IBEX Command Approval Checklist

Rev 16h reduces battery cell balancing offset from maneuvers

Orbit	636	**Special Ops**			
14 R_E asc. Date/Time	1/26/2024 15:49:36		**15 R_E asc. Date/Time**	1/26/2024 17:39:36	
Apogee	1/30/2024 20:21:13	**Maneuver Window Start**	1/30/2024 20:26:39	**Maneuver Window End**	1/30/2024 20:56:41
Apogee Target	targetX:0.6454800996903312|targetY:-0.7009051452091795| targetZ:-0.3034590883843477				
15 R_E desc. Date/Time	2/3/2024 22:55:38		**14 R_E desc. Date/Time**	2/4/2024 00:43:21	
Perigee	2/4/2024 10:13:15	**Maneuver Window Start**	2/4/2024 01:18:41	**Maneuver Window Stop**	2/4/2024 19:49:05
Perigee Target	targetX:0.7180800000000005|targetY:-0.63449999999999995| targetZ:-0.28595599999999999				
Eclipse	No	**Eclipse Start**		**Eclipse End**	
Sun Mnvr	Yes	**Apogee/Perigee**	Apogee	**Sun Angle at DESCENDING**	
Approved Version	IBEX_2023_026_o0636a_v001.scr				

Activity	Command Checks	Date Done	Done By
Supporting Materials	1. *IBEX_CrossingTimes_<date>_v00x.txt* on SFTP at /Archive-Incoming/IBEXIncoming/FDG/PredictedEphemeris/Orbit Events/. 2. Orbit Events File on SFTP at */IBEXOutgoing/MOC/Moc-Soc/oef/.* 3. Command Constraint Violations Report *on SFTP at /IBEXOutgoing/MOC/Moc-Soc/cvr/.* 4. Contacts this orbit *Orbit_oXXX.txt* included in the ATS approval email. 5. Science Tasking File at */Archive-Incoming/IBEXIncoming/MOC/Soc-Moc/stf/*. 6. Merged ATS at http://ibex.unh.edu/cgi-bin/ats.cgi.	01/15/24	NGA
Sun Maneuvers	• Additional contacts *should not* be planned to support IBEX Sun Precession Maneuvers due to star tracker outages. The standard apogee and perigee contacts should be used to verify that a maneuver has occurred. If it is not possible to plan one of the standard contacts after the star tracker outage is down to 50% and a valid quaternion reading can be made to verify the maneuver, the coarse Sun sensor angle and the thruster pulse count will be used to determine a) whether a maneuver took place, and b) whether the pointing after the maneuver is as expected +/- 2 degrees. • The nominal off-Sun pointing constraint is 7.25 degrees. Based on the missed maneuver in orbit 114, the payload team has determined that there is no hardware risk associated with off-Sun pointing up to angles of at least 13 degrees. There is a higher background noted in the data starting at around 9.5 degrees off Sun pointing.	01/15/24	NGA

File Input Check	1. Current OEF inputs are Forecast STF, last orbit's OEF & latest predictive ephemeris. 2. ATS inputs are this orbit's OEF & STF. (And ABS if present.) 3. ATS filename is of the format IBEX_yyyy_doy_o0xxxa_v0zz.scr. where IBEX is capitalized, yyyy is the year, doy is the day of year, xxx is the 3-digit orbit number and zz is the 2-digit version number. Any special operations ATSs will have another designation between the orbit number and version number (i.e. *o0186a_hgc_v001 for the Hi gain curve).	01/15/24 Orbit 634 oef used due to sun maneuvers ok	NGA
Eclipses	1. Check OEF for eclipses during the orbit. 2. Verify long eclipse flag start & stop times reflect Ryan Tyler's recommendations based on his eclipse diagnostic tool. Suggestions made by Ryan after the use of this tool trump the general guidelines below. (Please note, specific timing may shift if the recommendations are relative to eclipse timing. For example, it may say set LE flag to false X hours after the end of the eclipse with a given FALSE time suggested. If the eclipse timing changes as the ephemeris becomes more refined, this command time may shift.) 3. Verify no contacts planned during an eclipse. Note: If in conflict, the eclipse diagnostic recommendations will trump the general guidelines below. a Verify transmitter OFF from 30 minutes before eclipse start through the end of the eclipse. b For an eclipse where the long eclipse flag is set, schedule a SOH contact directly following the end of the eclipse (or per Ryan's assessment). c Set the LE flag according to Ryan's assessments. 4. Verify no maneuver planned during an eclipse. Note: If in conflict, the eclipse diagnostic recommendations will trump the general guidelines below. a Verify no maneuver or cat bed heaters on from 3 hours before eclipse start through 3 hours after eclipse end. b Verify no maneuver or cat bed heaters are on while the long eclipse flag is set. 5. Verify the following additional constraints (from battery balancing section). a Verify the first command sets the long eclipse flag to TRUE, the second command sets the flag to FALSE. b Verify P/L is in HVSTANDBY or HVENG. c Verify no charging cycle within 2 hours of ASCENDING or DESCENDING macro execution. **This applies to all eclipses, not just moderate or long eclipses.**	N/A	

Contact Commands	1. Verify STX on/off times, downlink rate against *Orbit_oXXX.txt* file. 2. Verify contacts in the previous ATS have not been duplicated. 3. Verify all currently planned contacts in Orbit_xxx.txt are in the ATS. 4. Verify each contact contains the following 5 commands. • SetRelay stx,on • SetDownlink2K (2K, 40K, 64K, 160K, or 320K) • SetBilevelOutputControlReg STXMODE_Strobe,ON • SetBilevelOutputControlReg COHERENT,ON • SetRelay stx,off 5. If contact is near an eclipse a. Verify transmitter OFF from 30 minutes before eclipse start through 30 minutes after eclipse end. b. If additional transmitter constraints exist, they will be captured in Ryan's recommendations. 6. If an APL contact is being used for an SSR Dump, the data rate should be at least 160 ksps & the SSR DUMP_NEW command should be included in the contact commands. Commands in Orange should only be sent if the SSR pointers need to be reset this perigee. These commands should be separated by 2s and occur 2s after the SSR_DUMP_NEW command. • SetRelay stx,on • SetDownlink2K • SetBilevelOutputControlReg STXMODE_Strobe,ON • SetBilevelOutputControlReg COHERENT,ON • SetDownlink320K • SSR_DUMP_NEW • SSR_SET_RD_PTR 70000 • SSR_SET_WRT_PTR 70000 • SetRelay stx,off	01/15/24	NGA
SC State Science: arc a	1. Transition to Science state will be first command of each ATS (at 14 Re). • SetScState science $TIME=2024/01:26:15:49:50 2. Lo science mode will be the next command (at 14 Re). • LO_SCIENCE_MODE NORMAL 3. Verify no transition to Science again at the end of the ATS. The ATS commands go from 14 Re to 14 Re in each orbit. 4. Verify the transition to Science commands for this orbit are not part of the previous ATS using http://ibex.unh.edu/cgi-bin/ats.cgi. 5. Verify that the beginning of this ATS does not overlap with the end of the previous orbit's ATS using http://ibex.unh.edu/cgi-bin/ats.cgi.	01/15/24	NGA

Payload Mode HVSCI : arc a	1. Verify w/ Crossing Times report that it occurs about 15 Re ascending. The arc a ASCENDING commands can start any time at or above 15 Re ascending. 2. Verify commanding takes ~ 24 minutes. • ASCENDING_PL1 $TIME=2024/01:26:17:39:48 • ASCENDING_HI • SET_PARAMETER 1, TLM_RATE_SOH • SET_PARAMETER 4, HV_STEP_DWELL • SET_PARAMETER 3, HV_STEP_FRAC • HI_COL_NEG_LVL 1400 • CEU_HI_CEM_1_LVL 1780 • CEU_HI_CEM_2_LVL 1780 • CEU_HI_CEM_3_LVL 1780 • CEU_HI_CEM_4_LVL 1900 • SET_PARAMETER 0, TLM_RATE_SOH • ASCENDING_PL2 • ASCENDING_PL1 • ASCENDING_LO • SET_PARAMETER 1, TLM_RATE_SOH_LO • SET_PARAMETER 4, HV_STEP_DWELL • SET_PARAMETER 1, HV_STEP_FRAC • CEU_LO_IF_MCP_VSET 2901 • SET_PARAMETER 0, TLM_RATE_SOH_LO • ASCENDING_PL2 $TIME=2024/01:26:18:04:07	01/15/24	NGA
Payload Mode HVSTANDBY : arc a	1. Payload DESCENDING commands end 1.5h before thruster enable. 2. Verify commands take ~23 minutes to execute. • DESCENDING_PL1 $TIME=2024/01:30:18:30:41 • DESCENDING_LO • ASCENDING_PL2 • DESCENDING_PL1 • DESCENDING_HI • DESCENDING_PL2 $TIME=2024/01:30:18:53:31	01/15/24	NGA
SC State HK : arc a	1. Spacecraft Housekeeping command occurs 1h before thruster enable. • SetScState housekeeping $TIME=2024/01:30:19:26:41	01/15/24	NGA

Inertial Maneuver : Apogee	**1.** Use this command sequence if an apogee inertial maneuver is used, otherwise skip to the 'Sun Precession Maneuver : Apogee' sequence below. **2.** Verify Thruster enable command occurs within STF maneuver window. **3.** Verify no eclipse occurs from cat bed heater on through set FC mode Mission. **4.** Verify cat bed heaters come on 55 min before burn. • CATBED_5N_HTR,ON **5.** Verify Kalman Filter input select is ground command & estimator update is disabled. • SetKFInputSelect GND_CMD, 0, 0, 0, 0 • SetEstUpdateEnables ENABLE, DISABLE **6.** Verify in FC mode Burn. • SetFcMode burn **7.** Compare SetInrDir in ATS with pointing as defined in the Forecast STF & verify the vectors match. • SetInrDir **8.** Verify inertial maneuver chosen. • SetLrTarget ACS_INERTIAL **9.** Verify thrust time set to 11 min. • SetThrustTime 660 **10.** Verify thruster enable command matches RepointingManeuverStart time in OEF. • SetThrustEnable ENABLE • RepointingManeuverStart **11.** Verify 10 minutes after thrusters enabled: thrusters disabled, cat bed heaters off, thrust time set to 0. • SetThrustEnable DISABLE • SetHTRCmd CATBED_5N_HTR,OFF • SetThrustTime 0 **12.** Verify 25 min after thrusters enabled: Static Z rate set, outage %valid set, FC mode Mission. • SetStaticZrate ESTIMATOR, 0.418 • SetKFInputSelect STA_PCT_VALID, 43,28,33,48 • SetFcMode Mission	N/A	NGA
Sun Precession Maneuver : Apogee	1. Use this command sequence in the event of an apogee Sun maneuver. 2. Verify Thruster enable command occurs within STF maneuver window. 3. Verify no eclipse occurs from cat bed heater on through set FC mode Mission. 4. Verify cat bed heaters powered on 55 min before thruster enable. • CATBED_5N_HTR,ON $TIME=2024/01:30:19:31:39 5. Verify in FC mode Burn and Sun target. • SetFcMode burn • SetLrTarget ACS_SUN 6. Verify thrust time set to 16 min. • SetThrustTime 960 7. Verify thruster enable command matches SunMvrBegin time in OEF. • SetThrustEnable ENABLE $TIME=2024/01:30:20:26:39 • SunMvrBegin 2024-01-30T20:26:39 8. Verify 15 minutes after thrusters enabled: thrusters disabled, cat bed heaters off, thrust time set to 0, FC mode Mission. • SetThrustEnable DISABLE $TIME=2024/01:30:20:41:39 • SetHTRCmd CATBED_5N_HTR,OFF • SetThrustTime 0 • SetFcMode Mission	01/15/24	NGA
SC State Science : arc b	1. Spacecraft Science commands occur ~1h after thruster Disable. • SetScState science $TIME=2024/01:30:21:41:45 • LO_SCIENCE_MODE NORMAL	01/15/24	NGA

Payload Mode HVSCI : arc b	1. Verify payload ASCENDING commands begin at least 1.5 hours after thruster DISABLE. 2. Verify commands take ~24 minutes to execute. • ASCENDING_PL1 $TIME=2024/01:30:22:11:45 • ASCENDING_HI • SET_PARAMETER 1, TLM_RATE_SOH • SET_PARAMETER 4, HV_STEP_DWELL • SET_PARAMETER 3, HV_STEP_FRAC • HI_COL_NEG_LVL 1400 • CEU_HI_CEM_1_LVL 1780 • CEU_HI_CEM_2_LVL 1780 • CEU_HI_CEM_3_LVL 1780 • CEU_HI_CEM_4_LVL 1900 • SET_PARAMETER 0, TLM_RATE_SOH • ASCENDING_PL2 • ASCENDING_PL1 • ASCENDING_LO • SET_PARAMETER 1, TLM_RATE_SOH_LO • SET_PARAMETER 4, HV_STEP_DWELL • SET_PARAMETER 1, HV_STEP_FRAC • CEU_LO_IF_MCP_VSET 2901 • SET_PARAMETER 0, TLM_RATE_SOH_LO • ASCENDING_PL2 $TIME=2024/01:30:22:36:04	01/15/24	NGA
Payload Mode HVSTANDBY : arc b	1. Verify w/ Crossing Times report that it occurs about 15 Re descending. The arc b DESCENDING commands can complete any time at or above 15 Re descending. 2. Verify commands take ~23 minutes to execute. • DESCENDING_PL1 $TIME=2024/02:03:22:29:37 • DESCENDING_LO • ASCENDING_PL2 • DESCENDING_PL1 • DESCENDING_HI • DESCENDING_PL2 $TIME=2024/02:03:22:52:27	01/15/24	NGA
SC State HK : arc b	1. Verify with Crossing Times report that Transition to Housekeeping state occurs at 14 Re desc (or an hour before the maneuver if the maneuver occurs less than 1 hour after 14 Re desc). • SetScState housekeeping $TIME=2024/02:04:00:13:22	01/15/24	NGA

Inertial Maneuver : Perigee	**1.** Use this command sequence if a perigee inertial maneuver is used, otherwise skip to the 'Sun Precession Maneuver : Perigee' sequence below. **2.** Verify no eclipse occurs from cat bed heater on through set FC mode Mission. **3.** Verify cat bed heaters come on 55 min before burn. • CATBED_5N_HTR,ON $TIME=2024/02:04:00:23:41 **4.** Verify in Housekeeping state. **5.** Verify Kalman Filter input select is ground command & estimator update is disabled. • SetKFInputSelect GND_CMD, 0, 0, 0, 0 • SetEstUpdateEnables ENABLE, DISABLE **6.** Verify in FC mode Burn. • SetFcMode burn **7.** Compare SetInrDir in ATS with target vector in the Forecast STF & verify the vectors match. • SetInrDir 0.71808,-0.6345,-0.285956 `targetX:0.7180800000000005|targetY:-0.63449999999999995|targetZ:-0.28595599999999999` Verify inertial maneuver chosen. • SetLrTarget ACS_INERTIAL **8.** Verify thrust time set to 11 min. • SetThrustTime 660 **9.** Verify thruster enable command matches RepointingManeuverStart time in OEF. • SetThrustEnable ENABLE $TIME=2024/02:04:01:18:41 • RepointingManeuverStart 2024-02-04T01:18:41 **10.** Verify 10 minutes after thrusters enabled: thrusters disabled, cat bed heaters off, thrust time set to 0. • SetThrustEnable DISABLE $TIME=2024/02:04:01:28:41 • CATBED_5N_HTR,OFF • SetThrustTime 0 **11.** Verify 25 min after thrusters enabled: Static Z rate set, outage %valid set, FC mode Mission. • SetStaticZrate ESTIMATOR, 0.418 $TIME=2024/02:04:01:43:51 • SetKFInputSelect STA_PCT_VALID, 43,28,33,48 • SetFcMode Mission	01/15/24	NGA
Sun Precession Maneuver : Perigee	1. Use this command sequence in the event of a perigee Sun maneuver. 2. Verify Thruster enable command occurs within STF maneuver window. 3. Verify no eclipse occurs from cat bed heater on through set FC Mode Mission. 4. Verify cat bed heaters come on 55 min before burn. • CATBED_5N_HTR,ON 5. Verify in FC mode Burn and Sun target. • SetFcMode burn • SetLrTarget ACS_SUN 6. Verify thrust time set to 16 min. • SetThrustTime 960 7. Verify thruster enable command matches SunMvrBegin time in OEF. • SetThrustEnable ENABLE • SunMvrBegin 8. Verify 15 minutes after thrusters enabled: thrusters disabled, cat bed heaters off, thrust time set to 0, FC mode Mission. • SetThrustEnable DISABLE • SetHTRCmd CATBED_5N_HTR,OFF • SetThrustTime 0 • SetFcMode Mission	N/A	

Battery Cell Balancing	1. There will be battery cell balancing every 2 out of 3 orbits. Battery cell balancing this orbit? Y 2. Verify charging cycle (Long eclipse flag=TRUE) is 90 minutes long. 3. Verify the first command sets the long eclipse flag to TRUE, the second command sets the flag to FALSE. 4. Verify P/L is in HVSTANDBY or HVENG. (The DESCENDING_PL1 macro leaves us in HVENG; the DESCENDING_PL2 macro leaves us in HVSTANDBY.) 5. Verify no charging cycle within 2 hours of ASCENDING or DESCENDING macro execution. 6. Verify no charging cycle within 15 minutes of maneuver. 7. Verify no charging cycle during an eclipse.	01/15/24	NGA
Cmd Violation	1. Review CCVR. If you have any questions Reply All to the ATS Approval email and ask the team.	01/15/24	NGA

Activity	Anomaly Response : Non-nominal burn	Date Completed	Completed By

	• If the maneuver has not occurred or the spacecraft pointing as designated by either the star tracker or coarse Sun sensor is off by more than 2 degrees from the expected pointing, an anomaly has occurred.
	  • If the spacecraft is in Contingency state all stored commands are flushed from the command queue. Follow standard anomaly process.
	  • If the Sun maneuver did not occur and the spacecraft is in either Science or Housekeeping state follow the steps below.
	  • If a partial Sun maneuver has occurred and the spacecraft is in either Science or Housekeeping state follow the steps below.
	• Please note that there is no anticipated hardware damage associated with exceeding the 12.5 degree constraint; this constraint is in place because we should not exceed the largest pointing achieved thus far in the mission.		

	1. If the payload is in HVSTANDBY, LVENG or OFF, and there are no commands loaded to bring it to HVSCI voltages, no operational pointing constraints will be violated. Follow standard anomaly process.
	2. If the payload is in HVSCI mode or there are uploaded commands to bring the payload to HVSCI mode,
	  a. Determine current off Sun pointing. If the off Sun angle has already exceeded 12.5 degrees, the MOC should notify the MOM and immediately send the DESCENDING command suite in real-time, as described below. If this cannot be done in the contact where the pointing anomaly was discovered, another contact will be planned as soon as possible to execute these commands.
	  @CEU_MACRO_EXEC DESCENDING_PL1 (< 1 min)
	  @CEU_MACRO_EXEC DESCENDING_LO (~ 10 min)
	  @CEU_MACRO_EXEC DESCENDING_HI (~ 8 min)
	  @CEU_MACRO_EXEC DESCENDING_PL2 (< 1 min)
	  Please note: The only scenario where hitting 12.5 degrees is expected is when a perigee Sun precession maneuver is completely missed after an inertial apogee maneuver which occurs late in the maneuver window (near apogee + 10 hours).
	  b. If current Sun pointing is below 12.5 degrees, the ISOC should input ST Sun-pointing angle into ibex_rotate to determine the Sun angle at the time of DESCENDING.
	  Sun-Angle at payload DESCENDING _____
	  c. If 12.5 degrees is not exceeded by the time of DESCENDING, no payload-specific action is needed for this arc. Follow standard anomaly response process.
	  d. If 12.5 degrees is exceeded by the time of DESCENDING, a new command set should be sent.
	  i. The ISOC will generate the new STF which has the DESCENDING commands executing early such that 12.5 degrees is not exceeded while the payload is in HVSCI.
	  ii. The MOC will create an associated ATS.
	  iii. Approval is needed by the MOM, MOC & ISOC prior to upload.
	  iv. The MOC will assess whether an additional pass is needed in order to upload the commands prior to exceeding the 12.5 degree constraint. The onboard DESCENDING commands do not need to be deleted.		