MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

R-693

GUIDANCE SYSTEM OPERATIONS PLAN FOR MANNED CM EARTH ORBITAL MISSIONS USING PROGRAM SKYLARK 1

SECTION 7 ERASABLE MEMORY PROGRAMS

March 1973

MIT CHARLES STARK DRAPER LABORATORY

CAMBRIDGE MASSACHUSETTS 02139

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SECTION 7 ERASABLE MEMORY PROGRAMS

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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 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

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

EMP		Downlist
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-51	P00	Coast and Align List
	P20	Rendezvous and Prethrust List
	P47	Powered List
SL-52		Any

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 ENDOFJOB.

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 VERB 96 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

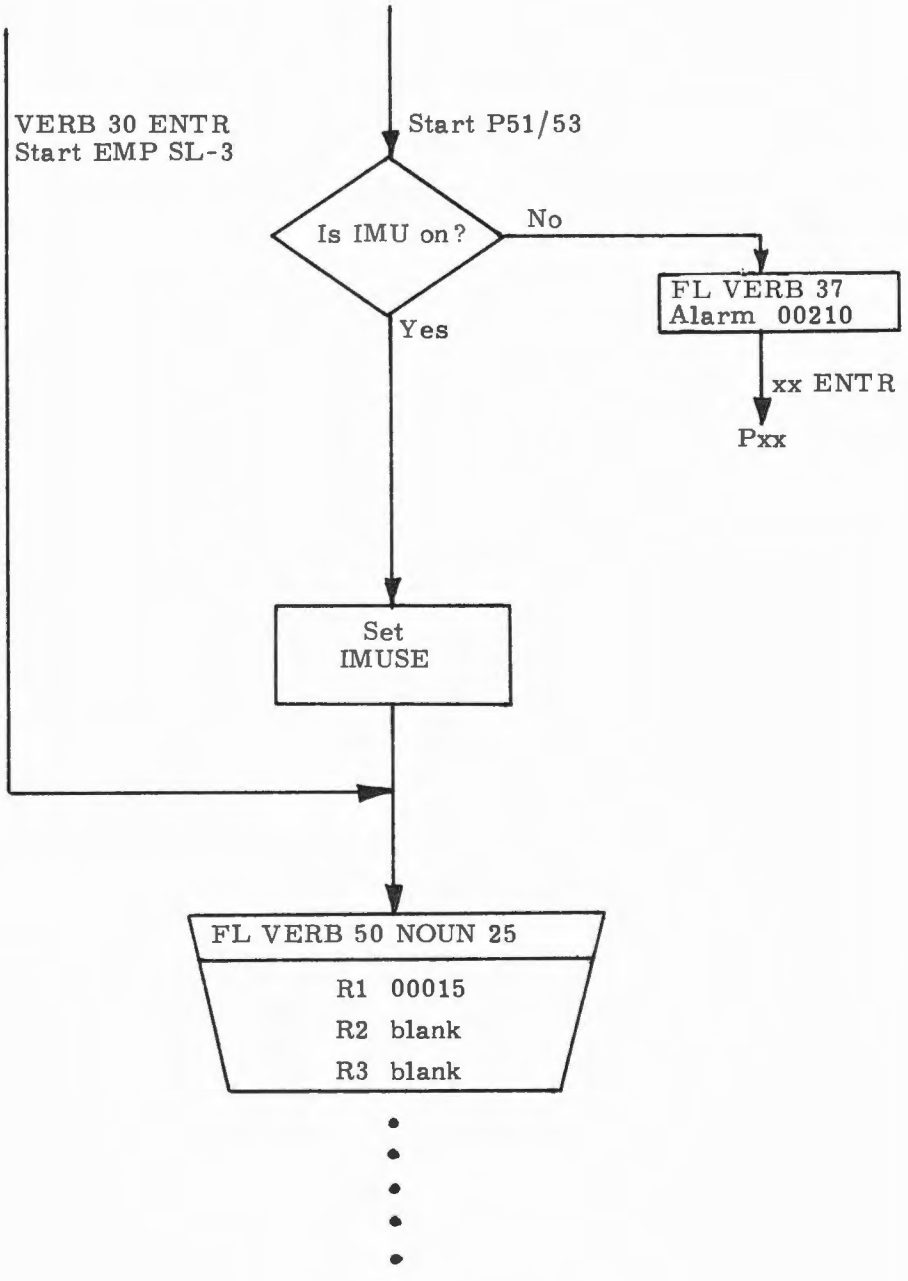
VERB 30 ENTR
Start EMP SL-3
Start P51/53
Is IMU on?
No
Yes
FL VERB 37
Alarm 00210
xx ENTR
Pxx
Set
IMUSE
FL VERB 50 NOUN 25
R1 00015
R2 blank
R3 blank

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 } of MARKDIF

NOTE.—The CDU transient-detection test (121_8 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 OWS
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.

   NOTE2.—LM-on attitude control remains in coding although it is not intended for use during SKYLAB.

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 overlayed 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 $-163.83 \leq xxx.xx \leq +163.83$)

   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:

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	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:

Load 1	Load 2
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

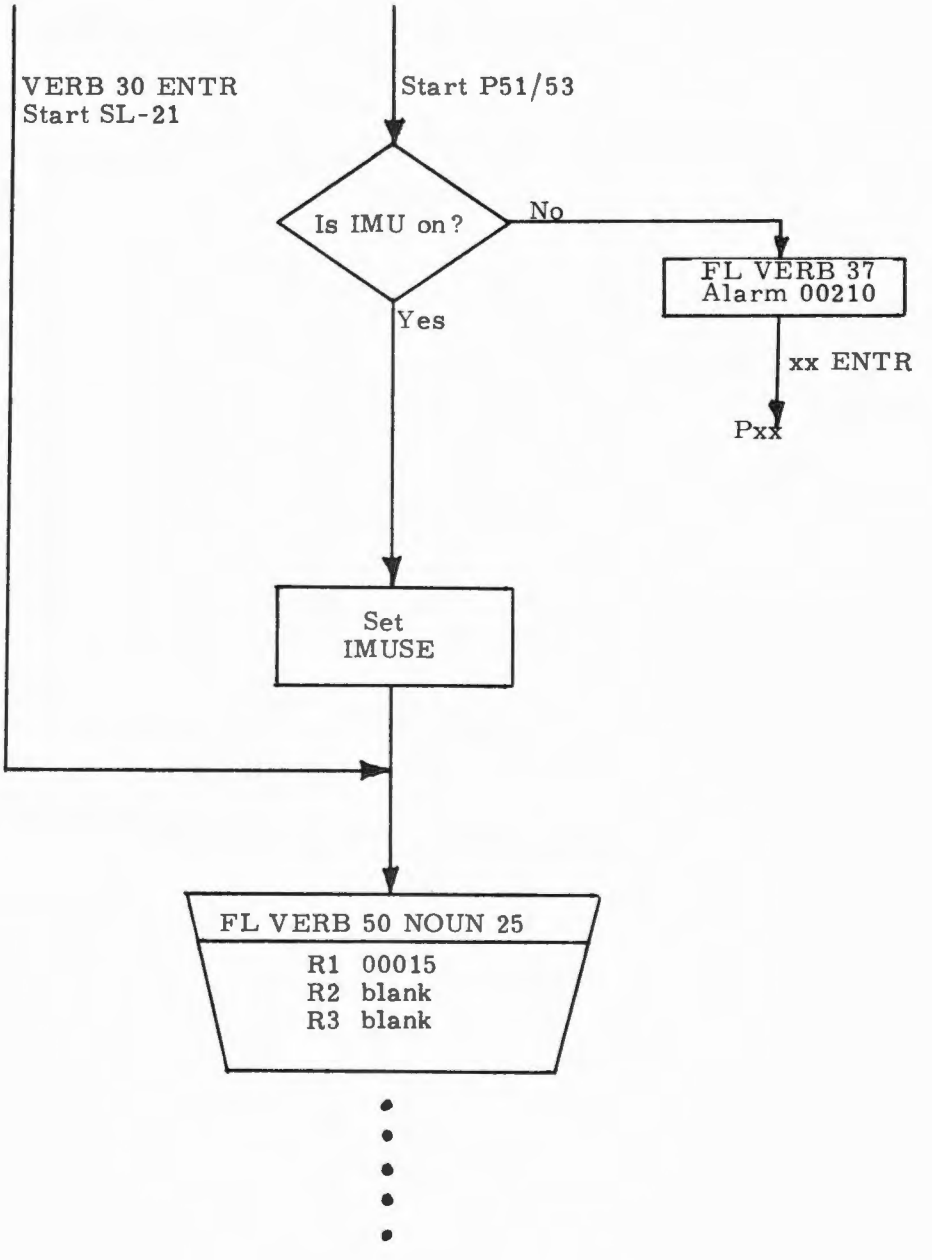
VERB 30 ENTR
Start SL-21
Start P51/53
Is IMU on?
No
FL VERB 37
Alarm 00210
xx ENTR
Pxx
Yes
Set
IMUSE
FL VERB 50 NOUN 25
R1 00015
R2 blank
R3 blank

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.
6. This EMP is ineffectual in detecting +X jet-on failures in the docked configuration.

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:

ECADR	Tag		Code	Octal
604		OCT	0	00000
605	JETCHECK	CA	7	30007
606		TS	VHFCNT	54764
607		TC	PHASCHNG	05415
610		OCT	05015	05015
611		OCT	77777	77777
612		CA	7	30007
613		TS	VAC4USE	54604
614	RECHECK	CS	ADB	41706
615		AD	-XDEG	60644
616		TS	L	54001
617		CA	TWO	35000
620	XSCHECK	TS	JETINDEX	54645
621		INDEX	JETINDEX	50645
622		CCS	ERRORX	11620
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	24764
635		TC	FIXDELAY	05270
636		DEC	100	00144
637		TC	RECHECK	00614
640	DINGDONG	CAF	BIT1	35001
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 SL-23 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
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:

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	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 modifed by EMP SL-28.

DOWNLINK operated portion of EMP SL-26:

ECADR	Tag		Code	Octal
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	DNPHASE2	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:

Load 1	Load 2	Load 3	Load 4	Load 5	Load 6
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 lose 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:

ECADR	Tag		Code	Octal
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      DNPHASE2    03452

2532    BELLS   CA      ALARMX      31540
2533            TC      FALTON +1   04363
2534            CA      CDUSAVE     31367
2535            TS      CDU?        5403X*
2536            TC      DNPHASE2    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:

Load 1	Load 2	Load 3	Load 4	Load 5	Load 6
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.
5. This EMP is ineffectual in detecting +X jet-on failures in the docked configuration.

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).

RESTRICTIONS AND LIMITATIONS:

1. RCS DAP is unavailable. Do VERB 48 ENTR. At FL VERB 04 NOUN 46, key VERB 21 ENTR 0xxxx ENTR. Subsequently, key VERB 46 ENTR. This 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. Therfore, 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-51 GENERALIZED ROTATIONAL RATE GENERATOR

PURPOSE:

This EMP provides a means of imparting a rotational rate to the Orbital Assembly. This capability can be of use in conjunction with docked +X translation maneuvers, CMG desaturation and the initiation of "Wide Deadband Attitude Hold".

During a docked RCS translational maneuver in the FREE mode, the +X jets do not thrust through the vehicle center of gravity (c.g.); a body attitude rate disturbance will therefore be imparted to the vehicle. In order to counter this body rate and also leave the contaminants from the attitude control firing jets in the old orbit, this EMP will generate opposing body rates prior to the translational maneuver.

CMG desaturation essentially involves changing the momentum state of the CMGs by a specified amount. One way of doing this is by using the RCS jets to apply an impulse to the OA which, when counteracted by the CMGs, will drive the CMGs to the desired final state. The angular rate commands needed to produce the proper impulse can be computed in advance external to the CMC.

Generally, at the initiation of the Wide Deadband Mode, the optimum vehicle rate is non-zero. EMP SL-51 can be used to impart the optimum rates to the vehicle at the initiation of the Wide Deadband Mode.

The EMP also has an option for restoring the DAP to its conventional attitude hold status after the EMP has been used in conjunction with any of the three above stated activities.

FUNCTIONAL DESCRIPTION:

Figure 1 is a functional flow graph of EMP SL-51. This EMP has two entry points for use in initiating rates. One entry point is used when rates are being imparted to the vehicle in conjunction with +X translations or CMG desaturation. The second entry point is for the initiation of the Wide Deadband Mode. EMP SL-51 also has a third entry point which is used for the restoration option of the EMP.

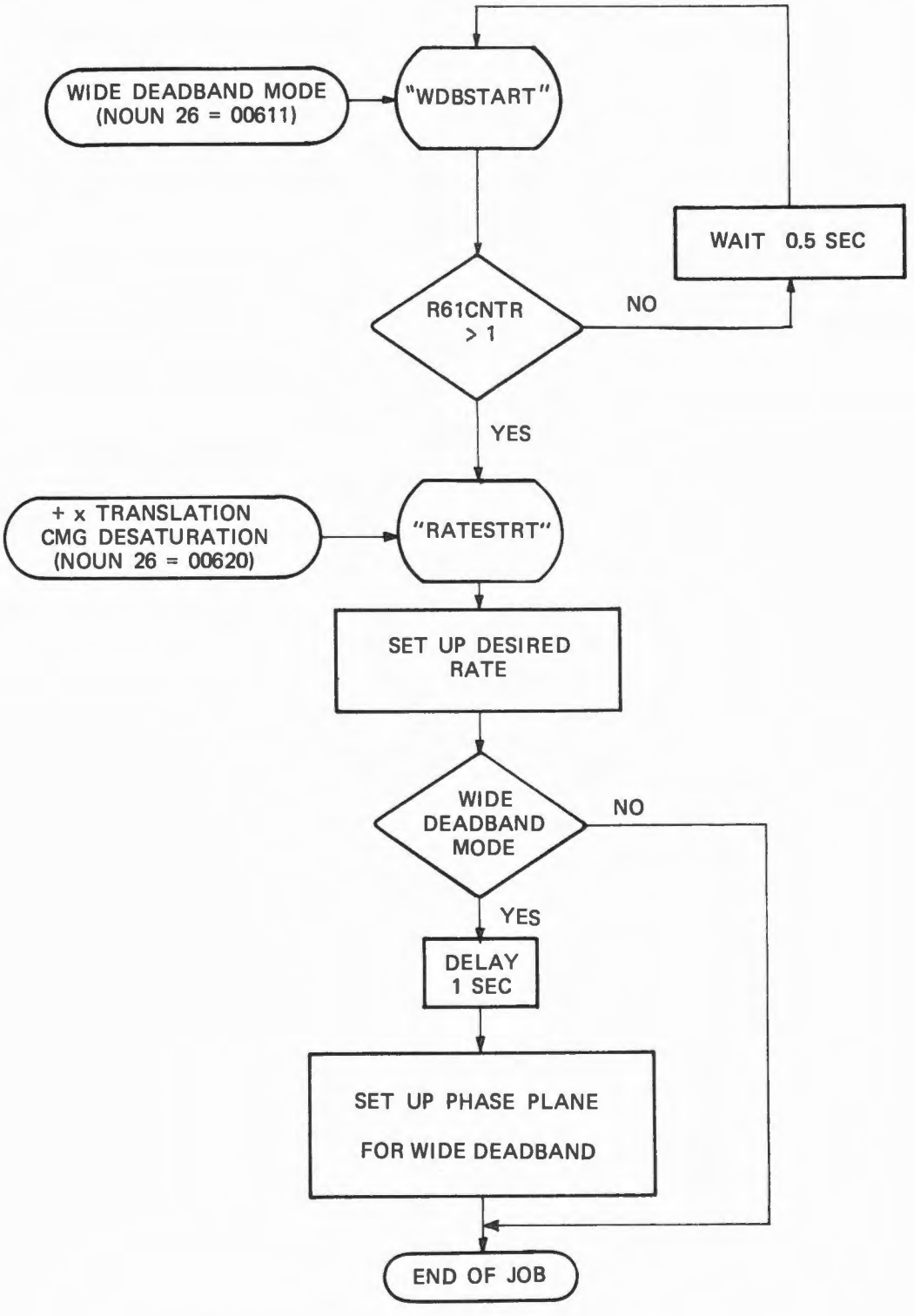

FIGURE SL-51-1 : FUNCTIONAL FLOW DIAGRAM.

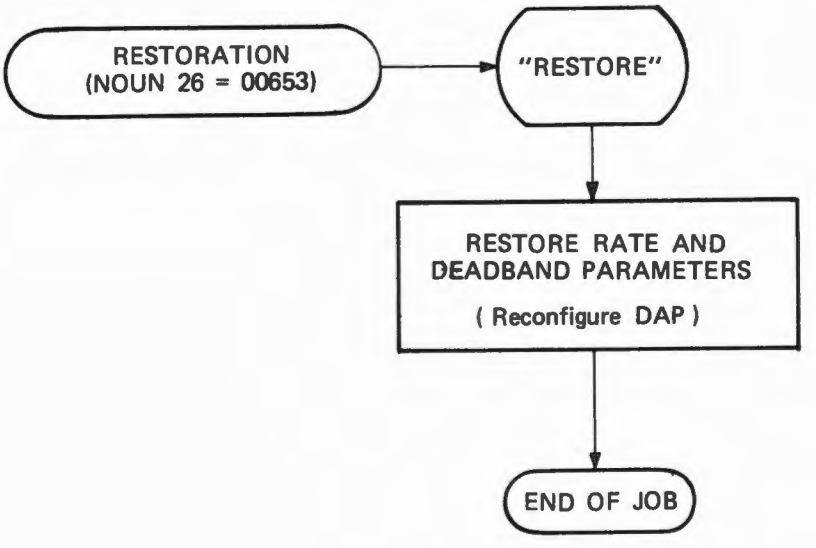

FIGURE SL-51-1 (continued)

When the +X translation/CMG desaturation entry point is used, EMP SL-51 alters two phase plane parameters to preclude multiple sets of firings. It then loads the desired rates for roll, pitch, and yaw (precomputed by the ground or the crew - one or more of the desired rates can be zero) into double precision DAP cells WBODY, WBODY1, and WBODY2. Finally, it sets HOLDFLAG negative and configures CH31TEMP so that on the next DAP pass, a single set of forced firings will occur that will establish the desired rates.

When the Wide Deadband Mode entry point is used, "R61CNTR" is checked to be sure P20 will not update command rates for at least one second. "R61CNTR" will be checked every 0.5 sec until this condition is met. This condition will be met within 2 seconds or less as long as P20 is running or Note 3 of the procedures is followed. Thereafter, EMP SL-51 does everything described for the +X translation/CMG desaturation entry point and in addition sets relevant phase plane parameters to appropriate Wide Deadband values.

The restoration entry point is used when it is desired to restore the DAP to a conventional configuration. When this entry point is used, the EMP zeros the double precision WBODYs and restores to nominal values all phase plane parameters altered by use of either of the above mentioned entry points. This means that when this restoration entry point is used subsequent to use of the EMP for +X translation or CMG desaturation, some of the parameters are reloaded with values that they already have. This activity is superfluous but harmless.

ASSUMPTIONS:

1. Docked DAP is on and properly loaded with nominal mission pad loads.

2. Program coding has been uplinked via P27.

RESTRICTIONS AND LIMITATIONS:

1. The initiation options of EMP SL-51 will not work in HOLD or FREE control mode, unless the IMU off procedures are used. (Steps 5a and 5b of procedure A and steps 4a and 4b of procedures B.)

2. The +X translation/CMG desaturation option of EMP SL-51 is designed to work in POO and P47 only.

3. The Wide Deadband Mode initiation option is designed to work only in POO or with options 1, 2 or 5 of P20 running in the background. If this option is to be used in POO, location E6,1776 (ECADR 3376) should be loaded with a positive number greater than or equal to 2.

4. Total ground-or crew-computed rate should not exceed 0.4 degree/sec.

5. When EMP SL-51 is used in conjunction with CMG desaturation, the TACS must be in an inactive or FREE drift type mode.

6. When EMP SL-51 is used in conjunction with +X translation or Wide Deadband Mode initiation, all OWS control systems (CMGs and TACS) must be in an inactive or FREE drift type mode.

7. The +X Translation and CMG Desaturation PROCEDURES can be modified to work with the IMU power off. Since the Wide Deadband Mode assumes active attitude control, it is pointless to attempt Wide Deadband initiation with the IMU off. The Restoration Option can be used with or without the IMU power on.

8. If a VERB 37 major mode change or a restart occurs following the uplink of EMP SL-51 coding and before VERB 30 ENTR, VAC area 4 should be checked to ensure that the program code is intact.

9. When EMP SL-51 is used in conjunction with +X translation with the IMU on, the VERB 30 ENTR must be keyed 5 or more seconds before switching to FREE prior to +X translation.

PROCEDURES:

A. +X TRANSLATION

1. Maneuver to burn attitude.

2. Load double precision desired rates into registers 1372 through 1377. (See notes (2), (3), and (4) listed at the end of the uplink).

3. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for this option of EMP SL-51:

   R1 14000
   R2 00620
   R3 00006

4. S/C CONT - CMC

5. CMC MODE - AUTO

   If the IMU is not on, perform the following steps:

   5a. Load C31FLWRD: (to set DAP mode CMC-AUTO when IMU power is off).
   Key—
   VERB 21 NOUN 1 ENTR
   373 ENTR
   30000 ENTR

   5b. Load IMODES 33: (to remove DAP disable due to IMU off).
   Key—
   VERB 21 NOUN 1 ENTR
   1324 ENTR
   26000 ENTR

6. At TIG-6 seconds,
   Key—
   VERB 30 ENTR
   to initiate EMP SL-51.

7. At TIG-1 seconds,
CMC MODE - FREE.
If IMU is not on, Step 7 is not required.

NOTE1.—If after Step 7 the CMC MODE switch is returned to either AUTO or HOLD, the DAP will perform an effective attitude hold function with a zero command rate and will use the deadband and WLH/SLOP+1 loaded by EMP SL-51. If IMU is not on, Note 1 does not apply.

8. At TIG, perform +X translational maneuver.

9. Reconfigure the Docked DAP by using procedure D of EMP SL-51.

NOTE2.—Attitude control of the OA will normally be taken over by the CMGs after step 9.

B. CMG DESATURATION

1. Load double precision desired rates into registers 1372 through 1377. (See notes (2), (3), and (4) listed at the end of the uplink).

2. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for this option of EMP SL-51:

R1	14000
R2	00620
R3	00006

3. S/C CONT - CMC

4. CMC MODE AUTO

If the IMU is not on, perform the following steps:
4a. Load C31FLWRD: (to set DAP mode CMC-AUTO when IMU power is off).

Key—
VERB 21 NOUN 1 ENTR
373 ENTR
30000 ENTR

4b. Load IMODES 33: (to remove DAP disable due to IMU off).
Key—
VERB 21 NOUN 1 ENTR
1324 ENTR
26000 ENTR

5. Key VERB 30 ENTR to initiate EMP SL-51.

6. Reconfigure the Docked DAP by using procedure D of EMP SL-51.

C. WIDE DEADBAND MODE INITIATION

1. Load double precision desired rates into register 1372 through 1377. (See notes (2), (3), and (4) listed at the end of the uplink).

2. Initiate P20 if it has not already been initiated.

NOTE3.—If P20 is not to run in the background:

Load R61 CNTR:
Key—
VERB 21 NOUN 1 ENTR
3376 ENTR
2 ENTR

3. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for this option of EMP SL-51:

R1 14000
R2 00611
R3 00006

4. S/C CONT - CMC
5. CMC MODE - AUTO
6. Key VERB 30 ENTR to initiate EMP SL-51.
7. When the Wide Deadband Mode is no longer desired perform procedure D to restore the DAP to a conventional configuration.

D. RESTORATION OPTION

1. Key VERB 5 NOUN 26 ENTR and verify that NOUN 26 is valid for this option of EMP SL-51:

R1	14000
R2	00653
R3	00006

2. CMC MODE - FREE
If IMU is not on, Step 2 is not required.

3. Key VERB 30 ENTR to initiate EMP SL-51.

NOTE4.—Desired activity can be resumed at any time after step 3.

RECOVERY/ TERMINATION:

1. The restoration procedure of EMP SL-51 is the standard recovery.

2. EMP SL-51 is not restart protected. If a restart occurs in Step 6 of +X translation procedures, Step 5 of CMG Desaturation procedures, or Step 3 of the Restoration procedures simply repeat the step. In the +X translation procedures this may force a TIG slip. If a restart occurs in step 6 of the Wide Deadband Mode initiation, execute the Restoration Option of EMP SL-51 and then repeat the Wide Deadband Mode initiation procedures in their entirety.

ERASABLE MEMORY:

Program Coding for EMP SL-51 follows:

ECADR	Tag	Code		Octal
0605	WAIT	CAF	.5SEC	35023
0606		TC	BANKCALL	04647
0607		CADR	E/BKCALL	24000
0610		CADR	DELAYJOB	01731
0611	WDBSTART	CS	ONE	45001
0612		AD	R61CNTR	61776
0613		CCS	A	10000
0614		TC	RATESTRT	00620
0615		TC	WAIT	00605
0616		TC	WAIT	00605
0617		TC	WAIT	00605
0620	RATESTRT	CA	DDB	31370
0621		TS	ADB	55706
0622		TS	DBPTC	55775
0623		CAF	EBANK5	35055
0624		TS	EBANK	54003
0625		TC	ZAP1	01400
0626	ZAP2	TC	E6SETTER	04611
0627		CA	CDUX	30032
0630		TS	CDUXD	55677
0631		CA	CDUY	30033
0632		TS	CDUYD	55701
0633		CA	CDUZ	30034
0634		TS	CDUZD	55703
0635		CAF	FIVE	35004
0636		TC	GENTRAN	05562
0637		ADRES	EXES	01372
0640		ADRES	WBODY	01554
0641		CA	FFB	31367
0642		TS	CH31TEMP	55663
0643		CA	HIGH9	37677
0644		TS	HOLDFLAG	55330
0645		RELINT		00003
0646		CA	EBANK5	35055
0647		TS	EBANK	54003
0650		TC	ZAP3	01411
0651		OCT	00000	00000
0652		OCT	00000	00000
0653	RESTORE	CA	ONE	35001
0654		TS	HOLDFLAG	55330
0655		CA	EBANK5	35055
0656		TS	EBANK	54003
0657		TC	RESTORE1	01472
1016		OCT	14000	14000
1017		OCT	ABC	00ABC(1)
1020		OCT	00006	00006
1366	RSTRTAD	ECADR	RATESTRT	00620
1367	FFB	OCT	37752	37752
1370	DDB	OCT	02660	02660

```
1371                    OCT     00000           00000
1372    EXES            OCT     XXXXX           XXXXX(2)
1373                    OCT     XXXXX           XXXXX(2)
1374    WISE            OCT     YYYYY           YYYYY(3)
1375                    OCT     YYYYY           YYYYY(3)
1376    ZEEZ            OCT     ZZZZZ           ZZZZZ(4)
1377                    OCT     ZZZZZ           ZZZZZ(4)

2400    ZAP1            TC      INTPRET         06006
2401                    DLOAD                   77745
2402                            WLSDUM          02463
2403                    STORE   WLH/SLOP        03034
2404                    VLOAD                   77775
2405                            ZEROVEC         15726
2406                    STORE   DELCDUX         03227
2407                    EXIT                    77776
2410                    TC      ZAP2            00626
2411    ZAP3            CS      N26/2CAD        41017
2412                    AD      RSTRTAD         61366
2413                    EXTEND                  00006
2414                    BZF     ENDOFJOB        15220
2415                    CAF     1SEC            35030
2416                    TC      BANKCALL        04647
2417                    CADR    E/BKCALL        24000
2420                    CADR    DELAYJOB        01731
2421                    TC      INTPRET         06006
2422                    DLOAD                   77745
2423                            SL2P1DUM - 1    02461
2424                    STORE   SLOPE - 1       03305
2425                    VLOAD                   77775
2426                            SL2P1DUM        02462
2427                    STORE   SLOPE2 + 1      03033
2430                    TLOAD                   77751
2431                            ECYWWDB         02470
2432                    STORE   ECYW            03041
2433                    TLOAD                   77751
2434                            JDM             02456
2435                    STORE   J/M             03255
2436                    EXIT                    77776
2437                    TC      ENDOFJOB        05220

2455    JDM             OCT     0231            00231
2456                    OCT     0231            00231
2457                    OCT     0231            00231
2460    BIGZ            OCT     00000           00000
2461    SL2P1DUM        OCT     00024           00024
2462    WLSDUM          OCT     00114           00114
2463                    OCT     10707           10707
2464                    OCT     00055           00055
2465                    OCT     02755           02755
2466                    OCT     37777           37777
2467    ECYWWDB         OCT     40000           40000
2470                    OCT     00000           00000
2471                    OCT     00000           00000
2472    RESTORE1        TC      INTPRET         06006
2473                    VLOAD                   77775
2474                            SL2P1R          02526
2475                    STORE   SLOPE2 + 1      03033
2476                    TLOAD                   77751
2477                            ECYWR           02534
2500                    STORE   ECYW            03041
```

2501		TLOAD		77751
2502			J/MDCKD	03047
2503		STORE	J/M	03255
2504		VLOAD		77775
2505			ZEROVEC	15726
2506		STORE	WBODY	03155
2507		SLOAD		77735
2510			DKDB	03075
2511		STORE	ADBR	02540
2512		STORE	ADBRP2	02542
2513		DLOAD		77745
2514			JUNKER	02541
2515		STORE	RATEPTC	03375
2516		DLOAD		77745
2517			SLOPER	02537
2520		STORE	SLOPE	03306
2521		EXIT		77776
2522		TC	ENDOFJOB	05220
2523		OCT	00000	00000
2524		OCT	00000	00000
2525	SL2P1R	OCT	07534	07534
2526		OCT	00114	00114
2527		OCT	00056	00056
2530		OCT	00055	00055
2531		OCT	00017	00017
2532		OCT	05225	05225
2533	ECYWR	OCT	72616	72616
2534		OCT	66670	66670
2535		OCT	24434	24434
2536	SLOPER	OCT	03656	03656
2537	ADBR	OCT	03000	03000
2540	JUNKER	OCT	00000	00000
2541	ADBRP2	OCT	03000	03000
2542	JUNKERP2	OCT	00000	00000

See notes ( ) listed at the end of the uplink.

UPLINK: For loading EMP SL-51 is as follows:

Load 1	Load 2	Load 3	Load 4	Load 5
V71E	V71E	V71E	V71E	V71E
24E	24E	11E	5E	14E
605E	627E	651E	1016E	1366E
35023E	30032E	E	14000E	620E
4647E	55677E	E	ABCE(1)	37752E
24000E	30033E	35001E	6E	2660E
1731E	55701E	55330E	V33E	E
45001E	30034E	35055E		XXXXXE(2)
61776E	55703E	54003E		XXXXXE(2)
10000E	35004E	1472E		YYYYYE(3)
620E	5562E	V33E		YYYYYE(3)
605E	1372E			ZZZZZE(4)
605E	1554E			ZZZZZE(4)
605E	31367E			V33E
31370E	55663E			
55706E	37677E			
55775E	55330E			
35055E	3E			
54003E	35055E			
1400E	54003E			
4611E	1411E			
V33E	V33E			

Load 6	Load 7	Load 8	Load 9	Load 10
V71E	V71E	V71E	V71E	V71E
24E	20E	24E	24E	24E
2400E	2422E	2455E	2477E	2521E
6006E	77745E	231E	2534E	77776E
77745E	2461E	231E	3041E	5220E
2463E	3305E	231E	77751E	E
3034E	77775E	E	3047E	E
77775E	2462E	24E	3255E	7534E
15726E	3033E	114E	77775E	114E
3227E	77751E	10707E	15726E	56E
77776E	2470E	55E	3155E	55E
626E	3041E	2755E	77735E	17E
41017E	77751E	37777E	3075E	5225E
61366E	2456E	40000E	2540E	72616E
6E	3255E	E	2542E	66670E
15220E	77776E	E	77745E	24434E
35030E	5220E	6006E	2541E	3656E
4647E	V33E	77775E	3375E	3000E
24000E		2526E	77745E	E
1731E		3033E	2537E	3000E
6006E		77751E	3306E	E
V33E		V33E	V33E	V33E

(1) ABC = 611 for Wide Deadband initiation

= 620 for +X Translation and CMG Desaturation

= 653 for Restoration

(2) XXXXX = Ground-computed desired roll rate, scaled B-3 revs/deci sec, DP.

(3) YYYYY = Ground-computed desired pitch rate, scaled B-3 revs/deci sec, DP.

(4) ZZZZZ = Ground-computed desired yaw rate, scaled B-3 revs/deci sec, DP.

EMP SL-52: CHECKSUM FOR EMPS USING VAC AREA 4

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.

EMPs using VAC area 4 are:
SL-23 Monitor Jet-On Failure
SL-28 Monitor Jet-On Failure and Do EMP SL-26
SL-51 Generalized Rotational Rate Generator

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 EMPs 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
SL-51 Loads 1, 2 and 3

RECOVERY/
TERMINATION: NA

ERASABLE MEMORY:

Program coding for EMP SL-52 is as follows:

ECADR	Tag	Code		Octal
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:

Load 1	Load 2	Load 3
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:

	TAG	ECADR	SL-23(1)	SL-28(1)	SL-51
ABCDE	ICNTR	3756	36	40	52
FGHIJ	CHKSUM	3757	23156	52610	12542

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

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R693

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