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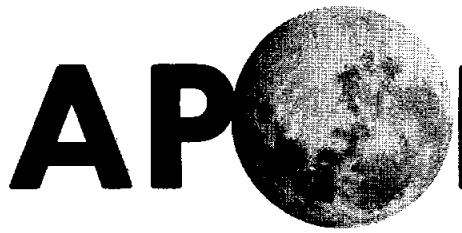

GUIDANCE, NAVIGATION AND CONTROL

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APOLLO GUIDANCE AND NAVIGATION PROGRAM

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R-577

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

SECTION 7 ERASABLE MEMORY PROGRAMS

Rev. 01

October 1972

MIT CHARLES STARK DRAPER LABORATORY

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R-577

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

SECTION 7 ERASABLE MEMORY PROGRAMS

REVISION 01

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REVISION INDEX COVER SHEET
GUIDANCE SYSTEM OPERATIONS PLAN

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

Section No. 7 Title: Erasable Memory Program (Revision 01)

PCR	TITLE
1190	EMP 520—Enter MINKEY at Post Plane Change Pulse Torquing (Rev. 1)
1192	EMP for Non-P40 SPS Gimbal Drive Test (EMP 522)
1194	EMP for Providing a Means of Monitoring for Jet-On Failures
1195	EMP for Monitoring Optics Mode Switch Position
1196	EMP for Monitoring CDU Transients
1199	EMP to Provide Both Jet Fail Monitor and CDU Transients Monitor Function

TABLE OF CONTENTS

Note: The Erasable Memory Programs (EMP) contained in this section are individually paginated within each EMP.

INTRODUCTION

GENERAL

Section 7 of the Guidance System Operations Plan (GSOP) describes erasable-memory programs (EMPs) designed for the guidance computers used in the command (CMC) and lunar modules (LGC). CMC programs are designated COLOSSUS 3, and the associated EMPs are identified by a three-digit number beginning with "5." LGC programs are designated LUMINARY 1E, and the associated EMPs are identified, with one exception, by a three-digit number beginning with "1." The exception is EMP 99.

The EMPs vary in complexity from a simple flagbit setting to a long and intricate logical structure. They all, however, cause the computer to behave in a way not intended in the original design of the programs; they accomplish this off-nominal behavior by some alteration of erasable memory to interface with existing fixed-memory programs to effect a desired result.

> CAUTION.—Great care must be taken when loading or performing an EMP. An erroneous digit loaded into NOUN 26, for example, could cause indeterminate operation upon program initiation.
>
> NOTE 1.—The EMPs described in this section should not be run simultaneously except when explicitly specified.
>
> NOTE 2.—Level 6 performance-evaluation testing has not been performed on EMPs.

The following format is used throughout this section:

NUMBER AND NAME OF EMP.

PURPOSE.

FUNCTIONAL DESCRIPTION—a brief description of the EMP and how it interfaces with fixed-memory programs (may include a functional-flow diagram).

ASSUMPTIONS—prerequisite conditions and configurations.

RESTRICTIONS AND LIMITATIONS—conditions and operations that would interfere with, or be affected by, the EMP.

PROCEDURES—instructions for performing the EMP.

RECOVERY/TERMINATION—procedures for terminating the EMP or recovering from a hardware or software restart.

ERASABLE MEMORY—listing of memory locations (octal) and the code (mnemonic and octal) comprised by the EMP.

UPLINK—P27 format for loading the EMP into erasable memory.

JOBS AND TASKS

A number of EMPs are initiated by VERB 30 ENTR (Request Executive) or VERB 31 ENTR (Request WAITLIST). When the EMP is programed as a JOB, the activation procedures specify VERB 30 ENTR; when the EMP is programed as a TASK, the procedures specify VERB 31 ENTR. The distinction is on the basis of how the program is dispatched. A JOB carries a priority; when the JOB's priority comes up on the executive queue, the JOB is activated. A TASK differs in that it is performed as a T3-clock interrupt. The AGC WAITLIST program sets the T3 clock to overflow at a specified time; when the overflow occurs, other program activity is interrupted, and the TASK is performed.

For VERB 30 use, the JOB's priority is specified in R1 of NOUN 26. R1 of NOUN 26 also contains in the low-order digit an indication of whether or not the JOB is to be assigned a VAC area: if the low-order digit is "1," a VAC area is reserved for the JOB; if it is "0," no VAC area is reserved.

For VERB 31 use, R1 of NOUN 26 must contain the time specified to elapse (in centiseconds) between the keying of ENTR (after VERB 31) and TASK execution.

EMPs activated by VERB 30 ENTR (i.e., JOB EMPs) require NOUN 26 to be loaded as follows:

R1 = $xx00y_8$

where

xx_8 = JOB Priority

y = 1 designates a VAC JOB;

y = 0 designates a NOVAC JOB.

R2 = $xxxxx_8$

where

$xxxxx_8$ is the JOB starting address

R3 = $xxxxx_8$

where

$xxxxx_8$ is the BBCON, containing the fixed, super, and erasable banks associated with the JOB

EMPs activated by VERB 31 ENTR (i.e., TASK EMPs) require NOUN 26 to be loaded as for a JOB EMP, except that R1 contain not a JOB priority, but a time delay as described above:

R1 = $xxxxx_8$	cs delay
R2 = $xxxxx_8$	starting address
R3 = $xxxxx_8$	BBCON

The BBCON is packed as follows:

Bit	15 14 13	12 11 10	9 8 7	6 5 4	3 2 1
	Octal F-bank		Octal S-bank		Octal E-bank

F-banks $00-27_8$ are addressed independently of S-bank contents; F-banks $30-37_8$ are addressed for S-bank values of 3_8 or less, and F-banks $40-43_8$ are addressed for an S-bank value of 4_8:

Example 1

BBCON = 66107_8

F-bank 33, S-bank 4 } F-bank 43_8

E-bank 7

Example 2

BBCON = 66063_8

F-bank 33, S-bank 3 } F-bank 33_8

E-bank 3

Example 3

BBCON = 02006_8

F-bank 01

S-bank unnecessary

E-bank 6

DOWNLINK .

Listed below are the EMPs and the particular downlist transmitted during the operation of each EMP:

COLOSSUS

EMP		Downlist
500		P22 List
501		P22 List
502		Any
503		Coast and Align List
504		Rendezvous and Prethrust List
505	P20/P23	Rendezvous and Prethrust List
	P22/P24	P22 List
	P5X	Coast and Align List
506		Rendezvous and Prethrust List
508		P22 List
509		Any
512		Powered List, Coast and Align List
513		Entry and Update List
514		Rendezvous and Prethrust List
515		Rendezvous and Prethrust List
517		Coast and Align List
518		Coast and Align List, Entry and Update List (during P27)
520		Rendezvous and Prethrust List, Coast and Align List
521		Coast and Align List
522		Any but Powered
523		Any but Powered
525A		Rendezvous and Prethrust List
526		Any but Rendezvous and Prethrust List
527		Rendezvous and Prethrust List
528		Coast and Align List

EMP 500: LANDMARK TRACKING WITH DATALINK FAILURE OR UNUSABLE OPTICS

PURPOSE:

EMP 500 provides a means of P24 mark taking with the COAS when the OSS is totally unusable or with the optics when the only failure is in the datalink between optics and CMC.

> NOTE.—If the optics are mechanically immobile ("frozen") but otherwise operational (good CDUs), use EMP 508. If optics are operational except for failed MARK or MARK REJ button, use EMP 501 or EMP 505.

FUNCTIONAL DESCRIPTION:

Certain flags, erasables, and nouns are changed (see PROCEDURES) to cause P24/R52 to enable the Tracking Attitude Routine (R61). R61 points a specified body axis (NOUN 78) at a landmark vector specified in RLS.

EMP 500 is started by VERB 30 ENTR. A PRO response to FL VERB 53 initiates the MARK function. MARK time, inertial CDU angles, and fixed optics angles are stored in temporary registers. The optics angles are obtained from NOUN 94, loaded manually at the start of P24. The existing fixed-memory task MARKCONT is then set up to store the mark data on the downlink and to set certain flags and counters as in a normal MARK.

The MARK REJ function is initiated by an ENTR response to FL VERB 53. Here, EMP 500 code is the same as the normal P24 MARK REJ code.

VERB 34 ENTR response to FL VERB 53 terminates EMP 500, which returns FL VERB 51 in P24. (See RECOVERY/ TERMINATION.)

ASSUMPTIONS:

EMP 500 is called (see PROCEDURES) when—

1. Either the optics are totally unusable or a datalink failure between optics and CMC has occurred (bad CDUs).

2. Program coding has been uplinked via P27 (see ERASABLE MEMORY and UPLINK).
3. If optics are totally unusable, COAS calibration has been performed.
4. P20 is not running.

RESTRICTIONS AND LIMITATIONS:

1. The following programs must not be operated between the time EMP 500 coding is uplinked and the time the program is initiated: P21, P22, P23, P29, P3x, P4x, P5x, P6x, P7x.
2. No optics positioning capability. (Use RHC to center landmark in COAS; use MIC to center landmark in SCT —failed datalink.)
3. Step 1 of PROCEDURES, used to initiate tracking in P24, requires that P24 be exited via VERB 37 ENTR xx ENTR rather than by the normal PRO on FL VERB 51. (See RECOVERY/TERMINATION.)
4. Use of the RHC terminates automatic tracking. (See PROCEDURES.)
5. A restart causes possibly erroneous automatic tracking. (See RECOVERY/TERMINATION.)
6. EMP 500 was designed for high-altitude use only.

PROCEDURES:

1. The following preliminary procedures should be accomplished at the FL VERB 06 NOUN 89 display in P24:

   a. Place OPT MODE switch in CMC
   b. Place OPT ZERO switch in ZERO
   c. Load/verify RLS (E-memory address 2025-2032) valid for landmark
   d. Load NOUN 78 as follows:

      1) COAS (Optics unusable)
         Key—
         VERB 25 NOUN 78 ENTR
         +ENTR (R1, +000.00 deg, γ)
         +ENTR (R2, +000.00 deg, ρ)
         +ENTR (R3, +000.00 deg, OMICRON)

or

2) SCT (datalink failed)
Key—
VERB 25 NOUN 78 ENTR
+xxxxx ENTR } nearest 0.01 deg
+xxxxx ENTR } Voiced from ground
+xxxxx ENTR

e. Load NOUN 79 (R2) with 0.5-deg deadband:
Key—
VERB 22 NOUN 79 ENTR
+50 ENTR

f. Load NOUN 94 as follows:

1) COAS
key—
VERB 24 NOUN 94 ENTR
+ ENTR (R1, 000.00 deg, shaft)
+57470 ENTR (R2, +57.470 deg, trunnion)

NOTE.—The actual values loaded here should be those obtained by the COAS calibration procedure.

or

2) SCT
key—
VERB 24 NOUN 94 ENTR
+xxxxx ENTR (R1, nearest 0.01 deg, TPAC shaft)
+xxxxx ENTR (R2, nearest 0.001 deg, TPAC trunnion)

2. Upon FL VERB 51 in P24,

a) key—
VERB 21 NOUN 1 ENTR
3374 ENTR

ENTR

to zero R61CNTR;

b) key VERB 44 ENTR to set SURFFLAG (FLAGWRD8, BIT 8).

c) key—

VERB 1 NOUN 1 ENTR

107 ENTR

to observe condition of AZIMFLAG (FLGWRD11, BIT 8). If set, three-axis maneuver will be performed in R61. If cleared, a VECPOINT maneuver will be performed in R61. To change AZIMFLAG, key—

VERB 25 NOUN 7 ENTR

107 ENTR

200 ENTR

x ENTR (where x = 1 for three-axis maneuver; x = 0 for VECPOINT maneuver)

d) key—

VERB 25 NOUN 7 ENTR

75 ENTR

1020 ENTR

1 ENTR

to set TARG1FLG (FLAGWRD1, BIT 10) and TRACKFLG (FLAGWRD1, BIT 5)

3. Perform automatic maneuver to tracking attitude
4. Observe FL VERB 51 ("Please MARK")
5. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 500:

R1 14000

R2 01603

R3 16067

6. Key VERB 30 ENTR to call EMP 500
7. Upon FL VERB 53 ("Please mark alternate LOS"), place CMC MODE switch in FREE, and

a) use RHC to center LMK in COAS, or

b) use MIC to center LMK in SCT (for failed datalink).

NOTE.—Use of RHC terminates automatic tracking. To reestablish, use normal P20 techniques (CMC AUTO, VERB 58 ENTR).

8. Key PRO to mark (to reject mark, key ENTR)
9. To exit EMP 500, key VERB 34 ENTR
10. To exit EMP 500 and P24, key—

    VERB 37 ENTR xx ENTR

    VERB 45 ENTR (to reset SURFFLAG, if desired).

RECOVERY/ TERMINATION:

1. EMP 500 is not restart protected. A restart during its operation results in a blank DSKY, except for "24" in the PROG registers, and possibly erroneous tracking. To recover from a restart perform the following:

   a. Key VERB 37 ENTR 24 ENTR.

   NOTE.—Any previous MARKs on downlist will be lost, i.e., zeroed by P24.

   b. At FL VERB 51, redo steps 2a, 2d, and, if necessary, 3 under PROCEDURES.
   c. At FL VERB 51, key VERB 30 ENTR to initiate EMP.

2. P24 should be exited by VERB 37 ENTR xx ENTR. (PRO response to FL VERB 51 does not effect normal exit.) Calling another program (Pxx) also restores flags specially configured by preliminary procedures —except SURFFLAG, which is reset by keying VERB 45 ENTR, if desired.

ERASABLE MEMORY:

Program coding for EMP 500 is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	14000	14000
1017		OCT	01603	01603
1020		OCT	16067	16067
3603	P24BKUP	CA	V53	31661
3604		TC	BANKCALL	04636
3605		CADR	E/BKCALL	26036
3606		CADR	GOMARKF	20576
3607		TC	MKVB5X	02052
3610		TC	+2	01612
3611		TC	P24REJ	01634
3612		INHINT		00004
3613		CA	MRKBUF1 +3	31725
3614		TS	MKCDUS	54357
3615		CA	MRKBUF1 +5	31727
3616		TS	MKCDUT	54361
3617		CA	CDUY	30033
3620		TS	MKCDUY	54356
3621		CA	CDUZ	30034
3622		TS	MKCDUZ	54360
3623		CA	CDUX	30032
3624		TS	MKCDUX	54362
3625		EXTEND		00006
3626		DCA	TIME2	30025
3627		DXCH	MKT2T1	52355
3630		CA	ONE	34770
3631		TC	TWIDDLE	05223
3632		ADRES	MARKCONT	02204
3633		TC	P24BKUP	01603
3634	P24REJ	CS	FLAGWRD1	40075
3635		MASK	MARKBIT	74765
3636		CCS	A	10000
3637		TC	P24BKUP	01603
3640		TC	DOWNFLAG	05561
3641		ADRES	MARKFLAG	00032
3642		TC	DOWNFLAG	05561
3643		ADRES	P24MKFLG	00052
3644		CCS	P22DEX	11753
3645		TC	+3	01650
3646		CA	OCT34	34172
3647		TC	+3	01652
3650		CS	SEVEN	44774
3651		AD	P22DEX	61753
3652		TS	MPAC	54154
3653		EXTEND		00006
3654		INDEX	MPAC	50154
3655		DCS	SVMRKDAT	41540
3656		INDEX	MPAC	50154
3657		DXCH	SVMRKDAT	53540
3660		TC	P24BKUP	01603
3661	V53	VN	5300	15200

UPLINK: P27 uplink for loading CMC erasable memory for EMP 500 is as follows:

Load 1	Load 2	Load 3	Load 4
V71E	V71E	V71E	V71E
5E	24E	24E	15E
1016E	3603E	3625E	3647E
14000E	31661E	6E	1652E
1603E	4636E	30025E	44774E
16067E	26036E	52355E	61753E
V33E	20576E	34770E	54154E
	2052E	5223E	6E
	1612E	2204E	50154E
	1634E	1603E	41540E
	4E	40075E	50154E
	31725E	74765E	53540E
	54357E	10000E	1603E
	31727E	1603E	15200E
	54361E	5561E	V33E
	30033E	32E	
	54356E	5561E	
	30034E	52E	
	54360E	11753E	
	30032E	1650E	
	54362E	34172E	
	V33E	V33E	

EMP 501: LANDMARK TRACKING WITH FAILED MARK/MARK REJ BUTTON

PURPOSE:

EMP 501 provides a means of using the DSKY PRO/ENTR keys for P24 mark taking when the optics MARK/MARK REJ button(s) are the only OSS malfunction.

> NOTE1.—If the optics are mechanically immobile ("frozen") but otherwise operational (good CDUs), use EMP 508. If OSS is totally unusable or if there is a failure in the datalink between the optics and the CMC, use EMP 500.
>
> NOTE2.—EMP 501 can be replaced by EMP 505.

FUNCTIONAL DESCRIPTION:

Normal P24 landmark tracking procedures (P20, option 2, then P24) are completed through the FL VERB 51 display. At this point, EMP 501 is called via VERB 30 ENTR. A FL VERB 53 is displayed. A PRO on this display will initiate the MARK function. The mark time, inertial CDUs and optics CDUs are stored in temporary registers. The existing fixed memory task MARKCONT is set up to store the mark on the downlink and set certain flags and counters as in a normal MARK. The FL VERB 53 is then redisplayed.

An ENTR response to the FL VERB 53 display will initiate the MARK REJ function. Here, EMP 501 code is the same as the normal P24 MARK REJ code. The FL VERB 53 is then redisplayed.

EMP 501 is terminated via VERB 34 ENTR, redisplaying FL VERB 51 in P24 via the fixed memory code at MKVB5X. (See RECOVERY/TERMINATION.)

ASSUMPTIONS:

1. A failure has occurred in the MARK or MARK REJ button. All other optics functions are working properly.
2. Program coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)

RESTRICTIONS AND LIMITATIONS:

The following programs must not be operated between the time EMP 501 coding is uplinked and the time the program is initiated: P21, P22, P23, P29, P3x, P4x, P5x, P6x, P7x.

PROCEDURES:

1. Normal landmark tracking procedures (P20, option 2, then P24) are completed through the FL VERB 51 ("Please MARK") display.
2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 501:

   R1 14000
   R2 01603
   R3 16067
3. Key VERB 30 ENTR to call EMP 501.
4. Upon FL VERB 53 ("Please mark alternate LOS"), use OHC to center LMK in optics.
5. Key PRO to mark (to reject mark, key ENTR).
6. To exit EMP 501, key VERB 34 ENTR (FL VERB 51 returns). (To exit EMP 501 and P24, key VERB 37 ENTR xx ENTR.)

RECOVERY/ TERMINATION:

1. EMP 501 is not restart protected. Therefore, the EMP must be reestablished after a restart via VERB 30 ENTR. Because of the restart in P24, the PROG Alarm Light will be on (120 alarm—"Optics torque request with optics not zeroed"). Therefore, the optics must be zeroed again and the landmark reacquired before more marks can be made.

   NOTE.—Since driving of the optics occurs even with the alarm, zeroing of the optics can be omitted if the CDUs can be shown to be valid, (e.g., by comparing NOUN 91 with the TPAC).

   During a restart in P24, the Sighting Mark Routine (R53) is restarted. Therefore, any marks taken after the restart will overwrite those taken before.

2. EMP 501 is terminated by VERB 34 ENTR, redisplaying FL VERB 51 in P24. P24 can be terminated normally. (PRO on FL VERB 51). (EMP 501 and P24 can be exited directly by VERB 37 ENTR xx ENTR.)

ERASABLE MEMORY:

Program coding for EMP 501 is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	14000	14000
1017		OCT	01603	01603
1020		OCT	16067	16067
3603	P24BKUP	CA	V53	31661
3604		TC	BANKCALL	04636
3605		CADR	E/BKCALL	26036
3606		CADR	GOMARKF	20576
3607		TC	MKVB5X	02052
3610		TC	+2	01612
3611		TC	P24REJ	01634
3612		INHINT		00004
3613		CA	CDUS	30036
3614		TS	MKCDUS	54357
3615		CA	CDUT	30035
3616		TS	MKCDUT	54361
3617		CA	CDUY	30033
3620		TS	MKCDUY	54356
3621		CA	CDUZ	30034
3622		TS	MKCDUZ	54360
3623		CA	CDUX	30032
3624		TS	MKCDUX	54362
3625		EXTEND		00006
3626		DCA	TIME2	30025
3627		DXCH	MKT2T1	52355
3630		CA	ONE	34770
3631		TC	TWIDDLE	05223
3632		ADRES	MARKCONT	02204
3633		TC	P24BKUP	01603
3634	P24REJ	CS	FLAGWRD1	40075
3635		MASK	MARKBIT	74765
3636		CCS	A	10000
3637		TC	P24BKUP	01603
3640		TC	DOWNFLAG	05561
3641		ADRES	MARKFLAG	00032
3642		TC	DOWNFLAG	05561
3643		ADRES	P24MKFLG	00052
3644		CCS	P22DEX	11753
3645		TC	+3	01650
3646		CA	OCT34	34172
3647		TC	+3	01652
3650		CS	SEVEN	44774
3651		AD	P22DEX	61753
3652		TS	MPAC	54154
3653		EXTEND		00006
3654		INDEX	MPAC	50154
3655		DCS	SVMRKDAT	41540
3656		INDEX	MPAC	50154
3657		DXCH	SVMRKDAT	53540
3660		TC	P24BKUP	01603
3661	V53	VN	5300	15200

UPLINK: P27 uplink for loading CMC erasable memory for EMP 501 is as follows:

Load 1	Load 2	Load 3	Load 4
V71E	V71E	V71E	V71E
5E	24E	24E	15E
1016E	3603E	3625E	3647E
14000E	31661E	6E	1652E
1603E	4636E	30025E	44774E
16067E	26036E	52355E	61753E
V33E	20576E	34770E	54154E
	2052E	5223E	6E
	1612E	2204E	50154E
	1634E	1603E	41540E
	4E	40075E	50154E
	30036E	74765E	53540E
	54357E	10000E	1603E
	30035E	1603E	15200E
	54361E	5561E	V33E
	30033E	32E	
	54356E	5561E	
	30034E	52E	
	54360E	11753E	
	30032E	1650E	
	54362E	34172E	
	V33E	V33E	

EMP 502: SOFTWARE RESTART

PURPOSE:

EMP 502 provides a means of causing a software restart by keying VERB 31 ENTR.

FUNCTIONAL DESCRIPTION:

EMP 502 uses existing fixed program code to perform BAILOUT and store Alarm Code 31211.

ASSUMPTIONS:

NA

RESTRICTIONS AND LIMITATIONS:

NA

PROCEDURES:

1. Key—
   VERB 25 NOUN 26 ENTR
   1 ENTR
   2071 ENTR } fixed-memory address of MKABORT
   16000 ENTR }
2. To effect software restart, key VERB 31 ENTR
3. Observe PROG alarm light
4. Key VERB 5 NOUN 9 ENTR to observe alarm code 31211, "Illegal interrupt of extended verb"
5. Key RSET to clear alarm

RECOVERY/ TERMINATION:

NA

ERASABLE MEMORY:

NA

UPLINK:

NA

EMP 503: GDC REFSMMAT DETERMINATION

PURPOSE:

EMP 503 provides a means of using the gyro display coupler (GDC) to determine orientation of the spacecraft. This program establishes the inertial reference for performing rendezvous with an unusable IMU.

> NOTE1.—EMP 503 complements EMP 504 and 506 for performing rendezvous navigation with a failed IMU.
>
> NOTE2.—To perform REFSMMAT determination with the IMU-OPERATE discrete failed off, use EMP 521.

FUNCTIONAL DESCRIPTION:

EMP 503 bypasses only the very first part of P51/P53 (see Figure: EMP 503), that part which determines whether the IMU is on and operating (bit 9 of IMODES30).

ASSUMPTIONS:

1. GDC is inertial
2. IMU is unusable

RESTRICTIONS AND LIMITATIONS:

Inertial reference established by EMP 503 is valid for only one spacecraft orientation, i.e., the orientation of the spacecraft when the two P51/P53 star sightings are made: the same orientation must be maintained during rendezvous sightings.

PROCEDURES:

To initiate EMP 503, perform the following:

1. Preliminary

   a. Key VERB 96 ENTR to clear all program activity.
   b. To set MODREG to decimal 51, key—
      VERB 21 NOUN 1 ENTR
      1214 ENTR
      63 ENTR
      to set MODREG to decimal 53, key—
      VERB 21 NOUN 1 ENTR
      1214 ENTR
      65 ENTR

c. Key—

VERB 25 NOUN 26 ENTR
13001 ENTR
3425 ENTR } fixed-memory address
30005 ENTR } of P51AA

to set up for the call to P51/P53 bypassing IMU-on check.

2. Activate

a. Key VERB 30 ENTR to start EMP 503 (and P51/P53)

NOTE.—If it is desired that the REFSMMAT calculated by P51/P53 approximate a valid GDC inertial-attitude description, key VERB 25 and load NOUN 20 as follows (before step 2b):

Key—
VERB 25 NOUN 20 ENTR
±xxxxx ENTR
±xxxxx ENTR
±xxxxx ENTR
where
R1 = GDC OGA to nearest 0.01 deg,
R2 = GDC IGA to nearest 0.01 deg,
R3 = GDC MGA to nearest 0.01 deg.

b. Perform normal P51/P53 star sightings and procedure, maintaining a fixed attitude

NOTE.—P51/P53 is activated when VERB 30 is selected in step 2a, but the mode lights will remain at 00 rather than displaying 51/53.

RECOVERY/
TERMINATION: Normal P51/P53 restart and termination procedures.

ERASABLE MEMORY:	NA
UPLINK:	NA

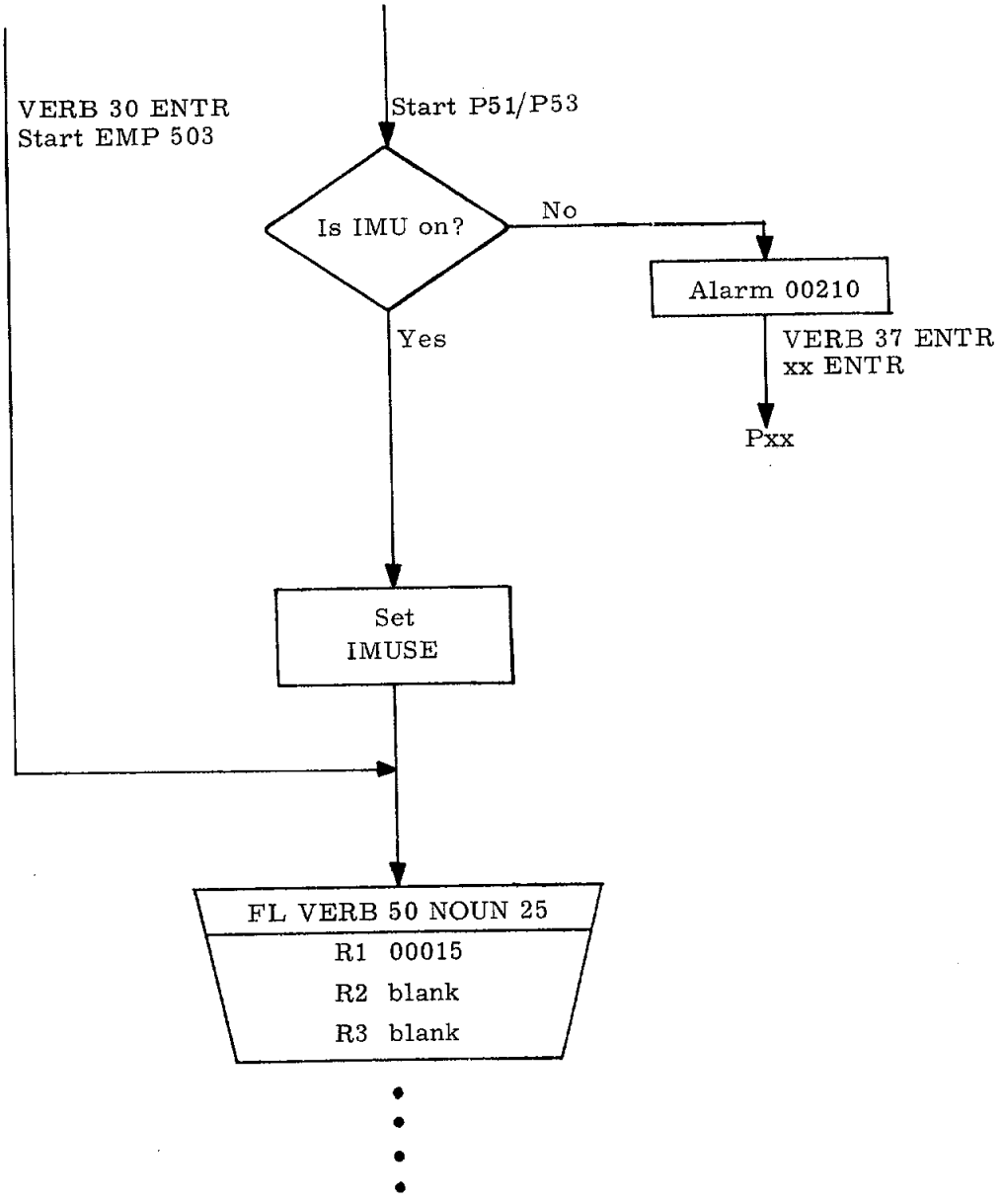

VERB 30 ENTR
Start EMP 503
Start P51/P53
Is IMU on?
No
Alarm 00210
VERB 37 ENTR
xx ENTR
Pxx
Yes
Set
IMUSE
FL VERB 50 NOUN 25
R1 00015
R2 blank
R3 blank

FIG: EMP 503

EMP 504: BACKUP OPTICS VARIANCE

PURPOSE:

EMP 504 provides a means of using ALTVAR in place of SXTVAR in R22.

FUNCTIONAL DESCRIPTION:

EMP 504 is used to compensate for increased uncertainty when processing optics data obtained with a degraded ISS or OSS. This procedure utilizes the erasable variable ALTVAR instead of the fixed memory SXTVAR as the a-priori estimate for the angular error variance per axis.

NOTE.—EMP 504 complements EMPs 503 and 506 for performing rendezvous navigation with a failed IMU.

ASSUMPTIONS:

1. SXT or SCT usable—may be immobile (if good IMU)
2. Good OCDUs
3. Good MARK button

RESTRICTIONS AND LIMITATIONS:

If EMP 504 is being used as complementary program to EMP 503 (failed IMU), spacecraft attitude during marking must be the same as that used in EMP 503 to establish inertial reference.

PROCEDURES:

1. If REFSMFLG (FLAGWRD3, BIT 13) is not set, key—

   VERB 25 NOUN 7 ENTR
   77 ENTR
   10000 ENTR
   1 ENTR

   to set REFSMFLG and enable selection of P20.

2. In P20, key—

   a. VERB 25 NOUN 7 ENTR
      76 ENTR
      20000 ENTR
      ENTR

      to clear R21MARK (FLAGWRD2, BIT 14)

   b. VERB 21 NOUN 1 ENTR
      301 ENTR
      37777 ENTR

to set MARKINDX to POSMAX

c. VERB 21 NOUN 1 ENTR
1336 ENTR
31264 ENTR

to load OPTCADR with fixed-memory address of ENDPLAC +1.

3. Use normal P20 marking procedures.

NOTE.—MARK REJ will cause FL VERB 51 to appear. To clear FL VERB 51, key PRO. (VERB 86 ENTR can be used in place of MARK REJ to avoid causing FL VERB 51.)

RECOVERY/ TERMINATION:

1. Any VERB 37 ENTR xx ENTR or
VERB 25 NOUN 7 ENTR
76 ENTR
20000 ENTR
1 ENTR (sets R21MARK—FLAGWRD2, BIT 14).
2. Any VERB 37 ENTR xx ENTR or restart disables program. To reenable, repeat PROCEDURES.

ERASABLE MEMORY: See PROCEDURES

UPLINK: NA

EMP 505: MARK TAKING WITH MARK BUTTON FAILURE

PURPOSE:

EMP 505 provides a general-purpose mark taking routine for use when the MARK button has failed.

FUNCTIONAL DESCRIPTION:

Normal program procedures are completed up to point when marking normally takes place (FL VERB 51, FL VERB 59, or P20 option 0 or 4). A VERB 31 ENTR will initiate the MARK function. The existing fixed-memory task MARKDIF is set up, and program operation will continue as if a normal mark had been taken.

ASSUMPTIONS:

EMP 505 is called when (see PROCEDURES) failure has occurred in the MARK button and all other optics functions are working properly.

RESTRICTIONS AND LIMITATIONS:

1. If the MARK or MARK REJ button has failed intermittently on, then neither regular marking nor execution of EMP 505 can be relied on.
2. Refer to the following matrix for EMP 505 contingencies under combination MARK/MARK REJ fail conditions:

	MARK REJ Button Failed Off	MARK REJ Button Failed On
MARK Button Failed Off	Use EMP 505 from NAV DSKY	EMP 505 cannot be used
MARK Button Failed On	Follow PROCEDURES Step 1 on the MAIN DSKY. Then depress any key on the NAV DSKY to effect a mark.	Follow PROCEDURES Step 1 on the MAIN DSKY. Then depress any key on the NAV DSKY to effect a mark.

PROCEDURES:

1. Perform normal program procedures up to point when marking normally takes place (FL VERB 51, FL VERB 59, or P20 option 0 or 4).

2. Load NOUN 26 as follows:
Key VERB 25 NOUN 26 ENTR

1 ENTR	
2165 ENTR	fixed-memory address of MARKDIF
16067 ENTR	

NOTE.—The CDU transient-detection test (121_8 PROG alarm) is less effective in EMP 505 than in normal marking.

3. Key VERB 31 ENTR to take mark. (The ENTR accomplishes the MARK.)

NOTE1.—Unless a monitor display is active or any new display is initiated by the program or crew, the VERB 31 will remain in the VERB lights. (A KEY REL will reestablish the program display, if any.) As long as VERB 31 is in the VERB lights, an ENTR will activate EMP 505 to accomplish a mark. If VERB 31 is not in the VERB lights, Step 3 must be repeated if a mark is desired.

NOTE2.—Normal MARK REJ procedures apply when EMP 505 is operating, subject to noted exceptions.

4. When marking has been completed, continue with normal procedures for the program in use.

RECOVERY/ TERMINATION:

1. Normal restart procedures apply.
2. Terminate marking program normally after keying KEY REL, if necessary, to reestablish program display.

ERASABLE MEMORY: NA

UPLINK: NA

EMP 506: DSKY DISPLAY OF VHF RANGE DURING P79

PURPOSE:

EMP 506 provides a means of displaying VHF range on the DSKY during Final Rendezvous Program (P79).

NOTE.—EMP 506 complements EMPs 503 and 504 for performing rendezvous navigation with a failed IMU.

FUNCTIONAL DESCRIPTION:

Setting UPDATFLG and enabling VHF ranging via VERB 87 ENTR during P20 option 0 or 4 enables VHF data processing in R22, thus allowing raw range data to be monitored.

ASSUMPTIONS:

1. P20 (option 0 or 4) operating
2. VHF locked on LM
3. CMC-computed range is less than 327.67 n.mi.
4. VHF ranging has been enabled via VERB 87 ENTR.

RESTRICTIONS AND LIMITATIONS:

1. EMP 506 enables state-vector updates in R22. (P79 does not normally enable state-vector updates.)
2. Astronaut-loaded monitor display (see PROCEDURES) blocks a possible VERB 06 NOUN 49 display. A response to FL VERB 06 NOUN 49 is necessary for further updating of range display.
3. VHF range display updates only about once a minute (in conjunction with R22 processing of VHF range data).

PROCEDURES:

To initiate EMP 506—

1. Set UPDATFLG via—
   VERB 25 NOUN 7 ENTR
   75 ENTR
   100 ENTR
   1 ENTR
2. Key VERB 16 NOUN 2 ENTR
   3703 ENTR
   to initiate VHF range display.
3. Observe VHF range:
   R1, xxx.xx n.mi.

NOTE.—If R1<0, range = 327.67 - |R1|.

RECOVERY/
TERMINATION:

1. To disable EMP 506,

   a) reset UPDATFLG via—
      VERB 25 NOUN 7 ENTR
      75 ENTR
      100 ENTR
      ENTR
   b) disable VHF ranging via—
      VERB 88 ENTR.

2. To recover from a restart,

   a) reselect P79 via—
      VERB 37 ENTR 79 ENTR
   b) repeat procedures.

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 508: LANDMARK TRACKING WITH FROZEN OPTICS

PURPOSE:

EMP 508 provides a means of using the SXT/SCT to track a landmark when the optics are immobile ("frozen") but otherwise operational (good CDUs).

> NOTE.—For landmark tracking with totally unusable optics (COAS tracking), use EMP 500; for landmark tracking with failed MARK/MARK REJ button, use EMPs 501 or 505.

FUNCTIONAL DESCRIPTION:

Certain flags, erasables, and nouns are changed (see PROCEDURES) to cause P24/R52 to enable the Tracking Attitude Routine (R61). R61 points the frozen LOS axis (manually loaded into NOUN 78) at a landmark vector specified in RLS.

Initial acquisition of the landmark is by the Attitude Maneuver Routine (R60). Then, the MIC is used to center the landmark in the optics. Normal MARK/MARK REJ procedures apply.

ASSUMPTIONS:

P20 is not running.

RESTRICTIONS AND LIMITATIONS:

1. No optics positioning capability. (Use MIC to center landmark in optics.)
2. Step 1, used to initiate tracking in P24, requires that P24 be exited via VERB 37 ENTR xx ENTR rather than by the normal PRO on FL VERB 51. (See RECOVERY/TERMINATION.)
3. A restart causes possibly erroneous automatic tracking. (See RECOVERY/TERMINATION.)

PROCEDURES:

1. Before initiating frozen-optics tracking, perform the following at the FL VERB 06 NOUN 89 display in P24:

   a. Place the OPT MODE switch in MAN
   b. Place OPT ZERO switch to OFF
   c. Verify that OCDUs are valid by comparing contents of NOUN 91 with TPAC. (If different, load NOUN 91 with TPAC numbers.)

d. Load/verify RLS (E-memory address 2025-2032) valid for landmark

e. Load NOUN 78 as follows, with values voiced from the ground:

Key—

VERB 25 NOUN 78 ENTR
+xxxxx ENTR (nearest 0.01 deg, ν)
+xxxxx ENTR (nearest 0.01 deg, ρ)
+xxxxx ENTR (nearest 0.01 deg, OMICRON)

f. Load NOUN 79 (R2) with 0.5-deg deadband:

Key—

VERB 22 NOUN 79 ENTR
+50 ENTR

g. Load NOUN 89 as follows:

Key—

VERB 25 NOUN 89 ENTR
±xxxxx ENTR (nearest 0.001 deg, Lat)
±xxxxx ENTR (nearest 0.001 deg, Long/2)
±xxxxx ENTR (nearest 0.01 n.mi., altitude of LMK)

2. Upon FL VERB 51 in P24—

a) Key VERB 21 NOUN 1 ENTR
3374 ENTR
ENTR
to zero R61CNTR

b) Key VERB 44 ENTR to set SURFFLAG (FLAGWRD8, BIT 8)

c) Key—

VERB 1 NOUN 1 ENTR
107 ENTR

to observe condition of AZIMFLAG (FLGWRD11, BIT 8). If set, three-axis maneuver will be performed in R61. If cleared, a VECPOINT maneuver will be performed in R61. To change AZIMFLAG, Key—

VERB 25 NOUN 7 ENTR
107 ENTR
200 ENTR
x ENTR (where x = 1 for three-axis maneuver; x = 0 for VECPOINT maneuver)

d) Key—

VERB 25 NOUN 7 ENTR
75 ENTR
1020 ENTR
1 ENTR

to set TARG1FLG (FLAGWRD1, BIT 10) and TRACKFLG (FLAGWRD1, BIT 5)

3. Perform automatic maneuver to tracking attitude

4. Upon FL VERB 51 ("Please MARK")—

a. Place SC CONT switch in CMC
b. Place CMC MODE switch in FREE
c. Use MIC to center LMK in optics
d. Depress MARK button to take mark. (Depress MARK REJ to reject mark.)
e. To exit EMP 508 and P24, key VERB 37 ENTR xx ENTR. VERB 45 ENTR to reset SURFFLAG (if desired).

RECOVERY/ TERMINATION:

1. A restart will cause automatic tracking (R61) to be restarted incorrectly for use with EMP 508. Restart recovery is as follows:

a. Key VERB 37 ENTR 24 ENTR
b. Verify that OCDUs are valid. (See step 1c under PROCEDURES.)
c. Redo steps 2a, 2d, and, if necessary, 3 under PROCEDURES.)
d. At FL VERB 51, continue marking.

NOTE1.—A restart during the operation of EMP 508 results in a blank DSKY. (P24 remains in PROG registers.) A PROG Alarm 120 ("Optics torque request with optics not zeroed") can be ignored, since OCDUs were verified in step b.

NOTE2.—OCDUs will not count back up to the frozen optics angles after zeroing.

2. P24 should be exited by VERB 37 ENTR xx ENTR. (PRO response to FL VERB 51 does not effect normal exit.) Calling another program (Pxx) also restores flags specially configured by preliminary procedures —except SURFFLAG, which is reset by keying VERB 45 ENTR, if desired.

ERASABLE MEMORY: NA

UPLINK: NA

EMP 509: INHIBIT GIMBAL LOCK MONITOR DOWNMODING

PURPOSE:

EMP 509 provides a means of inhibiting T4RUPT coarse alignment of the IMU when there is a runaway CDUZ.

FUNCTIONAL DESCRIPTION:

EMP 509 causes GLOCKMON to believe program is in SATURN thrusting flight, bypassing downmoding of IMU into Coarse Align mode if $|CDUZ| > 85$ deg.

ASSUMPTIONS:

NA

RESTRICTIONS AND LIMITATIONS:

1. R30 (VERB 82) data will refer to CSM at latest permanent state-vector time only.
2. Any VERB 37 ENTR xx ENTR while AVERAGEG is running (P1x, P4x, P6x) will disable EMP 509.
3. All translations will cause RCS DAP to use LM-on filter gains.

   NOTE.—If CDU has failed, RCS DAP will not operate normally.

4. TVC DAP does not operate normally.
5. ENTRY programs do not operate normally (AVERAGEG will not be enabled).
6. VERB 46 should not be selected.
7. EMP 509 deactivates the automatic moding to coarse align at gimbal angles greater than 85 deg; maneuvering the vehicle into the area of a real gimbal lock will cause an IMU dump, with possible permanent damage to the IMU.

PROCEDURES:

To initiate EMP 509—

1. Key VERB 48 ENTR and load NOUN 46 (R1) to 3xxxx.
2. Key VERB 34 ENTR to terminate R03 (do not key PRO).

3. Key—

VERB 25 NOUN 7 ENTR

75 ENTR

1 ENTR

1 ENTR

to set AVEGFLAG bit (FLAGWRD1, BIT 1).

NOTE.—This procedure will not inhibit the GIMBAL LOCK light from coming on.

RECOVERY/ TERMINATION:

To disable EMP 509—

1. Key VERB 48 ENTR and load NOUN 46 (R1) with desired configuration.
2. Reset AVEGFLAG bit as follows:

Key—

VERB 25 NOUN 7 ENTR

75 ENTR

1 ENTR

ENTR

ERASABLE MEMORY:

NA

UPLINK:

NA

EMP 512: P40/41/47 TERMINATION DURING AVERAGEG WHEN EMP 509 IS OPERATING

PURPOSE:

EMP 512 allows P40/41/47 to be exited without causing a conflict with EMP 509, "Inhibit Gimbal Lock Monitor Downmoding."

FUNCTIONAL DESCRIPTION:

The normal P40/41/47 exit resets AVEGFLAG, but EMP 509 requires this flag to be set. EMP 512, therefore, prevents the resetting of AVEGFLAG but otherwise allows correct termination of P40/41/47 and AVERAGEG. VERBS 93 (resets RENDWFLG and ORBWFLAG) and 44 (sets SURFFLAG) are used to prevent W-matrix and LM state-vector integration respectively. Since READACCS, which calls SERVICER, is still active while AVEGFLAG is set, these integration times would allow more SERVICERs to be called before completion of AVETOMID. A significant number of these could result in VAC or CORESET overflow. (See Figure: EMP 512.)

ASSUMPTIONS:

1. AVERAGEG is operating.
2. EMP 509 is operating.
3. Thrusting maneuver is controlled manually.

RESTRICTIONS AND LIMITATIONS:

1. See EMP 509 RESTRICTIONS AND LIMITATIONS.
2. After EMP 512 has been loaded (see UPLINK), Entry programs and P20, P22, and P23 mark incorporation are proscribed.
3. EMP 512 should not be selected during thrusting.
4. W-matrix will be invalid and will be reinitialized before next used.

PROCEDURES:

Before ignition in P40 (do not PRO on FL VERB 99 NOUN 40) or after shutdown, at the FL VERB 16 NOUN 40, FL VERB 16 NOUN 85, or FL VERB 37, key—

NOTE.—In P41/47, perform Step 1 after AVERAGEG starts.

1. VERB 93 ENTR to reset RENDWFLG and ORBWFLAG.
2. VERB 44 ENTR (set SURFFLAG) to prevent LM state-vector integration.
3. VERB 5 NOUN 26 ENTR to verify data (see ERASABLE MEMORY):

R1	00001
R2	01520
R3	76067

4. VERB 31 ENTR to call EMP 512, which terminates AVERAGEG, updates the permanent state vector, and exits P40/41/47 to P00.
5. Observe 00 in PROG registers.
6. Key VERB 45 ENTR (reset SURFFLAG) to allow LM state-vector integration if desired.

RECOVERY/ TERMINATION:

EMP 512 is terminated and normal program flow reestablished as described under PROCEDURES. (See also RESTRICTIONS AND LIMITATIONS.)

Restarts

If PROG registers show new program, continue normal operation. If PROG registers still show 40/41/47, repeat procedures.

ERASABLE MEMORY:

EMP 512 coding is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	00001	00001
1017		2CADR	CHNGEXIT	01520
1020				76067
3520	CHNGEXIT	EXTEND		00006
3521		DCA	EXITCADR	31525
3522		DXCH	AVGEXIT	53062
3523		TCF	TASKOVER	15314
3524	EXITCADR	2CADR	EXITAVG	01526
3525				76067
3526	EXITAVG	CA	PRIO22	37644
3527		TC	PRIOCHNG	05176
3530		CA	ZERO	34772
3531		TS	MMNUMBER	55200
3532		TC	AVGEND	03100

UPLINK: P27 uplink for loading CMC erasable memory for EMP 512 is as follows:

Load 1	Load 2
V 71 E	V 71 E
5 E	15 E
1016 E	3520 E
1 E	6 E
1520 E	31525 E
76067 E	53062 E
V33 E	15314 E
	1526 E
	76067 E
	37644 E
	5176 E
	34772 E
	55200 E
	3100 E
	V33 E

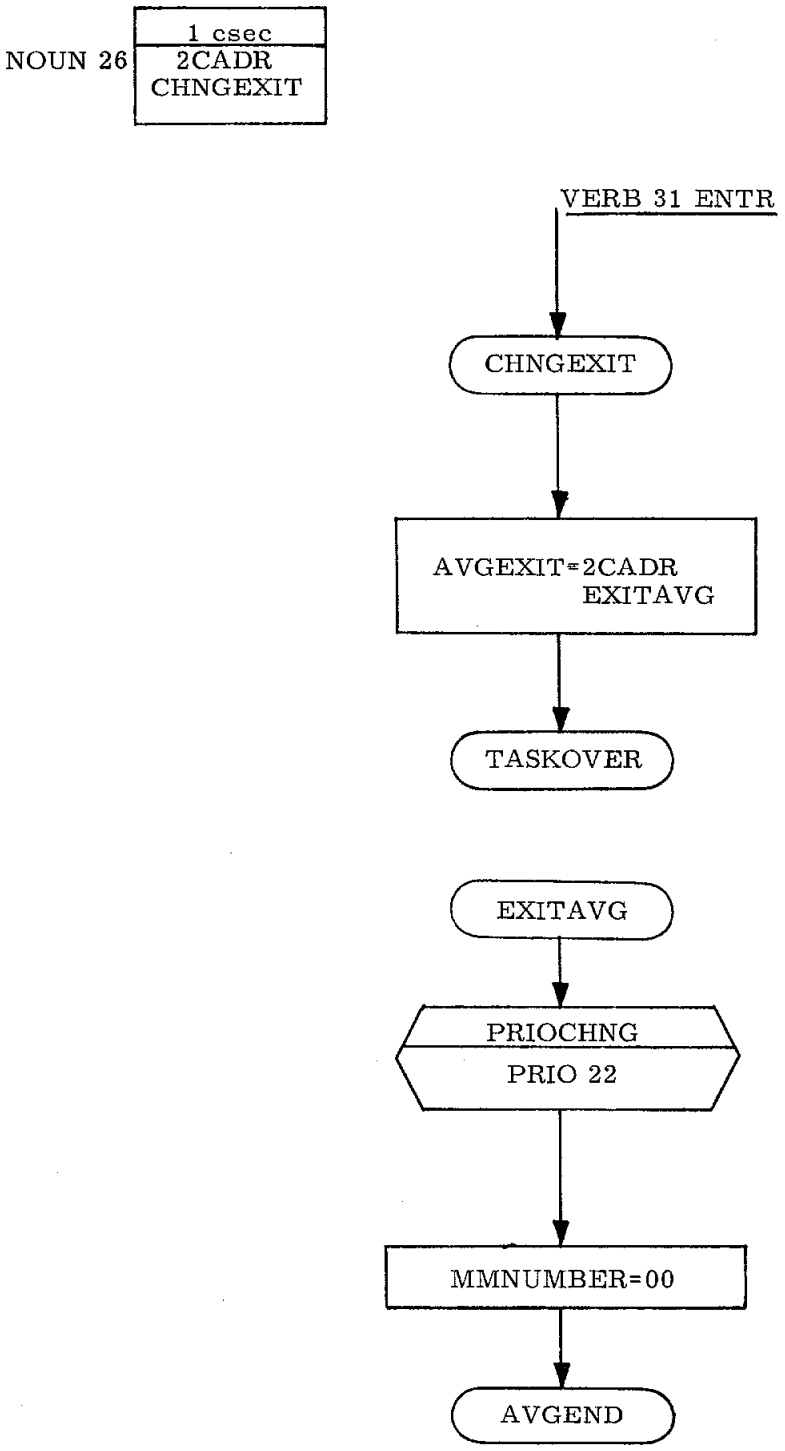

NOUN 26
1 csec
2CADR
CHNGEXIT
VERB 31 ENTR
CHNGEXIT
AVGEXIT=2CADR
EXITAVG
TASKOVER
EXITAVG
PRIOCHNG
PRIO 22
MMNUMBER=00
AVGEND

FIG: EMP 512

EMP 514: SHORTENED P23

PURPOSE:

Bypassing certain unnecessary displays, EMP 514 allows time and keystrokes to be saved during consecutive marks, in P23, on the same star-horizon combination.

FUNCTIONAL DESCRIPTION:

For the first mark on a given star-horizon combination, the crew follows normal P23 procedures (mark calibration if necessary, automatic acquisition of star-horizon, etc.). Then, before calling P23 for the second mark, the crew calls EMP 514, which inverts the state of REFSMFLG and immediately exits.

A cleared REFSMFLG allows the Sighting Mark Routine (R53) to be called immediately upon the crew's next calling P23—bypassing the star-horizon acquisition maneuver. Marking and mark processing follow the normal pattern. After the final mark on a given star-horizon, the crew again calls EMP 514 to invert (i.e., to set) REFSMFLG and restore normal P23 sequencing.

ASSUMPTIONS:

1. Before first call:
   a) REFSMFLG is set;
   b) the optics are pointing at the specified star-horizon;
   c) EMP 514 coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)
2. Before second call: the final mark for a given star-horizon has been taken and processed.

RESTRICTIONS AND LIMITATIONS:

1. With REFSMFLG cleared, any star-horizon acquisition must be done manually.
2. EMP 514 coding is nullified by the operation of P22, P32/P72, or P33/P73.

PROCEDURES:

1. For the first mark of a series of marks on a given star-horizon, perform normal P23 procedures except:

   a. At the FL VERB 37 display following FL VERB 06 NOUN 49, key VERB 5 NOUN 26 ENTR and verify:

      R1 10000
      R2 01444
      R3 14005

   b. Key VERB 30 ENTR to call EMP 514, which resets REFSMFLG (FLAGWRD3, Bit 13) and exits.
   c. Key KEY REL and observe return of FL VERB 37.

2. For the second mark on the same star-horizon, key 23 ENTR and observe immediate display of FL VERB 59.
3. Key in ENTR (assuming mark calibration has been done) and observe immediate display of FL VERB 51.
4. Proceed with normal procedures until all marks in the series have been taken and processed.
5. After the final mark on a given star-horizon, proceed to the end of P23; in response to FL VERB 37, key VERB 30 ENTR to call EMP 514, which now sets REFSMFLG and exits.
6. Key KEY REL and observe return of FL VERB 37. If marks are to be taken on a new star-horizon, repeat steps 1-5; otherwise, key xx ENTR, where xx is the desired CMC major mode. (See RESTRICTIONS AND LIMITATIONS.)
7. Key VERB 1 NOUN 1 ENTR 77 ENTR and verify that BIT 13 of R1 (REFSMFLG) is 1.

RECOVERY/
TERMINATION:

1. EMP 514 is not restart protected. Should a restart occur immediately after a VERB 30 ENTR, key VERB

1 NOUN 1 ENTR 77 ENTR and verify that BIT 13 of R1 (REFSMFLG) has the desired configuration (0 or 1). If not, key VERB 30 ENTR to recall EMP 514.

NOTE.—A restart occurring at the FL VERB 37 display in P23 results in a 21502 Alarm. To clear alarm, key RSET.

2. Because EMP 514 exits immediately after inverting REFSMFLG, no termination procedure is necessary other than to recall the program when finished marking on a given star-horizon.

3. Before calling another program after completing P23 mark taking, key—

VERB 1 NOUN 1 ENTR
77 ENTR

to check bit 13 of R1 (REFSMFLG) for the correct configuration (0 or 1).

ERASABLE
MEMORY:

Program coding for EMP 514 is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	10000	10000
1017		OCT	01444	01444
1020		OCT	14005	14005
2444		TC	INTPRET	06006
2445		INVERT	EXIT	77414
2446			REFSMFLG	01562
2447		TC	ENDOFJOB	05205

UPLINK: P27 uplink for loading CMC erasable memory for EMP 514 is as follows:

Either Load 1	Load 2	Or Load 3
V71E	V71E	V72E
5E	6E	17E
1016E	2444E	1016E
10000E	6006E	10000E
1444E	77414E	1017E
14005E	1562E	1444E
V33E	5205E	1020E
	V33E	14005E
		2444E
		6006E
		2445E
		77414E
		2446E
		1562E
		2447E
		5205E
		V33E

EMP 515: MANUAL RANGE INPUT

PURPOSE:

EMP 515 provides a means to manually input range data into the CMC in the event of a VHF ranging problem.

FUNCTIONAL DESCRIPTION:

After VERB 88 ENTR is executed to inhibit R22 from reading the VHF range, a future value of range in nautical miles is loaded into location RM via VERB 21 NOUN 2 ENTR. When the actual range nears the value loaded into RM, VERB 30 is keyed. The ENTR key is depressed when the range loaded in RM is reached to execute EMP 515. The time the actual range is reached will be determined by a "MARK" voice cue from the LMP or by monitoring the EMS range counter contents.

EMP 515 clears REFSMFLG to terminate R22, stores current time in MARKTIME, delays 5.12 seconds to allow time for R22 to terminate, and then restarts R22 to process the mark data.

ASSUMPTIONS:

VHF range data cannot be acquired automatically by the CMC.

RESTRICTIONS AND LIMITATIONS:

1. EMP 515 cannot be executed while R22 is processing a mark (optics or range).
2. Location 3703 cannot be reloaded until the last manual range mark is processed (Step 4 of PROCEDURES).
3. EMP 515 is overlayed by XSMD; therefore, the erasable program must be reloaded following the execution of P27, P40, P41, P52/P54 (options 2 or 4), or P52 for MINKEY plane change.

PROCEDURES:

1. Key VERB 88 ENTR to inhibit R22 VHF range processing.
2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 515:

R1	26001
R2	00306
R3	70067

3. Wait for R22 to complete processing of last mark. [NOUN 45 (R1) mark counter will be incremented when mark is incorporated.]
4. To load range into RM, key VERB 21 NOUN 2 ENTR
   3703 ENTR
   ±xxxxx ENTR (xxx.xx n.mi., future value of range, where $-163.83 \leq xxx.xx \leq +163.83$)

   NOTE.—To load ranges between 163.83 n.mi. and 327.68 n.mi., a negative value of range, computed as follows, must be loaded:
   Range (to be loaded) = Range (actual) -327.67 n.mi.
   If the actual range is 327.67 n.mi., -0 must be loaded. Ranges greater than 327.67 n.mi. cannot be used.

5. At a time prior to reaching the loaded range, key VERB 30.
6. At the time the actual range is reached, key ENTR to execute EMP 515.
7. To process another manual range mark, repeat steps 3-6.

RECOVERY/ TERMINATION:

EMP 515 is not restart protected. Depending upon where restart occurs, the following will result:

1. If R22 has started processing the mark, processing will continue normally.
2. If the restart occurs while REFSMFLG is off, P20 will terminate and the mark will be lost.

   To reenable P20:

   a. Set REFSMFLG (FLAGWRD3, BIT 13), key—

      VERB 25 NOUN 7 ENTR
      77 ENTR
      10000 ENTR
      1 ENTR

   b. Reselect P20.

ERASABLE MEMORY:

Program coding for EMP 515 is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	26001	26001
1017		OCT	306	306
1020		OCT	70067	70067
306		EXTEND		00006
307		DCA	TIME2	30025
310		DXCH	MARKTIME	53062
311		TC	DOWNFLAG	05561
312		ADRES	REFSMFLG	00057
313		CAF	BIT10	34757
314		TC	BANKCALL	04636
315		CADR	E/BKCALL	26036
316		CADR	DELAYJOB	01731
317		TC	UPFLAG	05547
320		ADRES	REFSMFLG	00057
321		TC	RANGERD1	02742

UPLINK: P27 uplink for loading CMC erasable memory for EMP 515 is as follows:

Load 1	Load 2
V71E	V71E
5E	16E
1016E	306E
26001E	6E
306E	30025E
70067E	53062E
V33E	5561E
	57E
	34757E
	4636E
	26036E
	1731E
	5547E
	57E
	2742E
	V33E

EMP 517: CONVERT OPTICS SHAFT AND TRUNNION ANGLES TO BODY ANGLES

PURPOSE:

In the event of immobile optics, EMP 517 provides a means of converting specified optics shaft and trunnion angles to equivalent body angles, which can be used for IMU realignments or for LM tracking in P20.

FUNCTIONAL DESCRIPTION:

With the specified shaft and trunnion angles in NOUN 94, the crew calls EMP 517 (via VERB 30 ENTR), which computes the corresponding body angles, loads them into NOUN 78, and exits. This EMP performs the same function as the SKYLARK R64 routine.

ASSUMPTIONS:

1. NOUN 94 contains the specified optics shaft and trunnion angles
2. EMP 517 coding has been uplinked via P27. (See ERASABLE MEMORY and UPLINK.)

RESTRICTIONS AND LIMITATIONS:

VERB 96 ENTR should be selected before EMP 517 is uplinked. Thereafter, programs and extended verbs should not be selected until operation of EMP 517 is completed.

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 517:

   R1 14001
   R2 00605
   R3 00000

2. Load NOUN 94 with specified shaft and trunnion angles:
   Key—

   VERB 24 NOUN 94 ENTR
   +xxxxx ENTR (R1, +xxx.xx deg, shaft)
   +xxxxx ENTR (R2, +xx.xxx deg, trunnion)

3. Key VERB 16 NOUN 78 ENTR to monitor computed body angles.
4. Key VERB 30 ENTR to call EMP 517; observe computed body angles in NOUN 78:

R1	±xxx.xx deg	gamma
R2	±xxx.xx deg	rho
R3	±xxx.xx deg	omicron

RECOVERY/
TERMINATION:

1. EMP 517 is not restart protected. If restart occurs during operation of EMP 517, FL VERB 37 will appear. Reinitiate via VERB 96 ENTR, VERB 30 ENTR.
2. EMP 517 is terminated upon completion of body angle computation.

ERASABLE MEMORY:

Program coding for EMP 517 is as follows:

ECADR	Tag	Code		Octal
1016	N26/PRI	OCT	14001	14001
1017		OCT	00605	00605
1020		OCT	00000	00000
0604		OCT	00000	00000
0605		TC	INTPRET	06006
0606		AXC,1		77760
0607			MRKBUF1	03722
0610		RTB		77634
0611			E/CALL	26055
0612			SXTNB	46000
0613		STODL	COSTH	14021
0614			COSTH+4	00025
0615		ASIN	DCOMP	57536
0616		STORE	UTPIT	03740
0617		RTB		77634
0620			E/CALL	26055
0621			ARCTAN	26614
0622		STORE	UTYAW	03742
0623		EXIT		77776
0624		TC	ENDOFJOB	05205

UPLINK: P27 uplink for loading CMC erasable memory for EMP 517 is as follows:

Load 1	Load 2
V71E	V71E
5E	23E
1016E	604E
14001E	E
605E	6006E
E	77760E
V33E	3722E
	77634E
	26055E
	46000E
	14021E
	25E
	57536E
	3740E
	77634E
	26055E
	26614E
	3742E
	77776E
	5205E
	V33E

EMP 518: RECOVERY FROM RESTART DURING PLANE CHANGE PULSE TORQUING

PURPOSE:

EMP 518 provides a means of achieving the desired stable-member orientation and the associated REFSMMAT should a restart occur during the MINKEY plane-change pulse-torquing procedures. EMP 518 applies whether the restart occurs during pulse torquing before or after the PC maneuver. In addition to recovery from the restart, EMP 518 provides a means of obtaining a precise alignment following restart recovery.

FUNCTIONAL DESCRIPTION:

Normally, the contents of XSMD are transferred into REFSMMAT at the end of MINKEY PC pulse torquing. XSMD contains the REFSMMAT computed for the stable member after torquing. Should a restart occur before the desired orientation has been achieved, however, pulse torquing stops and the XSMD-to-REFSMMAT transfer does not occur. Subject to RESTRICTIONS AND LIMITATIONS, recovery from this condition can be effected by first coarse aligning the IMU to the desired gimbal angles and then transferring XSMD into REFSMMAT via P27. Once this has been done, there are options available to the crew for obtaining a precise alignment, depending on the amount of time available and where the restart occurred (during the first or second pulse torquing).

ASSUMPTIONS:

Spacecraft orientation when coarse alignment angles were computed in P52 can be reestablished.

> NOTE.—The easiest way of satisfying this requirement is by maintaining SCS attitude hold (minimum deadband) throughout the plane-change alignments.

RESTRICTIONS AND LIMITATIONS:

1. See ASSUMPTIONS.
2. If a precise alignment is not performed before the burn, there could be a platform misalignment of as much as 1-2 deg, which could cause an error in the burn and the post-burn state vector. The in-plane velocity error for a 2-deg misalignment and a Δv of 100 ft/sec can be as much as 3.5 ft/sec, and the out-of-plane velocity error can be as much as 0.1 ft/sec.

PROCEDURES:

When restart occurs, FL VERB 50 NOUN 25 (R1, 00020) will reappear on the DSKY.

NOTE.—REFSMMAT contains the original (pre-torquing) basic-reference to stable member matrix. XSMD contains the desired (post-torquing) matrix.

1. Key VERB 41 NOUN 20 ENTR.
2. Observe FL VERB 21 NOUN 22

NOTE1.—NOUN 22 already contains the desired gimbal angles computed before the pulse torquing started.

NOTE2.—Spacecraft attitude should be as close to pre-pulse-torquing attitude as possible.

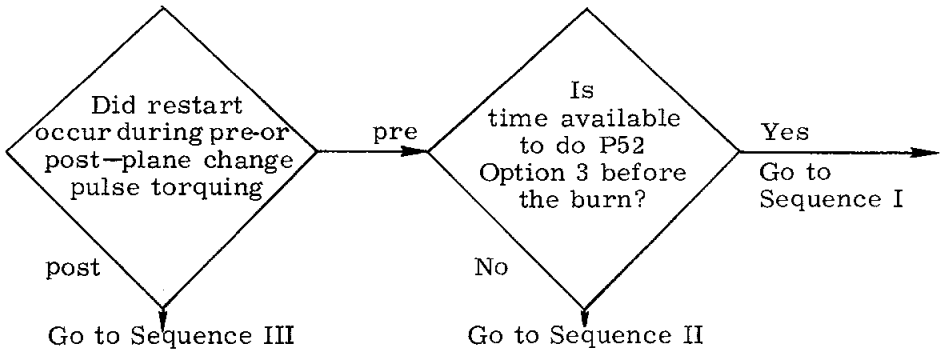
3. Key VERB 33 ENTR to coarse align to desired plane-change gimbal angles.
4. Observe VERB 41 on DSKY and NO ATT light on. Wait for return of FL VERB 50 NOUN 25 (R1, 00020).
5. Key VERB 40 ENTR to zero CDUs; observe NO ATT light off.
6. To change MODREG to zero to allow P27, key

VERB 21 NOUN 1 ENTR
1214 ENTR
ENTR

7. Transfer 18 registers of XSMD into REFSMMAT as follows:

   VERB 71 ENTR (observe 27 in PROG registers)
   24 ENTR
   1733 ENTR
   VERB 21 ENTR
   303 ENTR
   24 ENTR
   VERB 33 ENTR (observe 00 in PROG registers, although P52 is still the major mode)

8. In response to FL VERB 50 NOUN 25 (R1, 00020), key PRO to continue in MINKEY sequence.
9. Choose Sequence I, II, or III below.



SEQUENCE I: STAR ALIGNMENT BEFORE BURN. (RESTART DURING PRE-PLANE CHANGE PULSE TORQUING.)

10. At the first display in P40/P41 (entered automatically by MINKEY), key VERB 37 ENTR 52 ENTR and perform P52 Option 3 for a precise alignment.
11. At the completion of P52, key VERB 37 ENTR 40/41 ENTR to reselect P40/P41.
12. If LM performed the burn, key VERB 37 ENTR 76 ENTR and perform P76.
13. Execute EMP 520 to perform maneuver to track attitude and pulse torquing -45 deg and continue in MINKEY sequence.

SEQUENCE II: NO STAR ALIGNMENT BEFORE BURN. (RESTART DURING PRE-PLANE CHANGE PULSE TORQUING.)

10.	Continue in MINKEY sequence to the FL VERB 50 NOUN 25 (R1, 00020) display in the post-plane change P52.
11.	Key VERB 37 ENTR 52 ENTR to select P52.
12.	Perform P52 Option 1 alignment to XSMD.
13.	At the completion of P52 (FL VERB 37), key 33 ENTR to reselect MINKEY.

SEQUENCE III: RESTART DURING POST-PLANE CHANGE PULSE TORQUING.

10.	Upon MINKEY entrance to P33, key VERB 37 ENTR 52 ENTR and perform P52 Option 3 to obtain a precise alignment.
11.	At the completion of P52 (FL VERB 37), key 33 ENTR to reselect MINKEY.

RECOVERY/
TERMINATION: NA

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 520: ENTRANCE INTO MINKEY FOR POST-PLANE-CHANGE PULSE TORQUING

PURPOSE:

EMP 520 provides a means of entering the MINKEY sequence to perform the -45-deg post-plane-change pulse torquing should the MINKEY sequence be interrupted at any point after the +45-deg pre-plane-change pulse torquing. This EMP is also used in conjunction with Sequence I of EMP 518.

FUNCTIONAL DESCRIPTION:

AUTOSEQ flag is set to establish MINKEY sequencing; PCFLAG is reset to indicate second call to P52 for plane-change pulse torquing; and VERB 30 ENTR transfers control to the MINKEY sequence at the second call to P52.

ASSUMPTIONS:

The MINKEY sequence has been interrupted at some point after the +45-deg pulse torquing.

RESTRICTIONS AND LIMITATIONS:

NA

PROCEDURES:

1. Key VERB 37 ENTR 20 ENTR. Reselect option 4 if P20 has been permanently terminated or if 20 is in the PROG registers. (FL VERB 04 NOUN 06 will be displayed.)
2. Perform maneuver to track attitude if necessary (FL VERB 50 NOUN 18 will be displayed.)
3. To set AUTOSEQ (FLGWRD10, BIT 7), key

   VERB 25 NOUN 7 ENTR
   106 ENTR
   100 ENTR
   1 ENTR

4. To clear PCFLAG (FLGWRD10, BIT 1), key

   VERB 25 NOUN 7 ENTR
   106 ENTR
   1 ENTR
   ENTR

5. To load NOUN 26, key

   VERB 25 NOUN 26 ENTR
   13001 ENTR
   2632 ENTR
   10006 ENTR } fixed-memory address of P86CONT +4

6. To select MINKEY, key

   VERB 30 ENTR

7. Observe P52 in PROG registers. P52 will be entered automatically to perform pulse torquing -45 deg.
8. P52 is started at the normal MINKEY entry point, and nominal procedures should be exercised.

   If VHF navigation is desired, key

   VERB 87 ENTR

RECOVERY/
TERMINATION: NA

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 521: ENTER P51/P53 WITH IMU-OPERATE BIT FAILED OFF

PURPOSE:

EMP 521 provides a means of entering the IMU Orientation Determination Program (P51), or its backup (P53), when the IMU-operate bit has failed in the off state. (Channel 30, Bit 9 = 1.)

> NOTE.—To perform REFSMMAT determination (P51/P53) with unusable IMU, use EMP 503.

FUNCTIONAL DESCRIPTION:

EMP 521 bypasses only the very first part of P51/P53 (see Figure: EMP 521), that part which determines whether the IMU is on and operating (bit 9 of IMODES30).

ASSUMPTIONS:

1. IMU is inertial.
2. CDUs reflect vehicle attitude with respect to IMU.

RESTRICTIONS AND LIMITATIONS:

DAP- and IMU-failure warnings are inhibited.

PROCEDURES:

To initiate EMP 521, perform the following:

1. Key VERB 96 ENTR to clear all program activity.
2. To set MODREG to decimal 51 , key—

   VERB 21 NOUN 1 ENTR
   1214 ENTR
   63 ENTR

   to set MODREG to decimal 53 , key—

   VERB 21 NOUN 1 ENTR
   1214 ENTR
   65 ENTR

3. Key—

   VERB 25 NOUN 26 ENTR
   13001 ENTR
   3425 ENTR
   30005 ENTR } fixed-memory address of P51AA

to set up for the call to P51/P53 bypassing IMU-on check.

4. Key VERB 30 ENTR to start EMP 521 (and P51/P53).
5. Perform normal P51/P53 star sightings and procedure.

NOTE.—P51/P53 is activated when VERB 30 is selected in step 4, but the PROG registers will remain at 00 rather than displaying 51/53.

RECOVERY/
TERMINATION: Normal P51/P53 restart and termination procedures.

ERASABLE
MEMORY: NA

UPLINK: NA

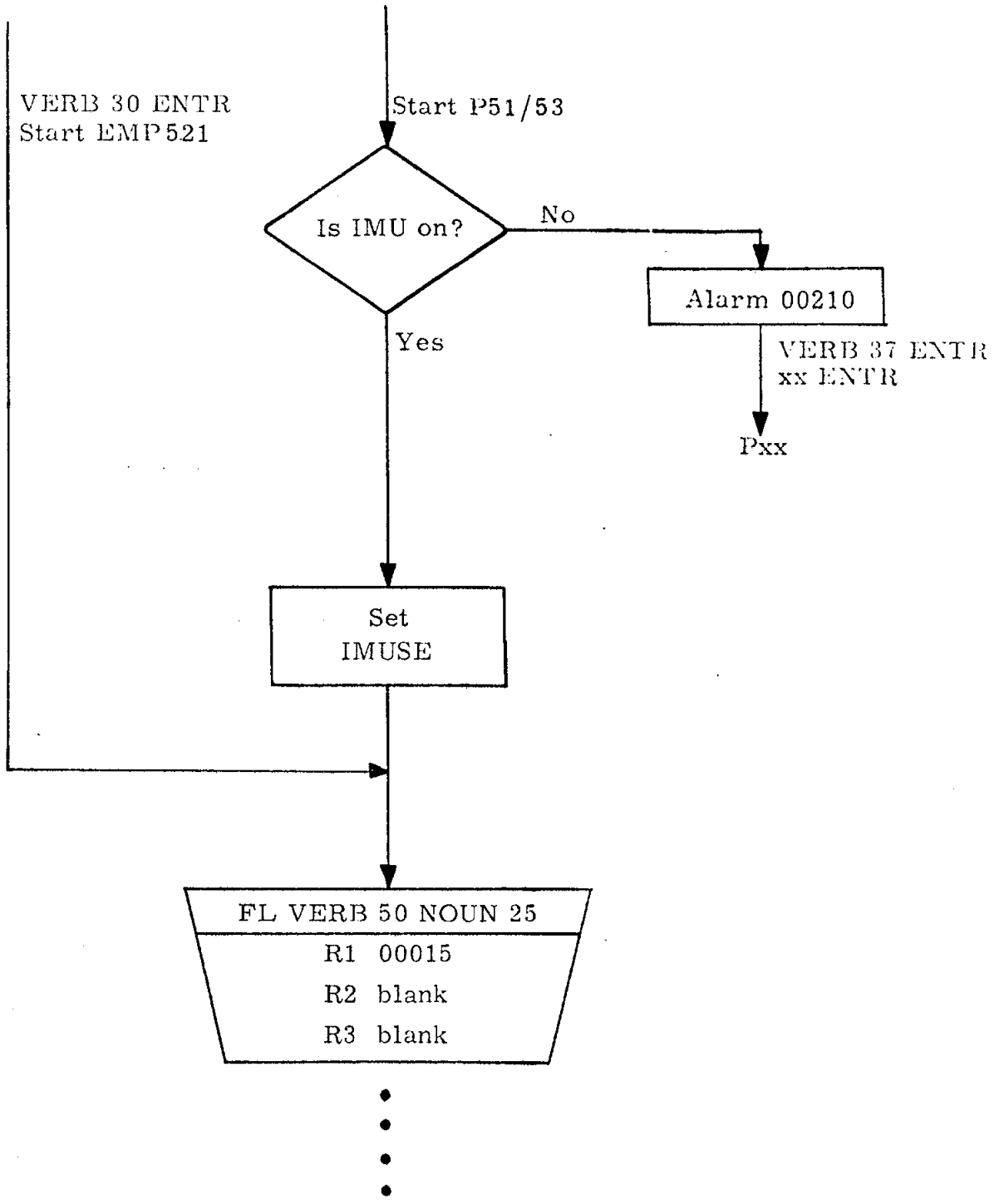

VERB 30 ENTR
Start EMP521
Start P51/53
Is IMU on?
No
Alarm 00210
VERB 37 ENTR
xx ENTR
Pxx
Yes
Set
IMUSE
FL VERB 50 NOUN 25
R1 00015
R2 blank
R3 blank

FIG: EMP 521

EMP 522: SPS GIMBAL DRIVE TEST

PURPOSE:

This EMP permits the SPS Gimbal Drive Test to be performed without calling P40.

FUNCTIONAL DESCRIPTION:

After loading certain erasables and NOUN 26 through the DSKY (see PROCEDURES), the crew calls EMP 522 via VERB 31 ENTR. The existing SPS Gimbal Drive Test Routine (S40.6) in P40 is immediately executed as a task. (See Figure 3.3.1 of R-577, Section 3 GSOP, Revision 14.)

ASSUMPTIONS:

1. Valid SPS engine-bell trim angles have been loaded via R03.
2. Checklist procedures for SPS engine gimbal use have been performed.

RESTRICTIONS AND LIMITATIONS:

This EMP should not be performed while in P40.

PROCEDURES:

1. To initialize erasable locations MRKRTMP and CNTR,key—

   VERB 25 NOUN 1 ENTR
   3044 ENTR
   1 ENTR
   ENTR
   ENTR

2. Key VERB 25 NOUN 26 ENTR

   1 ENTR
   2366 ENTR
   40066 ENTR } fixed-memory address of S40.6

3. Key VERB 31 ENTR to call EMP 522.
4. Monitor Gimbal Drive Sequence by reference to analog dials.
5. Key VERB 37 ENTR 00 ENTR to remove DAC commands, (zero CHAN 11, BITS 2, 8 and 11) after completion of gimbal drive test.

RECOVERY/
TERMINATION:

1. EMP 522 is not restart protected. If restart occurs during operation of EMP, redo steps 1, 3, and 4 of PROCEDURES.
2. EMP 522 is terminated upon completion of the PROCEDURES.

ERASABLE
MEMORY: NA

UPLINK: NA

EMP 523: MONITOR JET-ON FAILURE

PURPOSE:

EMP 523 provides a means of monitoring for jet-on failures and of activating the MASTER ALARM if a failure is detected.

FUNCTIONAL DESCRIPTION:

The DAP attitude errors are monitored once per second. If any error exceeds the DAP deadband (ADB) by more than a specified amount, the ISS warning (Channel 11 Bit 1) is turned on. The ISS warning activates the MASTER ALARM. The erasable cell VHFCNT is zeroed at the start of EMP 523 and incremented each pass to provide an indication to the ground that EMP 523 is active.

> NOTE.—The cell -XDEG (EC ADR 644) is to be loaded as the negative of the desired allowable excursion beyond the deadband. It is scaled B-1 rev. The value shown in this document is equivalent to approximately 1 degree.

ASSUMPTIONS:

1. Program coding has been uplinked.
2. CMC mode is AUTO or HOLD and the RCS DAP is active.

RESTRICTIONS AND LIMITATIONS:

1. If any VERB 37 major mode change or a restart occurs after EMP 523 coding is uplinked, VAC area 4 should be checked to ensure that the program code is intact.
2. EMP 523 operation does not survive a VERB 37 ENTR xx ENTR. It can be reselected (subject to RESTRICTION 1) via VERB 31 ENTR.
3. EMP 523 uses the same restart group as AVERAGEG and, therefore, should not be active during AVERAGEG.
4. EMP 523 should not be selected during P23 or P24 because of conflicting use of VHFCNT.
5. VHF marks must not be taken (Do not do VERB 87 during P20 options 0 or 4; do VERB 88 during MINKEY).
6. Automatic maneuvers may cause a false indication of a jet-on failure.

PROCEDURES:

1. The following preliminary procedures should be accomplished before executing EMP 523:

   a. CMC MODE—AUTO or HOLD
   b. SC CONT—CMC
   c. Turn on RCS DAP

2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 523:

   R1 00001
   R2 00605
   R3 00006

3. Key VERB 31 ENTR to call EMP 523.
4. Key VERB 16 NOUN 45 ENTR to verify operation of EMP 523:

   R1 xxByy where xx should be counting up to indicate EMP 523 active.

RECOVERY/ TERMINATION:

1. If the MASTER ALARM has been activated by this EMP, reset as follows:
   a. To reset Channel 11 Bit 1 (ISS Warning), key
      VERB 25 NOUN 7 ENTR
      11 ENTR
      1 ENTR
      ENTR
   b. Press to reset MASTER ALARM light.

   NOTE.—Bit 1 of Channel 11 will continually be set by EMP 523 as long as the attitude error exceeds the specified amount.

2. EMP 523 is restart protected.
3. EMP 523 is terminated by VERB 37 ENTR xx ENTR.
4. If it is desired to terminate EMP 523 during P20 without interrupting P20 tracking, the recommended procedure is to key
   VERB 37 ENTR 30 ENTR
   VERB 37 ENTR 20 ENTR

ERASABLE MEMORY:

Program coding for EMP 523 is as follows:

ECADR	Tag	Code		Octal
604		OCT	0	00000
605	JETCHECK	CA	7	30007
606		TS	VHFCNT	54771
607		TC	PHASCHNG	05402
610		OCT	05015	05015
611		OCT	77777	77777
612		CA	7	30007
613		TS	VAC4USE	54604
614	RECHECK	CS	ADB	41655
615		AD	-XDEG	60644
616		TS	L	54001
617		CA	TWO	34767
620	XSCHECK	TS	JETINDEX	54645
621		INDEX	JETINDEX	50645
622		CCS	ERRORX	11567
623		TC	+2	00625
624		TC	LOOPEND	00632
625		AD	L	60001
626		CCS	A	10000
627		TC	DINGDONG	00640
630		TC	LOOPEND	00632
631		TC	LOOPEND	00632
632	LOOPEND	CCS	JETINDEX	10645
633		TC	XSCHECK	00620
634	NOBELL	INCR	VHFCNT	24771
635		TC	FIXDELAY	05255
636		DEC	100	00144
637		TC	RECHECK	00614
640	DINGDONG	CAF	BIT1	34770
641		EXTEND		00006
642		WOR	DSALMOUT	05011
643		TC	NOBELL	00634
644	-XDEG	OCT	77643	77643*
645	JETINDEX	OCT	0	00000

*This octal value represents approximately 1 degree.

UPLINK: Uplink for loading EMP 523 code by P27 is as follows:

Load 1	Load 2	Load 3
V71E	V71E	V71E
24E	21E	5E
604E	626E	1016E
E	10000E	1E
30007E	640E	605E
54771E	632E	6E
5402E	632E	V33E
5015E	10645E	
77777E	620E	
30007E	24771E	
54604E	5255E	
41655E	144E	
60644E	614E	
54001E	34770E	
34767E	6E	
54645E	5011E	
50645E	634E	
11567E	*77643E	
625E	V33E	
632E		
60001E		
V33E		

*This octal value represents 1 degree.

EMP 525A: OPTICS SWITCH MONITOR

PURPOSE:

EMP 525A is used in the Rendezvous Marking sequence and prevents the switching of the TVC relay when Optics Mode Switch is placed in Manual.

FUNCTIONAL DESCRIPTION:

With C31FLWRD set to indicate CMC, no manual optics is available unless OPTIND is set to a minus one. This EMP monitors CHAN33 input and sets OPTIND accordingly.

ASSUMPTIONS:

1. Program coding has been uplinked.
2. The desired major mode has been selected.
3. Optics zeroing has been done. See note in step 3 of PROCEDURES.

RESTRICTIONS AND LIMITATIONS:

1. An attempt to start EMP 525A when not in P3X targeting program will result in OPR ERR illumination.
2. EMP 525A is not restart protected.
3. Self Test cannot be selected during the operation of this EMP.
4. This EMP must be reloaded after a Fresh Start and Self Test.

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 525A.

R1	00001	
R2	01772	Erasable-memory address of
R3	00003	of BEG

2. Key VERB 1 NOUN 1 ENTR
   374 ENTR
   R1 = AxxBx
3. Key VERB 21 NOUN 1 ENTR
   374 ENTR
   Axx1x ENTR
   to set C31FLWRD to CMC Optics Mode.

NOTE.—If Optics zeroing is required after this step has been performed, the following must be accomplished:
1) Switch Optics to ZERO
2) Load C31FLWRD with Axx0x
3) Prior to switching out of ZERO, restore C31FLWRD to Axx1x.

4. Key VERB 31 ENTR to call EMP 525A before going to Manual Optics in P3X targeting program.

RECOVERY/
TERMINATION:

EMP 525A is turned off by any VERB 37 ENTR xx ENTR, MINKEY mode changing, VERB 69 ENTR, or any software or hardware restart. EMP 525A can be reselected after any of these by keying VERB 31 ENTR.

When completed use of this EMP, load C31FLWRD with Axx0x. Note: Recognition of termination is that optics will not maintain manually attained position.

ERASABLE MEMORY:

Program coding for EMP 525A is as follows:

ECADR	Tag	Code		Octal
1365	START	CAF	BIT5	34764
1366		EXTEND		00006
1367		RAND	CHAN33	02033
1370		TC	+2	01372
1372		CCS	A	10000
1373		CAF	MINUS1	37702
1374		TS	OPTIND	55323
1375		TC	FIXDELAY	05255
1376		DEC	100	00144
1377		TC	START	01365
1772	BEG	CA	FLAGWRD1	30075
1773		MASK	TRACKBIT	74764
1774		CCS	A	10000
1775		TC	START	01365
1776		TC	FALTON	04362
1777		TC	TASKOVER	05314

UPLINK: Uplink for loading EMP 525A by P27 is as follows:

Load 1	Load 2	Load 3
V71E	V71E	V71E
5E	15E	10E
1016E	1365E	1772E
1E	34764E	30075E
1772E	6E	74764E
3E	2033E	10000E
V33E	1372E	01365E
	E	4362E
	10000E	5314E
	37702E	V33E
	55323E	
	5255E	
	144E	
	1365E	
	V33E	

EMP 526: IMU CDU TRANSIENT MONITOR

PURPOSE:

EMP 526 provides a means of restoring a CDU counter and of activating the MASTER ALARM and OPR ERR when a CDU transient has occurred. This EMP is not intended to operate during Rendezvous or on board navigation phases of the mission.

FUNCTIONAL DESCRIPTION:

Each CDU angle from 0.1 second previous is subtracted from its present value. If the magnitude of the result is greater than a specified amount,* the previous value is stored into the CDU counter and channel 11 is set as follows:

bit 01 = 1 ISS WARNING
bit 07 = 1 OPR ERROR
bit 11 = 1 if CDUX transient
bit 12 = 1 if CDUY transient
bit 15 = 1 if CDUZ transient

CDUZ, CDUY and CDUX are checked, in that order. EMP 526 will prevent COARSE ALIGN with actual yaw angles of 60 deg. or less, when a CDUZ transient occurs.

EMP 526 is initialized and enabled by VERB 31 ENTR and is connected to the downlink interrupt processing program by loading the register DNTMGOTO with the starting location of EMP 526. Since operation of this EMP is controlled by the downlink interrupt, a major mode change will not deactivate it (except as described in RECOVERY/ TERMINATION).

This EMP also increments the register VHFCNT every 0.1 second. Noun 45 can be displayed to confirm that the EMP is operating. (R1 is incrementing.)

---

* The register—NDEGS (ECADR 2511) is to be loaded as the negative of the desired CDU change threshold. It is scaled B-1 rev. The value shown in this EMP is equivalent to approximately 4 degrees.

Since EMP 526 is also operated by EMP 528, the OPR ERR light is lit in addition to the MASTER ALARM to distinguish a CDU transient from a jet-on failure. A jet-on failure, detected by EMP 528, will only turn on the MASTER ALARM.

ASSUMPTIONS:

1. Program coding has been uplinked
2. Downlink interrupts are received every 20 ms (high bit rate) or every 100 ms (low bit rate).
3. The W-matrix is invalid and will not be integrated.

RESTRICTIONS AND LIMITATIONS:

1. MINKEY, P20, options 0 and 4, P22, P23, P31, P32, P33, P36 or self-check are not operating.
2. VERB 74 ENTR or VERB 36 ENTR terminate this EMP. However, if a hardware restart (or VERB 69 ENTR) occurs after VERB 74 ENTR and before any VERB 37 ENTR xx ENTR the EMP will be restarted.
3. Gimbal angle errors as great as twice the magnitude of the angle chosen may result if a transient occurs.
4. This EMP is not restart protected during P11, P15, in the interval TIG-5 to ignition and in P40 from engine cut-off -6 to cut-off. A hardware restart (or VERB 69 ENTR) at these times will terminate this EMP.

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify that N26 is valid for EMP 526.

   R1 00001
   R2 01517
   R3 00005

2. Key VERB 31 ENTR to start EMP 526.

RECOVERY/ TERMINATION:

1. EMP 526 is terminated by restoring register DNTMGOTO with the downlink location and disengaging restart protection. This may be done in the following ways:

   a. VERB 74 ENTR followed by:
      VERB 37 ENTR xx ENTR.

(No wait required after VERB 74 ENTR.)

b. VERB 36 ENTR

c. VERB 21 NOUN 1 ENTR
334 ENTR
3454 ENTR,
followed by VERB 37 ENTR xx ENTR.

2. If it is desired to resume EMP 526 after it is terminated repeat PROCEDURES.

3. If the MASTER ALARM has been activated by this EMP, no program alarm will appear. Channel 11 indicateswhich CDU was affected. To determine which CDU was affected, key—

VERB 1 NOUN 10 ENTR
11 ENTR
Interpret R1 as follows:

4XXXX - CDUZ
5XXXX - CDUZ

X4XXX - CDUY
X5XXX - CDUY

X2XXX - CDUX
X3XXX - CDUX

X6XXX - CDUX and CDUY
X7XXX - CDUX and CDUY

To reset Channel 11 and ISS WARNING, key—
RSET
VERB 25 NOUN 7 ENTR
11 ENTR
46001 ENTR
ENTR
Reset MASTER ALARM

If OPR ERR cannot be cleared by RSET, a CDU runaway is in progress. The MASTER ALARM light can be shut off even though the alarm condition still exists but the OPR ERR light cannot.

5. If the MASTER ALARM has been activated by this EMP, IMU CDU ZERO should be performed as soon as possible to synchronize CDU counters. This EMP does not have to be disabled to perform IMU CDU ZERO (VERB 40 ENTR).

ERASABLE MEMORY:

Program coding for EMP 526 is as follows:

Initialization portion of EMP 526:

ECADR	TAG	CODE		OCTAL
2400	STARTV31	EXTEND		00006
2401		DCA	CDUX	30033
2402		DXCH	XSAVE	53513
2403		CA	CDUZ	30034
2404		TS	XSAVE +2	55514
2405		CA	ZERO	34772
2406		TS	528CTR	55370
2407		CA	TIME1	30025
2410		TS	TIME.R	55516
2411		CA	STARTLOC	31414
2412		TS	DNTMGOTO	54334
2413		TC	TASKOVER	05314
2414	STARTLOC	ADRES	START526	01372
2517		TC	STARTV31	01400*

* This location is modifed by EMP 528.

DOWNLINK operated portion of EMP 526:

ECADR	TAG	CODE		OCTAL
1372	START526	CA	EBANK5	35043
1373		TS	EBANK	54003
1374		TC	START	01415
2415	START	CCS	PHASE3	11162
2416		TC	+6	01424
2417		TC	PHASCHNG	05402
2420		OCT	07013	07013
2421		OCT	77777	77777
2422		2CADR	STARTV31	01400
2423				00005
2424		CS	TIME1	40025
2425		AD	TIME.R	61516
2426		CCS	A	10000
2427		COM		40000
2430		AD	OCT37776	67663
2431		AD	ONE	64770
2432		AD	-0.1SEC	61510
2433		CCS	A	10000
2434		TC	CHKCDU	01437
2435		TC	CHKCDU	01437
2436		TC	DNPHASE2	03454

```
2437  CHKCDU    CAF      TWO          34767
2440  LOOP      TS       IX           55515
2441            CA       IMODES33     31334
2442            MASK     BIT6         74763
2443            CCS      A            10000
2444            TC       OK           01462
2445            INDEX    IX           51515
2446            CA       CDUX         30032
2447            EXTEND                00006
2450            INDEX    IX           51515
2451            MSU      XSAVE        21512
2452            CCS      A            10000
2453            TC       +2           01455
2454            TC       OK           01462
2455            AD       -NDEGS       61511
2456            CCS      A            10000
2457            TC       BELLS        01475
2460            TC       OK           01462
2461            TC       OK           01462
2462  OK        INDEX    IX           51515
2463            CA       CDUX         30032
2464            INDEX    IX           51515
2465            TS       XSAVE        55512
2466  LOOP/CON  CCS      IX           11515
2467            TC       LOOP         01440
2470            CA       TIME1        30025
2471            TS       TIME.R       55516
2472            INCR     VHFCNT       24771
2473            INCR     528CTR       25370
2474            TC       DNPHASE2     03454
2475  BELLS     INDEX    IX           51515
2476            CA       ALARMX       31505
2477            TC       FALTON +1    04363
2500            INDEX    IX           51515
2501            CA       XSAVE        31512
2502            INDEX    IX           51515
2503            TS       CDUX         54032
2504            TC       LOOP/CON     01466
2505  ALARMX    OCT      02101        02101
2506            OCT      04101        04101
2507            OCT      40101        40101
2510  -0.1SEC   OCT      77765        77765
2511  -NDEGS    OCT      77224        77224*
2512  XSAVE
2515  IX
2516  TIME.R
```

* The value shown is approximately 4 degrees. Other values are:

77644=1 degree

77511=2 degrees

77356=3 degrees

UPLINK: Uplink for loading EMP 526 code by P27 is as follows:

Load 1	Load 2	Load 3	Load 4	Load 5
V71E	V71E	V71E	V71E	V72E
24E	24E	24E	24E	23E
2400E	2422E	2444E	2466E	2511E
6E	1400E	1462E	11515E	*77224E
30033E	5E	51515E	1440E	1372E
53513E	40025E	30032E	30025E	35043E
30034E	61516E	6E	55516E	1373E
55514E	10000E	51515E	24771E	54003E
34772E	40000E	21512E	25370E	1374E
55370E	67663E	10000E	3454E	1415E
30025E	64770E	1455E	51515E	1016E
55516E	61510E	1462E	31505E	1E
31414E	10000E	61511E	4363E	1017E
54334E	1437E	10000E	51515E	1517E
5314E	1437E	1475E	31512E	1020E
1372E	3454E	1462E	51515E	5E
11162E	34767E	1462E	54032E	2510E
1424E	55515E	51515E	1466E	77765E
5402E	31334E	30032E	2101E	2517E
7013E	74763E	51515E	4101E	1400E
77777E	10000E	55512E	40101E	V33E
V33E	V33E	V33E	V33E	

* Load:

77224E for 4 degree check
77356E for 3 degree check
77511E for 2 degree check
77644E for 1 degree check

EMP 527: MONITOR SINGLE IMU CDU

PURPOSE:

EMP 527 provides a means of restoring a particular IMU CDU counter and of activating the MASTER ALARM and OPR ERR when a CDU transient has occurred in the particular CDU. This EMP is intended for use during direct rendezvous.

FUNCTIONAL DESCRIPTION:

The designated CDU angle from 0.24 second previous (high bit rate) or 0.2 second (low bit rate) previous is subtracted from its present value. If the magnitude of the result is greater than 4 degrees, the previous value is stored into the CDU counter and channel 11 is set as follows:

bit 1 = 1, ISS WARNING
bit 7 = 1, OPR ERROR

If CDUZ is checked, EMP 527 will prevent COARSE ALIGN with actual yaw angles of 60 deg. or less, when a transient occurs.

EMP 527 is initialized and enabled by VERB 31 ENTR and is connected to the downlink interrupt processing program by loading the register DNTMGOTO with the starting location of EMP 527. Since operation of this EMP is controlled by the downlink interrupt, a major mode change will not deactivate it.

ASSUMPTIONS:

1. Program coding has been uplinked.
2. Downlink interrupts are received every 20 ms (high bit rate) or every 100 ms (low bit rate).

NOTE.—See Step 3 of PROCEDURES.

RESTRICTIONS AND LIMITATIONS:

1. P31, P32, P33, P36, P76 (in MINKEY, pre-TPI), self-check and P22 are not operating.
2. EMP 527 is not restart protected.
3. A hardware restart, VERB 69 ENTR, VERB 74 ENTR, or VERB 36 ENTR terminates EMP 527.

4. Gimbal angle errors as great as 8 degrees may result if a transient occurs.

5. Because this EMP operates from the telemetry interrupt, consideration must be given to the technique of switching bit rates in the CSM.

   When the CSM telemetry bit rate and the EMP are compatible, it is looking for an equivalent CDU rate of greater than 16.8 degrees/second during high bit rate and 20 degrees/second during low bit rate.

   When the CSM is in low bit rate but the EMP is set for high bit rate, then it is looking for an equivalent CDU rate of 3.3 degrees/second; adequate for transient detection, but close to realistic CDU rates which could unnecessarily trip the alarm.

   When the CSM is in high bit rate but the EMP is set for low bit rate, then it is looking for an equivalent CDU rate of 100 degrees/second, effectively disabling the transient detection.

   If continuous transient detection is essential, then when going from high to low bit rate location 1366 should be changed after the switch is thrown. Conversely when going from low to high bit rate location 1366 should be changed before the switch is thrown.

   If continuous transient detection is not essential it is probably easier to always modify location 1366 after throwing the switch.

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify that N26 is valid for EMP 527.

   R1 00001
   R2 01537
   R3 00005

2. Key VERB 31 ENTR to start EMP 527.

3. If it is desired to switch between high and low telemetry rates, location 1366_8 can be loaded by VERB 21 NOUN 1 ENTR 1366 ENTR xx ENTR

where xx is 01 - low bit rate

where xx is 13 - high bit rate

RECOVERY/
TERMINATION:

1. EMP 527 is not restart protected.
2. EMP 527 is terminated by a hardware restart, VERB 36 ENTR, VERB 69 ENTR or VERB 74 ENTR.
3. If it is desired to resume EMP 527 after it is terminated, repeat PROCEDURES.
4. If the MASTER ALARM has been activated by this EMP, no program alarm will appear.

   To reset Channel 11 and ISS WARNING, key

   RSET
   VERB 25 NOUN 7 ENTR
   11 ENTR
   1 ENTR
   ENTR
   Reset MASTER ALARM

   If OPR ERR cannot be cleared by RSET a CDU runaway is in progress. The MASTER ALARM light can be shut off even though the alarm condition still exists but the OPR ERR light can not.

5. If the MASTER ALARM has been activated by this EMP, IMU CDU ZERO should be performed as soon as possible to synchronize CDU counters. The EMP does not have to be disabled to perform IMU CDU ZERO (VERB 40 ENTR).

ERASABLE
MEMORY:

Program coding for EMP 527 is as follows:

Initialization portion of EMP 527:

ECADR	TAG		CODE	OCTAL
2537		CA	CDU?	3003X*
2540		TS	CDUSAVE	55367
2541		CA	OCT13E	31366
2542		TS	COUNTER	55370
2543		CA	527LOC	31546
2544		TS	DNTMGOTO	54334
2545		TC	TASKOVER	05314
2546	527LOC	ADRES	START	01772

Downlink operated portion of EMP 527:

ECADR	TAG		CODE	OCTAL
1772	START	CCS	COUNTER	11370
1773		TC	OUTX	01776
1774		CA	OCT13E	31366
1775		TC	CHKCDU	01372
1776	OUTX	TS	COUNTER	55370
1777		TC	DNPHASE2	03454
1372	CHKCDU	TS	COUNTER	55370
1373		CA	EBANK5	35043
1374		TS	EBANK	54003
1375		CA	IMODES33	31334
1376		MASK	BIT6	74763
1377		TC	CONT	01444
2532	BELLS	CA	ALARMX	31465
2533		TC	FALTON +1	04363
2534		CA	CDUSAVE	31367
2535		TS	CDU?	5403X*
2536		TC	DNPHASE2	03454
1366	OCT13E	OCT	00013	00013
1367	CDUSAVE	OCT	00000	00000
1370	COUNTER	OCT	00000	00000
2444	CONT	CCS	A	10000
2445		TC	OK	01461
2446		CA	CDU?	3003X*
2447		EXTEND		00006
2450		MSU	CDUSAVE	21367
2451		CCS	A	10000
2452		TC	+2	01454
2453		TC	OK	01461
2454		AD	-4DEGS	61464
2455		CCS	A	10000

```
2456                TC      BELLS       01532
2457                TC      OK          01461
2460                TC      OK          01461
2461    OK          CA      CDU?        3003X*
2462                TS      CDUSAVE     55367
2463                TC      DNPHASE2    03454
2464    -4DEGS      OCT     77224       77224
2465    ALARMX      OCT     00101       00101
```

*These locations must be changed to select the IMU CDU to be monitored.

X = 2, CDUX monitor

X = 3, CDUY monitor

X = 4, CDUZ monitor

UPLINK: Uplink for loading EMP 527 code by P27 is as follows:

Load 1	Load 2	Load 3	Load 4
V71E	V71E	V71E	V72E
24E	17E	14E	23E
2444E	2532E	1366E	1016E
10000E	31465E	13E	1E
1461E	4363E	E	1017E
*3003xE	31367E	E	1537E
6E	*5403xE	E	1020E
21367E	3454E	55370E	5E
10000E	*3003xE	35043E	1772E
1454E	55367E	54003E	11370E
1461E	31366E	31334E	1773E
61464E	55370E	74763E	1776E
10000E	31546E	1444E	1774E
1532E	54334E	V33E	31366E
1461E	5314E		1775E
1461E	1772E		1372E
*3003xE	V33E		1776E
55367E			55370E
3454E			1777E
77224E			3454E
101E			V33E
V33E			

*These locations must be changed to select the IMU CDU to be monitored.

X = 2, CDUX monitor
X = 3, CDUY monitor
X = 4, CDUZ monitor

EMP 528: MONITOR JET-ON FAILURE AND DO EMP 526

PURPOSE:

EMP 528 provides a means of monitoring for jet-on failures and of activating the MASTER ALARM if a failure is detected. EMP 528 also operates EMP 526 (IMU CDU TRANSIENT MONITOR) and is intended as a replacement for EMP 523 when both jet-on failure detection and CDU transient monitoring are desired.

FUNCTIONAL DESCRIPTION:

The DAP attitude errors are monitored once every second. If any error exceeds the DAP deadband (ADB) by more than a specified amount, the ISS WARNING (Channel 11 Bit 1) is turned on. The ISS WARNING activates the MASTER ALARM. EMP 528 is initialized and enabled by VERB 31 ENTR and is connected to the downlink interrupt processing program by loading DNTMGOTO with the starting address of EMP 528. Since operation of this EMP is controlled by the downlink interrupt, a major mode change will not deactivate it (except as described in RECOVERY/TERMINATION).

EMP 528 also initializes and operates EMP 526 which samples the CDU's every .1 second and turns on the MASTER ALARM plus the Operator Error light if a CDU change exceeds a specified amount. For details see EMP 526.

Provided that the CDU transient threshold angle (register -NDEGS in EMP 526) is set greater than 1.5 degrees (equivalent rate greater than 15 degrees per second), most failures should be distinguishable from CDU transients.

For a 35,000 lb. vehicle, assuming that jets A3, C4, B3, D4, A1, and C2 (or D1, B2) are the only ones enabled, a worst case (roll) jet-on failure can introduce an attitude rate greater than 10 degrees per second after 5 seconds from the failure, greater than 20 degrees per second after 25 seconds from the failure, and continuing to increase thereafter. If the jet-fail condition is not corrected before the specified CDU change threshold (register -NDEGS in EMP 526) is exceeded, a CDU transient will be erroneously detected, the OPR ERR turned on, and the CDU essentially frozen. With a frozen CDU the autopilot becomes ineffective in counteracting the failed-on jet. Jet-on failures in the pitch and yaw axes introduce attitude rates of about 1/3 those of the roll axis.

NOTE.—The cell -XDEG (ECADR 645) is to be loaded as the negative of the desired allowable excursion beyond the deadband for jet-on failure monitoring. It is scaled B-1 rev. The value shown in this document is equivalent to approximately 1 degree.

ASSUMPTIONS:

1. Program coding has been uplinked.
2. EMP 526 has been uplinked. See EMP 526.
3. CMC mode is AUTO or HOLD and the RCS DAP is active.
4. Downlink interrupts are received every 20 ms (high bit rate) or every 100 ms (low bit rate).
5. The W-matrix is invalid and will not be integrated.

RESTRICTIONS AND LIMITATIONS:

1. This EMP is intended and verified for use only in P00 and P20 options 2 and 5.
2. If a VERB 37 major mode change or a restart occurs following the uplink of EMP 528 coding and before VERB 31 ENTR, VAC area 4 should be checked to insure that the program code is intact.
3. The RESTRICTIONS and LIMITATIONS of EMP 526 apply.
4. Automatic maneuvers may cause a false indication of a jet-on failure.

PROCEDURES:

1. The following preliminary procedures should be accomplished before executing EMP 528:

   a. CMC MODE—AUTO or HOLD
   b. SC CONT—CMC
   c. Turn on RCS DAP

2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP 528:

   R1 00001
   R2 01522
   R3 00005

3. Key VERB 31 ENTR to call EMP 528.

RECOVERY/ TERMINATION:

1. If the MASTER ALARM has been activated by this EMP, and OPR ERR light is not on, a jet-on failure was detected. If OPR ERR light also is on, a CDU

transient was detected and Channel 11 indicates which CDU was affected. To display contents of Channel 11, key—

VERB 1 NOUN 10 ENTR
11 ENTR

Interpret R1 as follows:

4XXXX—CDUZ
5XXXX—CDUZ

X4XXX—CDUY
X5XXX—CDUY

X2XXX—CDUX
X3XXX—CDUX

X6XXX—CDUX and CDUY
X7XXX—CDUX and CDUY

To reset Channel 11 and MASTER ALARM, key
RSET
VERB 25 NOUN 7 ENTR
11 ENTR
46001 ENTR
ENTR
Reset MASTER ALARM.

NOTE.—Bit 1 of Channel 11 will continually be set as long as the DAP attitude error exceeds the specified amount.

Bits 1 and 7 (OPR ERR) of Channel 11 will continually be set as long as a CDU transient is present. If OPR ERR cannot be cleared by RSET, a CDU runaway is in progress. The MASTER ALARM light can be shut off even though the alarm condition still exists, but the OPR ERR light can not.

2. EMP 528 is terminated by restoring register DNTMGOTO to the downlink location and disengaging restart protection. This may be done in the following ways.

   a. VERB 74 ENTR followed by:
      VERB 37 ENTR XX ENTR (No wait required after VERB 74 ENTR.)
   b. VERB 36 ENTR
   c. VERB 21 NOUN 1 ENTR
      334 ENTR
      3454 ENTR
      followed by VERB 37 ENTR xx ENTR

3. EMP 528 may be terminated and EMP 526 continued by executing EMP 526 PROCEDURES.

ERASABLE
MEMORY:

Program coding for EMP 528 is as follows:

ECADR	TAG	CODE		OCTAL
604		OCT	00000	00000
605	528START	CS	528CTR	41370
606		AD	TEN	64355
607		CCS	A	10000
610		TC	NOBELL	00635
611		TC	+2	00613
612		TC	+1	00613
613		TS	528CTR	55370
614		TC	E6SETTER	04611
615		CS	ADB	41655
616		AD	-XDEG	60645
617		TS	L	54001
620		CA	TWO	34767
621	XSCHECK	TS	JETINDEX	54646
622		INDEX	JETINDEX	50646
623		CCS	ERRORX	11567
624		TC	+2	00626
625		TC	LOOPEND	00633
626		AD	L	60001
627		CCS	A	10000
630		TC	DINGDONG	00642
631		TC	LOOPEND	00633
632		TC	LOOPEND	00633
633	LOOPEND	CCS	JETINDEX	10646
634		TC	XSCHECK	00621
635	NOBELL	CA	EBANK5	35043
636		TS	EBANK	54003
637		CA	ZERO	34772
640		TS	VAC4USE	54604
641		TC	START*	01415
642	DINGDONG	CAF	BIT1	34770
643		TC	FALTON+1	04363
644		TC	NOBELL	00635
645	-XDEG	OCT	77643	77643
646	JETINDEX	OCT	00000	00000
647	528LOC	ADRES	528START	00605
2517		CA	526LOC	31524
2520		TS	STARTLOC*	55414
2521		TC	STARTV31*	01400
2522		CA	528LOC	30647
2523		TC	-3	01520
2524	526LOC	ADRES	START526	01372
1370	528CTR			

* These locations are in EMP 526.

UPLINK: Uplink for loading EMP 528 code by P27 is as follows:

LOAD 1	LOAD 2	LOAD 3
V71E	V71E	V72E
24E	24E	23E
604E	626E	2517E
E	60001E	31524E
41370E	10000E	2520E
64355E	642E	55414E
10000E	633E	2521E
635E	633E	1400E
613E	10646E	2522E
613E	621E	30647E
55370E	35043E	2523E
4611E	54003E	1520E
41655E	34772E	2524E
60645E	54604E	1372E
54001E	1415E	1016E
34767E	34770E	1E
54646E	4363E	1017E
50646E	635E	1522E
11567E	77643E	1020E
626E	E	5E
633E	605E	V33E
V33E	V33E	

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