

R-693

**GUIDANCE SYSTEM OPERATIONS PLAN
APOLLO SOYUZ TEST PROJECT
USING PROGRAM SKYLARK 1**

**SECTION 7 ERASABLE MEMORY PROGRAMS
REV. 02**

October 1974



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FOR APOLLO/SOYUZ TEST PROJECT MISSION
USING PROGRAM SKYLARK 1

SECTION 7 ERASABLE MEMORY PROGRAMS
REV. 02

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-693

Title: For Apollo/Soyuz Test Project
Mission Using Program Skylark 1

Section 7

Title: Erasable Memory Programs
(Revision 02)

Revision 01

Replaced SL-51 "Generalized Rotational
Rate Generator" with SL-51 (Rev. 1)
"Generalized Rotational Rate Generator".

Revision 02

Reissue of Section 7 for Apollo/Soyuz Test
Project Mission.

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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 computer used in the command module (CMC) program SKYLARK 1.

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.

NOTE 3.—If an EMP is to be recalled all procedures should be repeated, unless the EMP specifically gives alternate procedures for recalling the EMP.

NOTE 4.—Under RESTRICTIONS & LIMITATIONS the restriction in the use of self-check also includes V91 (BANKSUM). (See GSOP Section 1 of R-577.)

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 upon 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

$xx_8 = \text{JOB Priority}$

$y = 1$ designates a VAC JOB;

$y = 0$ designates a NOVAC JOB.

$R2 = xxxxx_8$

where

$xxxxx_8$ is the JOB starting address

$R3 = \text{xxxxx}_8$

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:

$R1 = \text{xxxxx}_8$ cs delay
 $R2 = \text{xxxxx}_8$ starting address
 $R3 = \text{xxxxx}_8$ 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	}	F-bank 43_8
S-bank 4		
E-bank 7		

Example 2

BBCON = 66063_8

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

Example 3

BBCON = 02006_8

F-bank 01
S-bank unnecessary
E-bank 6

Coding for EMPs can be loaded into VAC areas. These erasable registers are assigned by the AGC Executive when a job (fixed or erasable memory) requires scratch storage for vector arithmetic. To reserve a VAC area its first register is set to zero. A Fresh Start, Restart or Major Mode change will set the first register of each VAC area to its erasable memory address, making it available for assignment to a job. Hence, if a large amount of job activity takes place after a Fresh Start, Restart or Major Mode change, it is possible that the EMP code loaded into a VAC area could be overwritten. EMP SL-52 provides a means of determining whether or not EMP coding previously loaded into a VAC area is still intact.

DOWNLINK

Listed below are the EMP's and the particular downlist transmitted during the operation of each EMP.

<u>EMP</u>		<u>Downlist</u>
SL-1		Rendezvous and Prethrust List
SL-2		Any
SL-3		Coast and Align List
SL-4		Rendezvous and Prethrust List
SL-5	P20	Rendezvous and Prethrust List
	P5x	Coast and Align List
SL-6		Rendezvous and Prethrust List
SL-9		Any
SL-15		Rendezvous and Prethrust List
SL-21		Coast and Align List
SL-22		Any
SL-23		Any but Powered List
SL-26		Any but Rendezvous & Prethrust List
SL-27		Any
SL-28		Coast and Align List
SL-50		Coast and Align List
SL-52		Any
SL-55	P00	Coast and Align List
ASTP-75		Any
ASTP-77		Coast and Align List

EMP SL-1: RECOVER ANGLE PHI AT T_D

PURPOSE: EMP SL-1 provides a means for recovering the elevation angle ϕ in NOUN 77 if Skylark Anomaly SKY-001 has occurred, i.e., computation of ϕ_{t_D} is bypassed.

FUNCTIONAL DESCRIPTION: PHICOMP is a fixed memory routine used to compute ϕ . It is normally called as a job by routine PHIJOB at the optimization time t_D . NOUN 26 is loaded with the priority of PHIJOB and the address of PHIJOB + 3. Thus, when VERB 30 is selected, PHICOMP computes ϕ for t_D , (regardless of the present time), clears SNAPFLAG, and terminates via ENDJOB.

ASSUMPTIONS:

1. R27 optimization interval has been entered for the time t_D .
2. The crew has boresighted the SXT at t_D .
3. The anomaly has occurred: the code -00001 in R3 of NOUN 77 has not been overwritten with ϕ_{t_D} by the time $t_D + 10$ sec.

RESTRICTIONS AND LIMITATIONS:

1. Activation via VERB 30 ENTR not before $t_D + 10$, and not after $t_D + 85$ sec.
2. A prethrust computation cycle will delay execution of EMP SL-1.
3. A restart during any computation of ϕ_{t_D} may result in an error in the angle ϕ_{t_D} due to the CDU snapshot following the restart. (See SKYLARK Anomaly SKY-002.)

PROCEDURES:

1. Key:
VERB 25 NOUN 26 ENTR
27001 ENTR
2410 ENTR } fixed-memory address
60002 ENTR } of PHIJOB + 3
2. After $t_D + 10$ sec, key
VERB 30 ENTR

RECOVERY/
TERMINATION: NA

ERASABLE
MEMORY: NA

UPLINK: NA

EMP SL-2: SOFTWARE RESTART

PURPOSE: EMP SL-2 provides a means of causing a software restart by keying VERB 31 ENTR.

FUNCTIONAL DESCRIPTION: EMP SL-2 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
2055 ENTR } fixed memory address of
16000 ENTR } MKABORT
2. To affect 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 SL-3: GDC REFSMMAT DETERMINATION

PURPOSE: EMP SL-3 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 SL-3 complements EMPs SL-4 and SL-6 for performing rendezvous navigation with a failed IMU. No mission performance testing has been performed with this sequence.

NOTE2.—To perform REFSMMAT determination with failed IMU-OPERATE discrete failed off, use EMP SL-21.

FUNCTIONAL DESCRIPTION: EMP SL-3 bypasses only the very first part of P51/P53 (see Figure: EMP SL-3), 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:

1. Inertial reference established by EMP SL-3 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.
2. Because the IMU is unusable, the AUTO and ATT. HOLD modes of the CSM-alone and Docked RCS DAPs will be inoperative. The FREE mode of the CSM-alone and Docked DAPs, however, can be used.

PROCEDURES: To initiate EMP SL-3, perform the following:

1. Preliminary
 - a. Key VERB96 ENTR to clear all program activity.

- b. To set MODREG to decimal 51, key—

VERB 21 NOUN 1 ENTR

1204 ENTR

63 ENTR

- to set MODREG to decimal 53, key—

VERB 21 NOUN 1 ENTR

1204 ENTR

65 ENTR

- c. Key—

VERB 25 NOUN 26 ENTR

13001 ENTR

3266 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 SL-3 (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.

NOTE.—Should a restart occur, the PROG
registers will change to 51/53.

ERASABLE
MEMORY:

NA

UPLINK:

NA

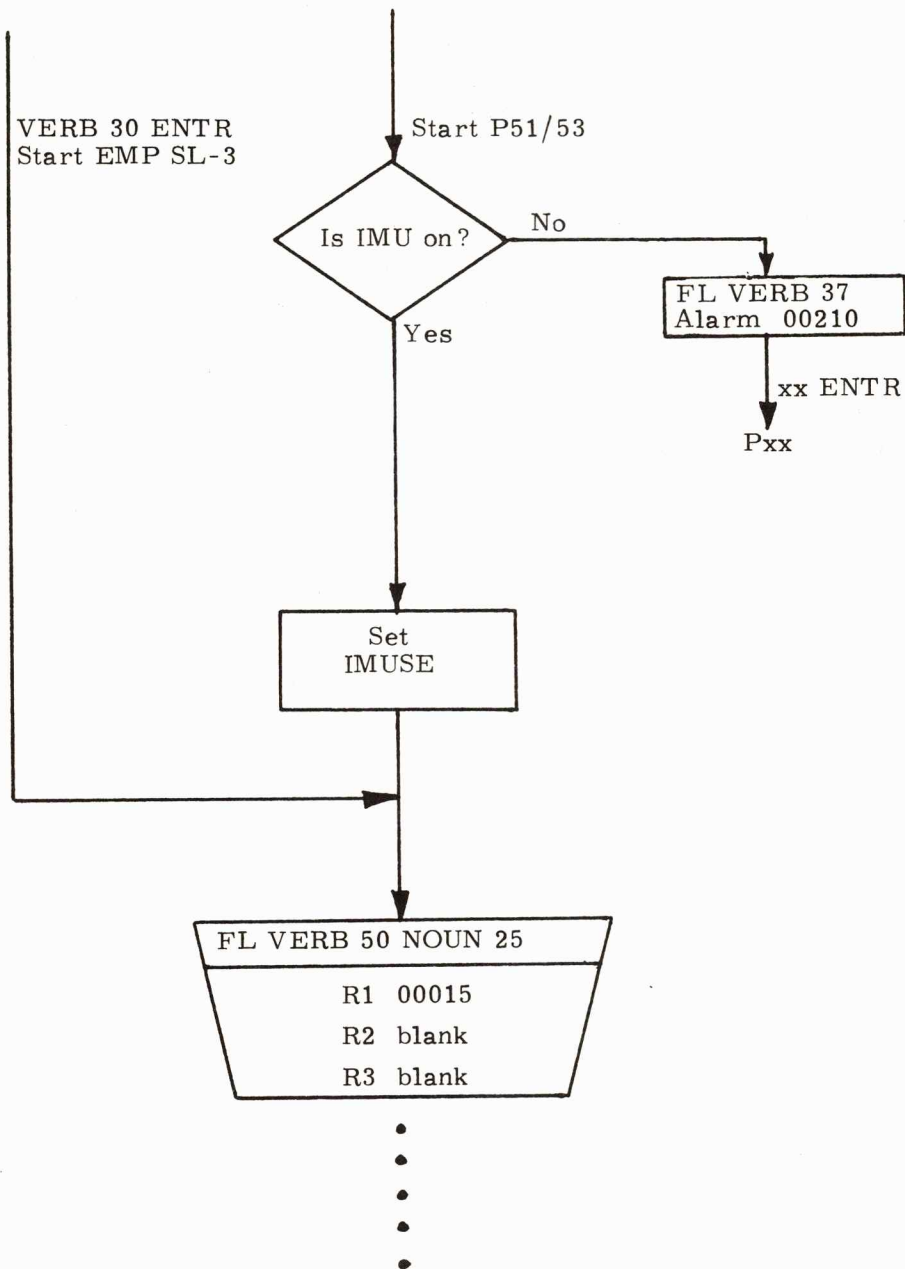


FIG: EMP SL-3

EMP SL-4: BACKUP OPTICS VARIANCE

PURPOSE: EMP SL-4 compensates for increased uncertainty when processing optics data obtained with a degraded ISS or OSS by using ALTVAR in place of SXTVAR in R22.

FUNCTIONAL DESCRIPTION: 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. Since ALTVAR is the variance used for COAS marks, clearing R21MARK (indicating COAS marking) forces ALTVAR to be used in place of SXTVAR when processing optics marks. Since R21MARK is cleared, MARKREJ causes FL VERB 51 to appear. Using VERB 86 ENTR the normal COAS mark reject procedure avoids the FL VERB 51.

NOTE.—EMP SL-4 complements EMPs SL-3 and SL-6 for performing rendezvous navigation with a failed IMU. No mission performance testing has been performed with this sequence.

ASSUMPTIONS:

1. SXT or SCT usable—may be immobile (if good IMU)
2. Good OCDUs
3. Good MARK button or use EMP SL-5.

RESTRICTIONS AND LIMITATIONS: If EMP SL-4 is being used as complementary program to EMP SL-3 (failed IMU), spacecraft attitude during marking must be the same as that used in EMP SL-3 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
1326 ENTR
31223 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 if desired 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 SL-5: MARK TAKING WITH A MARK/MARK REJ

INPUT CHANNEL BIT FAILURE

PURPOSE: EMP SL-5 provides a general-purpose mark taking routine for use when the MARK/MARK REJ input channel bit has failed. Bit 6 of channel 16 is the mark bit and bit 7 of channel 16 is the mark reject bit.

FUNCTIONAL DESCRIPTION: Normal program procedures are completed up to point when marking normally takes place (FL VERB 51 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 SL-5 is called when (see PROCEDURES) failure has occurred in the MARK input channel and all other optics functions are working properly.

RESTRICTIONS AND LIMITATIONS:

1. If the MARK or MARK REJ channel bit has failed intermittently on, then neither regular marking nor execution of EMP SL-5 can be relied on.
2. Refer to the following matrix for EMP SL-5 contingencies under combination MARK/MARK REJ fail conditions:

	MARK REJ bit valid or Failed Off	MARK REJ bit Failed On
MARK bit Failed Off	Use EMP SL-5 from NAV DSKY	EMP SL-5 cannot be used
MARK bit 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 or P20 option 0 or 4).

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

1 ENTR	
2151 ENTR	} fixed-memory address
16067 ENTR	

NOTE.—The CDU transient-detection test (1218 PROG alarm) is less effective in EMP SL-5 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 SL-5 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 SL-5 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 SL-6: DSKY DISPLAY OF VHF RANGE DURING P37

PURPOSE: EMP SL-6 provides a means of displaying VHF range on the DSKY during Rendezvous Final Phase Program (P37).

NOTE.—EMP SL-6 complements EMPs SL-3 and SL-4 for performing rendezvous navigation with a failed IMU. No mission performance testing has been performed with this sequence.

FUNCTIONAL DESCRIPTION:

EMP SL-6 enables either R27 (VHF Range Rate Mark Processing Routine) or R22 (Rendezvous Tracking Data Processing Routine). These routines read VHF Range counter, thus allowing the raw range data stored in RM to be monitored.

ASSUMPTIONS:

1. P20 (option 0 or 4) operating
2. VHF locked on **Soyuz Vehicle**
3. Either VHF range mark processing is enabled in R22 (by VERB 87 ENTR) or R27 is enabled (by VERB 76 ENTR or by manually setting R27FLAG).

RESTRICTIONS AND LIMITATIONS:

1. If VERB 87 ENTR has been keyed, state vector updating by VHF range data is allowed. Range display will change about once per minute.
2. If R27 is enabled, the range display will change about once every 5 seconds.
3. 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.

PROCEDURES:

To initiate EMP SL-6 enable R27 or R22 by performing either step 1 or 2.

1. If R27 has not been enabled prior to MINKEY selection of P37, R27 must be enabled by setting R27FLAG manually.

Key

VERB 25 NOUN 7 ENTR

107 ENTR

4000 ENTR

1 ENTR

to set R27FLAG (FLGWRD11, BIT 12).

2. To enable VHF range marking in R22, key VERB 87 ENTR.
3. To initiate VHF range display of erasable memory location RM,
key VERB 16 NOUN 2 ENTR
3663 ENTR or
VERB 16 NOUN 76 ENTR
4. Observe VHF range
R1, xxx.xx n.mi

NOTE.—If $R1 < 0$, range =
 $327.67 - |R1|$. Range is displayed
modulo 327.68 n.mi.

RECOVERY/
TERMINATION:

1. To disable EMP SL-6:
Key VERB 88 ENTR to disable VHF marking.
Key VERB 77 ENTR to disable R27.
2. If restart occurs, repeat steps 3 and 4 of procedures.

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP SL-9: INHIBIT GIMBAL LOCK MONITOR DOWNMODING

PURPOSE: EMP SL-9 provides a means of inhibiting T4RUPT coarse alignment of the IMU when there is a runaway CDUZ.

FUNCTIONAL DESCRIPTION: EMP SL-9 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 SL-9.
3. All translations will cause CSM-alone DAP to use LM-on filter gains.

NOTE1.—If CDU has failed, CSM-alone DAP and Docked 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. If the CSM-alone DAP is to run while SL-9 is in effect, the CSM-alone DAP should be loaded and turned on before the SL-9 procedures are performed.

NOTE.—VERB 45, however, can be selected while SL-9 is in effect i.e., a switchover from CSM-alone to Docked DAP can be performed while SL-9 is in effect. Also the docked deadband can be changed by an execution of VERB 44 followed by a VERB 45 ENTR.

7. EMP SL-9 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 SL-9—

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 SL-9—

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 SL-15: MANUAL RANGE INPUT

PURPOSE: EMP SL-15 provides a means to manually input range data into the CMC for state vector updates by R22 in the event of a VHF ranging problem.

NOTE.—No mission performance testing has been performed with this EMP.

**FUNCTIONAL
DESCRIPTION:**

After VERB 88 ENTR is executed to inhibit R22 from reading the VHF range and VERB 77 ENTR is executed to inhibit R27, 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 SL-15. The time the actual range is reached will be determined by monitoring the EMS range counter contents.

EMP SL-15 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 (at RANGERD1) to process the mark data.

ASSUMPTIONS:

1. VHF range data cannot be acquired automatically by the CMC.
2. Program coding has been uplinked.

**RESTRICTIONS
AND LIMITATIONS:**

1. EMP SL-15 cannot be executed while R22 is processing a mark (optics or range) or while R27 is operating.
2. Location 3663 cannot be reloaded until the last manual range mark is processed (Step 5 of PROCEDURES).
3. EMP SL-15 is overlaid by XSMD; therefore, the erasable program must be reloaded following the execution of P27, P40, P41, P52/P54 (options 1 or 2), or P52 for MINKEY plane change.

PROCEDURES:

1. Key VERB 88 ENTR to inhibit R22 VHF range processing.

2. Key VERB 77 ENTR to inhibit R27 VHF range processing.
3. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP SL-15:

R1 26001
R2 00306
R3 70067

4. Wait for R22 to complete processing of last mark.
[NOUN 45 (R1) mark counter will be incremented when mark is incorporated.]
5. To load range into RM, key VERB 21 NOUN 2 ENTR
3663 ENTR
±xxxxx ENTR (xxx.xx n.mi., future value of range,
where $-163.83 \leq \text{xxx.xx} \leq +163.83$)

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. must be loaded
modulo 327.68 n.mi.

6. At a time prior to reaching the loaded range, key VERB 30.
7. At the time the actual range is reached, key ENTR to execute EMP SL-15.
8. To process another manual range mark, repeat steps 4-7.

RECOVERY/
TERMINATION:

EMP SL-15 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 examine REFSMFLG, key VERB 1 NOUN 1 ENTR, 77 ENTR

If BIT 13 = 0, 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 SL-15 is as follows:

<u>ECADR</u>	<u>Tag</u>		<u>Code</u>	<u>Octal</u>
1016	N26/PRI	OCT	26001	26001
1017		OCT	306	306
1020		OCT	70067	70067
306		EXTEND		00006
307		DCA	TIME2	30025
310		DXCH	MARKTIME	53116
311		TC	DOWNFLAG	07722
312		ADRES	REFSMFLG	00057
313		CAF	BIT10	34770
314		TC	BANKCALL	04647
315		CADR	E/BKCALL	24000
316		CADR	DELAYJOB	01731
317		TC	UPFLAG	07710
320		ADRES	REFSMFLG	00057
321		CA	RETURN	30324
322		TS	RREADRET	54363
323		TC	RANGERD1	03363
324	RETURN	OCT	70700	70700

UPLINK:

P27 uplink for loading CMC erasable memory for EMP SL-15
is as follows:

<u>Load 1</u>	<u>Load 2</u>
V71E	V71E
5E	21E
1016E	306E
26001E	6E
306E	30025E
70067E	53116E
V33E	7722E
	57E
	34770E
	4647E
	24000E
	1731E
	7710E
	57E
	30324E
	54363E
	3363E
	70700E
	V33E

EMP SL-21: ENTER P51/P53 WITH IMU-
OPERATE BIT FAILED OFF

PURPOSE: EMP SL-21 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 SL-3.

FUNCTIONAL DESCRIPTION: EMP SL-21 bypasses only the very first part of P51/P53 (see Figure: EMP SL-21), that part which determines whether the IMU is on and operating (bit 9 of IMODES30).

ASSUMPTIONS: 1. IMU is inertial.

NOTE.—If the IMU-operate bit has failed, checklist procedures should be performed to enable IMU failure and RCS DAP.

2. CDUs reflect vehicle attitude with respect to IMU.

RESTRICTIONS AND LIMITATIONS: NA

PROCEDURES: To initiate EMP SL-21, 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
1204 ENTR
63 ENTR

to set MODREG to decimal 53 , key—

VERB 21 NOUN 1 ENTR
1204 ENTR
65 ENTR

3. Key—

VERB 25 NOUN 26 ENTR

13001 ENTR

3266 ENTR	}	fixed-memory address
30005 ENTR		of P51AA

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

4. Key VERB 30 ENTR to start EMP SL-21 (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.

NOTE.—Should a restart occur the PROG registers will change to 51/53.

ERASABLE
MEMORY:

NA

UPLINK:

NA

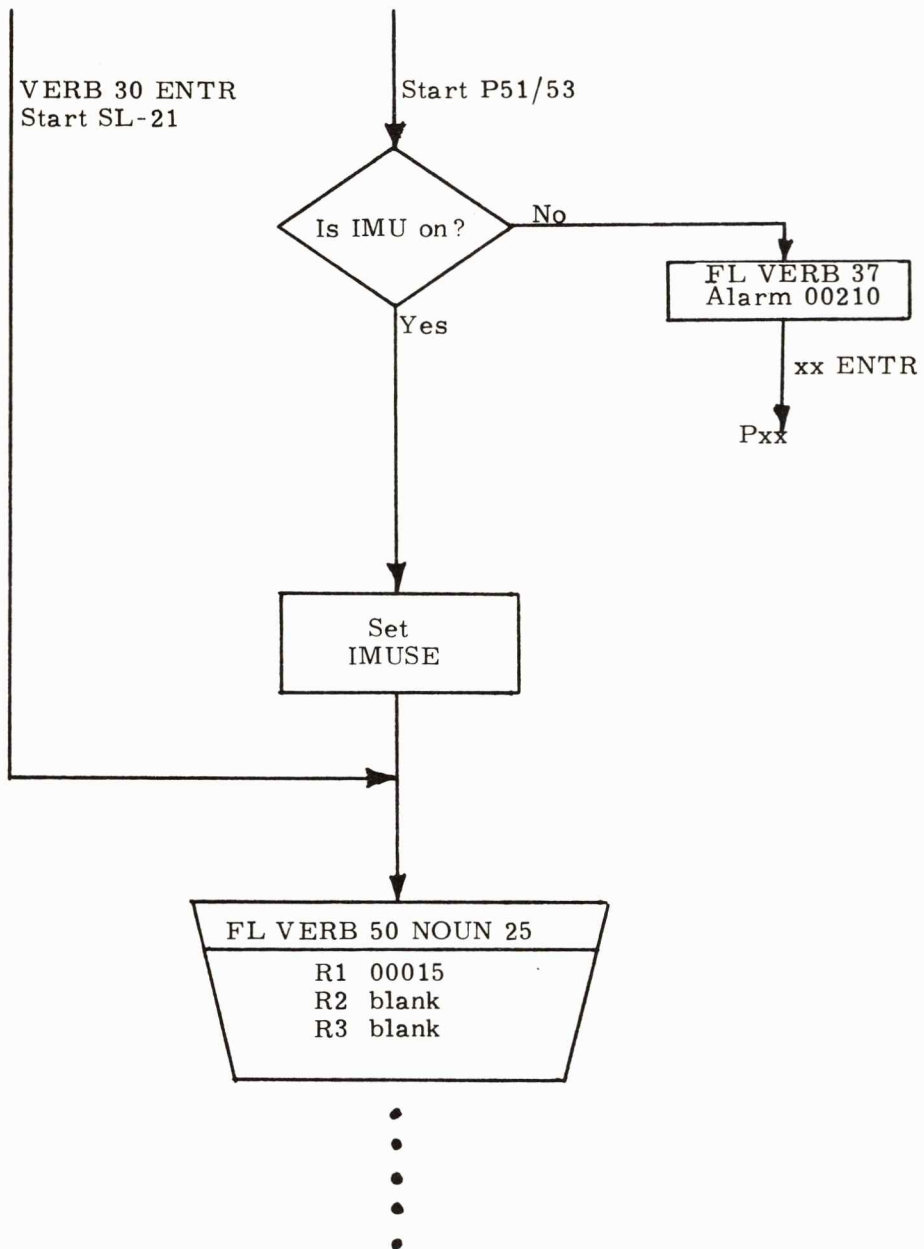


FIG: EMP SL-21

EMP SL-22: 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 SL-22 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-693, Section 3 GSOP.
- 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
3051 ENTR
1 ENTR
ENTR
ENTR
 2. Key VERB 25 NOUN 26 ENTR
1 ENTR
2323 ENTR } fixed-memory address
40066 ENTR } of S40.6
 3. Key VERB 31 ENTR to call EMP SL-22.
 4. Monitor Gimbal Drive Sequence by reference to analog dials.
 5. Key VERB 37 ENTR 00 ENTR to remove DAC commands (**zero** CHAN 12, BITS 2, 8 and 11, after completion of gimbal drive test.

RECOVERY/
TERMINATION:

1. EMP SL-22 is not restart protected. If restart occurs during operation of EMP, redo steps 1, 3, and 4 of PROCEDURES.
2. EMP SL-22 is terminated upon completion of the PROCEDURES.

ERASABLE
MEMORY:

NA

UPLINK:

NA

EMP SL-23: MONITOR JET-ON FAILURE

PURPOSE: EMP SL-23 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 SL-23 and incremented each pass to provide an indication to the ground that EMP SL-23 is active.

NOTE.—The cell -XDEG (ECADR 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 CSM-alone DAP or Docked DAP is active.

RESTRICTIONS AND LIMITATIONS:

1. If any VERB 37 major mode change or restart has occurred after EMP SL-23 coding is uplinked, ensure that the program code is intact.
2. EMP SL-23 operation does not survive a VERB 37 ENTR xx ENTR. It can be reselected (subject to RESTRICTION 1) via VERB 31 ENTR.
3. EMP SL-23 uses the same restart group as AVERAGEG and therefore, should not be active during AVERAGEG.
4. VHF marks must not be taken (Do not do VERB 87 during P20 options 0 or 4).
5. Automatic maneuvers or CDU failures may cause a false indication of a jet-on failure.

PROCEDURES:

1. The following preliminary procedures should be accomplished before executing EMP SL-23:
 - a. CMC MODE—AUTO
 - b. SC CONT—CMC
 - c. Turn on CSM-alone DAP or Docked DAP
2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP SL-23:

R1 00001

R2 00605

R3 00006

3. Key VERB 31 ENTR to call EMP SL-23.
4. Key VERB 16 NOUN 45 ENTR to verify operation of EMP SL-23:

R1 xxByy where xx should be
 counting up to indicate
 EMP SL-23 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. Clear MASTER ALARM.

NOTE.—Bit 1 of Channel 11 will continually be set by EMP SL-23 as long as the attitude error exceeds the specified amount.

2. EMP SL-23 is restart protected.
3. EMP SL-23 is terminated by VERB 37 ENTR xx ENTR.
4. If it is desired to terminate EMP SL-23 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 SL-23 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>
604		OCT	0
605	JETCHECK	CA	7
606		TS	VHFCNT
607		TC	PHASCHNG
610		OCT	05015
611		OCT	77777
612		CA	7
613		TS	VAC4USE
614	RECHECK	CS	ADB
615		AD	-XDEG
616		TS	L
617		CA	TWO
620	XSCHECK	TS	JETINDEX
621		INDEX	JETINDEX
622		CCS	ERRORX
623		TC	+2
624		TC	LOOPEND
625		AD	L
626		CCS	A
627		TC	DINGDONG
630		TC	LOOPEND
631		TC	LOOPEND
632	LOOPEND	CCS	JETINDEX
633		TC	XSCHECK
634	NOBELL	INCR	VHFCNT
635		TC	FIXDELAY
636		DEC	100
637		TC	RECHECK
640	DINGDONG	CAF	BIT1
641		EXTEND	
642		WOR	DSALMOUT
643		TC	NOBELL
644	-XDEG	OCT	77643
645	JETINDEX	OCT	0

* This octal value represents approximately 1 degree.

UPLINK:

Uplink for loading EMP SL-23 code by P27 is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>
V71E	V71E	V71E
24E	21E	5E
604E	626E	1016E
E	10000E	1E
30007E	640E	605E
54764E	632E	6E
5415E	632E	V33E
5015E	10645E	
77777E	620E	
30007E	24764E	
54604E	5270E	
41706E	144E	
60644E	614E	
54001E	35001E	
35000E	6E	
54645E	5011E	
50645E	634E	
11620E	*77643E	
625E	V33E	
632E		
60001E		
V33E		

* This octal value represents approximately 1 degree.

EMP SL-26: IMU CDU TRANSIENT MONITOR

PURPOSE: EMP SL-26 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 the Rendezvous phase 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 ERR
- 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 SL-26 was designed to prevent COARSE ALIGN with actual yaw angles of 60 deg. or less, when a CDUZ transient occurs.

EMP SL-26 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 SL-26. 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 SL-26 is also operated by EMP SL-28, 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 SL-28, 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, P31, P32, P33, P34, P35, 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, 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.
5. It is possible for large attitude rates to induce gimbal angle rates that would cause erroneous detection of a CDU transient, effectively freezing that CDU and resulting in loss of attitude control in that axis.

In selecting the value of -NDEGS the following table, showing the relationship of gimbal angle rates to body rate for various middle gimbal angles, should be consulted.

-NDEGS	Max GA Rate	Maximum Allowable Body Rate in Deg/Sec				
deg	deg/sec	MGA = 10	MGA = 20	MGA = 30	MGA = 45	MGA = 60
1	10	8	6.6	5.5	4.1	2.9
2	20	16	13.2	11	8.3	5.8
3	30	24	19.8	16.5	12.9	8.7
4	40	32	26.4	22	16.6	11.6

PROCEDURES:

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

R1 00001

R2 01517

R3 00005

2. Key VERB 31 ENTR to start EMP SL-26.
3. Key VERB 16 NOUN 45 ENTR to verify operation of EMP SL-26.

R1 XXBYY

where XX should be counting up to indicate EMP SL-26 is active.

RECOVERY/
TERMINATION:

1. If the MASTER ALARM has been activated by this EMP, no program alarm will appear. Channel 11 indicates which 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 OPR ERR, 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.

2. 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).
3. EMP SL-26 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.
4. If it is desired to resume EMP SL-26 after it is terminated repeat PROCEDURES.

ERASABLE
MEMORY:

Program coding for EMP SL-26 is as follows:
Initialization portion of EMP SL-26:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>
2400	STARTV31	EXTEND	00006
2401		DCA CDUX	30033
2402		DXCH XSAVE	53513
2403		CA CDUZ	30034
2404		TS XSAVE +2	55514
2405		CA ZERO	35003
2406		TS 528CTR	55370
2407		CA TIME1	30025
2410		TS TIME,R	55516
2411		CA STARTLOC	31414
2412		TS DNTMGOTO	54334
2413		TC TASKOVER	05327
2414	STARTLOC	ADRES START526	01372
2517		TC STARTV31	01400*

* This location is modified by EMP SL-28.

DOWNLINK operated portion of EMP SL-26:

<u>ECADR</u>	<u>Tag</u>		<u>Code</u>	<u>Octal</u>
1372	START526	CA	EBANK5	35055
1373		TS	EBANK	54003
1374		TC	START	01415
2415	START	CCS	PHASE3	11152
2416		TC	+6	01424
2417		TC	PHASCHNG	05415
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	65001
2432		AD	-0.1SEC	61510
2433		CCS	A	10000
2434		TC	CHKCDU	01437
2435		TC	CHKCDU	01437
2436		TC	DNPPhase2	03452
2437	CHKCDU	CAF	TWO	35000
2440	LOOP	TS	IX	55515
2441		CA	IMODES33	31324
2442		MASK	BIT6	74774
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	24764
2473		INCR	528CTR	25370
2474		TC	FIXRSTRT	01525
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			
2525	FIXRSTRT	CA	NEGO	35002
2526		TS	PHSPRDT3	55254
2527		TC	DNPHASE2	03452

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

77644=1 degree

77511=2 degrees

77356=3 degrees

UPLINK:

Uplink for loading EMP SL-26 code by P27 is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>	<u>Load 4</u>	<u>Load 5</u>	<u>Load 6</u>
V71E	V71E	V71E	V71E	V72E	V71E
24E	24E	24E	24E	23E	5E
2400E	2422E	2444E	2466E	2511E	2525E
6E	1400E	1462E	11515E	*77224E	35002E
30033E	5E	51515E	1440E	1372E	55254E
53513E	40025E	30032E	30025E	35055E	3452E
30034E	61516E	6E	55516E	1373E	V33E
55514E	10000E	51515E	24764E	54003E	
35003E	40000E	21512E	25370E	1374E	
55370E	67663E	10000E	1525E	1415E	
30025E	65001E	1455E	51515E	1016E	
55516E	61510E	1462E	31505E	1E	
31414E	10000E	61511E	4363E	1017E	
54334E	1437E	10000E	51515E	1517E	
5327E	1437E	1475E	31512E	1020E	
1372E	3452E	1462E	51515E	5E	
11152E	35000E	1462E	54032E	2510E	
1424E	55515E	51515E	1466E	77765E	
5415E	31324E	30032E	2101E	2517E	
7013E	74774E	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 SL-27: MONITOR SINGLE IMU CDU

PURPOSE:

EMP SL-27 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 terminal phase 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 ERR

If CDUZ is checked, EMP SL-27 will prevent COARSE ALIGN with actual yaw angles of 60 deg. or less, when a transient occurs.

EMP SL-27 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 SL-27. 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, P34 and self-check are not operating.
2. EMP SL-27 is not restart protected.
3. A hardware restart, VERB 69 ENTR, VERB 74 ENTR, or VERB 36 ENTR terminates EMP SL-27.

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.

6. It is possible for large attitude rates to induce gimbal angle rates that would cause erroneous detection of a CDU transient, effectively freezing that CDU and resulting in loss of attitude control in that axis.

Maximum allowable body rates are:
for

10 deg MGA = 13.33 deg/sec
20 deg MGA = 11.00 deg/sec
30 deg MGA = 9.17 deg/sec
45 deg MGA = 6.83 deg/sec
60 deg MGA = 4.83 deg/sec

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify that N26 is valid for EMP SL-27.
R1 00001
R2 01440
R3 00004
2. Key VERB 31 ENTR to start EMP SL-27.
3. If it is desired to switch between high and low telemetry rates, location 1366 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. If the MASTER ALARM has been activated by this EMP, no program alarm will appear.
To reset Channel 11, OPR ERR 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.

2. 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).
3. EMP SL-27 is not restart protected.
4. EMP SL-27 is terminated by a hardware restart, VERB 36 ENTR, VERB 69 ENTR or VERB 74 ENTR.
5. If it is desired to resume EMP SL-27 after it is terminated, repeat PROCEDURES.

ERASABLE
MEMORY:

Program coding for EMP SL-27 is as follows:
Initialization portion of EMP SL-27:

<u>ECADR</u>	<u>Tag</u>		<u>Code</u>	<u>Octal</u>
2040		CA	CDU?	3003X*
2041		TS	CDUSAVE	55367
2042		CA	OCT13E	31366
2043		TS	COUNTER	55370
2044		CA	S27LOC	31447
2045		TS	DNTMGOTO	54334
2046		TC	TASKOVER	05327
2047	S27LOC	ADRES	START	01372
2050	CONT1X	CCS	A	10000
2051		TC	INV40	01775
2052		TC	CONT2X	01375

Downlink operated portion of EMP SL-27:

1366	OCT13E	OCT	00013	00013**
1367	CDUSAVE	OCT	00000	00000
1370	COUNTER	OCT	00000	00000
1372	START	CA	EBANK4	34767
1373		TS	EBANK	54003
1374		TC	S27GO	01757
1375	CONT2X	CA	EBANK5	35055
1376		TS	EBANK	54003
1377		TC	CONT3X	01444
2357	S27GO	CCS	COUNTER	11370
2360		TC	OUTX	01763
2361		CA	OCT13E	31366
2362		TC	CHKCDU	01765
2363	OUTX	TS	COUNTER	55370
2364		TC	DNPHASE2	03452
2365	CHKCDU	TS	COUNTER	55370
2366		CA	IMODES33	31324
2367		MASK	BIT6	74774
2370		TC	CONT1X	01450
2375	INV40	CA	CDU?	3003X*
2376		TS	CDUSAVE	55367
2377		TC	DNPHASE2	03452
2444	CONT3X	CA	CDU?	3003X*
2445		EXTEND		00006
2446		MSU	CDUSAVE	21367
2447		CCS	A	10000
2450		TC	+2	01452
2451		TC	OK	01457

2452		AD	-NDEGS	61537
2453		CCS	A	10000
2454		TC	BELLS	01532
2455		TC	OK	01457
2456		TC	OK	01457
2457	OK	CA	CDU?	3003X*
2460		TS	CDUSAVE	55367
2461		TC	DNPBASE2	03452
2532	BELLS	CA	ALARMX	31540
2533		TC	FALTON +1	04363
2534		CA	CDUSAVE	31367
2535		TS	CDU?	5403X*
2536		TC	DNPBASE2	03452
2537	-NDEGS	OCT	77224	77224
2540		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

** EMP SL-27 operates from the telemetry interrupt, location 1366 should be loaded as follows: (See RESTRICTIONS & LIMITATIONS paragraph 5)

00013 - high bit rate
00001 - low bit rate

UPLINK:

Uplink for loading EMP SL-27 code by P27 is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>	<u>Load 4</u>	<u>Load 5</u>	<u>Load 6</u>
V71E	V71E	V71E	V71E	V71E	V72E
15E	14E	14E	20E	11E	15E
2040E	1366E	2357E	2444E	2532E	1016E
*3003XE	**13E	11370E	*3003XE	31540E	1E
55367E	E	1763E	6E	4363E	1017E
31366E	E	31366E	21367E	31367E	1440E
55370E	E	1765E	10000E	*5403XE	1020E
31447E	34767E	55370E	1452E	3452E	4E
54334E	54003E	3452E	1457E	77224E	2375E
5327E	1757E	55370E	61537E	101E	*3003XE
1372E	35055E	31324E	10000E	V33E	2376E
10000E	54003E	74774E	1532E		55367E
1775E	1444E	1450E	1457E		2377E
1375E	V33E	V33E	1457E		3452E
V33E			*3003XE		V33E
			55367E		
			3452E		
			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 SL-27 operates from the telemetry interrupt, location 1366 should be loaded as follows: (See RESTRICTIONS & LIMITATIONS paragraph 5)

00013 - high bit rate
00001 - low bit rate

EMP SL-28: MONITOR JET-ON FAILURE AND DO EMP SL-26

PURPOSE:

EMP SL-28 provides a means of monitoring for jet-on failures and of activating the MASTER ALARM if a failure is detected. EMP SL-28 also operates EMP SL-26 (IMU CDU TRANSIENT MONITOR) and is intended as a replacement for EMP SL-23 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 SL-28 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 SL-28. 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 SL-28 also initializes and operates EMP SL-26 which samples the CDU's every .1 second and turns on the MASTER ALARM plus the OPR ERR light if a CDU change exceeds a specified amount. For details see EMP SL-26.

Provided that the CDU transient threshold angle (register -NDEGS in EMP SL-26) 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 SL-26) 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 647) 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 SL-26 has been uplinked. See EMP SL-26.
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 SL-28 coding and before VERB 31 ENTR, VAC area 4 should be checked to ensure that the program code is intact.
3. The RESTRICTIONS and LIMITATIONS of EMP SL-26 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 SL-28:
 - 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 SL-28:

R1 00001

R2 01522

R3 00005

3. Key VERB 31 ENTR to call EMP SL-28.

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 OPR ERR, 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.

If a CDU transient occurred IMU CDU ZERO (VERB 40 ENTR) should be performed as soon as possible to synchronize CDU counters. A false indication of jet-on failure may be detected in the interval before the CDU ZERO.

2. EMP SL-28 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 SL-28 may be terminated and EMP SL-26 continued by executing EMP SL-26 PROCEDURES.

ERASABLE
MEMORY:

Program coding for EMP SL-28 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	41706
616		AD	-XDEG	60647
617		TS	L	54001
620		CA	TWO	35000
621	XSCHECK	TS	JETINDEX	54646
622		INDEX	JETINDEX	50646
623		CCS	ERRORX	11620
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	35055
636		TS	EBANK	54003
637		CA	ZERO	35003
640		TS	VAC4USE	54604
641		TC	START*	01415
642	DINGDONG	CAF	BIT1	35001
643		TC	FALTON+1	04363
644		TC	NOBELL	00635
645	528LOC	ADRES	528START	00605
646	JETINDEX	OCT	00000	00000
647	-XDEG	OCT	77643**	77643
2517		CA	526LOC	31524
2520		TS	STARTLOC*	55414
2521		TC	STARTV31*	01400
2522		CA	528LOC	30645
2523		TC	-3	01520
2524	526LOC	ADRES	START526	01372
1370	528CTR			

* These locations are in EMP SL-26.

** This register specifies the allowable excursion beyond the deadband. The value shown is approximately 1 degree.

UPLINK:

Uplink for loading EMP SL-28 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	30645E
55370E	35055E	2523E
4611E	54003E	1520E
41706E	35003E	2524E
60647E	54604E	1372E
54001E	1415E	1016E
35000E	35001E	1E
54646E	4363E	1017E
50646E	635E	1522E
11620E	605E	1020E
626E	E	5E
633E	*77643E	V33E
V33E	V33E	

* This register may be modified to select any desired excursion beyond the deadband. The value shown is approximately 1 degree.

EMP SL-50: CONVERT GYRO TORQUING ANGLES
TO CDU ANGLES FOR FAILED IMU

PURPOSE: EMP SL-50 provides a means of converting the gyro-torquing angles calculated by P52 into the resultant actual CDU angles, and of updating NOUN 20 with the CDU angles if desired. The NOUN 20 angles may then be used to do GDC Realign.

FUNCTIONAL DESCRIPTION: Normally, P52 calculates the gyro-torquing angles necessary to torque the stable member into agreement with REFSMMAT, and performs the torquing as specified in NOUN 93. If the IMU has failed, this EMP uses the input to the calculation of the NOUN 93 angles to compute CDU angles, displays them, and, if approved, updates NOUN 20 with them. Since REFSMMAT is not changed and the IMU is unavailable, this EMP effectively makes NOUN 20 reflect the instantaneous relationship between vehicle attitude and a fictitious stable member described by REFSMMAT.

ASSUMPTIONS:

1. IMU is unavailable
2. A valid REFSMMAT is stored.
3. Program coding has been uplinked (see Restriction 1).

RESTRICTION

AND LIMITATIONS: 1. RCS DAP is unavailable. To be certain that the DAP is totally disabled the NO DAP configuration must be entered from a CSM RCS DAP configuration. Entering the NO DAP configuration from a Docked DAP configuration will leave some coding active that will clobber EMP SL-50. The following sequence will ensure total DAP deactivation.

VERB 48 ENTR
VERB 21 ENTR
1XXXX ENTR
PRO, PRO, PRO
VERB 46 ENTR
VERB 48 ENTR
VERB 21 ENTR
OXXXX ENTR
PRO, PRO, PRO
VERB 46 ENTR

The above sequence can all be done in the FREE mode if desired. This deactivation of the RCS DAP must be done before EMP SL-50 is uplinked.

2. No active extended verbs are permitted between FL VERB 06 NOUN 93 and keying VERB 30 ENTR.
3. The EMP requires that the contents of NOUN 20 at the first mark, at the second mark, and at the execution of the EMP (at VERB 30 ENTR) be consistent, even if incorrect. Therefore, it is necessary to load NOUN 20 with the FDAI attitude just prior to the first mark. Thereafter, if the vehicle is maneuvered for the second mark, the FDAI attitude must again be loaded, and, if the vehicle is maneuvered prior to the execution of the EMP, the FDAI attitude must be loaded once again.
4. The gimbal angles calculated are correct for the time the EMP is executed. Constant FDAI attitude must therefore be maintained from that time until GDC Align.

PROCEDURES:

1. If REFSMFLG (FLAGWRD3, bit 13) is not set, key:
VERB 25 NOUN 07 ENTR
77 ENTR
10000 ENTR
1 ENTR, to set REFSMFLG and allow P52
2. Verify NOUN 46 R1=0xxxx.
If R1 is not 0xxxx, program coding must be reloaded.
3. Key VERB 05 NOUN 26 ENTR to verify that NOUN 26 contains:
R1 10001
R2 01642
R3 50006
4. Key VERB 37 ENTR 52 ENTR to begin P52, option 3. Follow option 3 procedures until the appearance of FL VERB 51 for the first mark.
5. At FL VERB 51 for the first mark, maneuver, if necessary, to acquire the first mark body.
Key—
Verb 25 NOUN 20 ENTR
and load the FDAI ball angles into NOUN 20. Perform the mark, and follow option 3 procedures until FL VERB 51 for the second mark.

6. At FL VERB 51 for the second mark, if the vehicle has been maneuvered since NOUN 20 was loaded for the first mark, the new FDAI attitude must be loaded via VERB 25 NOUN 20 before the second mark is taken.
7. After the second mark has been taken, follow option 3 procedures until the appearance of FL VERB 06 NOUN 93.
8. At FL VERB 06 NOUN 93, if the vehicle has been maneuvered since the second mark, the new FDAI attitude must be loaded via VERB 25 NOUN 20 before continuing into the EMP.
9. After loading NOUN 20 (if necessary), verify that no active extended verbs exist.

Key—

Verb 30 ENTR

To start EMP SL-50.

10. Observe FL VERB 06 NOUN 22, containing the CDU angles which relate vehicle attitude to REFSMMAT. If they are acceptable, key PRO to transfer the CDU angles to NOUN 20. Otherwise, key VERB 34 ENTR to exit EMP.
11. At reappearance of NOUN 93, key VERB 32 ENTR.
12. At FL VERB 50 NOUN 25, R1 00014, the normal options exist.
13. The gimbal angles calculated are correct for the time the EMP is executed. Constant FDAI attitude must therefore be maintained from that time until GDC align.

RECOVERY/

TERMINATION:

EMP SL-50 is not separately restart protected; normal P52 recovery procedures apply. After keying VERB 30 ENTR, a restart will cause the appearance of FL VERB 01 NOUN 70 for the second mark, and these procedures may be resumed at that point.

ERASABLE

MEMORY:

Program coding for EMP SL-50 is as follows:

ECADR	Tag	Code	Octal
1016	N26/PRI	OCT 10001	10001
1017	N26/2CAD	OCT 01642	01642
1020		OCT 50006	50006
3242	START	TC INTPRET	06006
3243		VLOAD	77775
3244		XDC	02703
3245		STORE XSM	02661
3246		VLOAD	77775
3247		YDC	02711
3250		STORE YSM	02667
3251		VLOAD	77775
3252		ZDC	02717
3253		STORE ZSM	02675
3254		RTB	77634
3255		E/CALL	24017
3256		CADR CDUTRIG	47471
3257		RTB	77634
3260		E/CALL	24017
3261		CADR CALCSMSC	34747
3262		RTB	77634
3263		E/CALL	24017
3264		CADR CALCGA	47303
3265		EXIT	77776
3266		CA OCT24	34124
3267		TS EXTVBACT	55237
3270		CA V06N22	35040
3271		TC BANKCALL	04647
3272		CADR E/BKCALL	24000
3273		CADR GOMARKF	20456
3274		TC ENDMARK	05537
3275		TC CDUSTOR	01677
3276		TC ENDMARK	05537
3277	CDUSTOR	INHINT	00004
3300		EXTEND	00006
3301		DCA THETAD	31300

3302	DXCH	CDUX	52033
3303	CA	THETAD+2	31301
3304	TS	CDUZ	54034
3305	TC	ENDMARK	05537

UPLINK:

P27 uplink for EMP SL-50 is as follows:

Load 1	Load 2	Load 3
V71E	V71E	V71E
5E	24E	24E
1016E	3242E	3264E
10001E	6006E	47303E
1642E	77775E	77776E
50006E	2703E	34124E
V33E	2661E	55237E
	77775E	35040E
	2711E	4647E
	2667E	24000E
	77775E	20456E
	2717E	5537E
	2675E	1677E
	77634E	5537E
	24017E	4E
	47471E	6E
	77634E	31300E
	24017E	52033E
	34747E	31301E
	77634E	54034E
	24017E	5537E
	V33E	V33E

EMP SL-52: CHECKSUM OF VAC AREA 4 FOR EMP SL-23 AND SL-28

PURPOSE: EMP SL-52 provides a means of determining whether or not that portion of an EMP previously loaded into VAC area 4 is still intact.

FUNCTIONAL DESCRIPTION: EMP SL-52 does a CHECKSUM of the VAC area 4 registers used by an EMP and gives an alarm (Code 01753) if that EMP is still not intact.

EMP's using VAC area 4 are:

SL-23 Monitor Jet-On Failure

SL-28 Monitor Jet-On Failure and Do EMP SL-26

ASSUMPTIONS:

1. Appropriate EMP has been uplinked in VAC area 4 prior to operation of EMP SL-52.
2. EMP SL-52 has been uplinked with appropriate values in location 3756 and 3757. (See table at end of UPLINK.)

RESTRICTIONS AND LIMITATIONS:

1. EMP SL-52 shares R27 erasables; therefore activation of R27 will destroy EMP SL-52.
2. For EMP's SL-23 and SL-28 the value of -XDEG is not included in this CHECKSUM procedure.

PROCEDURES:

1. Key VERB 15 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP SL-52:

R1 14000

R2 01727

R3 00007

2. Key VERB 30 ENTR
3. If the code in VAC area 4 is verified to be correct, zeros will appear in R1 of NOUN 26.
4. If the code in VAC area 4 has been altered, a PROG alarm will result. Key VERB 5 NOUN 9 ENTR to

observe alarm code 1753. New uplink of VAC area 4
in question should be requested.

SL-23 Loads 1 and 2

SL-28 Loads 1 and 2

RECOVERY/

TERMINATION: NA

ERASABLE
MEMORY:

Program coding for EMP SL-52 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>
3727	BEGIN	CA	ZERO 35003
3730		TS	SUM 55760
3731		TS	SUM+1 55761
3732		CA	ICNTR 31756
3733	BACK52	TS	CNTR52 55762
3734		NDX	CNTR52 51762
3735		CA	605 30605
3736		TS	L 54001
3737		CA	ZERO 35003
3740		DAS	SUM 21761
3741		CCS	CNTR52 11762
3742		TC	BACK52 01733
3743		CS	SUM+1 41761
3744		AD	CHKSUM 61757
3745		CCS	A 10000
3746		TC	+2 01750
3747		TC	OK 01753
3750		TC	ALARM 05644
3751		TC	OK 01753
3752		TC	ENDOFJOB 05220
3753	OK	CA	ZERO 35003
3754		TS	N26/PRI 55016
3755		TC	ENDOFJOB 05220
3756	ICNTR	OCT	ABCDE ABCDE*
3757	CHKSUM	OCT	FGHIJ FGHIJ*
3760	SUM	TEMP	
3761	SUM+1	TEMP	
3762	CNTR52	TEMP	

* See table of values given at the end of uplink.

UPLINK:

Uplink for loading EMP SL-52 code by P27 is as follows:

<u>Load 1</u>	<u>Load 2</u>	<u>Load 3</u>
V71E	V71E	V71E
5E	24E	11E
1016E	3727E	3751E
14000E	35003E	1753E
1727E	55760E	5220E
7E	55761E	35003E
V33E	31756E	55016E
	55762E	5220E
	51762E	*ABCDEE
	30605E	*FGHIJE
	54001E	V33E
	35003E	
	21761E	
	11762E	
	1733E	
	41761E	
	61757E	
	10000E	
	1750E	
	1753E	
	5644E	
	V33E	

* Table of values necessary for each of the EMPs using VAC area 4:

	<u>TAG</u>	<u>ECADR</u>	<u>SL-23⁽¹⁾</u>	<u>SL-28⁽¹⁾</u>
ABCDE	ICNTR	3756	36	40
FGHIJ	CHKSUM	3757	23156	52610

⁽¹⁾ EMP SL-52 does not check -XDEG register, because this register may change depending on the desired allowable excursion beyond the deadband.

EMP SL-55 IMU SLIP RING PROGRAM

PURPOSE: This EMP provides a means of simultaneously rotating all three gimbals about their axes at a 35° per second rate to clean the Slip Rings.

FUNCTIONAL DESCRIPTION:

When the program starts, the IMU is coarse aligned to $+20^{\circ}$, $+20^{\circ}$, $+20^{\circ}$. The CDU read counters are then zeroed and the coarse align discrete is issued. This sequence results in a disagreement between the actual gimbal angles and the read counters which causes the gimbals to rotate at a 35° per second rate. The gimbals are allowed to rotate for 100 revolutions in the positive direction and then 100 revolutions in the negative direction. Prior to reversing directions the gimbals are coarse aligned to 0° , 0° , 0° and then offset to -20° , -20° , -20° . Each 100 revolutions takes about 17.14 minutes at 35° per second rate.

ASSUMPTIONS: 1) An IMU malfunction has become evident during flight.
2) Program has been uplinked.

RESTRICTIONS

AND LIMITATIONS: This EMP is to be run in POO with State Vector integration disabled.

PROCEDURES:

- 1) Key VERB 96 ENTR
- 2) Key VERB 48 ENTR. At FL VERB 04 NOUN 46, key VERB 21 ENTR 0XXXX ENTR. Subsequently, key VERB 46 ENTR to disable DAP.
- 3) Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP SL-55:
R1 10000
R2 01420
R3 00007
- 4) Key VERB 30 ENTR to call EMP SL-55.
- 5) During the operation of EMP SL-55, the NO ATT light will be on continuously, while the GIMBAL LOCK light will go on and off once per MGA revolution.

RECOVERY/
TERMINATION:

- 1) EMP SL-55 is self-terminating at the end of ± 100 revolutions.
- 2) EMP SL-55 is not restart protected. If a restart occurs, the EMP is terminated by the restart but the gimbals are still rotating therefore the IMU power should be turned off and allow 5 minutes to elapse before powering up again.
- 3) EMP SL-55 can be terminated early by zeroing REV (ECADR 3400) and TLOOP (ECADR 3402).
- 4) Pad loaded SBDELT (ECADR 3424) is destroyed when this EMP is uplinked and therefore must be restored upon completion of the EMP. (Nominal value of SBDELT is 00121.)

ERASABLE

MEMORY:

Program coding for EMP SL-55 is as follows:

ECADR	Tag	Code	Octal
3420	START	CA RNUMB	31552
3421		TS REV	55400
3422	SLIPRING	CA +20DEG	31551
3423		TS ANGLE	55401
3424		CA ANGLE	31401
3425		TC CALIGN	01533
3426		CA IMODES30	31323
3427		TS L	54001
3430		CA BITS3+4	35750
3431		EXTEND	00006
3432		WOR L	05001
3433		TS IMODES30	55323
3434		CA BIT5	34775
3435		EXTEND	00006
3436		WRITE 12	01012
3437		CA BIT6	34774
3440		TC WAITLIST	05246
3441		2CADR RND+RND	01445
3442			00007
3443		RELINT	00003
3444		TC ENDOFJOB	05220
3445	RND+RND	CA BIT4	34776
3446		EXTEND	00006
3447		WRITE 12	01012
3450		CA LNUMB	31553
3451		TS TLOOP	55402
3452		CA BIT6	34774
3453	LOOP	TC VARDELAY	05273
3454		CA BITS4+6	35016
3455		EXTEND	00006
3456		WRITE 12	01012
3457		CCS TLOOP	11402
3460		TC +2	01462
3461		TC TIMEUP	01465

3462		TS	TLOOP	55402
3463		CA	TIMER	31554
3464		TC	LOOP	01453
3465	TIMEUP	CA	DSPTAB+11D	31231
3466		MASK	BIT6	74774
3467		CCS	A	10000
3470		TC	+2	01472
3471		TC	ENDLOOP	01474
3472		CA	1SEC	35030
3473		TC	LOOP	01453
3474	ENDLOOP	CA	BIT13	34765
3475		TC	NOVAC	05134
3476		2CADR	SYNC	01501
3477				00007
3500		TC	TASKOVER	05327
3501	SYNC	TC	BANKCALL	04647
3502		CADR	E/BKCALL	24000
3503		CADR	IMUZERO	16560
3504		TC	CHECKNJ	01521
3505		TC	BANKCALL	04647
3506		CADR	E/BKCALL	24000
3507		CADR	IMUSTALL	17575
3510		TC	ERROR	01526
3511		CA	ZERO	35003
3512		TC	CALIGN	01533
3513		CCS	REV	11400
3514		TC	+2	01516
3515		TC	ENDOFJOB	05220
3516		TS	REV	55400
3517		CS	ANGLE	41401
3520		TC	SLIPRING+1	01423
3521	CHECKNJ	EXTEND		00006
3522		QXCH	QRTN	23403
3523		CCS	NEWJOB	10067
3524		TC	CHANG1	05165
3525		TC	QRTN	01403
3526	ERROR	EXTEND		00006
3527		QXCH	QRTN	23403
3530		TC	ALARM	05644
3531		OCT	70707	70707

3532		TC	ENDOFJOB	05220
3533	CALIGN	EXTEND		00006
3534		QXCH	QSAVE	23404
3535		TS	THETAD	55277
3536		TS	THETAD+1	55300
3537		TS	THETAD+2	55301
3540		TC	CHECKNJ	01521
3541		TC	BANKCALL	04647
3542		CADR	E/BKCALL	24000
3543		CADR	IMUCOARS	16655
3544		TC	BANKCALL	04647
3545		CADR	E/BKCALL	24000
3546		CADR	IMUSTALL	17575
3547		TC	ERROR	01526
3550		TC	QSAVE	01404
3551	+20DEG	OCT	03434	03434
3552	RNUMB	OCT	1	00001
3553	LNUMB	OCT	10	00010
3554	TIMER	OCT	31072	31072

TEMP REGS

3400	REV
3401	ANGLE
3402	TLOOP
3403	QRTN
3404	QSAVE

UPLINK:

For loading EMP SL-55 is as follows:

Load 1	Load 2	Load 3	Load 4	Load 5	Load 6
V71E	V71E	V71E	V71E	V71E	V72E
24E	24E	24E	24E	24E	15E
3420E	3442E	3464E	3506E	3530E	1016E
31552E	7E	1453E	24000E	5644E	10000E
55400E	3E	31231E	17575E	70707E	1017E
31551E	5220E	74774E	1526E	5220E	1420E
55401E	34776E	10000E	35003E	6E	1020E
31401E	6E	1472E	1533E	23404E	7E
1533E	1012E	1474E	11400E	55277E	3552E
31323E	31553E	35030E	1516E	55300E	1E
54001E	55402E	1453E	5220E	55301E	3553E
35750E	34774E	34765E	55400E	1521E	10E
6E	5273E	5134E	41401E	4647E	3554E
5001E	35016E	1501E	1423E	24000E	31072E
55323E	6E	7E	6E	16655E	V33E
34775E	1012E	5327E	23403E	4647E	
6E	11402E	4647E	10067E	24000E	
1012E	1462E	24000E	5165E	17575E	
34774E	1465E	16560E	1403E	1526E	
5246E	55402E	1521E	6E	1404E	
1445E	31554E	4647E	23403E	3434E	
V33E	V33E	V33E	V33E	V33E	

EMP ASTP-75 COMPUTE S-BAND ANTENNA ANGLES

PURPOSE: This EMP computes and displays S-BAND antenna pointing angles for the current LOS between the CSM and the other vehicle state vectors.

FUNCTIONAL DESCRIPTION: This EMP is called via VERB 30 ENTR and operates like an extended verb (see Figure: EMP ASTP-75). The CSM and other vehicle state vectors are extrapolated to current time using the existing conic routines CSMCONIC and LEMCONIC. The angles RHO and GAMMA as defined in R-577 (Sec. 5) are computed and displayed in R1 and R2 of NOUN 43 at one second intervals.

ASSUMPTIONS: NA

RESTRICTIONS AND LIMITATIONS:

1. The restrictions and limitations of extended verbs which use the display system apply to this EMP.
2. This EMP shares erasable storage with the W-Matrix and P31 through P36 targeting programs. W-Matrix integration, navigation mark incorporation or P31 through P36 targeting programs will overwrite the EMP.
3. V32 ENTR is an improper response to the flashing VERB 16 NOUN 43. If V32 ENTR is inadvertently keyed, a meaningless display of NOUN 44 will result; to rectify, simply key NOUN 43 ENTR.

PROCEDURES:

1. Key VERB 5 NOUN 26 ENTR and verify
R1 10001
R2 01412
R3 66105
2. Key VERB 30 ENTR.
3. Observe flashing VERB 16 NOUN 43
R1 \pm XXX.XX deg RHO
R2 \pm XXX.XX deg GAMMA
R3 + 00000
4. Key PRO or VERB 34 ENTR to terminate.

ADVANCE \bar{R}_{cm} AND \bar{R}_{ows} TO PRESENT TIME
USING CONIC EXTRAPOLATION

$$\bar{R} = [SMNB][REFSMMAT] \text{ UNIT } (\bar{R}_{ows} - \bar{R}_{cm})$$

$$\bar{U}_{RP} = \begin{bmatrix} U_x \\ U_y \\ U_z \end{bmatrix} = \text{UNIT} \begin{bmatrix} R_x \\ R_y \\ 0 \end{bmatrix}$$

$$\rho = \cos^{-1}(R_z) - \pi/2$$

$$\gamma = \cos^{-1}(U_x)$$

yes

$$U_Y \geq 0$$

no

$$\gamma = 2\pi - \gamma$$

EXIT

EMP ASTP-75

RECOVERY/
TERMINATION:

1. This EMP is not restart protected. To re-establish, key VERB 30 ENTR.
2. PRO or VERB 34 ENTR terminates EMP ASTP-75.

ERASABLE
MEMORY:

Program coding for EMP ASTP-75 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>
2407	EM1643	OCT	04053
2410	EMPDSP	CA	EM1643
2411		TC	V82REDSP +1
2412	START	TC	TESTXACT
2413		CAF	ZERO
2414		TS	IND
2415	CYCLE	EXTEND	00006
2416		DCA	TIME2
2417		DXCH	MPAC
2420		CAF	ZERO
2421		TS	MPAC +2
2422		TS	MODE
2423		TS	ALT
2424		TS	ALT +1
2425		TC	INTPRET
2426		STORE	BASETIME
2427		STORE	TDEC1
2430		RTB	77634
2431			E/CALL
2432			CSMCONIC
2433		VLOAD	77775
2434			RATT
2435		STORE	BASETHP
2436		RTB	77634
2437			E/CALL
2440			CDUTRIG
2441		DLOAD	77745
2442			BASETIME
2443		STORE	TDEC1
2444		RTB	77634
2445			E/CALL
2446			LEMCONIC
2447		VLOAD	VSU
2450			RATT
2451			BASETHP
2452		UNIT	77656
2453		MXV	VSLI
2454			REFSMMAT
2455		RTB	77634
2456			E/CALL
2457			*SMNB*
2460		STODL	EMPTTEMP
2461			EMPTTEMP +4
2462		ACDS	DSU
2463			DPI/4
2464		STORE	LAT
2465		VLOAD	77775
2466			EMPTTEMP
2467		EXIT	77776
2470		CA	ZERO
2471		TS	MPAC +5
2472		TS	MPAC +6

2473	TC	INTPRET	06006
2474	UNIT		77656
2475	STODL	EMPTTEMP	16401
2476		EMPTTEMP	02401
2477	ACOS	EXIT	77526
2500	CCS	EMPTTEMP +2	11402
2501	TC	+7	01510
2502	TC	+6	01510
2503	CA	A	30000
2504	TC	INTPRET	06006
2505	BDSU		77621
2506		LODPMAX	15737
2507	EXIT		77776
2510	TC	INTPRET	06006
2511	STORE	LONG	00744
2512	EXIT		77776
2513	CA	EXTVBACT	31237
2514	MASK	BIT5	74775
2515	EXTEND		00006
2516	BZF	ENDEXT	15537
2517	CCS	IND	11406
2520	TC	+6	01526
2521	CAF	PRI010	34765
2522	TS	IND	55406
2523	TC	NOVAC	05134
2524	ADRES	EMPDSP	01410
2525	OCT	46005	46005
2526	CAF	.5SEC	35023
2527	TC	BANKCALL	04647
2530	CADR	E/BKCALL	24000
2531	CADR	DELAYJOB	01731
2532	TC	CYCLE	01415

UPLINK:

P27 uplink for loading EMP ASTP-75 is as follows:

<u>Load1</u>	<u>Load2</u>	<u>Load3</u>	<u>Load4</u>	<u>Load5</u>	<u>Load6</u>
V71E	V71E	V71E	V71E	V71E	V71E
24E	24E	24E	24E	16E	5E
2407E	2431E	2453E	2475E	2517E	1016E
4053E	24017E	76521E	16401E	11406E	10001E
31407E	11423E	1720E	2401E	1526E	1412E
2653E	77775E	77634E	77526E	34765E	66105E
2076E	1E	24017E	11402E	55406E	V33E
35003E	2156E	47623E	1510E	5134E	
55406E	77634E	16401E	1510E	1410E	
6E	24017E	2405E	30000E	46005E	
30025E	47471E	45326E	6006E	35023E	
52155E	77745E	33412E	77621E	4647E	
35003E	2224E	742E	15737E	24000E	
54156E	41E	77775E	77776E	1731E	
54163E	77634E	2401E	6006E	1415E	
54745E	24017E	77776E	744E	V33E	
54746E	11435E	35003E	77776E		
6006E	52375E	54161E	31237E		
2224E	1E	54162E	74775E		
41E	2156E	6006E	6E		
77634E	77656E	77656E	15537E		
V33E	V33E	V33E	V33E		

EMP ASTP 77 - RASTER SCAN

PURPOSE:

This EMP is employed to maneuver the spacecraft in a predefined manner to perform a RASTER SCAN to determine the misalignment of the Extreme Ultraviolet (EUV) Telescope.

FUNCTIONAL DESCRIPTION:

The maneuver sequence alternately does 60 second and 14 second rotations defined by a table of pairs of double precision ν and ρ angles; one pair for each rotation segment.

When the EMP starts, it takes the first pair, transfers that pair to NOUN 78 registers and then calls R67 (Rotation Routine) to start rotation.

The EMP then cycles through the table reloading NOUN 78 registers at predetermined intervals. The EMP also causes R67 to recycle by periodically setting HOLDFLAG to zero. (If R67 were not recycled the new NOUN 78 registers would never be looked at).

NOUN 79 must be loaded with a $0.1^\circ/\text{sec}$. command rate, to accomplish the scan described below, and the desired deadband. The length of the scan (6° in roll or 1° in pitch-yaw) is controlled by the length of time until the next HOLDFLAG zeroing (either 60 sec or 14 sec).

In the EMP program coding below, the maneuver sequence consists of 9 maneuver segments.

1. a 6 degree positive roll segment
2. a 1 degree pitch/yaw segment followed by
3. a 6 degree negative roll segment,
4. etc.

ASSUMPTIONS:

- 1) Program, including table of ν 's and ρ 's has been uplinked.
- 2) N79 has been loaded with $0.1^\circ/\text{sec}$ command rate and the desired deadband.
- 3) CMC MODE is AUTO and the CSM-alone DAP, CSM/LM ascent DAP or Docked DAP is active.

- 4) Proper initial attitude has been attained.

RESTRICTIONS

- AND LIMITATIONS:
- 1) This EMP is to be run in POO.
 - 2) Raster scan maneuver will be terminated by any RHC commands, it will require maneuvering back to the initial attitude and the PROCEDURES repeated. It is therefore recommended that the RHC be locked prior to initiating the EMP.

PROCEDURES:

- 1) Maneuver to initial attitude
- 2) Key VERB 5 NOUN 79 ENTR and verify that NOUN 79 has been loaded with a $0.1^{\circ}/\text{sec}$ command rate (i.e. $R1 = +01000$) and the desired deadband.
- 3) Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for EMP ASTP 77
 - R1 00001
 - R2 01622
 - R3 74007
- 4) Key VERB 31 ENTR to call EMP ASTP 77 and initiate SCAN.

RECOVERY/

TERMINATION:

- 1) EMP ASTP-77 is self terminating and should take approximately 6 minutes to complete. (Time based on a $0.1^{\circ}/\text{sec}$ rate command and a 60 sec x 14 sec scanning pattern.)
- 2) EMP ASTP-77 is not restart protected; if restart occurs repeat procedures.
- 3) EMP ASTP-77 will be terminated on a Fresh Start (V36E) or any major mode change Verb 37 ENTR XX ENTR.

ERASABLE
MEMORY:

Program coding for EMP ASTP 77 is as follows:

<u>ECADR</u>	<u>Tag</u>	<u>Code</u>	<u>Octal</u>	
3515	THISEMP	CA	BEGTAB	30607
3156		TS	TABENT	55555
3517		AD	TWO	65000
3520		TS	TABENT1	55560
3521		CA	ONE	35001
3522		TS	FLAG	54606
3523		TS	DONE	54605
3524		TC	UPFLAG	07710
3525		ADRES	UTFLAG	00176
3526		TC	UPFLAG	07710
3527		ADRES	TRACKFLG	00031
3530		TC	LOADANG	01554
3531		TC	5SCWAIT	01533
3532		TC	R67	02554
3533	5SCWAIT	CA	Q	30002
3534		TS	RETURN	55616
3535		CA	5SECS	31617
3536		TC	WAITLIST	05246
3537		2CADR	50R55	01542 00007
3541		TC	RETURN	01616
3542	50R55	TC	LOADANG	01554
3543		CCS	FLAG	10606
3544		TC	55WAIT	01551
3545		CA	ONE	35001
3546		TS	FLAG	54606
3547		CA	9SEC	31621
3550		TC	GENWAIT	01576
3551	55WAIT	TS	FLAG	54606
3552		CA	55SEC	31620
3553		TC	GENWAIT	01576
3554	LOADANG	EXTEND		00006
3555	TABENT	DCA	TABLE	30612
3556		DXCH	UTPIT	53720
3557		EXTEND		00006

3560	TABENT1	DCA	TABLE +2	30614		
3561		DXCH	UTYAW	53722		
3562		CA	FOUR	34777		
3563		ADS	TABENT1	27560		
3564		CA	FOUR	34777		
3565		ADS	TABENT	27555		
3566		CS	A	40000		
3567		AD	ENDTB +4	60610		
3570		CCS	A	10000		
3571		TC	Q	00002		
3572		TC	+2	01574		
3573		TC	ALARM	05644		
3574		TS	DONE	54605		
3575		TC	Q	00002		
3576	GENWAIT	TC	WAITLIST	05246		
3577		2CADR	GOTIME	01602	00007	
3601		TC	TASKOVER	05327		
3602	GOTIME	CCS	DONE	10605		
3603		TC	+2	01605		
3604		TC	ENDEMP	01611		
3605		CA	ZERO	35003		
3606		TS	HOLDFLAG	55330		
3607		TC	5SCWAIT	01533		
3610		TC	TASKOVER	05327		
3611	ENDEMP	CA	PRI026	37650		
3612		TC	FINDVAC	05150		
3613		2CADR	GOTOV56	04557	04557	
3615		TC	TASKOVER	05327		
3617	5SECS	DEC	500	00764		
3620	55SEC	DEC	5500	12574		
3621	9SEC	DEC	900	01604		
3622	INIT	TC	DOWNFLAG	07722		
3623		ADRES	STIKFLAG	00020		
3624		TC	THISEMP	01515		
0607	BEGTAB	DCA	TABLE	30612		
0610	ENDTB +4	DCA	TABLE +40D	30662		
0611	TABLE	2DEC	0.0	00000	00000	(ρ) 1st pr
0613		2DEC	0.0	00000	00000	(γ) " "
0615		2DEC	.39513889	14511	36450	(ρ) 2nd pr
0617		2DEC	.25	10000	00000	(γ) " "

0621	2DEC	0.0	00000	00000	(ρ) 3rd pr
0623	2DEC	0.50	20000	00000	(γ) " "
0625	2DEC	.39513889	14511	36450	(ρ) 4th pr
0627	2DEC	.25	10000	00000	(γ) " "
0631	2DEC	0.0	00000	00000	(ρ) 5th pr
0633	2DEC	0.0	00000	00000	(γ) " "
0635	2DEC	.39513889	14511	36450	(ρ) 6th pr
0637	2DEC	.25	10000	00000	(γ) " "
0641	2DEC	0.0	00000	00000	(ρ) 7th pr
0643	2DEC	0.50	20000	00000	(γ) " "
0645	2DEC	.39513889	14511	36450	(ρ) 8th pr
0647	2DEC	.25	10000	00000	(γ) " "
0651	2DEC	0.0	00000	00000	(ρ) 9th pr
0653	2DEC	0.0	00000	00000	(γ) " "
1016	OCT	1	00001		
1017	OCT	1622	01622		
1020	OCT	74007	74007		

Note:

TABLE contains 9 pairs of double precision ρ 's and γ 's scaled B0 revolutions. The above listing reflects the following set of angles in TABLE.

	ρ	γ
1st pr	0°	0°
2nd pr	142.25°	90°
3rd pr	0°	180°
4th pr	142.25°	90°
5th pr	0°	0°
6th pr	142.25°	90°
7th pr	0°	180°
8th pr	142.25°	90°
9th pr	0°	0°

UPLINK:

For loading EMP ASTP-77 is as follows:

LOAD1	LOAD2	LOAD3	LOAD4	LOAD5	LOAD6	LOAD7
V71E	V71E	V71E	V71E	V71E	V71E	V72E
24E	24E	24E	24E	24E	24E	13E
3515E	3537E	3561E	3603E	607E	631E	653E
30607E	1542E	53722E	1605E	30612E	E	E
55555E	7E	34777E	1611E	30662E	E	654E
65000E	1616E	27560E	35003E	E	E	E
55560E	1554E	34777E	55330E	E	E	1016E
35001E	10606E	27555E	1533E	E	14511E	1E
54606E	1551E	40000E	5327E	E	36450E	1017E
54605E	35001E	60610E	37650E	14511E	10000E	1622E
7710E	54606E	10000E	5150E	36450E	E	1020E
176E	31621E	2E	4557E	10000E	E	74007E
7710E	1576E	1574E	4557E	E	E	V33E
31E	54606E	5644E	5327E	E	20000E	
1554E	31620E	54605E	E	E	E	
1533E	1576E	2E	764E	20000E	14511E	
2554E	6E	5246E	12574E	E	36450E	
30002E	30612E	1602E	1604E	14511E	10000E	
55616E	53720E	7E	7722E	36450E	E	
31617E	6E	5327E	20E	10000E	E	
5246E	30614E	10605E	1515E	E	E	
V33E	V33E	V33E	V33E	V33E	V33E	

SKYLARK 7 (GSOP)

R693

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