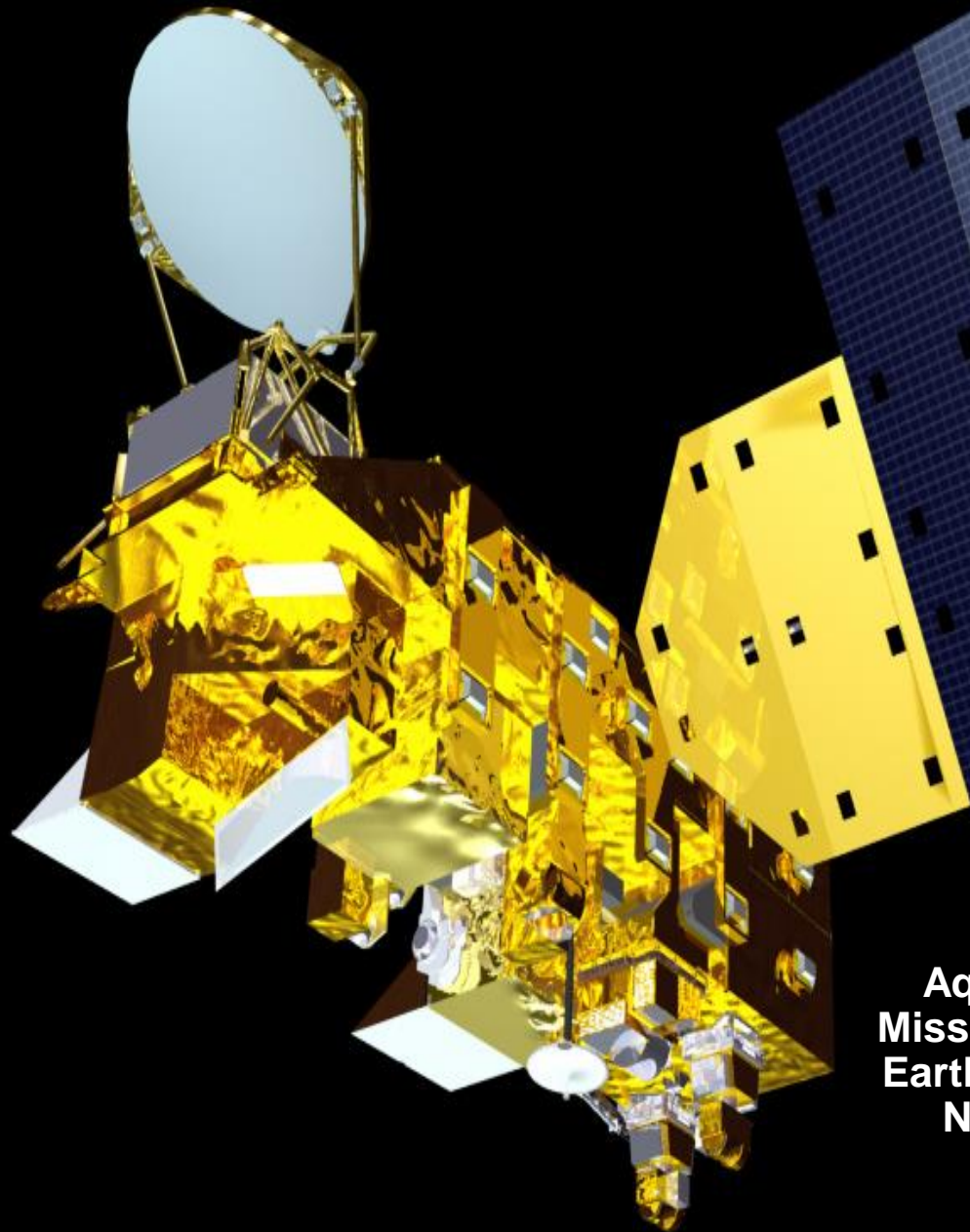


EOS Aqua



**Mission Status
at the
Earth Science
Constellation (ESC)
Mission Operations
Working Group
(MOWG) Meeting
at the Kennedy
Space Center (KSC)**

December 6, 2017

Bill Guit

**Aqua Mission Director - Code 584/428
Mission Validation and Operations Branch
Earth Science Mission Operations Project
NASA/Goddard Space Flight Center**

William.J.Guit@nasa.gov



Topics



- **Mission Summary**
- **Spacecraft Subsystems Summary**
- **Recent and Planned Activities & Process Improvements**
- **Inclination Adjust Maneuvers**
 - Spring 2018 Calendar – **FINAL**
 - Long-Term Plan – NO CHANGES (see Flight Dynamics Presentations)
- **Propellant Usage & Lifetime Estimate**
- **End of Mission Plan**
- **Mission Summary**
- **Additional Slides:**
 - Orbit Maintenance Maneuvers
 - Conjunction Assessment High Interest Events
 - Ground Track Error & Mean Local Time History
 - Spacecraft Orbital Parameters Trends & Predictions

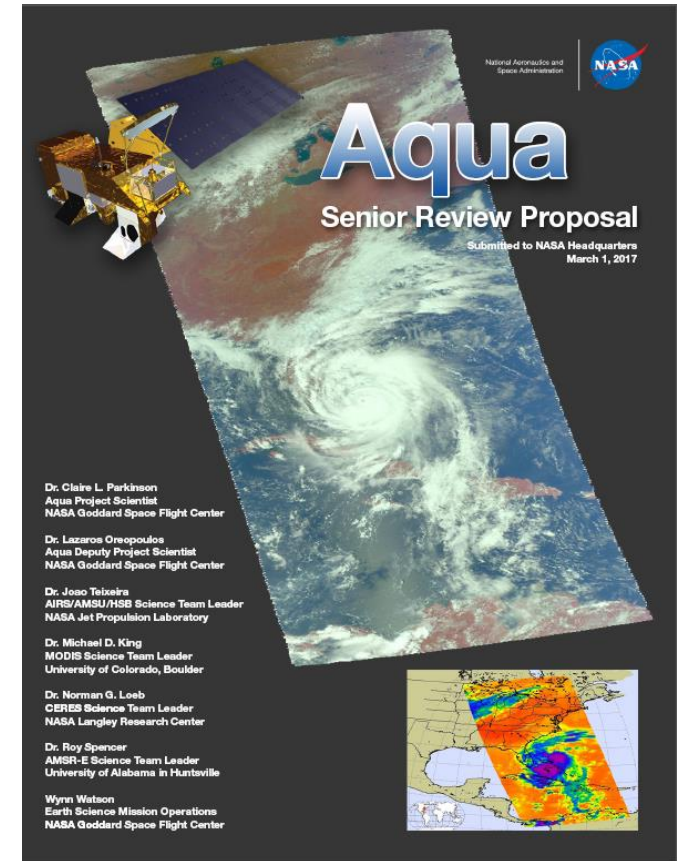


EOS Aqua Mission Summary

(Updates since June 2017 MOWG Meeting at GSFC in Greenbelt, MD are in blue text)



- **05/04/2002: Launch**
 - 6-Year Design Life
- **12/02/2008: End of Prime Mission Review**
- **12/08/2015: End of AMSR-E Operations**
- **11/17/2016: A-Train PS Teleconference**
- **01/25/2017: ESMO Annual Review #10**
- **03/03/2017: Senior Review Proposal #6**
 - Reliability Estimates thru 2025
 - Consumables through 2022
 - Potential After the A-Train Extended Mission
- **05/04/2017: Aqua 15-Year Anniversary**
- **06/22/2017: NASA Earth Science Senior Review Subcommittee Report – 2017**
 - Continue as baselined
 - Subcommittee recommended to continue at least through FY23 (Awaiting HQ Guidance)





Aqua Spacecraft Subsystems



All subsystems configured to primary hardware

Changes since June 2017 MOWG Meeting are in blue

- **Command & Data Handling (CDH) – Nominal**
 - Solid State Recorder (SSR) – only holds 2 orbits of data
 - SSR Ops Error Anomaly (12/2/2007) – fully recovered 1/28/2009
- **Communications (COMM) – Nominal**
- **Electrical Power System (EPS) – Nominal**
 - Array Regulator Electronics (ARE) 4A: 9/9/2004 – self-recovered – stable for 5+ years
 - » Re-occurred 1/11/2010 and 7/18/2013 (2 strings)
 - ARE-1C: 11/8/2010 (1 string) and ARE-3A: 2/14/2012 (1 string)
 - ARE-6C: 10/20/2011 – Numerous power drops/current fluctuations – last on 11/4/2015 (6 strings)
 - ARE-4C: 4/26/2015 – Power drop, current fluctuations 8/21/2016-11/15/2016 **and 7/17/2017** (2 strings)
 - ARE-5C: 5/3/2016 – Power drop, partial recovery on 6/17/2016 (1 string)
 - **Summary: Estimated that Aqua has lost 13 strings of solar cells out of a total of 132 strings**
 - » **Aqua continues to have significant power margin where the life limiting item is fuel**
 - Battery Cell Anomaly (9/2/2005)
 - Solar Array (SA) Panel #8 Thermistor #6 Failure (8/3/2009)
 - Solar Array (SA) Offset (Reported 11/17/09, Corrected 6/29/2010)
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
- **Propulsion (PROP) – Nominal**
 - Dual Thruster Module (DTM-2) Heater Anomaly (9/8/2007)
- **Thermal Control System (TCS) – Nominal**



Recent Spacecraft Activities

(June 2017 – 11/30/2017)



- **6 CARA High Interest Orbital Debris Events (HIEs):** see charts 19-21
 - 3 that required significant action
 - » 3 RMM/DAMs PLANNED – 3 SELF-MITIGATED – 0 EXECUTED
 - 0 Planned routine DMUMs postponed/replanned and/or rescheduled
- **1 Spacecraft Bus Anomaly: Ongoing loss of solar array (SA) strings**
 - 07/17/2017: ARE-4C Power drop and current fluctuations
- **0 Instrument Anomalies:**
- **6 Spacecraft Delta-V Maneuvers:**
 - 6 Routine Drag Make-Up Maneuvers (DMUMs):
 - » 2017: 6/28 (#119), 7/27 (#120), 8/23 (#121), 9/22 (#122), 10/18 (#123) and 11/8 (#124) – NEXT 12/13 (#125)
 - » All performed without yaw slews
 - 0 Inclination Adjust Maneuvers (IAMs)
 - 0 Debris Avoidance Maneuvers (DAMs)
- **7 Instrument Calibration Maneuvers:**
 - Monthly MODIS Lunar Calibrations



Ongoing Process Improvements



- **Aqua/Aura Maneuver Working Group: Reestablished in May 2016**
 - Develop retrograde maneuver capability for use during operational mission
 - Develop more fuel-efficient propulsive maneuvers
 - » Constellation exit retrograde maneuvers using reaction wheels and thrusters
 - » IAMs using reaction wheels for spacecraft attitude reorientation
- **EOS Automation (EA): Critical Design Review (CDR) 2/2013**
 - Phase II (S/C H&S Monitoring): CDR 1/29/2014, Delivery 2/2/2015
 - Phase II: R2.6.1 Development & Testing 9/1/2015 – 12/16/2016
 - Phase II: R2.7 Operations Readiness Review (ORR) 8/3/2017
 - Phase III (S/C Commanding and Contact Execution): CDR 10/5/2017
 - Phase III: ORR Summer 2018
- **Collision Risk Management System (CRMS)**
 - See summary on next slide
 - Additional details in Dimitrios Mantziaras presentation



Collision Risk Management System (CRMS)



- **ESMO has developed ground system capabilities to autonomously identify and develop maneuver options to assist in Risk Mitigation Maneuver (RMM) / Debris Avoidance Maneuver (DAM) planning**
- **Developed in response to an increased number of predicted close approaches with orbital debris and operational satellites (slides 21 & 22)**
 - More High Interest Events (HIEs) had led to more effort to plan mitigation maneuvers
 - Concern is that updates to the US Air Force Space Fence will significantly increase the size of the Space Catalog
- **Key CRMS capabilities include:**
 - User defined collision risk thresholds
 - Maneuver optimization to address multiple conjunctions with secondary object conjunctions including repeating conjunctions
 - Unconstrained and user defined constrained maneuver options
- **EOC is currently operating with CRMS Release 5.2 (ORR 06/22/2017)**
 - Patch allows for data retrieval of JSpOC and/or CARA generated CDMs



Planned Activities

(2018)



- **January 2018: Flight Operations Annual Review (#11)**
- **Spring 2018: Annual Inclination Adjust Maneuvers**
 - 3/1 (#56), 3/8 (#57), 3/15 (#58), 3/29 (#59) & 4/12 (#60) **Plus Backup 4/19**
- **Spring 2018: Aqua Decommissioning Review (DRAFT)**
 - Document Phase F spacecraft activities, any new products to be developed for spacecraft / instrument calibration, proposed Engineering Tests, and Passivation Sequence
- **June 5-7, 2018: ESC/A-Train MOWG Meeting in Sioux Falls, SD**
 - DRAFT 2019 Inclination Adjust Maneuver Schedule
- **July 2018: DRAFT 2018 Aqua Decommissioning & Lifetime Analysis**
- **October 2018: FINAL Aqua Decommissioning & Lifetime Analysis**
- **December 2018: ESC/A-Train MOWG Meeting**
 - Update propellant budget and decommissioning analysis
 - FINAL 2019 Inclination Adjust Maneuver Schedule
- **Late 2018: Updated End of Mission Plan (if necessary)**



Planned Activities

(Mid-to-Long-Term)



- **Aqua/Aura Maneuver Working Group**
 - Adopt experience and lessons learned on Aura for Aqua
 - Targeting Aqua 2019 IAMs for using reaction wheels to perform the spacecraft attitude reorientation necessary to align the spacecraft thrusters to perform the inclination adjust
- **EOS Automation (EA) – automation of routine operations**
 - EA Phase III – ORR Summer 2018
- **Continue to improve DAM planning and execution process**
 - CRMS: Full automation end-to-end, identification-to-approval 24x7
- **Possible Re-fueling Mission**



FINAL Spring 2018 Aqua/Aura Inclination Adjust Plan



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
18 Feb	19	20	21	22	23	24
25	26	27	28 Aura IAM #53	1 March Aqua IAM #56	2	3
4	5	6	7 Aura IAM #54	8 Aqua IAM #57	9	10
11	12	13	14 Aura IAM #55	15 Aqua IAM #58	16	17
18	19	20 Equinox	21 Spring Break	22 Spring Break Aqua Ideal Date (ID)	23	24
25	26	27 Aura ID	28 Aura IAM #56	29 Aqua IAM #59	30	31
1 April Easter	2	3	4 Easter Break	5 Easter Break	6	7
8	9	10	11 Aura IAM #57	12 Aqua IAM #60	13	14
15	16	17	18 Aura Back-up	19 Aqua Back-up	20	21
22	23	24	25	26	27	28
29	Golden Week in Japan					



Aqua Propellant Usage

(November 2017)



KEY: Updates since last MOWG Meeting in blue

- **2006: Initial Aqua lifetime fuel analysis**
- **2008: Detailed Aqua & Aura lifetime analyses**
 - Presented to A-Train MOWG and at Aqua EOPM Review
- **September 2012: Initial Aqua Decommissioning Plan**
 - Updated Lifetime Estimates
- **August 29, 2013: Updated Decommissioning Plan**
 - Updated Constellation Exit Plan
- **September 30, 2014: Updated Decommissioning Plan**
 - Updated definitive fuel usage and predicted solar flux levels
 - Updated propellant trends for IAMs & DMUMs
- **September 2015 Delayed to allow additional time to evaluate long-term plan and decommissioning maneuvers**
- **Summer 2016: Investigated more fuel efficient inclination adjust and retrograde maneuver options and various options for extending operations into mid-2020ies**
- **December 16, 2016: Updated Decommissioning Plan (V1.1)**
 - Updated definitive fuel usage & predicted solar flux levels
 - Updated propellant estimates for IAMs & DMUMs
- **November 13, 2017: Updated Decommissioning Plan (V1.1)**
 - Updated definitive fuel usage & predicted solar flux levels
 - Updated propellant estimates for IAMs & DMUMs
- **Annual updates will be provided each July (started in 2017)**
 - Final will be produced 60 days before start of decommissioning

FDSS II
Flight Dynamics Support Services II
FDSS-II-07-00XX
CONTRACT # NNG14VC09C

FDSS-II
Task Order 07
Earth Observing System Flight Dynamics System
(EOS FDS)
Updated Analysis for Aqua Decommissioning
Version 1.1
Issue Date: 13 November 2017
Prepared by:
Spencer Boone

Omitron, Inc.
7051-A Muirkirk Meadows
Beltsville, MD 20705



Aqua Remaining Fuel Estimate

(November 2017)

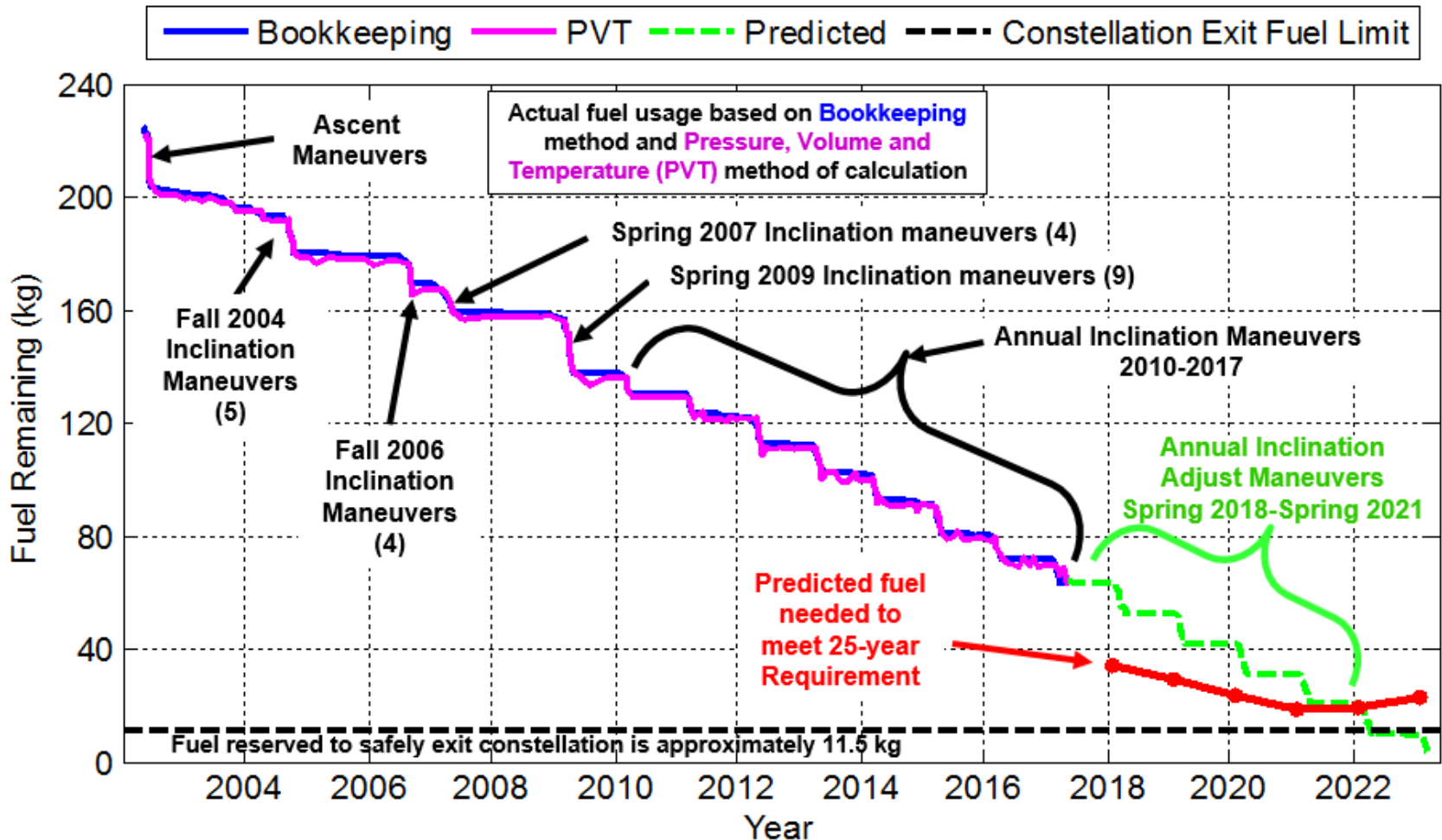


KEY: Updates since last MOWG Meeting in blue

- **Long-term orbit simulations were run for Aqua through 2023**
 - Used mean nominal Schatten solar flux predictions (March 2017)
 - Estimated the frequency of drag make-up maneuvers (DMUMs) to maintain Aqua's WRS-2 ground track requirements
 - Estimated the required number of annual inclination maneuvers (IAMs) for Aqua to maintain its mean local time (MLT) requirement
 - Did not include potential debris avoidance maneuvers
 - Utilized FreeFlyer 6.7.2 which incorporated the solid earth tide model allowing greater accuracy for long term predictions of inclination, beta angle, and mean local time
- **Lifetime predictions for Aqua shows that the spacecraft will have sufficient fuel to maintain its current orbit within the Afternoon Constellation through the 2021 inclination adjust series of maneuvers.**
- **Exit from the constellation in March 2022 will be into a new operational orbit, not the decommissioning and passivation orbit, approximately 4.4 km below the current ESC/A-Train operational orbit.**
- **Currently investigating various options to extend the potential Aqua mission life out into the 2025 time frame and possibly beyond.**
- **BOTTOM LINE: Aqua will hold sufficient fuel in reserve after exiting the constellation to lower perigee such that its reentry will meet the NASA 25-year reentry requirement.**



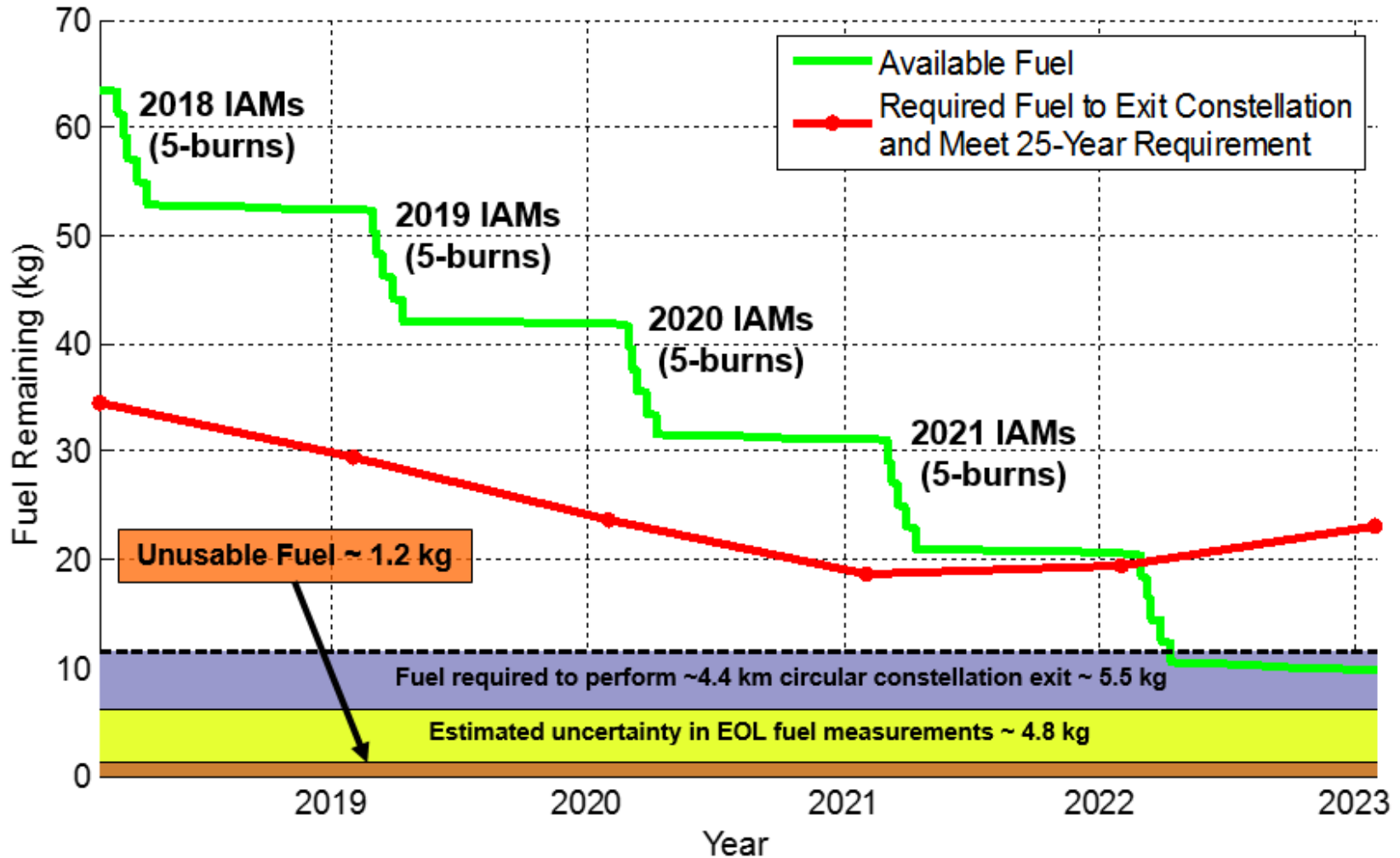
Fuel Usage: Actual & Predicted (November 2017)





Fuel Usage:

Predicted Available & Required (November 2017)





Debris Assessment Software

(November 2017)



KEY: Updates since last MOWG Meeting in blue

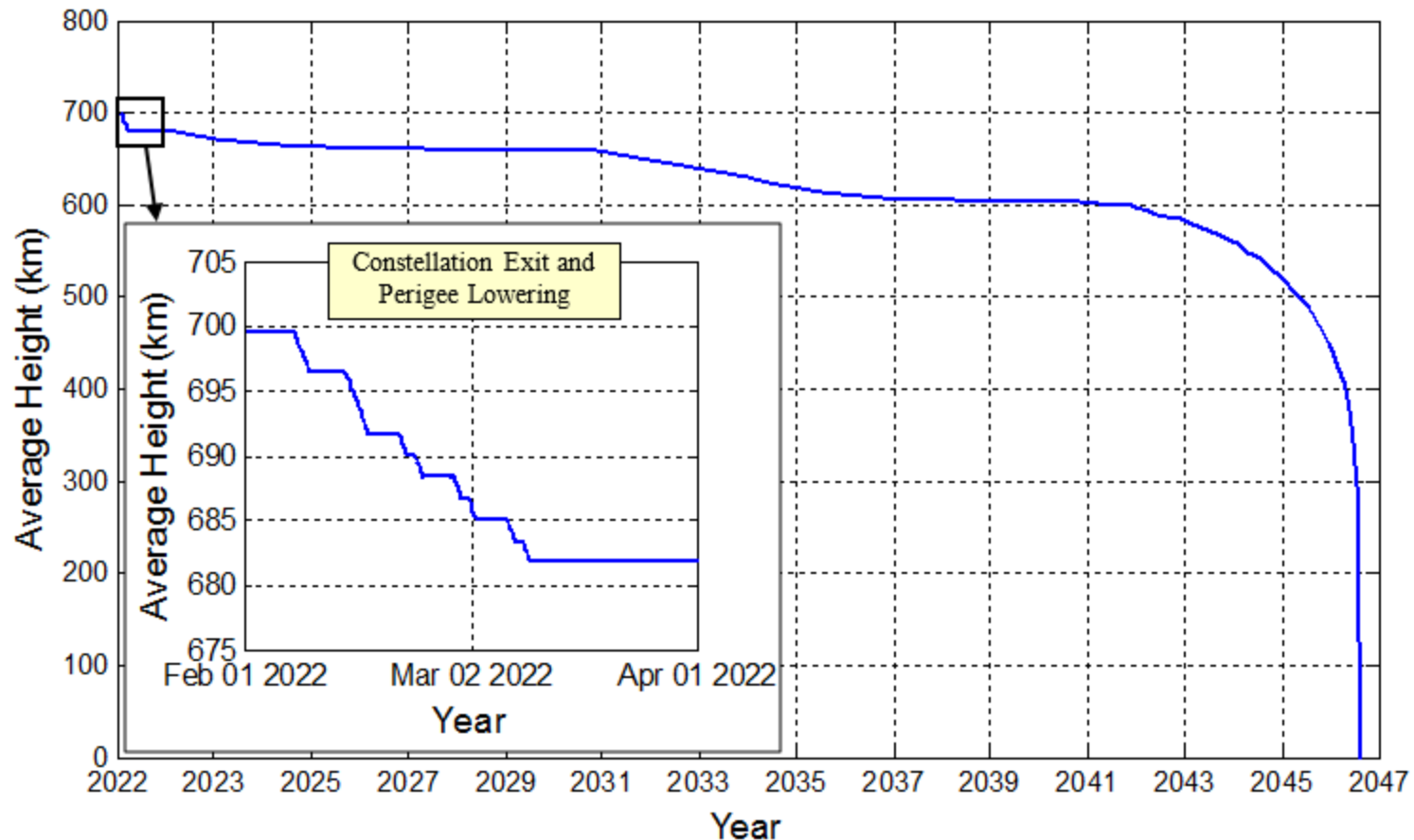
- **The Debris Assessment Software (DAS) was created by the Orbital Debris Office in Johnson Space Center and is the Agency standard for end of mission life analyses and lifetime estimations. (Current Version **2.1.1**)**
- **DAS requires several inputs describing the spacecraft's mission:**
 - Launch date = 05/04/2002
 - Start inclination = 98.2°
 - Tumbling Area = 47.80 m² (FDSS-II-07-0084 Aqua Average Area Version 1.0 Dated 28Feb2017)
 - Spacecraft dry mass = 2854.6 kg (includes 1.2 kg of unusable fuel and 4.8 kg of uncertainty)
 - Area to Mass Ratio = 0.01671 m²/kg = Tumbling Area/(Dry Mass + unusable + uncertainty)
 - Start Apogee (Average Height) of orbit after constellation exit (early-February 2022) = **~696 km**
 - Start Perigee of orbit after final perigee lowering burn (early-March 2022) = **678 km**
- **DAS outputs:**
 - If the mission is compliant with NASA requirements for limiting orbital debris.
 - A recommended apogee and perigee that will allow the spacecraft to reenter within a specific period and satisfy the NASA requirements.
- **Aqua has a waiver to the 30-years from launch requirement.**
- **Aqua will hold sufficient fuel in reserve to meet the 25-year requirement.**



Aqua Orbital Decay



With A-Train Exit and perigee lowering in early 2022, Aqua is predicted to reenter within the required 25-year Agency & International requirement.



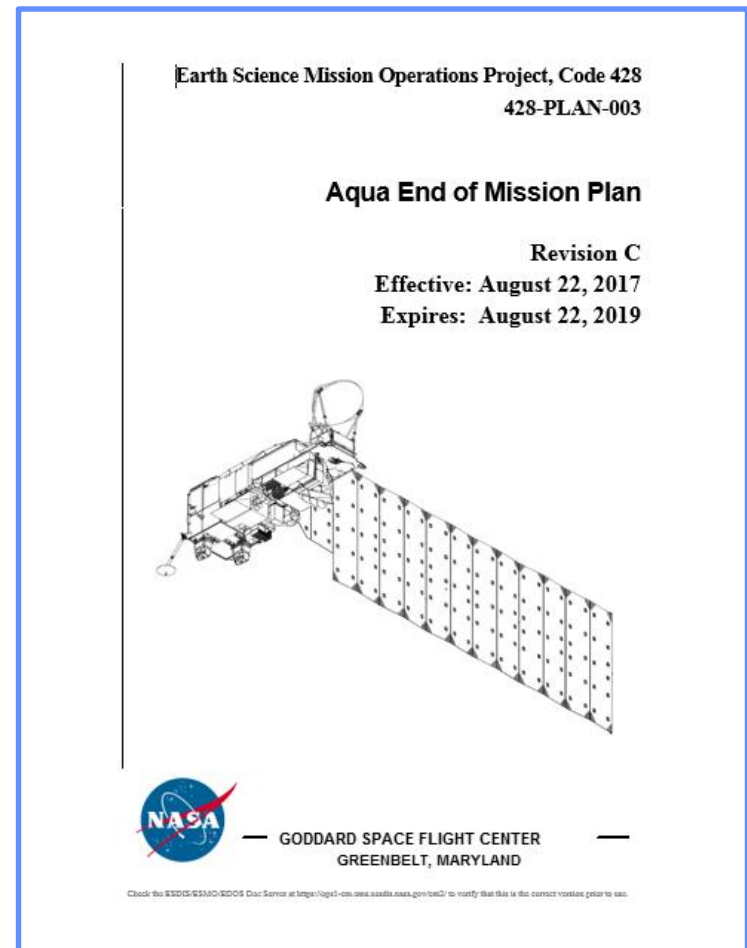


Aqua End of Mission Plan



KEY: Updates since last MOWG Meeting in blue

- **Initial draft February 2009**
- **“Interim” End of Mission Plan: May 2011**
 - Approved by NASA HQ July 2011
- **End of Mission Plan (Rev A): February 2013**
 - Updated Lifetime Estimates (09/2012)
 - Added Small Object Collision Assessment
- **End of Mission Plan (Rev B): June 2015**
 - Safely exit the A-Train Constellation (19 km)
 - Passivate to the extent possible for uncontrolled reentry
 - Aqua has five (5) approved waivers for passivation
 - » Pressurant Passivation
 - » Large Object Collision Probability
 - » Small Object Collision Probability
 - » Orbital Lifetime (30-Year)
 - » Re-entry Risk (Un-controlled)
 - **Waivers were approved in May 2013**
- **End of Mission Plan (Rev C): August 2017**
 - Latest Annual Lifetime Estimate
 - Includes ~4.4 km exit from A-Train in early 2022
 - Retrograde maneuver slews on reaction wheels
 - Currently in FINAL Signature cycle
- **Final produced 60 days before End of Mission**





Summary



KEY: Updates since last MOWG Meeting in blue

- **Spacecraft Status - GREEN**
- **Instrument Status - GREEN**
 - **AIRS, AMSU, CERES & MODIS:**
 - » AIRS, CERES and MODIS: Nominal Operations
 - » 09/24/2016: AMSU-A2 Anomaly – currently no further recovery attempts are planned
 - » 01/31/2017: JPL AMSU-A2 Anomaly Closeout Review
 - **HSB: Survival Mode since 2/5/2003**
 - **AMSR-E: Powered Down 03/03/2016**
- **Data Capture/L0 Processing Status – GREEN**
 - **SSR Data Capture November 2017: 100%**
 - **SSR Data Capture to 11/30/2017: 99.97897%**
- **Data Latency – Excellent**
- **Ground Systems – Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required**
 - **Automation Effort: CDR 2/2013, Phase II CDR 1/29/2014, Delivery 2/2/2015**
 - **EOS Automation (EA) 2.7: Phase 2 operational as of 8/7/2017**
 - **EA Phase 3: CDR 10/5/2017, ORR Summer 2018**



Additional Slides

**Orbit Maintenance Maneuvers
Conjunction Assessment High Interest Events
Ground Track Error & Mean Local Time History
Spacecraft Orbital Parameters Trends & Predictions**



Orbit Maintenance



KEY: Updates since last MOWG Meeting in blue

- **Mission Requirement: Perform Drag Make-Up Maneuvers (DMUMs) to maintain Aqua's ground track error (GTE) with respect to the World Reference System (WRS-2) within +/-10 Km at the Descending Node**
 - Changed from +/-20 Km with DMUM #19 (1/12/05)
 - 124 DMUMs have been performed to date (Last #124 on 11/8/2017, Next #125: 12/13/2017)
 - Variation in performance from -20.9% (cold) to +24% (hot) #108 was 20.9% COLD
- **Control Box Excursions: Since 2012 there have been 6 Control box Excursions**
 - 4 on +10km front-side: 11/4/12 to 11/14/12, 10/23/13 to 10/24/13 and 3/6/14 to 3/10/14
 - » 03/16/2015 to 04/02/2015
 - 2 on -10km back-side: 11/07/13 to 12/14/13 (Emergency DAM on 10/24 and DAM on 11/28)
 - » 04/02/2016 to 05/07/2016
- **Mission Requirement: Perform inclination adjust maneuvers (IAMs) to maintain the Mean Local Time (MLT) as measured at the Ascending Node between 1:30 and 1:45 MLT (Mission Goal starting in 2011: 13:35:45 +/- 45 seconds)**
 - **55 Inclination Adjustment Maneuvers (IAMs) performed to date**
 - » Fall 2003 (1), Spring 2004 (1), Fall 2004 (5), 2005 (NONE)
 - » Fall 2006 (4 of 6 - cancelled final 2 burns), Spring 2007 (4 - interrupted 2-weeks),
 - » Spring 2008 – NONE per special request from PARASOL
 - » Spring 2009 (9), Spring 2010 (3), Spring 2011 (3), Spring 2012 (4)
 - » Spring 2013 (4 with #3 being delayed 1-week), Spring 2014 (4), Spring 2015 (5)
 - » Spring 2016 (all 4 IAMs completed, one had to be re-scheduled), Spring 2017 (4)
 - » Spring 2018: 3/1 (#56), 3/8 (#57), 3/15 (#58), break, 3/29 (#59), break and 4/12 (#60)



Aqua Conjunction Assessment High Interest Events (HIEs)



KEY: Updates since last MOWG Meeting in blue

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2017	1	2	1	0	0	0	3	0	2	2			11
Tier 1	1	1	0	0	0	0	3	0	0	0			5
Tier 2	0	0	0	0	0	0	0	0	1	1			2
Tier 3	0	1	1	0	0	0	0	0	1	1			4
Tier 4	0	0	0	0	0	0	0	0	0	0			0

2013: 28 CARA HIEs – 9 required significant action
 2014: 34 CARA HIEs – 14 required significant action
 2015: 26 CARA HIEs – 16 required significant action
 2016: 21 CARA HIEs – 4 required significant action

**Tier 1 – Notify (email/phone), Tier 2 – Conduct Briefing,
 Tier 3 – Plan Maneuver, Tier 4 – Execute Maneuver**

2017 thru 10/30/2017: (11 CARA HIEs – 4 that required significant action (Tiers 3 & 4)

- 02/26/2017: CA vs. 81514 at 13:55:27 GMT – DAMs planned & approved, new tracking dropped risk (T3)
- 03/04/2017: CA vs. 33503 at 10:48:40 GMT – DAMs planned, self-mitigated (T3)
- 09/02/2017: CA vs. 82112 at 18:24:15 GMT – DAMs planned, self-mitigated (T3)
- 09/07/2017: CA vs. 37494 at 09:47:44 GMT – DAMs planned as part of DMUM replan, self-mitigated (T2)
- 10/16/2017: CA vs. 26294 at 15:33:42 GMT – DAMs planned, self-mitigated (T3)

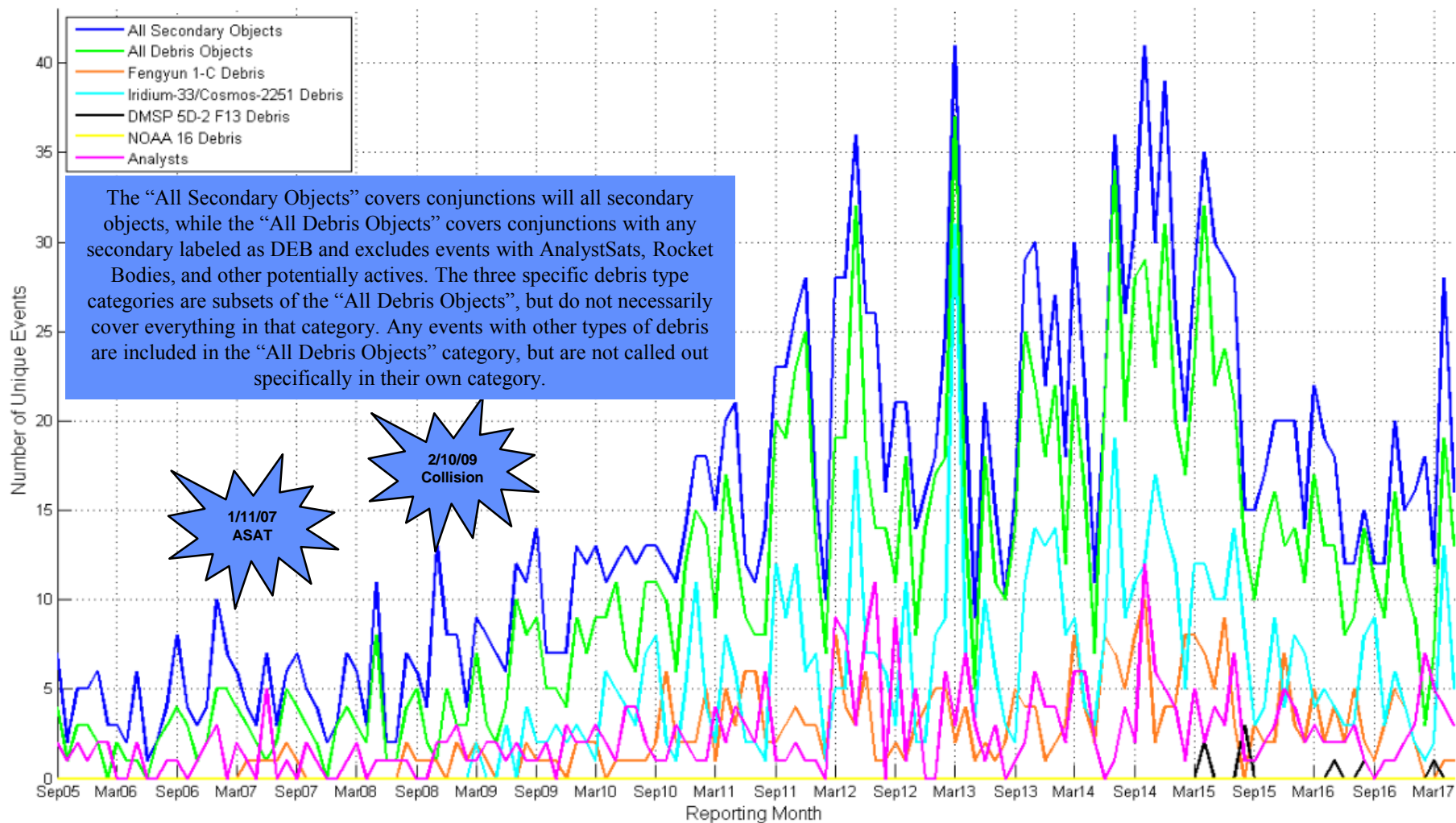
**2017 Aqua Summary: 5 DAM Planned, 0 DAMs Executed, 5 DAM that self-mitigated
 0 Routine maneuvers were postponed/replanned and/or rescheduled (Tier 4s)**



Aqua Conjunction Assessment Statistics



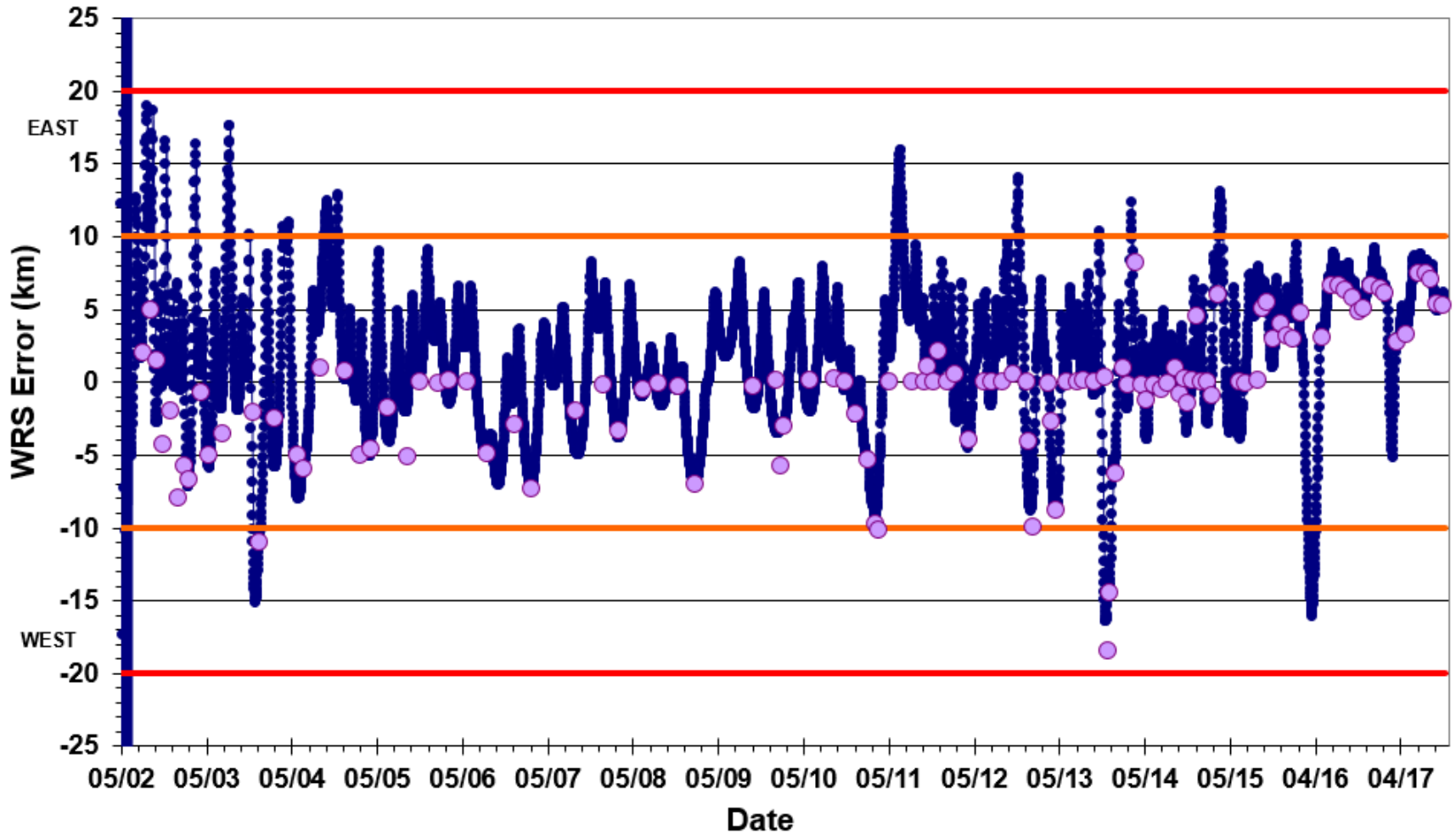
(September 2005 thru June 2016)





WRS Ground Track Error (GTE)

(As of November 11, 2017)

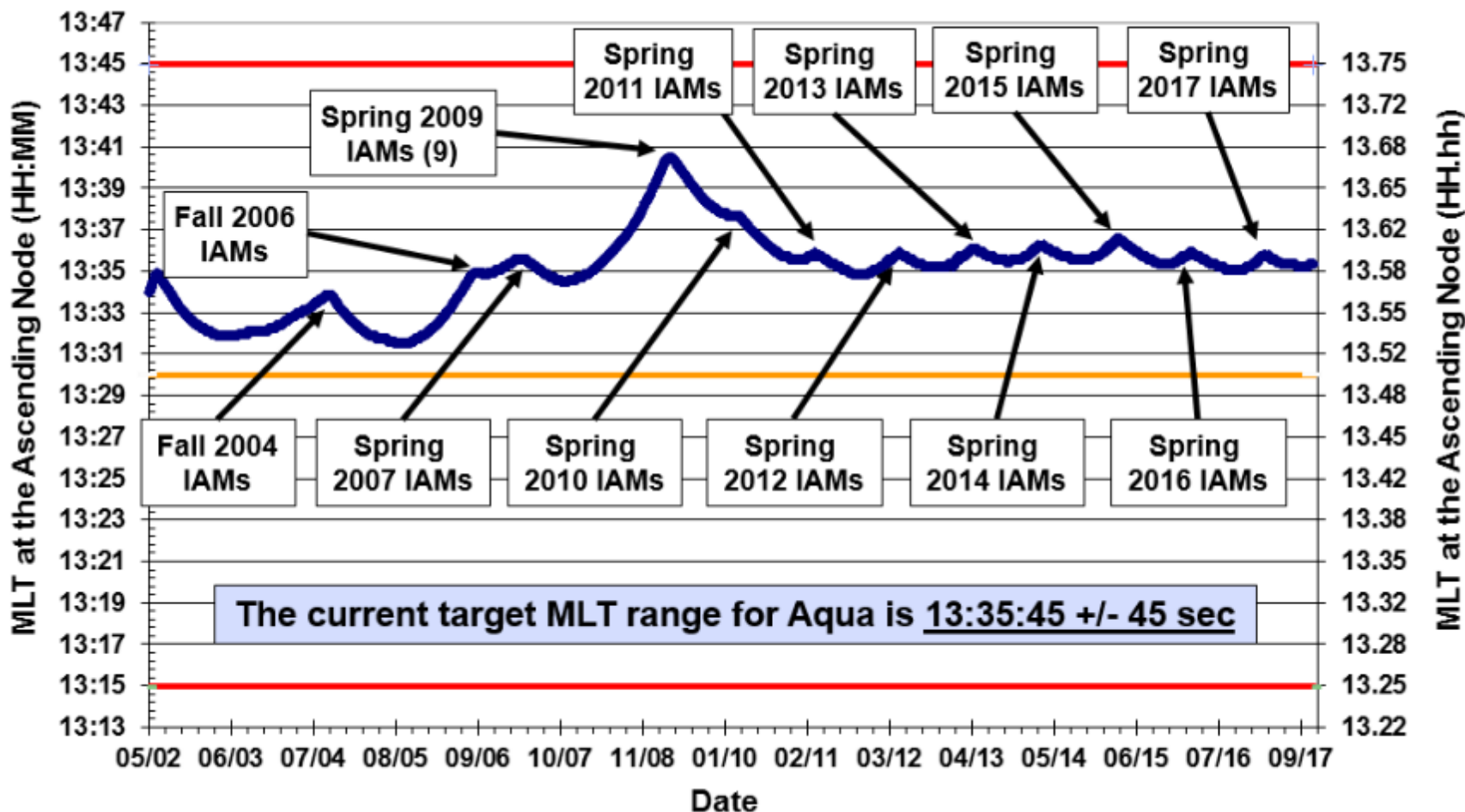




Aqua Averaged MLT

@ Ascending Node

(As of November 11, 2017)



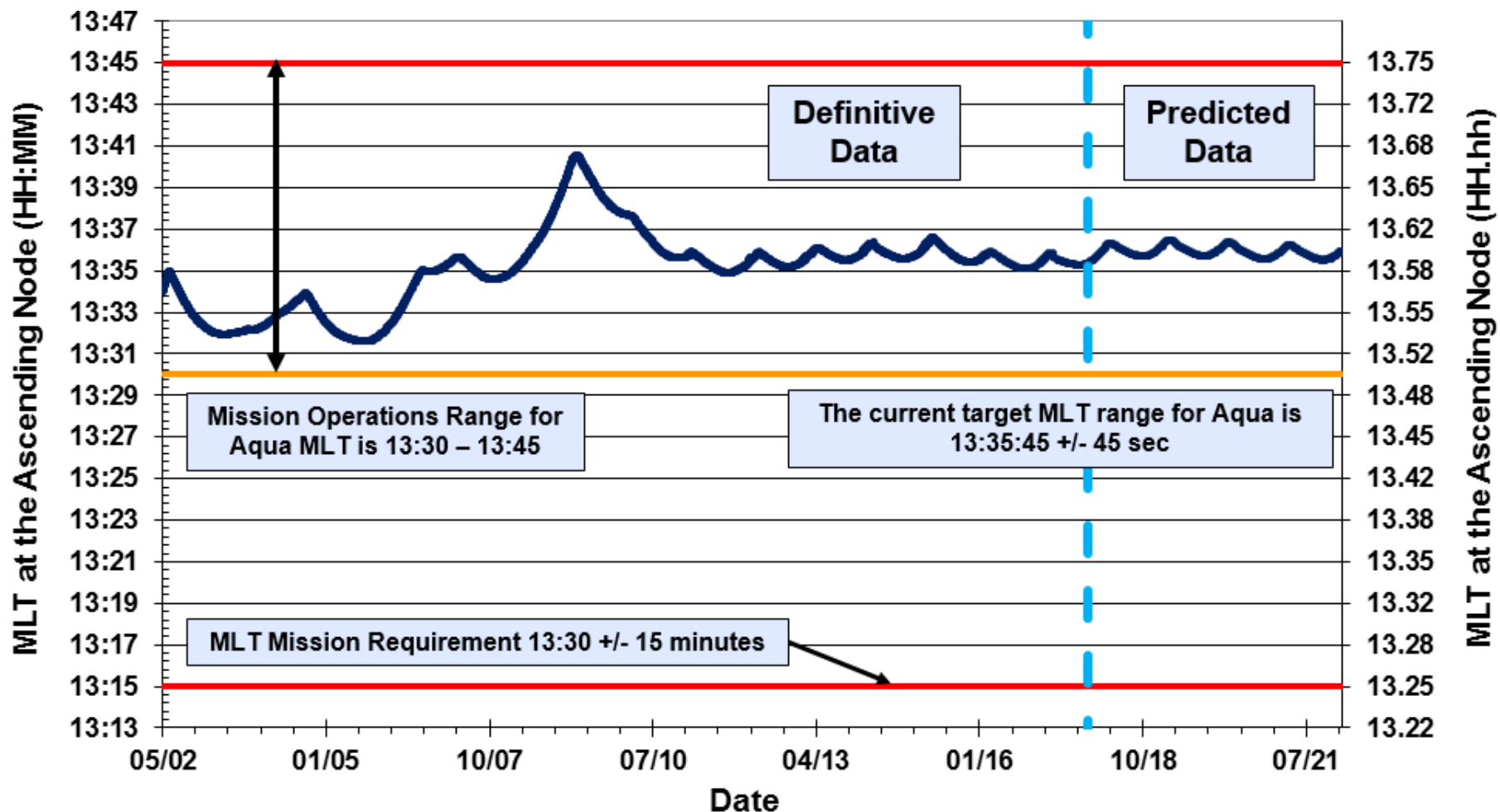


Aqua Definitive & Predictive MLT

@ Ascending Node



(As of November 11, 2017)





Inclination/MLT Maintenance

(May 2017)



KEY: Updates since last MOWG Meeting in blue

- **EOS Flight Dynamics has analyzed and updated the nominal inclination schedule that ensures Aqua's mean local time of the ascending node (MLTAN) remains within the current target range.**
 - The current target MLTAN range for Aqua is 13:35:45 +/- 45 sec.
 - Aqua's current mission MLTAN requirements are {13:30:00 - 13:45:00}
 - Aqua's performance for the 2017 inclination series was -0.64% (COLD)
- **Proposed long-term inclination adjust plan is predicted to keep Aqua within the target MLTAN range.**
 - Nominal case schedules Aqua inclination maneuvers that are not on weeks starting with Easter. The maneuvers are not currently centered around the ideal dates.
 - **Developing a more fuel-efficient Inclination Adjust Maneuver capability**
- **Will re-visit/re-validate the long-term plan after each series of annual inclination adjust maneuvers.**
- **See EOS Flight Dynamics Presentation for long-term plan.**



Inclination/MLT Maintenance (Long-Term Plan)



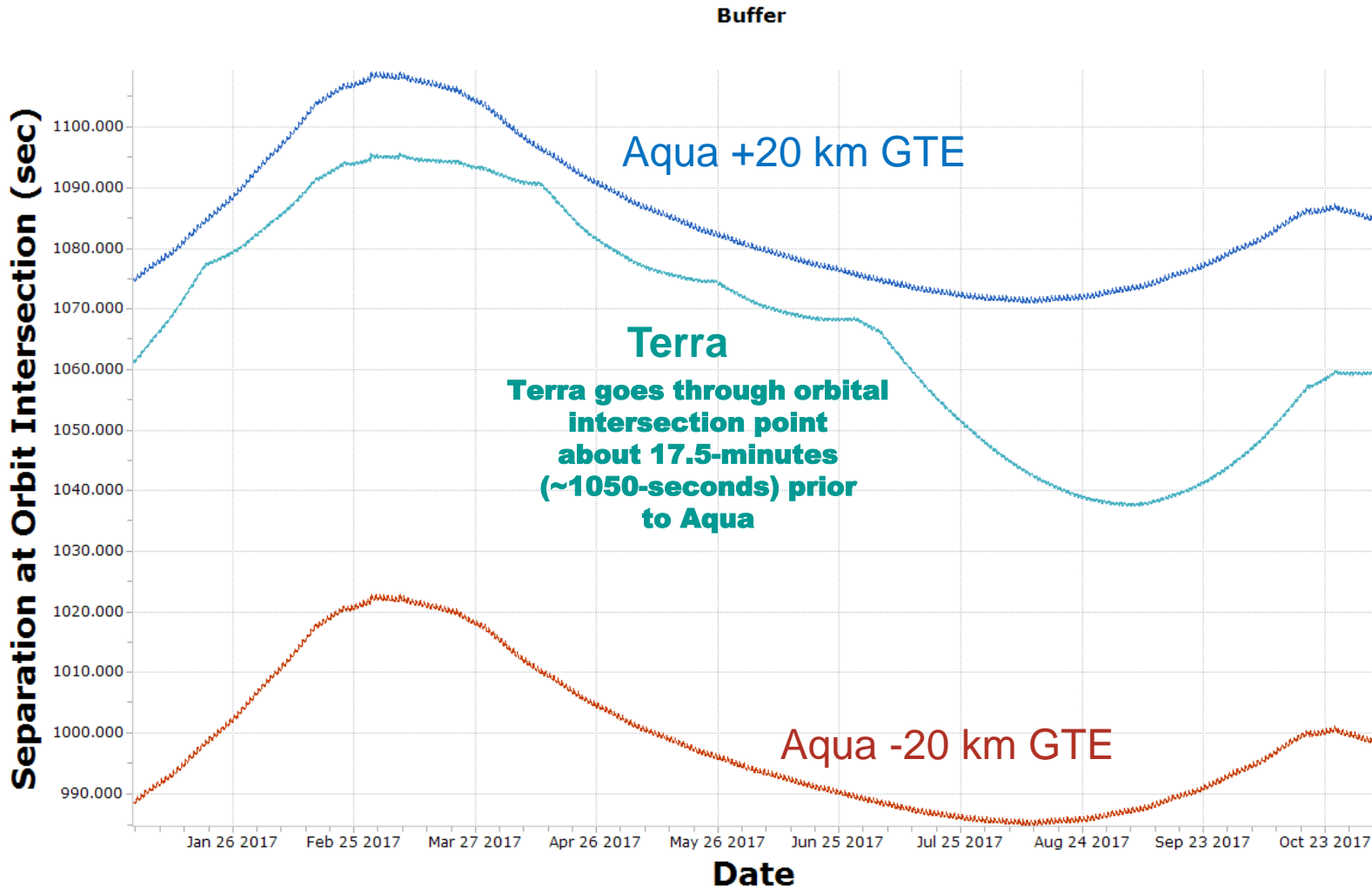
United States
 Brazil
 Canada
 Finland
 France
 Japan
 Netherlands
 United Kingdom

International Earth Science Constellation
Mission Operations Working Group
 December 6-8, 2017
Aqua/Aura Inclination Adjust Maneuver Series
Spring 2018 Planning
 Elena Trenholme, Omitron, Inc. Spencer Boone, Omitron, Inc.
 EOS FDS, esmo-eos-fds@lists.nasa.gov, +1.301.614.5050



Terra to Aqua Phasing

(as of November 11, 2017)





Questions



Abbreviations / Acronyms List



AIRS –	Atmospheric Infrared Sounder	ESMO –	Earth Science Mission Operations	NGAS –	Northrop Grumman Aerospace Systems
AMSR-E –	Advanced Microwave Scanning Radiometer for EOS	FDS –	Flight Dynamics System	NOAA –	National Oceanic and Atmospheric Administration
AMSU –	Advanced Microwave Sounding Unit	FDSS-II –	Flight Dynamics Support Services II contract	NYS –	No Yaw Slew
AN –	Ascending Node	FOT –	Flight Operations Team	ORR –	Operational Readiness Review
ARE –	Array Regulator Electronics	FSW –	Flight Software	PROP –	Propulsion
ASAT –	Anti-satellite Weapon	FY –	Fiscal Year	Pc –	Probability of Collision
CA –	Conjunction Assessment	GMT –	Greenwich Mean Time	PS –	Project Scientists
CARA –	Conjunction Assessment Risk Analysis	GNC –	Guidance Navigation & Control	RHEL –	Red Hat Enterprise Linux
CDH –	Command & Data Handling	GSFC –	Goddard Space Flight Center	RMM –	Risk Mitigation Maneuver
CDM –	Conjunction Data Message	GTE –	Ground Track Error	RWA –	Reaction Wheel Assembly
CDR –	Critical Design Review	H&S –	Health and Safety	SA –	Solar Array
CERES –	Clouds and the Earth's Radiant Energy System	HIE –	High Interest Event	SC –	Spacecraft
CNES –	Centre National d'Etudes Spatiales	HK –	Housekeeping	S/C –	Spacecraft
COTS –	Commercial Off the Shelf	HQ –	Headquarters	SSR –	Solid State Recorder
CRMS –	Collision Risk Management System	HSB –	Humidity Sounder for Brazil	TBD –	To Be Determined
DAM –	Debris Avoidance Maneuver	IAM –	Inclination Adjustment Maneuver	TCS –	Thermal Control System
DAS –	Debris Assessment Software	ID –	Ideal Date	USGS –	United States Geological Survey
DN –	Descending Node	JAXA –	Japan Aerospace Exploration Agency	WDE –	Wheel Drive Electronics
DMUM –	Drag Make-up Maneuver	JSpOC –	Joint Space Operations Center	WRS –	World Reference System
DMSP –	Defense Meteorological Satellite Program	Kg –	kilogram		
EA –	EOS Automation	km –	kilometer		
EDOS –	EOS Data Operations System	L0 –	Level-Zero		
EOC –	EOS Operations Center	MLT –	Mean Local Time		
EOL –	End of Life	MMOD –	Micrometeorite Orbital Debris		
EOMP –	End of Mission Plan	MMS –	Mission Management System		
EOPM –	End of Prime Mission	MODIS –	Moderate Resolution Imaging Spectroradiometer		
EOS –	Earth Observing System	MOWG –	Mission Operations Working Group		
EPS –	Electrical Power System	MTS –	Maneuver Trade Space		
ESC –	Earth Science Constellation	NASA –	National Aeronautics & Space Administration		