

1. APPLICATION: STATION-KEEPING (DELTA-V) PROCEDURE

IMPLEMENTATION: OD/POD

SUPERCEDES PRIOR FODS: S001I

page 1 of 5

2. DIRECTIVE:

INITIAL STATE: 3-AXIS CONTROL UNDER HOLD/SLEW ALGORITHM

A. SUMMARY OF DELTA-V SEQUENCE:

1. TWO SHIFTS PRIOR TO THE DELTA-V SHIFT THE S/C SHALL BE AT A HIGH BETA (WITHIN - 5° OR LESS OF POWER NEUTRAL) FOR OBC AND HAPS J2&8 COOLING.
2. SLEW TO DELTA-V ATTITUDE
3. ACQUIRE REFERENCE OBJECT
4. UNLOAD REACTION WHEELS, IF REQUIRED
5. VERIFY VHF TELEMETRY CAPABILITY
6. CLOSE SUN SHUTTER
7. TRANSFER TO RATE PLUS POSITION HOLD
8. PERFORM DELTA-V BURN
9. TRANSFER TO HOLD/SLEW MODE
10. OPEN SUN SHUTTER
11. RE-ACQUIRE ATTITUDE REFERENCE

- NOTES:**
1. IF BACKUP EVD & EVCL ARE BEING USED SEE FOD E015.
 2. IF BACKUP JETS ARE BEING USED BIT 4 OF ACSFLG MUST BE SET.

B. ABORT STRATEGY -- SEE SECTION H.

C. GROUND SYSTEM CONFIGURATION:

SIGMA 5 AND SIGMA 9 ON LINE:

	<u>SIGMA 5</u>	<u>SIGMA 9</u>
TELEMETRY DATA SOURCE	S-BAND	S-BAND
COMMAND	YES	NO

3. APPROVAL SIGNED:

[Handwritten Signature]

14/MAR/86
DATE

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IMPLEMENTATION: OO/POD

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2. DIRECTIVE:

CRT ASSIGNMENTS			SIGMA	STRIPCHART ASSIGNMENTS (SIGMA 9, DELAYED MODE)	
CHAN	PAGE /	RATE		PEN NO.	
1	SYSTEM2	10	5	1.	ABG11, ±5°
2	ACSM2	3	5	2.	RBG11, ±1° PER SEC
3	OBCRAW2	5	9	3.	ABG12, ±5°
4	DBASEB	-	5	4.	RBG12, ±1° PER SEC
5	ACSM2	3	9	5.	NRER1, ±300 COUNTS
6	SYSTEMP2	10	9	6.	WV3, ±2.5 VOLTS
7	SISTAT2	10	5	7.	AS1CH39, RAW (SAI 1)
8	EVENT	-	5	8.	SCI, RAW
9	ACS	10	9	9.	AS1CH46 (CATBD 2), ENG, 0, 500
10	EVENT	-	9	10.	AS1CH52 (CATBD 8), ENG, 0, 500

NOTE: ASSURE PROPER SCALING OF PENS
RUN SCR'S AT .2mm/SEC

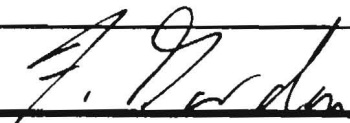
D. SPACECRAFT CONFIGURATION AT START:

1. TELEMETRY:
 FORMAT 2A, BITRATE 20Kbs
2. HEATER GROUP 2 ON
3. VHF ON, BUT NOT BEING PROCESSED
4. OTHERWISE, NORMAL CONFIGURATION

E. DELTA-V SETUP

1. SLEW TO DELTA-V ATTITUDE
2. UNLOAD REACTION WHEELS, IF REQUIRED
3. TURN VHF ON, GO TO 5Kbs & VERIFY LOCK; THEN RETURN TO 20 Kbs, S-BAND
4. SEARCH FOR REFERENCE OBJECT
5. SNAP ACSM2 TO RECORD PREBURN VALUES OF BETA, ROLL AND WHEEL RATES.
6. LOAD SYSPROC FILE
7. SET OBC PROGRAMMABLE DATA CELLS:
 EXEC DB13, 0'3000', 0'3002', 0'3017', 0'3001', 0'3003', 0'3020'

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2. DIRECTIVE:

F. DELTA-V PROCEDURE

EXEC DELV, N

/N=BURN TIME IN OBC COUNTS

THIS PROCEDURE PERFORMS THE FOLLOWING:

```

EXEC DB12, 3           /OBC TLM FORMAT ROTATION
: IMP 46              /CLOSE SUN SHUTTER
MBO=1, MB1=1, MB2=2   /WORKER 0 TO LOW GAIN
ME0=1, ME1=0, ME2=0
OBCDB21 MBO, MB1, MB2, ME0, ME1, ME2
: OBC LDBLK, 21
: OBC CMND, 7, 0      /ZERO ERROR FLAGS
: OBC CMND, 4, 9     /TURN OFF RATE ARREST WORKER
EXEC JETENA, 3055     /ENABLE ALL LTE'S AND HTE'S
                     2&8 IN PULSE MODE
: CRU ON, 3          /ENABLE EVD#1
: OBC CMND, 16, 0    /SET ACSFLG FOR RATE+POSITION
    
```

AT THE 'WAIT' STATEMENT, A 'GO' WILL TURN OFF WORKER 0; AND CONTROL IS LOST UNTIL WORKER 19 IS TURNED ON.

```

: OBC CMND, 4, 0      /W0 IS OFF - CONTROL LOST
: RW, RWMODE=0, RWENAB=1, PITCH=128, /NO COMMANDS TO WHEELS
  YAW=128, ROLL=128, REDUN=128
: IRA, IRAMC=0, IRAQB=1 /GYROS TO RATE MODE
: OBC CMND, 3, 19    /W19 ON - CONTROL REGAINED
    
```

AT THE 'WAIT' STATEMENT, MONITOR OPERATION ON SCR AND CRT. IF PERFORMANCE LOOKS GOOD - PROCEED. IF SPACECRAFT IS OUT OF CONTROL OR DOES NOT LOOK NOMINAL - GO TO ABORT STRATEGY.

A 'GO' WILL SET UP AND PERFORM THE DELTA-V BURN.

```

: OBC CMND, 17, N     /BURN TIME IN .1024 SEC
: OBC CMND, 16, 1    /START DELTA-V BURN
    
```

MONITOR OPERATION ON SCR & CRT. BURN TIME SHOULD BE OVER WITHIN 2-3 UPDATES. AT COMPLETION OF BURN, CONTROL SHOULD DEFAULT TO R+P HOLD. MONITOR VEHICLE RATES ON OBCRAW2 AND ACSM2, IF RATES ARE < 0.1° /SECOND - PROCEED. IF SPACECRAFT IS OUT OF CONTROL OR DOES NOT LOOK NOMINAL - GO TO ABORT STRATEGY.

3. APPROVAL SIGNED:

F. Gordon

14 March 1986
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IMPLEMENTATION: 00/POD
SUPERCEDES PRIOR FODS: S001I

2. DIRECTIVE:

A 'GO' WILL RETURN CONTROL BACK TO WORKER 0 - CONTROL WILL BE LOST UNTIL WORKER 0 IS TURNED BACK ON.

: CRU OFF, 3	/EVD#1 IS OFF
: OBC CMND, 4, 19	/W19 OFF - CONTROL LOST
: IRA, IRAMC=60, IRAQB=1	/GYROS TO H/S MODE
: RW, RWMODE=11, RWENAB=1	/WHEEL CMDS ACCEPTED
: OBC CMND, 3, 0	/W0 ON - CONTROL REGAINED

MONITOR SCR AND CRT FOR CAPTURE ON HOLD/SLEW WORKER; ONCE SAFE, RETURN ALL SYSTEMS TO NORMAL OPERATING CONFIGURATION.

EXEC JETENA, 2925	/ENABLE LTE'S TO PULSE MODE
ME0=1, ME1=1, ME2=1	/WORKER 0 TO HIGH GAIN
OBCDB21 ME0, ME1, ME2	
: OBC LDBLK, 21	
EXEC DB12, 1	/NORMAL OBC TLM ROTATION
: IMP 45	/OPEN SUN SHUTTER
IRAQB, RWENAB=0	/DISABLE IRA, RW COMMANDS

G. POST DELTA-V CLEANUP

BEFORE RETURNING TO SCIENCE OPERATIONS FOR ATTITUDE RECOVERY, VERIFY THAT SPACECRAFT CONFIGURATION, ALL EQUIPMENT AND COMMAND FIELDS ARE PROPERLY SET.

RE-ASSIGN OBC PROGRAMMABLE DATA CELLS:

EXEC DB13, 0'431', 0'2503', 0'725', 0'113', 0'1770', 0'754'

RELOAD OPERATIONS PROCFILE

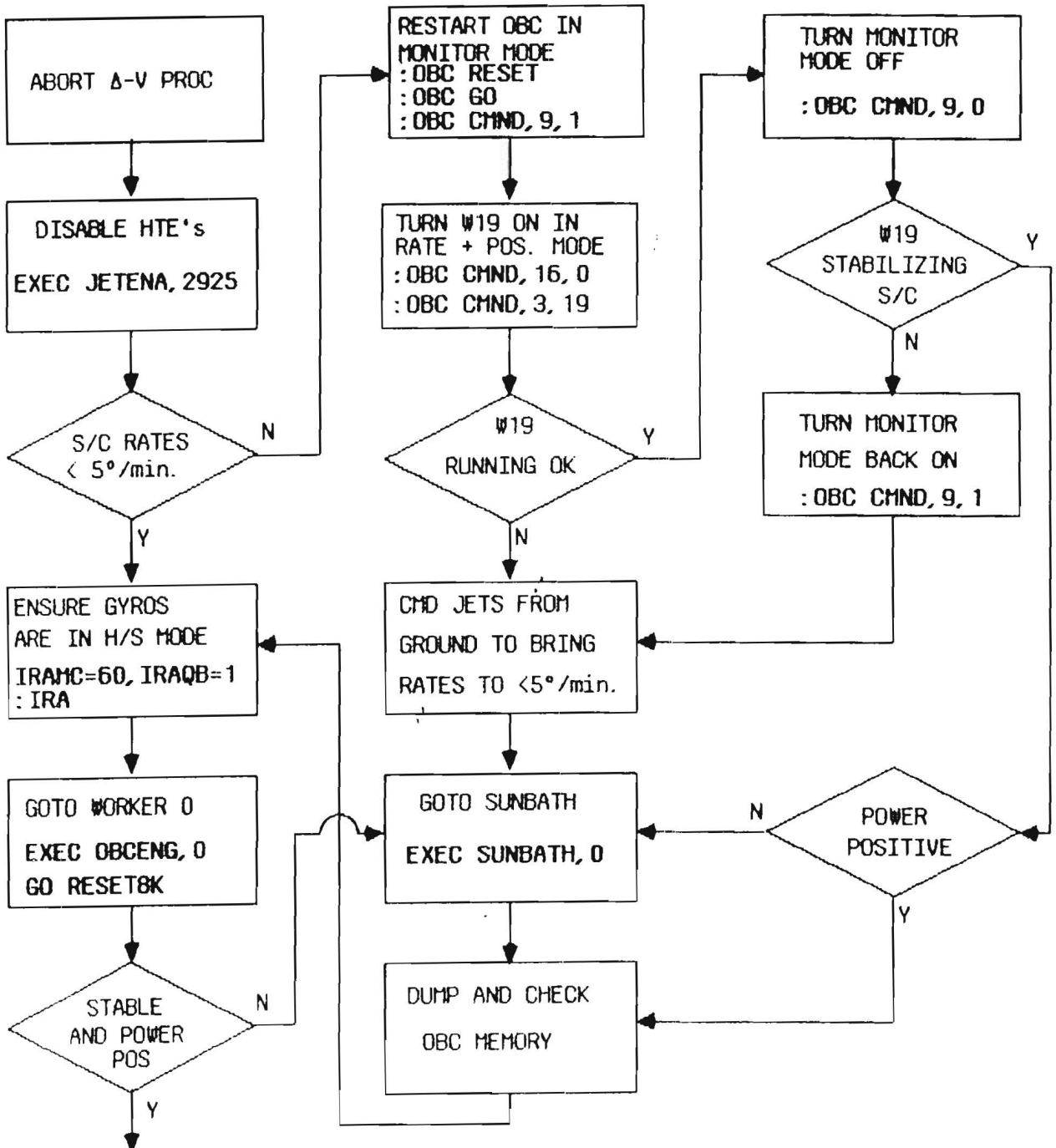
VERIFY THE FOLLOWING:

VHF IS OFF
 SUN SHUTTER IS OPEN
 WORKERS 1, 6 AND 8 ARE ON
 EVD'S ARE OFF
 IRAMC=60, IRAHTR=2, IRAQB=0
 RWENAB=0
 FIRE=0
 ACSFLG=0

3. APPROVAL SIGNED:



187 March 86
DATE



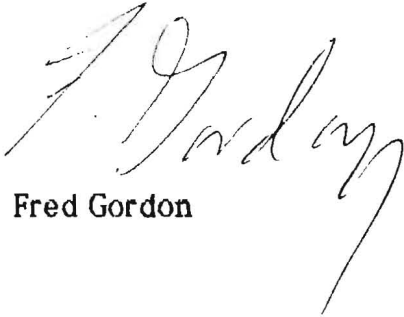
COMMAND CONFIGURATION - :EV, FIRE=(#)

TORQUE REQUEST	JETS	FIRE #
+ PITCH	7 & 3	PPITCH (68)
- PITCH	9 & 1	MPITCH (257)
+ YAW	10 & 6	PYAW (544)
- YAW	12 & 4	MYAW (2056)
+ ROLL	10 & 4	PROLL (520)
- ROLL	12 & 6	MROLL (2080)

AD

To: FOD Distribution
From: F. Gordon/IUE POD
Subj: Interim revision of S002M
Date: February 18, 1988

An excessive rise in the battery temperatures has again been occurring during the recharge cycle; this is an indication of an overcharge condition. Therefore, effective immediately, the amount of recharge that is to be returned to the batteries will be reduced to **120%** of the discharge energy lost, instead of the previous level of 130%.



Fred Gordon

To: FOD Distribution
From: F. Gordon/IUE POD
Subj: Interim revision of FOD S002M
Date: August 25, 1987

An excessive rise in the battery temperatures has been occurring during the recharge cycle, and is an indication of an overcharge condition. Therefore, effective immediately, the amount of recharge that is to be returned to the batteries will be reduced to 120% of the discharge energy lost, instead of the previous level of 130%.

Fred Gordon

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLIMENTATION: 00

SUPERCEDES PRIOR FODS: S002L

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2. DIRECTIVE:

This directive provides information and instruction for the IUE spacecraft system configuration and operation during the IUE orbit shadow periods. There are two types of shadow periods that will occur, earth and moon shadows. In both cases be prepared for loss of sun presence. LOSS OF SUN PRESENCE MEANS LOSS OF ATTITUDE CONTROL IF THE SPACECRAFT IS NOT PROPERLY CONFIGURED!

A. EARTH SHADOW:

An earth shadow period of up to approximately 75 minutes each day for about 25 days will occur every 6 months for the IUE orbit. Special consideration must be given to spacecraft system configuration, attitude control, temperatures, operations, and power load during these shadow periods.

B. MOON SHADOW:

A moon shadow may occur and result in a period when sun presence would be lost. Most frequently the moon shadow will result only in a penumbra condition. However, for ANY shadow the spacecraft should be configured with pitch and yaw on FES, and roll under gyro control.

If an umbra condition is predicted for a duration greater than 5 minutes, before penumbra starts place the active cameras in standby and configure the other spacecraft systems for shadow as defined in paragraph D3(c).

C. UNEXPECTED SHADOW:

LOSS OF SUN PRESENCE MEANS LOSS OF ATTITUDE CONTROL IF THE SPACECRAFT IS NOT PROPERLY CONFIGURED.

1. Check for loss of attitude reference by observing wheel speeds, FES data, solar array current, and other spacecraft system parameters. If the S/C is holding with pitch and yaw on FES and roll on gyros, attitude reference should be maintained. If attitude control has been lost, then go to Sunbath as soon as the shadow is over.
2. If attitude is stable contact WPS to bring up VHF system. If a shadow umbra exceeds 3 minutes PREPARE to proceed to power down the spacecraft systems.
3. If umbra exceeds 5 minutes:
 - a. Immediately place the cameras in standby, check with T.O. or R.A. before executing (or have executed by T.O.).

EXEC STOP,	NOCAL	/PROC TO PERFORM THE FOLLOWING
LWP		/LWP TO STANDBY
LWR		/LWR TO STANDBY
SWP		/SWP TO STANDBY
SWR		/SWR TO STANDBY

NOTE: PROC MUST BE RUN SEPARATELY FOR EACH ACTIVE CAMERA.

3. APPROVAL SIGNED:



14 Aug 87
DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLIMENTATION: 00

SUPERCEDES PRIOR FODS: S002L

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2. DIRECTIVE:

- b. When good VHF data is available transfer to VHF system and power down S-band system; also turn on battery chargers and power down SI heaters and HAPS heaters per paragraph D3(c). If VHF data link has been established run the shadow proc. The proc configures these systems and turns off the S-band system.

EXEC SHADOW, 0

D. SPACECRAFT SYSTEMS CONFIGURATION CHANGES FOR SHADOW PERIODS:

Spacecraft systems must be configured and operations must be reduced to limit the battery discharge current to less than 4.5A each and assure no more than 80% depth of battery discharge during the shadow.

1. SPACECRAFT HOLD MODES:

a. FES ONLY

Pitch and yaw are on FES with roll on gyros, and there is star presence with a count > 2000, in fast track mode. This mode is normally used whenever the predicted depth-of-discharge is < 50%.

b. SHADTRACK

Both worker 10 (wheel hold) and worker 0 are running; worker 10 is controlling while worker 0 tracks the S/C's movement in pitch and yaw. W0 will be configured with pitch and yaw on raw gyros, roll will be on FSS. During shadow the OBC will calculate pitch and yaw ABG's. Once shadow is over worker 10 is turned off, and worker 0 commanding is enabled; the accumulated errors will then be zeroed out by W0 and the IUE should nearly return to its original pointing (there may be some corruption of gyro data due to roll motion which will result in erroneous ABG's, thus requiring some attitude recovery). This mode is normally used whenever the predicted DOD \geq 50%.

NOTE: PATCHES ARE NECESSARY TO CONFIGURE THE OBC FOR THIS MODE, AND SHOULD BE DONE PRIOR TO THE SHADOW SEASON.

:OBC PATCH, 0'1575', 0

:OBC PATCH, 0'27676', 2

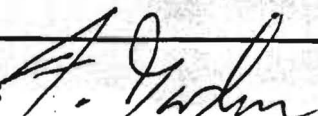
/PATCH OUT WORKER 10'S ACS FLAG

/ALLOW PROCESSING OF GYRO DATA
DESPITE NO SUN PRESENCE

2. SPACECRAFT OPERATION LIMITATIONS:

- a. Spacecraft attitude during the daily shadow shall be limited from Beta 45° to Beta 95°.
- b. Ranging will not be performed during the shadow.

3. APPROVAL SIGNED:

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1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLIMENTATION: 00

SUPERCEDES PRIOR FODS: S002L

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2. DIRECTIVE:

3. SPACECRAFT EQUIPMENT CHANGES:

- a. Control SI thermal balance before the shadow to minimize impact of shadow on telescope focus, per operations directive No. N011. All SI heaters will remain off during the shadow.
- b. 30 minutes prior to the expected start of penumbra the T.O. will place both cameras in standby and turn spacecraft control over to the O.D. to reconfigure for the shadow. When either battery would exceed 50% depth of discharge the T.O. will turn the active long wavelength camera off prior to turning over spacecraft control to the O.D.
- c. Configure WPS for VHF telemetry and transfer operations to the VHF system at least 10-15 minutes prior to the scheduled penumbra.

Configure the spacecraft for the shadow as follows:

EXEC TLM, FES2ROM, 5 /REDUCE DATA RATE TO 5KBPS
 EXEC VHF, 1 /VHF 1 ON, RANGING OFF

Set the wheel speeds as follows:

P & R LESS THAN 200 RPM, Y GREATER THAN 600 RPM (SUPERSEDES FOD N005)

After VHF data is verified and is going into OPS computer,

EXEC FESTRK, 2 /P&Y ON FES, R ON GYROS

OR

EXEC FESTRK, 0 /P&Y ON GYROS, R ON FSS

EXEC TREF, RAW(AS2CH11), RAW(AS2CH12), RAW(AS2CH13), 128
 /UPLINK TACH REF. SPEEDS

: OBC CMND, 18, 1; : OBC CMND, 3, 10 /SHADTRACK MODE ON

Once the control mode is selected, continue configuring the S/C,

EXEC SHADOW, 0

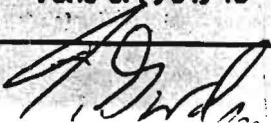
This procedure performs the following:

: CRU OFF, 25, 36, 42, 57 /S-BAND POWER AMP. OFF
 : CRU OFF, 7, 56 /S-BAND TRANSMITTER OFF

At the 'WAIT' statement: Hold until the start of penumbra is observed, as indicated by decreasing solar array current; then give the proc a 'GO' to turn on both battery chargers and to turn off the remaining equipment.

: IMP 5, 9 /CHARGERS 1 & 2 ON
 : IMP 92, 94, 96, 98, 102, 108, 110 /ALL HAPS HEATERS OFF
 : CRU OFF, 23, 2 /PR1 AND SEC MIRROR HTR 1 OFF
 : CRU OFF, 34, 47 /PR1 AND SEC MIRROR HTR 2 OFF
 : CRU OFF, 46, 55, 33 /CAM SELECT, DECK 1 & 2 HTR &
 FOCUS DRIVE OFF
 : CRU OFF, 31, 45 /PAS 1 & 2 OFF

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1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS
 IMPLIMENTATION: 00
 SUPERCEDES PRIOR FODS: S002L

2. DIRECTIVE:

When either battery would exceed 50% depth of discharge the VHF system will be cycled on/off about one minute of every five minutes for a sample of spacecraft data, to check spacecraft status and evaluate performance. This cycling will be started one minute after the start of umbra, as indicated by zero solar array current.

The VHF system will be turned on 1 minute before the expected termination of umbra and remain on through the end of the shadow.

E. EMERGENCY POWER OFF-LOADING DURING THE DAILY SHADOWS:

During any daily shadow, if the calculated depth-of-discharge (DOD) is projected to be greater than 80% on one battery for that day, take the following steps as needed to keep the DOD below the 80% level. In order to be able to decide if and when any corrective action is needed, a running calculation of DOD must be kept. The Systems analyst has the responsibility for this task as well as for keeping the OD and RA informed of any necessary action.

1. Turn off the active long wavelength camera. The powering off of the cameras must be coordinated with the R. A.
 - EXEC CAMOFF, LWR /LWR CAMERA OFF
 - EXEC CAMOFF, LWP /LWP CAMERA OFF
2. Turn off heaters on gyros 2, 6, 1 and 3 (one at a time) as needed. Each command is to be checked by the ACS analyst for syntax before being sent, and again before the command is approved.
 - :CRU OFF, 16 /GYRO 2 OFF
 - :CRU OFF, 5 /GYRO 1 OFF
 - :CRU OFF, 60 /GYRO 6 OFF
 - :CRU OFF, 27 /GYRO 3 OFF
3. Reset the OBC.
 - :OBC RESET /RESET THE OBC
 - :RW, RWMODE=0, RWENAB=1 /DISABLE THE WHEELS
4. Turn off the remaining scientific instruments, as needed. The powering off of these devices must be coordinated with the R. A.
 - :LVSW FES2, OFF /FES 2 OFF
 - EXEC CAMOFF, SWP /SWP CAMERA OFF
 - EXEC ALLOFF, 0 /ALL SCIENCE INSTRUMENTS OFF
5. Turn off the following equipment, as necessary.
 - :CRU OFF, 59 /OBC
 - :CRU OFF, 26, 37, 48 /REACTION WHEELS
 - :CRU OFF, 4 /WHEEL DRIVER ASSEMBLY
 - :CRU OFF, 21, 53 /FINE SUN SENSORS
 - EXEC VHF, 0 /VHF
 - :CRU OFF, 6 /DMU
 - :CRU OFF, 38, 44 /GYROS 4 and 5
 - :CRU OFF, 28 /COMMON ELECTRONICS

3. APPROVAL SIGNED: *F. G. ...*

14 Aug 87
DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002L

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2. DIRECTIVE:

F. SPACECRAFT RECONFIGURATION AFTER DAILY SHADOWS:

If emergency power off-loading was done to the extent that attitude control was lost, then as soon as the predicted umbra is over turn on the equipment necessary to command Sunbath mode.

: CRU ON, 6	/DMU ON
EXEC VHF, 1	/VHF ON
: CRU ON, 4	/WHEEL DRIVER ASSEMBLY ON
: CRU ON, 26, 37, 48	/REACTION WHEELS ON
: CRU ON, 21, 53	/FINE SUN SENSORS ON
EXEC SUNBATH, 0	/ENTER SUNBATH MODE ON

Once Sunbath is working minimize equipment off time and return the OBC, the IRA and the science heaters to their pre-shadow configuration. The scientific instruments and the associated electronics are to remain off pending a formal review of the battery situation and POD approval.

: CRU ON, 28	/COMMON ELECTRONICS ON
: CRU ON, 44	/GYRO 5 HEATER ON
: CRU ON, 38	/GYRO 4 HEATER ON
: IRA, IRAGYR=16, IRAQB=1	/GYRO 5 SPINUP
WAIT FOR G5 SYNC BEFORE SPINNING UP GYRO 4	
: IRA, IRAGYR=24, IRAQB=1	/GYRO 4 SPINUP
IRAQB=0	/DISABLE QUALIFIER BIT
: CRU ON, 16	/GYRO 2 HEATER ON
: CRU ON, 5	/GYRO 1 HEATER ON
: CRU ON, 60	/GYRO 6 HEATER ON
: CRU ON, 27	/GYRO 3 HEATER ON
: CRU ON, 59	/OBC ON
EXEC SIHTR, N	/SI HEATERS ON

If there was no emergency power off-loading affecting attitude control, then as soon as the solar array current returns to 50% of normal value return the spacecraft to pre-shadow configuration. (If any gyro heaters were turned off, turn them back on as described above.)

1. EXEC SHADOW, 1 /Performs the following...

: CRU ON, 49	/S-BAND SYSTEM 1 SELECT
: CRU ON, 7, 56	/S-BAND SYSTEM ON
: IMP 101	/HAPS HEATER GROUP 2 ON
: CRU ON, 47	/SEC MIRROR HEATER No. 2 ON
2. EXEC SIHTR, N /SI HEATERS TO DESIRED CONFIGURATION
3. If holding using SHADTRACK, return to Worker 0

: OBC CMND, 4, 10; : OBC CMND, 18, 0	/WORKER 10 OFF, WORKER 0 ENABLED
--------------------------------------	----------------------------------
4. Return operations to S-Band and establish telemetry into OPS computer

EXEC SBAND, N	/S-BAND ANTENNA N
EXEC VHF, OFF	/TURN VHF SYSTEM OFF
EXEC TLM, FESZROM, 20	/SELECT 20KBPS TLM RATE

3. APPROVAL SIGNED:

[Handwritten Signature]

[Handwritten Date]
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IMPLEMENTATION: 00

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2. DIRECTIVE:

- 5. Return the wheels to normal operation rates, when catbeds are heated and it is operationally feasible.
- 6. Resume normal operations as soon as possible. If the long wavelength camera has been turned off, the T.O. and R.A. will turn it on and return it to operation.

G. BATTERY CHARGE MANAGEMENT BETWEEN THE DAILY SHADOWS:

- 1. Normal operations between daily shadows should be done at power positive attitudes; **NO** battery discharge is permitted other than peak loads of short duration (e.g. wheel unloads or ranging).

NOTE: POWER POSITIVE IS DEFINED AS AT LEAST .060 AMPS CHARGE CURRENT ON EACH BATTERY OR HAVING DUMP CURRENT PRESENT.

POWER-NEUTRAL IS DEFINED AS THE ABSENCE OF DUMP CURRENT WITH CHARGE CURRENT OF LESS THAN .060 AMPS, BUT NO INDICATED DISCHARGE CURRENT ON EITHER BATTERY.

- 2. Battery recharge following shadow will be accomplished by using all three charging capabilities - main chargers, trickle-hi and trickle-low charge. The procedure is outlined below:

Conditions and Comments

- The spacecraft attitude must be such that dump current is present, with chargers on, to ensure that the maximum charge is going to each battery. The Beta range able to accommodate this condition is about $45^\circ < \beta < 95^\circ$.
- Whenever 130% of the measurable discharge energy has been replaced, return that battery to trickle-low charge.

BATTERY RECHARGE

	<u>Charge Method</u>	<u>Command</u>	<u>Conditions</u>
Battery 1 -	main charger	EXEC CHARGER, 1	until the charge current is either < 300 ma, OR until 130% of the measurable discharge energy has been replaced
		THEN	
	trickle-hi	:IMP 6, 7	until the battery voltage is either ≥ 25.84 v, OR until 130% of the measurable discharge energy has been replaced
		THEN	
	trickle-low	:IMP 8	for normal operations

3. APPROVAL SIGNED:

A. Jordan

14 Aug 87
DATE

1. **APPLICATION:** SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS
IMPLEMENTATION: 00
SUPERCEDES PRIOR FODS: S002L

2. **DIRECTIVE:**

<u>Charge Method</u>	<u>Command</u>	<u>Conditions</u>
Battery 2 — main charger	EXEC CHARGER, 1	until the charge current is either < 300 ma, OR until 130% of the measurable discharge energy has been replaced
	THEN	
trickle—hi	:IMP 10,11	until the battery voltage is either ≥ 25.50 v, OR until 130% of the measurable discharge energy has been replaced
	THEN	
trickle—low	:IMP 12	for normal operation

H. **NOTES:**

- Batteries cool down during recharge, and heat up during discharge and overcharge. In some cases, a battery temperature may exceed 25°C during discharge.
- If after cool-down during recharge either battery reaches 25°C, notify
 GEORGE MORROW (x6691 OR 730-7825)
 OR
 SID TILLER (x6489 OR 534-8587)

I. **FINAL INSTRUCTIONS:**

- Snap system page every five minutes from 5 minutes prior to shadow until 1/2 hour after shadow, then every 30 minutes during shadow season.
- During the daily shadow battery data will be collected/recorded using the MacIntosh PC. As a backup to this method, data off the five minute SYSTEM2 snaps will be used as input to the PC for the normal shadow graphs. The battery data from the 30 minute snaps will also be input into the PC for generation of the 24 hour graphs. Complete instructions for these procedures are included in the pre-shadow package.
- Retain history tapes of shadow periods.

3. **APPROVAL SIGNED:**

A. G. [Signature]

14 Aug 87
DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS
IMPLIMENTATION: 00
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2. DIRECTIVE:

4. One hour prior to scheduled shadow, and until the chargers are turned off, set up stripchart recorders to record:

MATRIX 12

EVENT PENS:

- a. SUN PRESENCE
- b. COMMAND COUNTER No. 2

ANALOG PENS:

- a. BATTERY 1 VOLTAGE
- b. BATTERY 2 VOLTAGE
- c. BATTERY 1 DISCHARGE CURRENT
- d. BATTERY 2 DISCHARGE CURRENT
- e. SOLAR ARRAY 1 CURRENT
- f. SOLAR ARRAY 2 CURRENT
- g. BUS VOLTAGE
- h. BUS CURRENT

MATRIX 11

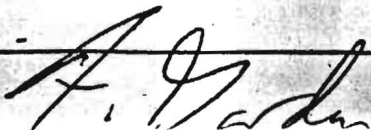
EVENT PENS:

- a. SUN PRESENCE
- b. COMMAND COUNTER No. 2

ANALOG PENS:

- a. BATTERY 1 VOLTAGE
- b. BATTERY 2 VOLTAGE
- c. BATTERY 1 CHARGE CURRENT
- d. BATTERY 2 CHARGE CURRENT
- e. BATTERY 1 3rd ELECTRODE
- f. BATTERY 2 3rd ELECTRODE
- g. BUS VOLTAGE
- h. BUS CURRENT

3. APPROVAL SIGNED:

14 Aug 87
DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002K

FOD BEING REVISED WITH
INDICATED CHANGES

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2. DIRECTIVE;

24 FEB 87

THIS DIRECTIVE PROVIDES INFORMATION AND INSTRUCTION FOR IUE SPACECRAFT SYSTEM CONFIGURATION AND OPERATION DURING THE IUE ORBIT SHADOW PERIODS. THERE ARE TWO TYPES OF SHADOW PERIODS THAT WILL OCCUR, EARTH AND MOON SHADOWS. IN BOTH CASES BE PREPARED FOR LOSS OF SUN PRESENCE. LOSS OF SUN PRESENCE MEANS LOSS OF ATTITUDE CONTROL IF THE SPACECRAFT IS NOT PROPERLY CONFIGURED!

A. EARTH SHADOW:

AN EARTH SHADOW PERIOD OF UP TO APPROXIMATELY 75 MINUTES EACH DAY FOR ABOUT 25 DAYS WILL OCCUR EVERY 6 MONTHS FOR THE IUE ORBIT. SPECIAL CONSIDERATION MUST BE GIVEN TO SPACECRAFT SYSTEM CONFIGURATION, ATTITUDE CONTROL, TEMPERATURES, OPERATIONS, AND POWER LOAD DURING THESE SHADOW PERIODS.

B. MOON SHADOW:

A MOON SHADOW MAY OCCUR AND RESULT IN A PERIOD WHEN SUN PRESENCE WOULD BE LOST. MOST FREQUENTLY THE MOON SHADOW WILL RESULT ONLY IN A PENUMBRA CONDITION. HOWEVER, FOR ANY SHADOW THE SPACECRAFT SHOULD BE CONFIGURED WITH PITCH AND YAW ON FES, AND ROLL UNDER GYRO CONTROL.

IF AN UMBRA CONDITION IS PREDICTED FOR A DURATION GREATER THAN 5 MINUTES, BEFORE PENUMBRA STARTS PLACE THE ACTIVE CAMERAS IN STANDBY AND CONFIGURE THE OTHER SPACECRAFT SYSTEMS FOR SHADOW AS DEFINED IN PARAGRAPH D3(c).

C. UNEXPECTED SHADOW:

LOSS OF SUN PRESENCE MEANS LOSS OF ATTITUDE CONTROL IF THE SPACECRAFT IS NOT PROPERLY CONFIGURED.

1. CHECK FOR LOSS OF ATTITUDE REFERENCE BY OBSERVING WHEEL SPEEDS, FES DATA, SOLAR ARRAY CURRENT, AND OTHER SPACECRAFT SYSTEM PARAMETERS. IF THE S/C IS HOLDING WITH PITCH AND YAW ON FES AND ROLL ON GYROS, ATTITUDE REFERENCE SHOULD BE MAINTAINED. IF ATTITUDE CONTROL HAS BEEN LOST, THEN GO TO SUNBATH AS SOON AS THE SHADOW IS OVER.

2. IF ATTITUDE IS STABLE CONTACT WPS TO BRING UP VHF SYSTEM. IF A SHADOW UMBRA EXCEEDS 3 MINUTES PREPARE TO PROCEED TO POWER DOWN THE SPACECRAFT SYSTEMS.

3. IF UMBRA EXCEEDS 5 MINUTES:

a. IMMEDIATELY PLACE THE CAMERAS IN STANDBY, CHECK WITH T.O. OR R.A. BEFORE EXECUTING (OR HAVE EXECUTED BY T.O.).

EXEC STOP, , NOCAL	/PROC TO PERFORM THE FOLLOWING
LWP	/LWP TO STANDBY
LWR	/LWR TO STANDBY
SWP	/SWP TO STANDBY
SWR	/SWR TO STANDBY

NOTE: PROC MUST BE RUN SEPARATELY FOR EACH ACTIVE CAMERA.

3. APPROVAL SIGNED:

DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002K

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2. DIRECTIVE:

- b. WHEN GOOD VHF DATA IS AVAILABLE TRANSFER TO VHF SYSTEM AND POWER DOWN S-BAND SYSTEM; ALSO TURN ON BATTERY CHARGERS AND POWER DOWN SI HEATERS AND HAPS HEATERS PER PARAGRAPH D3(c). IF VHF DATA LINK HAS BEEN ESTABLISHED RUN THE SHADOW PROC. THE PROC CONFIGURES THESE SYSTEMS AND TURNS OFF THE S-BAND SYSTEM.

EXEC SHADOW, 0

D. SPACECRAFT SYSTEMS CONFIGURATION CHANGES FOR SHADOW PERIODS:

SPACECRAFT SYSTEMS MUST BE CONFIGURED AND OPERATIONS MUST BE REDUCED TO LIMIT THE BATTERY DISCHARGE CURRENT TO LESS THAN 4.5A EACH AND ASSURE NO MORE THAN 80% DEPTH OF BATTERY DISCHARGE DURING THE SHADOW.

1. SPACECRAFT HOLD MODES:

a. FES ONLY

PITCH AND YAW ARE ON FES WITH ROLL ON GYROS, AND THERE IS STAR PRESENCE WITH A COUNT > 2000. THIS MODE IS NORMALLY USED WHENEVER THE PREDICTED DEPTH-OF-DISCHARGE IS < 50%.

b. SHADTRACK

BOTH WORKER 10 (WHEEL HOLD) AND WORKER 0 ARE RUNNING; WORKER 10 IS CONTROLLING WHILE WORKER 0 TRACKS THE S/C'S MOVEMENT IN PITCH AND YAW. W0 WILL BE CONFIGURED WITH PITCH AND YAW ON RAW GYROS, ROLL WILL BE ON FSS. DURING SHADOW THE OBC WILL CALCULATE PITCH AND YAW ABG'S. ONCE SHADOW IS OVER WORKER 10 IS TURNED OFF, AND WORKER 0 COMMANDING IS ENABLED; THE ACCUMULATED ERRORS WILL THEN BE ZEROED OUT BY W0 AND THE IUE SHOULD NEARLY RETURN TO ITS ORIGINAL POINTING (THERE MAY BE SOME CORRUPTION OF GYRO DATA DUE TO ROLL MOTION WHICH WILL RESULT IN ERRONEOUS ABG'S, THUS REQUIRING SOME ATTITUDE RECOVERY). THIS MODE IS NORMALLY USED WHENEVER THE PREDICTED DOD IS \geq 50%.

2. SPACECRAFT OPERATION LIMITATIONS:

- a. SPACECRAFT ATTITUDE DURING THE SHADOW SHALL BE LIMITED FROM BETA 40° TO BETA 100° . UNLESS PRIOR APPROVAL IS RECEIVED FROM THE GSFC POD.

- b. RANGING WILL NOT BE PERFORMED DURING THE SHADOW.

3. SPACECRAFT EQUIPMENT CHANGES:

- a. CONTROL SI THERMAL BALANCE BEFORE THE SHADOW TO MINIMIZE IMPACT OF SHADOW ON TELESCOPE FOCUS, PER OPERATIONS DIRECTIVE No. N011. ALL SI HEATERS WILL REMAIN OFF DURING THE SHADOW.

- b. 30 MINUTES PRIOR TO THE EXPECTED START OF PENUMBRA THE T.O. WILL PLACE BOTH CAMERAS IN STANDBY AND TURN SPACECRAFT CONTROL OVER TO THE O.D. TO RECONFIGURE FOR THE SHADOW. WHEN EITHER BATTERY WOULD EXCEED 50% DEPTH OF DISCHARGE THE T.O. WILL TURN THE ACTIVE LONG WAVELENGTH CAMERA OFF

3. APPROVAL SIGNED:

DATE

2 OBC PATCHES
REQUIRED
① W0 ACS FLAG = ϕ
② W0 - PROCESS GYRO
DATA IF NO
SUN PRESENCE.

FAST TRACK

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FOOS: S002K

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2. DIRECTIVE:

~~BEFORE TURNING THE SPACECRAFT CONTROL OVER TO THE O.D., AND DURING THE SHADOW THE VHF SYSTEM WILL BE CYCLED ON ABOUT 1 MINUTE EVERY 5 MINUTES FOR A SAMPLE OF SPACECRAFT DATA.~~

- c. CONFIGURE WPS FOR VHF TELEMETRY AND TRANSFER OPERATIONS TO THE VHF SYSTEM AT LEAST 10 MINUTES PRIOR TO THE SCHEDULED PENUMBRA.

CONFIGURE THE SPACECRAFT FOR THE SHADOW AS FOLLOWS:

EXEC TLM, FES2ROM, 5 /REDUCE DATA RATE TO 5KBPS

EXEC VHF, 1 /VHF 1 ON, RANGING OFF

SET THE WHEEL SPEEDS AS FOLLOWS:

P & R LESS THAN 200 RPM (SUPERSEDES FOO N005 FOR SHADOW)

Y GREATER THAN 600 RPM

AFTER VHF DATA IS VERIFIED AND IS GOING INTO OPS COMPUTER,

EXEC FESTRK, 2 /P&Y ON FES, R ON GYROS

OR

EXEC FESTRK, 0 /P&Y ON GYROS, R ON FSS

: OBC CMND, 18, 1; : OBC CMND, 3, 10 /SHADTRACK MODE ON

UPLINK DATA BLOCK WITH WHEEL SPEEDS PRIOR TO WID ON.

ONCE THE CONTROL MODE IS SELECTED, CONTINUE CONFIGURING THE S/C,

EXEC SHADOW, 0

THIS PROCEDURE PERFORMS THE FOLLOWING:

: CRU OFF, 25, 36, 42, 57

/S-BAND POWER AMP. OFF

: CRU OFF, 7, 56

/S-BAND TRANSMITTER OFF

AT THE 'WAIT' STATEMENT: HOLD UNTIL THE START OF PENUMBRA IS OBSERVED, AS INDICATED BY DECREASING SOLAR ARRAY CURRENT; THEN GIVE THE PROC A 'GO' TO TURN ON BOTH BATTERY CHARGERS AND TO TURN OFF THE REMAINING EQUIPMENT.

: IMP 5, 9

/CHARGERS 1 & 2 ON

: IMP 92, 94, 96, 98, 102, 108, 110

/ALL HAPS HEATERS OFF

: CRU OFF, 23, 2

/PR1 AND SEC MIRROR HTR 1 OFF

: CRU OFF, 34, 47

/PR1 AND SEC MIRROR HTR 2 OFF

: CRU OFF, 46, 55, 33

/CAM SELECT, DECK 1 & 2 HTR &

FOCUS DRIVE OFF

: CRU OFF, 31, 45

/PAS 1 & 2 OFF

WHEN EITHER BATTERY WOULD EXCEED 50% DEPTH OF DISCHARGE THE VHF SYSTEM WILL BE CYCLED ON/OFF ABOUT ONE MINUTE OF EVERY FIVE MINUTES FOR A SAMPLE OF SPACECRAFT STATUS AND EVALUATE PERFORMANCE. THIS CYCLING WILL BE STARTED ONE MINUTE AFTER THE START OF UMBRA, AS INDICATED BY ZERO SOLAR ARRAY CURRENT.

THE VHF SYSTEM WILL BE TURNED ON 1 MINUTE BEFORE THE EXPECTED TERMINATION OF UMBRA AND REMAIN ON THROUGH THE END OF THE SHADOW.

3. APPROVAL SIGNED:

DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002K

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2. DIRECTIVE:

- d. IF EITHER BATTERY DISCHARGE CURRENT AVERAGE $> 4.5A$ FOR 3 MINUTES AND IT IS MORE THAN 5 MINUTES TO UMBRA TERMINATION, TURN OFF THE ACTIVE LONG WAVELENGTH CAMERA TO REDUCE POWER LOAD. THE POWERING OFF OF THE CAMERAS MUST BE COORDINATED WITH THE R. A.

EXEC CAMOFF, LWR

/LWR CAMERA OFF

EXEC CAMOFF, LWP

/LWP CAMERA OFF

- e. MINIMIZE EQUIPMENT OFF TIME; RETURN HEATERS TO THE PRE-SHADOW CONFIGURATION AS SOON AS SOLAR ARRAY CURRENT RETURNS TO 50% OF NORMAL VALUE.

EXEC SHADOW, 1

THIS PROCEDURE PERFORMS THE FOLLOWING:

: CRU ON, 49

/S-BAND SYSTEM 1 SELECT

: CRU ON, 7, 56

/S-BAND SYSTEM ON

: IMP 101

/HAPS HEATER GROUP 2 ON

: CRU ON, 47

/SEC MIRROR HEATER No. 2 ON

- f. EXEC SIHTR, N /SI HEATERS TO DESIRED CONFIGURATION
- g. IF HOLDING USING SHADTRACK, RETURN TO WORKER 0
: OBC CMND, 4, 10; : OBC CMND, 18, 0 /WORKER 10 OFF, WORKER 0 ENABLED
- h. RETURN OPERATIONS TO S-BAND
EXEC SBAND, N /S-BAND ANTENNA N
ESTABLISH S-BAND TLM & PUT INTO OPS COMPUTER
EXEC VHF, OFF /TURN VHF SYSTEM OFF
EXEC TLM, FES2ROM, 20 /SELECT 20KBPS TLM RATE
- i. RETURN THE WHEELS TO NORMAL OPERATION RATES, WHEN CATBEDS ARE HEATED AND IT IS OPERATIONALLY FEASIBLE.
- j. RESUME NORMAL OPERATIONS AS SOON AS POSSIBLE. IF THE LONG WAVELENGTH CAMERA HAS BEEN TURNED OFF, THE T.O. AND R.A. WILL TURN IT ON AND RETURN IT TO OPERATION.

E. BATTERY CHARGE MANAGEMENT BETWEEN THE DAILY SHADOWS:

1. NORMAL OPERATIONS BETWEEN DAILY SHADOWS SHOULD BE DONE AT POWER POSITIVE ATTITUDES; NO BATTERY DISCHARGE IS PERMITTED OTHER THAN PEAK LOADS OF SHORT DURATION (e. g. WHEEL UNLOADS OR RANGING).

NOTE: POWER POSITIVE IS DEFINED AS HAVING AT LEAST .08 AMPS CHARGE ON EACH BATTERY OR HAVING DUMP CURRENT PRESENT.

POWER-NEUTRAL IS DEFINED AS A CONDITION OF NO BATTERY CHARGE AND NO BATTERY DISCHARGE.

3. APPROVAL SIGNED:

DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002K

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2. DIRECTIVE:

2. EACH CHARGER SHALL REMAIN ON AFTER START OF SUNLIGHT UNTIL 115 - 120% OF DISCHARGE ENERGY HAS BEEN RETURNED TO THE BATTERIES. THEN THE CHARGERS SHALL BE TURNED OFF. THE CHARGERS SHALL REMAIN OFF UNTIL PREPARING FOR THE NEXT SHADOW.

:IMP 6 /CHARGER 1 OFF
:IMP 10 /CHARGER 2 OFF

3. TARGETS FOLLOWING A SHADOW SHOULD BE SELECTED SUCH THAT THE BATTERIES WILL BE FULLY CHARGED WITHIN 12 TO 13 HOURS FROM THE END OF THE SHADOW. THE SPACECRAFT ANALYSTS SHALL MONITOR BATTERY CHARGE CURRENTS AND COORDINATE WITH THE RESIDENT ASTRONOMER TO ASSURE THAT THIS OBJECTIVE IS ACHIEVED.

a. THE MINIMUM CHARGE CURRENT MUST BE GREATER THAN 200mA TO EACH BATTERY TO OVERCOME CHARGE INEFFICIENCIES AND ASSURE SOME CHARGE OF THE BATTERIES IS TAKING PLACE.

b. A MAXIMUM CHARGE CURRENT IS ACHIEVED WHEN THERE IS SOME DUMP CURRENT.

IF AFTER 13 HOURS THE THE BATTERIES ARE NOT FULLY CHARGED, THE SPACECRAFT SHALL BE SLEWED TO A POWER FAVORABLE TARGET THAT WILL PROVIDE 500mA CHARGE CURRENT MINIMUM PER BATTERY OR SOME DUMP CURRENT IS PRESENT; THE SPACECRAFT SHALL BE HELD AT THIS ATTITUDE UNTIL THIS BATTERY CHARGE CRITERION IS MET. THE RESIDENT ASTRONOMER SHALL ASSURE THAT THE GUEST OBSERVER HAS ALTERNATE TARGETS PLANNED THAT WOULD PROVIDE ADEQUATE CHARGE CURRENT.

F. NOTES:

1. BATTERIES COOL DOWN DURING RECHARGE, AND HEAT UP DURING DISCHARGE AND OVERCHARGE. IN SOME CASES, A BATTERY TEMPERATURE MAY EXCEED 25°C DURING DISCHARGE.

2. IF AFTER COOL-DOWN DURING RECHARGE EITHER BATTERY REACHES 25°C, NOTIFY

SID TILLER (x6489 OR 534-8587)

OR

HARRY WANNAMAKER (x7927 OR 262-2765)

3. APPROVAL SIGNED:

DATE

1. APPLICATION: SPACECRAFT CONFIGURATION AND OPERATION DURING SHADOW PERIODS

IMPLEMENTATION: 00

SUPERCEDES PRIOR FODS: S002K

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2. DIRECTIVE:

G. OTHER INSTRUCTIONS:

1. ONE HOUR PRIOR TO SCHEDULED SHADOW, AND UNTIL THE CHARGERS ARE TURNED OFF, SET UP STRIPCHART RECORDERS TO RECORD:

EVENT PENS:

- a. SUN PRESENCE
- b. COMMAND COUNTER No. 2

ANALOG PENS:

- a. BATTERY 1 VOLTAGE
 - b. BATTERY 2 VOLTAGE
 - c. BATTERY 1 CHARGE/DISCHARGE CURRENT
 - d. BATTERY 2 CHARGE/DISCHARGE CURRENT
 - e. SOLAR ARRAY 1 CURRENT/POST SHADOW, BATTERY 1 3rd ELECTRODE
 - f. SOLAR ARRAY 2 CURRENT/POST SHADOW, BATTERY 2 3rd ELECTRODE
 - g. BUS VOLTAGE
 - h. BUS CURRENT
2. SNAP SYSTEM PAGE EVERY FIVE MINUTES FROM 5 MINUTES PRIOR TO SHADOW UNTIL 1/2 HOUR AFTER SHADOW, THEN EVERY 30 MINUTES DURING SHADOW SEASON.
 3. RETAIN HISTORY TAPES OF SHADOW PERIODS.

3. APPROVAL SIGNED:

DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER
IMPLEMENTATION RESPONSIBILITY: OD
SUPERCEDES PRIOR FODs : S003B
RESPONDS TO SCARs: NONE

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2. DIRECTIVE: THIS DIRECTIVE IS TO BE USED WHEN IT BECOMES NECESSARY TO MANEUVER THE SPACECRAFT TO A SAFE ATTITUDE. THE ANTICIPATED USE OF THIS DIRECTIVE WOULD OCCUR:

- a. IF GSFC CANNOT ACCEPT HANDOVER BEFORE VILSPA LOS.
- b. IF VILSPA HAS A FAILURE AND IT BECOMES NECESSARY DUE TO SUN, EARTH OR MOON POSITION FOR GSFC TO MANEUVER THE SPACECRAFT TO A SAFE ATTITUDE.
- c. IF AN EXTENDED PERIOD OF STDN NON-SUPPORT IS ANTICIPATED AND A SAFE ATTITUDE MANEUVER WOULD BE DESIRABLE (REF: FOD S004).
- d. OTHER SITUATIONS WHEN A SAFE ATTITUDE MANEUVER IS DEEMED NECESSARY.

IT IS BELIEVED THAT AT LEAST ONE OF THE TWO TARGETS PROVIDED HERE WOULD ALWAYS BE ACCESSIBLE AND PROVIDE A SAFE ATTITUDE FOR AN EXTENDED PERIOD. USE THE MANEUVER GENERATION PROGRAM AND THE ORBITAL ENVIRONMENT DISPLAY TO DETERMINE THE MOST DESIRABLE TARGET AND MANEUVER TO THAT TARGET. IF A PERIOD OF NO CONTACT IS ANTICIPATED, ASSURE ALL SYSTEMS ARE FUNCTIONING NORMALLY AND THE SPACECRAFT IS TRACKING A STAR. TO INSURE PROPER DOCUMENTATION, FILL OUT A "SAFE ATTITUDE MANEUVER" FORM.

NOTE: THE SPACECRAFT ATTITUDE SHOULD BE UPLINKED AS PART OF THE MANEUVER INITIATION OPERATION AND SHOULD BE CORRECT IN THE SPACECRAFT AT ALL TIMES. IF, FOR ANY REASON, THIS IS CHANGED BY THE IUESOC OR VILSPA, THE GSFC OD SHALL BE NOTIFIED WHEN THE ATTITUDE IS INCORRECT AND WHEN RETURNED TO THE CORRECT ATTITUDE.

A. ESTABLISH INITIAL ATTITUDE

THE CURRENT ATTITUDE OF THE SPACECRAFT MUST BE KNOWN EXACTLY BEFORE PERFORMING A MANEUVER. CONFIRM THE CURRENT RIGHT ASCENSION AND DECLINATION IN THE SPACECRAFT ARE CORRECT BY VOICE CONTACT WITH THE T.O., R.A. OR VILSPA. IF VOICE CONTACT IS NOT POSSIBLE, RELY ON THE RA AND DEC ON THE SYSTEM PAGE FROM THE SPACECRAFT ONLY IF YOU KNOW THAT THE ATTITUDE WAS CORRECTLY UPDATED AFTER THE LAST SLEW.

COLCURAT 1

/ENTER CURRENT ATTITUDE INTO SYSTEM

PROCEED TO PARAGRAPH D IF THE CURRENT ATTITUDE IS UNKNOWN.

1. UPDATE THE SPACECRAFT ROLL ANGLE BEFORE PROCEEDING

USE THE MANEUVER PROC TO UPDATE THE SPACECRAFT ROLL ANGLE.

3. APPROVAL SIGNED: IVAN J. MASON



7 DEC 79
DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER

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IMPLEMENTATION RESPONSIBILITY: OD

SUPERCEDES PRIOR FODs: S003B

RESPONDS TO SCARs: NONE

2. DIRECTIVE

a. IF THE CURRENT RIGHT ASCENSION IS KNOWN IN HOURS AND THE DECLINATION IN DEGREES:

EXEC MANEUVER,HR,MIN,SEC,DEG,MIN,SEC /GENERATE UPDATED ATTITUDE

RA

DEC

IF THE MANEUVER IS CONSTRAINED:

SELECT 1

/SELECT CONSTRAINED MANEUVER

WHEN THE TIMELINE COMES UP, CHECK THAT PITCH AND YAW ARE ON THE ORDER OF ARCSECONDS IF CORRECT ATTITUDE IS IN THE S/C. ROLL SHOULD BE ON THE ORDER OF ARC MINUTES. THEN:

SNAP

/SNAP MANTMLN1

GO UP

/UPDATE CURRENT ATTITUDE

b. IF THE CURRENT RIGHT ASCENSION AND DECLINATION ARE IN DEGREES:

MANEUVER /CALL MANEUVER PROCESSOR

SLEW A(DEG,MIN,SEC),D(DEG,MIN,SEC) /CURRENT ATTITUDE

RA

DEC

MANEUVER GEN

/GENERATE UPDATED MANEUVER

IF THE MANEUVER IS CONSTRAINED:

SELECT 1

/SELECT CONSTRAINED MANEUVER

WHEN THE TIMELINE COMES UP, CHECK THAT PITCH AND YAW ARE ON THE ORDER OF ARCSECONDS IF CORRECT ATTITUDE IS IN THE S/C. ROLL SHOULD BE ON THE ORDER OF ARCMINUTES. THEN:

SNAP

/SNAP MANTMLN1

:CURRATT UPDATE

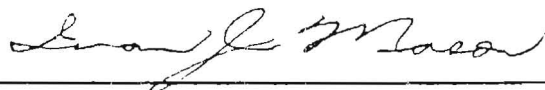
/UPLINK CURRENT ATTITUDE

2. CORRECT FSS ROLL ANGLE

RECORD THE PREDICTED ROLL FROM THE BOTTOM OF MANTMLN1 PAGE ON MANEUVER FORM NEXT TO 'PREDICTED FSS ROLL'.

NOTE: THIS ANGLE SHOULD BE SMALL WITH A MAGNITUDE $\leq 2'$.

3. APPROVAL SIGNED: IVAN J. MASON



7 DEC 79

DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER
 IMPLEMENTATION RESPONSIBILITY: OD
 SUPERCEDES PRIOR FODs: S003B
 RESPONDS TO SCARs: NONE

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2. DIRECTIVE

THIS IS THE ROLL ANGLE FROM WHICH YOU MUST START. ROLL THE SPACECRAFT TO THIS OPTIMUM ROLL AS FOLLOWS:

EXEC FESLEWRT,2,- $\Delta R \times 6000,5000$ /ROLL S/C TO OPTIMUM FSS ROLL

ΔR IS THE DIFFERENCE BETWEEN ROLL ON ACSM PAGE AND PREDICTED ROLL ON MANTMLN1 IN ARCMINUTES. ENTER ΔR IN 'ROLL CORRECTION' SPACE ON MANEUVER FORM.

EXAMPLE

ROLL ON ACSM PAGE $R=0^{\circ}10'6''$
 PREDICTED ROLL FROM MANTMLN1 $R=-0^{\circ}0'30''$

$$\begin{array}{r} 10.1' \\ - -.5' \\ \hline 10.6' \end{array} \text{ IN NEGATIVE DIRECTION}$$

EXEC FESLEWRT,2,-10.6*6000,5000

3. PUT STAR AT KNOWN FES POSITION

IT IS BEST TO BEGIN THE MANEUVER WITH THE STAR AT A KNOWN POSITION IN THE CENTER OF THE FES FIELD. IF IT IS KNOWN THAT THE STAR IS IN ONE OF THE FOUR APERTURES OR AT THE REFERENCE POINT, PROCEED TO PARAGRAPH B. IF IT IS NOT, MOVE IT TO THE REFERENCE POINT. MAKE SURE YOU HAVE STAR PRESENCE THEN:

EXEC FESCALCM,300,144 /MOVE STAR TO REFERENCE POINT

CHECK THE APPROPRIATE BOX ON THE MANEUVER FORM NEXT TO 'INITIAL TARGET LOCATION'.

B. CALCULATE MANEUVER1. CHOOSE A STAR

EXAMINE ORBITAL ENVIRONMENT AND CHOOSE ONE OF THESE TWO STARS:

	RA	DEC
ZETA DRACONIS	17 ^h 08 ^m 38.2 ^s	+65 ^o 46'34"
EPSILON DORADUS	5 ^h 49 ^m 56.6 ^s	-66 ^o 54'49"

3. APPROVAL SIGNED: IVAN J. MASON

Ivan J. Mason

7 DEC 79
DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER

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IMPLEMENTATION RESPONSIBILITY: OD

SUPERCEDES PRIOR FODs: S003B

RESPONDS TO SCARs: NONE

2. DIRECTIVE

1. WHEN THE TRACKER LOCKS ON A STAR:

EXEC FESPNT,0 /DETERMINE NUMBER OF COUNTS

THIS WILL GIVE THE NUMBER OF COUNTS. THE CORRECT NUMBER SHOULD BE APPROXIMATELY:

ZETA DRACONIS 1,500 (UNDERLAP)
EPSILON DORADUS 22,500 (OVERLAP, FAST TRACK)

OVERLAP/UNDERLAP ARE AUTOMATICALLY SELECTED BY THE PROC.
IF THE COUNTS ARE CORRECT, MOVE THE STAR TO THE REFERENCE POINT:

EXEC FESCALCM,300,144 /MOVE STAR TO REFERENCE POINT

IF THE COUNTS ARE NOT CORRECT, PROCEED TO 2.

RECORD THE SIZES OF PITCH AND YAW ON MANEUVER FORM NEXT TO 'ERRORS'.

EXEC FESPRIM,300,144 /COMMAND FES TO THE REFERENCE POINT

THEN GET THE COUNTS:

EXEC FESPNT,0 /DETERMINE COUNTS

IF THEY ARE CORRECT, THE S/C IS SAFE.

EXEC FESTRK,1 /GO TO FES + GYRO CONTROL

2. IF THE COUNTS ARE NOT CORRECT, THE STAR MAY BE IN AN APERTURE, FOCUS SLOT, OR THE LOW REFLECTIVITY PATCH. FIRST, IMPULSE THE FES SEVERAL TIMES TO MAKE SURE IT IS THE BRIGHTEST STAR IN THE FIELD:

EXEC FESIMP,0 /IMPULSE TRACKER

WHEN THIS IS VERIFIED, MOVE THE STAR TO THE REFERENCE POINT AND RE-CHECK THE COUNTS.

EXEC FESCALCM,300,144 /MOVE STAR TO REFERENCE POINT

EXEC FESPRIM,300,144 /COMMAND FES TO REFERENCE POINT

3. APPROVAL SIGNED: IVAN J. MASON



7 DEC 79
DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER
 IMPLEMENTATION RESPONSIBILITY: OD
 SUPERCEDES PRIOR FODs: S003B
 RESPONDS TO SCARs: NONE

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2. DIRECTIVE

EXEC FESPNT,Ø /CHECK COUNTS

IF THE COUNTS ARE CORRECT, GO TO FES+GYRO:

EXEC FESTRK,1 /FES+GYRO CONTROL

IF THE COUNTS ARE STILL NOT CORRECT THE SPACECRAFT ATTITUDE REFERENCE MAY BE LOST, TRACK ON ANY STAR AVAILABLE. IF NO STAR IS FOUND REMAIN ON GYRO HOLD.

D. IF THE CURRENT ATTITUDE IS UNKNOWN

1. VERIFY THAT THE FES IS TRACKING A STAR. IF IT IS NOT, SEARCH THE FIELD FOR A STAR AND GO TO FES + GYRO CONTROL:

EXEC FESST,Ø,Ø,1792 /SEARCH FIELD FOR A STAR

IF A STAR IS FOUND:

EXEC FESTRK,1 /GO TO FES + GYRO HOLD

2. MONITOR THE FES COUNTS CAREFULLY. IF THEY BEGIN TO INCREASE RAPIDLY IT IS PROBABLY DUE TO EARTH OR MOON IMPINGEMENT. IMMEDIATELY GO TO GYRO ONLY HOLD:

EXEC FESTRK,Ø /GYRO HOLD MODE

WHEN THE COUNTS RETURN TO NORMAL GO BACK TO FES + GYRO HOLD:

EXEC FESTRK,1 /FES + GYRO HOLD

3. MAINTAIN BETA BETWEEN 20° AND 120°. IF BETA EXCEEDS THESE LIMITS, PITCH THE SPACECRAFT 15° TO BRING IT BACK WITHIN LIMITS. GENERATE THE MANEUVER WITH THE FOLLOWING SEQUENCE:

MANEUVER /CALL MANEUVER PROCESSOR

IF BETA LESS THAN 20°

SLEW PITCH(-15)

/+15° BETA CHANGE

OR

IF BETA GREATER THAN 120°

SLEW PITCH(15)

/-15° BETA CHANGE

RECORD ALL SLEWS ON THE MANEUVER FORM.

3. APPROVAL SIGNED: IVAN J. MASON



7 DEC 79
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1. APPLICATION: SAFE ATTITUDE MANEUVER
IMPLEMENTATION RESPONSIBILITY: OD
SUPERCEDES PRIOR FODs: S003B
RESPONDS TO SCARs: NONE

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2. DIRECTIVE

MANEUVER GEN /GENERATE MANEUVER

IF THE MANEUVER IS NOT CONSTRAINED, PROCEED TO b.

a. IF THE MANEUVER IS CONSTRAINED:

SELECT 1 /SELECT CONSTRAINED MANEUVER

ANY CONSTRAINT CAN BE OVERRIDDEN EXCEPT A WHEEL SPEED CONSTRAINT. IN THE EVENT OF A WHEEL SPEED CONSTRAINT, UNLOAD THE WHEELS AND RE-GENERATE THE MANEUVER. IF THE MANEUVER COMES UP UNLOADED (ZERO WHEEL SPEEDS) AND UNLOAD MUST BE PERFORMED AND THE MANEUVER RE-GENERATED.

b. VERIFY THAT THE PREDICTED BETA IS THE BETA DESIRED AND UPLINK THE MANEUVER:

EXEC UPLINK,Ø /CONFUGURE S/C

EXEC CONMAN,4 /UPLINK MANEUVER

WHEN THE MANEUVER IS COMPLETE, SEARCH THE FIELD FOR A STAR AS BEFORE (PARAGRAPH D1).

4. MAINTAIN ROLL LESS THAN 5° . IF THE FSS ROLL IS GREATER THAN 5° GENERATE A MANEUVER TO ROLL THE S/C TO 0° AS FOLLOWS:

MANEUVER /CALL MANEUVER PROCESSOR

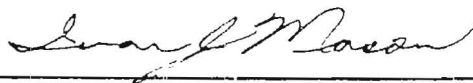
SLEW ROLL ($-\Delta R$) /ROLL MANEUVER

MANEUVER GEN /GENERATE MANEUVER

ΔR IS THE FSS ROLL ON THE ACSM PAGE, FOR EXAMPLE, IF THE ROLL IS $-5^{\circ}12'0''$, THE SLEW WOULD BE $5^{\circ}12'0''$. PROCEED TO PARAGRAPH D3b IF UNCONSTRAINED, D3a IF CONSTRAINED.

RECORD ALL SLEWS ON THE MANEUVER FORM.

3. APPROVAL SIGNED: IVAN J. MASON



7 DEC 79
DATE

1. APPLICATION: SAFE ATTITUDE MANEUVER
 IMPLEMENTATION RESPONSIBILITY: OD
 SUPERCEDES PRIOR FODs: S003B
 RESPONDS TO SCARs: NONE

PAGE 8 OF 8

2. DIRECTIVE SAFE-ATTITUDE MANEUVER FORM

TARGET _____ ZETA DRACONIS _____ EPSILON DORADUS
 UPLINK TIME: _____ DAY _____ GMT TIME _____

PREDICTED FSS ROLL: _____

ROLL CORRECTION: _____

INITIAL: B = _____, _____, _____

R = _____, _____, _____

INITIAL TARGET LOCATION:

_____ REFERENCE POINT (300,144)

_____ SWSA (244,-91)

_____ SWLA (94,-89)

_____ LWSA (47,61)

_____ LWLA (-113,50)

_____ OTHER X _____ Y _____

FINAL: B = _____, _____, _____

R = _____, _____, _____

TARGET TO: _____ REFERENCE POINT (300,144)

_____ OTHER X _____ Y _____

ERRORS: PITCH _____

YAW _____

3. APPROVAL SIGNED: IVAN J. MASON

Ivan J. Mason

7 DEC 79
DATE

1. APPLICATION: DECLARATION OF CRITICAL SUPPORT PAGE 1 OF 2
 IMPLEMENTATION RESPONSIBILITY: OD (APPLICABLE TO GSFC ONLY)
 SUPERCEDES PRIOR FODs: 036
 RESPONDS TO SCARs: NONE

2. DIRECTIVE: THIS OPERATIONS DIRECTIVE PROVIDES THE GENERAL GUIDELINES THAT WILL BE FOLLOWED TO DETERMINE "SAFE SPACECRAFT CONDITION" AND THE REQUIREMENT FOR STDN "CRITICAL SUPPORT DECLARATION" FOR IUE.

A. EVALUATION

1. ASSURE SPACECRAFT SYSTEMS ARE OPERATING "NORMALLY".
2. USE ORBITAL ENVIRONMENT DISPLAY TO EVALUATE POSITION RELATIVE TO SUN, EARTH AND MOON.

B. GUIDELINES FOR SAFE SPACECRAFT CONDITION DETERMINATION

1. GREATER THAN 1 HOUR UNTIL SUN, MOON, EARTH IMPINGEMENT INTO THE TELESCOPE.
2. IF EXTENSIVE OR UNDETERMINED LENGTH OF OUTAGE IS ANTICIPATED MANEUVER TO ONE OF TWO "SAFE" TARGETS (REF. FOD NO. S003).

TARGETS

NAME	ZETA DRACONIS	NAME	EPSILON DORADUS
R.A.	17 ^h ,08 ^m 38.2 ^s	R.A.	5 ^h ,49 ^m 56.6 ^s
DECLINATION	+65°46'34"	DECLINATION	-66°54'49"

3. OBC TEMPERATURE SHALL BE EQUAL TO 52.3°C OR LESS.
4. THE SPACECRAFT SHALL BE HOLDING ON BRIGHT STAR APPROXIMATELY 300 COUNTS @ 20 KB (OR EQUIVALENT).
5. S/C SYSTEMS OPERATING NORMALLY (e.g. LOW GYRO DRIFT RATE, SAFE TEMPS, ETC.) AN EXPOSURE MAY BE IN PROGRESS IF IT WILL BE TERMINATED NORMALLY BY THE OBC.

C. CRITICAL SUPPORT DECLARATION

1. CRITICAL SUPPORT WILL BE DECLARED FOR AS LONG A PERIOD OF TIME AS NECESSARY TO PROVIDE FOR EVALUATION OF THE SPACECRAFT CONDITION.

3. APPROVAL SIGNED: IVAN J. MASON

Ivan J. Mason

17 MAR 79
DATE

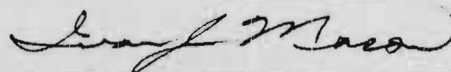
1. APPLICATION: DECLARATION OF CRITICAL SUPPORT PAGE 2 OF 2
IMPLEMENTATION RESPONSIBILITY: OD (APPLICABLE TO GSFC ONLY)
SUPERCEDES PRIOR FODs: 036
RESPONDS TO SCARs: NONE

2. DIRECTIVE: THIS OPERATIONS DIRECTIVE PROVIDES THE GENERAL GUIDELINES THAT WILL BE FOLLOWED TO DETERMINE "SAFE SPACECRAFT CONDITION" AND THE REQUIREMENT FOR STDN "CRITICAL SUPPORT DECLARATION" FOR IUE.
2. SCIENCE OPERATIONS WILL BE TERMINATED AND CRITICAL SUPPORT DECLARED IF IT BECOMES NECESSARY TO MANEUVER S/C TO A SAFE ATTITUDE. WHEN AT THE SAFE ATTITUDE AND SAFE SPACECRAFT CONDITIONS ARE MET, CRITICAL SUPPORT REQUIREMENT WILL BE TERMINATED.
3. CRITICAL SUPPORT WILL BE DECLARED TO OBTAIN A MINIMUM OF 5 MIN. S/C HOUSEKEEPING DATA/HOUR. THE SUPPORT TIME SHOULD BE SCHEDULED TO MINIMIZE IMPACT WITH OTHER S/C OPERATIONS, WHEN POSSIBLE.
4. CRITICAL SUPPORT SHALL NOT BE DECLARED TO CONTINUE SCIENCE OPERATIONS.

NOTE

A BRIEF WRITTEN RATIONALE FOR CRITICAL SUPPORT WILL BE PROVIDED TO THE POD EACH TIME CRITICAL SUPPORT IS DECLARED.

3. APPROVAL SIGNED: IVAN J. MASON



17 MAR 79
DATE

1. APPLICATION: PAS OPERATIONS
 IMPLIMENTATION:
 SUPERCEDES PRIOR FODS: S005

page 1 of 2

2. DIRECTIVE:

THIS DIRECTIVE PROVIDES INSTRUCTIONS FOR ATTITUDE DETERMINATION USING THE PAS.

NOTE: THE PAS TEMPERATURE SHOULD BE >-15°C BEFORE BEING USED. IT TAKES PAS #2 ABOUT 25 MINUTES TO WARM UP FROM -35° TO -15°. THEREFORE THE PAS SHOULD BE TURNED ON ABOUT 30 MINUTES PRIOR TO THE ANTICIPATED PASS.

A. TURN PAS2 ON, SELECT TELEMETRY FORMAT 2A, AND A BITRATE OF 5 KBPS:

:CRU ON, 45

/TURN PAS2 ON

EXEC TLM, FES2ROM, 5

/FORMAT 2A, 5KBPS

AT THE WAIT IN THE PROC:

IA2=9

/SET INDIRECT ADDRESS 2 = 9 FOR PAS2

EXAMINE SERIAL, DMU

/VERIFY THE COMMAND FIELDS

GO

/SENDS THE DMU COMMAND

B. COMMAND THE PA TO THE PLANNER MODE WITH THE SCAN ENABLED, AS FOLLOWS:

PASM0D=1

PASLEW=1

EXAMINE SERIAL, PAS

/VERIFY THE PAS COMMAND FIELD

*PAS2**PASM0D**PASCLK**PASDIR**PASMAX**PASLEW**PASCAN**PASSUN**PASMIN*

1

0

0

0

1

0

0

0

:PAS

/STARTS PAS SCANNING

NOTE: DON'T FORGET TO CHANGE PASLEW TO 0 WHEN DATA COLLECTION IS COMPLETE (PARAGRAPH D BELOW). IF LEFT IN THE SCANNING MODE, THE PAS CREATES NOISE IN CAMERA IMAGES FROM THE STEPPING MOTOR OF THE OPTICAL SCANNER.

C. PERFORM ATTITUDE DETERMINATION AS FOLLOWS:

1. ON CONSOLE 3 CALL UP PAGE ACS FOR PAS INFORMATION

2. ON CONSOLE 6 ENTER ATTOET TO INITIATE THE [5] ([9]) PROGRAM FOR DETERMINING S/C RA AND DEC.

3. WHEN PAS DATA IS SEEN IN AOS1-LOS1 OF THE ACS PAGE, BEGIN DATA COLLECTION BY ENTERING THE FOLLOWING ON CONSOLE 6:

COLL YES

/STARTS COLLECTION OF DATA SAMPLES

OBSERVE "NUMBER OF PAS DATA SAMPLES AVAILABLE", WHEN THE SAMPLE NUMBER HAS REACHED 50 OR MORE.

COLL NO "

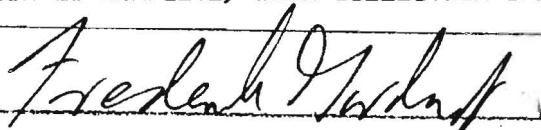
/HALTS COLLECTION OF DATA SAMPLES

COMP YES

/RETURNS TO NO WHEN COMPUTATION IS COMPLETE

THE COMPUTED RA AND DEC IS PRINTED ON THE HIGH SPEED PRINTER. WHEN THE COMPUTATION IS COMPLETE, DATA COLLECTION CAN BE RESTARTED BY ENTERING

3. APPROVAL SIGNED:



10 May '85
DATE

1. APPLICATION: PAS OPERATIONS

IMPLIMENTATION:

SUPERCEDES PRIOR FODS: S005

page 2 of 2

2. DIRECTIVE:

"COLL YES" AND REPEATING THE STEPS FOR A NEW COMPUTATION OF RA AND DEC,
AS ABOVE.

NOTE: SOLUTIONS FOR BETA OTHER THAN BETA=90° ARE VALID.

4. TERMINATE THE ATTITUDE DETERMINATION PROGRAM BY ENTERING MODE TERM TO
RETURN CONSOLE 6 TO NORMAL.

D. RETURN THE PAS TO NORMAL CONFIGURATION AND TURN IT OFF:

PASM0D=0

PASLEW=0

EXAMINE SERIAL, PAS

/VERIFY ALL COMMAND FIELDS = 0

:PAS

/STOPS PAS SCANNING

:CRU OFF, 45

/TURNS PAS2 OFF

E. RETURN TELEMETRY SYSTEMS TO NORMAL CONFIGURATION:

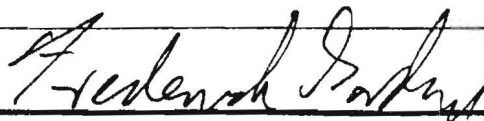
EXEC TLM, FES2ROM, 20

/RETURNS TLM TO 20KBPS FOR FMT 2A, FES2

F. TARGET PREDICTION:

THE BACKGROUND PROGRAM TAPRED IS USED TO PREDICT EARTH TARGET TIMES FOR PAS
OPERATIONS. INSTRUCTIONS FOR THE USE OF THE PROGRAM ARE CONTAINED IN THE
SOFTWARE USER'S GUIDE. THE PROGRAM SHOULD BE RUN BY THE ACS ENGINEER ON DAY
SHIFT ONCE A WEEK. THE PROGRAM WILL PREDICT TARGETS CORRECTLY FOR BETA=90°.

3. APPROVAL SIGNED:

10 May 85
DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
 IMPLEMENTATION RESPONSIBILITY:
 SUPERCEDES PRIOR FODs:
 RESPONDS TO SCARs:

PAGE 1 OF 9

2. DIRECTIVE: THIS DIRECTIVE PROVIDES A WAY TO RECOVER IUE ATTITUDE REFERENCE BY SLEWING TO A LOW BETA.

CONDUCTING THE ATTITUDE RECOVERY NEAR THE ANTI-SUN HAS THE ADVANTAGE THAT NEARLY ALL THE UNCERTAINTY IN ATTITUDE IS CONVERTED INTO AN UNCERTAINTY IN ROLL. THIS ALLOWS US TO SEARCH A MUCH SMALLER AREA OF THE SKY IN ORDER TO MAKE STAR IDENTIFICATION, BUT REQUIRES US TO CALCULATE THE ROLL ANGLE ACCURATELY.

THE ACCURACY IN DETERMINING THE DIRECTION OF S/C POINTING AND S/C ROLL DEPENDS UPON THE NUMBER OF CATALOGUE STARS IN THE FIELD AT WHICH THE RECOVERY IS TO BE PERFORMED. IF TWO OR MORE STARS ARE FOUND, THE S/C ATTITUDE CAN BE DETERMINED UNIQUELY. IF ONLY ONE STAR IS FOUND, YOU MUST ITERATE BETWEEN THE S/C ROLL AND POINTING. IF NO STARS OF KNOWN POSITION ARE AVAILABLE, A ROUGH ATTITUDE CAN BE DERIVED AT THE ANTI-SUN POSITION ($BETA=0$) BY ESTIMATING THE ROTATION OF THE FES IMAGE COMPARED TO A FINDING CHART OF THE FIELD.

FOR SOLUTIONS WITH ONE CATALOGUE STAR YOU ARE ASSUMING THE S/C IS AT OPTIMUM ROLL. HENCE THE ACCURACY OF THE S/C ROLL DETERMINATION IS INCREASED BY PERFORMING THE RECOVERY AT THE HIGHEST POSSIBLE BETA. IF AN APPROXIMATE INITIAL POSITION IS KNOWN YOU CAN DERIVE THE LINE OF APPROACH TOWARDS $BETA=0$ AND CAN JUDGE THE MERITS OF AIMING FOR A PARTICULAR STELLAR FIELD (STEP 2). IF YOU HAVE NO IDEA OF THE INITIAL S/C POINTING, YOU MUST SLEW TO $BETA=0$ AND WORK WITH WHATEVER FIELD IS AVAILABLE.

THE STEPS TO BE TAKEN FOR AN EFFICIENT LOW BETA RECOVERY ARE:

STEPS 1-3 DESCRIBE THE PLANNING REQUIRED.

STEPS 4-6 DESCRIBE THE S/C OPERATIONS NECESSARY TO REACH AN IDENTIFIABLE STAR FIELD. (FOR AN EFFICIENT RECOVERY, PORTIONS OF THE PLANNING WILL BE DONE CONCURRENTLY WITH THE EXECUTION OF SOME S/C OPERATIONS ESPECIALLY THE GYRO TRIMMING IN STEP 4).

STEP 7 DETAILS HOW TO USE CATALOGUE STARS TO DETERMINE ATTITUDE.

STEP 8 DESCRIBES ATTITUDE DETERMINATION WITHOUT CATALOGUE STARS.

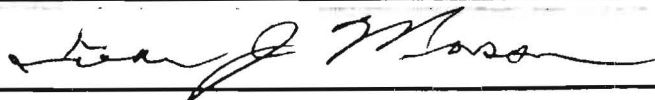
STEP 9 DESCRIBES VERIFICATION AND FINE TUNING.

STEP 10 GIVES AN EXAMPLE.

1. ANTI-SUN LOCATION

CALCULATE THE 1950 LOCATION OF THE ANTI-SUN FOR TIMES BRACKETING THE EXPECTED TIME OF RECOVERY (PRECESS THE SOLAR POSITION AS GIVEN IN THE AMERICAN EPHEMERIS & NATURAL ALMANAC OR EQUIVALENT SOURCE). IF YOU WILL BE SLEWING ALL THE WAY TO $BETA=0$, THE SOLAR POSITION WILL HAVE TO BE INTERPOLATED TO THE NEAREST MINUTE IN TIME FOR THE TIME AT WHICH THE FSS ROLL IS OPTIMIZED (STEP 5).

3. APPROVAL



2/23/83
DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
 IMPLEMENTATION RESPONSIBILITY:
 SUPERCEDES PRIOR FODs:
 RESPONDS TO SCARs:

PAGE 2 OF 9

2. DIRECTIVE

2. RECOVERY FIELD CHOICE

LOCATE SUITABLE REFERENCE STARS NEAR THE ANTI-SUN USING THE SAO CHARTS AND THE PALOMAR SKY SURVEY (PSS). BE AWARE OF THE DIRECTION OF APPROACH OF THE S/C TOWARDS BETA=0. IF YOU MUST SLEW TO BETA=0, SKIP TO STEP 3.

IF THE APPROXIMATE INITIAL POINTING IS KNOWN, DETERMINE THE LINE OF APPROACH OF THE S/C TOWARDS THE ANTI-SUN BY USING THE FSS VALUE OF β .

$$X = \cos^{-1} \left[\frac{\sin \delta(A) \cos \beta - \sin \delta(S/C)}{\cos \delta(A) \sin \beta} \right]$$

WHERE $\delta(A)$ =DEC OF ANTI-SUN, $\delta(S/C)$ = APPROXIMATE INITIAL DEC OF S/C AND THE ANGLE OF APPROACH IS:

180+X IF $RA_A - RA_{SC} > 0$

180-X IF $RA_A - RA_{SC} < 0$

AS MEASURED EAST FROM NORTH. IDENTIFICATION STARS SHOULD BE SELECTED ALONG THIS LINE OF APPROACH.

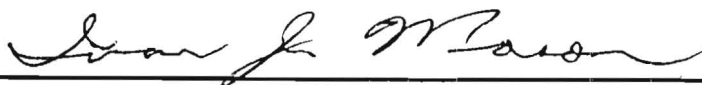
TO COMPUTE THE HIGHEST BETA AT WHICH RECOVERY CAN BE ACCOMPLISHED REQUIRES AN ESTIMATE OF THE YAW ERROR, SINCE THIS ERROR WILL DETERMINE HOW CLOSELY YOU WILL ARRIVE TO A DESIRED POSITION AFTER THE FINAL PITCH MANEUVER. THE YAW ERROR CAN BE ESTIMATED BY EITHER ASSUMING IT IS AS LARGE AS THE ROLL OR BETA ERROR AFTER THE LOSS OF ATTITUDE OR BY REQUESTING AN ESTIMATE FROM THE WHEEL SPEEDS BY THE OPERATIONS STAFF (IUECC).

THE HIGHEST BETA AT WHICH THE S/C WILL PITCH-IN TO WITHIN 8' OF THE DESIRED POSITION IS:

$$\beta_{\max} = \tan^{-1} (\tan 8' \cot Y_{\text{error}} \sin \beta_{\text{initial}})$$

FROM YOUR CHARTS CHOOSE A SUITABLE FIELD ALONG THE LINE OF APPROACH AND BELOW β_{\max} FOR WHICH AT LEAST ONE STAR (PREFERABLY MORE) HAS 1950 COORDINATES AVAILABLE.

3. APPROVAL


2/23/83
DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
IMPLEMENTATION RESPONSIBILITY:
SUPERCEDES PRIOR FODs:
RESPONDS TO SCARs:

PAGE 3 OF 9

2. DIRECTIVE

IF THERE IS A SIGNIFICANTLY BETTER SELECTION OF STARS ALONG A DIFFERENT LINE OF APPROACH, THIS CAN BE OBTAINED BY FIRST PITCHING TO BETA=90 AND THEN YAWING BY AN AMOUNT EQUAL TO THE CHANGE IN THE ANGLE OF APPROACH. THE LENGTH OF THE APPROXIMATE YAW MANEUVER CAN BE ESTIMATED FROM A MANEUVER GENERATION USING THE APPROXIMATE INITIAL POSITION OF THE S/C AND THE POSITION OF THE CENTER OF THE DESIRED FIELD.

3. FINDING CHARTS

MAKE FINDING CHARTS FOR THE DESIRED RECOVERY REGION. IF THERE ARE NO CATALOG STARS IN THE RECOVERY REGION, BE CAREFUL WITH THE ORIENTATION OF THE CHARTS AS YOU WILL BE ESTIMATING THE S/C ROLL BY LOCATING NORTH ON THE FES. MAKE SURE THE CHARTS YOU PRODUCE CONTAIN STARS FAINT ENOUGH TO UNAMBIGUOUSLY IDENTIFY THE FIELD.

4. GYRO TRIM

THE S/C GYROS MUST BE WELL TRIMMED, ESPECIALLY IN ROLL. FIND A FIELD STAR AT YOUR INITIAL ATTITUDE TO EVALUATE THE DRIFT RATE. IF THE OBC HAS BEEN RELOADED, TRIMMING WILL BE NECESSARY. GYRO TRIMMING SHOULD PROCEED CONCURRENTLY WITH THE PLANNING STAGES 1 THROUGH 3 ABOVE.

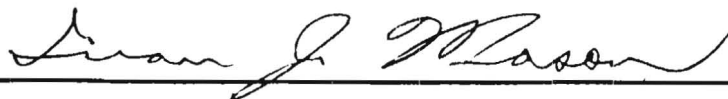
5. MANEUVER TO BETA = 20°

BEFORE PITCHING TO THE RECOVERY FIELD, A PITCH TO BETA=20° SHOULD BE PERFORMED SO THAT THE FSS ROLL CAN BE OPTIMIZED BEFORE THE SUN IS LOST FROM VIEW. AT YOUR INITIAL POSITION TAKE THE S/C TO ZERO ROLL BY DRIVING THE FSS READING TO ZERO. IF YOU ARE MODIFYING THE LINE OF APPROACH BY A PYP MANEUVER (STEP 2), GENERATE YOUR 3-LEG SLEW WITH THE FINAL PITCH GOING TO BETA=20.

6. MANEUVER INTO THE ANTI-SUN REGION

THIS STEP GIVES DETAILED INSTRUCTIONS FOR PITCHING FROM BETA=20° TO THE CHOSEN RECOVERY FIELD.

3. APPROVAL

2/23/83
DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
 IMPLEMENTATION RESPONSIBILITY:
 SUPERCEDES PRIOR FODs:
 RESPONDS TO SCARs:

PAGE 4 OF 9

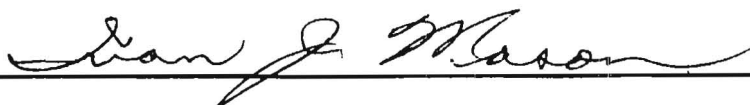
- 6.1 AT BETA=20°, ROLL THE S/C SO THAT THE FSS ROLL IS ZEROED.
- 6.2 NOTE THE GMT AT WHICH THE FSS ROLL IS ZEROED. ALL SUBSEQUENT CALCULATIONS WILL USE THIS OBSTIME, WHICH SHALL BE CALLED T_0 . IN ESSENCE, THIS FREEZES THE LOCATION OF THE SUN FOR THE S/C WHILE THE SUN IS OUT OF THE FIELD OF VIEW OF THE FSS.
- 6.3 PERFORM THE FINAL PITCH SLEW FROM BETA=20° TO THE DESIRED FINAL BETA.
- 6.4 TAKE A FULL FIELD FES IMAGE AT A BIT/SAMPLE RATE APPROPRIATE FOR THE IDENTIFICATION STARS YOU WILL BE USING.
- 6.5 IF YOU HAVE NO CATALOGUE STARS, SKIP TO STEP 8.
- 6.6 SMALL DB10 SLEWS MAY BE REQUIRED TO LOCATE THE IDENTIFICATION STARS. IF SO, USE ONLY PROC FESCALCM WITH SPECIFIC INITIAL AND FINAL FES COORDINATES SPECIFIED. KEEP TRACK OF ANY SLEWS PERFORMED AS THEY WILL HAVE TO BE RE-TRACED TO RECOVER ATTITUDE. NOTE THAT THE ATTITUDE DERIVED IN STEP 7 REFERS TO THE POSITION OF THE S/C ROLL AXIS AT THE END OF THE PITCH FROM BETA=20°. IT IS IMPERATIVE THAT THE ROLL AXIS BE RETURNED TO THIS POINTING BEFORE SLEWING AWAY TO VERIFY ATTITUDE AS DESCRIBED IN STEP 9.3.

7. ATTITUDE COMPUTATION WITH CATALOGUE STARS

THIS STEP EXPLAINS HOW TO COMPUTE ATTITUDE FROM THE FES POSITIONS OF CATALOGUE STARS.

- 7.1 FOR EACH STAR WITH KNOWN COORDINATES, MEASURE THE FES POSITIONS X AND Y.
- 7.2 CALCULATE X_R AND Y_R , THE OFFSETS IN FES COORDINATES OF THE IDENTIFICATION STARS FROM THE APPROXIMATE LOCATION OF THE ROLL AXIS, $X=103$, $Y=-370$. INCLUDE ANY DB10 POSITION CHANGES DONE IN STEP 6.6 TO CALCULATE X_R AND Y_R FOR THE ORIGINAL S/C POINTING. FOR EXAMPLE, SUPPOSE THE IDENTIFICATION STAR IS FOUND AT $X=+500$, $Y=+600$ AFTER A DB10 MANEUVER INITIATED BY FESCALCM, 0, 0, 0, 2000. THEN $X_R = +500 - 103 = 397$ AND $Y_R = +600 + 2000 - (-370) = 2970$.
- 7.3 CALCULATE THE ATTITUDE USING STEPS 7.3.1 AND 7.3.3 IF ONE IDENTIFICATION STAR IS AVAILABLE, OR USING STEPS 7.3.2 AND 7.3.3 IF TWO OR MORE IDENTIFICATION STARS ARE AVAILABLE.

3. APPROVAL



2/23/83

DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
 IMPLEMENTATION RESPONSIBILITY:
 SUPERCEDES PRIOR FODs:
 RESPONDS TO SCARs:

PAGE 5 OF 9

2. DIRECTIVE

7.3.1 IF ONLY ONE CATALOGUE STAR IS AVAILABLE, THE S/C ATTITUDE MUST BE DETERMINED BY ITERATION. FROM THE ORIENTATION OF THE FIELD, ESTIMATE THE S/C ROLL. USE THIS ROLL ESTIMATE AND THE PROCEDURE DESCRIBED IN STEP 7.3.3 TO DERIVE AN ESTIMATE FOR THE S/C POINTING. IN TURN, THIS POINTING ESTIMATE CAN BE USED TO DERIVE THE S/C ROLL. DO THIS BY GENERATING A MANEUVER TO THE ESTIMATED S/C POINTING USING OBSTIME T_0 . USE THE PREDICTED DESTINATION S/C ROLL AS AN IMPROVED ESTIMATE FOR THE S/C ROLL. ITERATE ON THIS PROCESS UNTIL A CONSISTENT S/C ROLL AND POINTING ARE DERIVED. UPDATE THE S/C ATTITUDE AND GO TO STEP 9.

7.3.2 IF TWO OR MORE CATALOGUE STARS ARE FOUND, THEIR FES POSITIONS CAN BE USED TO DERIVE THE S/C ROLL UNIQUELY.

FOR EACH PAIR OF STARS EVALUATE ΔX , ΔY , Δ "RA AND Δ "DEC. WHERE THESE ΔS REPRESENT THE POSITION OF ONE CATALOGUE STAR RELATIVE TO ANOTHER. THE HP PROGRAM BELOW WILL THEN GIVE THE S/C ROLL. AVERAGE THE VALUES OBTAINED FROM EACH PAIR.

HP PROGRAM TO EVALUATE S/C ROLL FROM ΔX , ΔY , ΔRA & ΔDEC MEASUREMENTS

```

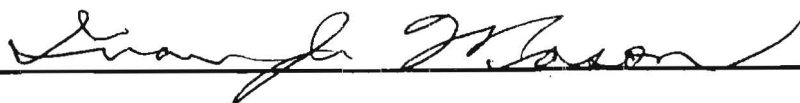
 $\Delta$ "DEC
enter +
 $\Delta$ "RA
g+p
X $\neq$ Y
 $\Delta y$ 
enter +
 $\Delta x$ 
g+p
roll +  $\downarrow$ 
-
151.7
+
read S/C roll

```

NOTE: Δ "RA AND Δ "DEC MUST BE IN ARC SECONDS; ΔX AND ΔY IN FES UNITS; AND BOTH REPRESENT DIFFERENCES IN STELLAR POSITIONS.

ONCE THE S/C ROLL AS BEEN DETERMINED, USE THE PROCEDURE OF STEP 7.3.3 TO DERIVE THE S/C POINTING. USING THE S/C POINTING AND ROLL, UPDATE THE S/C ATTITUDE. VERIFY THE S/C ROLL BY GENERATING A MANEUVER TO THE DERIVED S/C ATTITUDE (USE OBSTIME T_0). IF THE S/C IS AT OPTIMUM ROLL THEN THE TWO ROLLS (MANEUVER & MEASURED) SHOULD AGREE. GO TO STEP 9.

3. APPROVAL


2/23/83
DATE

1. APPLICATION: BETA-0 ATTITUDE RECOVERY PROCEDURE
 IMPLEMENTATION RESPONSIBILITY:
 SUPERCEDES PRIOR FODs:
 RESPONDS TO SCARs:

PAGE 6 OF 9

2. DIRECTIVE

- 7.3.3 THIS STEP DESCRIBES HOW TO CALCULATE THE S/C POINTING IF THE S/C ROLL ANGLE IS GIVEN, BY USING THE FOLLOWING FOR EACH REFERENCE STAR:

$$\begin{aligned} RA^h(SC) &= RA^h(STAR) + \delta RA(") / \cos DEC(STAR) / 15 / 3600 \\ DEC^o(SC) &= DEC^o(STAR) + \delta DEC(") / 3600 \end{aligned}$$

where

$$\begin{aligned} \delta RA(") &= 0.268 X_R \cos \Psi - 0.2617 Y_R \sin \Psi \\ \delta DEC(") &= 0.268 X_R \sin \Psi + 0.2617 Y_R \cos \Psi \end{aligned}$$

and

$$\Psi = S/C \text{ roll} + 28.3$$

as used in the following HP program:

HP25 PROGRAM TO TRANSFORM FES COORDINATES INTO Δ RA & Δ DEC

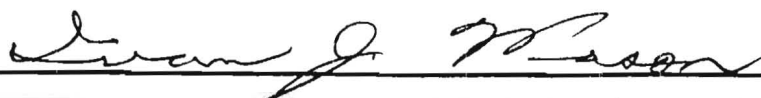
```

KEY IN   XR
ENTER↑
KEY IN   YR
OFFSETS FROM THE ROLL AXIS

↑ENTER
+.2617
*
X↔Y
+.2680
*
g→p
X↔Y
S/C ROLL
+
28.3
+
X↔Y
f→R
R/S→ δ RA(")
X↔Y→ δ DEC(")

```

3. APPROVAL


2/23/83
DATE

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8. ATTITUDE ESTIMATION WITHOUT CATALOGUE STARS

THIS STEP EXPLAINS HOW TO ESTIMATE ATTITUDE IF NO CATALOGUE STARS ARE AVAILABLE. (NOTE: IF AMPLE TIME IS AVAILABLE IN PLANNING, IT IS PREFERABLE TO MEASURE POSITIONS OF FAINT STARS ON THE PSS PRINTS AND TO USE STEP 7.)

- 8.1 AT BETA= \emptyset , THE S/C POINTING IS TOWARDS THE POSITION OF THE ANTI-SUN AT TIME T_0 . INTERPOLATE THE RA AND DEC OF THE ANTI-SUN AT T_0 FROM THE LOCATIONS CALCULATED IN STEP 1.
- 8.2 COMPARE THE NORTH DIRECTION ON THE FINDING CHART WITH THE NORTH ARROW ON THE FESOVL. FROM THE DIFFERENCES, ESTIMATE A CORRECTION TO THE ROLL ATTITUDE CURRENTLY IN THE SYSTEM.
- 8.3 CURRATT THE CORRECTED ROLL ANGLE ALONG WITH THE RA AND DEC OF THE ANTI-SUN AND RE-DISPLAY THE FESOVL.
- 8.4 ITERATE STEPS 8.2 AND 8.3 UNTIL THE NORTH DIRECTION IN THE OVERLAY AGREES WITH THE DIRECTION ON THE CHART. WITH CARE, THE ESTIMATED ROLL SHOULD BE GOOD TO 10°.

9. ATTITUDE VERIFICATION

ONE MUST NOW PROCEED TO VERIFY THE ATTITUDE, TO ELIMINATE SMALL POINTING ERRORS, AND TO IMPROVE THE ACCURACY TO THE S/C ROLL DETERMINATION.

- 9.1 ANY SMALL DB10 MANEUVERS DONE TO LOCATE THE REFERENCE STARS SHOULD BE REVERSED NOW BEFORE THE ATTITUDE VERIFICATION SLEW DESCRIBED IN STEP 9.3.
- 9.2 CHECK THE FES IMAGE AND FESOVL WITH THE FINAL UPDATED ATTITUDE AGAINST THE FINDING CHART AS A CRUDE VERIFICATION OF THE S/C ROLL.
- 9.3 TO VERIFY THE ATTITUDE, SLEW TO A NEARBY SAO STAR. USE THE MANEUVER PROCESSOR TO CALCULATE THE MANEUVER FOR TIME T_0 . BE CAREFUL THAT THE CORRECT ROLL IS USED FOR THE INITIAL ATTITUDE. CHOOSE A STAR SUCH THAT THE MANEUVER IS PRIMARILY IN PITCH. KEEP THE PITCH LEG AS SMALL AS POSSIBLE, PREFERABLY 1° TO 2°, TO AVOID LARGE FINAL ERRORS.

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- 9.4 AT THE END OF THE SLEW, MANEUVER THE TARGET TO THE LOCATION OF THE ROLL AXIS ($X=103$, $Y=-370$). IF THE STAR IS NOT IN THE FIELD OF VIEW AT THE END OF THE SLEW, SEARCH FOR IT WITH DB10 YAW SLEWS. USE THE MEASURED YAW ERROR TO REFINE THE ROLL ANGLE ESTIMATE:

$$\text{REFINED ROLL} = \text{OLD ROLL} + \text{ARCSIN} \left(\frac{\text{YAW ERROR}}{|\text{PITCH LEG}|} \right)$$

(NOTE: THE SIGN OF THE YAW ERROR IS THE SAME AS THE MANEUVER NECESSARY TO MOVE THE TARGET TO $X=103$, $Y=-370$.)

- 9.5 UPDATE THE ATTITUDE AND SLEW TO A SUITABLE STAR AT $\text{BETA} \geq 14^\circ$.

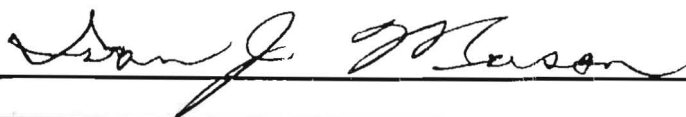
10. EXAMPLE

THIS STEP GIVES SOME DETAILS OF THE $\beta=0^\circ$ ATTITUDE RECOVERY FOLLOWING THE 1980 JUNE 24 ΔV .

- 10.1 THE 1950 POSITION OF THE SUN AT 17:00 GMT WAS $6^{\text{h}}12^{\text{m}}35.2, +23^\circ24'29.7$ AND AT 20:00 GMT WAS $6^{\text{h}}13^{\text{m}}06.4, +23^\circ24'21.0$. THEREFORE, A RECOVERY FIELD WAS LOCATED NEAR $18^{\text{h}}12^{\text{m}}$ AND -23° . (STEP 1 & 2)
- 10.2 FOLLOWING THE ΔV THE BETA WAS $83^\circ49'47''$. A MANEUVER OF PITCH $-6^\circ10'$, YAW $+41^\circ56'$, AND PITCH $+70^\circ$ WAS EXECUTED TO ALIGN THE LINE OF APPROACH WITH THE RECOVERY FIELD AND TO REACH $\beta=20^\circ$. (STEP 5)
- 10.3 AT 18:09 GMT (T_0) A PITCH $+19^\circ39'$ WAS EXECUTED TO THE RECOVERY FIELD. THREE CATALOGUE STARS WERE IDENTIFIED. (STEP 6)
- 10.4 THE ATTITUDE WAS CALCULATED USING ALL THREE STARS (STEP 7).

	SAO NO.	M_V	RA	DEC	FES X	FES Y	X_R	Y_R
1	186518	9.2	$18^{\text{h}}11^{\text{m}}31^{\text{s}}.2$	$-23^\circ11'56''$	864	576	761	946
2	186522	9.5	18 11 36.4	-23 07 58	-64	544	-167	914
3	186526	9.0	18 11 45.9	-23 04 00	-1056	736	-1159	1106

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THESE STARS PERMIT A S/C ROLL OF $43.4^{\circ} \pm 0.5^{\circ}$ TO BE DETERMINED FROM THE RELATIVE OFFSETS GIVEN IN THE TABLE BELOW.

	FES OFFSET X, Y			DERIVED ROLL	
	1	2	3	2	3
POSITION OFFSET	1	928,32	1920,-160	42.89	43.37
Δ "RA, Δ "DEC	2	-72,-238	992,-192	--	43.82
	3	-203,-476	-131,-238	--	--

THE S/C POSITION WAS DETERMINED FROM EACH IDENTIFICATION STAR:

STAR	Δ RA	Δ DEC	DERIVED POINTING	
			S/C RA	S/C DEC
1	-171"	+271"	18 ^h 11 ^m 18 ^s .8	-23°07'25"
2	-241"	+33"	18 11 18.9	-23 07 25
3	-372"	-204"	18 11 18.9	-23 07 24

FROM THE DERIVED LOCATION A MANEUVER WAS EXECUTED TO HD165516 AT $\beta = 2.8^{\circ}$. A CORRECTION TO THE S/C ROLL WAS MADE AND RECOVERY WAS COMPLETED BY A SLEW TO HD156928 AT $\beta = 17^{\circ}$.

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