

OMI Science Team Meeting

Goddard Space Flight Center (GSFC)

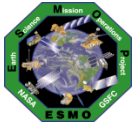
September 12th – 14th, 2017

Mission Operations Working Group (MOWG)

Report to the OMI Science Team

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

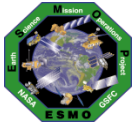
dominic.m.fisher@nasa.gov



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.

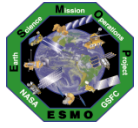
20 years of collaboration between the various Ops teams!



2017 OMI IOT / FOT MOWG Meeting



| <u>Name</u> | <u>Affiliation</u> |
|----------------|--------------------------|
| Dominic Fisher | Aura MD / ESMO / GSFC |
| Bill Guit | Aqua MD / ESMO / GSFC |
| Lindsai Bland | EOS FOT Mgr / EOS / GSFC |
| Chuck Hudson | Aura FSM / EOS / GSFC |
| Jacob Williams | Aura Inst / EOS / GSFC |
| Tim Russell | Aura CDH / EOS / GSFC |
| Sam Lewis | Aura GNC / EOS / GSFC |
| Grant Barrett | Aura GNC / EOS / GSFC |
| Joshua Bowman | Aura GNC / EOS / GSFC |
| Mirna van Hoek | OMI Lead / KNMI |
| Mike Stoddard | OMI IAM Lead / NGAS |

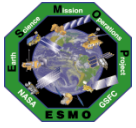


OMI IOT / FOT MOWG

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 sys issues)**

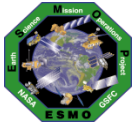


OMI IOT / FOT MOWG Meeting Agenda

(September 13, 2017)



| Time | Topic | Presenter |
|-------|---|--------------|
| 02:00 | Welcome / Introduction | Fisher / All |
| 02:05 | GSFC ESMO Update | Fisher |
| 02:10 | Aura Mission Status | Fisher |
| 02:20 | Aura Spacecraft / EOS Ground System Status | Hudson |
| 02:30 | OMI Instrument Status | Van Hoek |
| 02:40 | OMI IAM Status | Stoddard |
| 02:50 | Special Topics Discussion | All |
| | <ul style="list-style-type: none">• Survival Transition Recovery plans• White Light Source Degradation• Solar Calibration Measurement Constraints• Inclination Adjust Maneuvers using RWs• Retrograde Maneuvers | |
| 03:50 | Summary / Review Actions | All |



OMI IOT / FOT MOWG Meeting Detailed Agenda

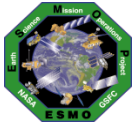


GSFC ESMO Update

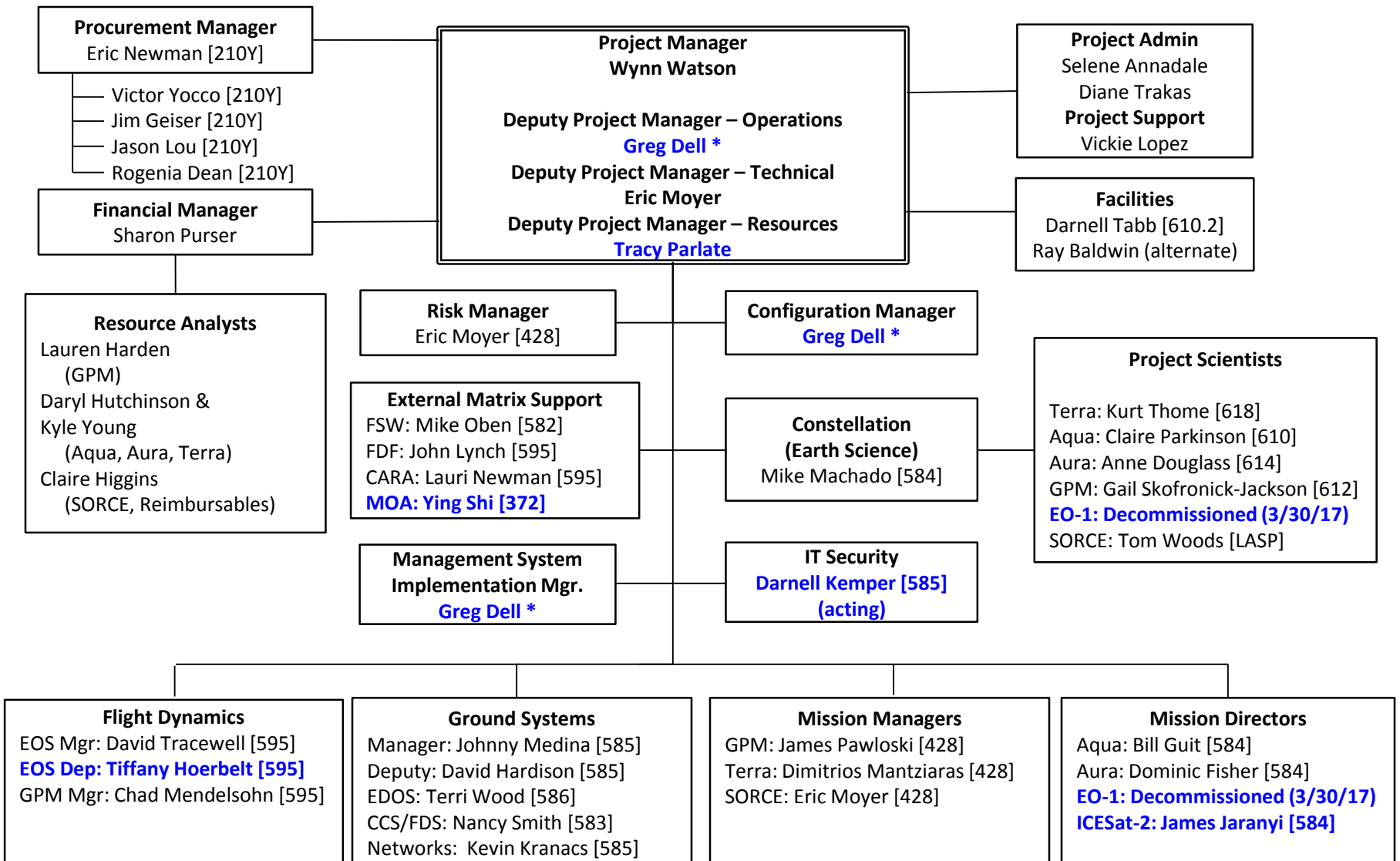
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|--------------------|--------|
| ESMO Organization | Fisher |
| 2017 Senior Review | |

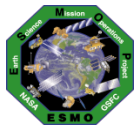
Aura Mission Status

| | |
|---|--------|
| Mission Summary | Fisher |
| Spacecraft Subsystem Summary | |
| Recent Activities | |
| Planned Activities | |
| Overall Summary | |
| Additional Slides – Spacecraft Maneuvers, Ground Track, HIEs, Data Capture, & Ops Error Stats | |



ESMO Organization



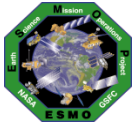


Aura's 13th Anniversary!



**Launch Date:
July 15, 2004**





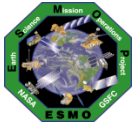
Aura Spacecraft Subsystems

(Changes since Sept 2016 MOWG @ Rotterdam)



- **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**
- **Electrical Power System (EPS) – Nominal**
 - *Array Regulator Electronics (ARE) Anomalies:*
 - » *Solar Panel Connector Anomaly – ARE-3C (January 12, 2005) – loss of ~11 strings*
 - » *MMOD Strike – ARE-5A (March 12, 2010 & April 25, 2013) – loss of ~6 strings*
 - *ARE Degradation due to aging – each occurrence is loss of ~ 1 string:*
ARE-5C (9/27/12, 2/4/13), ARE-1A (3/12/10, 11/5/11), ARE-6A (9/14/13), ARE-4A (12/8/14), ARE-1C (7/14/17)
 - » ***Estimated that Aura has lost 25 strings of solar cells out of a total of 132 strings (~18.9%)***
 - » ***Aura continues to have significant power margin where the life limiting item is fuel***
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
 - ***Reaction Wheel Assembly (RWA) #3 Anomaly (12/03/2016) – Recovered on 12/13/16***
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**

All subsystems configured to primary hardware

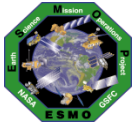


Summary of Activities

(Since Sept 2016 MOWG @ Rotterdam)



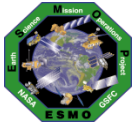
- **17 CARA High Interest Orbital Debris Events (Tiers 1-4) (As of 7/25/17)**
 - 8 required significant action (T3 / T4)
 - Tier 1 – Notify, Tier 2 – Briefing, Tier 3 – Plan, Tier 4 – Execute DAM or alter DMU
- **2 Spacecraft Bus Anomalies**
 - RWA #3 Spin-down (12/3/16) – recovered 12/13/16
 - FMU/SSR Anomaly – new symptoms since January 2017 – on-going
- **7 Instrument Anomalies**
 - MLS: R2 Phased Locked Loop (PLL) loss of lock – adjusted 3/08/17
 - OMI: 1 Instrument Survival Event (3/12/17) – recovered 3/16/17
 - TES: 6 ICS Stalls (10/24/16, 2/5/17, 2/18/17, 2/26/17, 3/12/17, 7/29/17) – on-going
- **14 Spacecraft Maneuvers**
 - **10 Drag Make-up Maneuvers (DMUMs # 96 – 105)**
 - » (6) Routine: 09/23/16, 11/15/16, 12/15/16, 1/20/17, 6/21/17, 8/16/17
 - » (4) CA Impacted: 10/13/16 (replan), 3/26/17 (DAM), 5/3/17 & 7/21/17 (replan)
 - **4 Inclination Adjust Maneuvers (IAMs # 49 – 52)**
 - » 3/2/17, 3/9/17, 3/23/17, 3/30/17
- **1 Instrument Calibration Maneuvers**
 - **MLS Yaw & Moon Scan #12 (3/14/17) (GSFC Code Red – FOT support remotely)**



Planned Activities

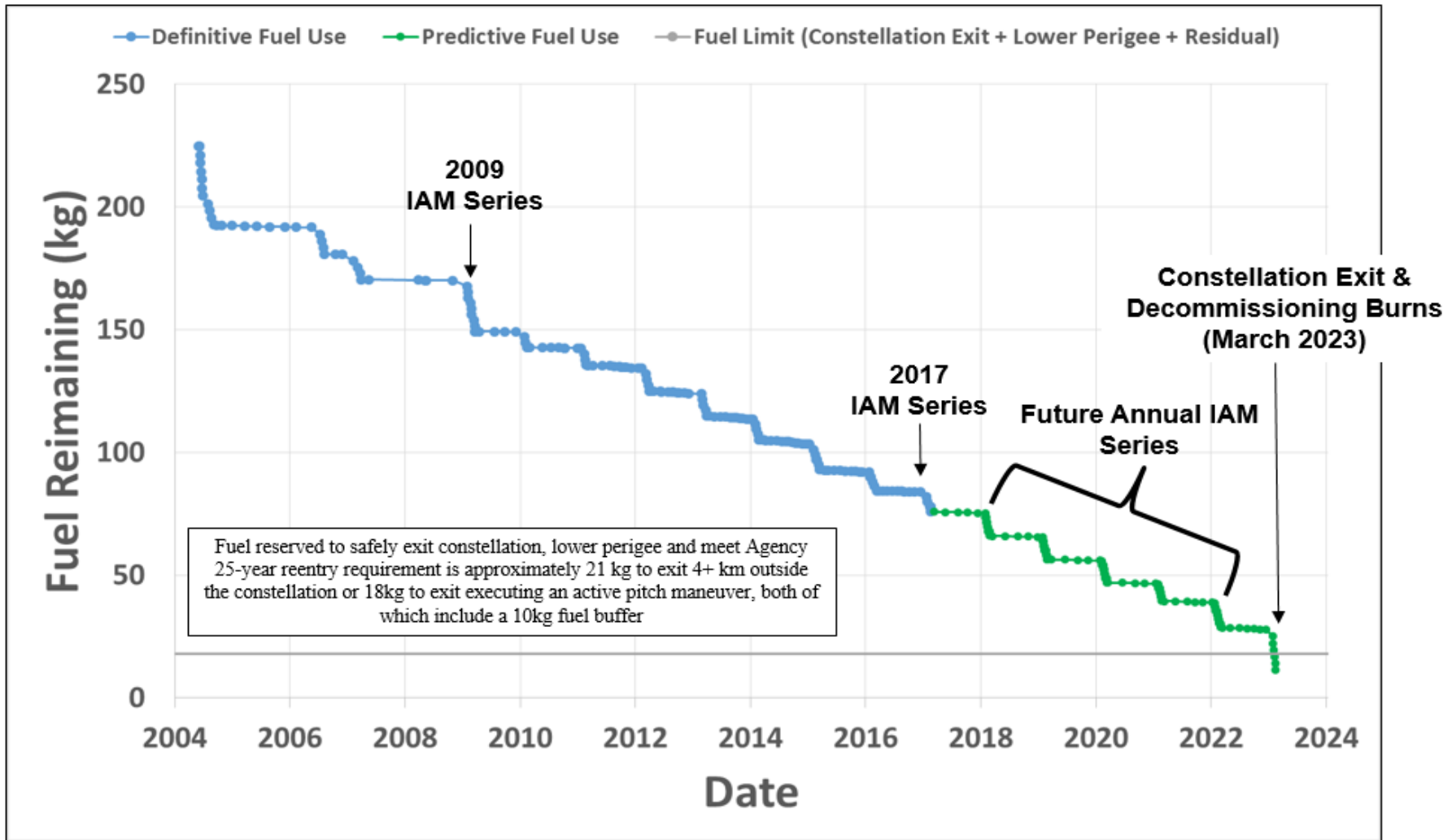
- **September 2017: OMI Science Team Meeting**
- **December 2017: Earth Science Constellation (ESC) MOWG (12/5-7 / @ NASA KSC)**
 - Update propellant budget, decommissioning analysis, reliability predictions,...
- **January 2018: ESMO Annual Review #11**
- **Spring 2018: Annual Inclination Adjust Maneuvers (DRAFT SCHEDULE)**
 - 2/28/18 (#53), 3/7/18 (#54), 3/14/18 (#55), 3/28/18 (#56), & 4/11/18 (#57)
- **April 2018: Draft Aura Decommissioning Review**
 - Document Phase F spacecraft activities, any new products to be developed for SC / Inst Calibration, proposed Engineering Tests, and Passivation Sequence
- **Summer 2018: Aura Science Team Meeting (Location TBD)**

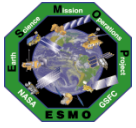
- **Mid-to-Long-Term Plans**
 - **Continue to improve RMM / DAM execution**
 - » CA automation (CRMS) development
 - **Aqua/Aura Maneuver Working Group**
 - » Develop retrograde maneuver capability and explore any fuel saving options (IAM w/ RWs)
 - **EOS Automation (EA) – automation of routine operations**
 - » Phase II (Monitoring / Alerting) ORR – July 2017; Phase III - TBD



Fuel Usage: Actual & Predicted

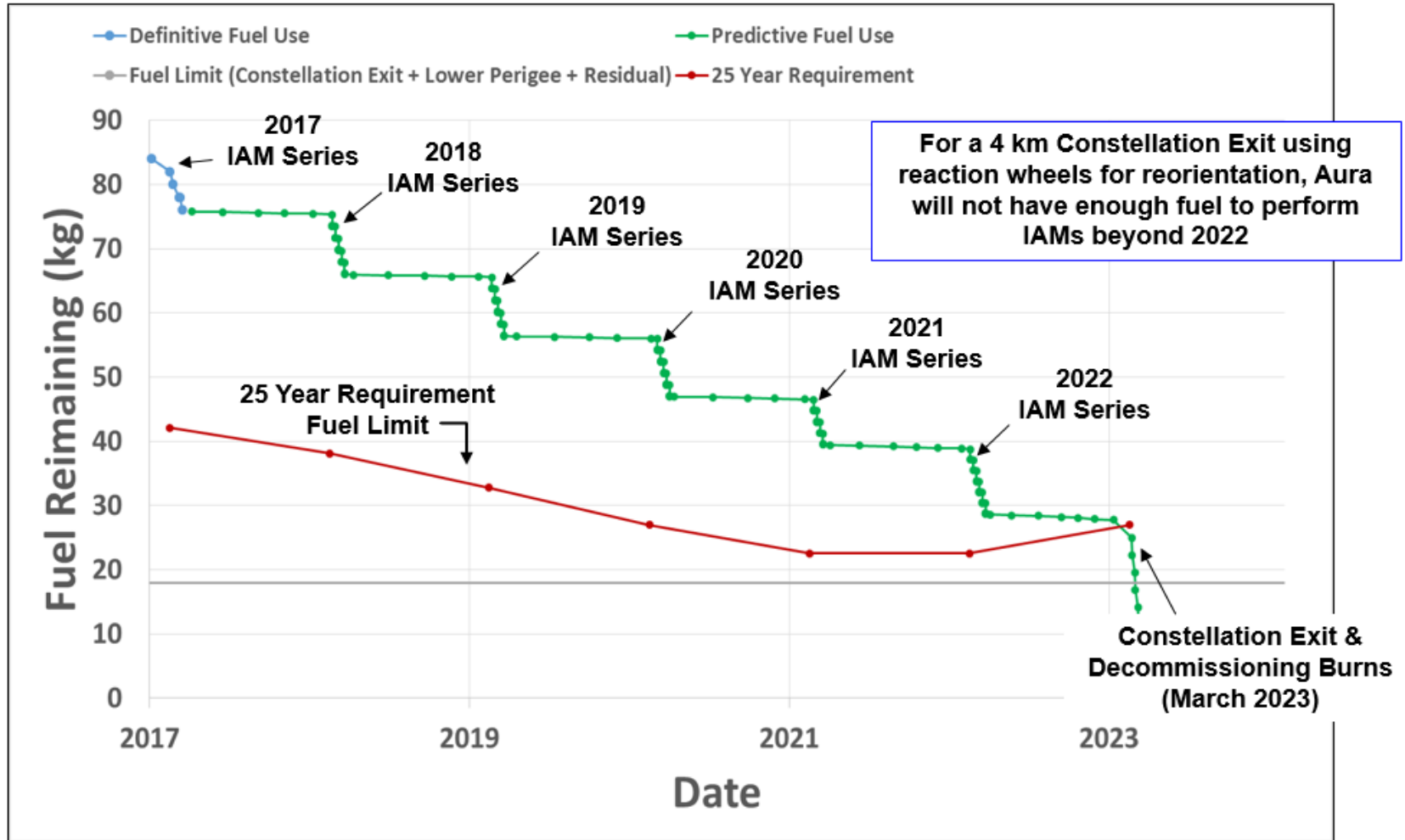
(Updated December 2016)

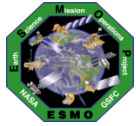




Aura DAS End of Life Predictions

(Updated December 2016)

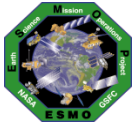




Summary



- **Spacecraft Status - GREEN**
- **Instrument Status - GREEN**
 - **HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data**
 - **MLS: Operating Normally – Only periodic Band 13 measurements**
 - » THz module (Standby Mode) – Expect one final set of measurements – TBD date
 - » **08/06/2013: Band 12 Shut down (reached end of useful life – 2-year design)**
 - » **02/25/2017: R2 Lock Status Yellow Alarms (due to aging, voltage fine-tuned 03/08/17)**
 - **OMI: Operating Normally**
 - » **Field-of-View Anomaly started in September 2007 – currently stable**
 - » **03/12/2017: OMI Survival Mode Transition (Recovered 03/16/17)**
 - **TES: Budget reductions driving decommissioning at end of FY17**
 - » **ICS Stalls (#11 - #16): 10/24/16, 02/05/17, 02/18/17, 02/26/17, 03/12/17, 07/29/17**
 - » **09/20/2016: TES Safe Mode Event (Recovered 9/22/16)**
- **Data Capture/L0 Processing Status – GREEN**
 - **SSR Data Capture to 07/31/2017: 99.99579749%**
- **Ground Systems –**
 - **Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required**
 - **04/11/2017: MMS Build 24.2.0 (RHEL7) Transition for Aura**
 - **08/03/2017: EOS Automation (EA) R2.7 ORR (Phase II)**

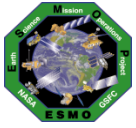


OMI IOT / FOT MOWG Meeting Detailed Agenda



Aura Spacecraft / EOS Ground System Status

| | |
|--|-----|
| Overview | FOT |
| 2015 / 2016 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 | |
| Debris Avoidance Maneuvers Working Group | |
| EOS Automation (Ground System) | |



Flight Operations Team (FOT) Status



- Data Capture Rates continue to be stellar (+99.99%)
- No data losses or Ops Errors in +6 years
- Most spacecraft risks are stable with the exception of TES ICS stalls
- Operations Agreements are outdated, reviewing and updating with IOTs
- Drafting Instrument Safe / Survival SOPs, reviewing with IOTs
- FOT capturing routine instrument activities in standard operating procedures
- Export Control Assessment completed in Fall 2016
- Senior Review inputs completed in Spring 2017

Project Overview / Objective

Aura Features
 Launch Date: July 15, 2004 (Delta, VAFB)
 Orbit:
 782 km alt
 98.2° Incl
 1:45 PM
 Instruments:
 AIR - OIB
 MLI2 - M
 OMI - OIB
 TES - TCS
 Project Man:
 Spacecraft P:
 ADJC, Aeron
 Instrument O:
 respective Ac
 Mission Durr
 began on 7/15

EOS-Aura 2015 Summary

EOS-Aura 2016 Summary

Aura 2015 Spacecraft Risk Matrix

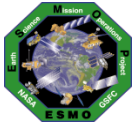
Aura 2015 Spacecraft Risk Matrix Details

Aura Staffing

| Position | Prime | Back-Up |
|----------|-----------------------|-----------------------|
| FSM | Charles Hudson | Benee Durham |
| CDH | vacant | Jason Webber |
| COMM | Christopher Thompson | Christos Galatsatos** |
| EPS/TCS | Christos Galatsatos** | 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 |

**Tr-Mission Certified

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

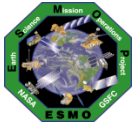


OMI IOT / FOT MOWG Meeting Detailed Agenda



OMI Status

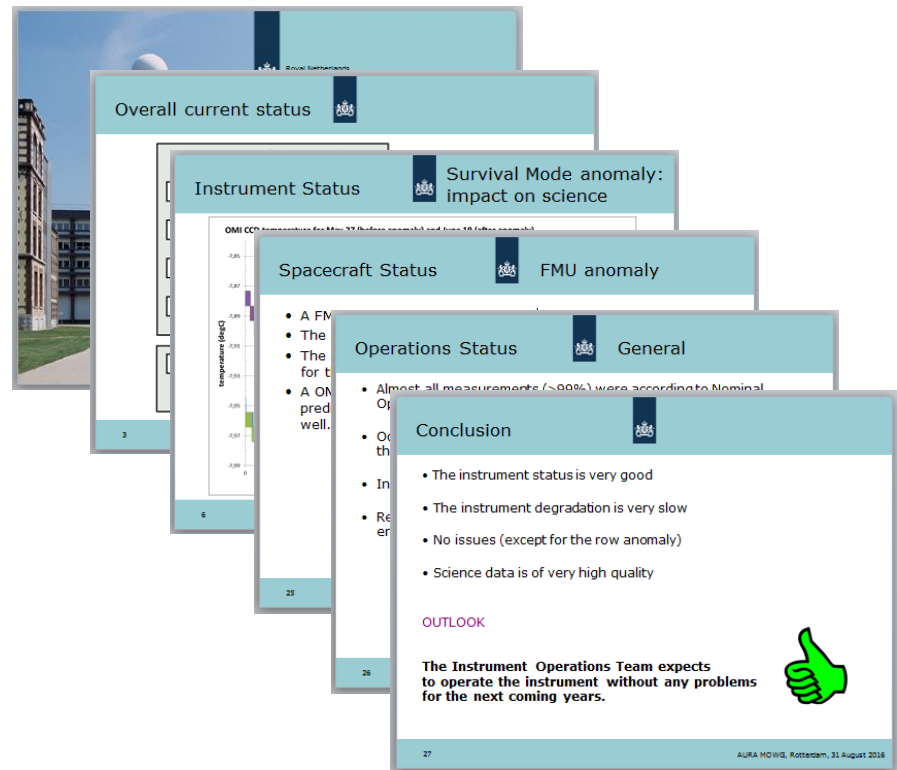
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| Instrument Status | OMI IOT |
| Spacecraft Status | |
| Operations Status | |
| Focus is on those items that can potentially impact the quality of the science data. | |

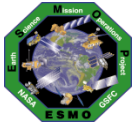


OMI Instrument Operations Team (IOT) Status



- There was 1 anomaly in 2017 that impacted the OMI science data (only 6 since launch):
 - OMI transition to Survival Mode on March 12, 2017: status solved
 - No remaining impact on science quality
- Instrument performs nominal (with exception of row anomaly)
- CCD temperatures still very stable (despite OMI to survival anomaly)
- All three mechanisms behave nominal
- Life limited items (mechanisms, internal calibration source) within budget
- Instrument degradation is very slow
- >99% of all measurements are according to Nominal Operations Baseline



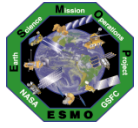


OMI IOT / FOT MOWG Meeting Action Items



Action Items Captured

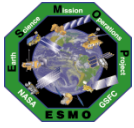
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| Update OMI OA and constraint database (for rescheduling within 6 vs. 3 orbits) | IOT |
| Draft Safe / Survival Mode Standard Operating Procedures (SOPs) | FOT / IOT |
| FOT to share CCD trending data with IOT for further analysis | FOT / IOT |
| Prepare for maneuver demonstration using reaction wheels (Fall 2017) | FOT / IOT |



Summary

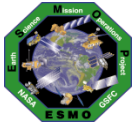


**The Mission Operations Teams
(spacecraft and instruments)
are dedicated to keeping Aura
operational as long as possible**



***Thank you for your attention.
Dank je wel
Kiitos***

Questions?



Abbreviations / Acronyms List



| | | | | | |
|---------------|---|-----------------|--|---------------|--|
| ARE – | Array Regulator Electronics | HIRDLS – | High Resolution Dynamics Limb Sounder | ORR – | Operational Readiness Review |
| CA – | Conjunction Assessment | HK - | Housekeeping | PROP - | Propulsion |
| CARA – | Conjunction Assessment Risk Analysis | HQ - | Headquarters | Pc – | Probability of Collision |
| CCD - | Charge Coupled Device | IAM – | Inclination Adjustment Maneuver or Interface Adapter Module | PLL – | Phased Locked Loop |
| CDH – | Command & Data Handling | ICS – | Interferometer Control System | R2 – | Receiver 2 |
| COTS - | Commercial-off-the-Shelf | IOT - | Instrument Operations Team | RHEL – | Red Hat Enterprise Linux |
| CRMS – | Collision Risk Management System | IT - | Information Technology | RMM – | Risk Mitigation Maneuver |
| DAM – | Debris Avoidance Maneuver | kg - | kilogram | RW – | Reaction Wheel |
| DAS – | Debris Assessment Software | km – | kilometer | RWA – | Reaction Wheel Assembly |
| DMUM – | Drag Make-up Maneuver | KNMI - | Royal Netherlands Meteorological Institute | SC - | Spacecraft |
| EA – | EOS Automation | KSC - | Kennedy Space Center | SOP - | Standard Operating Procedure |
| EOS – | Earth Observing System | L0 – | Level-Zero | SSR – | Solid State Recorder |
| EPS – | Electrical Power System | MD - | Mission Director | TBD – | To Be Determined |
| ESC – | Earth Science Constellation | MLS – | Microwave Limb Sounder | TCS – | Thermal Control System |
| ESMO – | Earth Science Mission Operations | MMOD – | Micrometeorite Orbital Debris | TES – | Tropospheric Emissions Spectrometer |
| FDS – | Flight Dynamics System | MMS – | Mission Management System | THz - | Terahertz |
| FMU – | Formatter Multiplexer Unit | MOWG – | Mission Operations Working Group | | |
| FOT – | Flight Operations Team | NASA – | National Aeronautics & Space Administration | | |
| FSM - | Flight Systems Manager | NGAS - | Northrup Grumman Aerospace Systems | | |
| FSW – | Flight Software | OA - | Operations Agreement | | |
| FY – | Fiscal Year | OMI – | Ozone Monitoring Instrument | | |
| GMT – | Greenwich Mean Time | | | | |
| GNC – | Guidance Navigation & Control | | | | |
| GSFC – | Goddard Space Flight Center | | | | |
| HIE – | High Interest Event | | | | |