribution List

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Group 23A	<u>S. MacDougall</u> Berberian Gustafson Higgins Kachmar Klumpp Kriegsman	<u>IL7-205</u> Levine Muller Pippenger Pu Reber Robertson	15
Group 23B	<u>J. Flaherty</u> Barnert Berman Eyles Finkelstein Gilson	<u>IL7-238A</u> Kirven McCoy Millard Moore	9
Group 23B	<u>J. Kaloustian</u> Bernikowich Dunbar OstaneK	<u>IL7-221L</u> Volante White	5
Group 23B	<u>D. Lutkevich</u> Reinke Babicki Beck Danforth Daniel DeCain Entes Flaherty Glendenning	<u>IL7-228</u> Good Hubbard Kana Klawnsnik Maher Nayer Reed (20) Williams Wolff Smith	38
Group 23P	<u>A. Tuscholke</u> Battin	<u>IL7-203</u>	1
Group 23B	<u>C. Taylor</u> Densmore Hamilton	<u>IL7-221L</u> Rosenberg Rye	4
Group 33	<u>J. Hargrove</u> Drane Glick	<u>IL7-111</u> Johnson (23P) Mimno	4
Group 23H	<u>B. Lynn</u> Cook Kossuth	<u>IL7-234A</u> O'Connor	3
Group 23C	<u>M. Erickson</u> Bairnsfather Fraser Goss Jones Kalan Keene	<u>IL11-102</u> Penchuk Pope Schlundt Stengel Work	11

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Group 23D	<u>S. Prangle</u> <u>Nevins</u>	<u>IL7-209</u>	1
Group 23P	<u>J. Sutherland</u> <u>Greene</u>	<u>IL7-266</u> <u>Stubbs</u>	2
Group 23D	<u>F. McGann</u> Davis Dunbar Dimcock Johnson Kiburz Metzinger	<u>IL7-332</u> Olsson Schroeder Schulte Sewall Walsh Woolsey Groome	13
Group 23P	<u>C. Mitaris</u> Cherry Copp	<u>IL7-213</u> Larson	3
Group 23S	<u>P. Amsler</u> Adams Aiyawar Day Felleman Johnston	<u>IL7-240</u> McQuat Petrillo Strunce Werner White	10
Group 23T	<u>D. Farrell</u> Day Edmonds Grace Kido Laats Lawrence Lones	<u>IL7-140</u> McKern Mega Mills Sarda Sheridan St. Armand	13
Group 23N	<u>G. Grover</u> <u>Blanchard</u> Johnson Ogletree	<u>IL7-202</u> Parr Tanner	5
Group 23P	<u>A. Rubin</u> Hoag	<u>IL7-252</u> Larson	2
Group 23P	<u>E. Johnson</u> Ragan	<u>IL7-248</u> Stameris	2
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NASA/GSFC:	National Aeronautics and Space Administration Goddard Space Flight Center Greenbelt, Maryland Attn: Mr. Paul Pashby, Code 813	(2)
GA:	Grumman Aerospace LEM Crew Systems Bethpage, Long Island, New York 11714 Attn: Mr. J. Marino (1R) Mr. C. Tillman (13) Mr. F. Wood (1) Mr. H. Sherman (Attn: W. Webster) (3) Mr. R. Pratt (4) Mr. B. Sidor (1) Mr. R. Kress (1)	(23 + 1R)
NAR:	North American Rockwell, Inc. Space and Information Systems Division 12214 Lakewood Boulevard Downey, California 90241 Attn: CSM Data Management D/396-402 AE99	(1 + 1R)
NASA/RASPO GA:	National Aeronautics and Space Administration Resident APOLLO Spacecraft Program Officer Grumman Aerospace LEM Crew Systems Bethpage, Long Island, New York 11714	(1):
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NASA/RASPO NAR	National Aeronautics and Space Administration Resident APOLLO Spacecraft Program Office North American Rockwell, Inc. Space and Information Systems Division 12214 Lakewood Boulevard Downey, California	(1)

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John F. Kennedy Space Center  
J.F. Kennedy Space Center, Florida 32899  
Attn: Technical Document Control Office

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Attn: Mr. A.S. Lyman

NASA/HDQ: NASA Headquarters (6)  
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Attn: MAP-2 (4)  
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