

CDM1, 6/1/2011



<p>IBEX</p> <p>Maintenance Maneuver Procedure</p> <p>S924-OP31117</p> <p>REVISION A</p>

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REVISION HISTORY			
REV	DATE	REASON FOR CHANGE/CHANGE	SECTION(s) AFFECTED
-	05/19/11	ECN-00000063427: INITIAL RELEASE, PRODUCTION	ALL
A	06/01/11	3.3: Combined steps 21 & 24 into single item (step 21, upload ADV2 and ADV3 ATS). Added aborting ADV3 to any abort of ADV2. Re-numbered steps to match deleted step 24 (old ADV3 upload step). 3.5: Added running the set payload limits script ECN-00000063757	3.3, steps 21-24 3.5, step 51

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1. INTRODUCTION

1.1 Purpose

This procedure describes the activities to be performed in the process of performing an orbit maintenance maneuver. This is an over-arching procedure that calls several sub-procedures. The details of many parts of performing this maintenance maneuver are located in those sub-procedures.

1.2 Procedure Outline

Prior to performing this procedure, S924-OP31102, Acquisition Complete Operations Procedure, must be complete.

The flow of this commissioning procedure is shown in Figure 1.

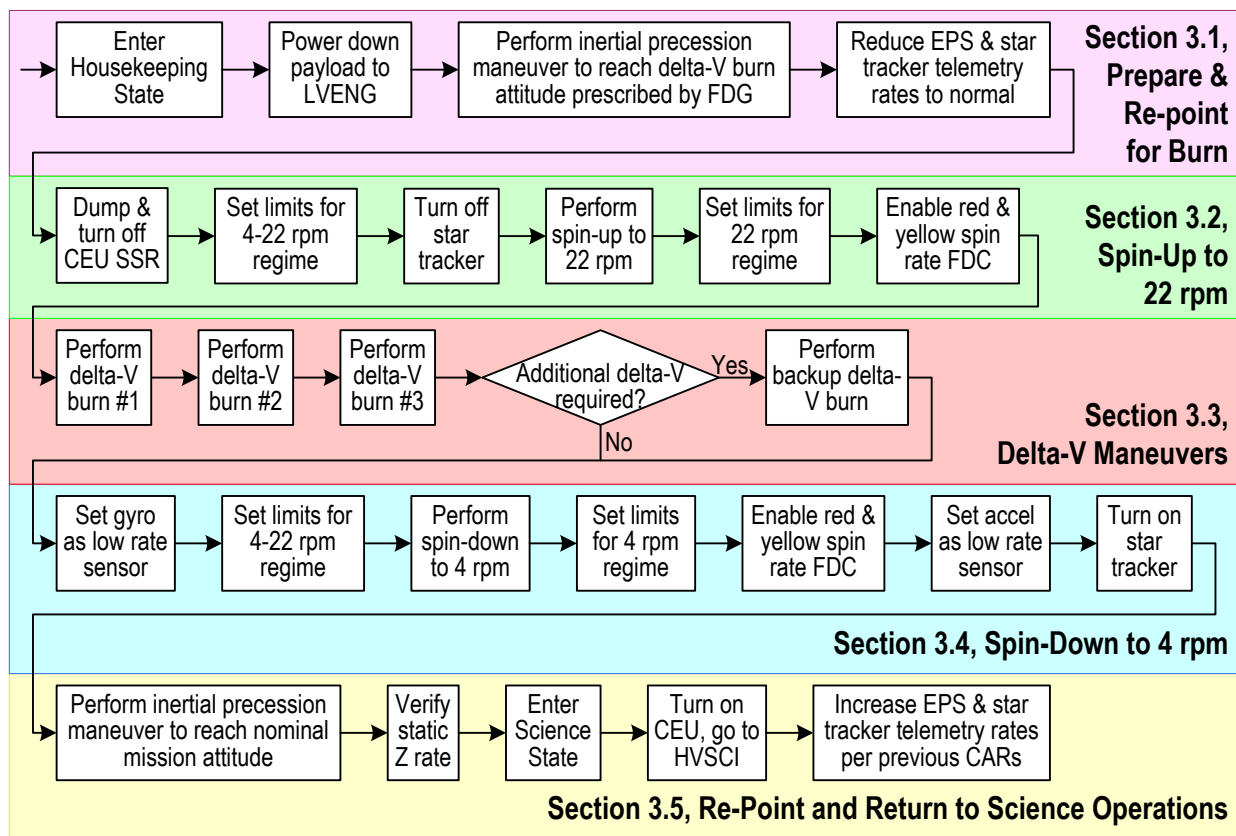


Figure 1 Maintenance Maneuver Procedure Flow Diagram

1.3 Telemetry Displays

The following display pages should be opened while performing this procedure. These display pages contain the telemetry points required to verify the completion of this procedure:

- lbex_leops fastpage
- Other telemetry displays as specified in individual sub-procedures

2. COMMAND TABLES

Note: commands sent within the scripts are not included in this list.

2.1 Set Spacecraft State

Command Name: FCT_SetScState

Parameter	Description	C Type	Bytes	Constraint	Conversion
SpacecraftState	Spacecraft State	UINT_8	1	One_Of(FCT_SPACECRAFTSTATE_STATE)	Str_To_Hex(FCT_SPACECRAFTSTATE_STATE)

Telemetry Packet: FCT_SetScState_Pkt

Description: Set current spacecraft state in the Flight Computer.

2.2 Dump FC Backorbit Buffer

Command Name: FTG_DumpBackorbit

Parameter	Description	C Type	Bytes	Constraint	Conversion
DumpType	Dump type	UINT_16	2	One_Of(FTG_DUMPTYPE_STATE)	Str_To_Hex(FTG_DUMPTYPE_STATE)
StartWeek	Start GPS week (for time-to-time dumps only)	UINT_16	2	RANGE(0,2500)	
StartSecs	Start GPS week (for time-to-time dumps only)	UINT_32	4	RANGE(0,604799)	
EndWeek	End GPS week (for time-to-time dumps only)	UINT_16	2	RANGE(0,2500)	
EndSecs	End GPS week (for time-to-time dumps only)	UINT_32	4	RANGE(0,604799)	

Telemetry Packet: FTG_DumpBackorbit_Pkt

Description: Dump the flight computer backorbit buffer.

2.3 Enable/Disable ACS FDC Test

Command Name: ACT_EnableFdcTest

Parameter	Description	C Type	Bytes	Constraint	Conversion
fdcNumIn		UINT_32	4	One_Of(ACT_FDC_TASK_STATE)	Str_To_Hex(ACT_FDC_TASK_STATE)
cmpntNumIn		UINT_32	4	One_Of(ACT_FDC_COMPONENT)	Str_To_Hex(ACT_FDC_COMPONENT)
testNumIn		UINT_32	4		
enabledIn		UINT_32	4	One_Of(DISABLE_ENABLE_STATE)	Str_To_Hex(DISABLE_ENABLE_STATE)

Telemetry Packet: ACT_EnableFdcTest_Pkt

Description: Enables/Disables individual ACS FDC test

2.4 Delete Timed Command

Command Name: FCH_DeITimedCmd

Parameter	Description	C Type	Bytes	Constraint	Conversion
TrackNum		UINT_16	2		

Telemetry Packet: FCH_DelTimedCmd_Pkt

Description: Delete a single timed command by entering a unique tracking number.

2.5 Set Thrust Enable

Command Name: ACT_SetThrustEnable

Parameter	Description	C Type	Bytes	Constraint	Conversion
Enable		UINT_8	1	One_Of(DISABLE_ENABLE_STATE)	Str_To_Hex(DISABLE_ENABLE_STATE)

Telemetry Packet: ACT_SetThrustEnable_Pkt

Description: Enables the 5N thrusters to fire for attitude control.

2.6 Set Delta-V Thrust Enable

Command Name: ACT_SetDvEnable

Parameter	Description	C Type	Bytes	Constraint	Conversion
Enable	State, Enable	UINT_8	1	One_Of(DISABLE_ENABLE_STATE)	Str_To_Hex(DISABLE_ENABLE_STATE)

Telemetry Packet: ACT_SetDvEnable_Pkt

Description: Enables the 22N thrusters to fire for delta-V.

2.7 Set Spin Pulse Protect Enable

Command Name: ACT_SetSpinPulseProtectEnable

Parameter	Description	C Type	Bytes	Constraint	Conversion
Enable		UINT_8	1	One_Of(DISABLE_ENABLE_STATE)	Str_To_Hex(DISABLE_ENABLE_STATE)

Telemetry Packet: ACT_SetSpinPulseProtectEnable_Pkt

Description: Enables or disables the spin pulse protection logic.

2.8 Collect ACT Control Telemetry

Command Name: ACT_TMctl

Telemetry Packet: ACT_TMctl_Pkt

Description: Collects control telemetry from the ACT task.

2.9 Collect Heater2 Telemetry

Command Name: ECT_TM2Heater

Telemetry Packet: ECT_TM2Heater_Pkt

Description: Reads the heater table configuration

2.10 Set Heater Trip Points

Command Name: EHH_SetHeatTrip

Parameter	Description	C Type	Bytes	Constraint	Conversion
Heaternum	HTR Number	UINT_8	1	One_Of(EHH_HEATERNUM_STATE)	Str_To_Hex(EHH_HEATERNUM_STATE)
Override	Override CSD (Y or N)	UINT_8	1	One_Of(NO_YES_STATE)	Str_To_Hex(NO_YES_STATE)

TripOn	Trip ON Temp	INT_16	2		
TripOff	Trip OFF Temp	INT_16	2		

Telemetry Packet: EHH_SetHeatTrip_Pkt

Description: Sets trip conditions for the heater.

2.11 Turn On/Off Component Powered via PCM

Command Name: FMI_LoadPowerSwitchCntlReg_1

Parameter	Description	C Type	Bytes	Constraint	Conversion
PwrSwitch Cntl1Reg		UINT_8	1	One_Of(FMI_PWR_CNT_REG1)	Str_To_Hex(FMI_PWR_CNT_REG1)
State		UINT_8	1	One_Of(FMI_SWITCH_STATE)	Str_To_Hex(FMI_SWITCH_STATE)

Telemetry Packet: FMI_LoadPowerSwitchCntlReg_1_Pkt

Description: Write to MIU power switch control 1 register to enable MIU thruster bus, turn on CEU 28V, or star tracker.

2.12 Dump SSR

Command Name: CEU_SSR_DUMP_NEW

Description: Dumps all previously un-downlinked data from the SSR in the CEU

2.13 Contingency Message

Command Name: CEU_SC_CNTG

Description: Sets the SSR in the CEU into auto-refresh mode in preparation of removal of 28V power in order to maintain SSR data while 28V power is off.

2.14 CEU Macro Commands

Command Name: CEU_MACRO_EXEC

Description: Commands CEU internal macro sequences to configure payload modes.

Macro number (32 bits). Range [0-255].

Mnemonic	Value	Description
OFF_TO_STANDBY_PL1	0	Put CEU in HVENG mode.
OFF_TO_STANDBY_HI	1	Ramp IBEX-Hi to HVSTANDBY levels.
OFF_TO_STANDBY_LO	2	Ramp IBEX-Lo to HVSTANDBY levels.
OFF_TO_STANDBY_PL2	3	Put CEU in HVSTANDBY mode.
ASCENDING_PL1	8	Put CEU in HVENG mode.
ASCENDING_HI	9	Ramp IBEX-Hi to HVSCI levels.
ASCENDING_LO	10	Ramp IBEX-Lo to HVSCI levels.
ASCENDING_PL2	11	Put CEU in HVSCI mode.

3. PROCEDURE

This procedure spans from the entire operations surrounding a delta-V orbit maintenance maneuver. Note that once the CEU has been powered down, the FC will be the lone source of backorbit data storage, so the FC backorbit buffer should be downlinked frequently.

Prior to running this procedure, the operation of the gyro should be verified. This has been done previously using CAR 403, and that or an equivalent CAR should be run. The CAR sets the gyro as the low rate sensor shortly after completion of a re-pointing maneuver, so it must be planned and executed prior to the last inertial maneuver before beginning this procedure.

This procedure is broken into several sections to cover the various phases of the maintenance maneuver process.

3.1 Prepare for maneuver and re-point to burn direction (Steps 1-7)

This section of the procedure starts with a few steps to get from nominal operations to the right state for the maintenance maneuver. It includes going to Housekeeping State, reducing telemetry rates that will swamp the FC backorbit buffer, and performing a re-pointing maneuver to the proper delta-V burn attitude.

This section requires a prepared stored command load for the inertial maneuver based on the instructions provided in the Mission Operations Handbook (S924-OP3121). The target vector X, Y, and Z values for the maneuver should be provided by FDG to be the proper pointing vector for the delta-V burn. That pointing vector should be designed to keep the solar array within 45 deg of the sun vector throughout the duration of the activities in this procedure. This command load will be referred to as “**inertial_maneuver_to_deltaV_attitude**” in this procedure, but the actual ATS script name and X, Y, and Z parameters should be recorded below:

ATS Filename: _____

Inertial Target Vector:

X: _____

Y: _____

Z: _____

The start time for the maneuver should, if possible, be at a time that it is verified in STK that both the Earth and moon are on the +Z side of the spacecraft. If that is not possible then it should be independently verified that neither the moon nor Earth enters the star tracker FOV during the maneuver. The duration of the maneuver should be **25 minutes**. This is done by manually changing the execution time for the SetThrustEnable DISABLE command and all commands following that in the command load and altering the parameter on the ACT_SetThrustTime command, which is specified in seconds (add an additional 60 seconds to this duration beyond the 10 minutes identified above).

The maneuver should be scheduled for a time that a ground contact can be scheduled to coincide with the maneuver, either throughout the maneuver or within 20 minutes of the completion of the maneuver, to allow a chance to verify that the spacecraft is maintaining its power positive status once the cat bed heaters and thrusters are turned off.

A command load should also be developed, called **contingency_abort_sun_find**, which is loaded and executed only if the spacecraft is not power positive after the completion of the inertial maneuver and other attempts to get it power positive are not effective. This command load should include a maneuver planned to execute 90 minutes after the completion of the initial inertial maneuver, to allow time for troubleshooting and loading the commands if needed.

Following completion of this section, fill out the Burn Success Assessment & Fuel Usage Table of the MAC checklist.

Step 1 – Gyro Test Verification

Verify completion of gyro aliveness test prior to continuing on with this procedure.

Step 2 – State & Mode Check

It is expected that the final nominal operations ATS prior to beginning this procedure will leave the spacecraft in Housekeeping State and the payload in LVENG mode.

If the spacecraft is not currently in housekeeping state then set the spacecraft state to Housekeeping:

CMD: @FCT_SetScState HOUSEKEEPING

Step 3 – Upload Inertial Maneuver ATS

Upload the stored command load for the inertial maneuver to the delta-V burn attitude, **inertial_maneuver_to_deltaV_attitude**.

Note in telemetry the command number for the command to enable thrusters and record this command number below. This command number will be needed if the command must be deleted in an abort scenario in the following step.

Thruster ENABLE command number: _____

Step 4 – Operations During Inertial Maneuver

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [command number recorded from Step 3]

CMD: @ACT_SetThrustEnable DISABLE

During the ground contact the inertial precession maneuver uploaded in Step 3, verify that the stored commands for the maneuver are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for the maneuver the engineering team determines that the commands are not having the desired effect the maneuver should be aborted. In this case, the pre-loaded commands above should be executed immediately.

Step 5 – Verify Sun Angle and EPS Performance Following Inertial Maneuver

Review telemetry to verify that the spacecraft is power positive after the cat bed heaters and thrusters are turned off. Below, record the sun angle using the coarse sun sensors and quaternions and EPS sign-off of proper EPS performance in the new attitude:

Sun Angle (based on quaternions): _____ deg

Sun Angle (based on CSS telemetry): _____ deg

If the spacecraft is not power positive, the following 3 steps should be taken in turn, continuing through the steps until the spacecraft stops losing power:

1. Skip ahead to Step 10 of this procedure to turn off the star tracker.
2. Enable reference power tracking using procedure S924-OP31303. If this is unsuccessful, disable reference power tracking using the same procedure.
3. Upload the ATS **contingency_abort_sun_find**, which contains the commands for a sun precession maneuver. If that maneuver is performed, do not continue on to the next step until the anomaly is resolved.

The EPS Engineer should provide verification that the spacecraft is power positive and the EPS is behaving normally in the new attitude prior to continuing to the next step:

EPS Engineer Initial: _____

Step 6 – Reduce High Rate ECT_TMNorm Telemetry Storage

Reduce the ECT_TMNorm telemetry rate by running procedure **S924-OP31418**.

When prompted for the number of the entry to modify, enter **“178”**.

The script will prompt a confirmation of the contents of the entry to be changed. To do this, verify the response in the FTG_ReadTGEntry wildpage, which should show that the RtPeriod = 30 and the BoPeriod = 10.

When requested by the script, enter the following responses:

Rt_period = “30”

Rt_start = same value current shown in the FTG_ReadTGEntry table

Bo_period = “300”

Bo_start = same value currently shown in the FTG_ReadTGEntry table

Let the script run to completion; the script will verify the entry has been properly updated.

Step 7 – Delete Backorbit Star Tracker Attitude Telemetry

Reduce the star tracker telemetry rate by running procedure **S924-OP31416** and selecting **“Delete”**. When prompted for the telemetry table entry to delete, enter **“188”**.

3.2 Spin-Up to 22 rpm (Steps 8-14)

This portion of the procedure turns off the CEU and star tracker, then executes a command load to spin the spacecraft up to 22 rpm. This section requires a stored command load for a spin-up toward 22 rpm as directed in the Mission Operations Handbook (S924-OP3121). The duration of this maneuver should be **6 minutes**. This stored command load will be referred to as “**spin_up_to_22**” in this procedure, but the actual name should be recorded below:

ATS Filename for Spin-Up: _____

Ground contacts should be added as needed for this command load, such that the maneuver will occur during a ground contact.

Following completion of this section, fill out the Burn Success Assessment & Fuel Usage Table of the MAC checklist.

Step 8 – Dump and Turn Off CEU

Perform final CEU dump before turning off the CEU (only if high rate contact available):

CMD: @CEU_SSR_DUMP_NEW

After the SSR Blocks Remaining telemetry returns to zero, turn off the CEU by running the script:

Script: ceu_off.scr

Step 9 – Set Limits for 22 rpm Spin Rate

Run the **ops_acs_limits_on.scr** script and choose **22to4rpm** as the limit set to use.

Step 10 – Turn Off Star Tracker

Turn off the star tracker by running the procedure **S924-OP31202**, Star Tracker On/Off Procedure.

When running this procedure, there is a prompt to provide a different target than PointInertial. Select **ACS_NONE** as this different target.

Step 11 – Upload Spin-Up ATS

During a ground contact, upload the stored command load for the spin up to 22 rpm, **spin_up_to_22**.

Note in telemetry the command number for the command to enable thrusters and record this command number below. This command number will be needed if the command must be deleted in an abort scenario in the following step.

Thruster ENABLE command number: _____

Step 12 – Prior to Spin-Up Contact

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [command number recorded from Step 11]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_EnableFdcTest AC_FDC FDC_CTL FDC_CTL_SPINRATE_REDTTEST DISABLE

CMD: @ACT_EnableFdcTest AC_FDC FDC_CTL FDC_CTL_SPINRATE_YELLTEST DISABLE

Step 13 – Spin-Up Contact

During the ground contact during the spin-up to 22 rpm uploaded in Step 11:

Verify that the stored commands leading up to the start of the maneuver are executing at the proper time.

90 seconds before the time for enabling thrusters, verify that spin rate FDC is disabled:

CMD: @ACT_TMctl

ACS engineering should verify that the returned telemetry indicates that both yellow and red spin rate limits are disabled (expect the EnabledBits telemetry point to change from 15 to 12).

If AND ONLY IF the spin rate limits are not disabled, execute the two spin rate disable commands pre-loaded in Step 12.

During the maneuver, verify that the spin rate is increasing as expected and thrusters 2 and 3 are firing. Verify all ATS commands are executed at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for the maneuver the engineering team determines that the commands are not having the desired effect the maneuver should be aborted by sending the first 2 commands that were pre-loaded in Step 12 immediately.

Verify that the maneuver ends with the spacecraft at 22 ± 1 rpm. If the spacecraft spin rate increased but did not reach 22 ± 1 rpm by the time the maneuver ended then a new maneuver will have to be planned to complete the spin-up prior to continuing on to the next step. Record the post-maneuver spin-rate (from accelerometer telemetry) below:

Post Maneuver Spin Rate: _____ rpm

Step 14 – Enable Spin Rate FDC

During a contact following the spin-up maneuver (may or may not be the same contact as the maneuver is performed), enable red and yellow spin rate FDC limits by running procedure **S924-OP31203**. Provide the following responses to the prompts in the script:

Change Status of FDC as a whole or individually?: **Individually**

Change accelerometer FDC?: **No**

Change gyro FDC?: **No**

Change star tracker FDC?: **No**

Change coarse sun sensor FDC?: **No**

Change jet FDC?: **No**

Change estimator FDC?: **No**

Change control FDC?: **Yes**

Change control FDC as a whole or individually?: **As a whole**

Desired status of control FDC?: **Enable**

Change state FDC?: **No**

After making these selections, the script will bring up a text box showing the status of each FDC test. Verify that the red and yellow spin rate tests are enabled.

3.3 Delta-V Maneuvers (Steps 15-33)

The following steps include the steps required to perform the series of delta-V burns required to perform orbit maintenance. For this maneuver, it is assumed that there are 3 planned apogee delta-V (ADV) burns and one back-up delta-V trajectory correction maneuver (TCM):

ADV1 on the apogee of orbit 128

ADV2 & ADV3 on the apogee of orbit 129

TCM on the apogee of orbit 130 (if needed)

The first three of these stored command loads will be referred to as “**ADV1**”, “**ADV2**”, and “**ADV3**” in this procedure. Record the actual filenames in the individual steps for uploading the burn ATS in this section of the procedure. The backup burn for the following orbit will be referred to as “**TCM**”. If the number or breakdown of maneuvers is different than described above then this procedure should be redlined accordingly.

These stored command loads should be planned as directed in the Mission Operations Handbook (S924-OP3121). The maneuver duration and the thruster to be fired (minus-Z or plus-Z) should be as provided by FDG. For each delta-V burn, the following 4 stored commands should be manually added to the command load generated by MPS:

@EHH_SetHeatTrip TANK1, yes, 12, 14 [180 minutes prior to start of burn]

@EHH_SetHeatTrip TANK2, yes, 12, 14 [180 minutes prior to start of burn]

@EHH_SetHeatTrip TANK1, yes, 16, 18 [1 minute after end of burn]

@EHH_SetHeatTrip TANK2, yes, 16, 18 [1 minute after end of burn]

Ground contacts should be scheduled as needed for these command loads, such that there is a ground contact at the same time as each of the maneuvers.

Depending on the results of any given maneuver, one or more subsequent maneuvers may need to be edited to change the duration of the maneuver (or delete it altogether). Original and modified maneuver command loads must be approved through the MAC process.

Following completion of each delta-V burn in this section, fill out the Burn Success Assessment & Fuel Usage Table of the MAC checklist.

Step 15 – Reduce Telemetry Rates for Delta-V Burns

Prepare for the delta-V burns by reducing telemetry rates using the script:

Script: Reduce_TG_rates_for_dV.scr

Enter below the predicted date/time for the end of ADV1 plus 3.5 days.

Date/Time 3.5 Days After ADV1: _____

Send the stored command to disable the backorbit buffer 3.5 days after ADV1:

CMD: @FTV_DisableBoTm \$time=[date/time recorded above]

Note in telemetry the command number for this timed command.

Disable Backorbit Telemetry Command Number: _____

Step 16 – Upload ADV1 ATS

During a ground contact, upload the stored command load for the first delta-V maneuver, **ADV1**. Record the ATS filename.

ATS Filename for ADV1: _____

Note in telemetry the command number for the commands to enable both the 5N and 22N thrusters. These command numbers will be needed if the commands must be deleted in an abort scenario in the following step.

ADV1 5N Thruster ENABLE Command Number: _____

ADV1 22N Thruster ENABLE Command Number: _____

Step 17 – Verify Heater Setpoints for ADV1

During the first contact less than 3 hours prior to ADV1, check that the commands to change the heater setpoints were successful. Send the following command:

CMD: @ECT_TM2Heater

Verify in received telemetry that the setpoints are now 12/14 instead of 16/18.

Step 18 – ADV1

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [ID# for 5N enable CMD recorded in step 16]

CMD: @FCH_DeITimedCmd [ID# for 22N enable CMD recorded in step 16]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_SetDvEnable DISABLE

During the ground contact during ADV1, verify that the stored commands for the maneuver from the ATS uploaded in Step 16 are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for ADV1 the engineering team determines that the commands are not having the desired effect the maneuver should be aborted. In this case, the pre-loaded commands above should be executed immediately.

During the maneuver, verify that the -Z thruster is firing by looking at the accumulated thrust time (thruster [1] is -Z) and looking at 22N REA temperatures (“Rea2” is -Z).

Note that PCM-B will be automatically turned off by the spacecraft following the maneuver; this is expected and has no impact.

Step 19 – Enable Backorbit Telemetry Prior to ADV2

This step undoes the disabling of backorbit telemetry from Step 15. The means of doing so depends on when a Flight Computer backorbit dump can be performed.

If the FC backorbit buffer data including the telemetry from ADV1 has already been dumped prior to the time recorded in Step 15 then delete the timed command to disable writing to the backorbit buffer:

CMD: @FCH_DeITimedCmd [ID# for recorded in step 15]

If the FC backorbit buffer data including the telemetry from ADV1 has NOT been dumped prior to the time recorded in Step 15 then dump the FC backorbit buffer at the earliest opportunity, then enable writing to the backorbit buffer:

CMD: @FTV_EnableBoTm

Step 20 – Send Timed Command to Disable Backorbit Buffer for ADV2 and ADV3

Enter below the predicted date/time for the end of ADV3 plus 3.5 days.

Date/Time 3.5 Days After ADV3: _____

Send the stored command to disable the backorbit buffer 3.5 days after ADV3:

CMD: @FTV_DisableBoTm \$time=[date/time recorded above]

Note in telemetry the command number for this timed command.

Disable Backorbit Telemetry Command Number: _____

Step 21 – Upload ADV2 and ADV3 ATS

During a ground contact, upload the stored command load for the second and third delta-V maneuvers, **ADV2** and **ADV3**. Record the ATS filenames.

ATS Filename for ADV2: _____

ATS Filename for ADV3: _____

Note in telemetry the command number for the commands to enable both the 5N and 22N thrusters. These command numbers will be needed if the commands must be deleted in an abort scenario in the following step.

ADV2 5N Thruster ENABLE Command Number: _____

ADV2 22N Thruster ENABLE Command Number: _____

ADV3 5N Thruster ENABLE Command Number: _____

ADV3 22N Thruster ENABLE Command Number: _____

Step 22 – Verify Heater Setpoints for ADV2

During the first contact less than 3 hours prior to ADV2, check that the commands to change the heater setpoints were successful. Send the following command:

CMD: @ECT_TM2Heater

Verify in received telemetry that the setpoints are now 12/14 instead of 16/18.

Step 23 – ADV2

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [ID# for ADV2 5N enable CMD from step 21]

CMD: @FCH_DeITimedCmd [ID# for ADV2 22N enable CMD from step 21]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_SetDvEnable DISABLE

CMD: @FCH_DeITimedCmd [ID# for ADV3 5N enable CMD from step 21]

CMD: @FCH_DeITimedCmd [ID# for ADV3 22N enable CMD from step 21]

During the ground contact during ADV2, verify that the stored commands for the ADV2 maneuver from the ATS loaded in Step 21 are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for ADV2 the engineering team determines that the commands are not having the desired effect the ADV2 maneuver should be aborted along with ADV3. In this case, the pre-loaded commands above should be executed immediately.

During the maneuver, verify that the -Z thruster is firing by looking at the accumulated thrust time (thruster [1] is -Z) and looking at 22N REA temperatures (“Rea2” is -Z).

Note that PCM-B will be automatically turned off by the spacecraft following the maneuver; this is expected and has no impact.

Step 24 – Verify Heater Setpoints for ADV3

During the first contact less than 3 hours prior to ADV3, check that the commands to change the heater setpoints were successful. Send the following command:

CMD: @ECT_TM2Heater

Verify in received telemetry that the setpoints are now 12/14 instead of 16/18.

Step 25 – ADV3

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [ID# for ADV3 5N enable CMD from step 21]

CMD: @FCH_DeITimedCmd [ID# for ADV3 22N enable CMD from step 21]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_SetDvEnable DISABLE

During the ground contact during ADV3, verify that the stored commands for the ADV3 maneuver from the ATS loaded in Step 21 are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for ADV3 the engineering team determines that the commands are not having the desired effect the maneuver should be aborted. In this case, the pre-loaded commands above should be executed immediately.

During the maneuver, verify that the -Z thruster is firing by looking at the accumulated thrust time (thruster [1] is -Z) and looking at 22N REA temperatures (“Rea2” is -Z).

Note that PCM-B will be automatically turned off by the spacecraft following the maneuver; this is expected and has no impact.

Step 26 – Enable Backorbit Telemetry Following ADV3

This step undoes the disabling of backorbit telemetry from Step 20. The means of doing so depends on when a Flight Computer backorbit dump can be performed.

If the FC backorbit buffer data including the telemetry from ADV2 and ADV3 has already been dumped prior to the time recorded in Step 20 then delete the timed command to disable writing to the backorbit buffer:

CMD: @FCH_DelTimedCmd [ID# for recorded in step 20]

If the FC backorbit buffer data including the telemetry from ADV2 and ADV3 has NOT been dumped prior to the time recorded in Step 20 then dump the FC backorbit buffer at the earliest opportunity, then enable writing to the backorbit buffer:

CMD: @FTV_EnableBoTm

Step 27 – TCM Assessment

If FDG and the MAC process indicate that no further maneuvers are needed, skip ahead to step 33. If a further maneuver is needed, proceed to step 28.

Step 28 – Send Timed Command to Disable Backorbit Buffer for TCM

Enter below the predicted date/time for the end of TCM plus 3.5 days.

Date/Time 3.5 Days After TCM: _____

Send the stored command to disable the backorbit buffer 3.5 days after ADV1:

CMD: @FTV_DisableBoTm \$time=[date/time recorded above]

Note in telemetry the command number for this timed command.

Disable Backorbit Telemetry Command Number: _____

Step 29 – Upload TCM ATS

During a ground contact, upload the stored command load for the first delta-V maneuver, **TCM**. Record the ATS filename.

ATS Filename for TCM: _____

Note in telemetry the command number for the commands to enable both the 5N and 22N thrusters. These command numbers will be needed if the commands must be deleted in an abort scenario in the following step.

TCM 5N Thruster ENABLE Command Number: _____

TCM 22N Thruster ENABLE Command Number: _____

Step 30 – Verify Heater Setpoints for TCM

During the first contact less than 3 hours prior to TCM, check that the commands to change the heater setpoints were successful. Send the following command:

CMD: @ECT_TM2Heater

Verify in received telemetry that the setpoints are now 12/14 instead of 16/18.

Step 31 – TCM

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [ID# for 5N enable CMD recorded in step 29]

CMD: @FCH_DeITimedCmd [ID# for 22N enable CMD recorded in step 29]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_SetDvEnable DISABLE

During the ground contact during TCM, verify that the stored commands for the maneuver from the ATS uploaded in Step 29 are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for TCM the engineering team determines that the commands are not having the desired effect the maneuver should be aborted. In this case, the pre-loaded commands above should be executed immediately.

During the maneuver, verify that the -Z thruster is firing by looking at the accumulated thrust time (thruster [1] is -Z) and looking at 22N REA temperatures (“Rea2” is -Z).

Note that PCM-B will be automatically turned off by the spacecraft following the maneuver; this is expected and has no impact.

Step 32 – Enable Backorbit Telemetry Following TCM

This step undoes the disabling of backorbit telemetry from Step 28. The means of doing so depends on when a Flight Computer backorbit dump can be performed.

If the FC backorbit buffer data including the telemetry from TCM has already been dumped prior to the time recorded in Step 28 then delete the timed command to disable writing to the backorbit buffer:

CMD: @FCH_DeITimedCmd [ID# for recorded in step 28]

If the FC backorbit buffer data including the telemetry from TCM has NOT been dumped prior to the time recorded in Step 28 then dump the FC backorbit buffer at the earliest opportunity, then enable writing to the backorbit buffer:

CMD: @FTV_EnableBoTm

Step 33 – Restore Nominal Telemetry Rates

Prepare for the delta-V burns by reducing telemetry rates using the script:

Script: Restore_TG_rates_for_dV.scr

3.4 Spin-Down to 4 rpm (Steps 34-40)

Once the team has verified that the delta-V maneuvers went as planned and no more delta-V maneuvers are required, the spacecraft can be spun-down to 4 rpm. This section requires a stored command load for a spin-down to 4 rpm as directed in the Mission Operations Handbook (S924-OP3121). The duration of this maneuver should be **as determined by ACS as the exact time needed to reach 3.5 rpm in flatsat simulations** (will depend on the spin rate after completion of all delta-V maneuvers). Record this time below:

Spin-Down Time: _____ seconds

This spin-down time should be applied by setting the time for ending the spin-down to the start time plus the spin-down time. The `enable_duration` parameter should be the spin-down time plus 60 seconds.

This stored command load will be referred to as “**spin_down_to_4**” in this procedure. Record the actual ATS name below.

ATS Filename for Spin-Down: _____

Ground contacts should be added as needed for this command load, such that the maneuver will occur during a ground contact.

Following completion of this section, fill out the Burn Success Assessment & Fuel Usage Table of the MAC checklist.

Step 34 – Set Gyro as Low-Rate Sensor

Run procedure S924-OP31206, selecting the **Gyro** as the low rate sensor. Note that this will have no impact in telemetry until the spin-down to 4 rpm is being performed and the ACS is in Low Rate Mode.

Step 35 – Upload Spin-Down ATS

During a ground contact, upload the stored command load for the spin-down to 4 rpm, **spin_down_to_4**.

Note in telemetry the command number for the command to enable thrusters and record this command number below. This command number will be needed if the command must be deleted in an abort scenario in the following step.

Thruster ENABLE command number: _____

Step 36 – Prior to Spin-Down Contact

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeIimedCmd [command number recorded from Step 35]

CMD: @ACT_SetThrustEnable DISABLE

CMD: @ACT_EnableFdcTest AC_FDC FDC_CTL FDC_CTL_SPINRATE_REDTEST DISABLE

CMD: @ACT_EnableFdcTest AC_FDC FDC_CTL FDC_CTL_SPINRATE_YELLTEST DISABLE

Step 37 – Spin-Down Contact

During the ground contact during the spin-down to 4 rpm uploaded in Step 35:

Verify that the stored commands leading up to the start of the maneuver are executing at the proper time.

90 seconds before the time for enabling thrusters, verify that spin rate FDC is disabled:

CMD: @ACT_TMctl

ACS engineering should verify that the returned telemetry indicates that both yellow and red spin rate limits are disabled (expect the EnabledBits telemetry point to change from 15 to 12).

If AND ONLY IF the spin rate limits are not disabled, execute the two spin rate disable commands pre-loaded in Step 36.

During the maneuver, verify that the spin rate is decreasing as expected and thrusters 1 and 4 are firing. Verify all ATS commands are executed at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for the maneuver the engineering team determines that the commands are not having the desired effect the maneuver should be aborted by sending the first 2 commands that were pre-loaded in Step 36 immediately.

Verify that the maneuver ends with the spacecraft at 4 ± 0.2 rpm. If the spacecraft spin rate decreased but did not reach 4 ± 0.2 rpm by the time the maneuver ended then a new maneuver will have to be planned to complete the spin-down prior to continuing on to the next step. Record the post-maneuver spin-rate (from accelerometer telemetry) below:

Post Maneuver Spin Rate: _____ rpm

Step 38 – Enable Spin Rate FDC

During a contact following the spin-down maneuver (may or may not be the same contact as the maneuver is performed), enable red and yellow spin rate FDC limits by running procedure **S924-OP31203**. Provide the following responses to the prompts in the script:

Change Status of FDC as a whole or individually?: **Individually**

Change accelerometer FDC?: **No**

Change gyro FDC?: **No**

Change star tracker FDC?: **No**

Change coarse sun sensor FDC?: **No**

Change jet FDC?: **No**

Change estimator FDC?: **No**

Change control FDC?: **Yes**

Change control FDC as a whole or individually?: **As a whole**

Desired status of control FDC?: **Enable**

Change state FDC?: **No**

After making these selections, the script will bring up a text box showing the status of each FDC test. Verify that the red and yellow spin rate tests are enabled.

Step 39 – Set Accelerometer as Low Rate Sensor

Run procedure **S924-OP31206**, selecting the **Accelerometer** as the low rate sensor.

Step 40 – Turn Star Tracker On

During a contact that is NOT during a star tracker outage, turn on the star tracker by running the procedure **S924-OP31202**, Star Tracker On/Off Procedure and following the path for turning the star tracker **ON**. The ACS Engineer must verify that the star tracker is operating normally prior to continuing on with this procedure.

ACS Engineer Initial: _____

3.5 Re-point and Return to Science Operations (Steps 41-54)

The final portion of this procedure begins with the re-pointing maneuver to return to the nominal mission attitude following the spin-down to 4 rpm. It concludes with going back to Science State, turning the payload back on, and undoing some of the telemetry collection changes performed earlier in this procedure.

This section requires a prepared stored command load for the inertial maneuver based on the instructions provided in the Mission Operations Handbook (S924-OP3121). The target vector X, Y, and Z values for the maneuver should be as normally produced in the nominal operations planning cycle for science operations over the next several days. This ATS will be referred to as “**inertial_maneuver_to_nominal_attitude**” in this procedure, but the actual ATS script name and X, Y, and Z parameters should be recorded below:

ATS Filename: _____

Inertial Target Vector:

X: _____

Y: _____

Z: _____

The start time for the maneuver should, if possible, be at a time that it is verified in STK that both the Earth and moon are on the +Z side of the spacecraft. If that is not possible then it should be independently verified that neither the moon nor Earth enters the star tracker FOV during the maneuver. The duration of the maneuver should be **33 minutes**. This is done by manually changing the execution time for the SetThrustEnable DISABLE command and all commands following that in the command load and altering the parameter on the ACT_SetThrustTime command, which is specified in seconds (add an additional 60 seconds to the SetThrustTime command duration beyond the 33 minutes identified above).

The maneuver should be scheduled for a time that a ground contact can be scheduled to coincide with the maneuver, either throughout the maneuver or within 20 minutes of the completion of the maneuver.

Following completion of this section, fill out the Burn Success Assessment & Fuel Usage Table of the MAC checklist.

Step 41 – Upload Inertial Maneuver ATS

Upload the stored command load for the inertial maneuver to the nominal science attitude, **inertial_maneuver_to_nominal_attitude**.

Note in telemetry the command number for the command to enable thrusters. This command number will be needed if the command must be deleted in an abort scenario in the following step.

Thruster ENABLE command number: _____

Step 42 – Operations During Inertial Maneuver

Prior to the contact prepare the following maneuver abort commands in the command history so they can be executed quickly if needed. **DO NOT** send these commands with an active command link unless requested by Engineering.

CMD: @FCH_DeITimedCmd [command number recorded from step 41]

CMD: @ACT_SetThrustEnable DISABLE

During the ground contact the inertial precession maneuver uploaded in Step 41, verify that the stored commands for the maneuver are executing at the proper time.

If AND ONLY IF at any point prior to or during the planned execution period for the stored commands for the maneuver the engineering team determines that the commands are not having the desired effect the maneuver should be aborted. In this case, the pre-loaded commands above should be executed immediately.

Review telemetry to verify that the spacecraft is now in the nominal mission attitude. Below, record the inertial vector (converted from a post-maneuver quaternion) and the sun angle using the coarse sun sensors and quaternions.

Post-Maneuver Inertial Vector: X = _____, Y = _____, Z = _____

Sun Angle (based on quaternions): _____ deg

Sun Angle (based on CSS telemetry): _____ deg

Step 43 – Set Limits for 4 rpm

Following completion of the inertial maneuver, run the **ops_acs_limits_on.scr** script and choose **4 rpm** as the limit set to use.

Step 44 – Verify Static Z Rate

Following completion of the inertial maneuver (after the thrusters are disabled and the static Z rate has been set via the stored command load), use standard nominal operations procedures verify that the static Z rate selected autonomously by the ACS is appropriate and change it if necessary. Currently, this is part of **Standing CAR 377**.

Step 45 – Enter Science State

Put the spacecraft in Science State, verifying each command before sending the next:

CMD: @ACT_SetSpinPulseProtectEnable DISABLE

CMD: @FCT_SetScState SCIENCE

Wait 1 minute before sending the next command:

CMD: @ACT_SetSpinPulseProtectEnable ENABLE

Step 46 – Increase ECT_TMNorm Telemetry Rates

Increase the ECT_TMNorm telemetry rate by running procedure **S924-OP31418**.

When prompted for the number of the entry to modify, enter **“178”**.

The script will prompt a confirmation of the contents of the entry to be changed. To do this, verify the response in the FTG_ReadTGEntry wildpage, which should show that the RtPeriod = 30 and the BoPeriod = 300.

When requested by the script, enter the following responses:

Rt_period = **30**

Rt_start = **same value current shown in the FTG_ReadTGEntry table**

Bo_period = **10**

Bo_start = **same value currently shown in the FTG_ReadTGEntry table**

Let the script run to completion; the script will verify the entry has been properly updated.

Step 47 – Add Star Tracker Attitude Telemetry to Back-Orbit

Run procedure **add_del_TG.scr** and select **“Add”**. When prompted by the script called in that procedure, enter the following values:

Enabled? = **“Enabled”**

Qid = **0x3037**

Function = **0x08**

Subfunction = **0x4a**

Num_params = **0**

Param_0 = **0**

Param_1 = **0**

Param_2 = **0**

Param_3 = **0**

Real-time period (sec) = **0**

Real-time start (sec) = **0**

Backorbit period (sec) = **10**

Backorbit start (sec) = **0**

Mode = **“MISSION_LR_MODE”**

Let the script run to completion; the script will verify the entry has been properly updated. Record the table entry for future use (188 is expected).

Star Tracker Attitude Packet Telemetry Gatherer Table Entry: _____

Step 48 – Turn CEU On

Turn on the CEU by running the **CEU_ON** script.

Step 49 – Payload Low Voltage Checkout

Run the scrip **LV_Checkout.scr**. When prompted make the following selections. Do not proceed to the next part of script until confirmation received from Hi, Lo & CEU.

Turn IBEX-Lo IFB on?	YES	Proceed Y/N
Turn IBEX-Lo TOF on?	YES	Proceed Y/N
Turn IBEX-Hi on?	YES	Proceed Y/N
Configure IBEX-Hi electronics?	YES	Proceed Y/N
LVSCI Test?	YES	Proceed Y/N

Step 50 – IBEX-Hi Diagnostic Tests

The ISOC has provided an STF to run IBEX-Hi diagnostic tests offline. Upload ATS for IBEX-Hi diagnostics test. This will be the last activity of the contact.

ATS filename _____

Step 51 – Set Payload Limits

Run the following script to set the payload limit checks in MAESTRO.

Script: set_payload_limits.scr

There will be known out-of-limit conditions because HV is not enabled. Note red out-of-limits conditions and get assessment from payload team before proceeding.

Step 52 – Enter HVSTANDBY

On the contact after the IBEX-Hi diagnostic test, run the macros to enable payload High Voltage and configure payload into HVSTANDBY.

The steps of the macros can be found in **IBEX_LUT_v13b.xls** on tabs **Macro 0 - Macro 3**. Each macro is completed when the 'Macro' telemetry point reads **MACRO_31** (*ceu_hv* TPage).

CMD: @CEU_MACRO_EXEC OFF_TO_STANDBY_PL1 (enter HVENG)

CMD: @CEU_MACRO_EXEC OFF_TO_STANDBY_LO (configure Hi)

CMD: @CEU_MACRO_EXEC OFF_TO_STANDBY_HI (configure Lo)

CMD: @CEU_MACRO_EXEC OFF_TO_STANDBY_PL2 (enter HVSTANDBY)

Step 53 – Upload Nominal Operations ATs

After the Science Acceptance Committee meeting has approved the transition to HVSCI, upload the time-tagged commands for orbit 131 (the remainder of this orbit) and orbit 132 (next orbit). This will put IBEX into nominal operations configuration with 2 orbits of commands uploaded.

Orbit 131 ATS filename _____

Orbit 132 ATS filename _____

Step 54 – Enter HVSCI

(Note: DESCENDING commands, included in the orbit 131 ATS from Step 52, must be uploaded prior to the ASCENDING command execution in this step.)

Run the macros to configure payload into HVSCI.

The steps of the macros can be found in **IBEX_LUT_v13b.xls** on tabs **Macro 8 - Macro 11**.

CMD: @CEU_MACRO_EXEC ASCENDING_PL1 (enter HVENG)
CMD: @CEU_MACRO_EXEC ASCENDING_HI (configure Hi)
CMD: @CEU_MACRO_EXEC ASCENDING_LO (configure Lo)
CMD: @CEU_MACRO_EXEC ASCENDING_PL2 (enter HVSCI)

End of Procedure.

4. ACRONYM LIST

ACE	Attitude Control Electronics
ACS	Attitude Control System
ADV	Apogee delta-V maneuver
ATS	Absolute Time Sequence (stored command load)
BCR	Battery Charge Regulator
CAR	Command Action Request
CEU	Combined Electronics Unit
CMD	Command
CSS	Coarse Sun Sensors
EPS	Electrical Power System
FC	Flight Computer
FDC	Fault Detection & Correction
FDG	Flight Dynamics Group
HPS	Hydrazine Propulsion System
ISOC	IBEX Science Operations Center
MAC	Maneuver Acceptance Committee
MOC	Mission Operations Center
STK	Satellite Toolkit
TCM	Trajectory Correction Maneuver