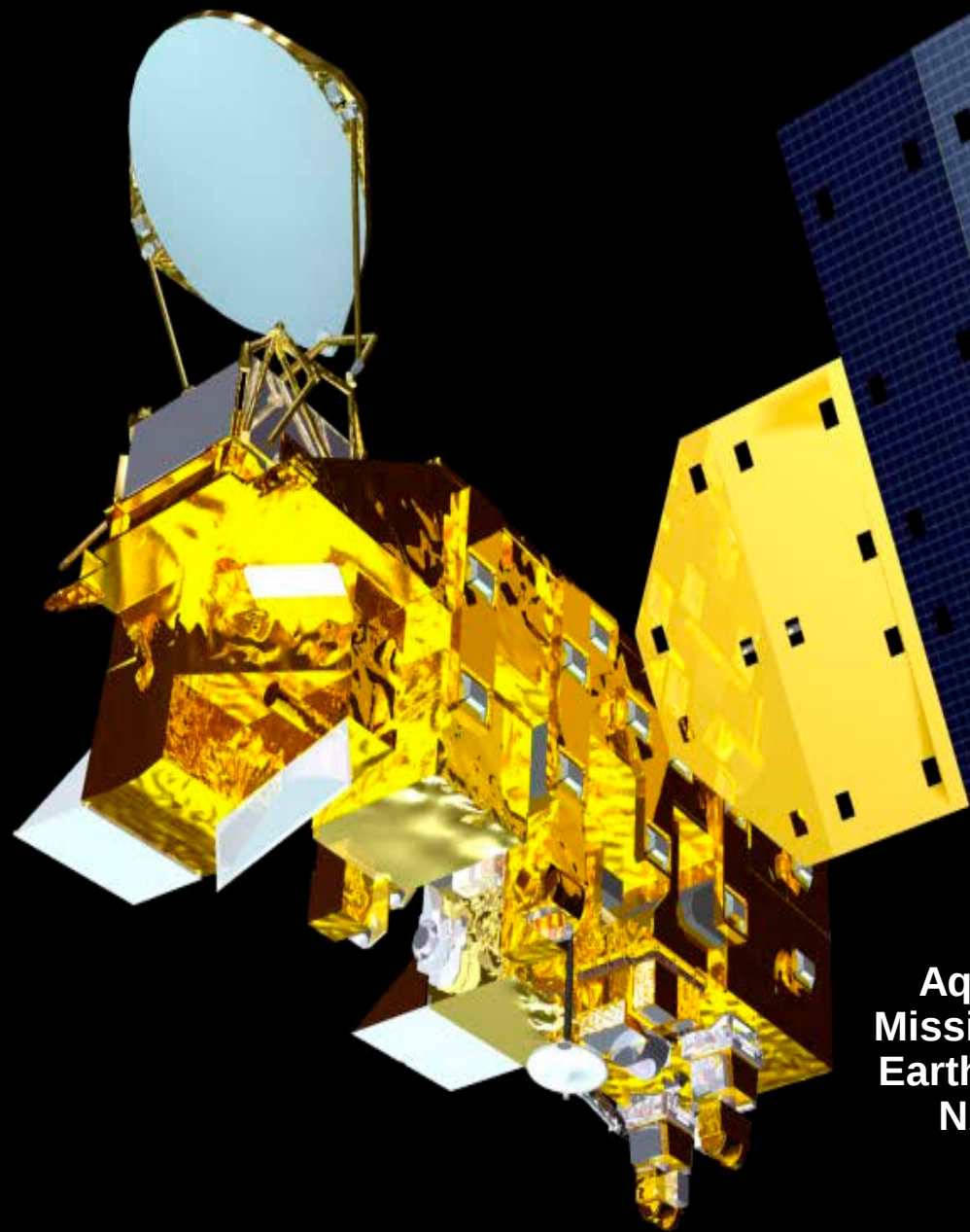


EOS Aqua



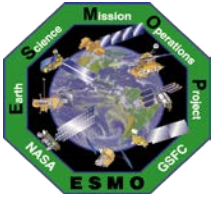
**Mission Status
at the
Earth Science
Constellation (ESC)
Mission Operations
Working Group
(MOWG) Meeting
In Gilbert, AZ**

December 3, 2019

Bill Guit

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

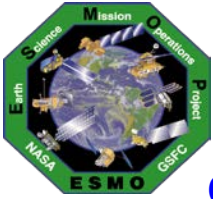
William.J.Guit@nasa.gov



Topics

Changes since June 2019 MOWG Meeting are in blue

- Mission Summary
- Spacecraft Subsystems Summary
- Recent and Planned Activities & Process Improvements
- Inclination Adjust Maneuvers
 - Spring 2020 Calendar – Slide 15 (Version 3 – 7/25/2019)
 - Long-Term Plan – see Flight Dynamics Presentations
- Propellant Usage & Lifetime Estimate
- End of Mission Plan & Orbital Decay
- After-the-A-Train Extended Mission & Decommissioning
- Summary
- Additional Slides:
 - Orbit Maintenance Maneuvers
 - Conjunction Assessment High Interest Events
 - Ground Track Error & Mean Local Time History
 - Spacecraft Orbital Parameters Trends & Predictions

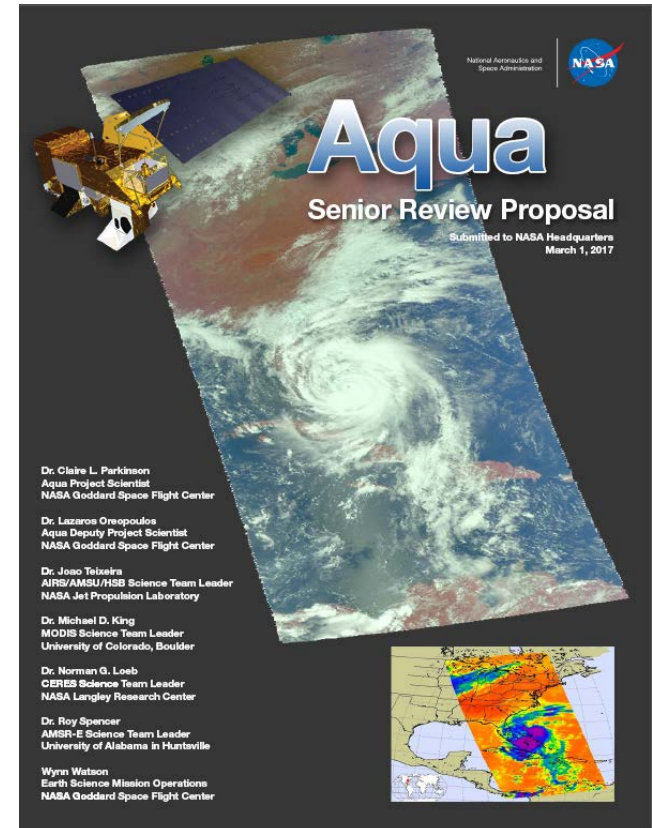


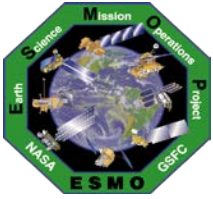
EOS Aqua Mission Summary



Changes since June 2019 MOWG Meeting in blue – None

- 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
 - Maintain tight Mean Local Time (MLT)
- 03/03/2017: Senior Review Proposal #6
 - Reliability Estimates thru 2025
 - Consumables through 2022
 - Potential After the A-Train Extended Mission
- 06/22/2017: NASA Earth Science Senior Review Subcommittee Report – 2017
 - Continue as baselined through at least FY23
- 12/21/2017: Received HQ Guidance
- 03/30/2018: Updated Aqua Phase F Plan
- 10/02/2018: Aqua Decommissioning Review
- 04/02/2019: ESMO Annual Review #12
- 05/04/2019: Aqua 17-Year Anniversary





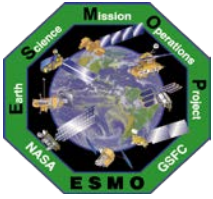
Aqua Spacecraft Subsystems

All subsystems configured to primary hardware



Changes since June 2019 MOWG Meeting in blue

- **Command & Data Handling (CDH) – Nominal** (Solid State Recorder (SSR) 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** (Numerous power drops and current fluctuations)
 - Array Regulator Electronics (ARE) 4A: 8/13/2004 – self-recovered – stable for 5+ years
 - » Re-occurred 1/11/2010 and 7/17/2013 (3 strings)
 - ARE-6C: 9/3/2010 numerous – most recent 5/29/2018 (4 strings), ARE-6A: 7/19/2012 (1 string)
 - ARE-1C: 11/7/2010 (1 string) and ARE-1A: 6/28/2011 (1 string)
 - ARE-3A: 2/15/2012 (1 string), **9/12/2019 (1 string)** and ARE-3C: 4/29/2019 (2 strings) – likely due to MMOD strike
 - ARE-4C: 4/26/2015 – Reoccurrences in 2016, 2017: 7/17 & 12/2, 2018: 2/22 & 5/19 (2 strings)
 - ARE-5C: 5/3/2016 – Partial recovery on 6/17/2016 (1 string), ARE-5A: 12/26/2017 (1 string)
 - **Summary: Estimated that Aqua has lost up to 19 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**

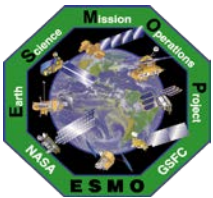


Recent Spacecraft Activities

(June 2019 – 11/30/2019)



- **7 CARA High Interest Orbital Debris Events (HIEs):** see charts 27 & 28
 - 7 Debris Avoidance Maneuvers (DAMs) PLANNED – 6 SELF-MITIGATED
 - » **1 EXECUTED (9/11)**
 - 0 Maneuvers cancelled and/or re-planned due to orbital debris concerns
- **1 Spacecraft Bus Anomaly: Ongoing solar array (SA) string losses**
 - 9/12/2019: ARE-3A Current Drop (1 string)
 - » Latest observed on Aqua (Aqua has lost up to 19 of 132 strings)
- **0 Instrument Anomalies:**
- **7 Spacecraft Maneuvers:**
 - 4 Routine Drag Make-Up Maneuvers (DMUMs) – Last DMUM #143 on 11/6/2019
 - 1 Debris Avoidance Maneuver (DAM) – 09/11/2019 (DAM #12, DMUM # 142)
 - 1 Inclination Adjust Maneuvers (IAM) – 10/02/2019 (IAM #66)
 - **1 Reaction Wheel Yaw Slew IAM Test Maneuver – 11/14/2019**
- **4 Instrument Calibration Maneuvers:** 6/12, 7/12, 10/9 and 11/7 (#180)
 - Monthly MODIS Lunar Calibrations (Skipped August & September)



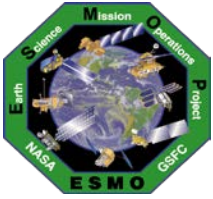
Completed/Planned Activities

(mid-2019 thru early 2020)



Completed since June 2019 MOWG Meeting in blue

- **07/10/2019: 2019 Aqua Decommissioning & Lifetime Analysis (V1.0)**
 - Updated propellant budget and DRAFT 2020 Inclination Adjust Maneuver Schedule
 - Transition to bi-annual IAMs “saves” one IAM (9-IAM Plan vs. 10-IAM plan)
- **08/28/2019: Met with AIRS Instrument Operations Team (IOT) at JPL**
 - Aqua Future Maneuver Plans
 - Additionally briefed all the other Aqua IOTs – MODIS, CERES
- **10/02/2019: Completed CARA Devolution ESMO Pilot Program**
- **November 2019: FINAL 2019 Aqua Decommissioning & Lifetime Analysis**
- **November 2019: Updated End of Mission Plan for 2020 Senior Review**
- **12/03/2019: ESC/A-Train MOWG Meeting in Gilbert, AZ**
 - Update propellant budget and decommissioning analysis (As a result of 10/2 IAM)
 - FINAL 2020 Inclination Adjust Maneuver Schedule (4-Spring IAMs and 2 Fall IAMs)
- **Late 2019: After the A-Train Extended Mission Plan (2022 – 2026)**
- **02/04/2020: ESMO Annual Review #13**
- **03/06/2020: Next Senior Review Proposal due to NASA HQ**
- **Spring 2020: Aqua IAMs on Reaction Wheels and Thrusters**



Planned Activities

(Mid-to-Long-Term)



Completed since June 2019 MOWG Meeting in blue

- **Aqua/Aura Retrograde Maneuver Working Group – also working Aqua IAMs on combination of reaction wheels and thrusters**
 - Adopt experience and lessons learned on Aura for Aqua
 - Retrograde maneuver capability to be fully simulated in 2019
 - » **Constellation Exit Maneuver (CEM) simulated in June 2019**
 - » Perigee Lowering Maneuver (PLM) similar to CEM
 - **On-orbit retrograde capability by Aqua A-Train exit in early 2022**
- **EOS Automation (EA) – automation of routine operations**
 - EA Release 3.4 – ORR early 2020
- **Collision Risk Management System (CRMS)**
 - Continue to improve DAM planning and execution process
 - Full automation end-to-end, identification-to-approval 24x7x365
 - **CRMS Release 8.0 targeted for December, Operational early 2020**
 - **Awaiting Space Fence data**
- **Possible Re-fueling Mission – Unlikely – but not giving up hope**

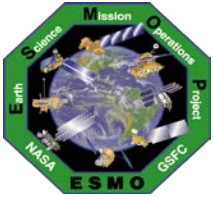


Ongoing Process Improvements



Completed since June 2019 MOWG Meeting in blue

- **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
 - » **Refine CEMs and PLMs (work in progress)**
- **EOS Automation (EA): Multi-year/Multi-phase development**
 - **Version 3.3: Enhancements ongoing → OPS in summer 2019**
 - Version 3.4 ORR in Early 2020
 - **Next step – 2-man “Fire Watch” on midnight-shift**
- **Collision Risk Management System (CRMS) – Initiated in 2015**
 - Operating with CRMS Release 7.0 (ORR: April 25, 2019)
 - **CRMS Release 8.0 Targeted to be operational by early 2020**
- **“CARA Devolution” details in Dimitrios Mantziaras presentation**
 - » **ESMO Pilot Program Parallel Operations: 3/26/2019 – 10/2/2019**



Aqua Propellant Usage

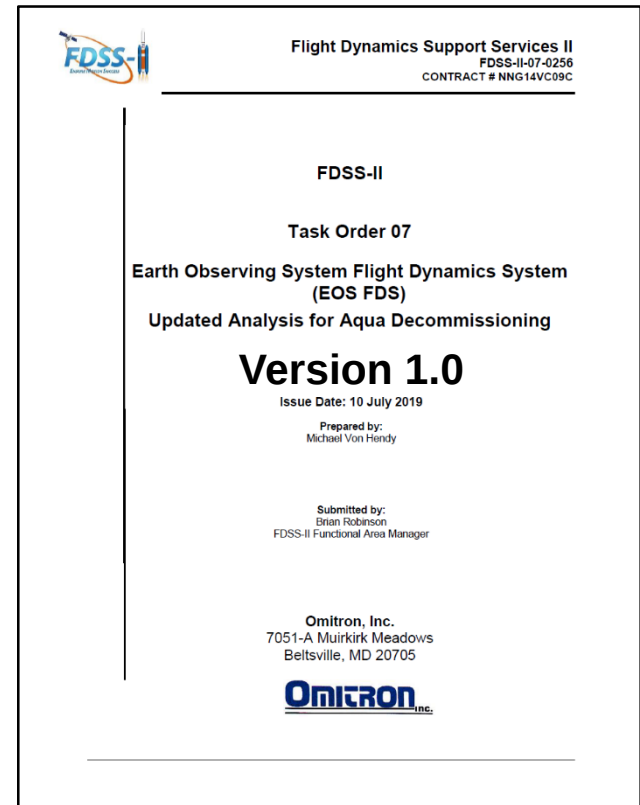
(July 2019)



- **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)**
- **November 13, 2017: Updated Decommissioning Plan (V1.1)**
- **July 3, 2018: Updated Decommissioning Plan (V1.0)**
 - 08/02/2018 Summer IAM required update to document and IAM Plans
- **November 16, 2018: Updated Decommissioning Plan (V2.0)**
- **July 10, 2019: Updated Decommissioning Plan (V1.0)**
 - Updated definitive fuel usage & predicted solar flux levels
 - 10/02/2019 IAM will require update to plots and figures only
- **Annual updates will be provided each July (started in 2017)**
 - Final will be produced 60 days before start of decommissioning

12/3/2019

ESC MOWG Meeting - December 2019 - Gilbert, Arizona



Next Update November 2019
(Plots and Tables)



Aqua Remaining Fuel Estimate

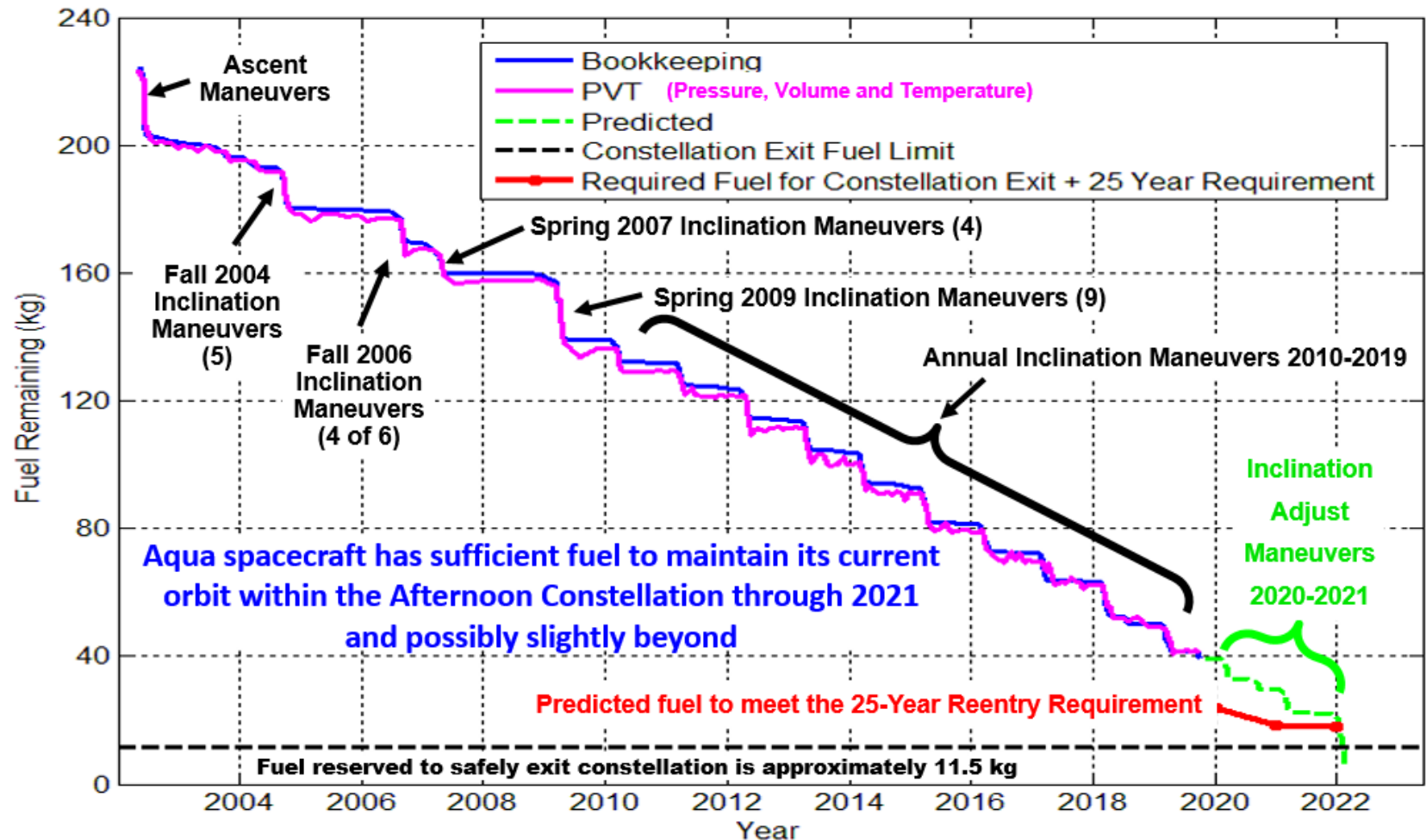
(July 2019 – Updated in November)



- **Long-term orbit simulations were run for Aqua through 02/25/2023**
 - Used mean nominal Schatten solar flux predictions (**May 2019**)
 - 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 it's mean local time (MLT) requirement
 - Did not include potential debris avoidance maneuvers
 - Utilized **FreeFlyer 6.10.0** 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 early 2022 will be into a new operational orbit, approximately 4.4 km below the current ESC/A-Train orbit. Will then immediately lower perigee to approximately **675 km and continue operations.**
- Currently investigating various options to extend the potential Aqua mission life out into the 2026 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.**



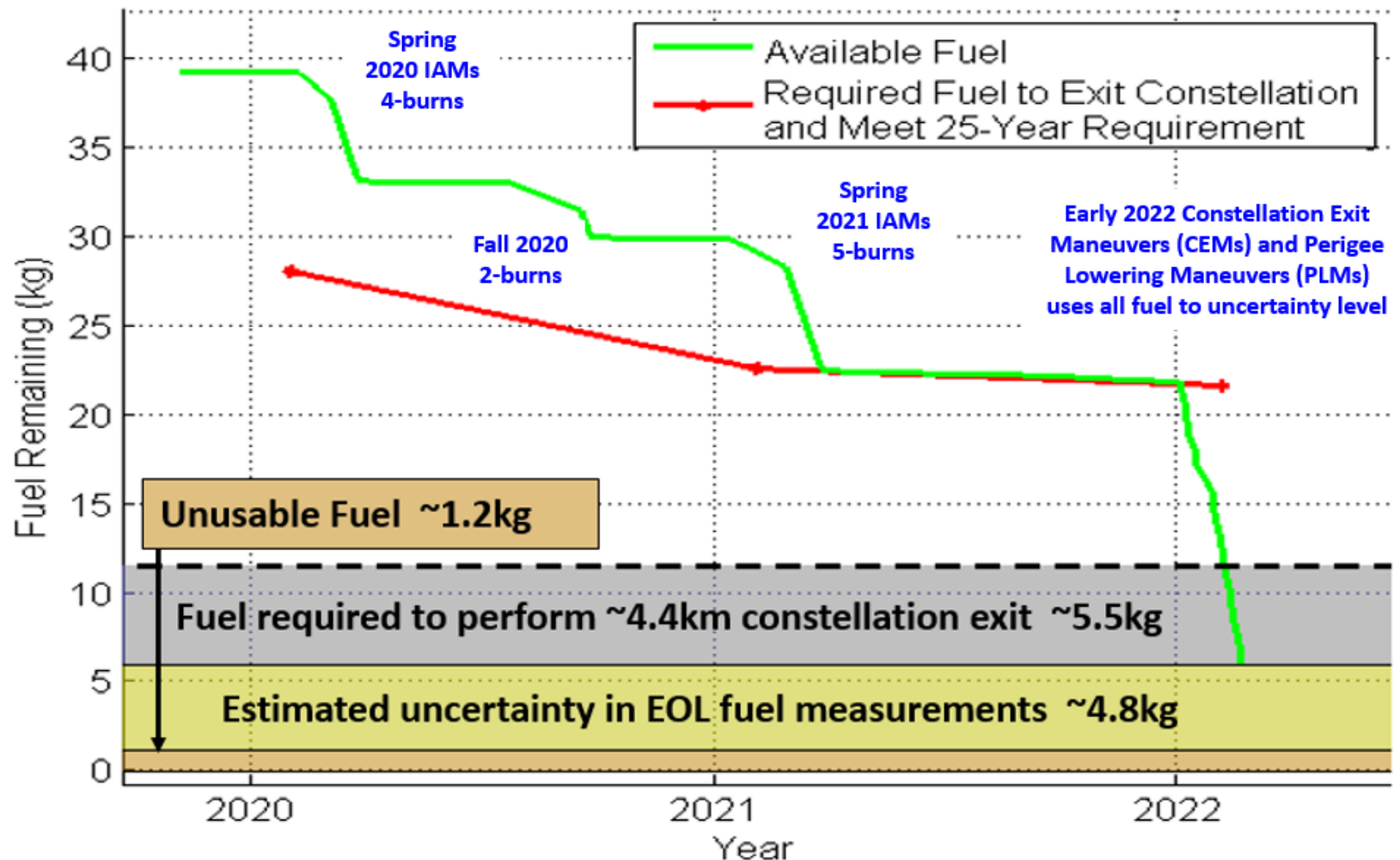
Fuel Usage: Actual & Predicted (Updated November 2019)





Fuel Usage:

Predicted Available & Required (Updated November 2019)





Spring 2020 Aqua/Aura Inclination Adjust Plan



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
16 February	17	18	19	20 Terra IAM	21	22
23	24	25	26	27 Terra IAM	28	29
1 March	2	3	4 Aura IAM #64	5 Aqua IAM #67	6	7
8	9	10	11 Aura MLS Moon Scan (~08:33 GMT) Aura IAM #65	12 Aqua IAM #68 Aqua Ideal Date for RWA/Thrusters IAMs	13	14
15	16	17	18 Aura IAM #66	19 Aqua IAM #69	20 Equinox EPS State of Health Test	21
22	23	24	25 Aura IAM #67	26 Aqua IAM #70	27	28
29	30	31	1 April Aura Back-up	2 Aqua Back-up	3	4
5	6	7	8	9	10	11
12 Easter	13	14	15	16	17	18
19	Golden Week in Japan (April 28 – May 6, 2020)					

12/3/2019

2020 Aqua/Aura IAM Calendar (V3 - 7/25/2019)

13

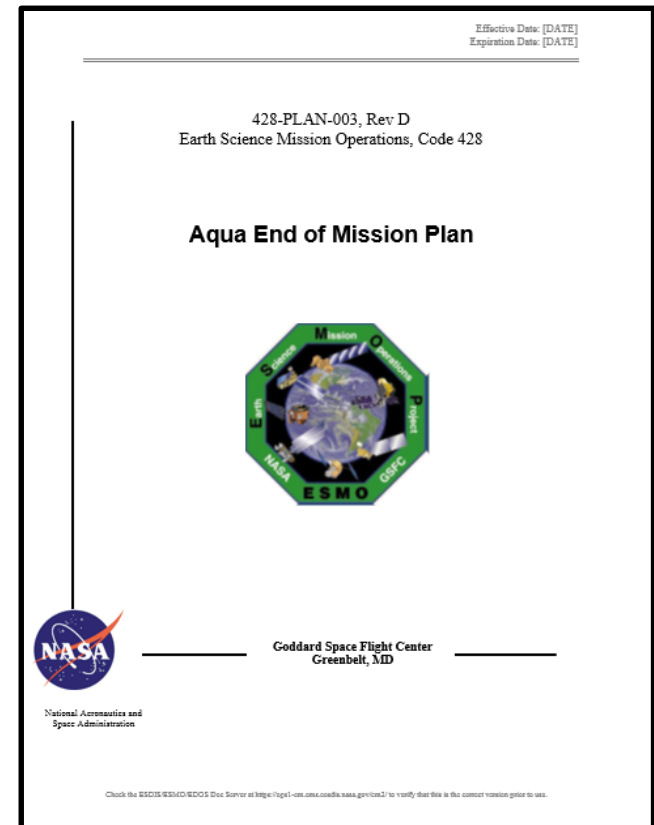


Aqua End of Mission Plan

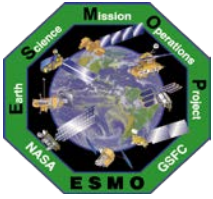


KEY: Updates since last MOWG Meeting in blue

- 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
 - Includes ~4.4 km exit from A-Train in early 2022
- End of Mission Plan (Rev D): November 2019
 - Latest Annual Lifetime Estimate (November 2019)
 - Retrograde maneuver slews on reaction wheels
 - Currently in review
- Final produced 60 days before End of Mission



**Approval targeted for
Late 2019**



Debris Assessment Software

(Updated November 2019)



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
 - Total end-of-life mass = 2860.6 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)
 - Final Apogee (Average Height) of orbit after constellation exit (early 2022) = **697.34 km**
 - Final Perigee of orbit after final perigee lowering burn (early 2022) = **675.22 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. ([Using DAS September 2019 Solar Flux Model](#))
- **Aqua has a waiver to the 30-years from launch requirement.**
- **Holding sufficient fuel in reserve to meet the 25-year reentry requirement.**

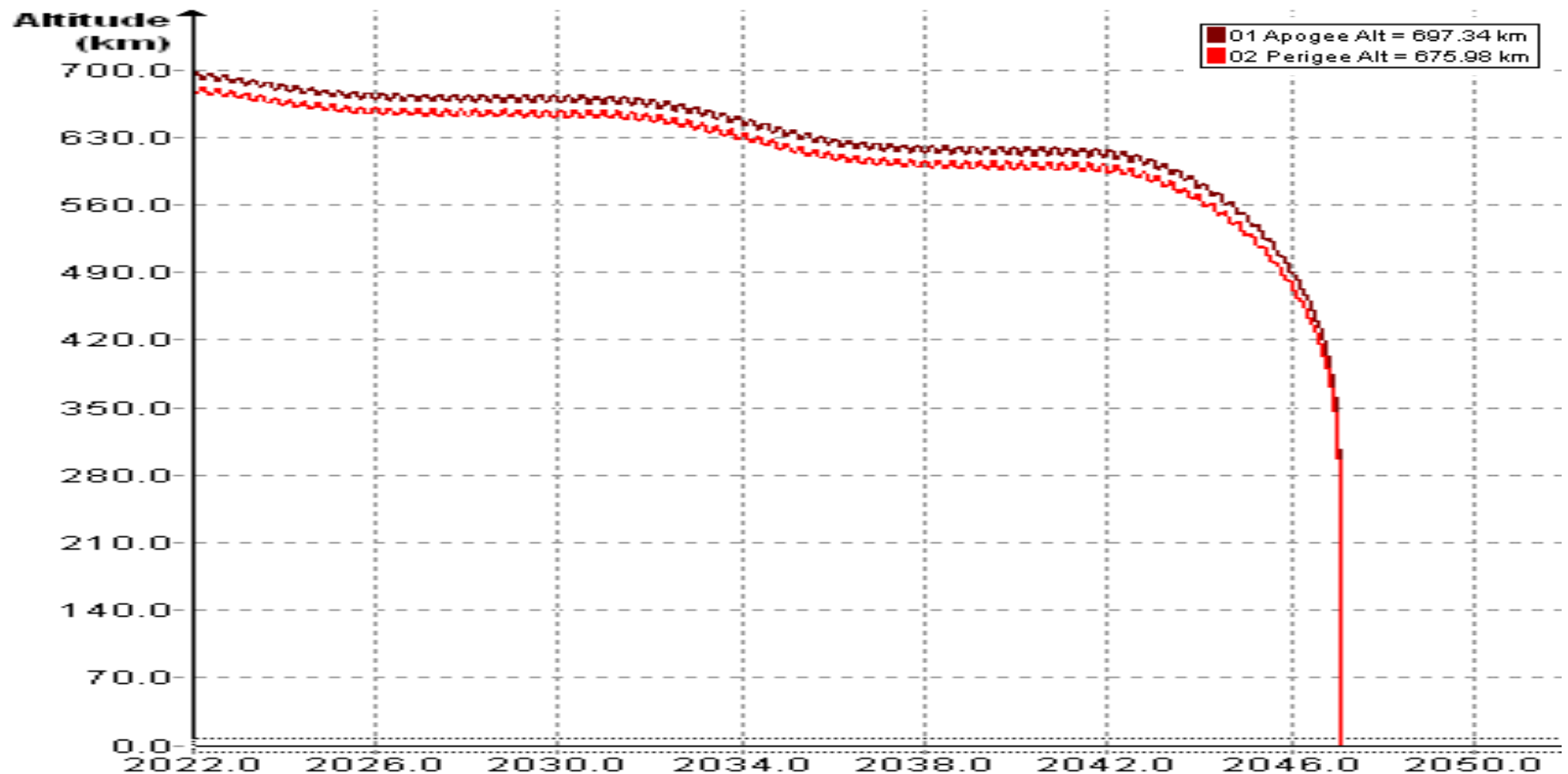


Aqua Orbital Decay

(Updated November 2019)

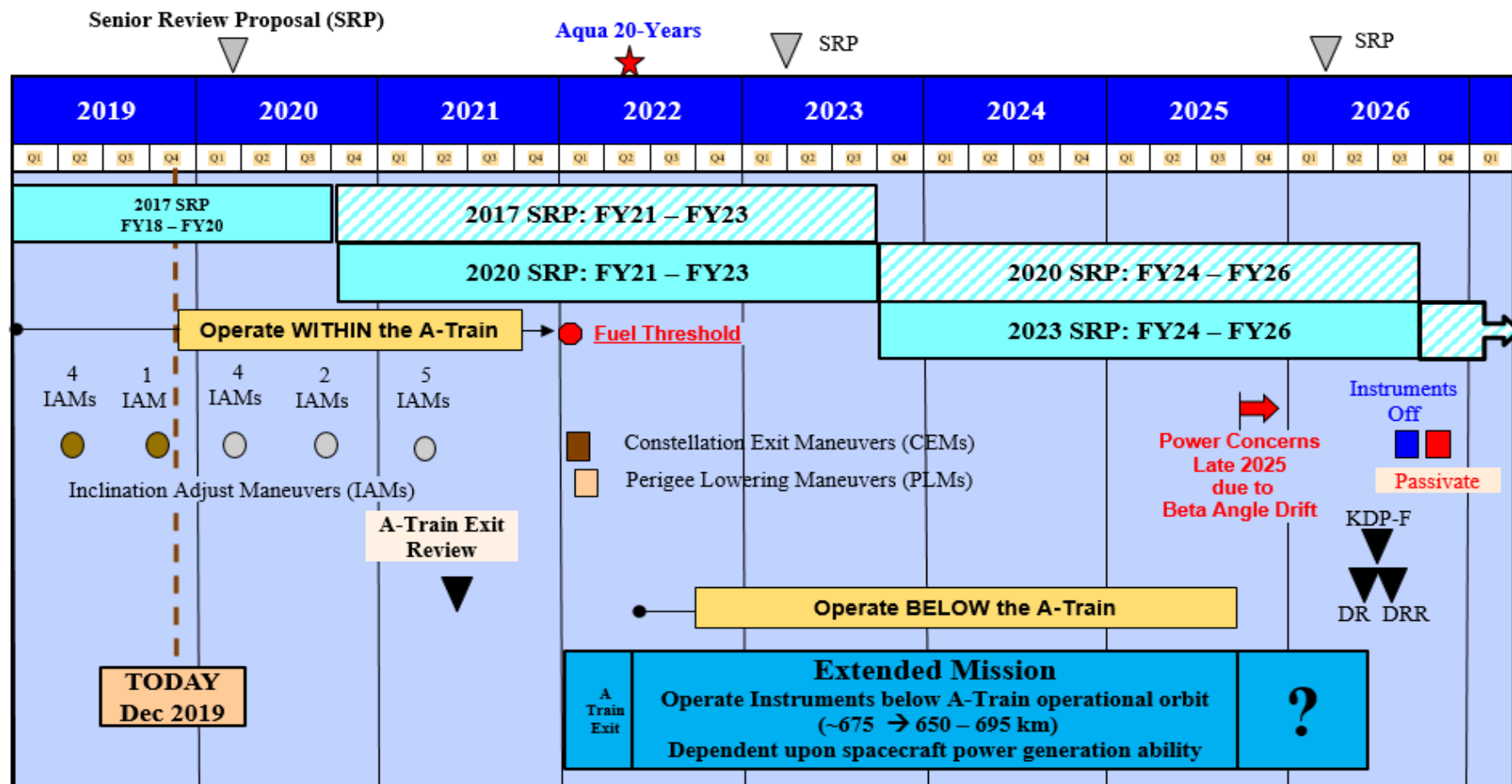


With A-Train Exit and perigee lowering in early 2022, Aqua is predicted to reenter within the required 25-year Agency & International requirement.





Aqua After-the-A-Train Extended Mission Timeline



DR – Decommissioning Review

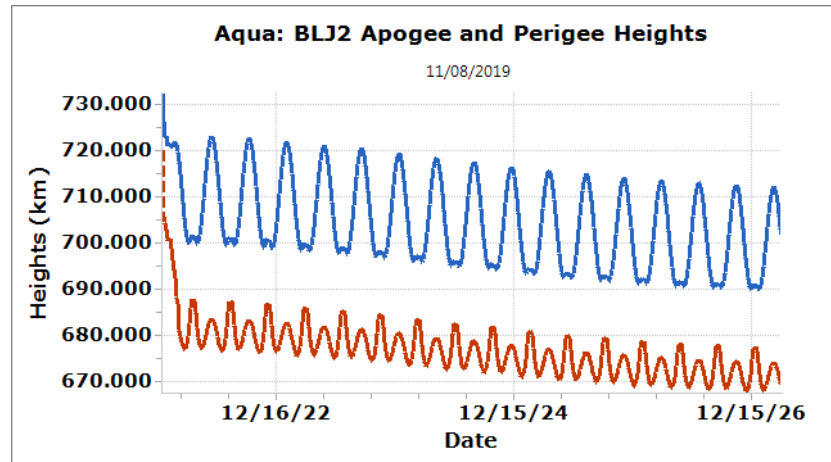
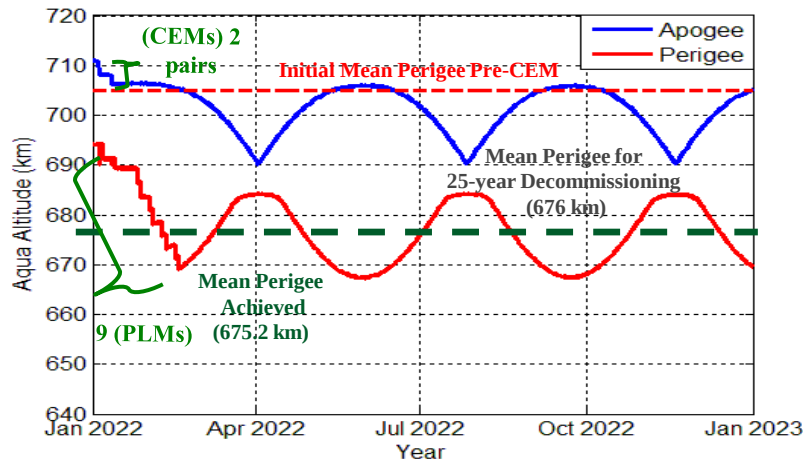
KDP-F – HQ Key Decision Point
to proceed with Phase F

DRR – Disposal Readiness Review



Aqua A-Train Exit Scenario

(Updated November 2019)



Man. #	Maneuver Type	Maneuver Date	Delta-SMA (m)	Tank Mass (kg)	Delta-V (m/s)
1	Perigee Burn	Jan 04 2022 14:10:19.500	-1454.5	20.35	0.7452
2	Apogee Burn	Jan 06 2022 13:07:44.375	-1422.8	18.94	0.7043
3	Perigee Burn	Jan 11 2022 14:13:16.650	-925.78	18.03	0.4743
4	Apogee Burn	Jan 13 2022 13:09:15.275	-893.98	17.13	0.4736

- Constellation Exit Review – **Mid 2021 at ESC MOWG Meeting (June?)**
- Perform 4 Constellation Exit Maneuvers (CEMs)
- Perform 9 Perigee Lowering Maneuvers (PLMs)

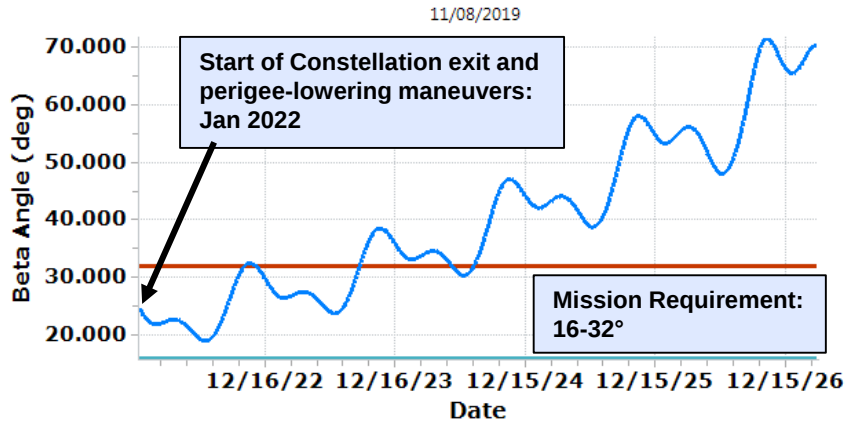


Aqua “After-the-A-Train”

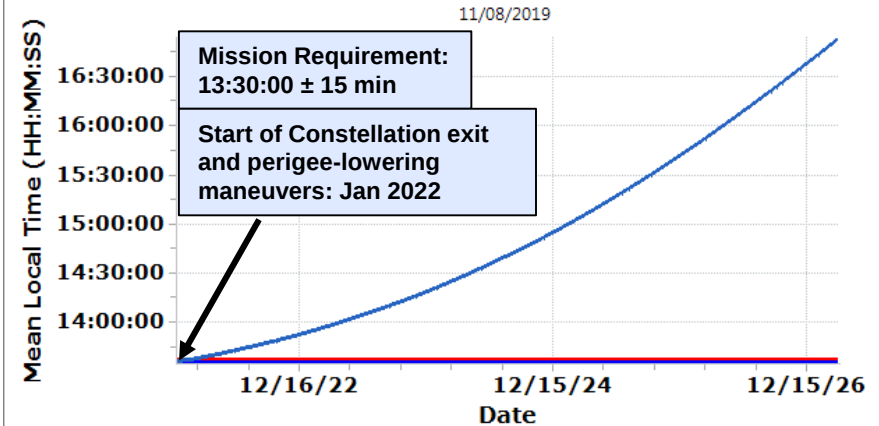
(Updated November 2019)



Aqua: Beta Angle



Aqua: Mean Local Time at Ascending Node



Decommissioning Plan	A-Train Exit Year	Perigee Lower Year	# of Lowering Burns*	Apogee at Depletion (km)	Perigee at Depletion (km)	End of Mission (EOM)	EOM to Reentry (years)	Reentry Date
Baseline	2022	2022	9	697.3	675.2	2026	23	2047

After the A-Train Science Operations Plan Overview:

1. Exit Constellation and lower orbit perigee to reenter within 25-years
2. Drift until Science no longer good or budget is projected to run out
3. Decommission the mission – passivate and dispose of spacecraft (2026?)

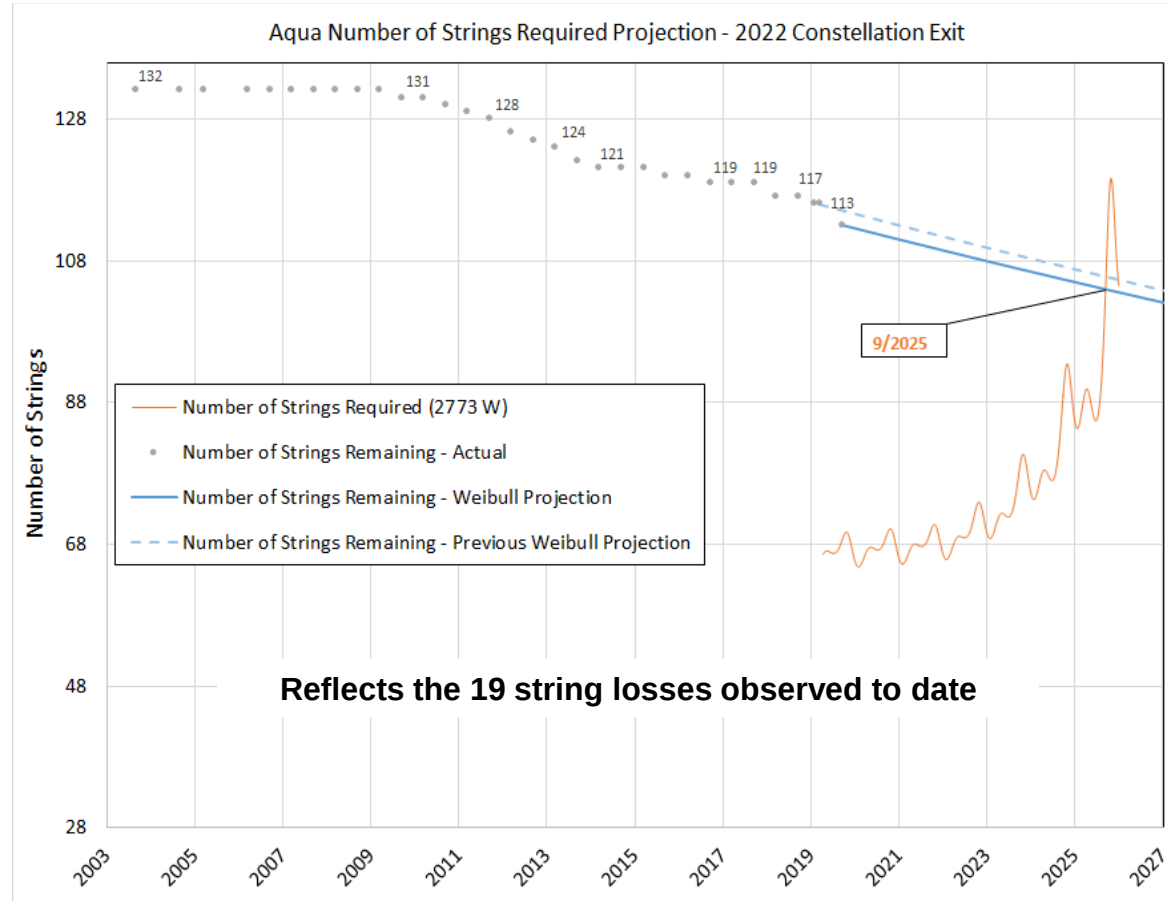


Aqua Future Power Generation

(2022 Constellation Exit – Power Availability)



- Current power margin analysis estimates the **Minimum Required Power for Loads and Battery Charging = 2773 W**
- Current best estimates for the 2022 exit case predict the power margin threshold would be violated in approximately September 2025**
- The number of strings required depends on what power we want to achieve and the Power per String
- The solar array strings remaining projection comes from the GSFC Code 371 Weibull Analysis
Updated 11/13/2019



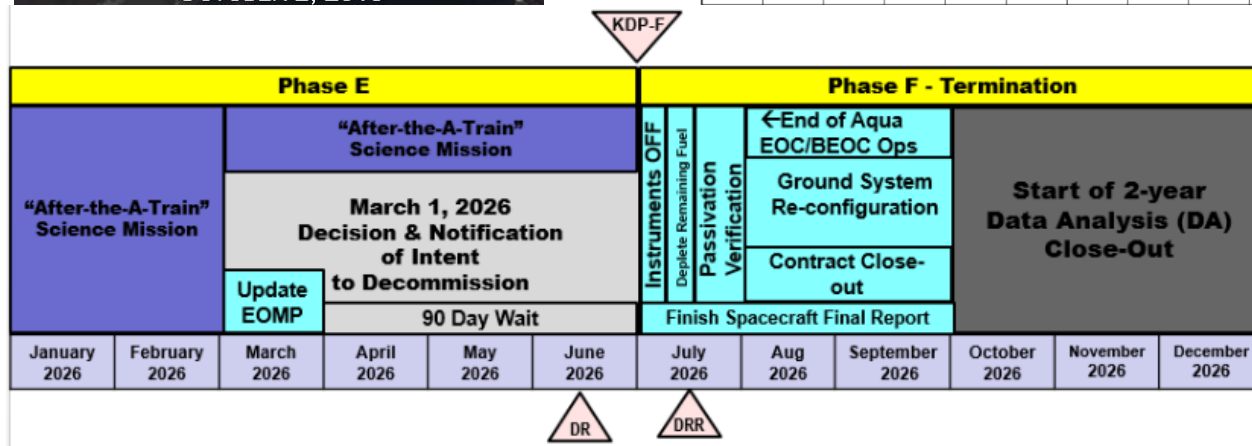
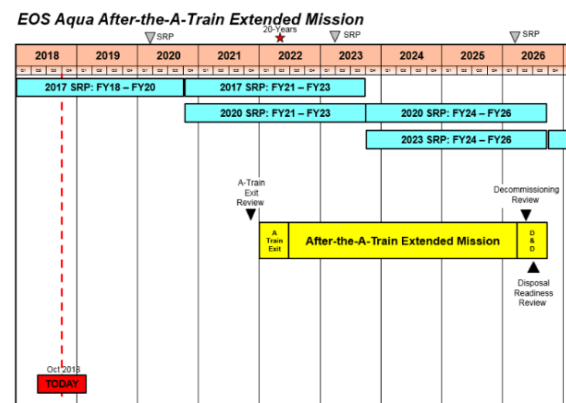


Aqua Decommissioning Review

(October 2, 2018)

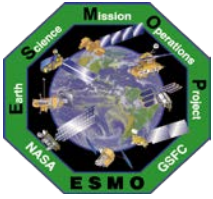


- Request from ESMO Management – “DRAFT” Decommissioning Review
 - Document Phase F spacecraft activities, any new products to be developed for Spacecraft and/or Instrument calibrations, any proposed Engineering Tests, and the final Passivation and Disposal Sequence



12/3/2019

21



Summary



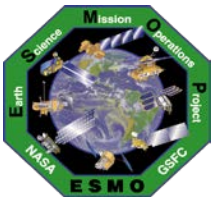
KEY: Updates since last MOWG Meeting in blue

- **Spacecraft Status - GREEN**
- **Instrument Status - GREEN**
 - AIRS and MODIS: Nominal Operations
 - AMSU: Nominal Operations except for Channels 1, 2, 4, 5 and 7
 - CERES: Nominal Operations except for CERES-Fore instrument
 - AMSR-E: Powered Down 3/3/2016
 - HSB: Survival Mode since 2/5/2003
- **Data Capture/L0 Processing Status – GREEN**
 - SSR Data Capture **October 2019:** **99.9799744%**
 - SSR Data Capture to **10/31/2019:** **99.9804893%**
- **Data Latency – Excellent**
- **Ground Systems – Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required**
 - **07/22/2019: Online (Eclipse) Build 21.02 ORR**
 - **09/03/2019: EOS Automation (EA) Release 3.3 ORR**



Additional Slides

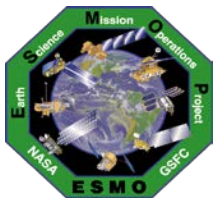
**Orbit Maintenance Maneuvers
Conjunction Assessment High Interest Events
Ground Track Error & Mean Local Time History
Spacecraft Orbital Parameters Trends & Predictions**



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 (A-Train Requirement/Goal)
 - Changed from +/-20 Km Mission Requirement with DMUM #19 (1/12/05)
 - **143** DMUMs have been performed to date (**Last #143 on 11/6/2019 – Next #144 on 12/5/2019**)
 - Variation in performance from -20.9% (cold) to +24% (hot) #108 was 20.9% COLD
- **Control Box Excursions:** Since 2012 there have been 7 Control box Excursions
 - **4 on +10km front-side:**
 - » 11/4/12 to 11/14/12, 10/23/13 to 10/24/13, 3/6/14 to 3/10/14 and 3/16/2015 to 4/2/2015
 - **3 on -10km back-side:** 11/7/13 to 12/14/13 (Emergency DAM on 10/24/13 and DAM on 11/28/13)
 - » 4/2/2016 to 5/7/2016 and **7/29/2018 to 8/21/2018 (DAM on 7/12/2018)**
- **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)
 - **65 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 (4 with one having to be re-scheduled), Spring 2017 (4)
 - » Spring 2018: (5 with one having to be re-scheduled due to PMCOC), Summer 2018 #61 on 8/2/2018
 - » Spring 2019: (4 planned on: 3/7 (#62), 3/14 (#63), 3/22 → 4/4 (#64), 3/28 → 4/11 (#65)
 - » **Fall 2019: 10/02/2019 IAM #66**
 - » **Spring 2020 (4): 3/5, 3/12, 3/19 & 3/26 (Back-up Date 4/2/2020)**



Aqua Conjunction Assessment High Interest Events (HIEs) – 2019



KEY: Updates since last MOWG Meeting in blue

2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
TOTAL	3	1	2	0	0	2	0	0	3	1	1		13
Tier 1	0	0	1	0	0	0	0	0	0	0	0		1
Tier 2	2	0	0	0	0	0	0	0	0	0	0		2
Tier 3	1	1	0	0	0	2	0	0	2	1	1		8
Tier 4	0	0	1	0	0	0	0	0	1	0	0		2

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

2017: 16 CARA HIEs – 11 required significant action

2018: 19 CARA HIEs – 13 required significant action (T3 & T4), 18 DAMs Planned, 1 DAM Executed, 1 Maneuver (IAM #60) postponed/replanned

2019 thru 11/30/2019: (13 CARA/CRMS HIEs – 10 that required significant action (Tiers 3 & 4))

1. 01/28/2019: CA vs. 43345 at 01:48:46 GMT – DAMs planned and screened, Self-mitigated (T3)
2. 02/22/2019: CA vs. 35624 at 11:03:44 GMT – DAMs planned and screened, Self-mitigated (T3)
3. 03/28/2019: CA vs. 41533 at 23:34:46 GMT – Post-Maneuver Conjunction of Concern (PMCO) – Tier 4 – Postponed IAM
4. 06/07/2019: CA vs. 38524 at 05:52:26 GMT – DAMs planned and screened, Self-mitigated (T3)
5. 06/14/2019: CA vs. 38324 at 17:56:19 GMT – DAMs planned and screened, Self-mitigated (T3)
6. 09/04/2019: CA vs. 44356 at 14:28:16 GMT – DAMs planned and screened, Self-mitigated (T3)
7. 09/12/2019: CA vs. 35858 at 13:07:17 GMT – DAMs planned and screened, DAM executed on 9/11 (T4)
8. 09/16/2019: CA vs. 81436 at 20:07:58 GMT – DAMs planned and screened, Self-mitigated (T3)
9. 10/13/2019: CA vs. 81455 at 22:07:48 GMT – DAMs planned and screened, Self-mitigated (T3)
10. 11/28/2019: CA vs. 29278 at 12:36:48 GMT – DAMs planned and screened, Self-mitigated (T3)

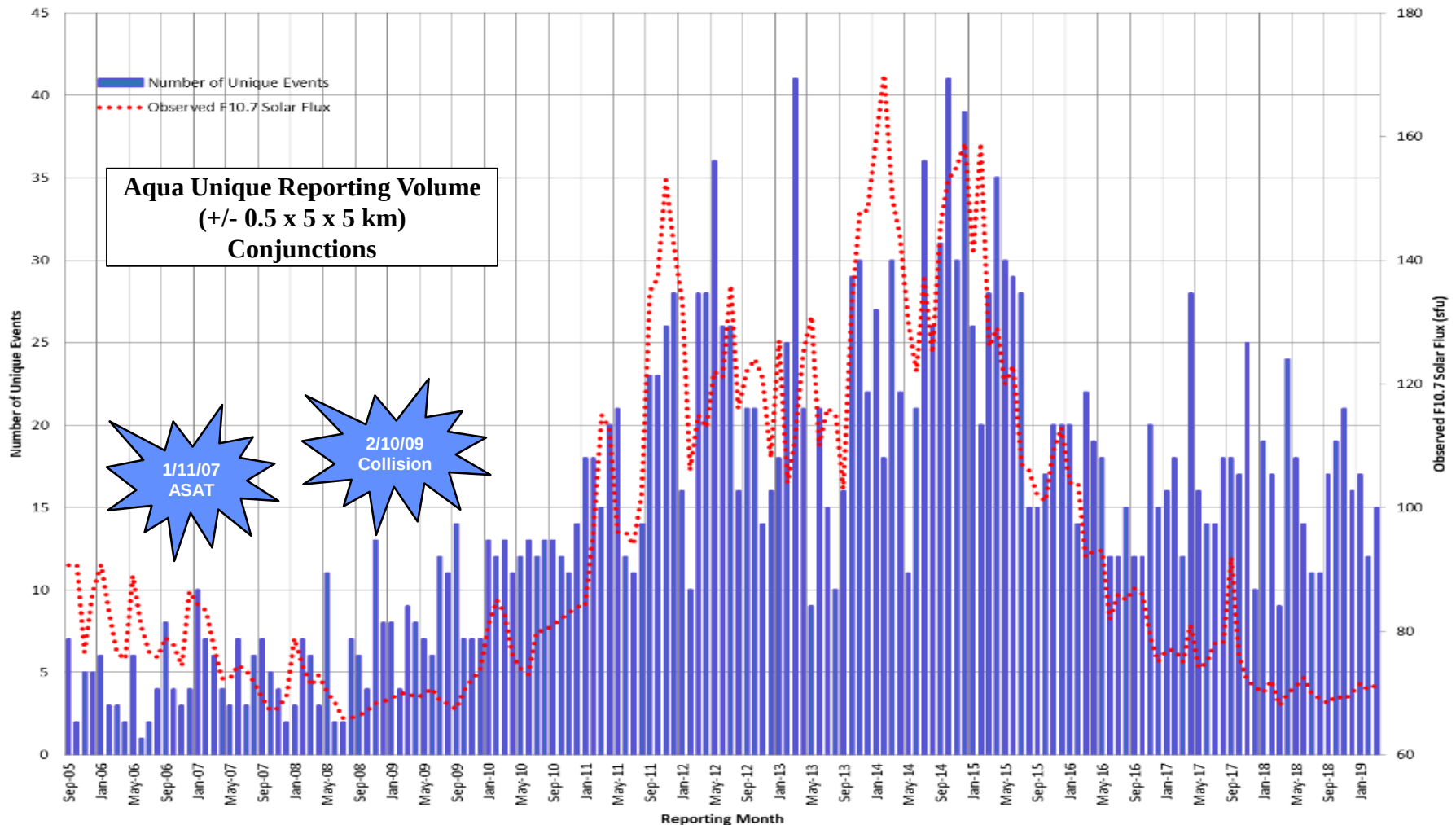
**Tier 1 – Notify (email/phone), Tier 2 – Conduct Briefing,
Tier 3 – Plan Maneuver, Tier 4 – Execute Maneuver
Tier 4 – Postponed and/or replanned Maneuver**



Aqua Conjunction Statistics

(Monthly Average – September 2005 thru March 2019)

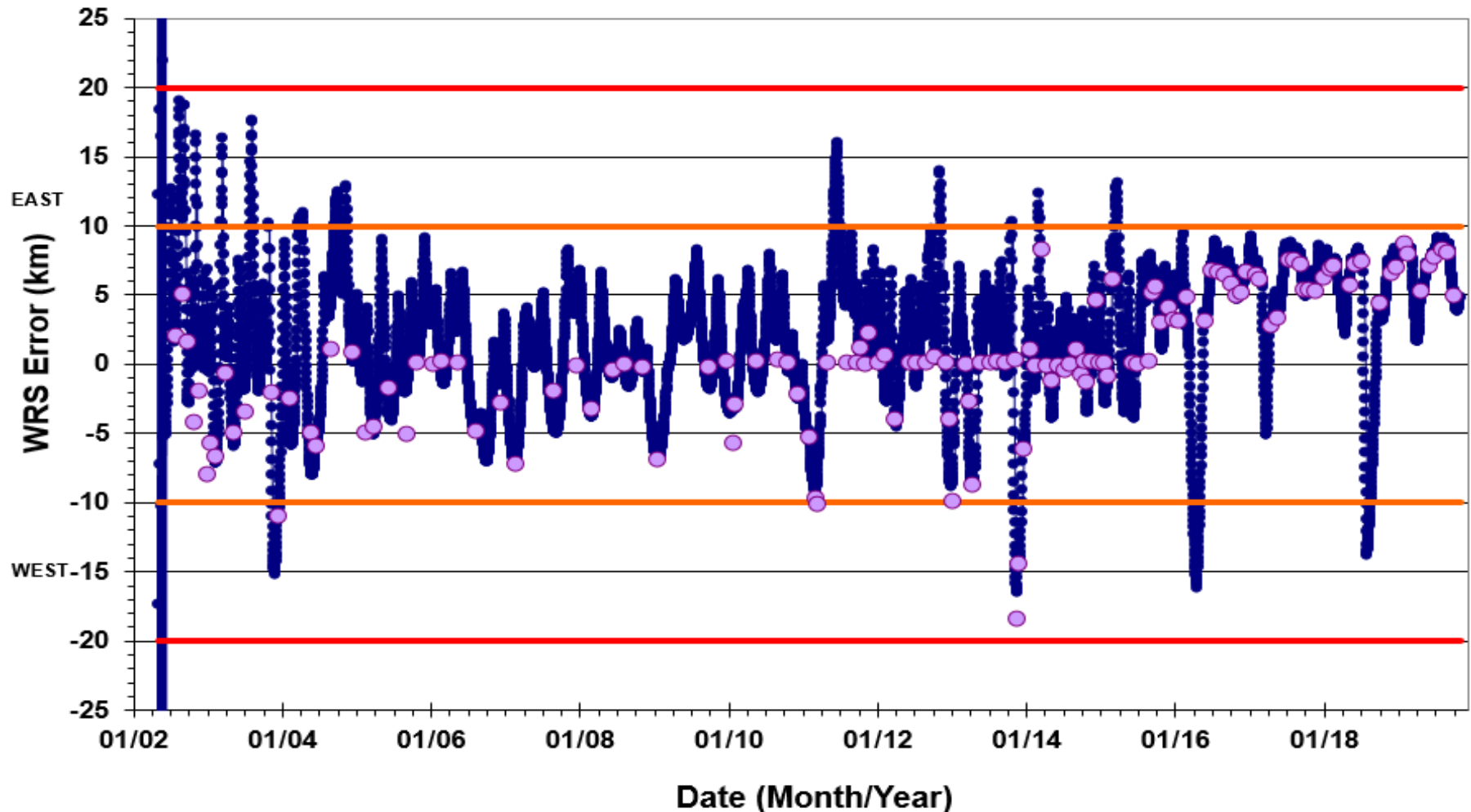
CREDIT: Megan Johnson & Joseph Bryce/CARA Team





WRS Ground Track Error (GTE)

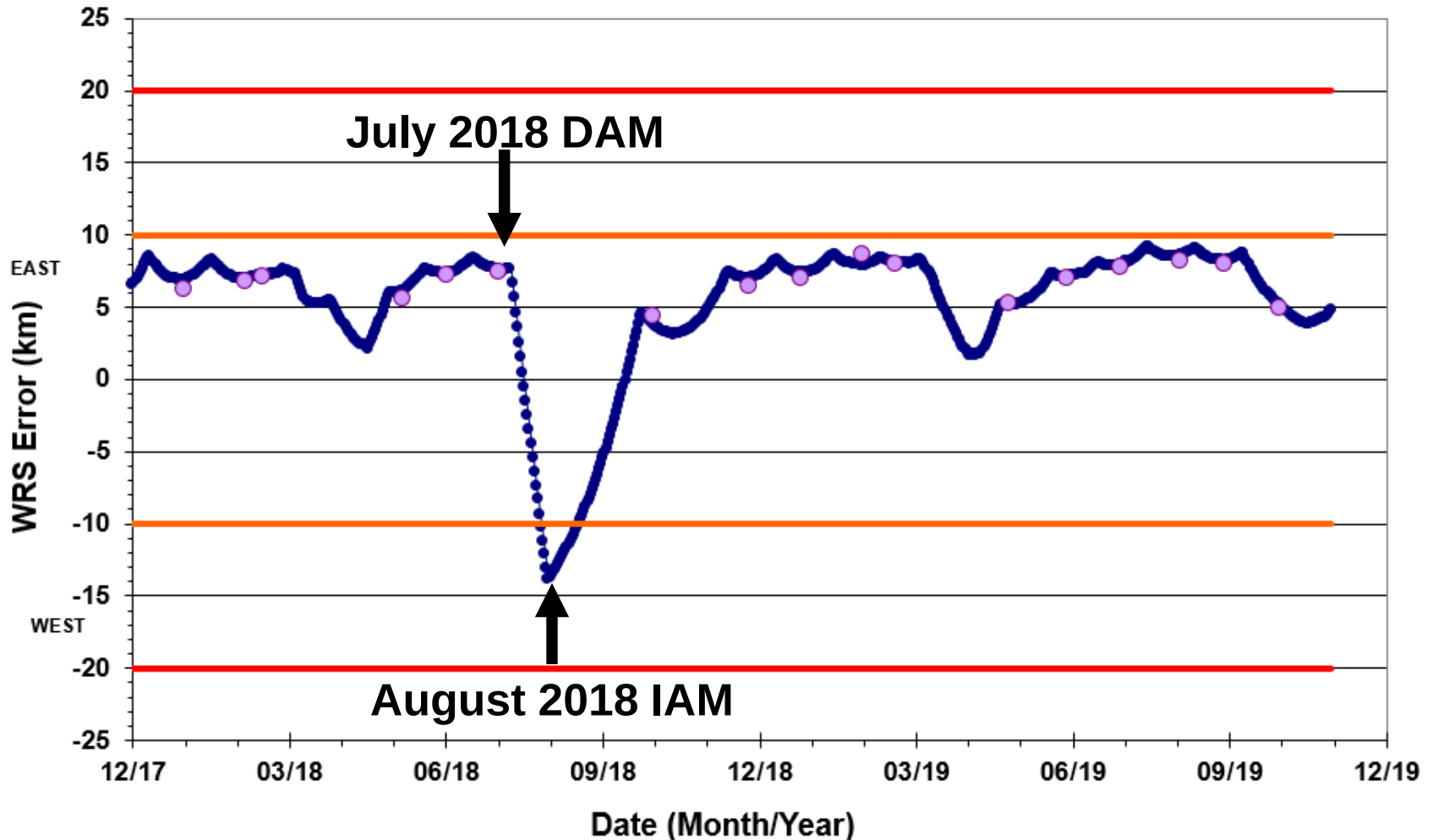
(As of Nov 6, 2019)





WRS Ground Track Error (GTE)

(Last 2-years as of Nov 6, 2019)

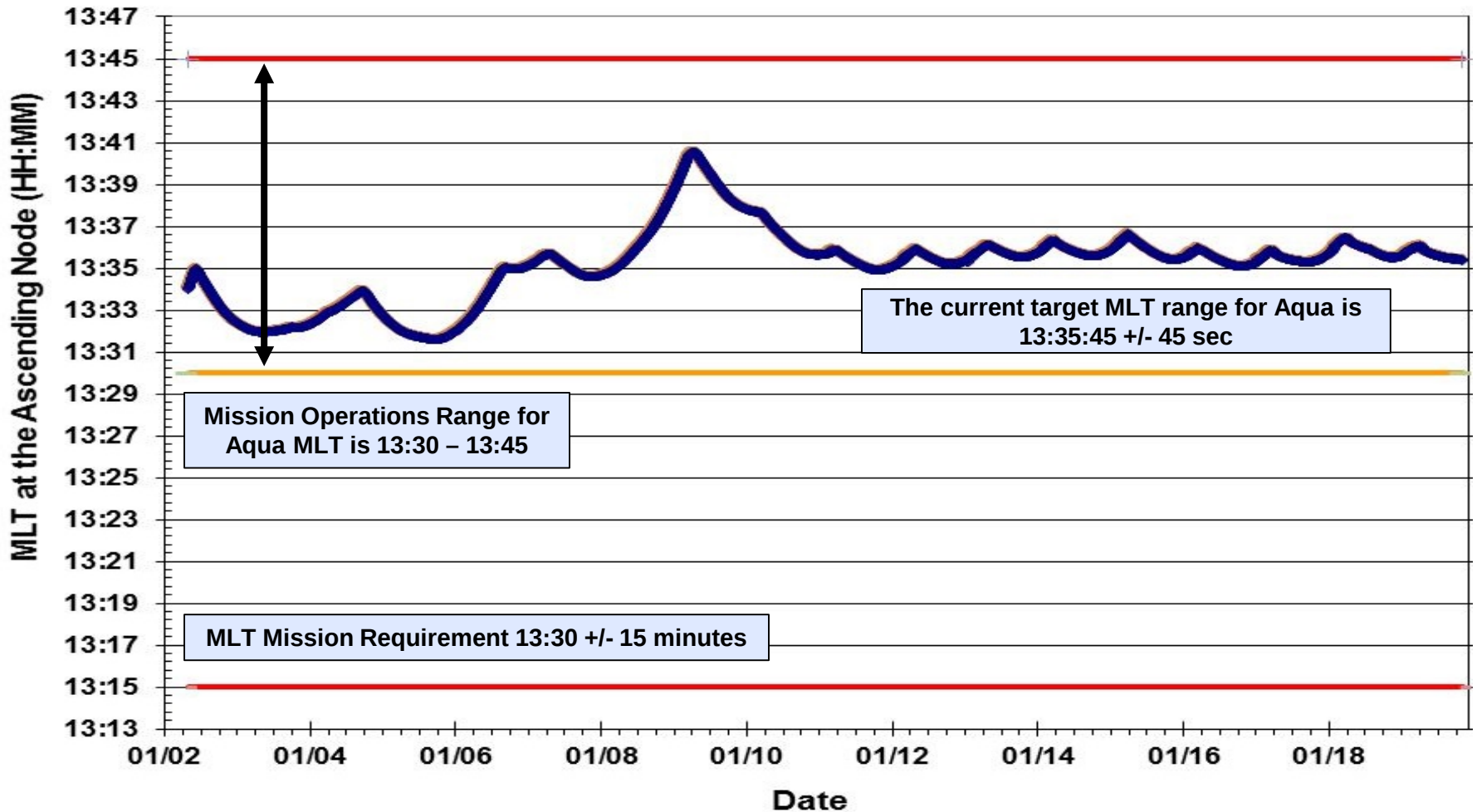


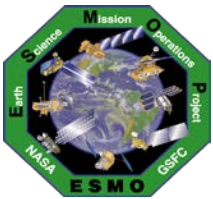


Aqua Averaged MLT

@ Ascending Node

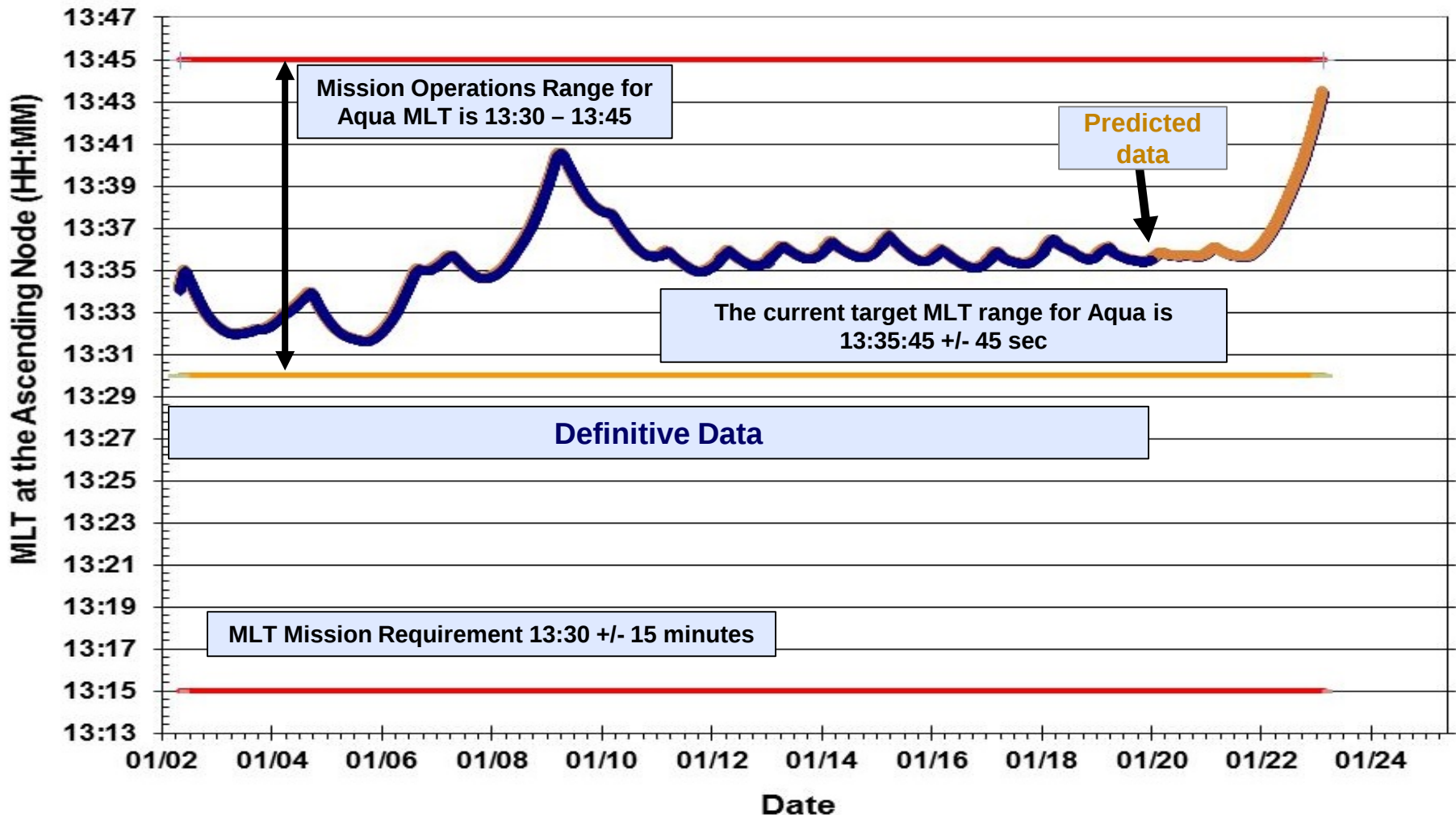
(As of Nov 06, 2019)

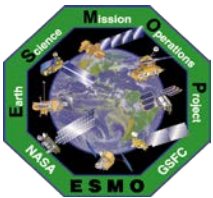




Aqua Definitive and Predictive MLT

@ Ascending Node
(as of Nov 6, 2019)





Inclination/MLT Maintenance

(November 2019)

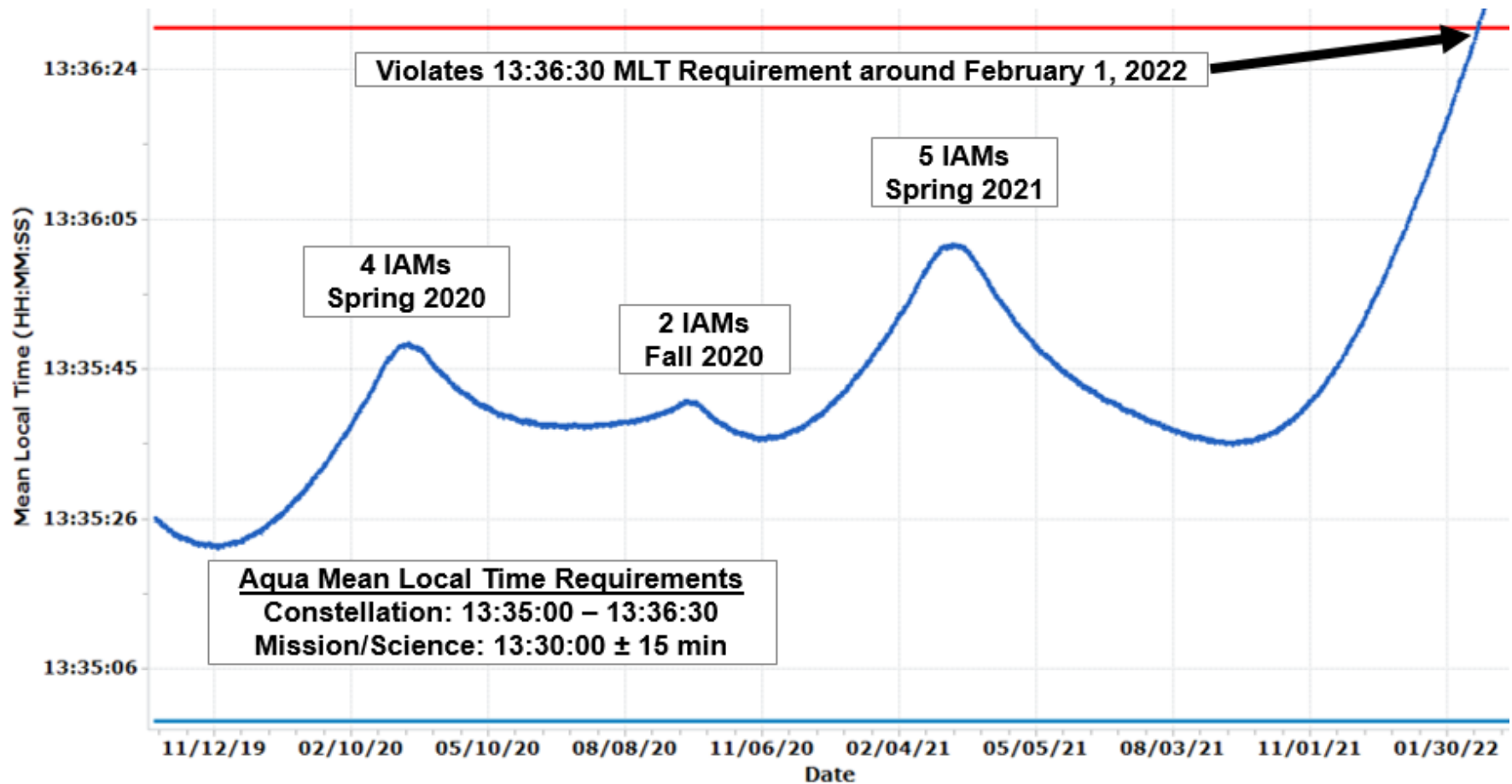


KEY: Updates since last MOWG Meeting in blue

- **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 October 2, 2019 IAM was **-0.41% (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. **Schedule for 2020 has maneuvers centered around the ideal date with no breaks to optimize overall performance.**
 - **Plan to execute 2020-2021 IAMs using reaction wheels and thrusters.**
- **We re-visit/re-validate the long-term plan after each series of inclination adjust maneuvers.**
- **See EOS Flight Dynamics Presentation for long-term plan.**

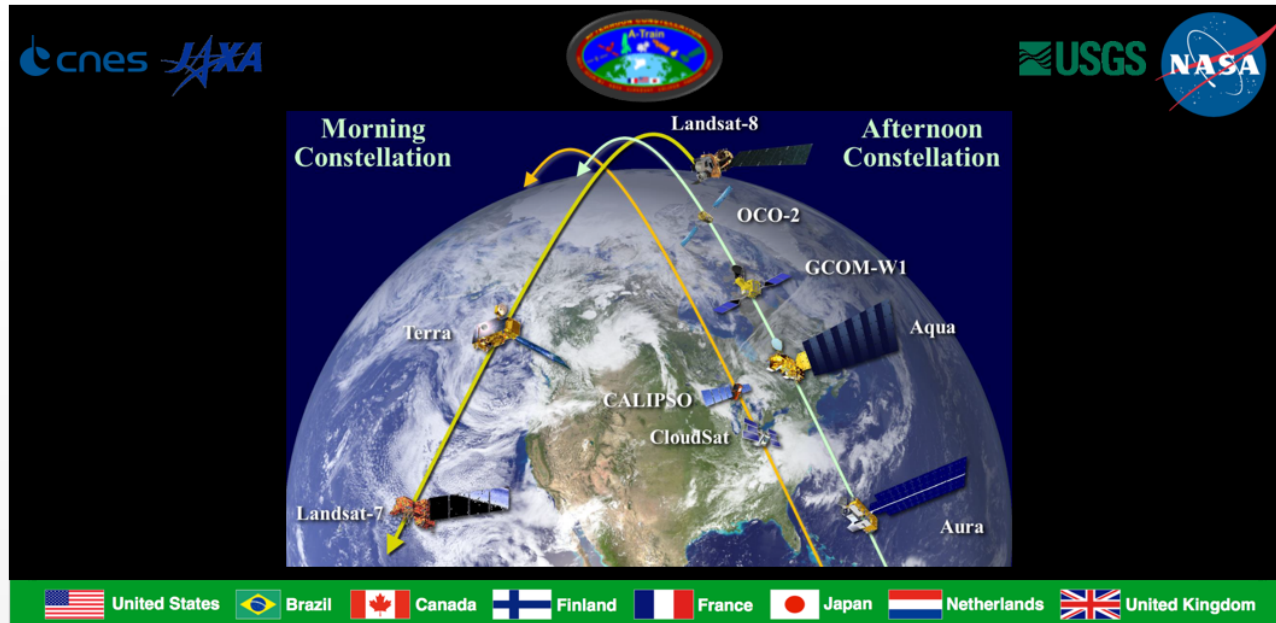


Aqua Predicted Mean Local Time (MLT) at Ascending Node (November 2019)





Inclination/MLT Maintenance (Long-Term Plan)



**International Earth Science Constellation
Mission Operations Working Group (MOWG)
December 3-5, 2019**

Aqua 2019 Fall IAM Series Results and Spring 2020 Planning

Michael Von Hendy, a.i. solutions

EOS FDS, esmo-eos-fds@lists.nasa.gov, +1.301.614.5050

4

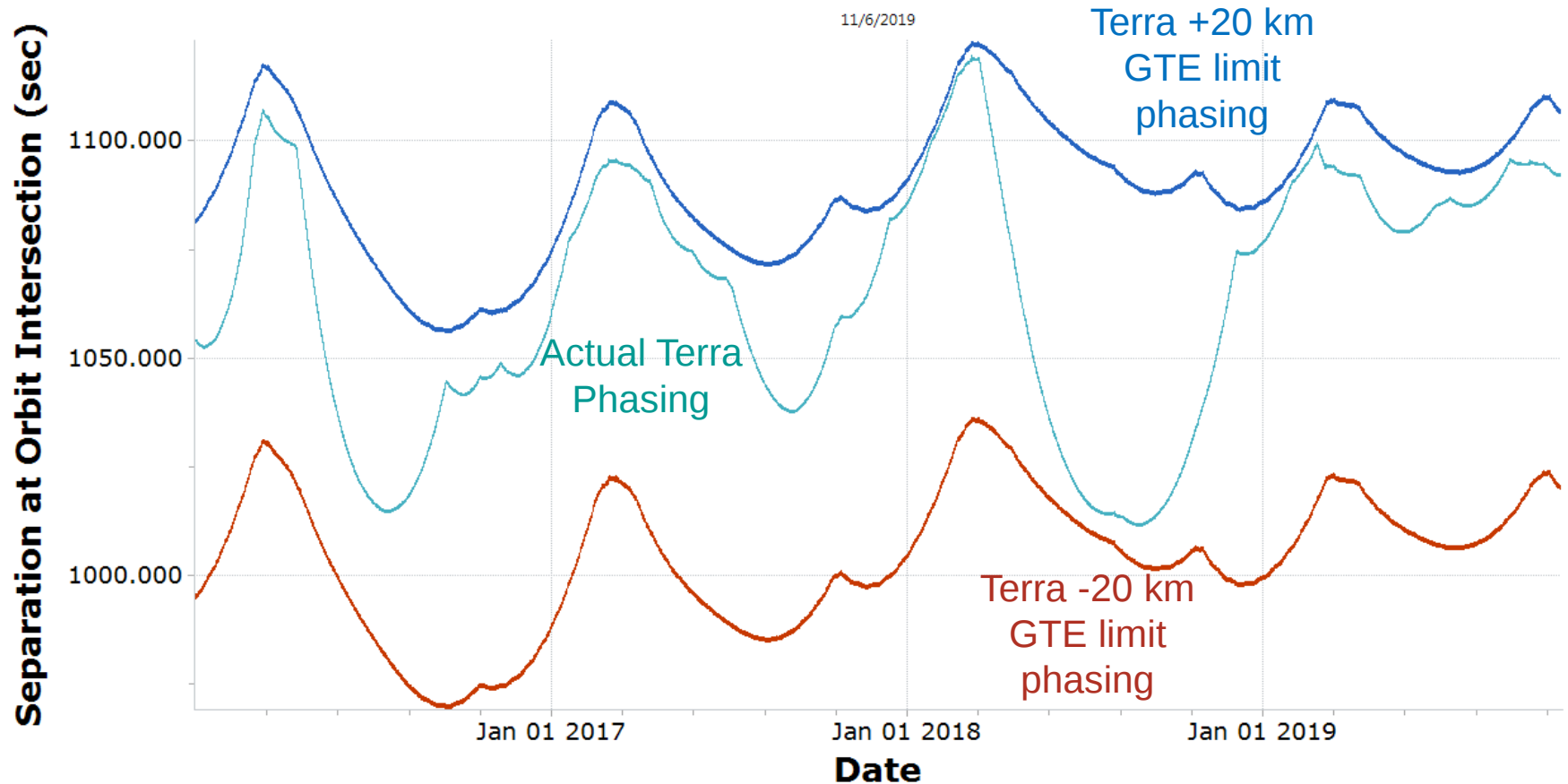


Terra to Aqua Phasing

(as of November 06, 2019)



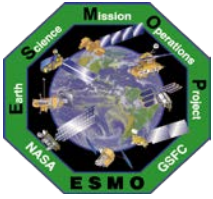
Terra goes through orbital intersection point about 17.5-minutes (~1050-seconds) prior to Aqua.
All phasing is shown relative to the center of Aqua's control box





Questions ?

**A-Train/Aqua on Wednesday
November 27, 2019 at 1:30pm EDT
(CVT)**



Abbreviations / Acronyms List



AIRS –	Atmospheric Infrared Sounder	EPS –	Electrical Power System	MOWG –	Mission Operations Working Group
AMSR-E –	Advanced Microwave Scanning Radiometer for EOS	ESC –	Earth Science Constellation	NASA –	National Aeronautics & Space Administration
AMSU –	Advanced Microwave Sounding Unit	ESMO –	Earth Science Mission Operations	OCO-2 –	Orbiting Carbon Observatory-2
ARE –	Array Regulator Electronics	FDS –	Flight Dynamics System	Ops –	Operations
ASAT –	Anti-satellite Weapon	FDSS-II –	Flight Dynamics Support Services II contract	ORR –	Operational Readiness Review
BEOC –	Backup EOC	FOT –	Flight Operations Team	PARASOL –	Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
CA –	Conjunction Assessment	FSW –	Flight Software		
CARA –	Conjunction Assessment Risk Analysis	FY –	Fiscal Year		
CDH –	Command & Data Handling	GCOM-W1 –	Global Change Observation Mission for Water (1)	PLM –	Perigee Lowering Maneuvers
CEF –	CERES Fore	GMT –	Greenwich Mean Time	PMCOG –	Post Maneuver Conjunction of Concern
CEM –	Constellation Exit Maneuver	GN&C –	Guidance Navigation & Control		
CERES –	Clouds and the Earth's Radiant Energy System	GPM –	Global Precipitation Measurement	PROP –	Propulsion
COTS –	Commercial Off the Shelf	GTE –	Ground Track Error	PS –	Project Scientists
CNES –	Centre National d'Etudes Spatiales	HIE –	High Interest Event	PVT –	Pressure, Volume, & Temperature
CRMS –	Collision Risk Management System	HQ –	Headquarters	RMM –	Risk Mitigation Maneuver
CVT –	Constellation Visualization Tool	HSB –	Humidity Sounder for Brazil	RW –	Reaction Wheels
DA –	Data Analysis	IAM –	Inclination Adjustment Maneuver	s or sec –	second
DAM –	Debris Avoidance Maneuver	JAXA –	Japan Aerospace Exploration Agency	SA –	Solar Array
DAS –	Debris Assessment Software	kg –	kilogram	S/C –	Spacecraft
DMUM –	Drag Make-up Maneuver	km –	kilometer	SEU –	Single Event Upset
DTM –	Dual Thruster Module	L0 –	Level-Zero	SME –	Subject Matter Expert
EA –	EOS Automation	m –	meter	SSR –	Solid State Recorder
EDT –	Eastern Daylight Time	min –	minute	TBC –	To Be Confirmed
EOC –	EOS Operations Center	MLT –	Mean Local Time	TBD –	To Be Determined
EOL –	End of Life	MMOD	Micrometeorite Orbital Debris	TCS –	Thermal Control System
EOM –	End of Mission	MOCA –	Mission Operations Conjunction Assessment	US –	United States
EOMP –	End of Mission Plan	MODIS –	Moderate Resolution Imaging Spectroradiometer	USGS –	United States Geological Survey
EOPM –	End of Prime Mission	MOU –	Memorandum of Understanding	WRS –	World Reference System
EOS –	Earth Observing System				