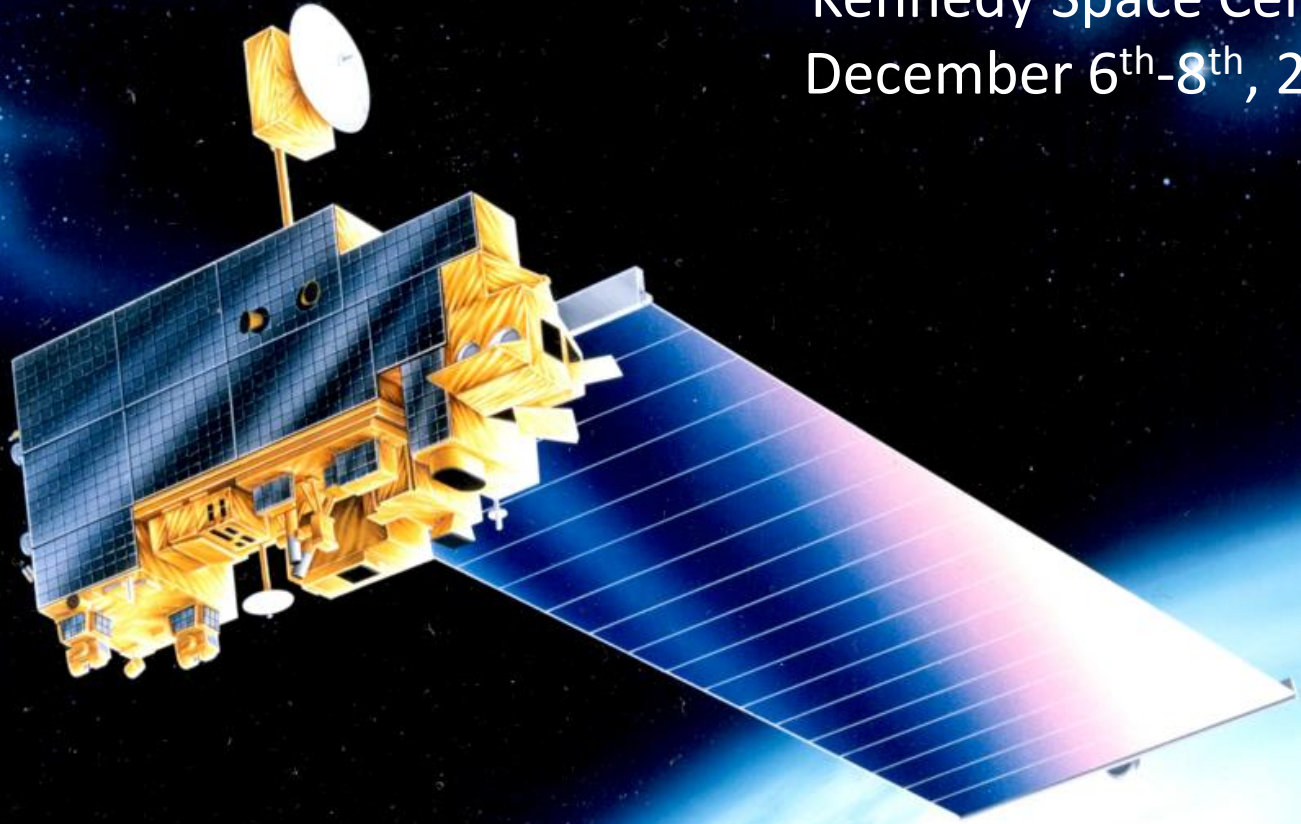


EOS Terra

Mission Status
Constellation MOWG
Kennedy Space Center
December 6th-8th, 2017

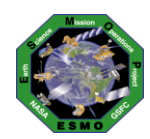


Dimitrios Mantziaras

Terra Mission Director - Code 428

phone 301-614-5234

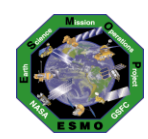
Dimitrios.C.Mantziaras@nasa.gov



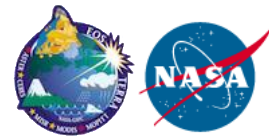
Topics



- **Mission Summary**
- **Spacecraft Subsystems Summary**
- **Recent Activities**
- **Inclination Adjust Maneuvers**
- **Conjunction History**
- **End-Of-Mission Plan**
- **Upcoming Activities**
- **Summary**
- **Backup Slides**



Terra Mission Overview

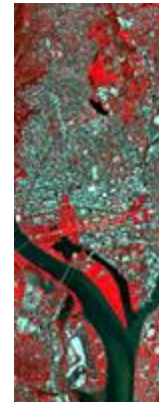


Terra Features

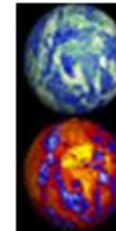
- **Launch Date:** December 18, 1999 (Atlas IIAS, VAFB)
- **Orbit:** 705 km, Sun-synchronous polar, 98.2° Inclination, 10:30 AM MLT descending node
- **Instrument Payload:**
 - **ASTER (SWIR, TIR & VNIR)** - Advanced Spaceborne Thermal Emission and Reflection Radiometer (Japan)
 - **CERES (Fore & Aft)** - Clouds and the Earth's Radiant Energy System (USA – Langley)
 - **MISR** - Multi-angle Imaging Spectro-Radiometer (USA – JPL)
 - **MODIS** - Moderate Resolution Imaging Spectro-radiometer (USA – GSFC)
 - **MOPITT** - Measurement of Pollution in the Troposphere (Canada)
- **Project Management:** Earth Science Mission Operations (ESMO)
- **Spacecraft Flight Operations:** Contracted by GSFC to KBR team and supported by NASA NENs and TDRSS
- **Instrument Operations and Science Data processing:** Performed at respective Instrument Locations where developed
- **Mission Duration:** Successfully completed Prime mission of 5 years. Currently in Extended Operations.
- **Distributed Active Archive Centers:** LP DAAC – MODIS, ASTER; Langley DAAC – CERES, MISR, MOPITT

Science

- The primary objective of the Terra Mission is to simultaneously study clouds, water vapor, aerosol, trace gases, land surface and oceanic properties, as well as the interaction between them and their effect on the Earth's energy budget and climate.



ASTER



CERES



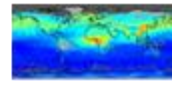
Terra (EOS AM-1)



MODIS

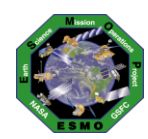


MISR



MOPITT

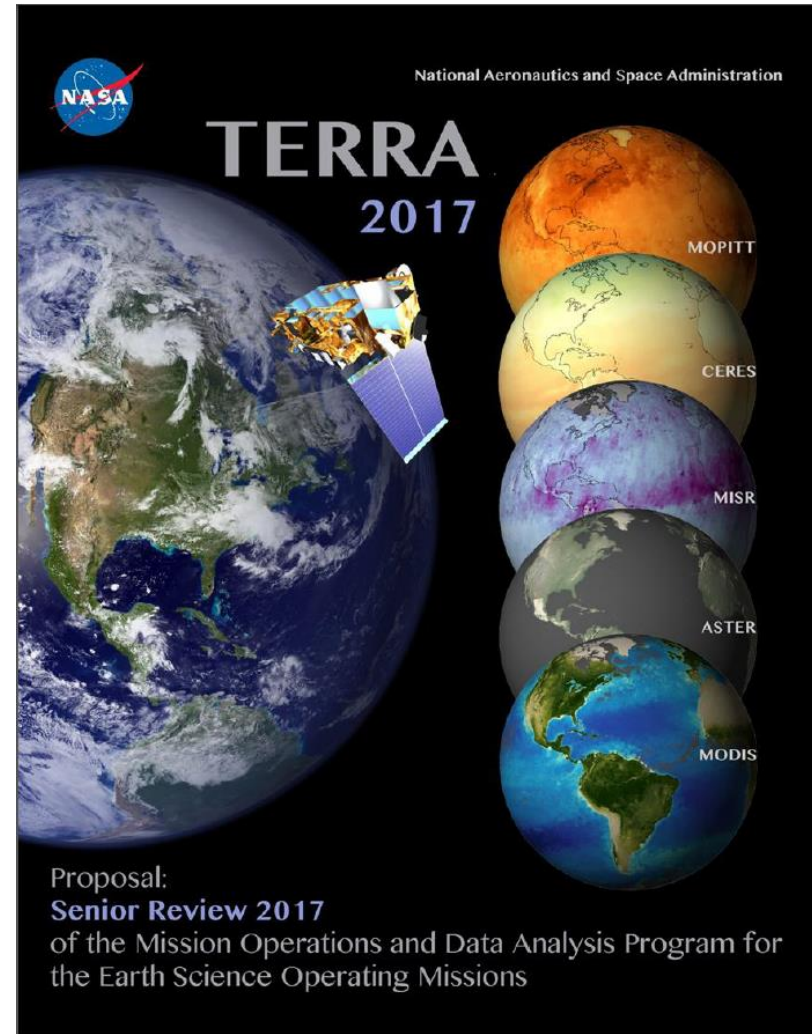


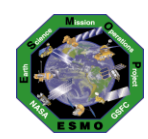


EOS Terra Mission Summary



- **May 2017: Mission Extension Senior Review Proposal Panel Report**
 - Mission extension through **FY23**
 - Senior Review submission delivered in Mar 2017
- **2017-18 Inclination Adjust Maneuvers**
 - Spring 2017 Inclination Maneuvers
 - IAM #47 – February 16th
 - IAM #48 – February 23rd
 - Fall 2017 Inclination Maneuvers
 - IAM #49 – October 19th
 - IAM #50 – October 26th
 - Spring 2018 Inclination Maneuvers
 - IAM #51 – February
- **12/18/17: Terra 18-Year Anniversary**
 - 5-Year Design Life, 6 year goal
 - Reliability Estimates thru 2022+
 - Consumables through 2020+
- **January 2018: EOS Flight Operations Annual Review #12**





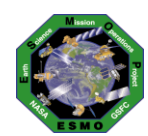
Terra Spacecraft Status

No Change



All subsystems on Primary Hardware except as noted

- **Command & Data Handling (CDH) – Nominal**
 - Solid State Recorder (SSR) – holds ~1 orbit of data
 - 10 of 58 SSR Printed Wire Assembly tripped off resulting in reduced recording capacity
- **Communications (COMM) – Nominal**
 - DAS Modulator Failure on 05/29/2008 (Operating on Redundant)
 - Use K-Band primarily, X-Band as needed for Science Playback
- **Electrical Power System (EPS) – Good**
 - Battery Cell and Heater Controller Anomaly (10/13/2009)
 - 1 of 24 Solar Panel Failed (9/24/2000)
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
 - Minor loss of sensitivity in SSSTs – updated tracker biases to compensate
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**
- **Instruments (INST) – Nominal**
 - Only ASTER SWIR failed, all other instruments are taking science

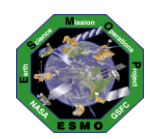


Spacecraft Component Status

No Change



Subsystem	Component	Design	Current	Capability	Comments
EPS	Solar Array	24 Shunts	23 Shunts	96%	Degradation is minimal. Fully capable of supporting mission thru 2020 unless future failures occur
	Batteries	108 Cells	107 Cells	99%	BBAT cell #50 failed on 10/15/09.
	Batteries	36 Heater Controls	28 Heater Controls	77%	BBAT heater control failed on 4 of 9 heater groups on primary, redundant, and survival. Battery cell charging/discharging and the remaining heater groups are preventing cells from freezing. PBAT heater control performance is nominal.
TCS	MOPITTCPHTS	2	2	Full	Performance is nominal
	SWIR CPHTS	2	2	Full	Performance is nominal
	TIR CPHTS	2	2	Full	Random temperature fluctuations. Performance within requirements.
SCC	SCC	2	2	Full	Performance is nominal
COMM	HGA	2	2	Full	MDA BITE failures occur 2-3/week due to SEU. Recoverable
	X-Band	2	1	75%	DAS Modulator 1 failed (50%). Solid State Power Amplifier redundancy still available (100%).
	CTIU	2	2	Full	Performance is nominal
	OMNI	2	2	Full	Performance is nominal
CDH	MO	2	2	Full	Drift rate changes have occurred since 10/3/10. Performance is within requirements.
	SFE	2	2	Full	SFE SEU occur 1-2/year. Recoverable
	SSR	59 PWA	49 PWA	83.1%	Recycle of Data Memory Unit likely to recover all Printed Wire Assemblies
GNC	IRU	3	3	Full	Performance is nominal. 2 for 3 redundancy
	TAM	2	2	Full	Performance is nominal
	SSST	2	2	Full	Minor loss of sensitivity in SSSTs – tracker biases updated
	CSS	2	2	Full	Performance is nominal
	ESA	2	2	Full	Performance is nominal
	FSS	1	1	Full	Performance is nominal. Not currently used
	RWA	4	4	Full	Performance is nominal. 3 for 4 redundancy
	MTR	3	3	Full	Performance is nominal
Prop	REAs	16	16	Full	Performance is nominal
Instruments	ASTER - SWIR	2	2	0%	Cooler is unable to maintain detector temperature. Science Data is unusable (Fully Saturated) and is no longer being recorded. Still collecting and monitoring Engineering data.
	ASTER - TIR	2	2	Full	Performance is nominal
	ASTER - VNIR	2	2	Full	Performance is nominal
	CERES - Aft	1	1	Full	Performance is nominal
	CERES - Fore	1	1	Full	Performance is nominal
	MISR	2	2	Full	Performance is nominal
	MODIS	2	1	50%	Power Supply #2 failed, Formatter A degraded, cross-strapped. All Science is nominal.
	MOPITT	2	1	50%	Displacer B and Chopper Motor failed. Loss of redundancy only. All Science is nominal.

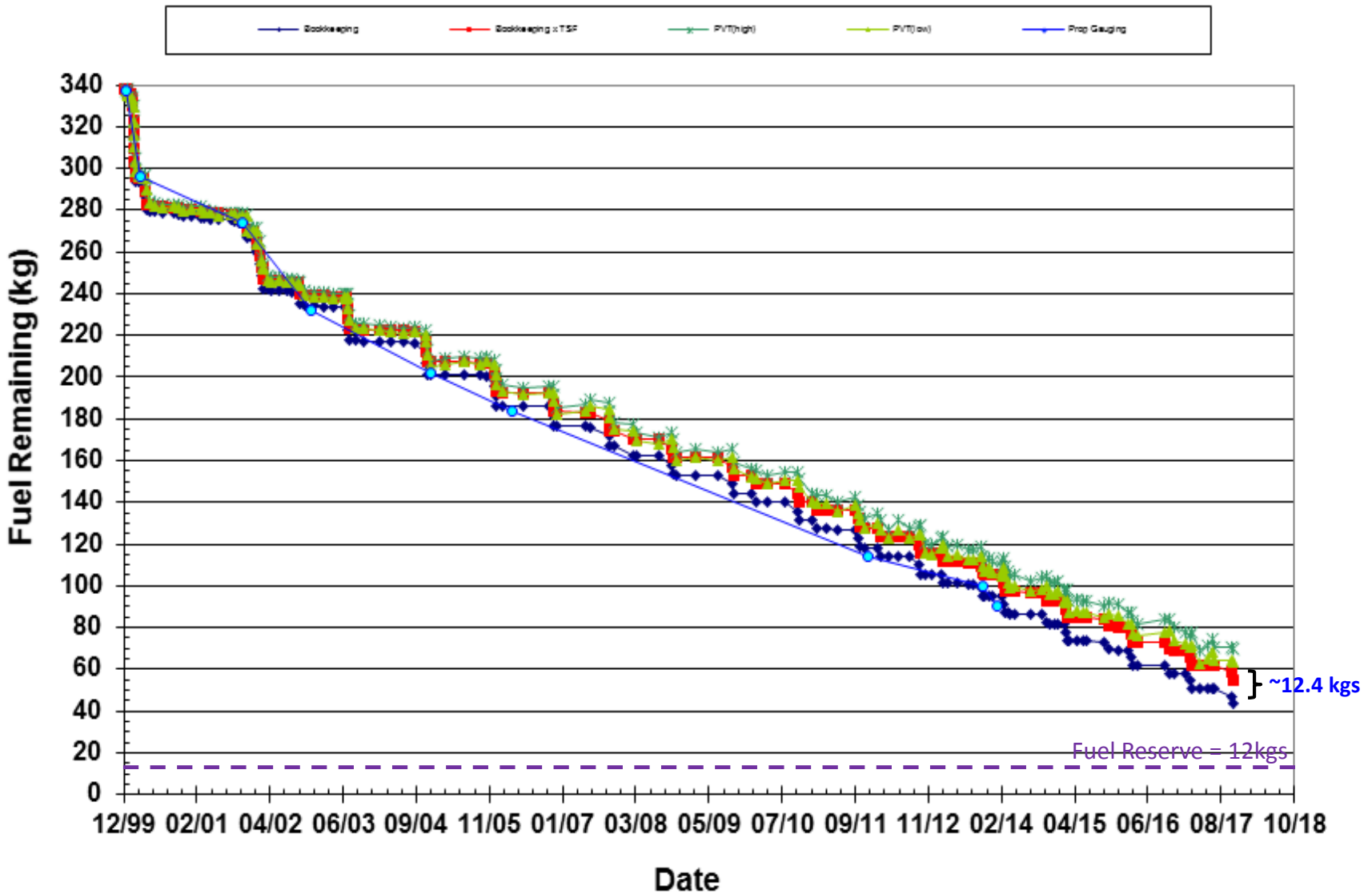


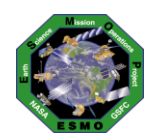
Lifetime Fuel Estimates



TerraFuel Usage Comparison

Fuel Usage Approximations:
~4 kg of fuel for every IAM
~0.15 kg of fuel for every DMU





Recent Activities



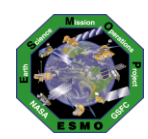
• Propulsive Maneuvers

- Drag Make Up Maneuver (DMU) #99 executed on 01/19/17
- [Inclination Adjust Maneuver \(IAM\) #47 on 02/16/17](#)
- [Inclination Adjust Maneuver \(IAM\) #48 on 02/23/17](#)
- Drag Make Up Maneuver (DMU) #100 executed on 04/06/17
- Drag Make Up Maneuver (DMU) #101 executed on 05/25/17
- Drag Make Up Maneuver (DMU) #102 executed on 06/29/17
- Risk Mitigation Maneuver (RMM) #11 (DMU #103) executed on 07/05/17
- [Inclination Adjust Maneuver \(IAM\) #49 on 10/19/17](#)
- [Inclination Adjust Maneuver \(IAM\) #50 on 10/26/17](#)

• Calibration Maneuvers

- MODIS Roll #171 executed on 01/16/17
- MODIS Roll #172 executed on 02/15/17
- MODIS Roll #173 executed on 03/16/17
- MODIS Roll #174 executed on 04/16/17
- MODIS Roll #175 executed on 06/14/17
- MODIS Roll #176 executed on 07/13/17
- MODIS Roll #177 executed on 08/12/17
- MODIS Roll #178 executed on 09/10/17
- MODIS Roll #179 executed on 10/09/17
- MODIS Roll #180 to be executed on 11/08/17

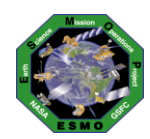
- **01/25/17 – 01/26/17: ESMO Annual Review**
- **02/01/17: FDIR RTCS 99 (OA -> Wheel Safe hold) Uplink**
- **03/13/17: Terra FOT LDSC Full Team Simulation**
- **03/15/17 – 03/16/17: ASTER IOT LDSC Working Group**
- **03/16/17: Terra ASTER IOT LDSC Full Team Simulation**
- **04/18/17 – 04/20/17: LDSC Sun Safe Recovery Simulation**
- **04/26/17: TAM data source (BDU -> ACE) switch (part 1) and initial onboard TAM Predict file test**
- **04/27/17: TAM Predict file test #2**
- **06/03/17: MODIS Skipped EDU**
- **06/04/17: SFE Anomaly (TMON 16 Trip)**
- **07/20/17: Terra COMM SPSH RTCS Uplink**
- **07/29/17: Terra IRU-B Anomaly Current Spike**
- **07/30/17: SFE Anomaly (TMON 16 Trip)**
- **08/05/17: [Terra DSC # 3 \(LDSC #2\) Executed Successfully](#)**
- **08/21/17 Terra Lunar Induced Solar Eclipse #40**



Inclination Adjust Maneuvers



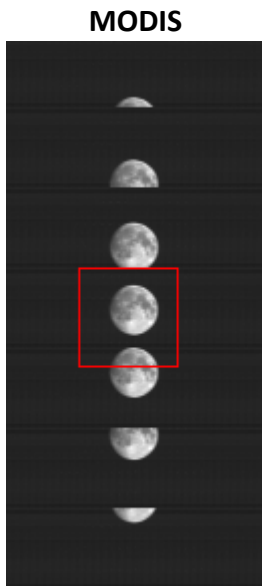
- **Inclination Adjust Maneuvers used to maintain nominal spacecraft mean local time (descending node) of 10:30 AM**
 - 10/19/2017 IAM #49 (320 sec burn) executed successfully
 - 10/26/2017 IAM #50 (320 sec burn) executed successfully
 - February 2018 IAM #51 planned
- **Predictions indicate need to perform 3-4 maneuvers per year**
 - 2017: (2 in Spring, 2 in Fall) -- **COMPLETE**
 - 2018: (1 in Spring, 2 in Fall)
 - 2019: (2 in Spring, 1 in Fall)
 - 2020: (2 in Spring, **0 in Fall**) -- **last inclinations for Terra mission**

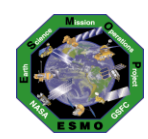


Terra Lunar Deep Space Calibration (LDSC)

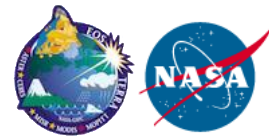


- After approximately three years of discussion, planning and preparations, the FOT successfully executed a Lunar Deep Space Calibration maneuver on **Aug. 5, 2017**
 - LDSC requires pitching the spacecraft a complete 360 degrees during spacecraft night, while precisely scanning the moon at a fixed rate through the center of the instrument field of views
 - The Original Terra Design did not account for a DSC (special Fault Detection was developed)
 - The DSC is the only maneuver where Terra's Earth Sensors lose view of the Earth
 - It had been 14+ years since the last LDSC in 2003





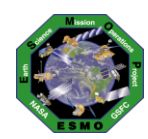
Terra High Interest Events



Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2016 (T1-T4)	1	2	1	1	2	1	1	1	1	0	0	0	11
Tier 3	0	0	0	1	0	1	1	0	1	0	0	0	4
Tier 4	0	0	0	0	0	0	0	0	0	0	0	0	0
2017 (T1-T4)	0	2	0	0	1	0	2	2	0	0			7
Tier 3	0	0	0	0	0	0	1	0	0	0			1
Tier 4	0	0	0	0	0	0	1	0	0	0			1

CARA Defines the 4 Tiers as: T1 – Notify (email/phone), T2 – Conduct Briefing, T3 – Plan Maneuver, T4 – Execute Maneuver

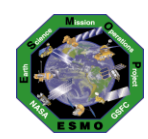
- **2005:** 4 HIEs – 1 Debris Avoidance Maneuver (DAM) performed on 10/21/2005: Terra vs. 14222 CA on 10/23
- **2006:** 1 HIE – 1 maneuver waived off due to CA. Maneuver originally planned for 01/12/2006: Terra vs. 1716 CA on 1/12 @ 17:46z
- **2007:** 4 HIEs – 1 DAM performed on 06/22/2007: Terra vs. 31410 CA on 6/23
- **2008:** 2 HIEs – 1 DAM planned and waived off: Terra vs. 82832 CA on 10/28/2008 @ 06:17z
- **2009:** 2 HIEs – No DAMs planned or performed
- **2010:** 5 HIEs – 1 DAM performed on 01/22/2010: Terra vs. 34700 CA on 1/23 @ 20:46z
- **2011:** 20 HIEs – 2 DAM planned and waived off: (1) Terra vs. 26181 CA on 3/28/2011 @ 12:14z (2) Terra vs. 30440 Repeating CA 05/07-09/2011
- **2012:** 19 HIEs – 1 maneuver waived off due to CA. Maneuver originally planned for 05/31/2012: Terra vs. 37789 CA on 6/1 @ 22:49z
- **2013:** 17 HIEs – 7 that required significant action
- **2014:** 24 HIEs – 6 that required DAM execution or nominal maneuver waive-off and replanning
- **2015:** 33 HIEs – 8 that required DAM execution or nominal maneuver waive-off and replanning
- **2016:** 11 HIEs – 0 that required DAM execution or nominal maneuver waive-off and replanning
- **2017 thru present:** **7 High Interest Events (HIEs) – 1 that required DAM execution or nominal maneuver waive-off and replanning**
 - DAM #11 executed successfully on July 5th (Terra vs. 35627)



ESMO RMM Planning Automation



- **ESMO has updated its Close Approach (CA) Process Flow to move towards a more Automated approach**
 - Prepares for future increased object catalog w/ Space Fence
 - Reduces workload for each event
 - Keeps solution “at the ready” for short notice events
- **ESMO Flight Dynamics team has developed an autonomous ephemeris generation tool**
- **Ephemeris built off optimal and constrained cases solved for by the Collision Risk Management System (CRMS)**
- **CARA accepts delivery of these ephemeris and ships them to JSpOC for screening**
 - Delivery from FDS to CARA will be manual for now as we become more familiar with which solutions are most valuable
 - Eventually delivery to CARA will be automatic based on logic built into the FDS ephemeris tool
(goal by end of 2017)
- **Screening results automatically compiled and outputted via an email report from CRMS**
- **Auto Ephemeris Generation Implemented on February 13th, 2017**
- **Auto Ephemeris Delivery scheduled for December 2017**



Terra End-of-Mission Plan



Document Status

- Rev D - End-of-Mission Plan Document has been revised and under review cycle
- **Hope is to have signed version in CM prior to February 2018 inclination maneuver**

Content


- Terra will continue normal operations through **October 2020**
- Once all non-reserved fuel has been used, MLT will be drifted to 10:15 AM
- **January 2022**, Terra exits constellation
- Remain fuel used to lower perigee prior to spacecraft passivation
- Exit plan is consistent with the current Constellation Operations Coordination Plan

Effective Date: June 2017
Expiration Date: June 2019

Earth Science Mission Operations Project, Code 428
428-PLAN-002

**Earth Observing System (EOS)-Terra
End of Mission Plan (EOMP)**

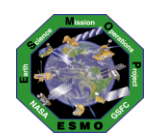
Revision D
Effective: June 2017
Expires: June 2019

A detailed illustration of the Terra satellite, showing its complex body, various instruments, and its large solar panel array extended to the right.

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Check the ESDIS/ESMO/EDOS Doc Server at <https://eps1-cm.esdis.nasa.gov/cm/> to verify that this is the correct version prior to use.



Upcoming Activities



Upcoming Activities

Terra MODIS Roll #180 **11/08/17**

Terra FSSE CCB **11/16/17 @ 11 AM**

Terra Power Working Group **Early/Mid November**

Terra TONS Safehold Working Group **Early/Mid November**

Terra Instrument November Telecon **11/20/17 @ 2 PM**

Constellation MOWG @ KSC **12/06/17 – 12/08/17**

Terra Science Panel @ New Orleans **12/10/17**

Terra Instrument December Telecon **12/18/17 @ 2 PM**

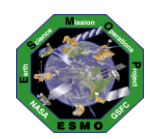
MISR Bi-Monthly Calibration **12/19/17**

Terra LDSC Technical Exchange with JPSS-1 **TBS**

Update to SSR Auto-LUR Patch **4Q2017**

Removal of Star 493 Patch **4Q2017**

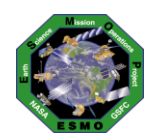
Update Drag Scale Factor **1Q2018**



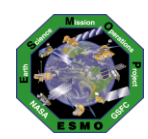
Summary



- **Terra remains very healthy 17+ years into the mission**
 - Electrical Power Subsystem performance has been stabilized following 2009 anomaly
 - Fuel Remaining to continue operations to 2020 and beyond
- **Data Capture percentages continue at ~100%**
- **Collision Avoidance events continue to be part of routine ops**
- **End of Mission Plan (Rev D) currently out for signatures**
 - Updated dates and analysis based on latest drag predicts
 - Target completion date is ~~Sept/Oct 2017~~ prior to February 2018



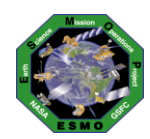
FUTURE PLAN



Overview of Terra EOM Work



- Fuel ~ 100kg triggering maneuver option analysis – **Summer/Fall 2013**
 - Options sent to IOTs for their feedback – **April 2014**
 - **EOM Engineering Peer Review – July 2014**
 - Science Team Meeting – **Aug 2014**
 - IOT feedback received – **Sept 2014** (Proposed plan selected)
 - **Constellation MOWG – Oct 2014**
 - Briefing to NASA Program Exec – **Jan/Feb 2015**
 - Waivers generated and sent for Goddard Signatures – **Feb 2015**
 - Terra Senior Review Proposal Submitted – **March 2015**
 - Waiver signatures received for Goddard – **June 2015**
 - **Constellation MOWG – June 2015**
 - Aerospace presented their debris risk analysis
 - Science Team Meeting – **March 2016**
 - **Constellation MOWG – April 2016**
 - Removed “Baseline” Plan and Created new “fallback” options – **May->Aug 2016**
 - **Constellation MOWG – September 2016**
 - Presented Future Maneuver Options to NASA HQ – **October 2016**
 - **OSMA states that Terra Waivers are not required – November 2016**
 - Terra Senior Review Proposal Submission – **March 2017**
 - **Constellation MOWG – June 2017**
-
- **Submitted End of Mission Plan (Rev D) to NASA HQ for signatures – Sept/Oct 2017**
 - **Independent Science Panel – December 2017**
 - ****NEW** Final Decision Deadline – Prior to February 2018 IAM**



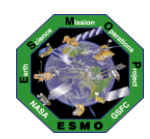
Option Summary

Time-on-Orbit Comparisons



Decommissioning Plan	Exit Year	De-orbit Year	# of de-orbit burns	Final Apogee (km)	Final Perigee (km)	End of Mission (EOM)	EOM to Reentry (yrs)	Reentry date
Option 1	2022	2026	6	702.31	671.43	2026	50	2076
Option 2	2018	2018						
Fallback Option 4	2021	2023	13			2023	40	2063

- Reference Only
- Planned Option
- Fallback Options



Option 1



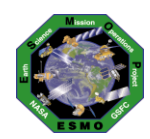
Lifetime and Orbit Lowering Maneuvers

- Terra Lifetime (in constellation):**

Mission Year (-)	Inclination Maneuvers (-)	DMU Maneuvers (-)	Fuel Used (kg)	Fuel Remaining (kg)
2016	0 Spring, 1 Fall	1	3.92	73.43
2017	2 Spring, 2 Fall	3	15.05	58.39
2018	1 Spring, 2 Fall	1	10.79	47.59
2019	2 Spring, 1 Fall	3	10.77	36.82
2020	2 Spring, 0 Fall	2	7.11	29.72
2021	0 Spring, 0 Fall	2	0.23	29.48

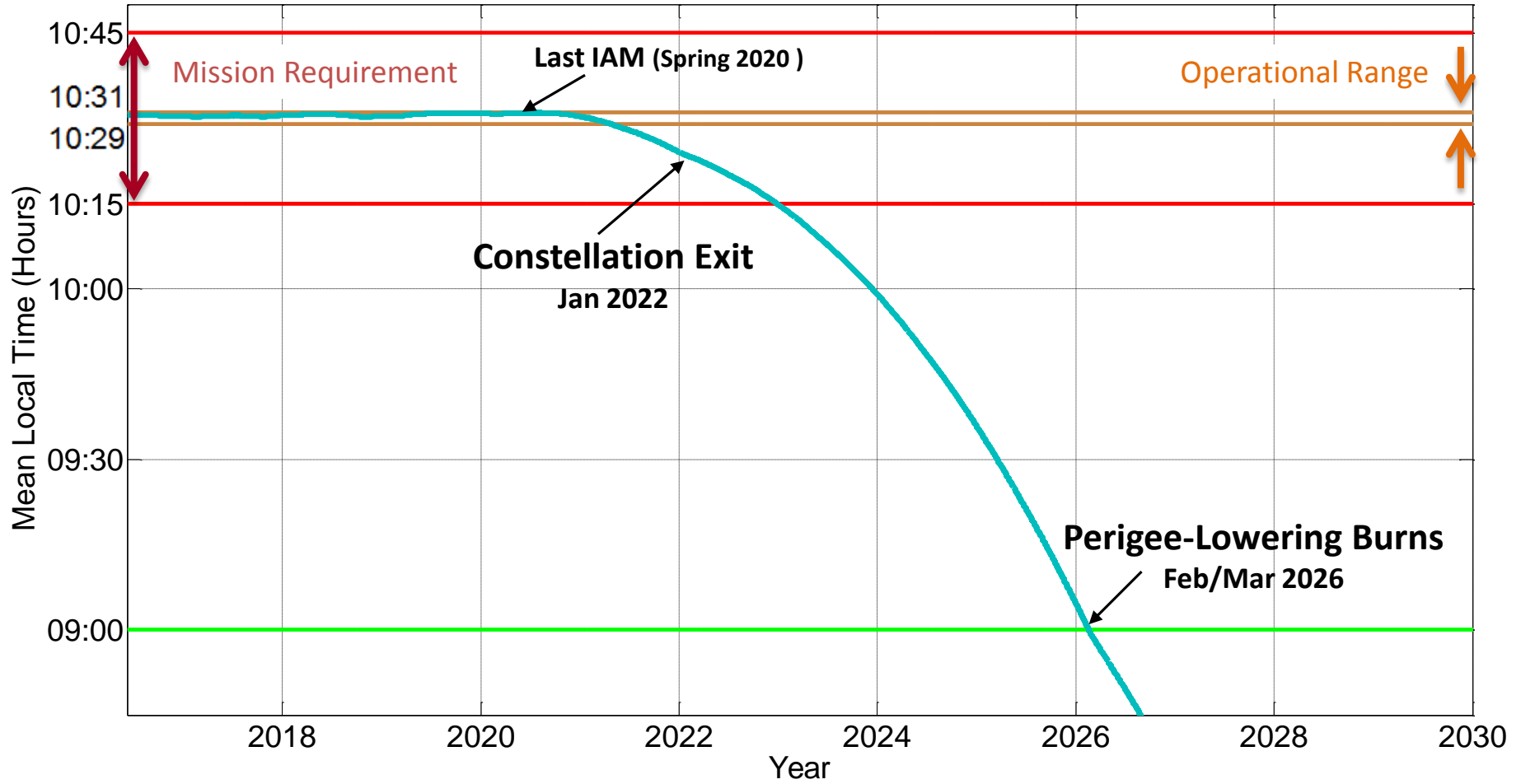
- Terra Constellation Exit and Orbit Lowering:**

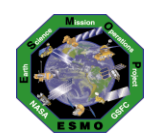
Mission Year (-)	Maneuver Type (-)	Fuel Used (kg)	Fuel Remaining (kg)
1/11/2022	Envelope Exit #1	3.44	26.04
1/11/2022	Envelope Exit #2	3.42	22.62
2/19/2026	De-orbit #1	3.40	19.21
2/24/2026	De-orbit #2	3.39	15.83
2/26/2026	De-orbit #3	3.37	12.46
3/3/2026	De-orbit #4	3.35	9.11
3/5/2026	De-orbit #5	3.33	5.78
3/10/2026	De-orbit #6	3.31	2.47



Option 1

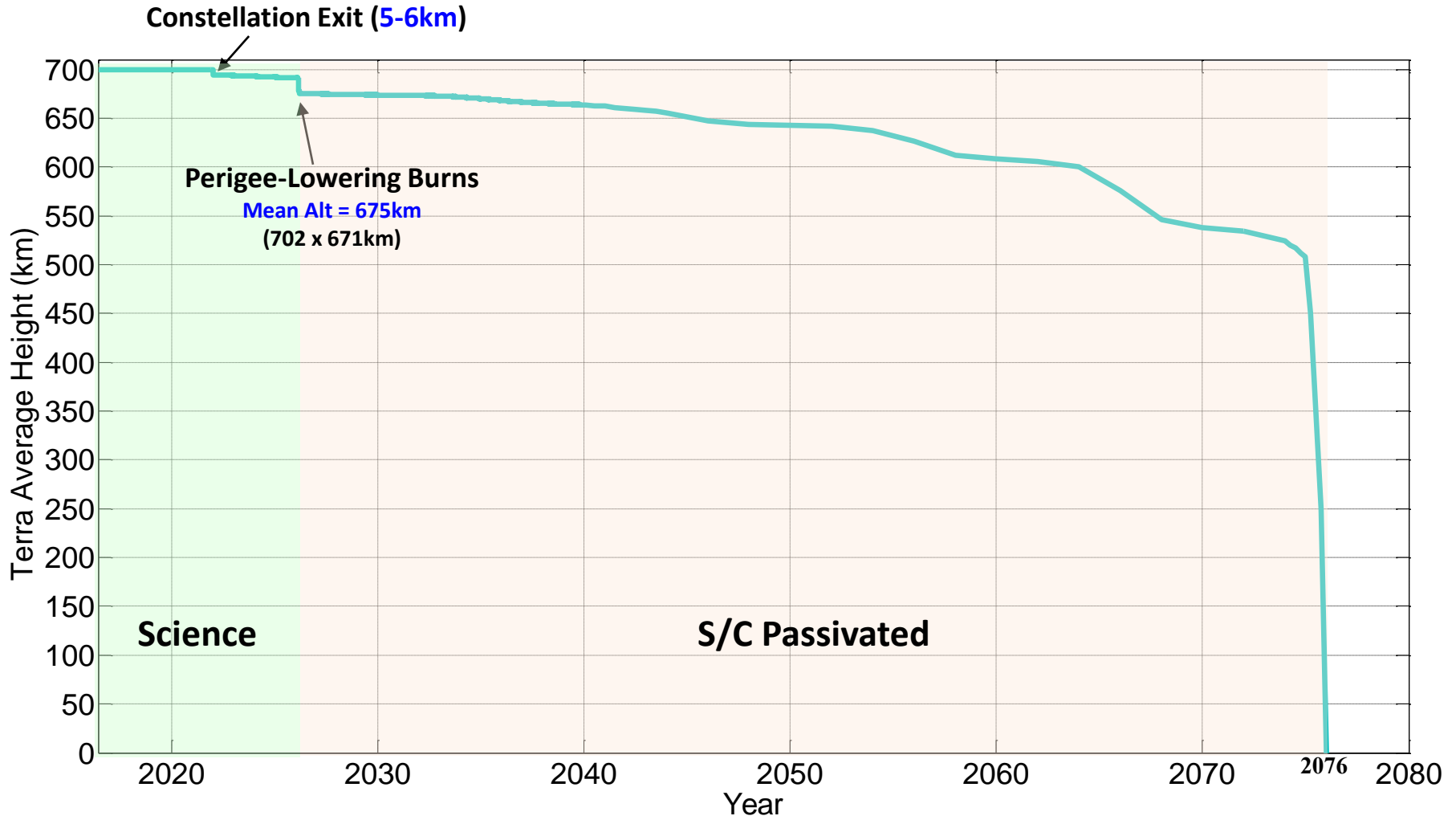
Mean Local Time

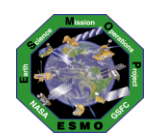




Option 1

Lifetime Average Height

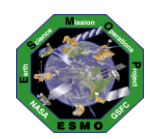




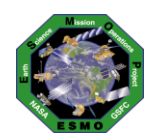
Conclusion/Summary



- It was determined officially that Terra does not require waivers
- Based on that fact, decision for Terra's future lies with Earth Science Division @ NASA HQ
- A signed EOMP or other NASA HQ official direction will serve as authorization to proceed
 - Official Direction awaiting the results of the Science Panel (12/10)
- If Science Panel not conducted and/or EOMP not signed prior to next inclination series, then ESMO will request written authorization from NASA HQ to execute inclination maneuvers
- Plan is for Terra to Exit Constellation in early 2022 and end mission in early 2026

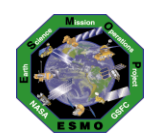


Questions



Additional Slides

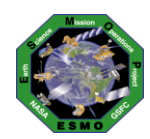
- **Orbit / Inclination / MLT Maintenance**
- **WRS Ground Track Error**
- **EPS Performance**
- **Terra Safehold**
- **OSMA Waiver Email**



Orbit/Inclination/MLT Maintenance



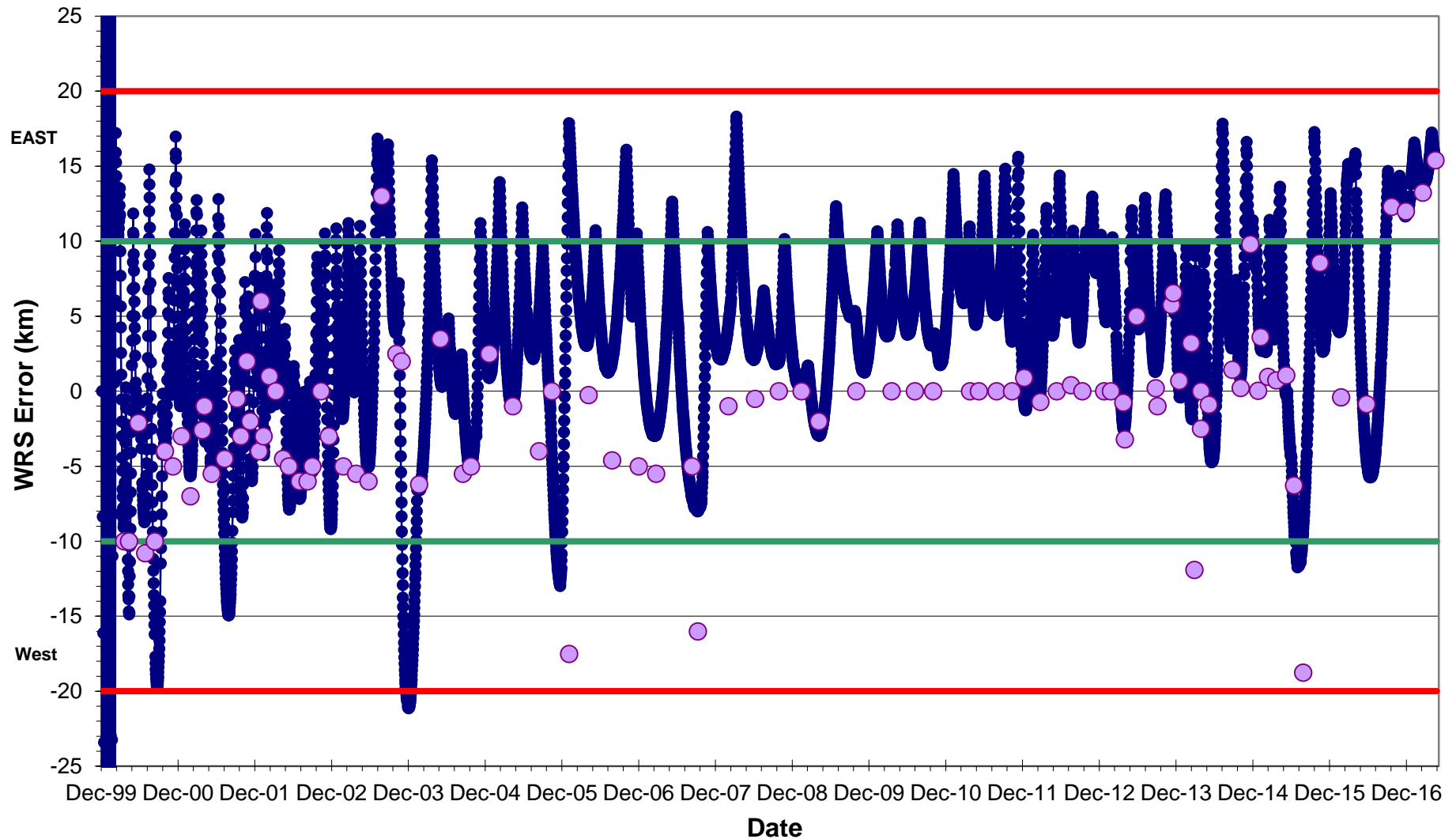
- **Requirement:** Mean Local Time (MLT) maintained between 10:15 and 10:45 measured at the Descending Node.
- **Goal:** Maintain Terra mean local time of the descending node (MLTDN) below 10:31.
- **Constraint:** OCO-2 has requested Terra maintain a MLT less than 10:31 for the duration of its lifetime to maintain a safe separation at the poles.
- **Requirement:** Maintain WRS-2 ground track error, 0 +/-20 km.
- **Requirement:** Maintain Frozen orbit with Argument of Perigee at 90 degrees +/-20 and Eccentricity of 0.0012 +/- 0.0004.
- **Constraint:** Maximum burn duration limited to 320 seconds by spacecraft manufacturer. Complete yaw slews and inclination maneuvers during spacecraft orbital night. Maneuver close to spring and fall equinox to maximize efficiency.

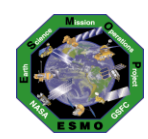


WRS Ground Track Error (GTE)



TERRA WRS Groundtrack Error at the Descending Node
(Maneuver planning targets included)

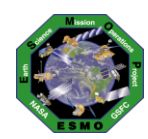




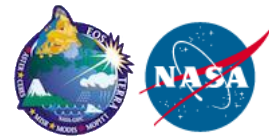
EPS Subsystem Performance



- **Bus Load: Nominal**
 - Average bus load: [2308.78 Watts](#)
 - Average housekeeping current: [11.90 A](#)
 - Total instrument current: [7.137 A](#)
- **Battery Performance: Nominal with exception of anomalous BBAT condition**
 - BBAT cell # 50 failed following IAM #24 on October 13 (DOY 286) 2009
 - BBAT Voltage Temperature curve changed to better reflect a failed cell
 - BBAT heater control electronics (HCE) anomaly occurred following IAM #24 on October 13 (DOY 286) 2009
 - Performed soft reset, power cycle, switching to redundant side and re-enabling one of the nonfunctioning heater groups to recover HCE functionality without success
 - At least 4 of 9 BBAT heater groups are no longer being controlled
 - Heater control setpoints changed for controllable heater groups to reduce the thermal gradient
 - PBAT Charge/Discharge Ratio was reduced from 105% to 104% on April 25, 2013 in an effort to extend PBAT life
 - PBAT BPC Channel A Disabled January 14, 2014; increases BBAT cold temperatures due to increased discharge
 - PBAT Charge/Discharge Ratio was reduced from 104% to 103% on August 20, 2015 in an effort to extend PBAT life
- **Battery Temperatures: Nominal with exception of anomalous BBAT data**
 - PBAT and half of BBAT Battery temperatures are regulated by flight software to $\approx -1^{\circ}\text{C}$ to -5°C
 - Almost half of BBAT cell temperatures are below normal (but stable) in the -5°C to -13°C range
- **Battery Voltages (BBAT)**
 - Minimum battery voltages at [66.152 Volts](#)
- **Solar Array**
 - Last offset adjustment performed on [October 19th, 2017](#)
 - Average drift rate for the month, [0.672 deg/day](#)
 - Present offset drift rate is [decreasing](#)
- **BBAT Cell with Lowest Temperature** (excluding Cell #50)
 - Cell # 21 : [-10.31 \$^{\circ}\text{C}\$](#)
 - Thermal Gradient(avg): [7.13 \$^{\circ}\text{C}\$](#)



Terra Earth Point Safe Mode (DOY 049)

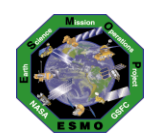


Process Improvement

- **Root Cause and Corrective Action (RCCA) process was performed to document what happened and capture preventative actions to prevent a similar safe event in the future**
 - The FOT generated the RCCA document and conducted a review board on 04/07/16 identifying 4 Preventative Actions to be completed prior to the next IAM series in October 2016

Action #	Preventative Action	Status
1	Update and CM IAM SOP <ul style="list-style-type: none"> • Planning, Verification, Execution, and Waive-Off • Update and Document timing constraints, including Inhibit IDs • Document Contingencies, including new "incorrect slew" contingency 	COMPLETED: Initial version of SOP in CM. Updated version Delivered to CM
2	Add constraints to Script and check tool	COMPLETED: Script expanded to more clearly show sequence of ATC and GND commands and constraint for IAM #44 and #45
3	Generate pre-planned contingency response for incorrect slew event <ul style="list-style-type: none"> • Test on simulator to ensure it works as designed • Document in CAM and Script 	COMPLETED: Developed and simulated generic and specific contingency responses prior to executing IAM #44 & #45
4	Lock down all IAM maneuver parameters <ul style="list-style-type: none"> • If change occurs then additional simulation is needed (time permitting) or waive-off & reschedule for another day 	COMPLETED: Established new lock-down schedule with FDS group (Integrated into documentation)

- **External NASA review was held on 4/28/16 to review the event and corrective actions**
 - FOT integrated RFAs into IAM and Safe hold working groups
- **IAM Redesign and actions completed prior to October 20th, 2016 IAM**
- **Only one remaining Safehold improvements to be completed in 2017**
 - TONS updates



OSMA Official Direction



From: Aleman, Suzanne M. (HQ-GD000)
Sent: Wednesday, November 02, 2016 11:37 AM
To: Yuhas, Cheryl L. (HQ-DK000) <cheryl.l.yuhas@nasa.gov>
Cc: Liou, Jer-chyi (JSC-XI411) <jer-chyi.liou-1@nasa.gov>; Hull, Scott M. (GSFC-5920) <scott.m.hull@nasa.gov>
Subject: FW: Terra need for Orbital Debris waivers

Hi Cheryl,

I received your voice mail regarding the question on whether a waiver is needed for the 25 year rule for TERRA.

I consulted with J. C Liou on this question we have concluded that a waiver is not needed. Please see the e-mails below.

Please let me know if you have any questions.

Best regards,

Sue Aleman
NASA HQ OSMA
MMOD Program Executive