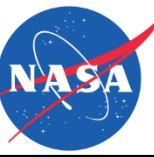# EOS Terra Spacecraft Status
MODIS Science Team Meeting

May 21, 2015

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Section 1

SPACECRAFT STATUS

Spacecraft Status Summary

Terra Spacecraft Subsystem and Instrument Status

	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15
CDH	Green[3,4]	Green	Green[5]	Green	Green	Green[3,8]	Green	Green	Green	Green	Green[9]	Green[4]
COM	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
EPS	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]	Yellow[2]
FSW	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
GNC	Green	Green	Green[7]	Green	Green	Green	Green	Green	Green	Green	Green	Green
NAV	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
TCS	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]	Green[4]
ASTER	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]	Green[1]
CERES	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
MISR	Green	Green	Green[6]	Green	Green	Green	Green	Green	Green	Green	Green	Green
MODIS	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
MOPITT	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

1 – ASTER SWIR is no longer providing usable science data. No further recovery attempts planned. **SWIR data processing turned OFF 8/21/13. No impact to MODIS**

2 – Hex Bay Battery (BBAT) cell #50 failed and multiple BBAT heater control groups failed on 10/13/09. **No impact to MODIS**

4 – ASTER TIR CPHTS reservoir line temperature fluctuations (6 occurrences in 2015, 33 occurrences in 2014). **No impact to MODIS**

3 – A PWA Failure occurred in the MODIS Buffer on 10/14/14 in PWA-57, the PWA was removed from the Buffer on 10/15/14.

4 – A Science Formatter Equipment Side A (SFE-A) Anomaly occurred on 5/24/14 (Data Loss 00:05:52), on 04/10/15 (Loss : 05:20), on 04/14/15 (Loss : 03:31), on 04/24/15 (Loss : 04:50). **There were 3 SFE anomalies in 2 weeks in April 2015, this happened previously in 2009.**

5 – MISR Halt Anomaly occurred on 7/8/14 and was a SEU resulting on MISR no longer outputting data and the FOT running a Red Limit Response to power MISR OFF. MISR was successfully returned to Normal Operations 8/1/14. **No Impact to MODIS**

7 – ACE-B Sensor Select Anomaly occurred on 7/5/14, new TMON immediately responded and returned the ACE-B to the correct configuration. **No Impact to MODIS**

8 – MODIS SFE Data Corruption occurred on 10/26/14 at 01:35:30 requiring the MODIS interface card on the SFE to be reset. This anomaly was not detectable in telemetry and relied on EDOS data processing to detect. The MODIS Data corruption was successfully recovered after ~17:53:57.

9 – ASTER Skipped EDU on DOY 075. **No Impact to MODIS**

Highlights in Last Year
(Maneuvers)

- **Propulsive Maneuvers**
  - DMU #85 executed on 09/24/14
  - IAM #39 executed on 10/29/14
  - DMU #86 executed on 11/13/14
  - DMU #87 executed on 12/12/14
  - DMU #88/DAM #8 executed on 12/31/14
  - DMU #89 executed on 02/04/15
  - IAM #40 executed for 02/19/15
  - IAM #41 executed for 02/25/15
  - DMU #90 executed on 03/04/15
  - DMU #91 executed on 04/22/15

- **Calibration Maneuvers**
  - MODIS Roll #140 executed on 06/17/14
  - MODIS Roll #141 executed on 07/16/14
  - MODIS Roll #142 executed on 08/14/14
  - MODIS Roll #143 executed on 09/12/14
  - MODIS Roll #144 executed on 10/12/14
  - MODIS Roll #145 executed on 11/11/14
  - MODIS Roll #146 executed on 12/11/14
  - MODIS Roll #147 executed on 01/10/15
  - MODIS Roll #148 executed on 02/09/15
  - MODIS Roll #149 executed on 03/10/15
  - MODIS Roll #150 executed on 04/08/15
  - MODIS Roll #151 executed on 05/08/15

- **SFE Interface card error resulted in MODIS Data Corruption (SSR and DB)**
 - On 10/26/14 the Flight Operations Team (FOT) was notified by EDOS that they were having issues processing MODIS data
  - Issue is not detectable in telemetry (No changes seen in SFE or MODIS telemetry)
  - Issue only identifiable by EDOS in data processing
    - Was initially being worked as a data processing issue by EDOS not Data Quality delaying FOT response
  - Issue was resolved by disabling and re-enabling the associated interface card on the SFE without affecting data flows for other instruments
    - *Resulted in ~17:53:57 of MODIS Data Loss*

- **Previous occurrence**
  - Anomaly had previously occurred in 2012 and was recovered similarly
  - Both Data Corruption issues only affected MODIS data, however it is conceivable that a future reoccurrence could affect other interfaces and other instruments
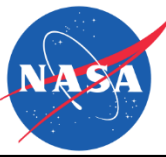
- **SFE Interface card error required SFE Reset**
  - Historical issue, automatically recovered by TMON 16 on occurrence
    - Normally occurs 1-2 times per year
  - Recent SFE occurrences
    - 04/10/15 (DOY 100) @ 11:48:16z; **MODIS Data Loss 05:20**
    - 04/14/15 (DOY 104) @ 01:48:47z; **MODIS Data Loss 05:31**
    - 04/24/15 (DOY 114) @ 13:19:24z; **MODIS Data Loss 04:50**
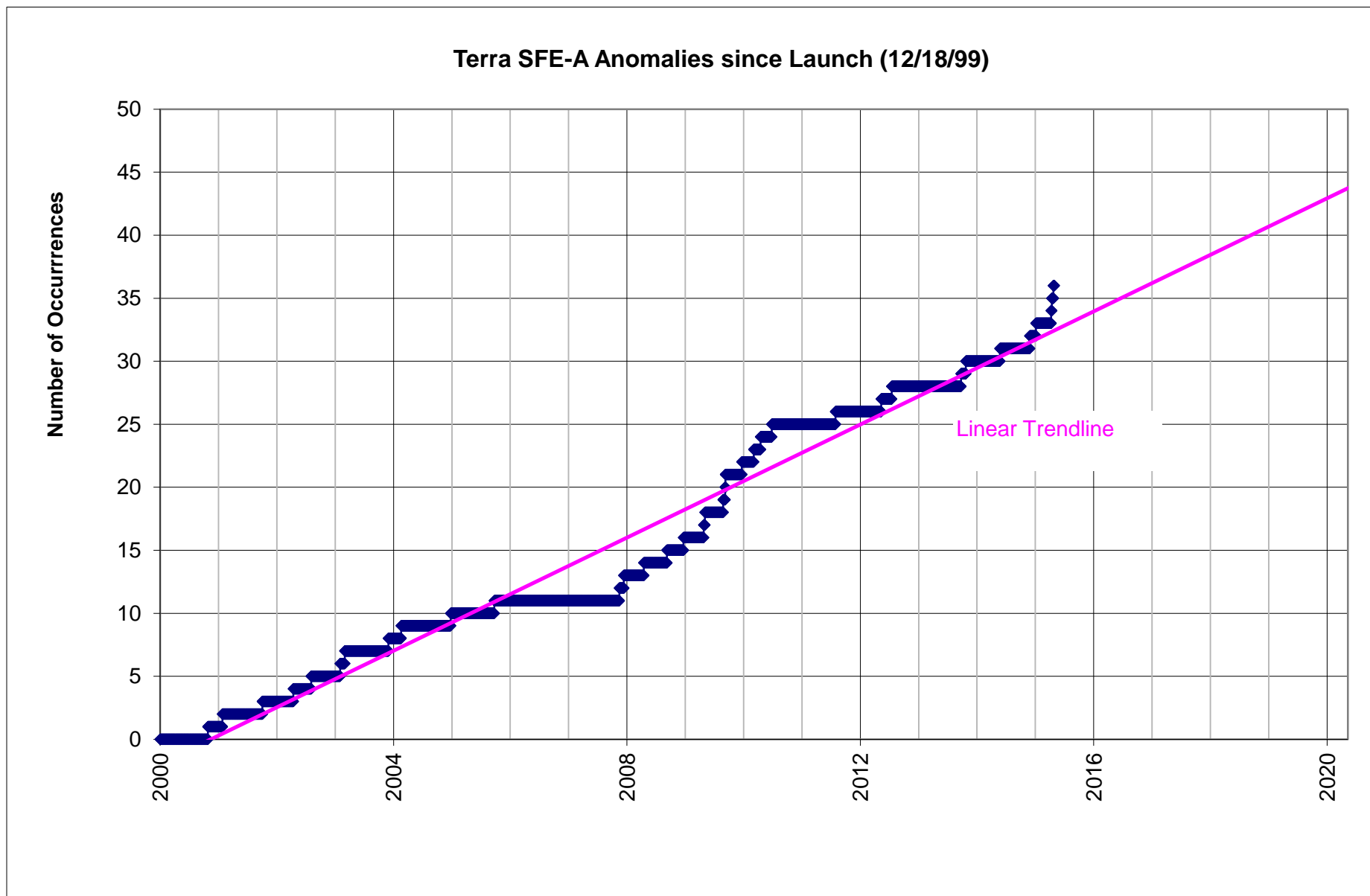   - 3 occurrences in 2 weeks rare (has occurred before in 2009)

- **Previous occurrence**
  - Anomaly had previously occurred in 2012 and was recovered similarly
  - Both Data Corruption issues only affected MODIS data, however it is conceivable that a future reoccurrence could affect other interfaces and other instruments

Terra SFE-A Anomalies since Launch (12/18/99)
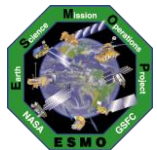
- **A PWA Failure (PWA – 57; Superset 112 and 113) was seen in the MODIS Buffer on 10/14/14**
  - Resulted in loss of 1 Superset (SS) for MODIS (33 SS -> 32 SS)
    - Each PWA failure results in 2 SS failing but Trash Buffer SS was reallocated to MODIS to minimize capacity Loss
  - First PWA failure in MODIS Buffer since transitioning MODIS to Data Module Unit (DMU)-2 in 2007
    - DMU-2 (3 PWA Failures) appears less susceptible to PWA failures than DMU-1 (7 PWA Failures)
- **It is believed a SSR/DMU Reset will recover the failed PWAs**
  - SSR reset early in mission due to an SSR Halt recovered the one PWA (PWA-16) that had failed at that point
  - The recovered PWA has been operational
- **An additional PWA Failure in MODIS would result in a 6.25% reduction in Buffer Capacity (Current ~90% Buffer Full -> ~96%)**

- **MODIS should consider options in case of additional PWA Failures**
  - Accept reduced SSR Capacity (May result in additional data losses)
  - Reallocate DMU-2 SSR Supersets to MODIS (Would need to be coordinated with MISR)
  - Consider SSR/DMU Reset to recover failed PWAs (Would need approval from other IOTs and NASA HQ)

KEY

Color	Label
Blue	LRS
Purple	MISR
Yellow	MODIS
Orange	ASTER
Green	TRASH
Red	Offline

DMU-1					DMU-2			
Backplane-A		**Backplane-B**			**Backplane-A**		**Backplane-B**	
PWA#	Superset	PWA#	Superset		PWA#	Superset	PWA#	Superset
PWA-2	2	PWA-17	32		PWA-31	60	PWA-46	90
PWA-2	3	PWA-17	33		PWA-31	61	PWA-46	91
PWA-3	4	PWA-18	34		PWA-32	62	PWA-47	92
PWA-3	5	PWA-18	35		PWA-32	63	PWA-47	93
PWA-4	6	PWA-19	36		PWA-33	64	PWA-48	94
PWA-4	7	PWA-19	37		PWA-33	65	PWA-48	95
PWA-5	8	PWA-20	38		PWA-34	66	PWA-49	96
PWA-5	9	PWA-20	39		PWA-34	67	PWA-49	97
PWA-6	10	PWA-21	40		PWA-35	68	PWA-50	98
PWA-6	11	PWA-21	41		PWA-35	69	PWA-50	99
PWA-7	12	PWA-22	42		PWA-36	70	PWA-51	100
PWA-7	13	PWA-22	43		PWA-36	71	PWA-51	101
PWA-8	14	PWA-23	44		PWA-37	72	PWA-52	102
PWA-8	15	PWA-23	45		PWA-37	73	PWA-52	103
PWA-9	16	PWA-24	46		PWA-38	74	PWA-53	104
PWA-9	17	PWA-24	47		PWA-38	75	PWA-53	105
PWA-10	18	PWA-25	48		PWA-39	76	PWA-54	106
PWA-10	19	PWA-25	49		PWA-39	77	PWA-54	107
PWA-11	20	PWA-26	50		PWA-40	78	PWA-55	108
PWA-11	21	PWA-26	51		PWA-40	79	PWA-55	109
PWA-12	22	PWA-27	52		PWA-41	80	PWA-56	110
PWA-12	23	PWA-27	53		PWA-41	81	PWA-56	111
PWA-13	24	PWA-28	54		PWA-42	82	PWA-57	112
PWA-13	25	PWA-28	55		PWA-42	83	PWA-57	113
PWA-14	26	PWA-29	56		PWA-43	84	PWA-58	114
PWA-14	27	PWA-29	57		PWA-43	85	PWA-58	115
PWA-15	28	PWA-30	58		PWA-44	86	PWA-59	116
PWA-15	29	PWA-30	59		PWA-44	87	PWA-59	117
PWA-16	30				PWA-45	88		
PWA-16	31				PWA-45	89		

Science Data Capture Statistics

Month	Days	Tbits	Capture	Reason for Data Loss
May 2014	31	36.99	99.98%	SFE-A Anomaly
June 2014	30	38.36	99.99%	Incorrect Lockup Replay
July 2014	31	34.63	83.57%	MISR Anomaly
August 2014	31	39.27	100.0%	N/A
September 2014	30	38.60	99.87%	MODIS/MISR Buffers Disabled
October 2014	31	32.92	98.45%	PWA & SFE-A Anomalies / Missed LUR
November 2014	30	36.49	99.99%	MDA2 Bite during PB
December 2014	31	38.44	100.0%	N/A
January 2015	31	39.49	99.94%	Incorrect LUR / Negative Acq
February 2015	28	35.88	100.0%	N/A
March 2015	31	36.38	100.0%*	AST Skipped EDU (150 CADUs lost)
April 2015	30	35.26	99.92%	SFEA anomaly X 3 / Incorrect LUR

Terra Collision Avoidance Activities
High Interest Events (HIEs)
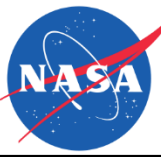
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2014 (T1-T4)	1	2	3	1	1	2	1	1	2	1	4	5	24
Tier 3	0	2	1	1	0	1	0	0	1	0	1	2	9
Tier 4	0	2	1	0	0	0	1	0	0	0	1	1	6
2015 (T1-T4)	5	2	4	5									16
Tier 3	2	0	0	1									3
Tier 4	1	0	0	0									1

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

- **2005**: 4 HIEs – 1 Risk Mitigation Maneuver (RMM) 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 RMM performed on 06/22/2007: Terra vs. 31410 CA on 6/23
- **2008**: 2 HIEs – 1 RMM planned and waived off: Terra vs. 82832 CA on 10/28/2008 @ 06:17z
- **2009**: 2 HIEs – No RMMs planned or performed
- **2010**: 5 HIEs – 1 RMM performed on 01/22/2010: Terra vs. 34700 CA on 1/23 @ 20:46z
- **2011**: 20 HIEs – 2 RMM 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 replan
- **2015 thru present: 16 High Interest Events (HIEs) – 3 that required DAM execution or nominal maneuver waive-off and replanning**
    - 12/31/2014: CAs vs. 35925 TCA Thu 01/01 at 08:02:55 GMT – RED HIE, repeating CAs (10) DAM #9 planned and executed (T4)
    - 01/02/2015: CAs vs. 87161 TCA Sun 01/04 at 18:26:50 GMT – RED HIE, repeating CAs (8+), DAMs planned, not actionable (T3)
    - 01/11/2015: CAs vs. 80767 TCAs 01/14 and 01/15 – Repeating CAs (16), DAMs planned, no viable maneuver, suspended planning (T3)
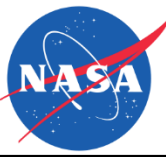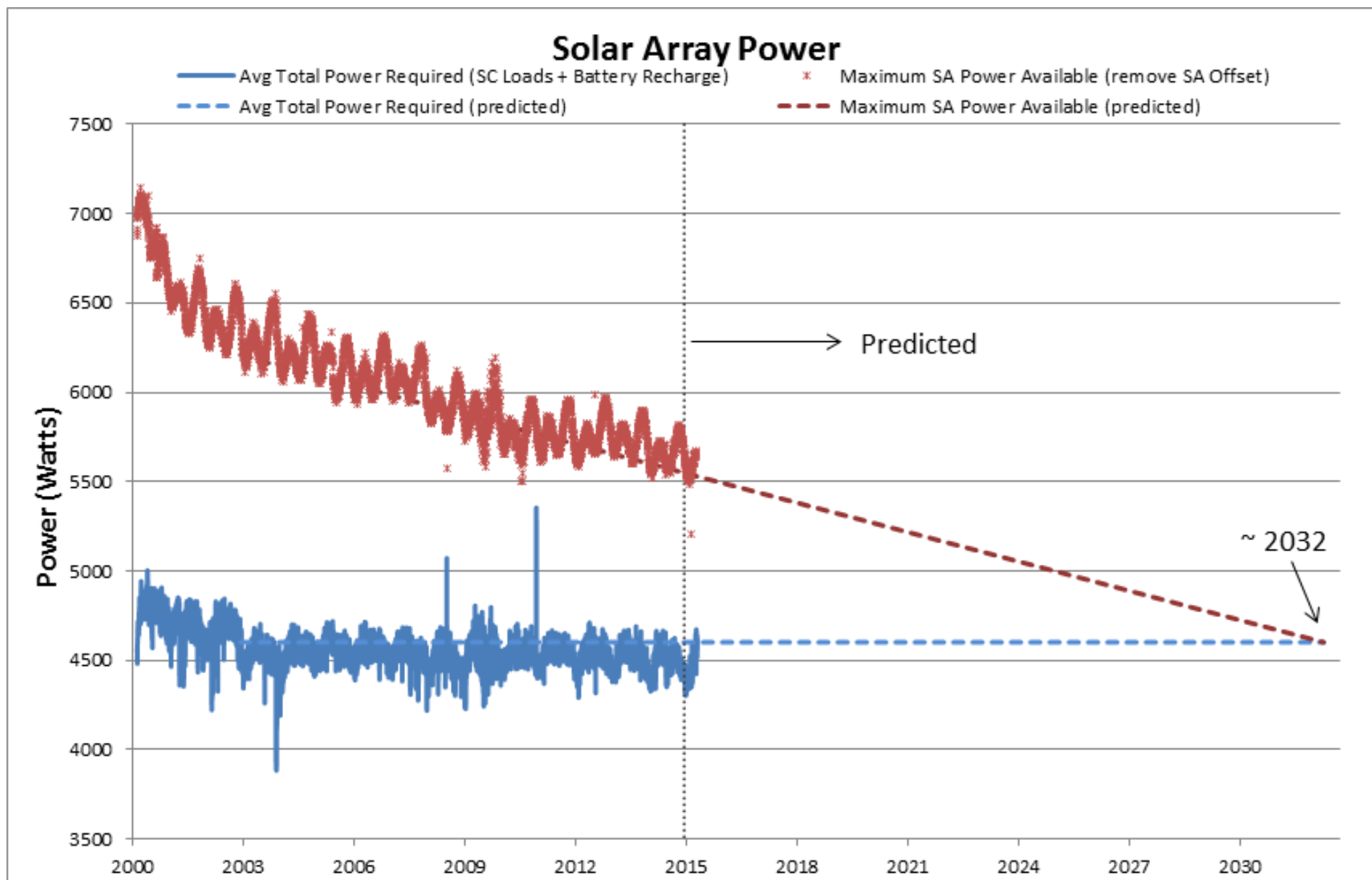
- **Bus Load:** **Nominal**
  - Average bus load: 2314 Watts average housekeeping current: 11.91 A; Total instrument current: 7.171 A
- **Battery Performance**: **Nominal with exception of anomalous BBAT condition**
  - BBAT cell # 50 failed following IAM #24 on October 13 (DOY 286) 2009
  - BBAT heater control electronics (HCE) anomaly occurred following IAM #24 on October 13 (DOY 286) 2009
    - 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 to extend PBAT life
  - PBAT BPC Channel A Disabled January 14, 2014; increases BBAT cold temperatures due to increased discharge
  - **Reduced BBAT Heater 1-3 Setpoints May 19-23, 2014; for further reduction of thermal gradient**
  - **Reduced BBAT Heater 6 Setpoint June 10, 2014**
- **Battery Temperatures**: **Nominal with exception of anomalous BBAT data**
- **Battery Voltages** (BBAT)
  - Minimum battery voltages at 65.99 Volts
- **Solar Array**
  - Last offset adjustment performed on April 17th 2015

NO IMPACT TO SCIENCE

Solar Array Power

Terra Fuel Usage Comparison

Based on predicted fuel usage, Terra has enough fuel to support science requirements until 2020 (Baseline) and possibly beyond (~2022)

Will be discussed in more detail during Constellation Exit presentation
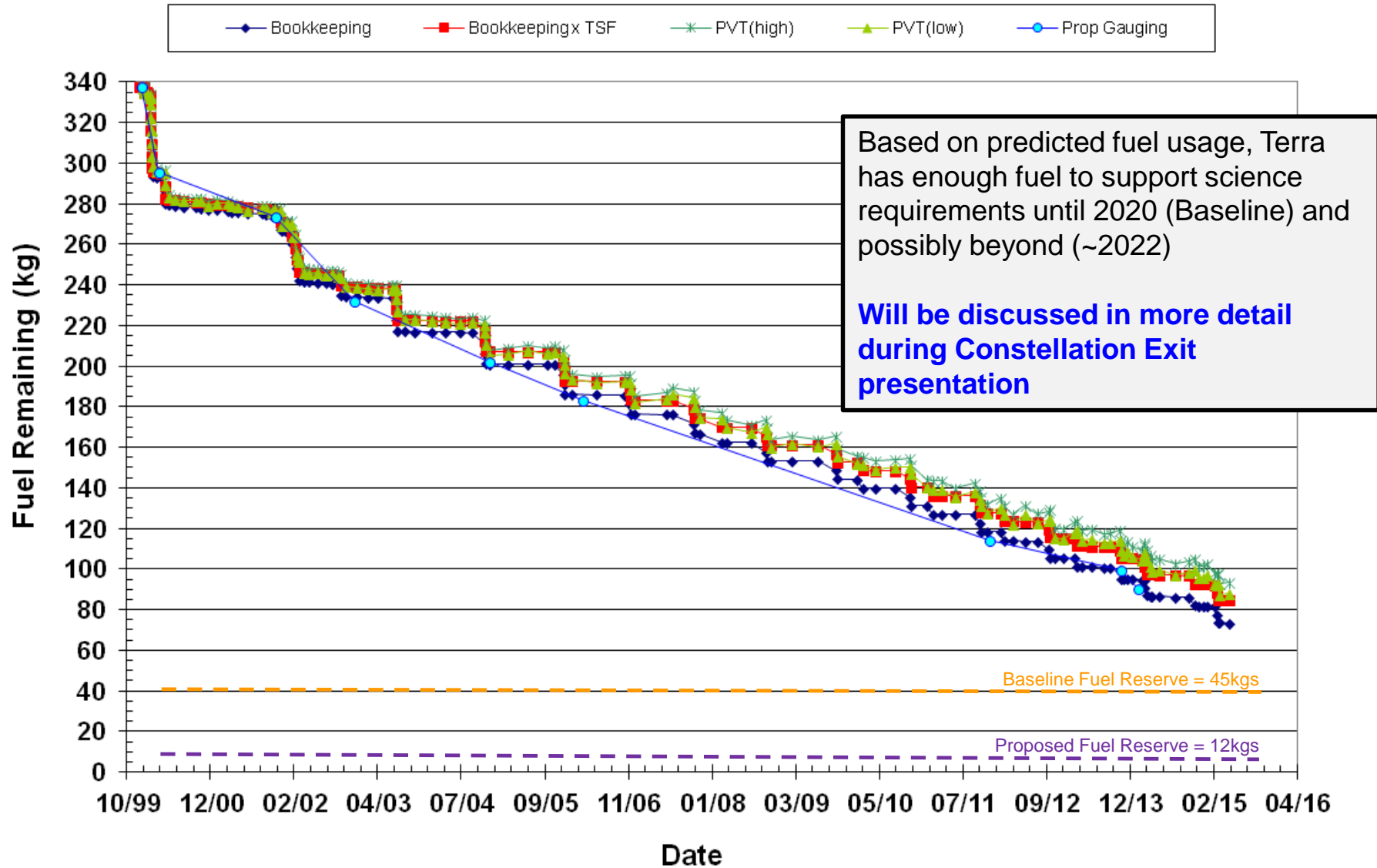
Future Plans
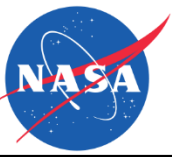
Upcoming Activities	
MODIS Roll #151	**May 08, 2015**
MISR Bi-Monthly Calibration	**May 20, 2015**
Master DMU RTCS and CERES DMU RTCSs	**Late May 2015**
Leap Second # 36	**June 30, 2015**
Onboard Lock Up Replay Automation	**3Q2015**
Ground Based Automation Implementation	**3Q2015**
Activity log PB and SA adjusts, improve SSR automation via FSW	**3Q2015**
Update Drag Scale Factor	**4Q2015**
Leap Second # 36	**June 30, 2015**
HGA Model/Keyhole Unwind; MMS Dev - HGA Gimbal motor sun exposure model	**3Q2015**

Life Limiting Components

| Subsystem	Component	Design	Current	Capability	Comments
EPS	Solar Array	24 Shunts	23 Shunts	96%	Degradation is minimal. Fully capable of supporting mission through 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. Improved HCE TMON contingency response.
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 DMU likely to recover all PWAs
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, Bias patch uplinked to account for sensitivity loss**
	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.**

Critical S/C Subsystem components still have full redundancy
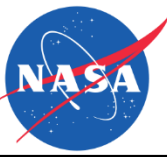
- **Terra remains very healthy 15+ years into the mission**
  - Electrical Power Subsystem performance has been stabilized following 2009 anomaly
  - Fuel Remaining to continue operations to 2020 and beyond

- **Data Capture percentages continue at ~100%**

- **Collision Avoidance events are increasing in frequency**

- **FOT continues to monitor all trends/anomalies**

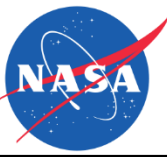- **FOT continues to come up with new ideas/process improvements to maximize mission life and efficiency**
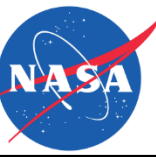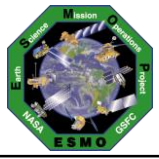
Terra Constellation Exit Proposal

Jason Hendrickson & Dimitrios Mantziaras

Constellation Exit Proposal

- Baseline Plan
  - Constellation Exit Original Definition : Lower orbit Apogee 2 km below lowest Perigee of constellation envelope (692 km Altitude)
  - Requires 45 kg of Fuel held in reserve
  - Exit Constellation: **Jan. 2020**

- Proposed Plan (Pending Waivers and Approvals from NASA HQ)
  - Constellation Exit According to Revised Definition : Lower orbit 4 km below constellation envelope
    - New Apogee will be above constellation perigee
    - Ensures safe distance from constellation because argument of Perigee and eccentricity of lowered orbit will remain in sync (frozen orbit) with constellation for an extended period as orbit decays
  - Requires 12 kg of Fuel held in reserve
  - Exit Constellation: **Aug. 2022**
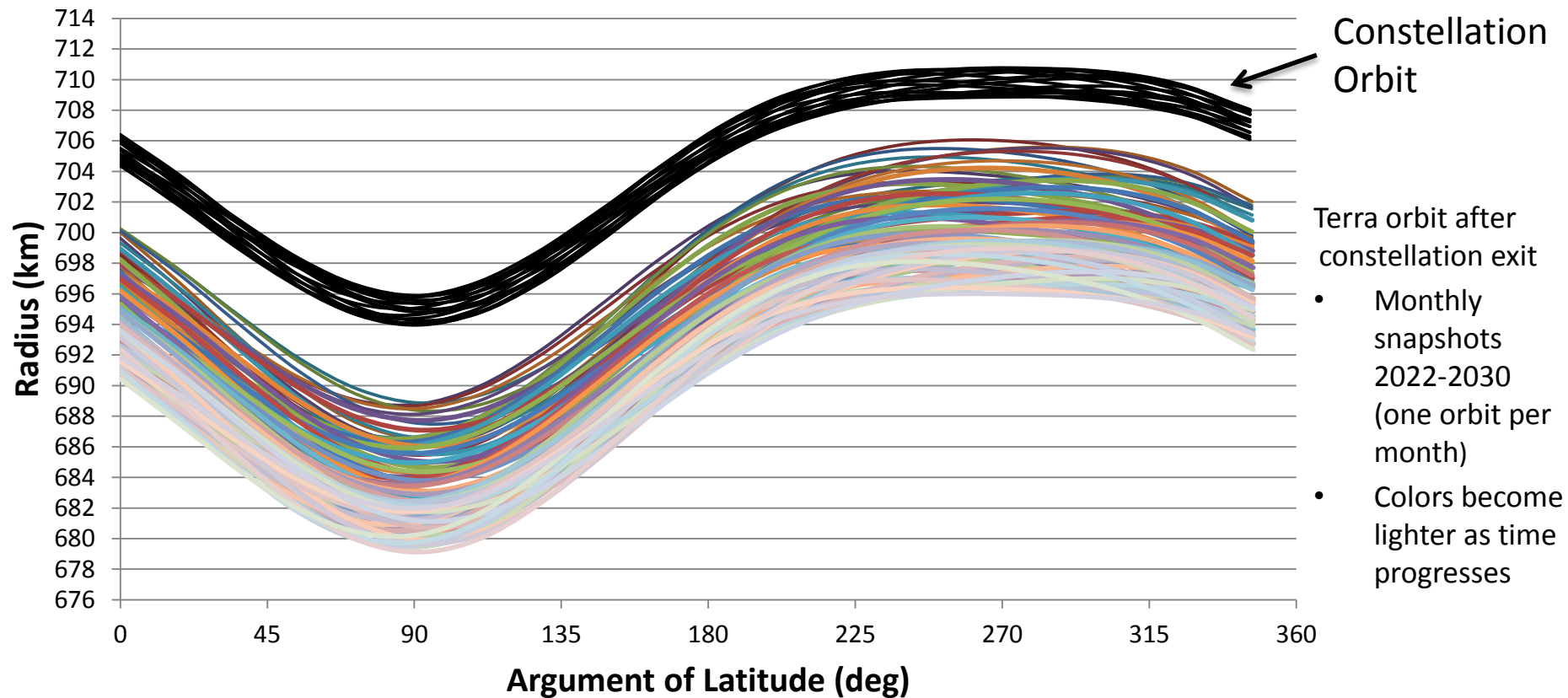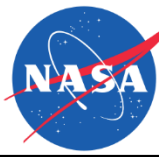
- Over eight years the orbit eccentricity remains fairly consistent
- No interaction with the Constellation orbit envelope over time
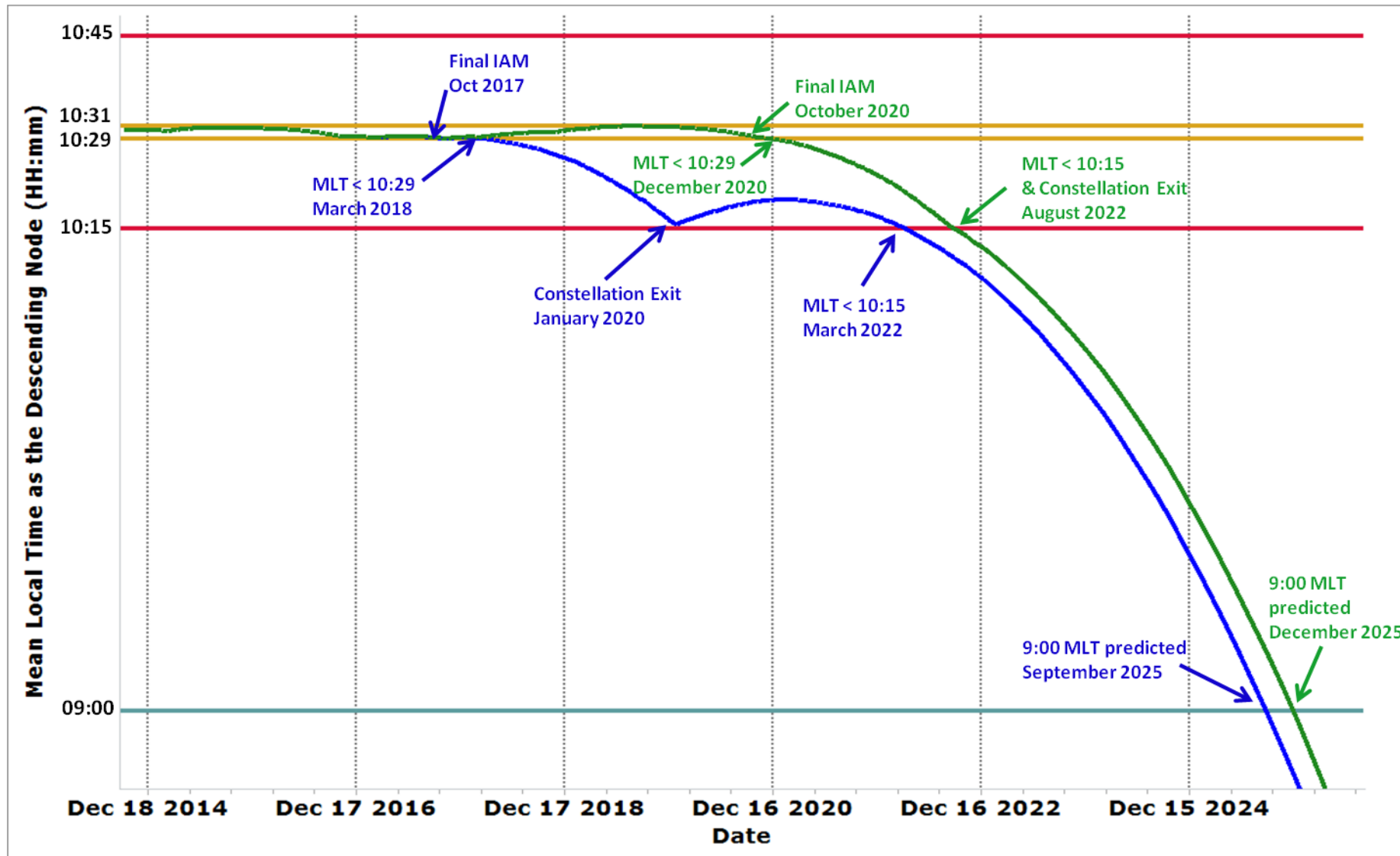
- Difference in overall mission lifetime between baseline and proposed plan is 5 months
- Difference in science collection is additional ~3years at tight MLT and current altitude

- Terra intends to continue operations and science data collection after Constellation Exit
  - Presumes continued NASA funding and continued health of platform
  - Overall Mission Lifetime limited to once MLT drifts to 09:00

- FOT Operations
  - The Terra FOT will continue to maintain the Terra platform after constellation exit until it is deemed necessary by NASA to decommission Terra
  - Continued Maintenance will include Debris Avoidance Maneuvers as needed, using remaining fuel, to avoid orbital debris

- Science Data Collection
  - Instruments will continue to be able to collect data after Constellation Exit
  - Data processing and Science Analysis will need to updated to take into account lower orbit and drifting MLT

- Terra Spacecraft Hardware continues to be healthy after 15+ years on orbit
  - 2009 Battery Cell 50 and Heater Group Failures have stabilized
  - Solar Array Degradation rate indicates it should continue to meet Terra power needs past 2030
- Terra still has sufficient propellant to continue to meet Science Requirements for 5-7 years and beyond
  - Baseline
    - Current Operations : March 2018
    - Science Requirements : January 2020
  - Pending approval:
    - Current Operations : December 2020
    - Science Requirements : August 2022
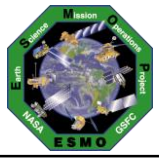
Backup slides

Acronyms
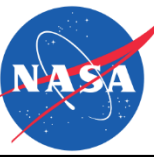
- ATC   Automated Time Commands
- BBAT   Hex Bay Battery
- BPC   Battery Power Conditioner
- C/D   Charge/Discharge
- CA   Conjunction Avoidance Activity
- CPHTS   Capillary Pumped Heat Transfer System
- DAM   Debris Avoidance Maneuver
- DAS   Direct Access System
- DCU   Data Control Unit
- DMU   Drag Make-Up
- EDU   Engineering Data Unit
- ESA   Earth Sensor Assembly
- FOT   Flight Operations Team
- FSW   Flight Software
- HCE   Heater Control Electronics
- HIE   High Interest Event
- IAM   Inclination Adjust Maneuver
- IOT   Instrument Operations Team
- LM   Lockheed Martin
- MLT   Mean Local Time
- MO   Master Oscillator
- PBAT   Power Equipment Module Battery
- RMM   Risk Mitigation Maneuver
- RTCS   Relative Time Command Sequence

- S/C   Spacecraft
- SA   Solar Array
- SCC   Spacecraft Control Computer
- SEU   Single Event Upset
- SFE   Science Formatter Equipment
- SSR   Solid State Recorder
- TMONs   Telemetry Monitors
- WRS   World Reference System

EPS Process Improvements
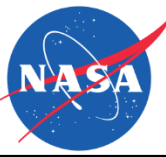
1) New Solar Array Operations

- Since 2013, to reduce stress on the battery and streamline DMU execution, the Terra Solar Array (SA) has been managed to maximize charging while avoiding plume impingement danger regions by using more flexible SA parking locations and SA rotation rates

## 2) Raised average BBAT Cell temperatures by disabling BPC Channel

- Successfully executed Jan. 14, 2014
- Raised average BBAT cells temperatures by 1 degree (2 degrees for coldest cell)
  - This improves our contingency posture in the event of a load shedding incident and reduces the thermal gradient of BBAT (reduces uneven wear)

3) Implemented improved response to HCE Anomaly

- In 2009 a Single Event Upset (SEU) on the Heater Control Electronics (HCE) disabled heaters on BBAT and PBAT
- A telemetry monitor (TMON) was developed and successfully uplinked Feb. 20, 2014 to immediately recover from the anomaly and ensure the heaters are re-enabled

4) Lowered BBAT Heater Set Points

- From 5/19/14 to 6/10/14 the FOT reduced the set points for BBAT heaters 1, 2, 3, and 6 by 1ºC
- This reduced the BBAT thermal gradient by 0.5 – 0.75ºC, reducing uneven wear on BBAT cells
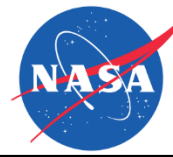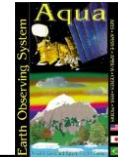
EOS Aqua Spacecraft Status
MODIS Science Team Meeting

May 21, 2015

Beneé Durham, Aqua Flight Systems Manager

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Aqua Features

- **Launch Date:** *May 4TH, 2002 (Delta II, 7920-10L, VAFB)*
- **Orbit:** *705 km, sun-synch. polar, 98.2^o Inc., 1:30$_{PM}$ MLT asc. node*
- **Instrument Payload:**
  - **AIRS -** *Atmospheric Infrared Sounder* (USA/JPL)
  - **AMSR-E -** *Advanced Microwave Sounding Radiometer –* (JAPAN/JAXA)
  - **AMSU-** *Advanced Microwave Sounding Unit* (USA/JPL)
  - **CERES -** *Clouds & the Earth's Radiant Energy System* (USA/Langley)
  - **HSB -** *Humidity Sounder for Brazil* (Brazil/IPNE)
  - **MODIS -** *Moderate Resolution Imaging Spectroradiometer* (USA/GSFC)
- **Project Management:** *Earth Science Mission Operations (ESMO)*
- **Spacecraft Flight Operations:** *Contracted by GSFC to Honeywell / ASRC/ AIMM/GATS and supported by NASA TDRSS and EPGN*
- **Instrument Operations and Science Data processing:** *Performed at respective Instrument Locations where developed*
- **Mission Duration:** *Completed 6-year Prime Mission (completed May 2008). Extended Operation began in May 2008.*

Science

- *Aqua emphasizes observations of the Earth's Water Cycle, including evaporation, water vapor in the atmosphere, clouds, precipitation, soil moisture, sea ice, land ice, and snow cover. Additional variables also being measured by Aqua include radiative energy fluxes, aerosols, vegetation cover on the land, phytoplankton and dissolved organic matter in the oceans, and air, land, and water temperatures.*
- *Aqua leads the Afternoon Constellation (A-Train) to maximize coincident Science with Calipso, CloudSat, Parasol & Aura.*


CERES

AMSU-A

AMSR-E

HSB   AIRS   MODIS

27
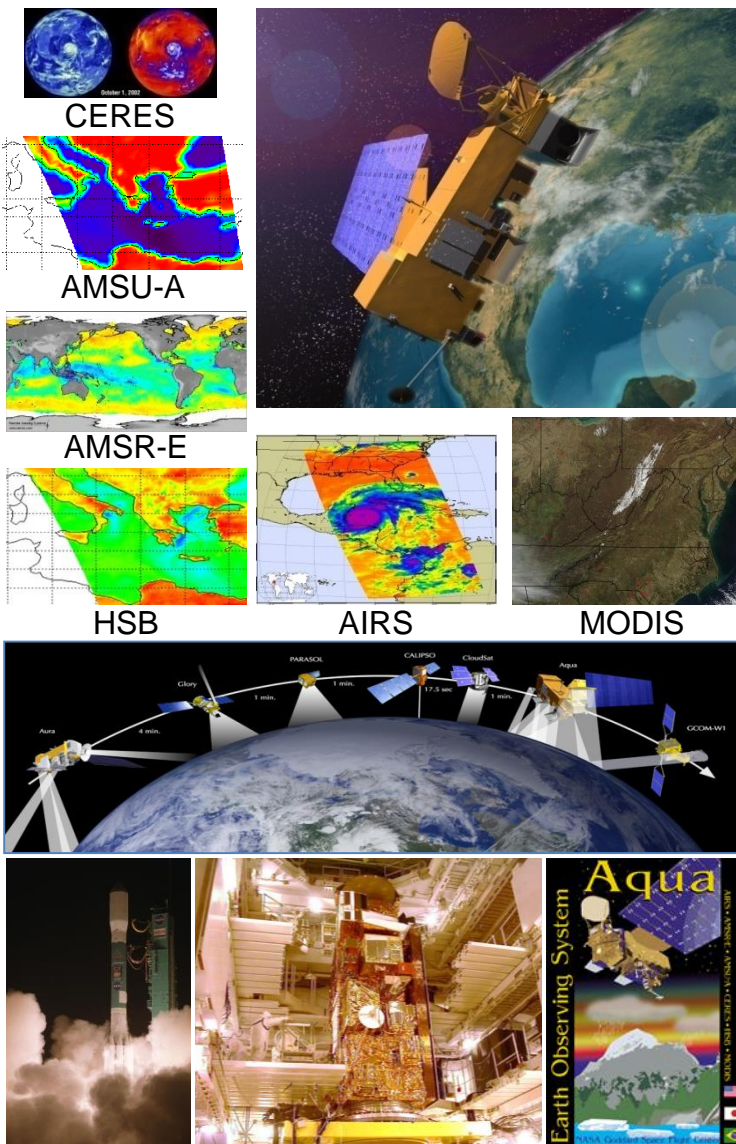
Aqua Spacecraft Component Status
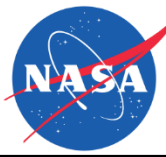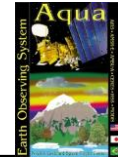
Subsystem	Component	Design	Current	Capability	Comments
Elect. Power	Solar Array	12 Panels	12 Panels	Full	Aqua has loss of 11 strings of solar cells out of a total of 132 strings
	Battery	24 Cells	24 Cells	Full	Anomalous performance on BM A-2 Cell 4 in September 2005, returned to nominal within weeks.
Thermal	TCLs	42	42	Full	Nominal Performance
OBC's	CTC	2	2	Full	2026 FSW Anomaly
	GNCC	2	2	Full	2026 FSW Anomaly
	PC	2	2	Full	2026 FSW Anomaly
	ISC	2	2	Full	2026 FSW Anomaly
Communications	X-Band String	2	2	Full	Nominal Performance
	S-Band String	2	2	Full	Nominal Performance
C&DH	USO-1	2	2	Full	Nominal Performance
	USO-2	2	2	Full	Nominal Performance
	FM U/SSR	136Gbits	136Gbits	Full	Nominal Performance - P6 correceted 01/28/09
	C&T Bus	2	2	Full	Nominal Performance
	S/C Support Bus	2	2	Full	Nominal Performance
	PC Bus	2	2	Full	Nominal Performance
	GN&C Bus	2	2	Full	Nominal Performance
GN&C	CSSA	2	2	Full	Nominal Performance
	ESA	2	2	Full	Nominal Performance
	MTA	3	3	Full	Nominal Performance
	ODE	2	2	Full	Nominal Performance
	RWA	4	4	Full	Nominal Performance
	STA	2	2	Full	STA Residuals
	SADA	2	2	Full	Nominal Performance
	TAM	2	2	Full	Nominal Performance
	VDE	2	2	Full	Nominal Performance
	WDE	4	4	Full	Nominal Performance
Propulsion	DTM	4	4	Full	Nominal Performance

Aqua Science Data Capture Statistics
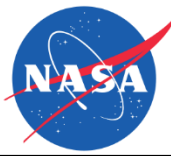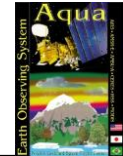
Aqua Data Capture Trend
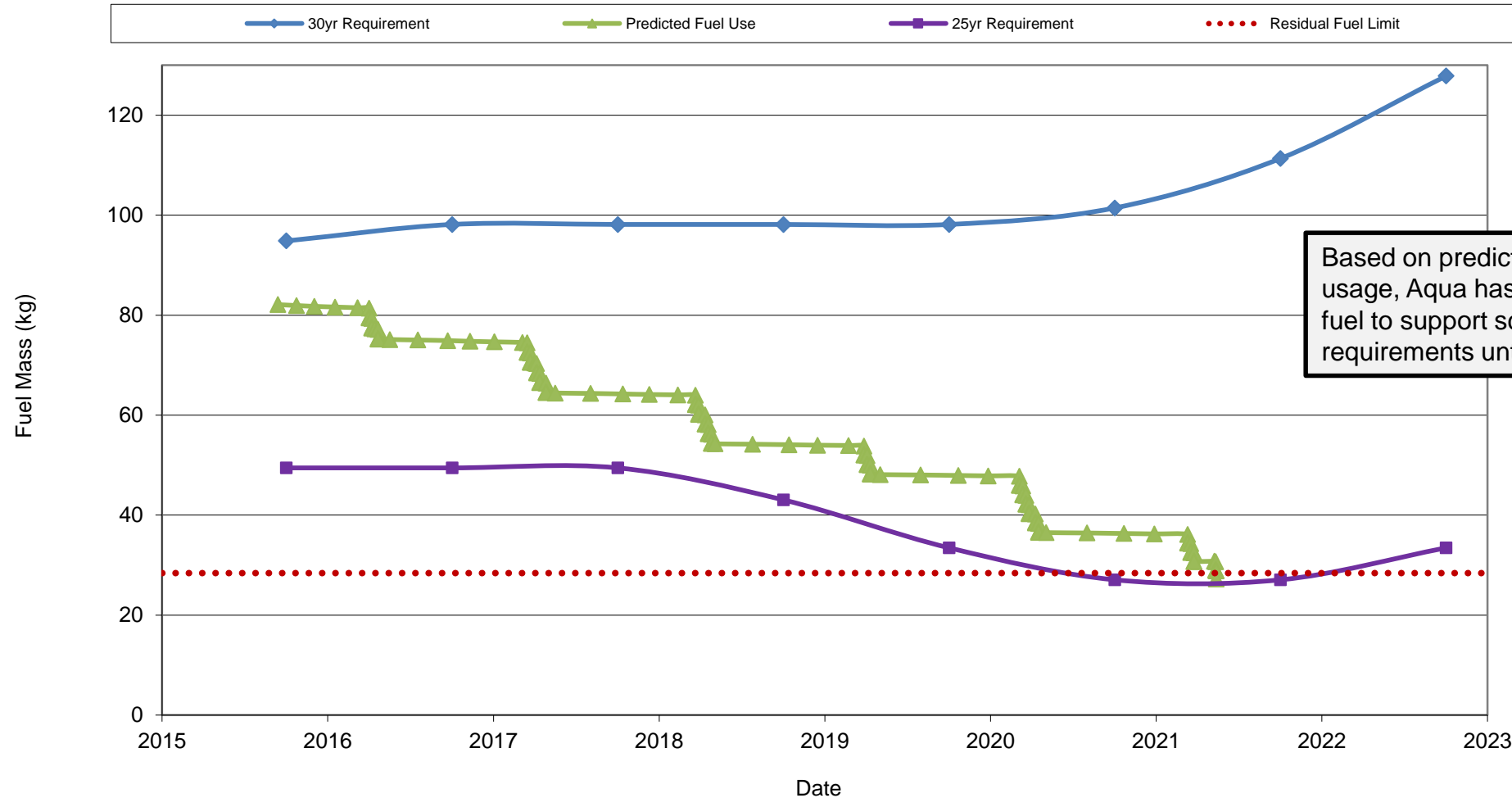
April 2015 = 99.99999712 %

Norway Line Outage
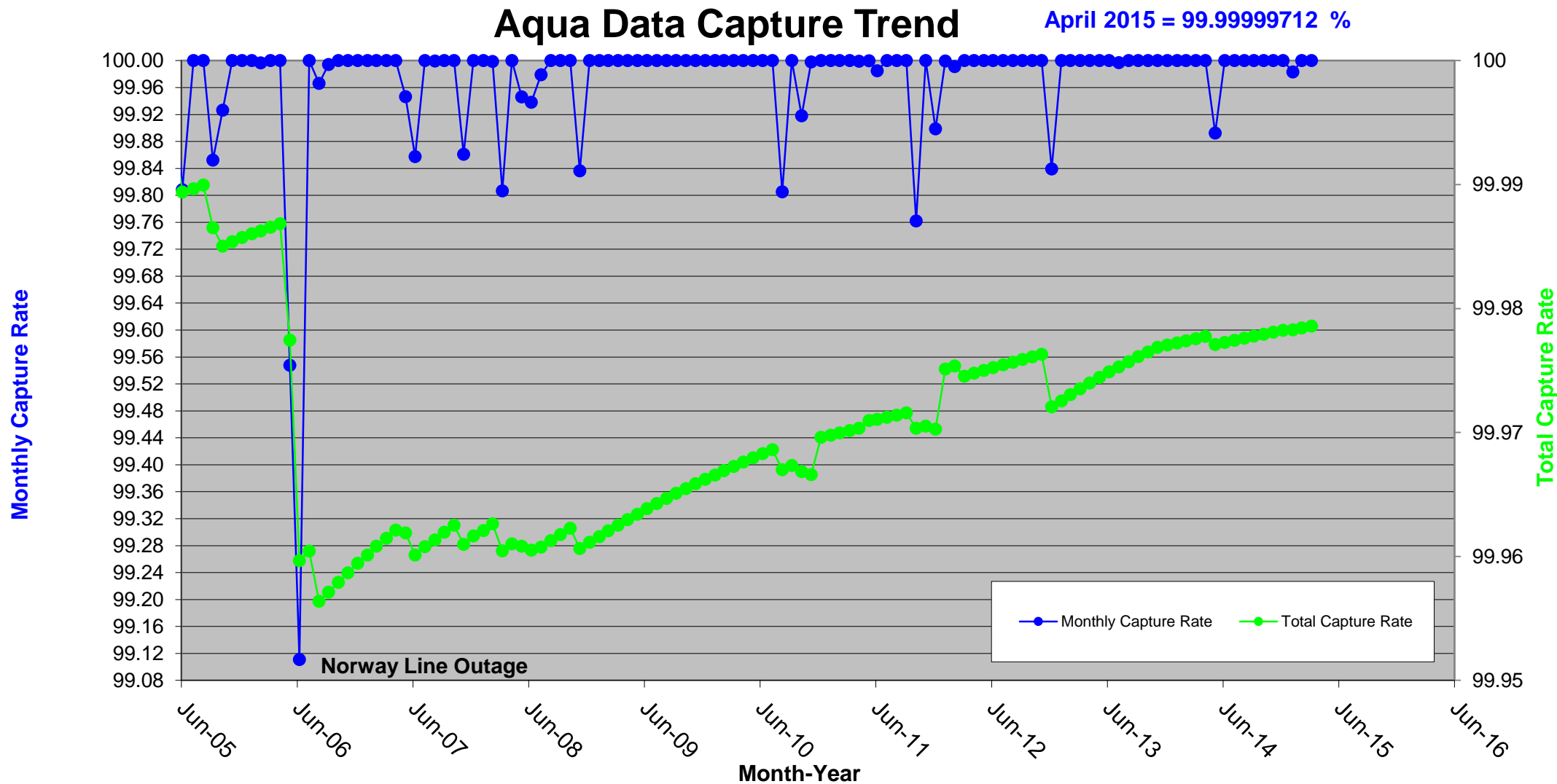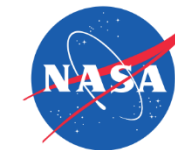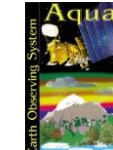
Aqua Fuel Remaining

Aqua Required Fuel
Nominal Solar Flux Predictions and Operational Reentry Area

Based on predicted fuel usage, Aqua has enough fuel to support science requirements until 2021

Aqua currently plans to meet the NASA 25-year reentry requirement as well as baseline Constellation Exit Requirement.
Aqua may consider the Terra strategy at a later date as fuel reserve diminishes (based on Aqua Science Justification)