

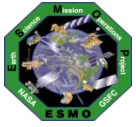
A 3D computer-generated rendering of the Aura satellite in orbit above Earth. The satellite is shown from a perspective that highlights its complex structure, including a large white parabolic dish antenna on the right side, various gold-colored thermal blankets, and white structural components. The Earth's blue and white atmosphere is visible in the background.

OMI Science Team Meeting
De Bilt, Netherlands (KNMI)
September 11th – 13th, 2018

Mission Operations Working Group (MOWG)
Report to the OMI Science Team

Presented by Dominic M. Fisher,
Aura Mission Director (GSFC – ESMO - Code 428/584)

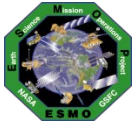
dominic.m.fisher@nasa.gov



Aura Mission Operations Working Group (MOWG)

The MOWG, established in 1997, is dedicated to ensuring the health and safety of the Aura satellite (spacecraft bus and instruments) to enable science observations.

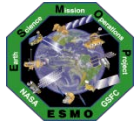
21 years of collaboration between the various Ops teams!



2018 OMI IOT / FOT MOWG Meeting (September 12th, 2018)



<u>Name</u>	<u>Affiliation</u>
Dominic Fisher	Aura MD / ESMO / GSFC
Bill Guit	Aqua MD / ESMO / GSFC
Lindsai Bland	EOS FOT Manager / EOS / GSFC
Chuck Hudson	Aura FSM / EOS / GSFC
Jacob Williams	Aura Instruments / EOS / GSFC
Ava Afghahi	Aura CDH / EOS / GSFC
Chris Galiatsatos	Aura GNC / EOS / GSFC
Joshua Bowman	Aura GNC / EOS / GSFC
Mirna van Hoek	OMI IOT Lead / KNMI
Jacques Claas	OMI IOT / KNMI
Quintus Kleipool	OMI Calibration / KNMI
Mike Stoddard	OMI IAM Lead / NGAS



OMI IOT / FOT MOWG

Key Meeting Objectives



- **Discuss current Aura spacecraft and OMI instrument status**
- **Highlight any performance trends of note and project any impacts to continued OMI operations**
- **Identify any operational changes that may be needed to ensure continued OMI operations**
- **Express any concerns or potential process improvements (i.e., any interface / ground system issues)**
- **Discuss future Aura spacecraft and OMI instrument plans (i.e., potential early exit from the A-train)**



OMI IOT / FOT MOWG Meeting Agenda

(September 12, 2018)

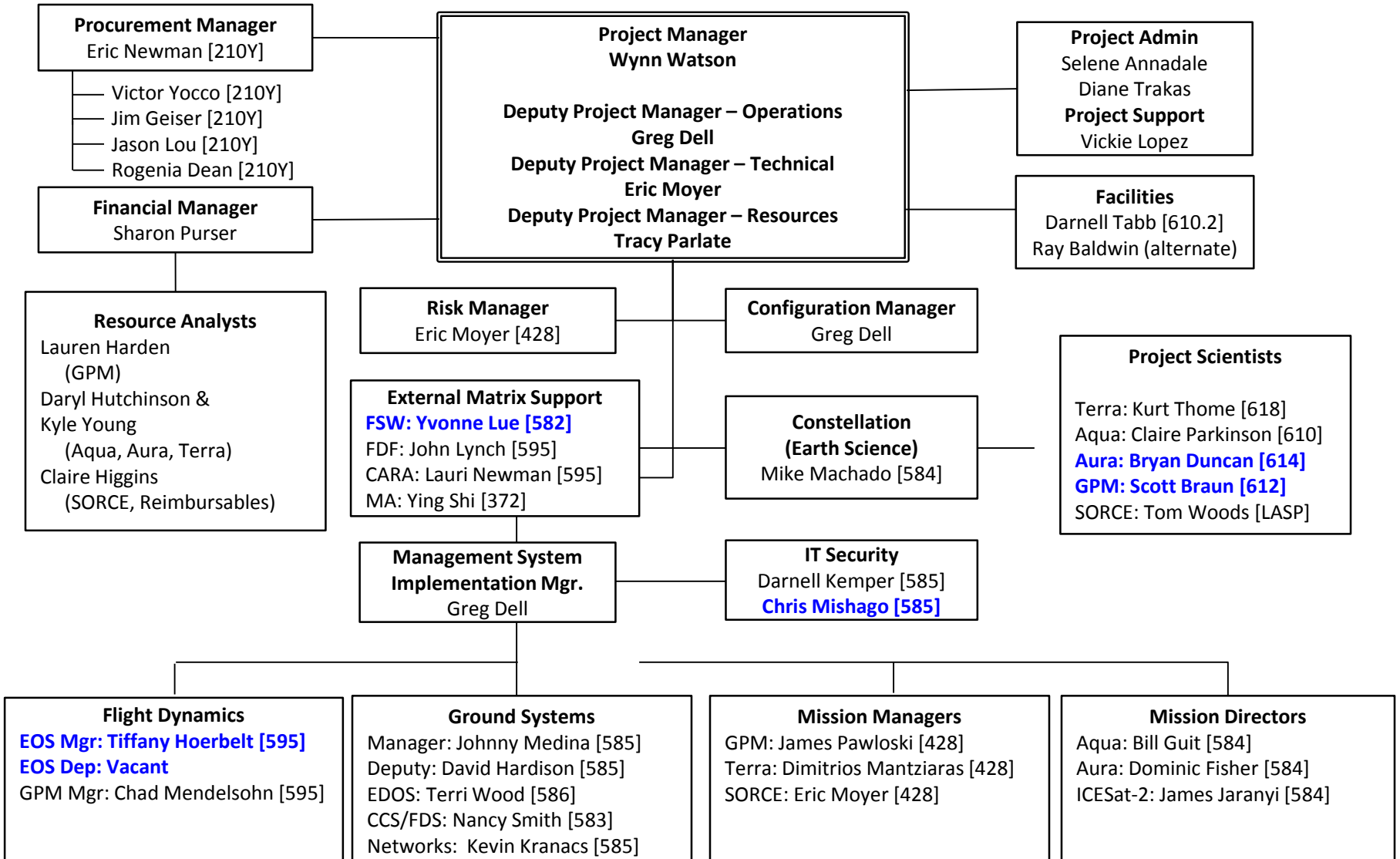


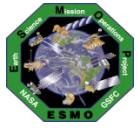
Time	Topic	Presenter
03:00	Welcome / Introduction	Fisher / All
03:05	GSFC ESMO Update	Fisher
03:10	Aura Mission Status	Fisher
03:20	Aura Spacecraft / EOS Ground System Status	Hudson
03:30	OMI Instrument Status	Van Hoek
03:40	OMI IAM Status	Stoddard
03:50	Summary / Review Actions	All
04:00	Special Topic Discussion	All
	<ul style="list-style-type: none">• Early A-train Exit planning	



ESMO Organization

(Changes since Sept 2017 MOWG @ GSFC)





Aura's 14th Anniversary!



**Launch Date:
July 15, 2004**





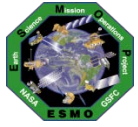
Aura Spacecraft Subsystems

(Changes since Sept 2017 MOWG @ GSFC)



- **Command & Data Handling (CDH) – Nominal**
 - **Solid State Recorder (SSR) Anomaly (December 4-18, 2007)**
 - » Initial symptoms occurred December 4-18, 2007
 - » Newest symptoms started in January 2017 and remain active (impacting S-Band HK data capture)
- **Communications (COMM) – Nominal**
 - **Transmitter-B Reflected Power Anomaly (2 occurrences) (Oct 17-21, 2017 & Jan 5, 2018)**
- **Electrical Power System (EPS) – Nominal**
 - **Array Regulator Electronics (ARE) Anomalies:**
 - » **Solar Panel Connector Anomaly – ARE-3C (01/12/05) – loss of ~11 strings**
 - » **MMOD Strike – ARE-5A (03/12/10) – loss of ~6 strings**
 - **ARE Degradation due to aging – ARE-5C (9/27/12, 2/4/13), ARE-1A (3/12/10, 11/5/11), ARE-5A (4/25/13), ARE-6A (9/14/13), ARE-4A (12/8/14), ARE-1C (7/14/17, 12/22/17), ARE-2C (8/18/17)**
 - » **Estimated that Aura has lost 28 strings of solar cells out of a total of 132 strings (~78.8% remain)**
 - » **Aura continues to have significant power margin where the life limiting item is fuel**
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**

All subsystems configured to primary hardware

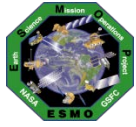


Summary of Activities

(Since Sept 2017 MOWG @ GSFC)



- **2 Spacecraft Bus Anomalies**
 - **COMM: 2 Tx-B Reflected Power Anomalies (10/17-21/17, 01/05/18)**
- **9 Instrument Anomalies**
 - **MLS: 1 Receiver-1A Anomaly (06/05/18), 1 GHz Mirror Electronics B Anomaly (06/20/18), and 1 Survival Mode Transition (07/10/18)**
 - **OMI: 3 OMI-IAM Warm Restart Anomalies (01/02/18, 04/30/18, 07/30/18)**
 - **TES: 3 ICS Stalls (11/18/17, 12/22/17, 01/24/18) – instrument decommissioned**
- **14 Spacecraft Maneuvers**
 - **8 Drag Make-up Maneuvers (DMUMs # 106 – 113)**
 - » 09/13/17, 10/25/17, 11/30/17, 02/14/18, 05/03/18, 05/31/18, 06/28/18, 08/22/18
 - **6 Inclination Adjust Maneuvers (IAMs # 53 – 58)**
 - » 02/28/18, 03/07/18, 03/14/18, 03/28/18, 04/18/18*, 08/01/18**
 - * IAM #57 was initially planned for 04/11/18, Aqua post-maneuver debris concern
 - ** IAM #58 needed in order to keep phasing, Aqua used IAM to correct large RMM
- **1 Instrument Calibration Maneuvers**
 - **MLS Yaw & Moon Scan #13 (03/03/18)**
- **2 Spacecraft Test Maneuvers**
 - **Reaction Wheel Assembly Yaw Slew Tests (-25°) (#1a – 12/12/17, #1b – 01/11/18)**

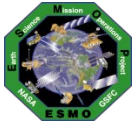


Summary of Activities

(Since Sept 2017 MOWG @ GSFC)

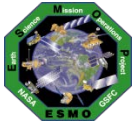


- **12 CARA High Interest Orbital Debris Events (Tiers 1-4) (As of 7/26/18)**
 - 8 required significant action (Tier 3)
 - 0 required Debris Avoidance Maneuver (DAM) or altered DMU (Tier 4)
 - Tier 1 – Notify, Tier 2 – Briefing, Tier 3 – Plan, Tier 4 – Execute DAM or alter DMU
- **TES Decommissioning**
 - TES Decommissioning Review @ JPL – 01/18/18
 - FOT / IOT reconfigured instrument to decommissioned state – 01/31/18
 - TES Close-out Review & Science Highlights @ NASA HQ – 04/13/18
 - TES Laser End-of-Life Testing – 6-weeks of tests in June & July 2018
- **Aqua / Aura Maneuver Working Group**
 - Aura Reaction Wheel Assembly (RWA) Slew Maneuver Test (#1a) – 12/12/17
 - Aura RWA Slew Maneuver Test (#1b) – 01/11/18
 - Simulations found issues during abort scenario responses – January 2018
 - Updates to fault management thresholds – Summer 2018



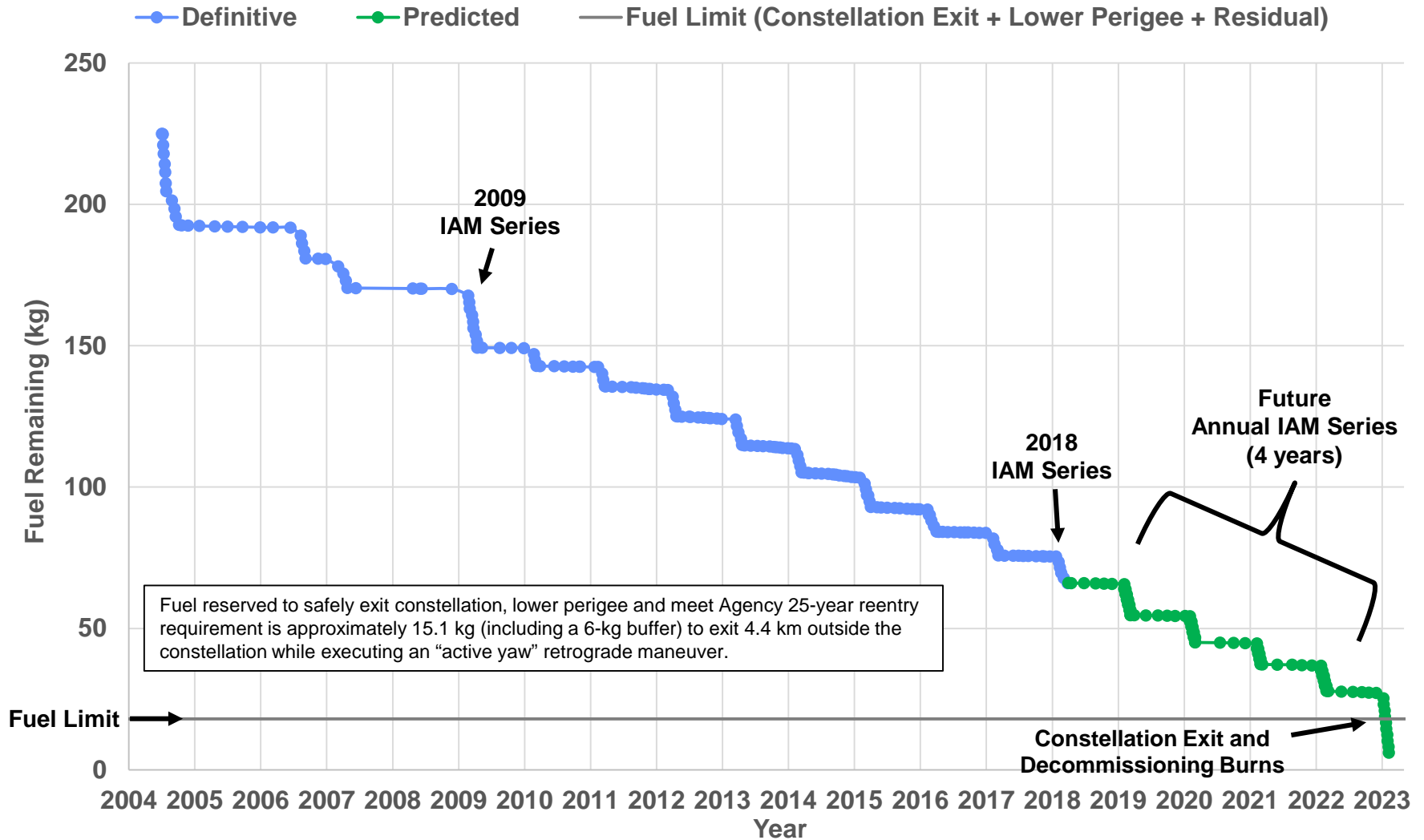
Planned Activities

- **Aqua/Aura Maneuver Working Group:**
 - Reschedule Engineering Peer Review (EPR) – October 2018
 - Aura RWA Slew Maneuver Test (#2) – November 2018
- **Aura Alternate Decommissioning Plan Evaluation (Early A-Train Exit Scenario)**
 - Discuss during OMI Science Team Meeting – September 2018
 - Discuss during Aura Science Team Meeting – January 2019
- **September 2018: Aura Decommissioning Review (*DRAFT*)**
 - Document Phase F spacecraft activities, any new products to be developed for spacecraft / instrument calibration, proposed Engineering Tests, and Passivation Sequence
- **December 2018: Earth Science Constellation (ESC) MOWG (Location GSFC)**
 - Update propellant budget, decommissioning analysis, reliability predictions, etc.
- **January 2019: ESMO Annual Review #12**
 - ESMO has been reevaluating the purpose and content of the review moving forward
- **Spring 2019: Annual Inclination Adjust Maneuvers (*DRAFT*)**
 - 2/27/19 (#58), 3/6/19 (#59), 3/13/19 (#60), 3/21/19 (#61), 3/27/19 (#62), & 4/3/19 (#63)
- **Mid-to-Long-Term Plans:**
 - **EOS Automation (EA) – automation of routine operations**
 - » EA Phase 3.2 – Fall 2018
 - **Continue to improve RMM / DAM execution**
 - » Support ESMO / CARA devolution initiative



Fuel Usage: Actual & Predicted

(Baseline Fuel Plan – Analysis Updated April 2018)



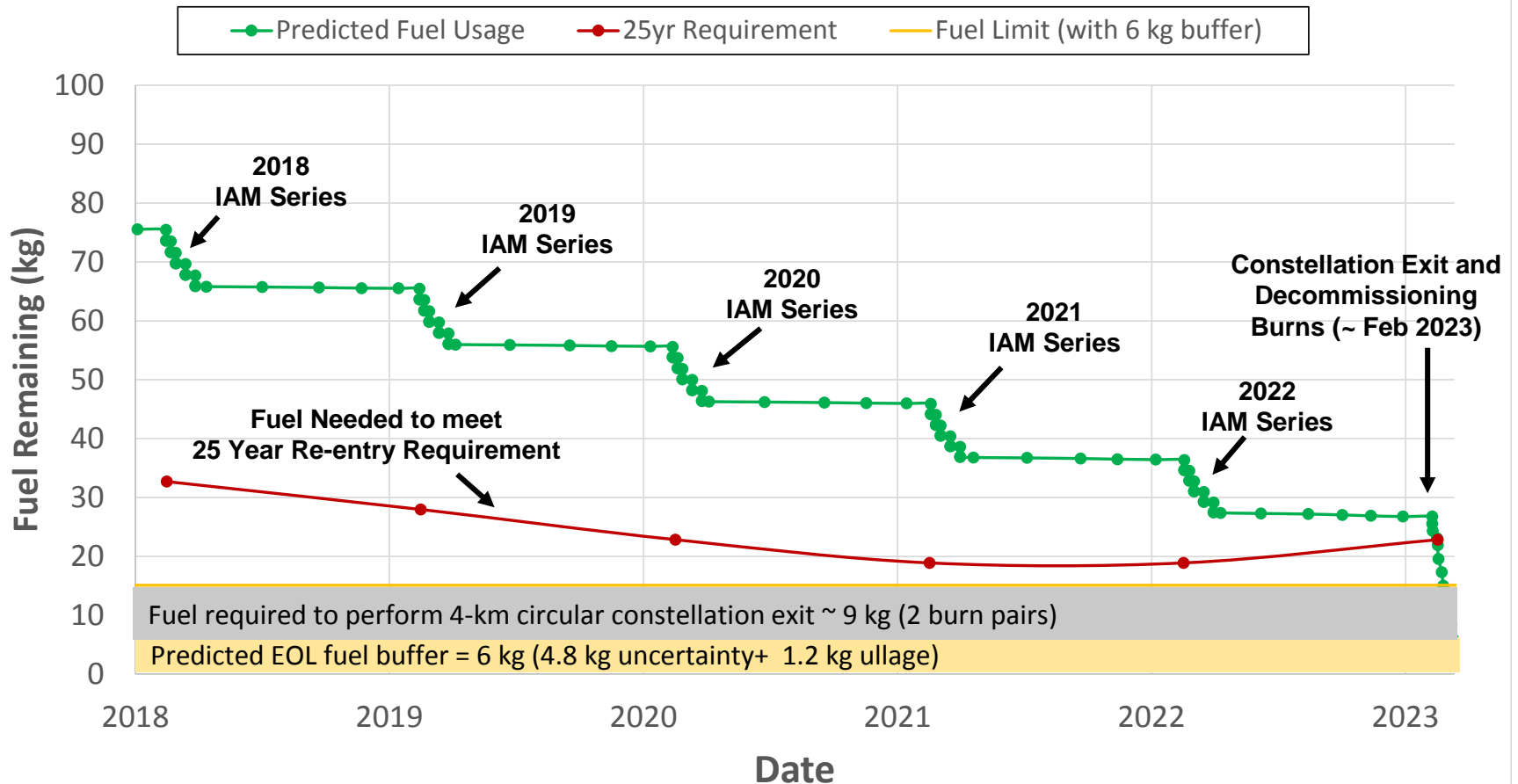


Aura End of Life Predictions

(Baseline Fuel Plan – Analysis Updated October 2017)



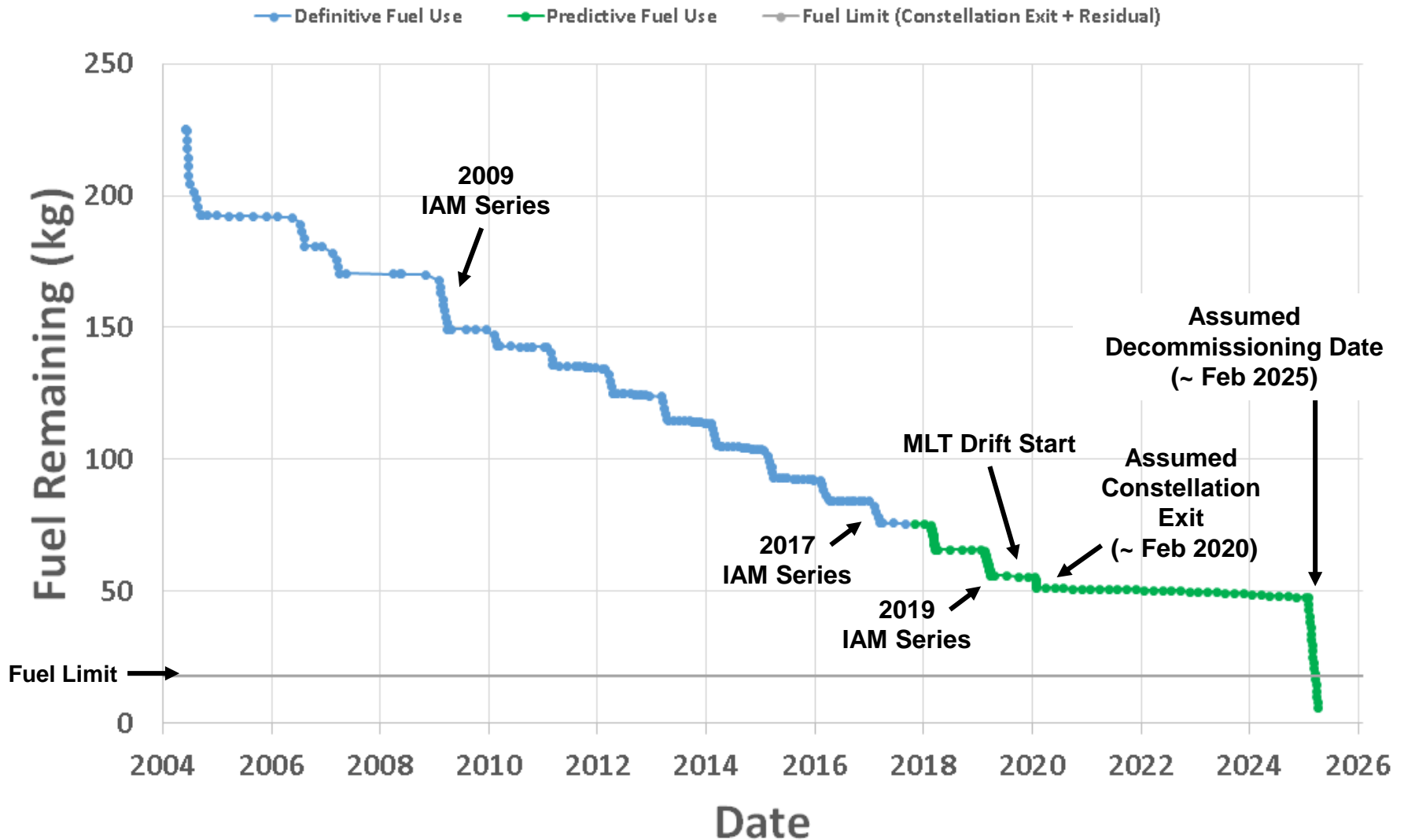
Aura Required Fuel Nominal Solar Flux Predictions and Tumbling Reentry Area 4.4 km Exit and Active Yaw Deorbit Maneuvers





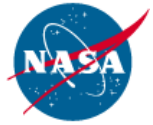
Fuel Usage: Actual & Predicted

(Alternate Fuel Plan – Analysis Updated October 2017)

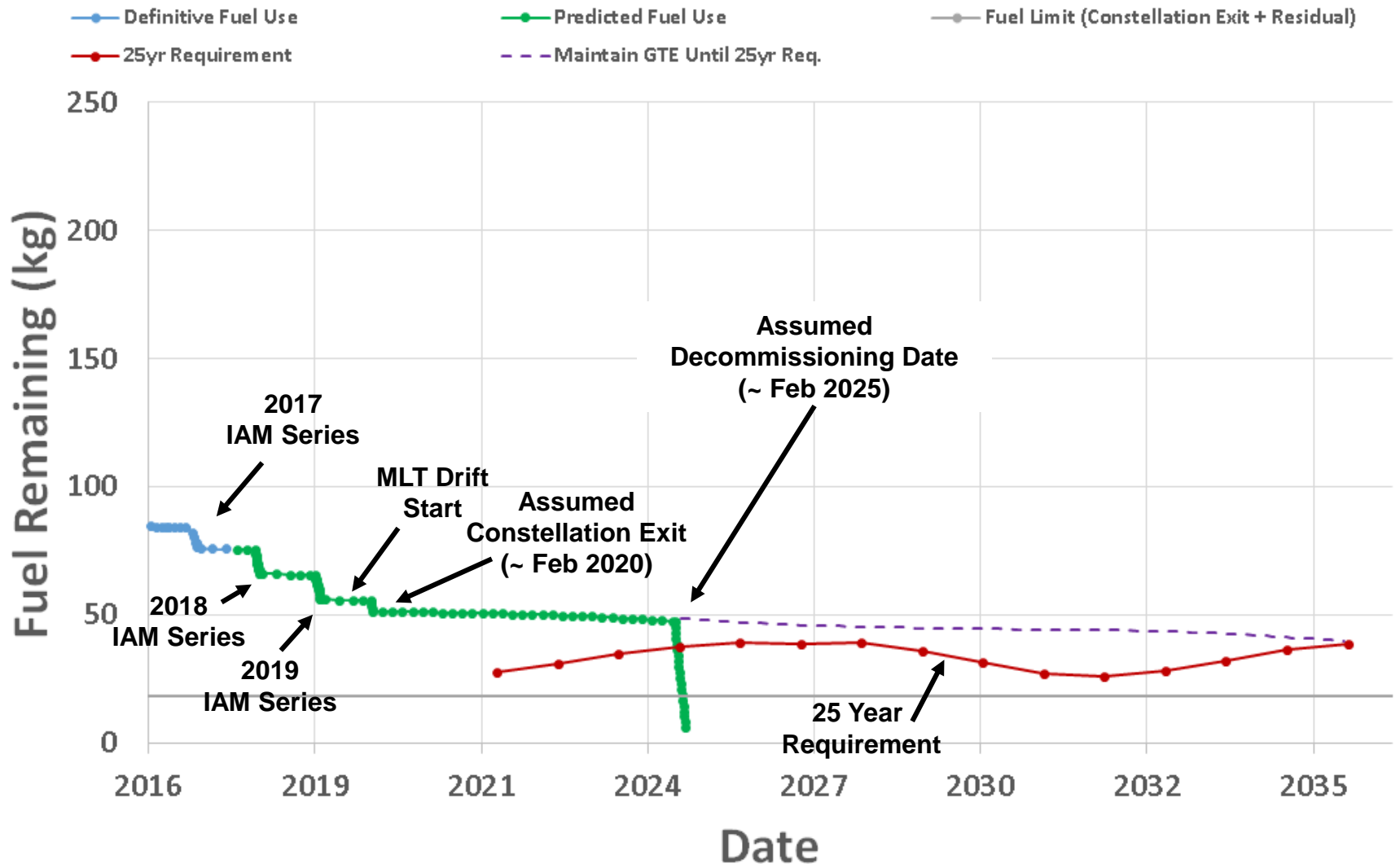


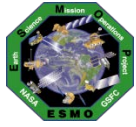


Aura Predicted Fuel Usage



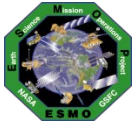
(Alternate Fuel Plan – Analysis Updated October 2017)





Overall Summary

- **Spacecraft Status – GREEN**
 - **COMM: Transmitter-B Reflected Power Anomaly (Oct '17 & Jan '18)**
- **Instrument Status - GREEN**
 - **HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data**
 - **MLS: Operating Normally (Only periodic Band 13 measurements)**
 - » **06/04/2018: 118 GHz Receiver-1A (R1A) Anomaly (Recovered 06/11/18)**
 - » **06/20/2018: GHz Mirror Electronics (GME-B) Anomaly (Recovered 06/26/18)**
 - » **07/10/2018: MLS Survival Mode Transition (Recovered 07/18/18)**
 - **OMI: Operating Normally**
 - » **01/02/2018: OMI IAM Warm Restart (Recovered 01/03/18)**
 - » **04/30/2018: OMI IAM Warm Restart (Recovered 05/01/18)**
 - » **07/30/2018: OMI IAM Warm Restart (Recovered 07/31/18)**
 - **TES: Instrument Decommissioned on 01/31/18**
- **Data Capture/L0 Processing Status – GREEN**
 - **SSR Data Capture to 07/31/18: 99.995878943%**
- **Ground Systems – GREEN**
 - **Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required**
 - **09/05/2018: EOS Automation (EA) Release 3.1 ORR**
 - **05/01/2018: MMS Build 25.2.0 Transition for Aura**



Flight Operations Team (FOT) Status



- Data Capture Rates continue to be stellar (+99.99%)
- 1 Data Loss (Ops Error) this year; first in +6 years
- Spacecraft risks remain stable with FMU/SSR anomaly recovery remaining the top risk
- Continue to review any outdated Operations Agreements with IOTs
- Reviewing draft Instrument Safe / Survival SOPs with IOTs
- FOT capturing routine instrument activities in standard operating procedures
- TES Decommissioning completed in January 2018
- Maneuver development efforts to utilize the reaction wheels is a priority (IAMS / Retrograde)

Project Overview / Objective

Aura Features
 Launch Date: July 15, 2004 (Delta, VAFB)
 Orbit:
 702 km alt
 98.2 Incl
 2:42 PM
 Instrument P
 HIRDLIS
 LIR - OBS
 MLI2 - M
 OMI - O
 TES - T
 Project Man
 Spacecraft P
 ASAC, Aeron
 Instrument O
 Mission Durr
 began on 7/15

EOS-Aura 2015 Summary

EOS-Aura 2016 Summary

Aura 2015 Spacecraft Risk Matrix

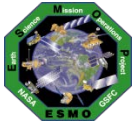
Aura 2015 Spacecraft Risk Matrix Details

Aura Staffing

Position	Prime	Back-Up
FSM	Charles Hudson	Benee Durham
CDH	vacant	Jason Webber
COMM	Christopher Thompson	Christos Galitsatos**
EPS/TCS	Christos Galitsatos**	Samuel Lewis**
FSW	Cara Smith	Mike Cabrera
GNC	Samuel Lewis**	Samuel Lewis**
	Damien Rogier	Damien Rogier
	Joshua Bowman	Joshua Bowman
INST	Jacob Williams	Byron Graves

**Tri-Mission Certified

All positions have identified back-up ready to support on-call duties if required



OMI Instrument Operations Team (IOT) Status



- There were 3 anomalies in 2018; none of which impacted the OMI science data (only 6 since launch):
 - 3 OMI-IAM warm restarts around the SAA
 - No impact on science quality
- Instrument performs nominally (with exception of row anomaly)
- CCD temperatures are very stable
- All three mechanisms behaving nominally
- Life limited items (mechanisms, internal calibration source) within budget
- Instrument degradation is very slow
- >99% of all measurements are according to Nominal Operations Baseline

Overall current status

Instrument Status

Survival Mode anomaly: impact on science

Spacecraft Status

FMU anomaly

Operations Status

General

Conclusion

- The instrument status is very good
- The instrument degradation is very slow
- No issues (except for the row anomaly)
- Science data is of very high quality

OUTLOOK

The Instrument Operations Team expects to operate the instrument without any problems for the next coming years.

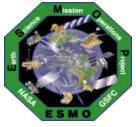
27 AURA HOWG, Rotterdam, 31 August 2018



Summary



The Mission Operations teams, both flight and instrument, are dedicated to keeping Aura (and OMI) operational for as long as possible

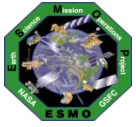


**Thank You
Dank Je Wel
Kiitos**

Questions?



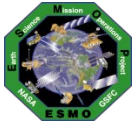
Back Up Slides



Abbreviations / Acronyms List



ARE –	Array Regulator Electronics	GHz -	Gigahertz	MMOD –	Micrometeorite Orbital Debris
A-Train -	Afternoon Constellation	GME -	GHz Mirror Electronics	MMS –	Mission Management System
CARA –	Conjunction Assessment Risk Analysis	GNC –	Guidance Navigation & Control	MOWG –	Mission Operations Working Group
CCD -	Charge Coupled Device	GPM -	Global Precipitation Measurement	NASA –	National Aeronautics & Space Administration
CCS -	Constellation Coordination System	GSFC –	Goddard Space Flight Center	NGAS -	Northrup Grumman Aerospace Systems
CDH –	Command & Data Handling	HIE –	High Interest Event	OA -	Operations Agreement
COMM -	Communications	HIRDLS –	High Resolution Dynamics Limb Sounder	OMI –	Ozone Monitoring Instrument
COTS -	Commercial-off-the-Shelf	HK -	Housekeeping	ORR –	Operational Readiness Review
DAM –	Debris Avoidance Maneuver	HQ -	Headquarters	PROP -	Propulsion
DAM -	Debris Avoidance Maneuver	IAM –	Inclination Adjustment Maneuver or Interface Adapter Module	R1A -	Receiver-1A
DMUM –	Drag Make-up Maneuver	ICS –	Interferometer Control System	RMM –	Risk Mitigation Maneuver
EA –	EOS Automation	IOT -	Instrument Operations Team	RW –	Reaction Wheel
EDOS -	EOS Data & Operations System	IT -	Information Technology	RWA –	Reaction Wheel Assembly
EOL -	End of Life	JPL -	Jet Propulsion Lab	SAA -	South Atlantic Anomaly
EOS –	Earth Observing System	kg -	kilogram	SOP -	Standard Operating Procedure
EPR -	Engineering Peer Review	km –	kilometer	SORCE -	SOLar Radiation & Climate Experiment
EPS –	Electrical Power System	KNMI -	Royal Netherlands Meteorological Institute	SSR –	Solid State Recorder
ESC –	Earth Science Constellation	L0 –	Level-Zero	TCS –	Thermal Control System
ESMO –	Earth Science Mission Operations	MA -	Mission Assurance	TES –	Tropospheric Emissions Spectrometer
FDF -	Flight Dynamics Facility	MD -	Mission Director	Tx-B -	Transmitter B
FDS –	Flight Dynamics System	MLS –	Microwave Limb Sounder		
FMU –	Formatter Multiplexer Unit	MLT -	Mean Local Time		
FOT –	Flight Operations Team				
FSM -	Flight Systems Manager				
FSW –	Flight Software				



OMI IOT / FOT MOWG Meeting Detailed Agenda



GSFC ESMO Update

ESMO Organization

Fisher

Aura Mission Status

Mission Summary

Fisher

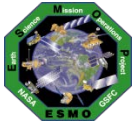
Spacecraft Subsystem Summary

Recent Activities

Planned Activities

Overall Summary

Additional Slides – Spacecraft Maneuvers, Ground Track, HIEs, Data Capture, & Ops Error Stats



OMI IOT / FOT MOWG Meeting Detailed Agenda



Aura Spacecraft / EOS Ground System Status

	Overview	FOT
	2017 / 2018 Summary (Status, Statistics, Special Activities, Maneuvers, Anomalies)	
	Spacecraft Risk Matrix	
	Aura FOT Staffing	
	Documentation (Ops Agreements, SOPs, Export Control Assessment, Senior Review)	
	Fault Management Readiness	
	Maneuver Working Group	
	EOS Automation (Ground System)	

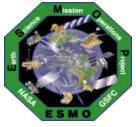


OMI IOT / FOT MOWG Meeting Detailed Agenda



OMI Status

Instrument Status	OMI IOT
Spacecraft Status	
Operations Status	
Focus is on those items that can potentially impact the quality of the science data.	



OMI IOT / FOT MOWG Meeting Action Items



Status Action Items

Update OMI OA and constraint database (for rescheduling within 6 vs. 3 orbits)	IOT
Safe / Survival Mode Standard Operating Procedures (SOPs)	FOT / IOT
CCD trending data for further analysis	FOT / IOT
Prepare for further maneuver tests using reaction wheels (Fall 2018)	FOT / IOT