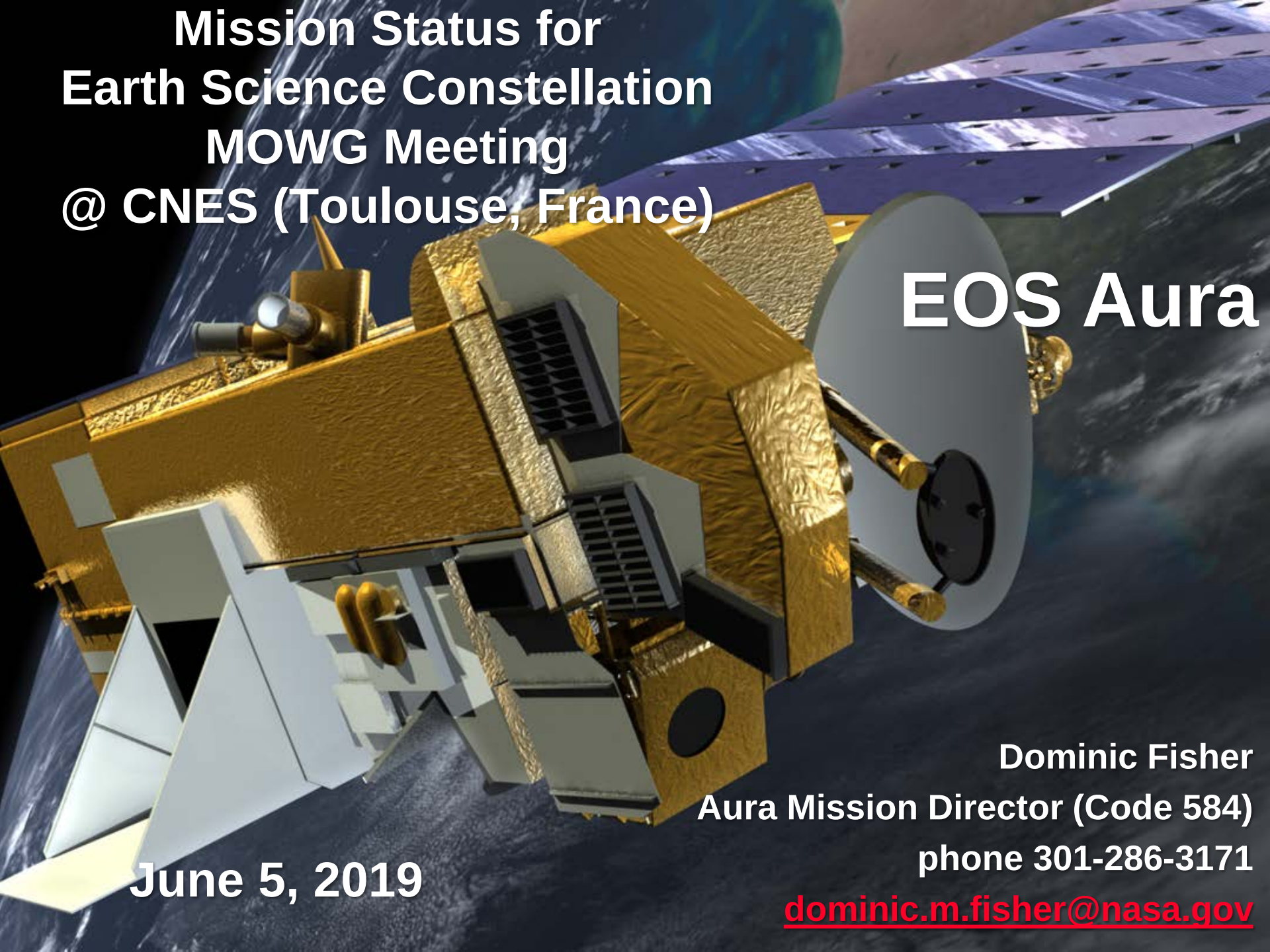
Mission Status for Earth Science Constellation MOWG Meeting @ CNES (Toulouse, France)



June 5, 2019

Dominic Fisher
Aura Mission Director (Code 584)
phone 301-286-3171
dominic.m.fisher@nasa.gov

Topics

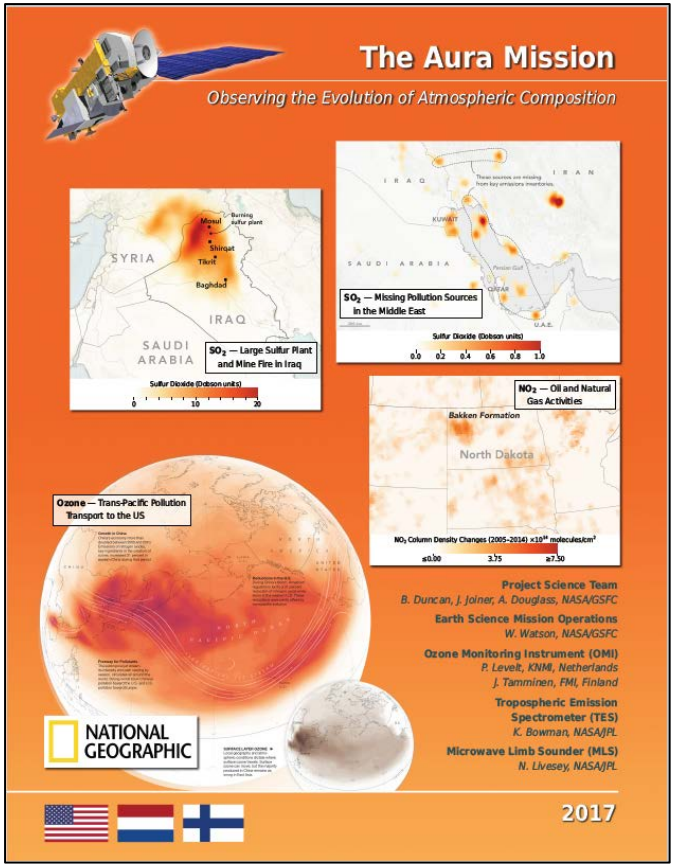
- **Mission Summary**
- **Spacecraft Subsystems Summary**
- **Recent Activities**
- **Planned Activities**
- **Propellant Usage & Lifetime Estimates**
- **Overall Summary**

- **Additional Slides:**
  - **Spacecraft Maneuvers & Ground Track History**
  - **Conjunction Assessment**
  - **Data Capture & Ops Error Statistics**
  - **Extended Mission Plans**

EOS Aura Mission Summary

(Updates since December 2018 MOWG @ GSFC)

- 07/15/04: Launch
  - 6-Year Design Life
- 09/30/10: End of Prime Mission Review
- 09/18/15: 2015 Mission Extension Senior Review Proposal Panel Report
- 03/03/17: Senior Review Proposal #5
  - Reliability Estimates thru 2022
  - Consumables through 2022
- 06/22/17: NASA Earth Science Senior Review Subcommittee Report
  - High Utility, Excellent science merit
- 12/21/17: Received NASA HQ Guidance
- 01/31/18: TES Decommissioning
- 03/30/18: Updated Aura Phase F Plan
- 07/15/18: Aura 14-Year Anniversary
- 04/02/19: ESMO Annual Review #12



Aura Spacecraft Subsystems

(No changes since December 2018 MOWG @ GSFC)

- **Command & Data Handling (CDH) – Nominal**
  - **Formatter Multiplexer Unit (FMU) / Solid State Recorder (SSR) Anomaly**
    - » **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 (10/17/17, 01/05/18)**
- **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 (3/12/10) – 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 (9/23/14, 12/8/14), ARE-1C (7/14/17, 12/22/17), ARE-2C (8/18/17)***
    - » ***Updated analysis of ARE-4A revealed an additional 1 string lost around 9/23/14***
    - » ***Estimated that Aura has lost 29 strings of solar cells out of a total of 132 strings (~78.0% 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

Recent Activities

(December 2018 – May 2019)

- **6 High Interest Events (HIEs) (Tiers 1-4) (As of 04/30/19)**
  - **5** required significant action (T3 / T4)
  - 03/20/2019: CA vs. 87932 at 03:17:19 GMT – DAMs planned, screened, and maneuver executed (T4)
- **0 Spacecraft Bus Anomalies**
- **1 Instrument Anomalies**
  - **MLS:** 1 Survival Mode Transition (01/27/19, recovered on 01/31/19)
    - » TMON 19 (Stale Telemetry Monitor) triggered while in SAA region – same as July 2018 event
- **10 Spacecraft Maneuvers**
  - **6 Drag Make-up Maneuvers (DMUMs #117 – 122)**
    - » Routine: 12/12/18, 01/17/19, 02/07/19, 04/17/19, 05/08/19
    - » DAM: 03/19/19
  - **4 Inclination Adjust Maneuvers (IAM #59, #60, #61, #62)**
    - » 03/06/19, 03/13/19, 04/03/19, 04/10/19
    - » First series to utilize the new RWA slew approach
- **1 Instrument Maneuver**
  - **MLS:** Yaw (Moon Scan) #14 (03/22/19)

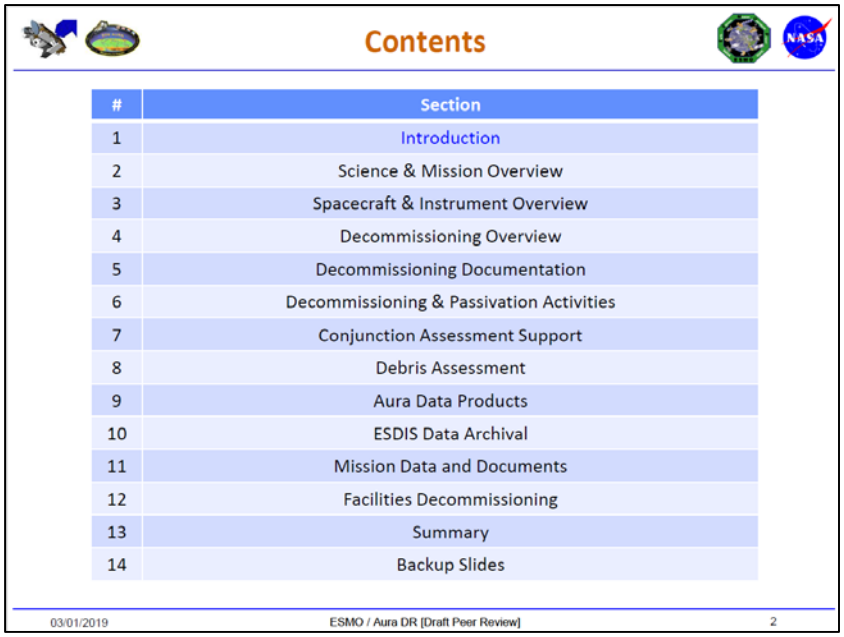
Spring 2019
Calendar of Recent Activities

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
24 **Feb**	25	26	27	28	1 **March**	2
3	4	5	6 Aura IAM #59	7 Aqua IAM #62	8	9
10	11	12	13 Aura IAM #60	14 Aqua IAM #63	15	16
17	18	19 Aura RMM (DMU #120)	20 Equinox EPS SOH Test	21	22 Aura MLS Yaw #14	23
24	25	26	27	28	29	30
31	1 **April**	2	3 Aura IAM #61	4 Aqua IAM #64	5	6
7	8	9	10 Aura IAM #62	11 Aqua IAM #65	12	13

Recent Activities

(December 2018 – May 2019)

- **ESMO Decommissioning Reviews (*Draft Internal Peer Review*)**
  - **Aura peer review completed on 03/01/19 (along with Terra / SORCE)**
  - **ESMO Management requested after lessons learned from EO-1 decommissioning process (2017)**
  - **Conducted initial reviews with GPM and Aqua on 10/02/2018**
  - **Rescheduled from January due to Government Shutdown**



Contents

#	Section
1	Introduction
2	Science & Mission Overview
3	Spacecraft & Instrument Overview
4	Decommissioning Overview
5	Decommissioning Documentation
6	Decommissioning & Passivation Activities
7	Conjunction Assessment Support
8	Debris Assessment
9	Aura Data Products
10	ESDIS Data Archival
11	Mission Data and Documents
12	Facilities Decommissioning
13	Summary
14	Backup Slides

03/01/2019 ESMO / Aura DR [Draft Peer Review] 2

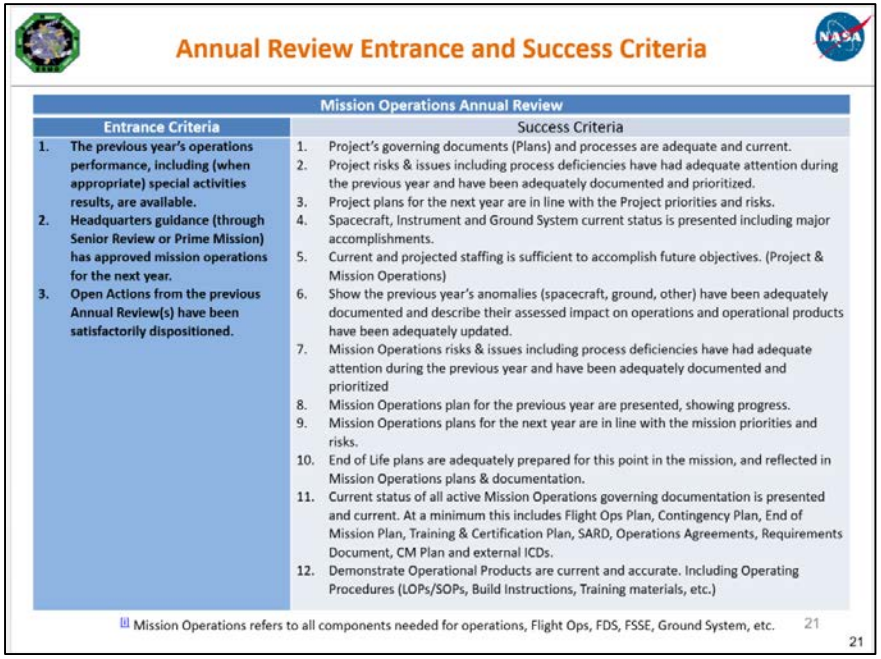
- **Actions:**
  - » Identify a 2-year development schedule
  - » Develop Constellation Exit Maneuvers (CEM) & Perigee Lowering Maneuvers (PLM)
  - » Develop Aura passivation and disposal approach (stand up new Decommissioning WG)

Recent Activities

(December 2018 – May 2019)

- **ESMO Annual Review**
  - **Annual Review completed on 04/02/19 & 04/03/19**
  - ***Updated Purpose and Entrance/Success Criteria:***

Mission Operations Annual Review (MOAR) evaluates Mission Operations systems, processes and personnel to continue current routine operations in accordance with entrance and success criteria. The review also evaluates the status of the mission plans with emphasis on mission risks, processes that ensure successful near-term operations and critical events including required changes to mission operations.



Annual Review Entrance and Success Criteria

Mission Operations Annual Review	
Entrance Criteria	**Success Criteria**
1. The previous year's operations performance, including (when appropriate) special activities results, are available.	1. Project's governing documents (Plans) and processes are adequate and current.
2. Headquarters guidance (through Senior Review or Prime Mission) has approved mission operations for the next year.	2. Project risks & issues including process deficiencies have had adequate attention during the previous year and have been adequately documented and prioritized.
3. Open Actions from the previous Annual Review(s) have been satisfactorily dispositioned.	3. Project plans for the next year are in line with the Project priorities and risks.
	4. Spacecraft, Instrument and Ground System current status is presented including major accomplishments.
	5. Current and projected staffing is sufficient to accomplish future objectives. (Project & Mission Operations)
	6. Show the previous year's anomalies (spacecraft, ground, other) have been adequately documented and describe their assessed impact on operations and operational products have been adequately updated.
	7. Mission Operations risks & issues including process deficiencies have had adequate attention during the previous year and have been adequately documented and prioritized
	8. Mission Operations plan for the previous year are presented, showing progress.
	9. Mission Operations plans for the next year are in line with the mission priorities and risks.
	10. End of Life plans are adequately prepared for this point in the mission, and reflected in Mission Operations plans & documentation.
	11. Current status of all active Mission Operations governing documentation is presented and current. At a minimum this includes Flight Ops Plan, Contingency Plan, End of Mission Plan, Training & Certification Plan, SARD, Operations Agreements, Requirements Document, CM Plan and external ICDs.
	12. Demonstrate Operational Products are current and accurate. Including Operating Procedures (LOPs/SOPs, Build Instructions, Training materials, etc.)

Mission Operations refers to all components needed for operations, Flight Ops, FDS, FSSE, Ground System, etc. 21

21

- **Actions:**
  - » No direct RFAs for Aura mission operations
  - » Look into process for capturing and sharing lessons learned

Recent Activities

(December 2018 – May 2019)

- **TES Laser End of Life Testing [since Decommissioning on 01/31/18]**
  - **Laser End of Life (EOL) Testing plan proposed by TES IOT (JPL) on 04/23/18, NASA HQ approved Phase 1 on 05/14/18**
    - » 06/04/2018: Start of Phase 1 testing activities
    - » 07/27/2018: End of Phase 1 testing activities
    - » 08/07/2018: Debrief of Phase 1 testing activities
  - **NASA HQ approved Laser EOL Phase 2 testing activities on 09/25/18**
  - **Laser EOL Testing Phase 2 Activities:**
    - » Phase 2 testing will alternate leaving Laser A or B ON for extended durations and characterize performance every 6 months
    - » Round 1 Testing:
      - 11/15/18: Start of round 1; Characterized Laser B performance
      - 11/16/18: End of round 1; Characterized Laser A performance and left Laser A ON
      - 03/28/19: Debrief of Round 1 and planning for Round 2
    - » Round 2 Testing:
      - 04/17/18: Start of round 2; Characterized Laser A performance; Turn Laser B ON
      - 04/18/18: End of round 2; Characterized Laser B & A performance, left Laser B ON

Recent Activities

(December 2018 – May 2019)

- **Aqua/Aura Maneuver Working Group (MWG)**
  - **Aura RWA Maneuver Engineering Peer Review (EPR) – 10/24/18**
  - **Aura RWA Test Maneuver (TM) #2 – 11/30/18**
  - **FOT / FDS planned for Spring 2019 IAM Series with RWAs**
- **Spring 2019 Aura IAM Series**
  - **IAM series completed successfully**
    - » 03/06/19 & 03/13/19 Aura Inclination Adjust Maneuver (IAM) #59 & #60
    - » 04/03/19: Aura Inclination Adjust Maneuver (IAM) #61
      - Postponed from 03/21/19 due to Aura RMM performed on 03/19/19
      - Postponed from 03/27/19 due to Aqua post-maneuver conjunction of concern
    - » 04/10/19: Aura Inclination Adjust Maneuver (IAM) #62
  - **First IAMs to utilize the new RWA slew approach – success!**
    - » This series saved about 0.43 kg over thruster-slewed IAMs
  - **IAM #59 performance was ~12% COLD**
    - » Due to using simulated maneuver inputs
    - » Subsequent IAMs were adjusted to maintain GTE and MLT; overall 0.31% HOT
  - **Continue to observe degraded propulsion system performance**
    - » Thrust scale factor and duty cycles show a decrease in burn efficiency
    - » Working with FOT, FDS, and NG to assess the thruster issues

Recent Activities

(December 2018 – May 2019)

- **Aura Alternate Fuel Usage Plan Evaluation**
  - Assumptions for an Early Exit scenario have included:
    - » Full IAM Series through 2019 & 2020, then MLT & Beta angle are allowed to drift
    - » Constellation Exit Maneuver (CEM) in May 2021
    - » Continue to drift until December 2026 (approximate MLTAN of 16:30)
    - » Perigee Lowering Maneuvers (PLM) to begin in December 2026
  - Concerns have arisen about the ability to maintain power generation as the Beta angle drifts

Preliminary Future Power Generation Analysis:

- » Working as part of the EPS PWG with FOT / NG / ETD
- » Determine how the Angle of Incidence (AOI) between the sun and the solar array affects the power that can be generated at given conditions
- » Specifically, determine at what AOI the S/C is no longer able to generate enough power to power loads and charge batteries

Initial Predicts –

Oct 2022 – reach the Minimum Required Power for Loads and Battery Charging with a 10% Safety Margin (3494 W)

Oct 2023 – reach the Minimum Required Power for Loads and Battery Charging (3176 W)

Aug 2026 – reach the Minimum Required Power for Loads, but without any battery charging (1876 W)

Planned Activities

- **June 2019: Earth Science Constellation (ESC) MOWG (Toulouse, France)**
  - Update propellant budget, decommissioning analysis, reliability predictions, etc.
- **August 2019: Aura Science Team Meeting (Pasadena, CA)**
- **Summer 2019: EOMP and Decommission Plan (Lifetime Analysis) Updates**
  - Updates will lead into 2020 Senior Review Proposal cycle
- **November 2019: Earth Science Constellation (ESC) MOWG (TBC)**
  - Update propellant budget, decommissioning analysis, reliability predictions, etc.
- **January 2020: ESMO Annual Review #13**
- **March 2020: Senior Review Proposal submission**
- **Spring 2020: Annual Inclination Adjust Maneuvers (6) (*DRAFT Dates*)**
  - 3/4/20 (#63), 3/11/20 (#64), 3/18/20 (#65), 3/25/20 (#66), 4/1/20 (#67), 4/8/20 (#68)
- **Mid-to-Long-Term Plans:**
  - **EOS Automation (EA) – automation of routine operations**
    - » EA Phase 3.3 ORR – Summer 2019
    - » Continue FOT automation procedure development through 2019
  - **Continue to improve RMM / DAM execution**
    - » CRMS Release 8.0 – Fall 2019
    - » Support ESMO / CARA devolution initiative – Parallel Operations

Spring 2020
Inclination Adjust Plan (*DRAFT Dates*)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
23	24	25	26 Aura IAM #63	27 Aqua IAM #66	28	29
1 **March**	2	3	4 Aura IAM #64	5 Aqua IAM #67	6	7
8	9	10	11 Aura IAM #65	12 Aqua IAM #68	13	14
15	16	17	18 Aura IAM #66	19 Aqua IAM #69	20 Equinox EPS SOH Test	21
22	23	24	25 Aura IAM #67	26 Aqua IAM #70	27	28
29	30	31	1 **April** Aura IAM #68	2 Aqua IAM #71	3	4
5	6	7	8 Aura Backup	9 Aqua Backup	10	11

Collision Risk Management System (CRMS) Process Improvements

- **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**
  - 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

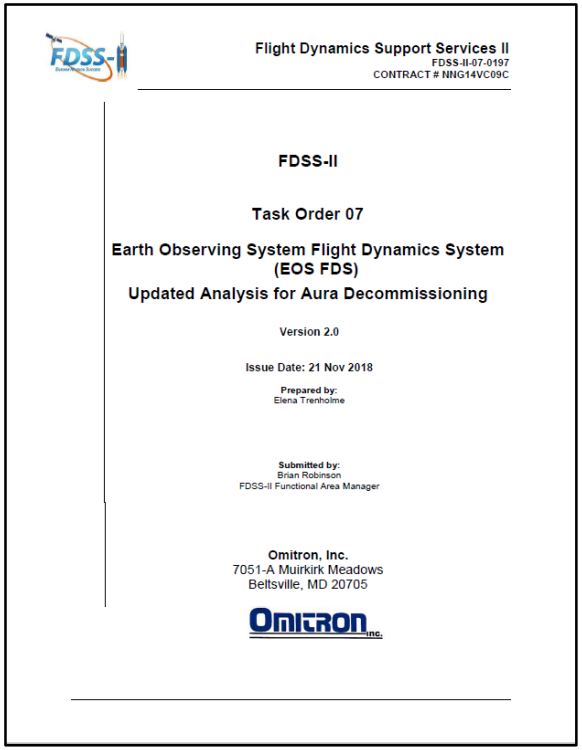
- **EOC is currently operating with CRMS Release 7 (ORR 04/25/19)**

- **ESMO developed MOCA CONOPS in support of CARA Devolution initiative**
  - **Parallel operations test phase Spring / Summer 2019 (TRR 03/25/19)**

Aura Propellant Usage
(Analysis Updated November 2018)

- **2006: Initial Aura lifetime fuel analysis**
- **2008: Detailed Aqua & Aura lifetime analysis**
  - Presented to MOWG and at Aura End of Prime Mission Review in September 2010
- **2012 (September): Initial Aura Decommissioning Plan**
  - Included updated Lifetime Estimates
- **2013 (August): Updated Decommissioning Plan**
  - Included updated Constellation Exit Plan
- **2014 (September): Updated Decommissioning Plan**
- **2015 (September): Decommission Plan Update Postponed**
  - Postponed to evaluate long-term plan and decommissioning maneuvers
- **2016 (January): Updated Decommission Plan (v1.2)**
  - Included hypothetical MLT drift analysis with LS-8
- **2017 (October): Updated Decommission Plan (v1.0)**
- **2018 (July): Updated Decommission Plan (v1.0)**
  - Summer IAM required update to document and IAM Plans
  - Included Appendix B with alternate plan to drift after 2019 IAMs
- **2018 (November): Updated Decommission Plan (v2.0)**
  - Updated definitive fuel usage & predicted solar flux levels
  - Updated propellant estimates for IAMs w/ RWAs & DMUs
- **2019 (Summer): Expect updated Decommission Plan (v1.0)**
  - Update definitive fuel usage & predicted solar flux levels

- **Annual updates will be provided each July (starting in 2017)**
- **Final will be produced 60 days before start of decommissioning**



Flight Dynamics Support Services II
FDSS-II-07-0197
CONTRACT # NNG14VC09C

FDSS-II

Task Order 07

Earth Observing System Flight Dynamics System (EOS FDS)
Updated Analysis for Aura Decommissioning

Version 2.0

Issue Date: 21 Nov 2018

Prepared by:
Elena Trenholme

Submitted by:
Brian Robinson
FDSS-II Functional Area Manager

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

Remaining Fuel Estimate
(Analysis Updated November 2018)

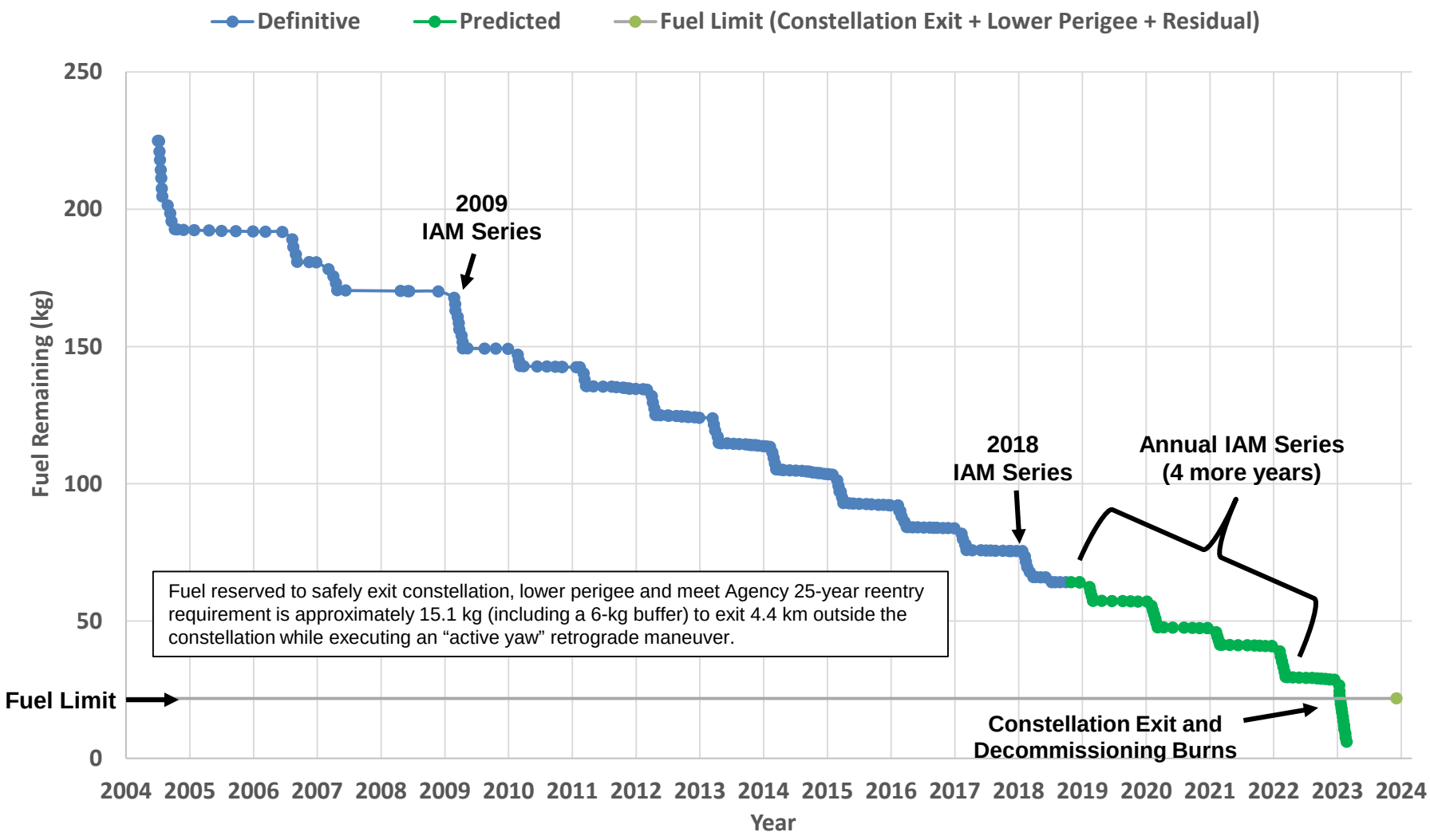
- **Long-term orbit simulations were run for Aura through Feb 2023**
  - **Used mean nominal Schatten solar flux predictions (May 2018)**
  - **Estimated the frequency of drag make-up maneuvers to maintain Aura's WRS-2 ground track requirements**
  - **Estimated the required number of annual inclination maneuvers for Aura to maintain it's mean local time (MLT) requirement (20 IAMs through 2022) [w/ Baseline Plan]**
  - **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 Aura shows that the spacecraft will have sufficient fuel to maintain its current orbit within the Afternoon Constellation through 2022 (before 2023 IAM series) [w/ Baseline Plan]**
- **Aura will hold sufficient fuel in reserve after exiting the constellation to lower perigee such that reentry will meet the NASA 25-year reentry requirement.**
- **Analyses are updated annually by ESMO Flight Dynamics Team**
  - **Currently developing a retrograde maneuver capability and a more efficient inclination/mean local time option to extend the potential lifetime**

Debris Assessment Software

(Analysis Updated November 2018)

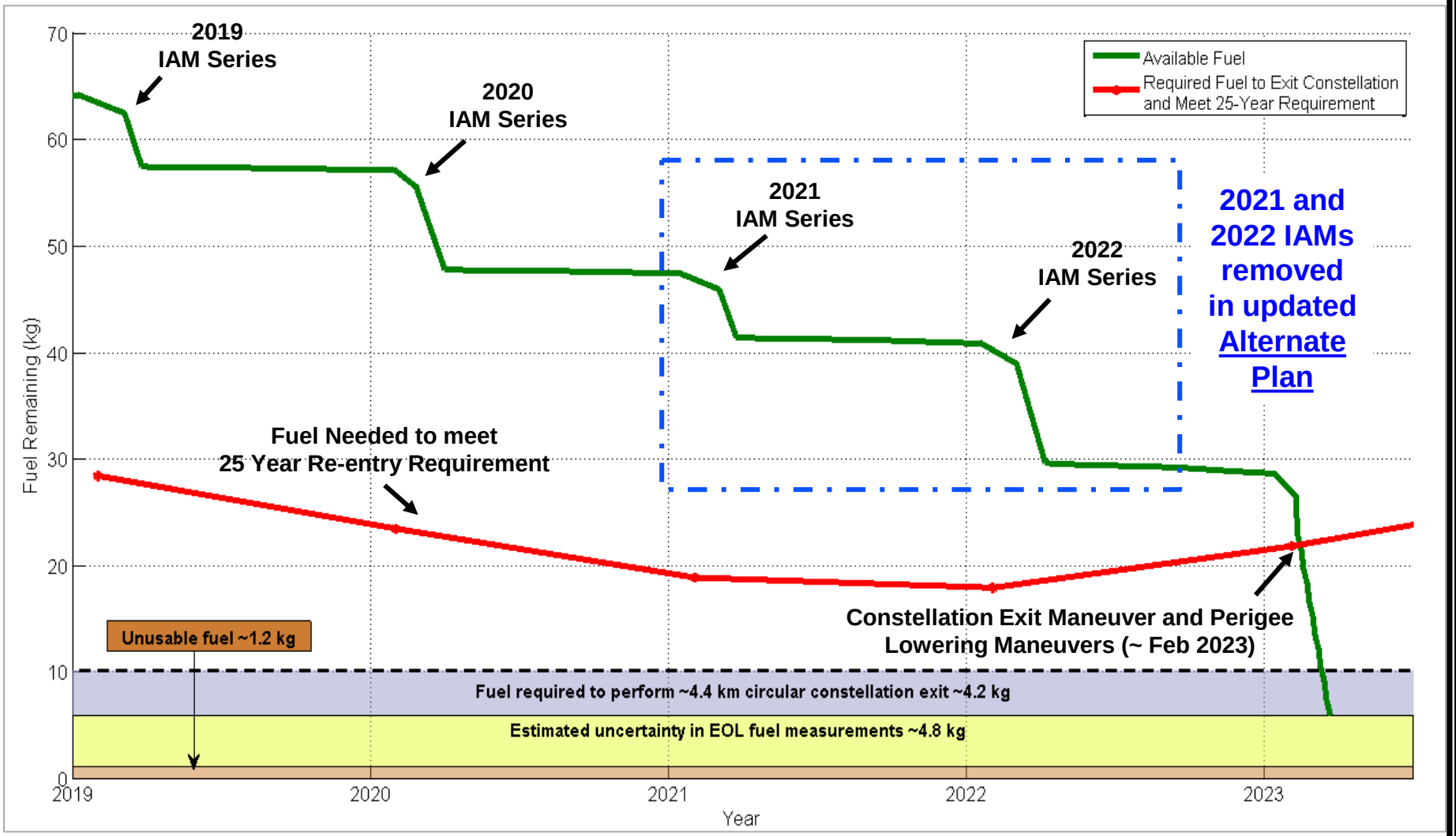
- **The Debris Assessment Software (DAS) was created by the Orbital Debris Office at Johnson Space Center and is the Agency standard for end of mission life analyses and lifetime estimations (Version 2.1.1)**
- **Solar Flux file from April 2018**
- **DAS requires several inputs describing the spacecraft's mission:**
  - Start apogee = Average Height = ~695 km (at constellation exit)
  - Spacecraft Dry Mass = 2791.746 kg (includes 1.2 kg of unusable fuel and 4.8 kg of uncertainty)
  - Tumbling Area = 46.1 m^2 (FDSS-II-07-0085_Aura Average Area _V1.0 (3/1/17))
  - Area-to-Mass Ratio = Tumbling Area / Dry mass = 0.016485 m^2/kg
  - Start inclination = 98.2^o
  - Launch date = 07/15/2004
- **In turn, 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
- **Aura has a waiver to the 30-years from launch requirement**
- **Aura will hold sufficient fuel in reserve to meet the 25-year requirement**

Fuel Usage: Actual & Predicted
(Current Baseline Plan – Analysis Updated November 2018)



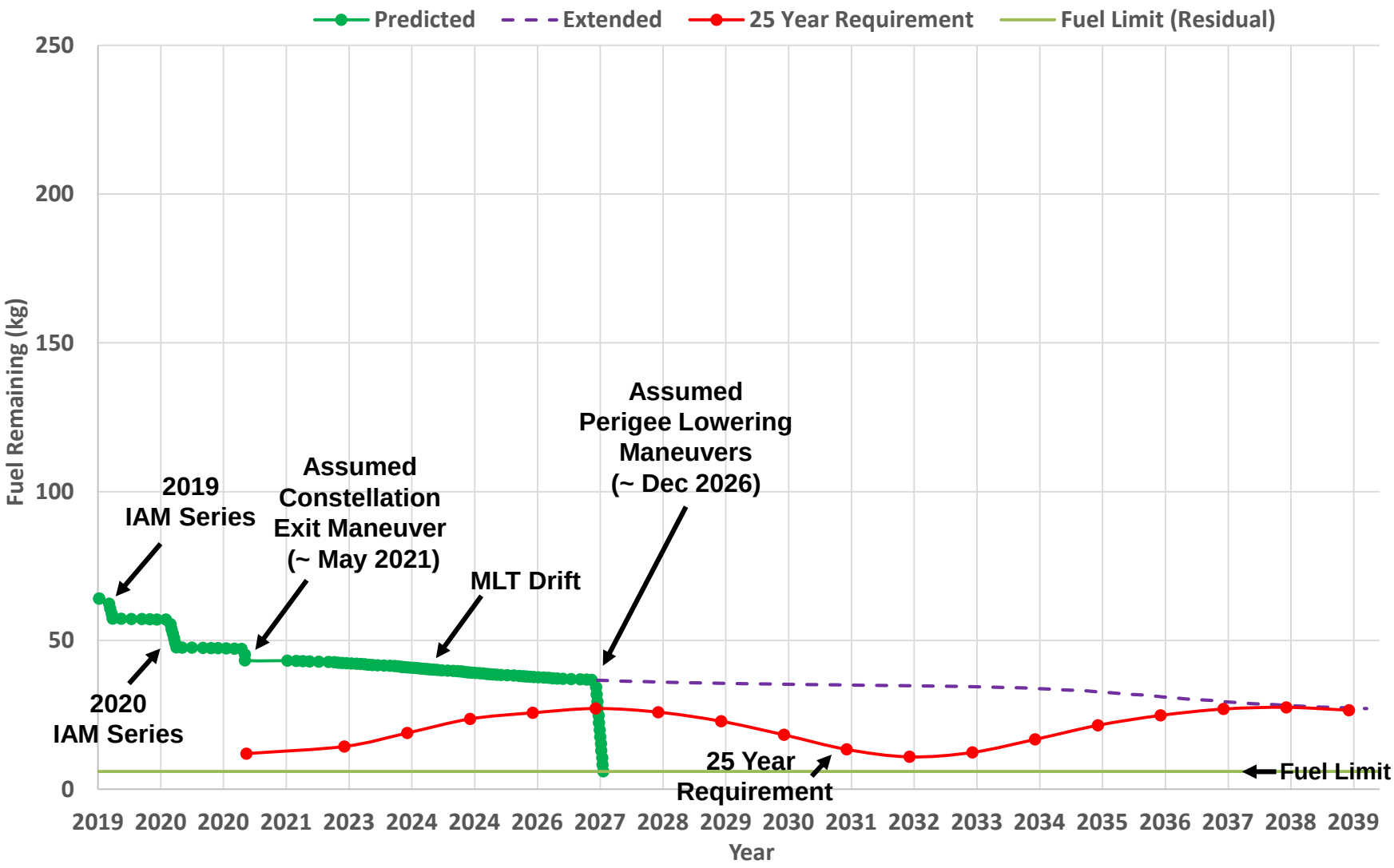
Aura DAS End of Life Predictions

(Current Baseline Plan – Analysis Updated November 2018)



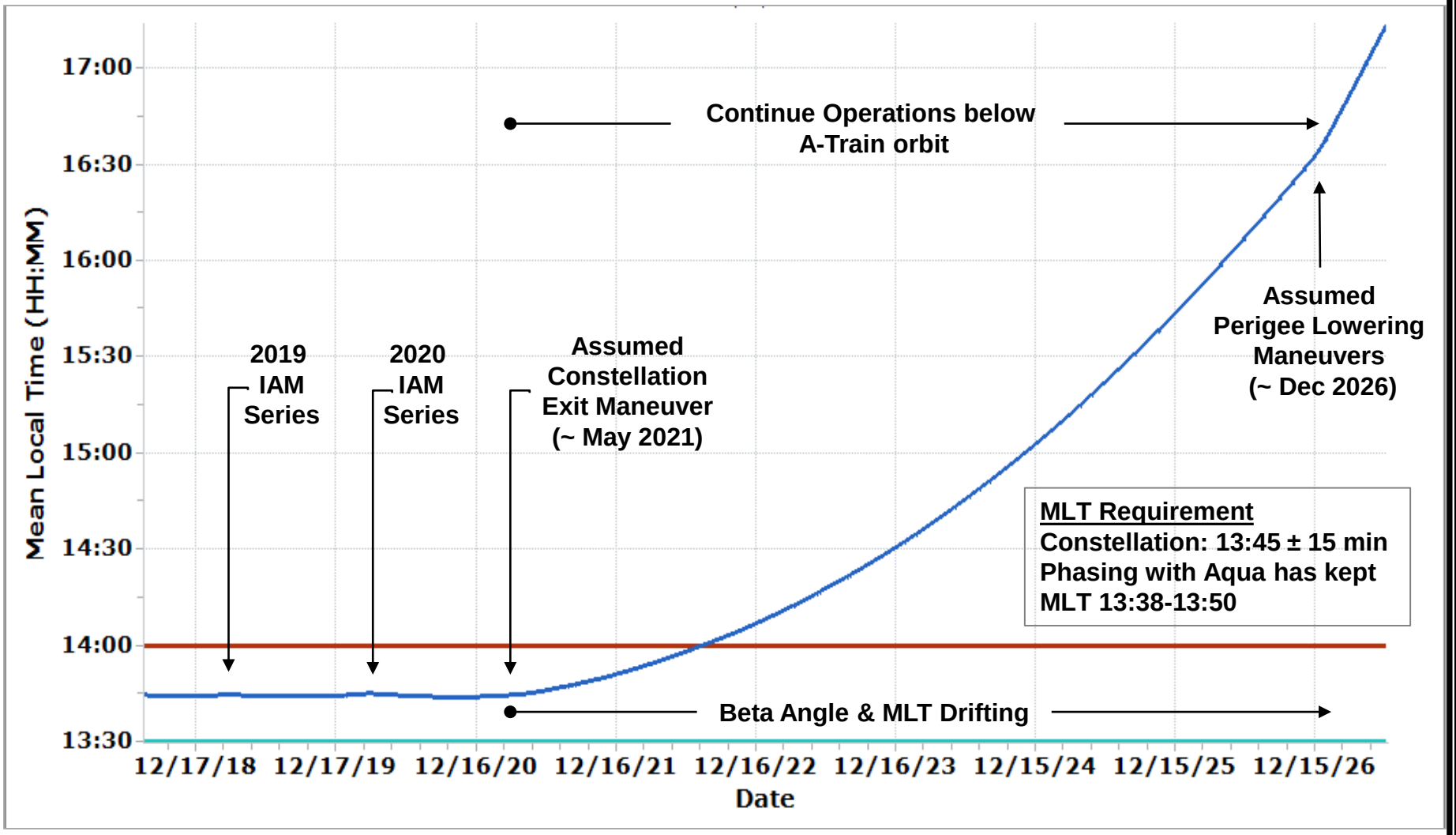
Aura Predicted Fuel Usage

(Alternate Plan – Analysis Updated November 2018)



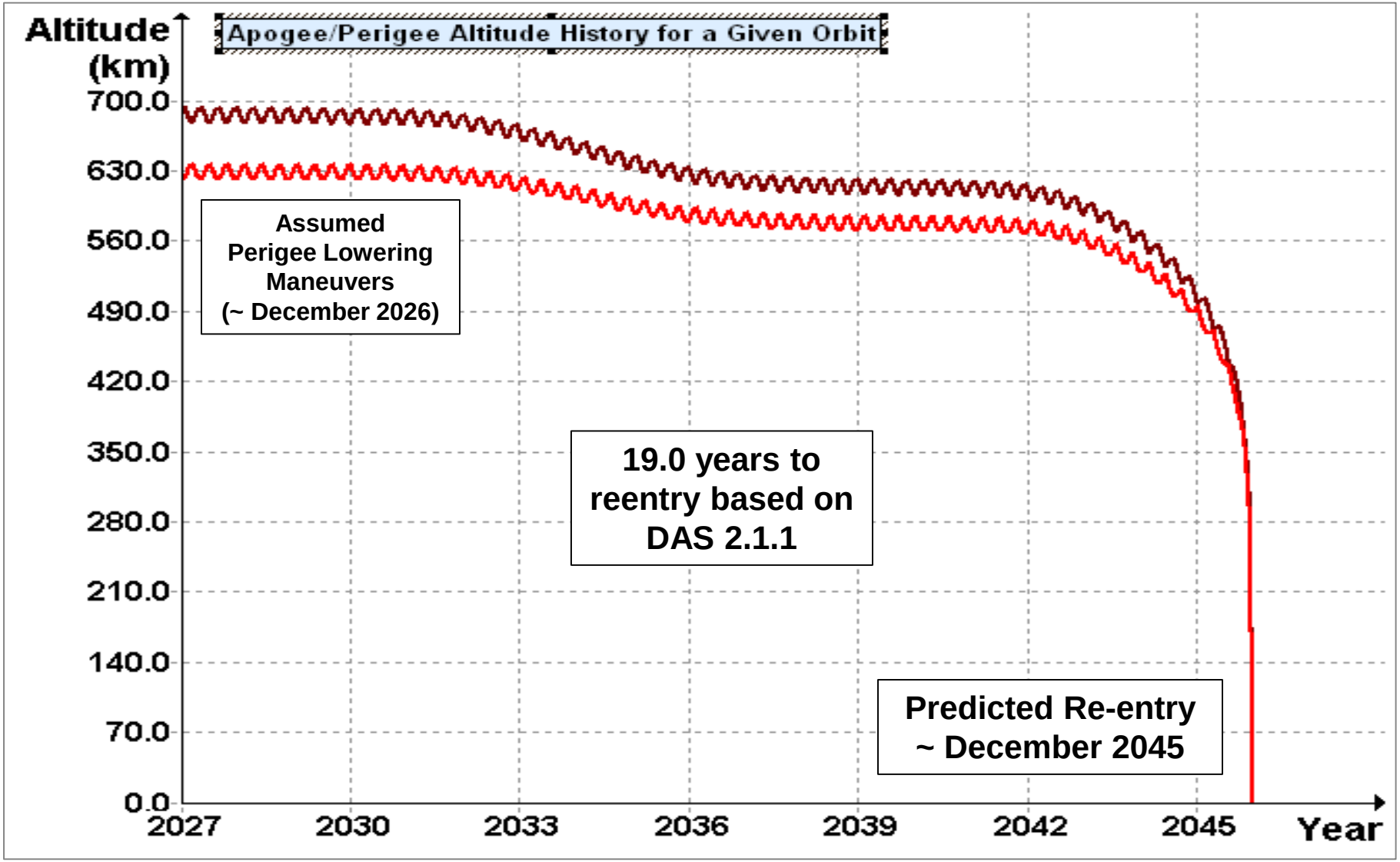
Aura Predicted Mean Local Time

(Alternate Plan – Analysis Updated November 2018)



Aura Predicted Re-entry

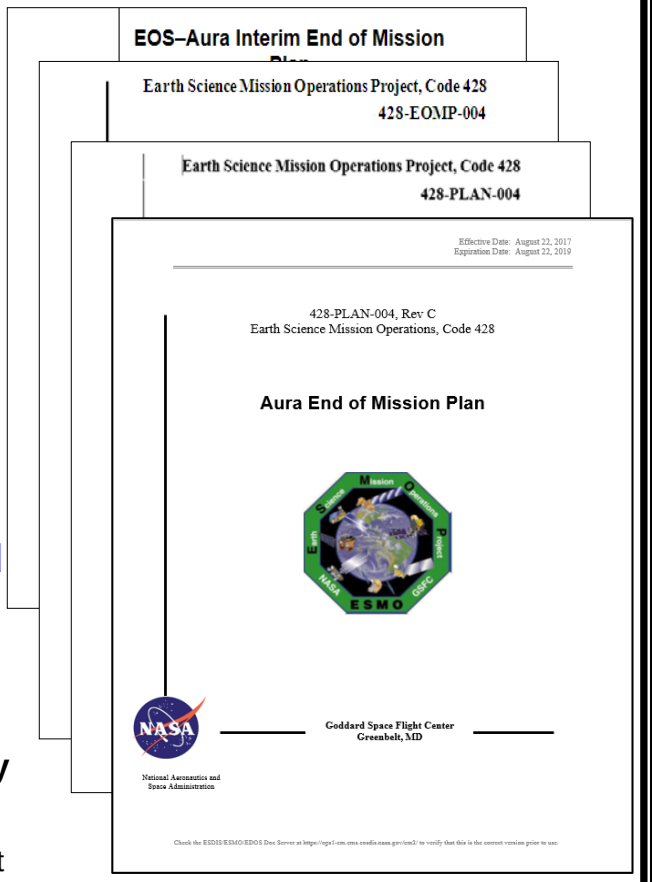
(Alternate Plan – Analysis Updated November 2018)



Aura End of Mission Plan (EOMP)

(Rev. C Updated Spring 2017)

- Initial draft February 2009
- Produced the first "Interim" End of Mission Plan (EOMP) in May 2011
  - Approved by NASA HQ July 2011
- Produced EOMP Rev A: February 2013
  - Updated Lifetime estimates, Small Object Collision Assessment
  - Waivers were approved in May 2013
- Produced EOMP Rev B: February 2015
  - Updated Lifetime Estimate
- Produced EOMP Rev C: August 2017
  - Lifetime estimates (as of 12/2016) & Reliability estimates
- **Rev D. to be produced for Summer 2019 with re-baselined plan – may need some waivers updated & reapproved**
- Content Synopsis:
  - Safely exit the A-Train Constellation
  - Passivate Aura to the extent possible for uncontrolled reentry
  - Aura has five (5) approved waivers for passivation
    - » Pressurant Passivation, Large Object Collision Probability, Small Object Collision Probability, Orbital Lifetime (30-Year), and Re-entry Risk (Un-controlled)
- Final will be produced 60 days before End of Mission



Summary

- Spacecraft Status – GREEN
- Instrument Status - GREEN
  - HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data
  - MLS: Operating Normally –
    - » 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)
    - » 10/25/2018: GHz Mirror Electronics (GME-B) Anomaly (Recovered 10/25/18)
    - » 01/27/2019: MLS Survival Mode Transition (Recovered 01/31/19)
  - OMI: Operating Normally
    - » 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 04/30/19: 99.99499076%
- Ground Systems – GREEN
  - Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required
  - 12/18/2018: Online (Eclipse) Build 21.01 ORR
  - 02/06/2019: EOS Automation (EA) Release 3.2.2 eORR

Questions

Additional Charts

Maneuvers & Ground Track History
Orbital Trends

Aura Conjunction Assessment
High Interest Events (HIEs)

Data Capture & Operations Errors

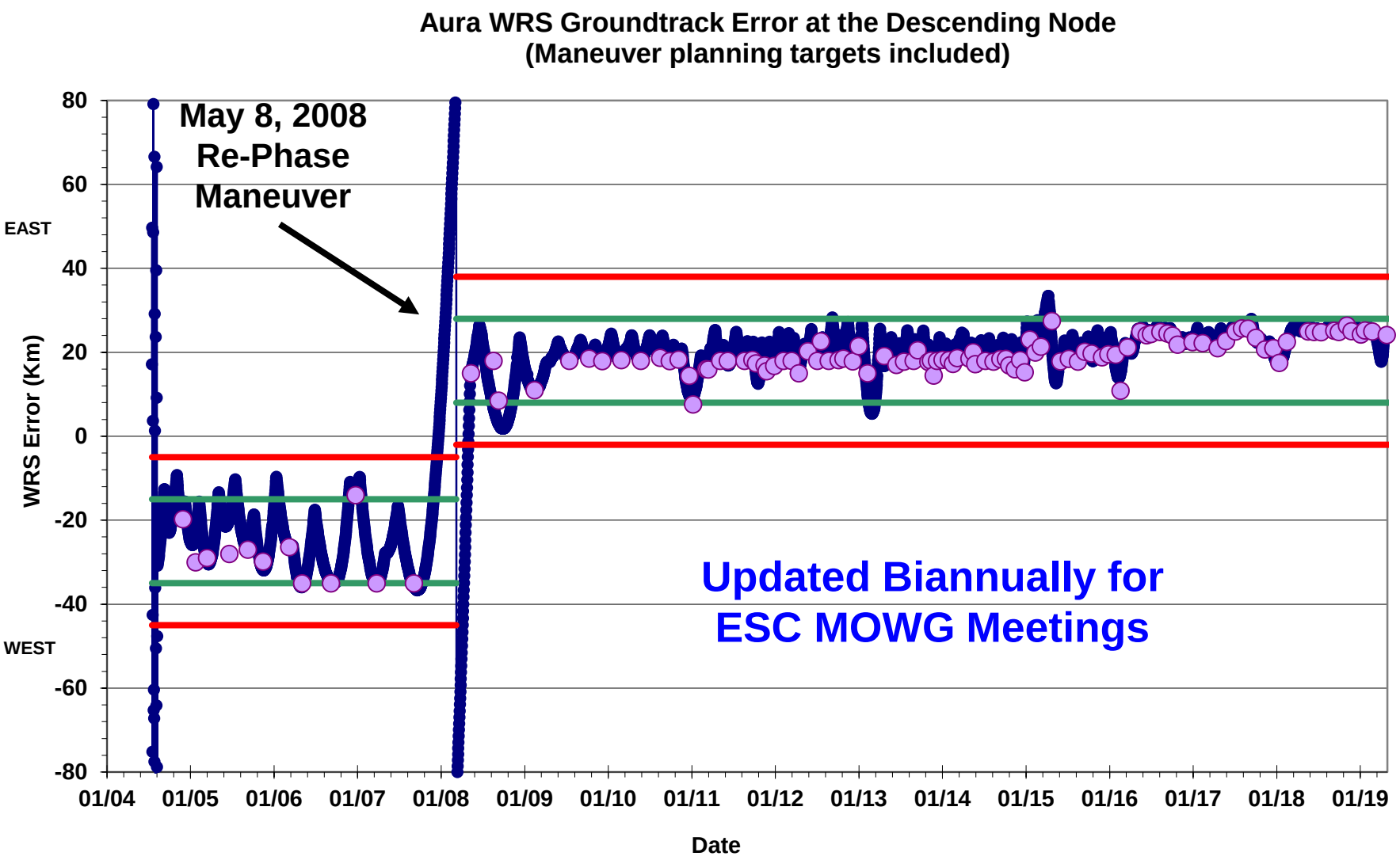
Extended Mission Plans
(Analysis Updates)

Orbit Maintenance

- **Mission Requirements: Perform Drag Make-Up Maneuvers (DMUMs) to maintain Aura's Ground Track Error (GTE) with respect to the World Reference System (WRS-2)**
  - **Requirement: +/-20 Km as measured at the Descending Node**
- **To meet coincident viewing requirements, Aura's initial ground track was offset from Aqua's by one WRS path plus 25.4 Km**
  - **Aura was maintained -5.4 to -45.4 Km west of Aqua until late 2007**
  - **Since May 8, 2008, a new control box, +/- 10 Km from a +18 Km (east) offset of the Aqua WRS-2 path is used to maintain MLS-CALIPSO viewing request**
- **To date a total of 122 routine DMUMs have been performed**
  - **07/19/2012: DMUM # 43 No Yaw Slew Maneuver (NYS) #1 – NYS Maneuvers (37)**
  - **Last maneuver 05/08/2019 (#122) – Next maneuver target for 05/30/2019 (#123)**
  - **Variation in performance from –3.5% (cold) to +3.3% (hot)**
- **Conducted 14 series of inclination adjustment maneuvers**
  - **Fall '04 (4), Fall '06 (4 of 6), Spring '07 (4), Spring '09 (9), Spring '10 (3), Spring '11 (3), Spring '12 (4), Spring '13 (4), Spring '14 (4), Spring '15 (5), Spring '16 (4), Spring '17 (4), Spring '18 (5), Summer '18 (1), & Spring '19 (4)**
  - **Variation in performance from -4.5% (cold) to +1.9% (hot)**

WRS Ground Track Error (GTE)

(As of April 29, 2019)

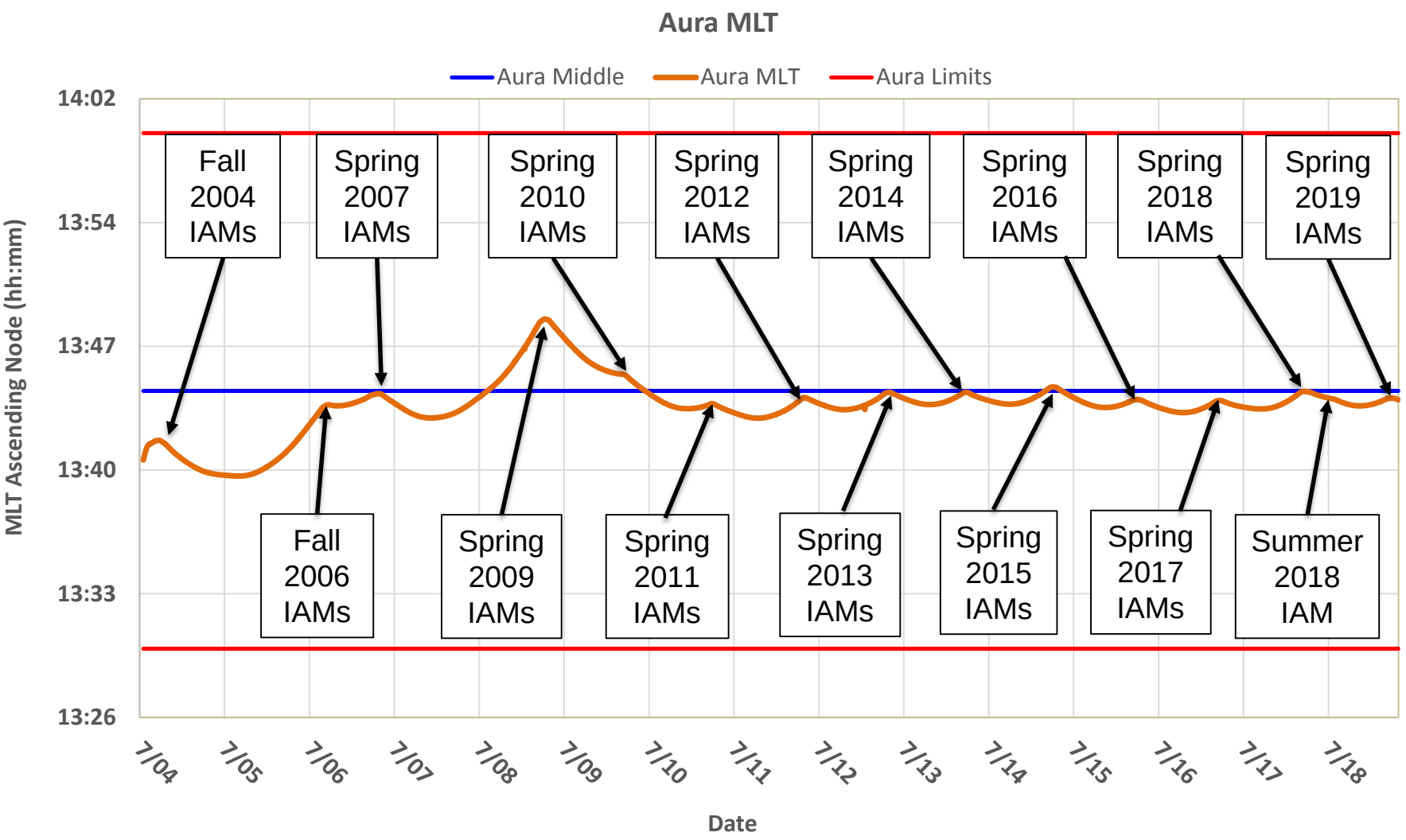


WRS Ground Track Error (GTE)

(As of April 29, 2019)

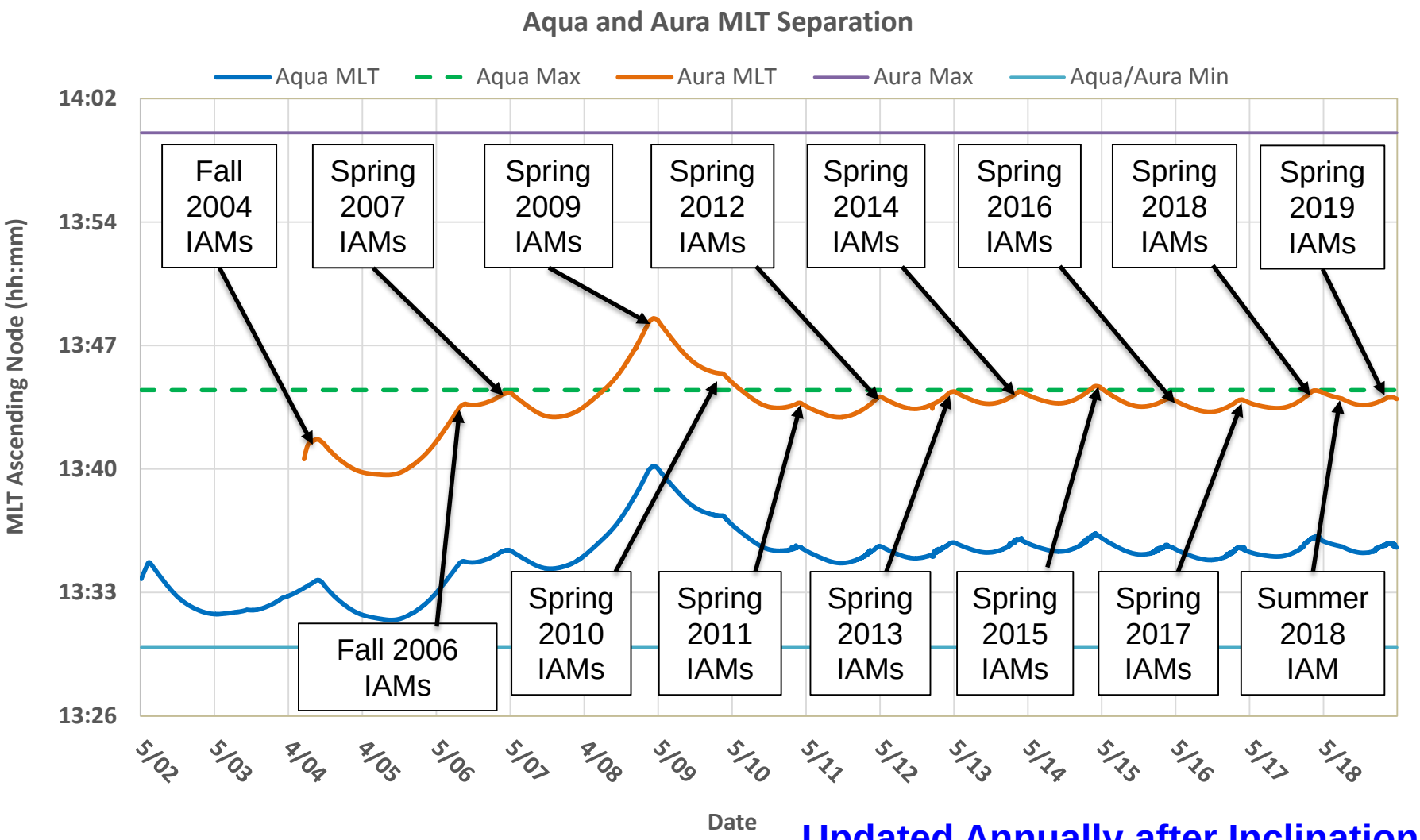
Aura Averaged MLT @ Ascending Node

(As of April 29, 2019)



Aqua/Aura Mean Local Time (MLT)

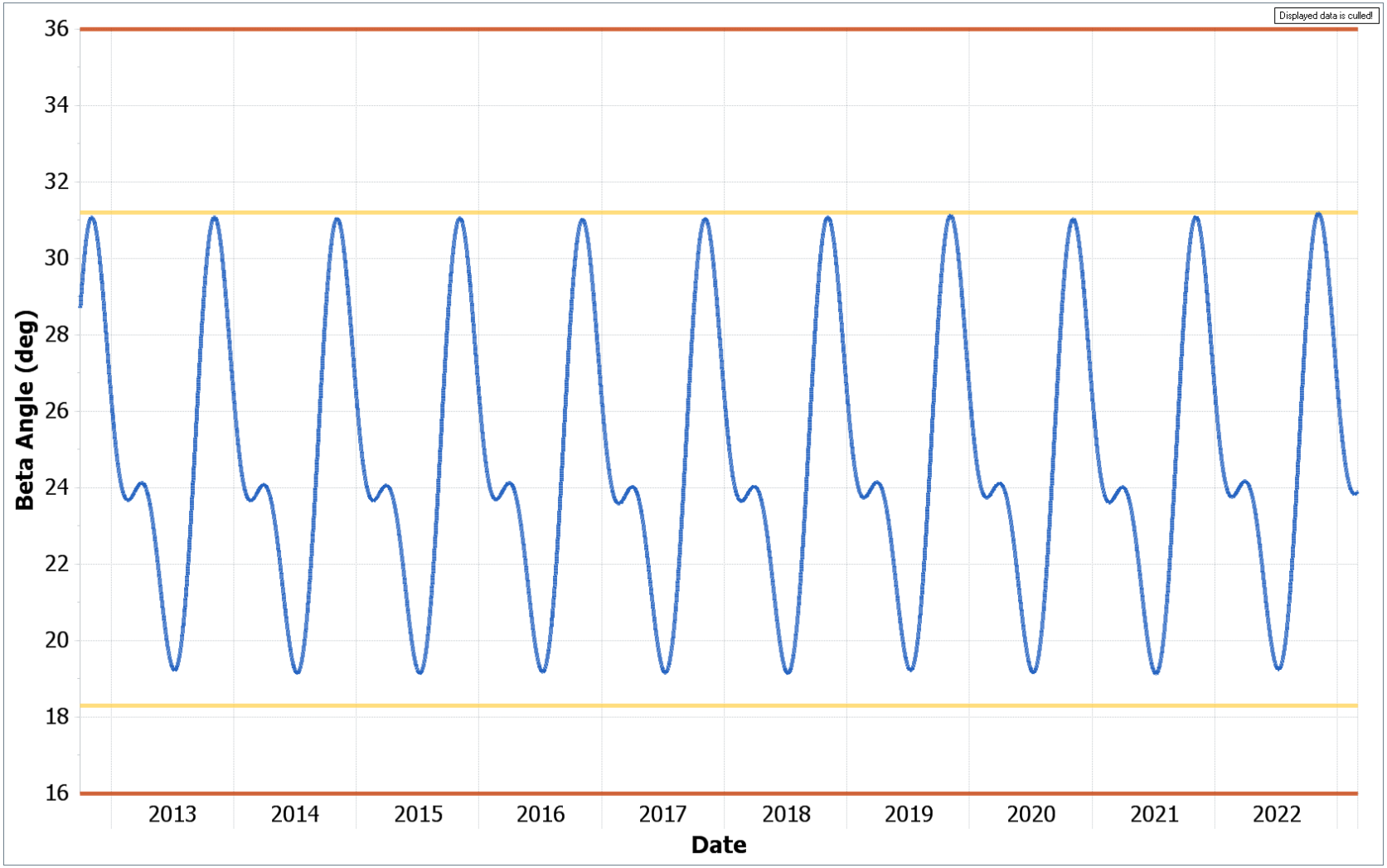
@ Ascending Node (As of April 29, 2019)



Updated Annually after Inclination Adjust Maneuvers

Aura Predicted Beta Angle

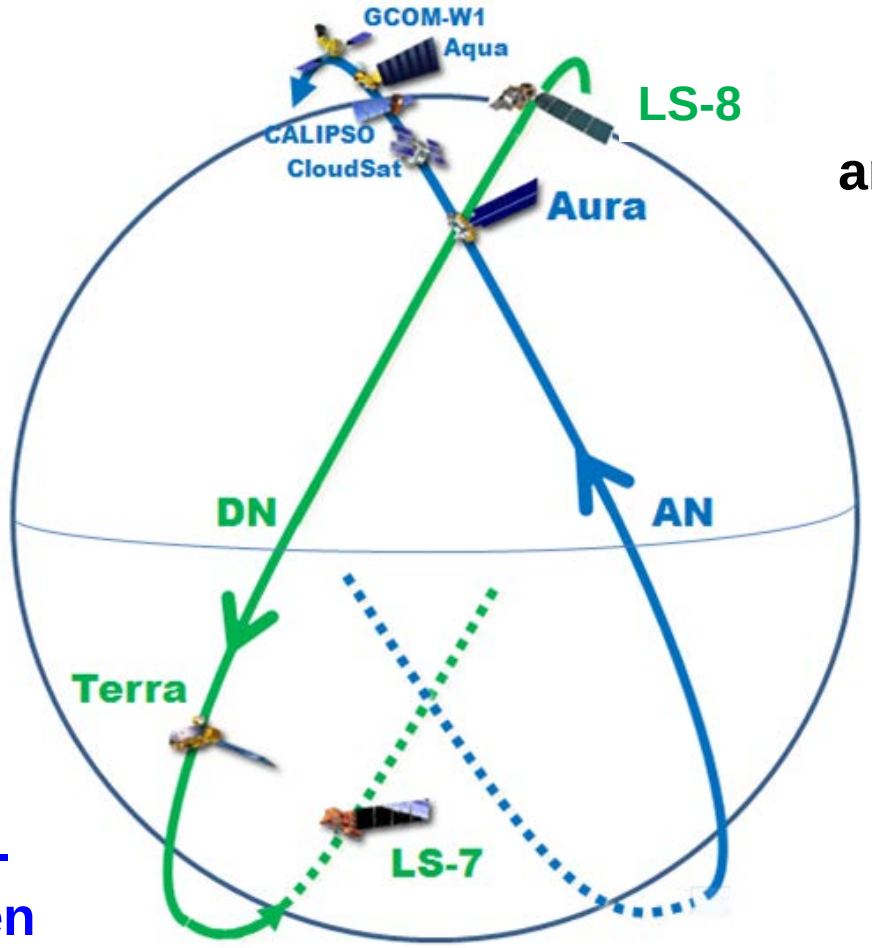
(With Yearly Inclination Maneuvers) (No Change)



Aura and Landsat-8 (LS-8)

Orbit Phasing

With Aura in the intersection point LS-8 will be ~ 77 seconds away from the intersection Point worse case



By Design – LS-8 and LS-7 are ½ orbit apart

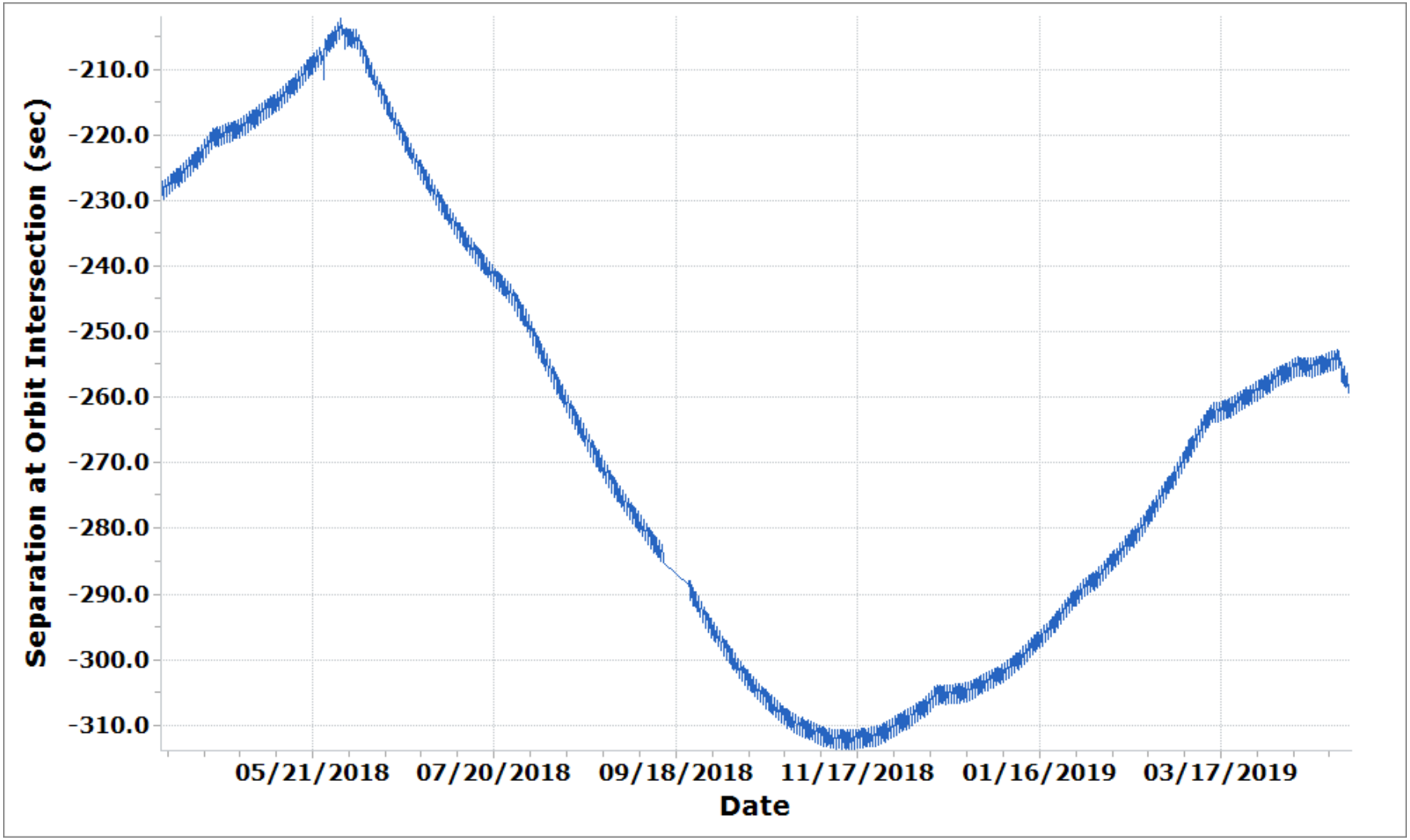
Over the past 12 months (Apr-Mar) there has been 200-315 seconds between Aura and LS-8

Terra ~ 30 min behind LS-7

1 Orbit = ~ 100 minutes

LS-8/Aura Phasing at Poles

@ Northern Intersection Point (as of April 29, 2019)



Aura Conjunction Assessment

High Interest Events (HIEs)

	Dec `18	Jan `19	Feb `19	Mar `19	Apr `19	May `19	Total
Tier 1	0	0	0	0	0		0
Tier 2	1	0	0	0	0		1
Tier 3	1	1	2	0	0		4
Tier 4	0	0	0	1	0		1
Total	2	1	2	1	0		6

2014: 33 CARA HIEs – 18 required significant action (T2-T4)
2015: 32 CARA HIEs – 18 required significant action (T2-T4)
2016: 24 CARA HIEs – 16 required significant action (T2-T4)
2017: 19 CARA HIEs – 16 required significant action (T2-T4)

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

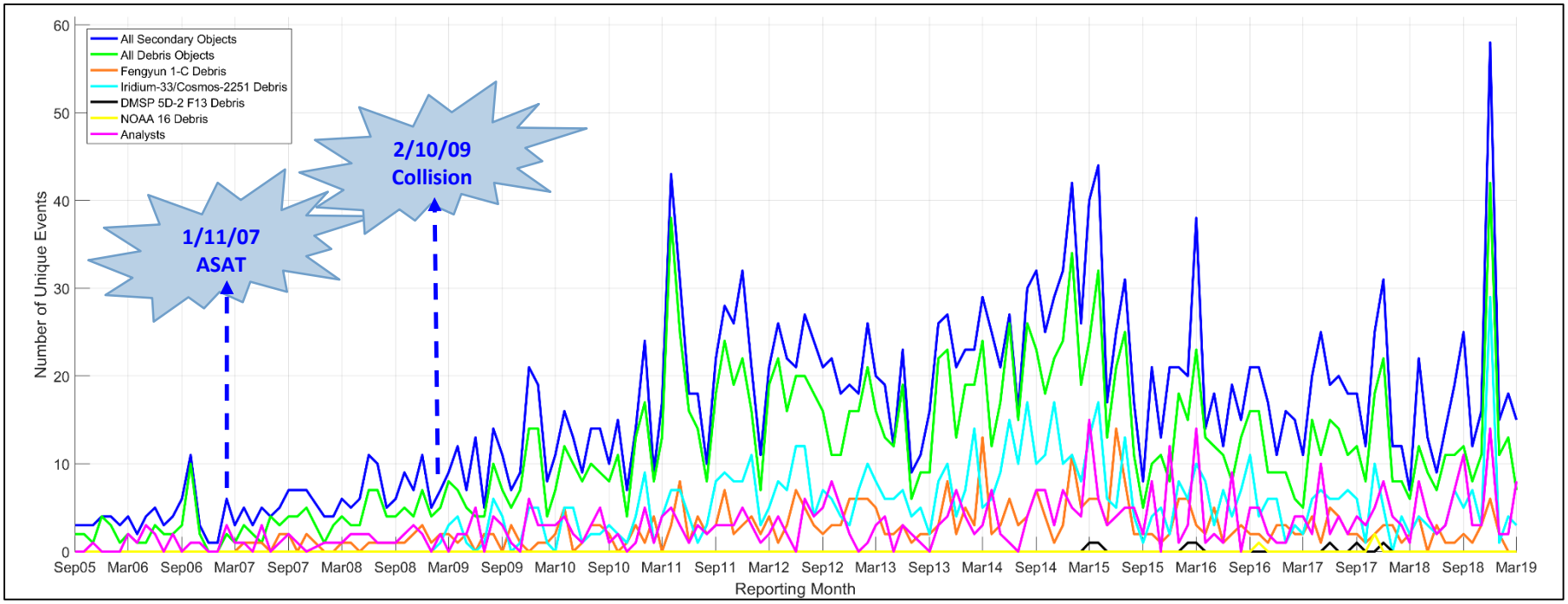
2018: 16 CARA HIEs (thru 12/31/2018) – 16 required significant monitoring and/or actions (T2-T4)

15. **12/05/2018: CA vs. 40225 at 23:59:24 GMT – Repeating conjunction; Pc dropped w/ updated tracking (T2)**
16. **12/22/2018: CA vs. 30451 at 15:41:23 GMT – Maneuver options generated and screened, Pc dropped (T3)**

2019: 4 CARA HIEs (thru 04/30/2019) – 4 required significant monitoring and/or actions (T2-T4)

1. **01/10/2019: CA vs. 43387 at 10:10:58 GMT – DAMs planned and screened, Self-mitigated (T3)**
2. **02/05/2019: CA vs. 43387 at 05:50:18 GMT – DAMs planned and screened, Self-mitigated (T3)**
3. **02/17/2019: CA vs. 81798 at 23:55:50 GMT – DAMs planned and screened, Self-mitigated (T3)**
4. **03/20/2019: CA vs. 87932 at 03:17:19 GMT – DAMs planned, screened, and maneuver executed (T4)**

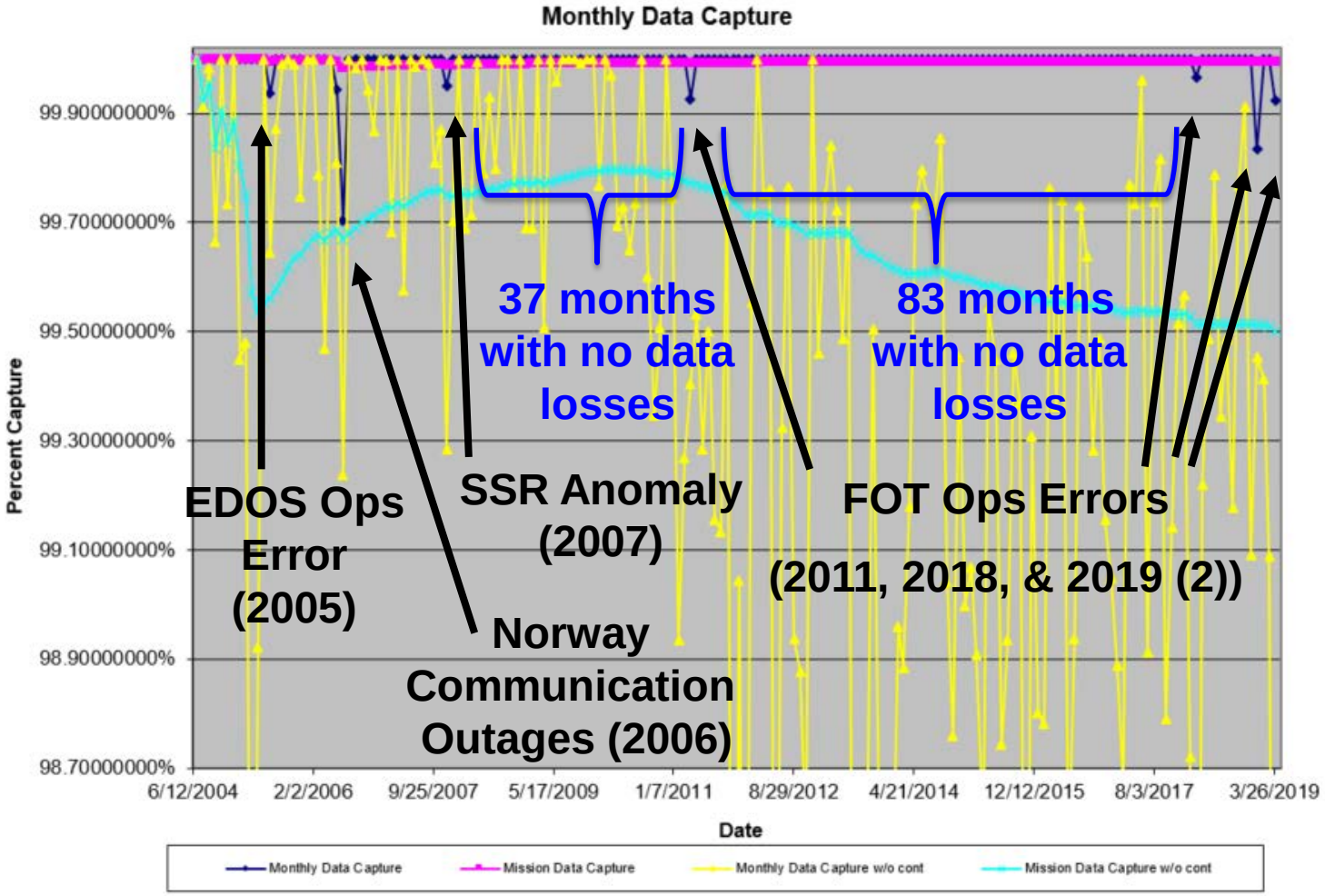
Aura Conjunction Assessment
(September 2005 thru March 2019)



Credit: NASA CARA Team

Aura Monthly Data Capture

SSR Data Capture to 04/30/2019: 99.99499076%



Mission Capture Req. = 95%

SSR Data Losses – 2019

Last Data Loss: April 2019 (FOT Ops Error)

January: Data Loss #1025 on DOY 030 (January 30, 2019)

- **Aura experienced OMI data loss from 030/11:36:55 to 030/11:47:17**
  - » MLS was not collecting science (Survival Mode) during this time frame

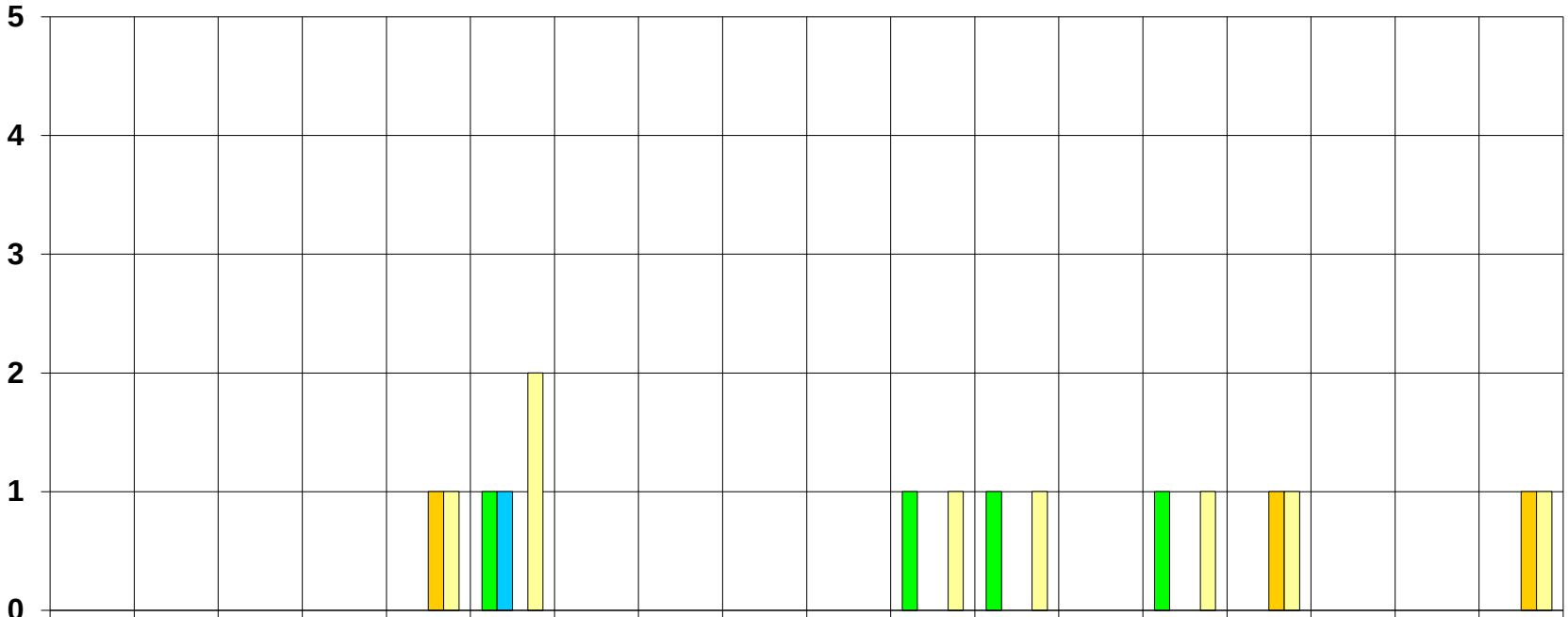
April: Data Loss #1029 on DOY 094 (April 04, 2019)

- **Ground station issues initially forced the need to take data capture contingency action**
- **Recovery actions were unsuccessful due to unforeseen issues with recently updated procedures (i.e., CDH_SSR_REPLAY)**
- **Data gaps were observed in Low Rate Data from 14:11:54 - 14:46:02, and in OMI data from 14:12:26 - 15:10:47.**
- **FOT will be conducting a Root Cause and Corrective Action (RCCA) Investigation**

Operational Errors

(18-Months: November 2017 – April 2019)

Aura: 0 Months since last operational error (April 2019)



	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Terra	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0
Aqua	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Aura	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1
Total	0	0	0	0	1	2	0	0	0	0	1	1	0	1	1	0	0	1

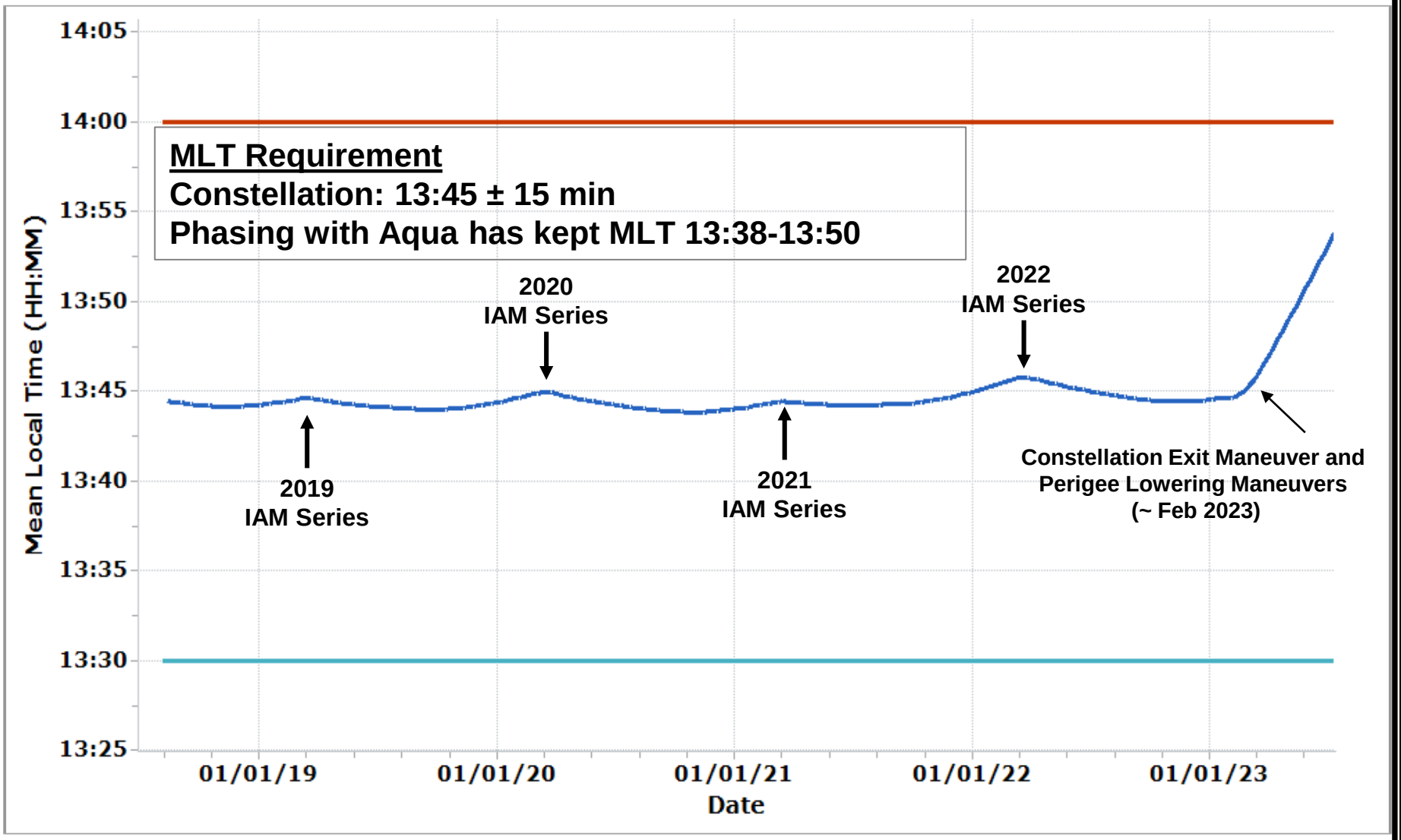
Aura Baseline Decommissioning Plan
(Current Baseline Plan – Analysis Updated November 2018)

- **Baseline Decommissioning Plan Assumptions:**
  - Maintain MLT and WRS-2 Ground Track requirements until the DAS 25-year re-entry fuel limit is reached (Spring 2023)
    - ➢ Perform nominal annual IAMs to maintain MLT
    - ➢ Perform periodic DMUs to maintain WRS-2 Ground Track Error

To be documented in 'EOS FDS Updated Analysis for Aura Decommissioning' (v2.0, 11/21/18)

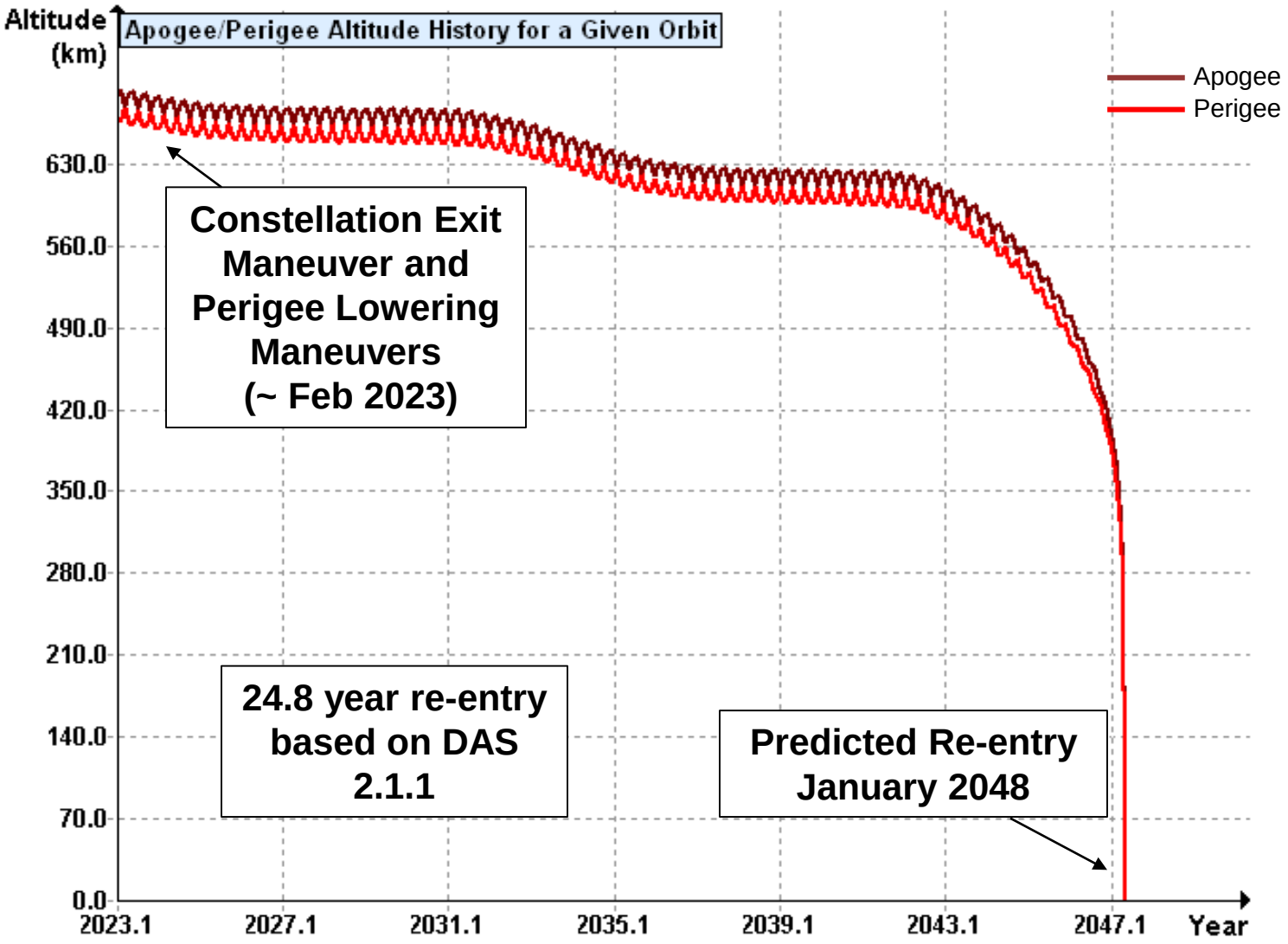
Aura Predicted Mean Local Time

(Current Baseline Plan – Analysis Updated November 2018)



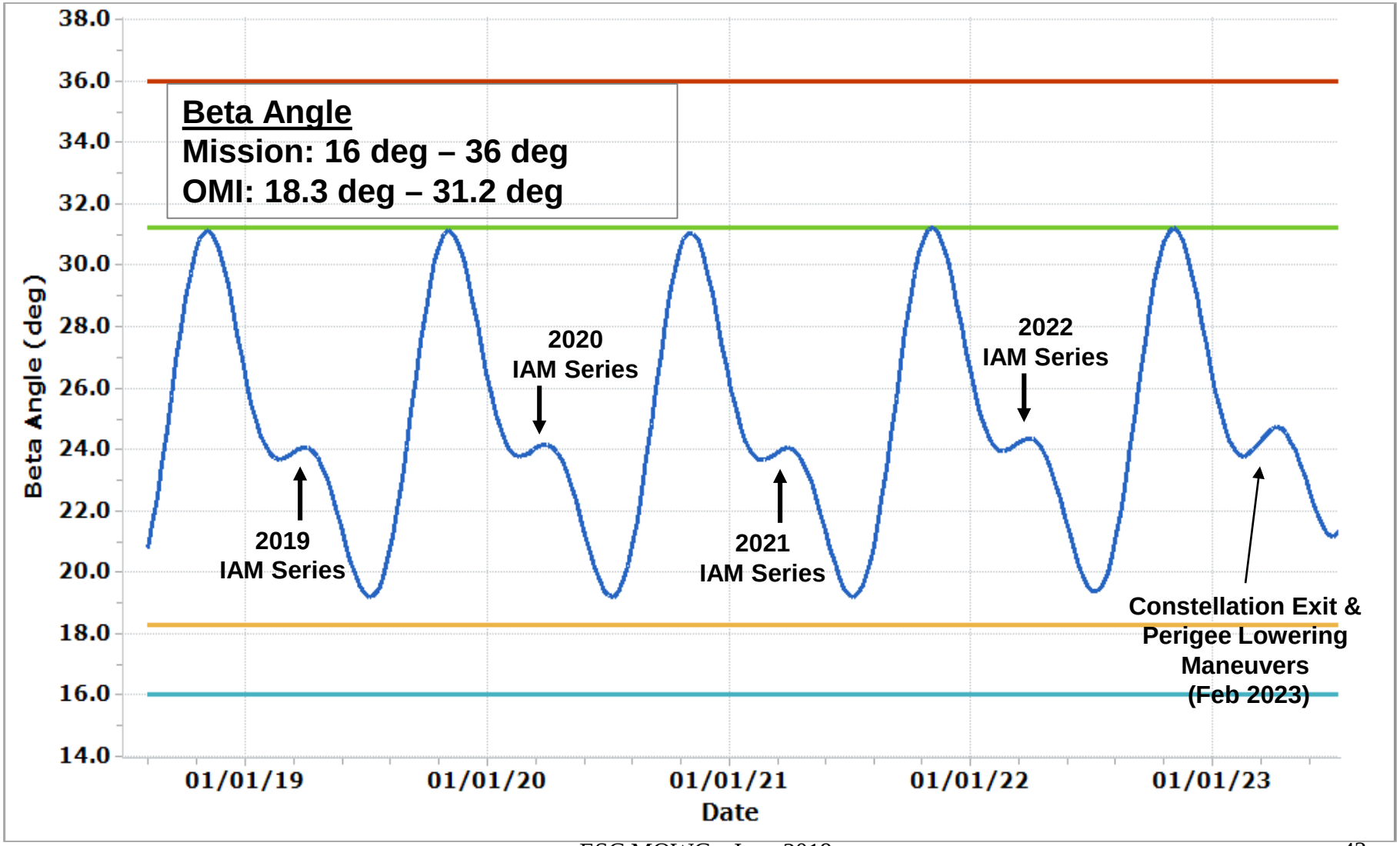
Aura Predicted Re-entry

(Current Baseline Plan – Analysis Updated November 2018)



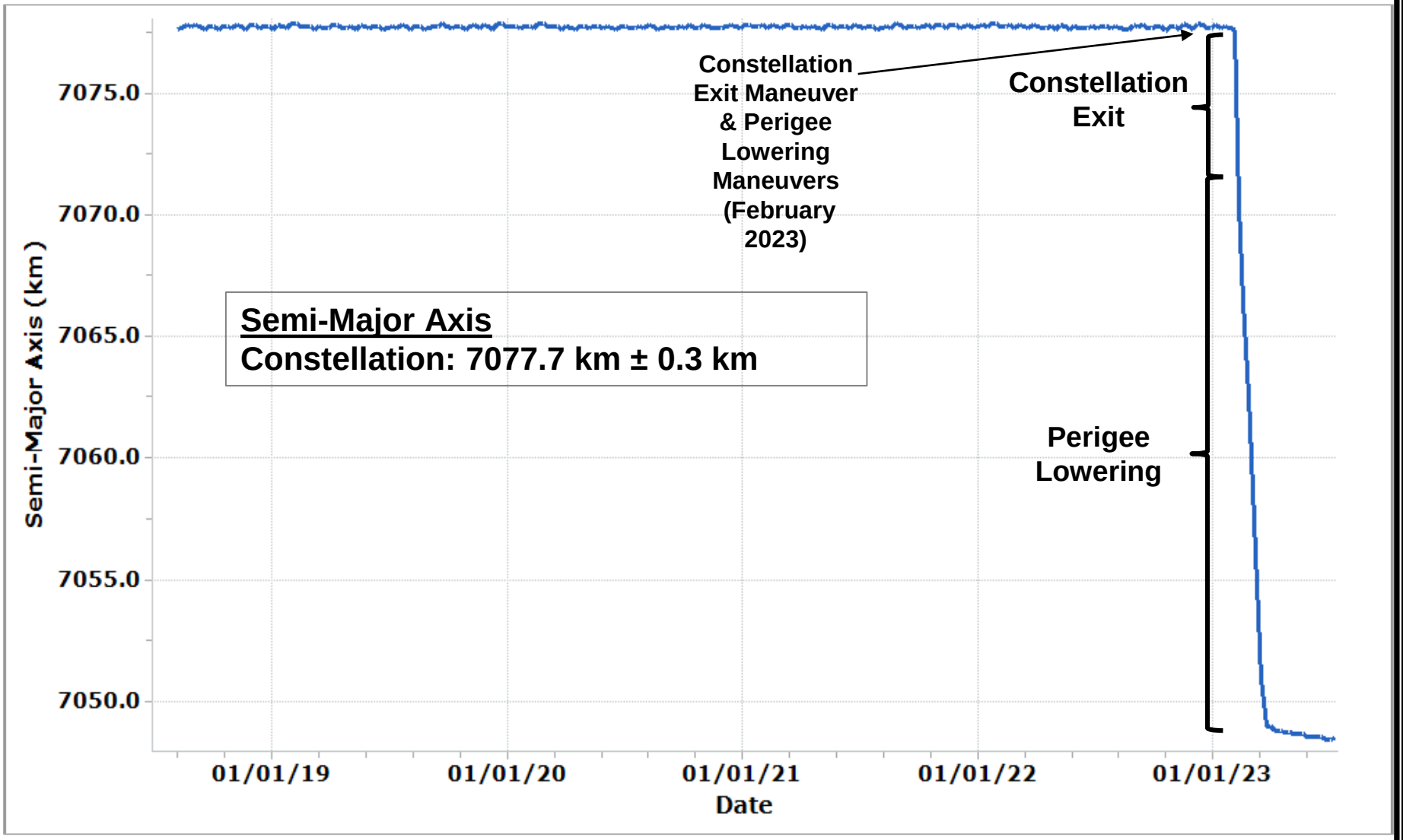
Aura Predicted Beta Angle

(Current Baseline Plan – Analysis Updated November 2018)



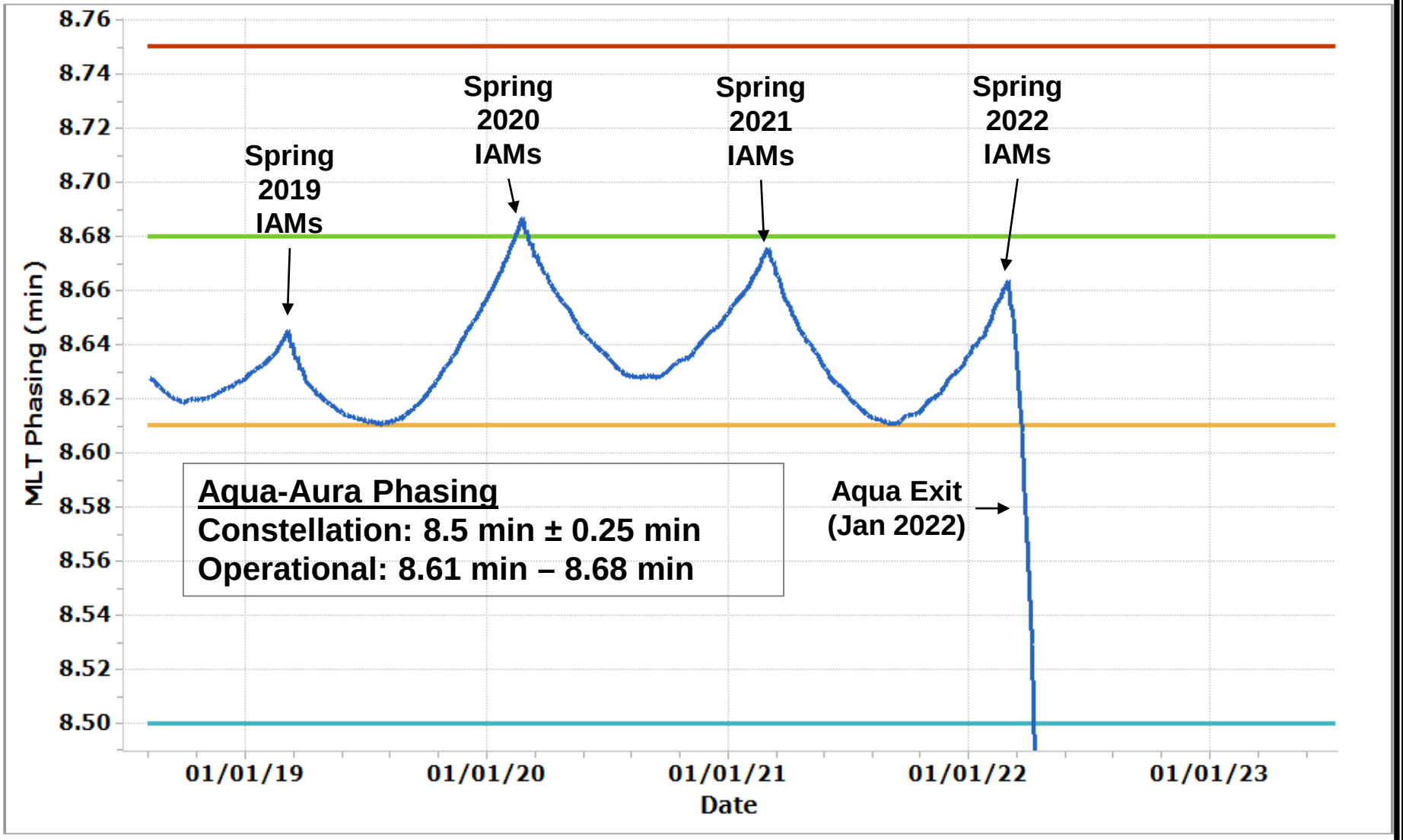
Aura Predicted Semi-Major Axis

(Current Baseline Plan – Analysis Updated November 2018)



Aura MLT Phasing with Aqua

(Current Baseline Plan – Analysis Updated November 2018)



Aura Alternate Decommissioning Plan

(Alternate Plan – Analysis Updated November 2018)

- **Alternate Decommissioning Plan Rationale:**
  - After the OMI / TROPOMI 2-year overlap period ends, May 2020, fuel saving orbital maintenance schemes may be a consideration

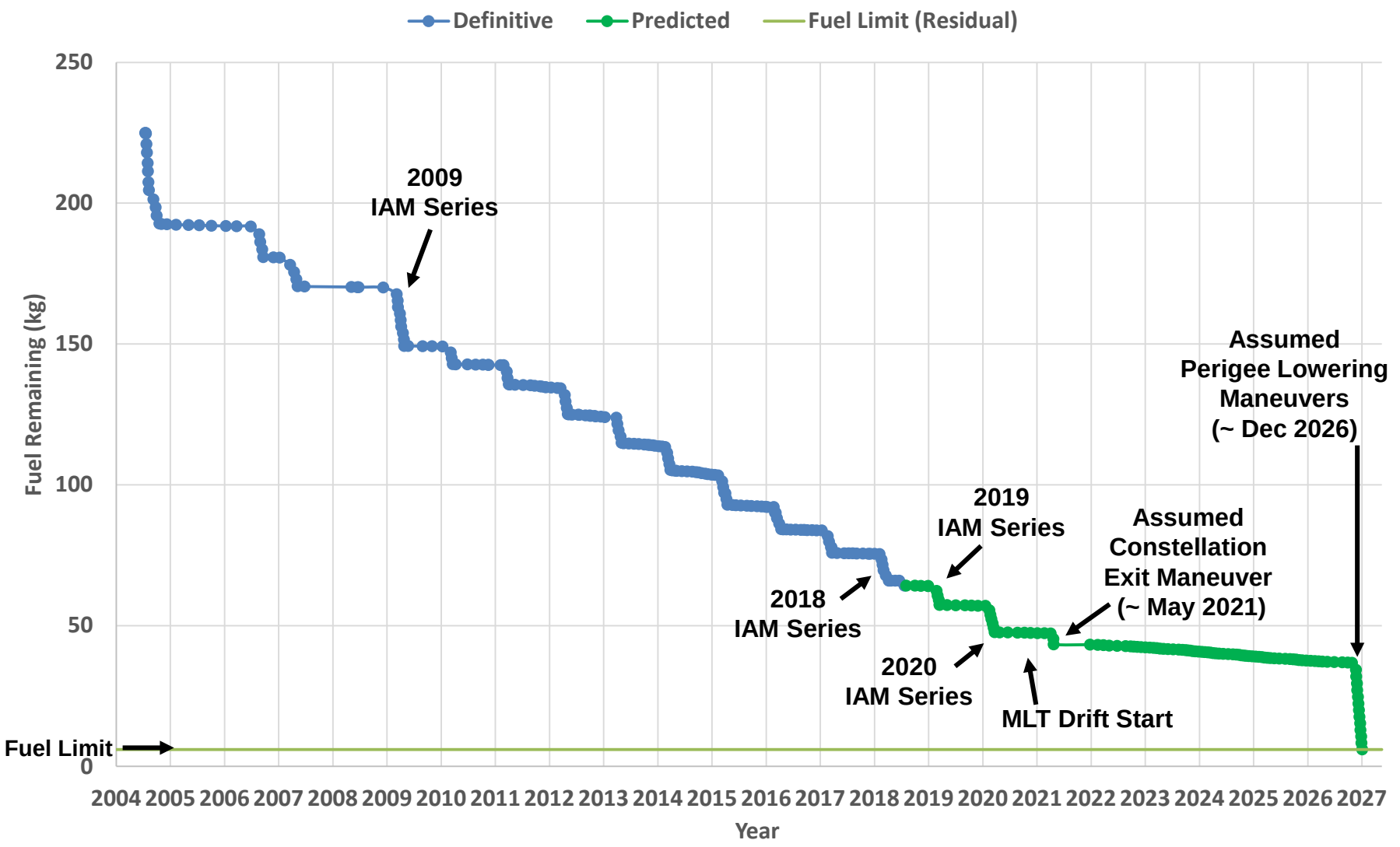
  (Sentinel-5P launch on 10/13/17, TROPOMI completed check out in April 2018)

- **Alternate Decommissioning Plan Assumptions:**
  - Full IAM Series through 2019 & 2020
    - Exit A-Train in May 2021 (4.4 km lower in SMA)
  - Stop performing annual IAMs after the 2020 series
    - Allow MLT and Solar Beta Angle to drift through 2026
  - Perform periodic DMUs until 2026
    - Maintain ground track and frozen orbit

To be documented in 'EOS FDS Updated Analysis for Aura Decommissioning' (v2.0, 11/21/18, Appendix B)

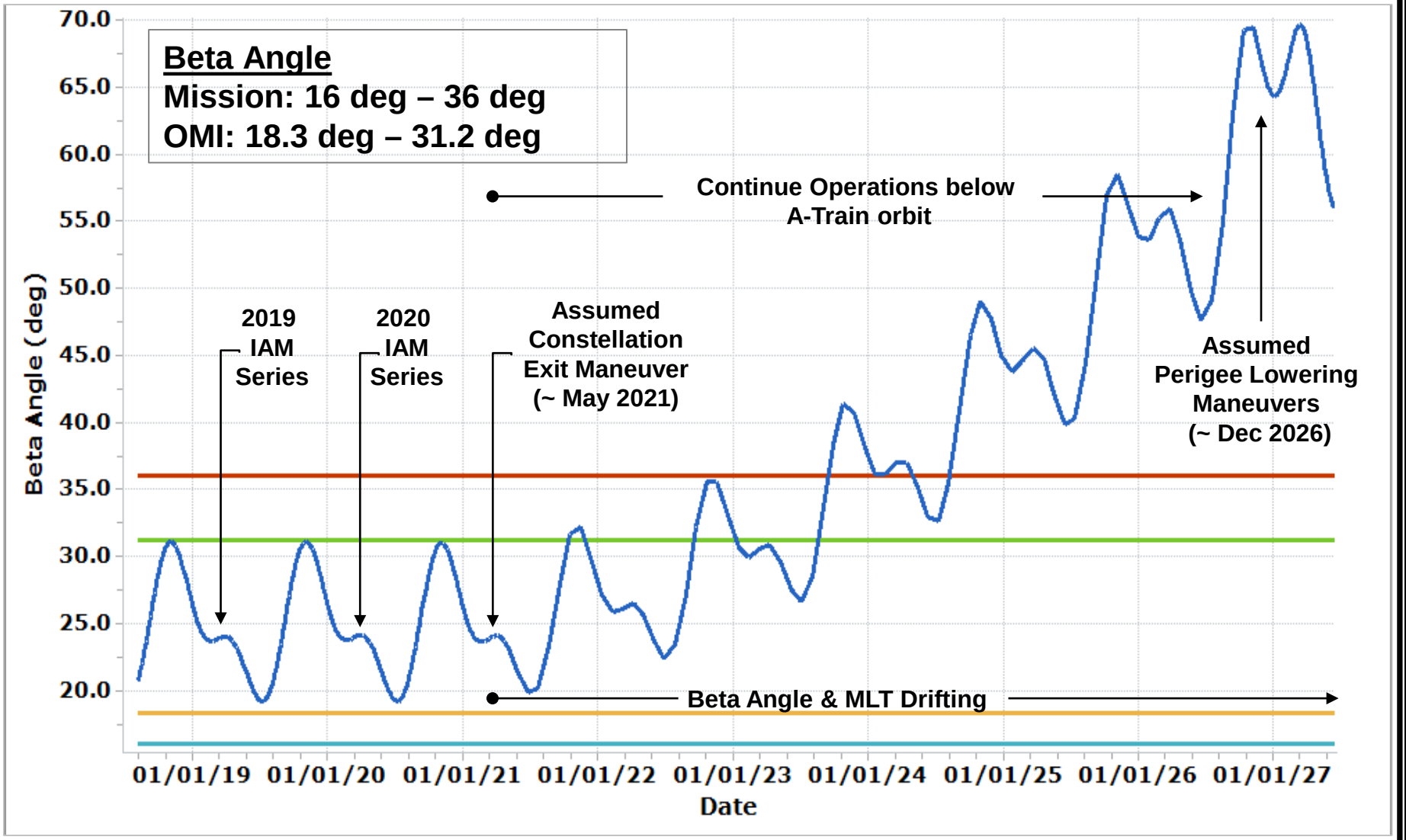
Aura Fuel Usage: Actual & Predicted

(Alternate Plan – Analysis Updated November 2018)



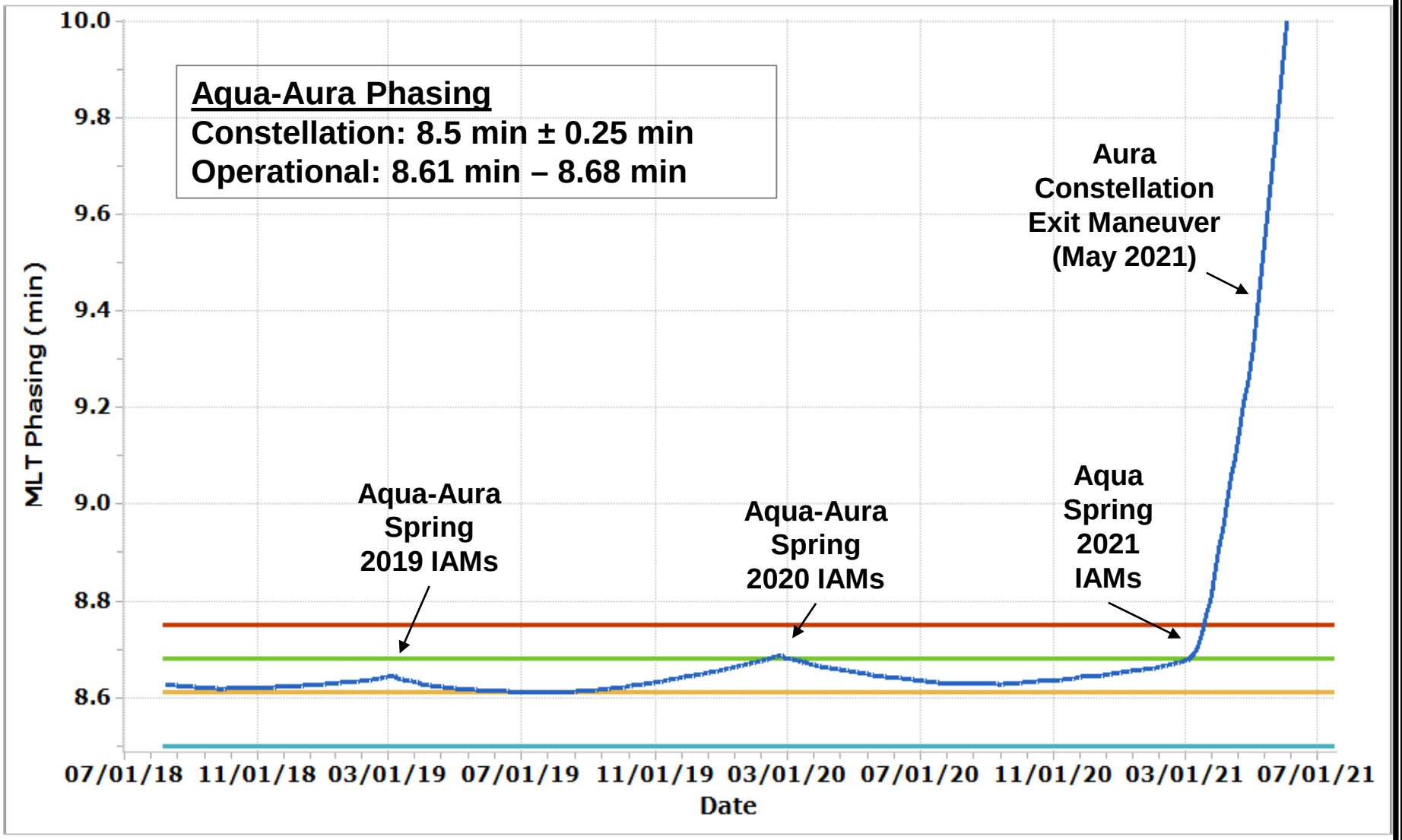
Aura Predicted Beta Angle

(Alternate Plan – Analysis Updated November 2018)



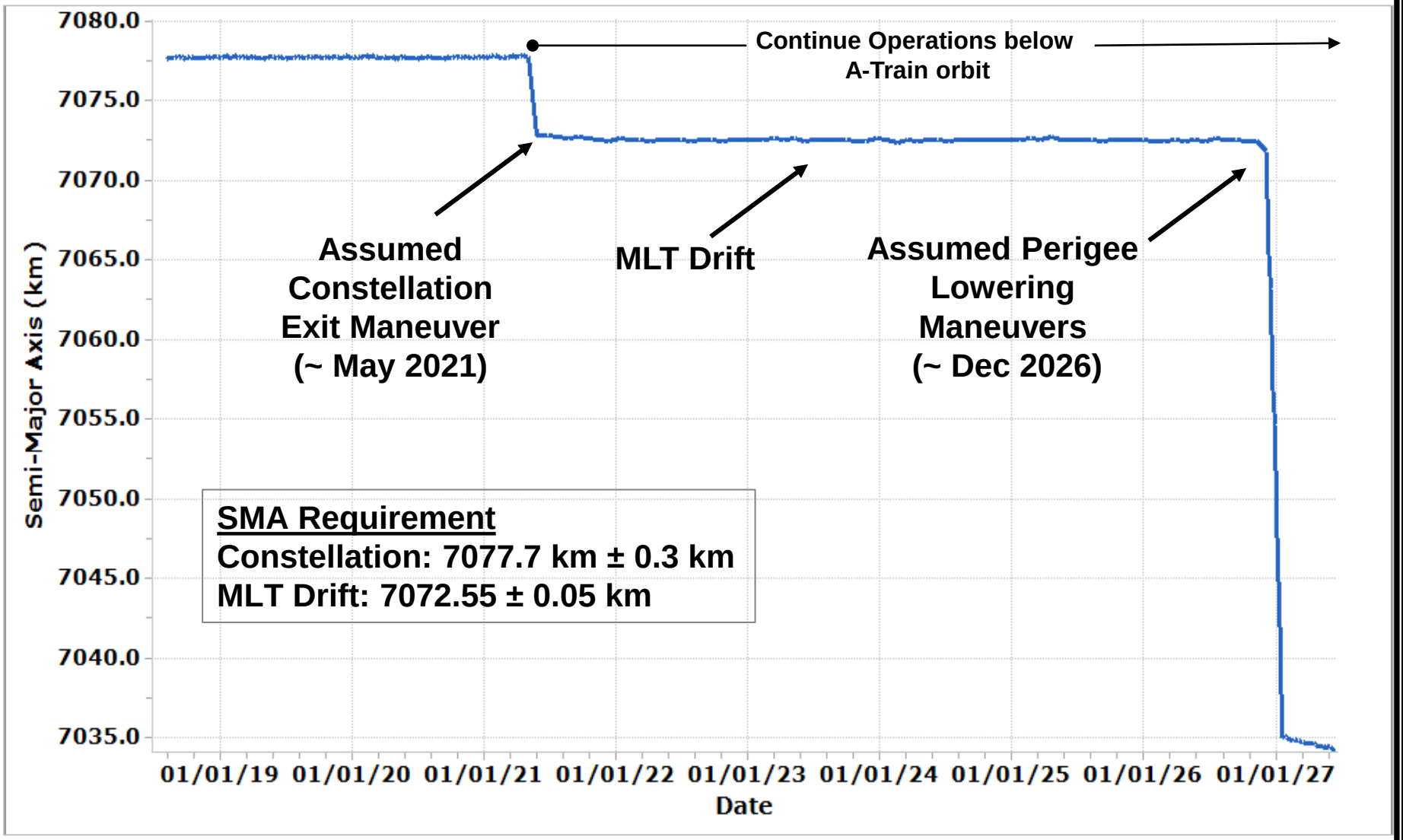
Aura MLT Phasing with Aqua

(Alternate Plan – Analysis Updated November 2018)



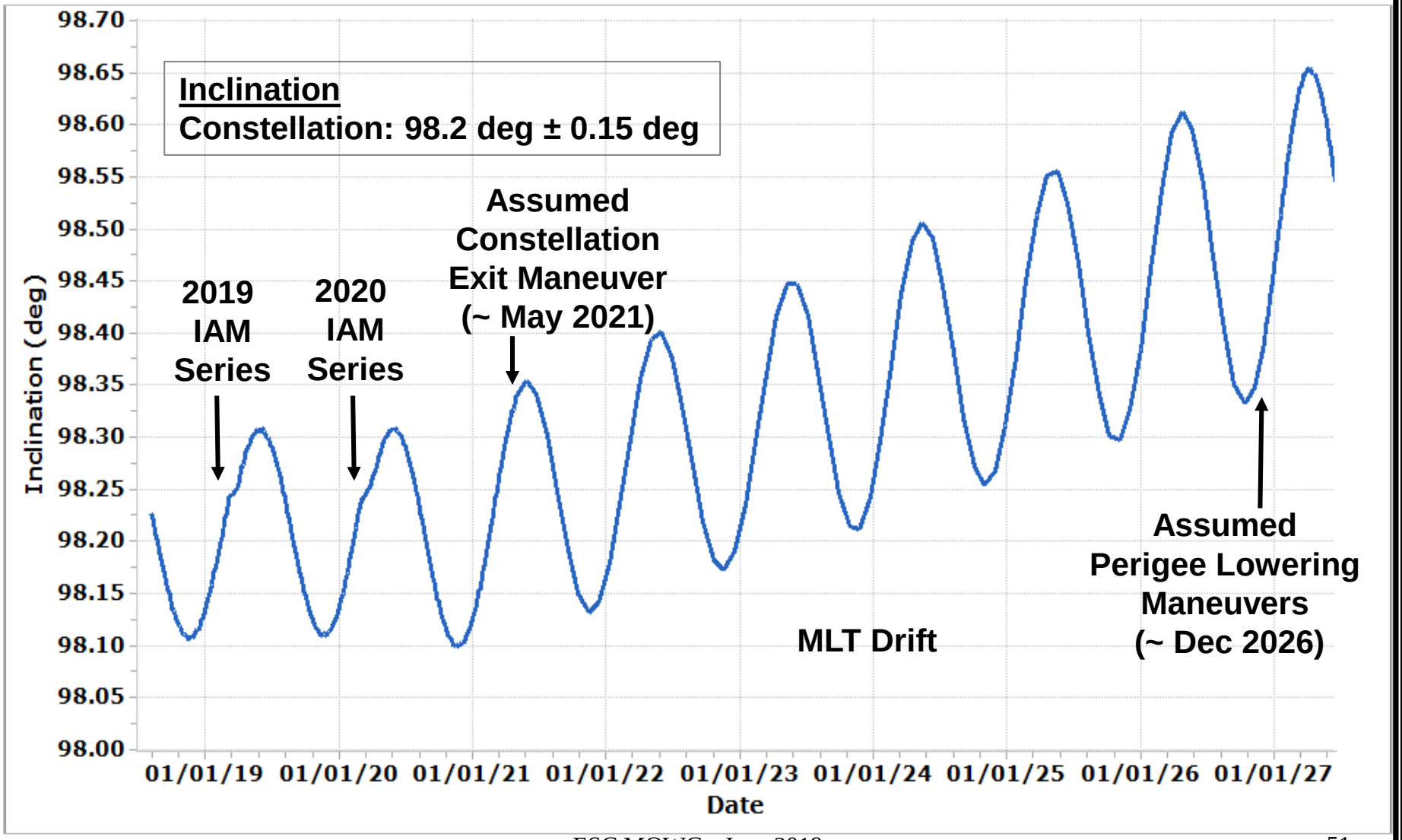
Aura Predicted Semi-Major Axis

(Alternate Plan – Analysis Updated November 2018)



Aura Predicted Inclination

(Alternate Plan – Analysis Updated November 2018)



Abbreviations / Acronyms List

AOI –	Angle of Incidence
ARE –	Array Regulator Electronics
ASAT –	Anti-satellite Weapon
CA –	Conjunction Assessment
CALIPSO –	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CARA –	Conjunction Assessment Risk Analysis
CDH –	Command & Data Handling
CEM –	Constellation Exit Maneuver
CNES –	Centre National D'études Spatiales
COMM –	Communications
CONOPS –	Concept of Operations
COTS –	Commercial-Off-The-Shelf
CRMS –	Collision Risk Management System
DAM –	Debris Avoidance Maneuver
DAS –	Debris Assessment Software
DMUM –	Drag Make-up Maneuver
EA –	EOS Automation
EDOS –	EOS Data Operations System
EO-1 –	Earth Observing-1
EOC –	EOS Operations Center
EOL –	End of Life
EOMP –	End of Mission Plan
EOS –	Earth Observing System
EPR –	Engineering Peer Review
EPS –	Electrical Power System
ESC –	Earth Science Constellation
ESMO –	Earth Science Mission Operations
ETD –	Engineering & Technology Directorate
FDS –	Flight Dynamics System
FMU –	Formatter Multiplexer Unit
FOT –	Flight Operations Team
FSW –	Flight Software
GHz –	Gigahertz
GME –	Gigahertz Mirror Electronics
GMT –	Greenwich Mean Time
GNC –	Guidance Navigation & Control
GPM –	Global Precipitation Measurement
GSFC –	Goddard Space Flight Center
GTE –	Ground Track Error
HIE –	High Interest Event
HIRDLS –	High Resolution Dynamics Limb Sounder
HK –	Housekeeping
HQ –	Headquarters
IAM –	Interface Adapter Module
IAM –	Inclination Adjustment Maneuver
IOT –	Instrument Operations Team
JPL –	Jet Propulsion Lab
kg –	kilogram
km –	kilometer
L0 –	Level-Zero
LS –	Landsat
m –	meters
MLS –	Microwave Limb Sounder
MLT –	Mean Local Time
MLTAN –	MLT of the Ascending Node
MMOD –	Micrometeorite Orbital Debris
MOAR –	Mission Operations Annual Review
MOCA –	Mission Operations Conjunction Assessment
MOWG –	Mission Operations Working Group
MWG –	Maneuver Working Group
NASA –	National Aeronautics & Space Administration
NG –	Northrop Grumman
NYS –	No Yaw Slew
Ops –	Operations
OMI –	Ozone Monitoring Instrument
ORR –	Operational Readiness Review
Pc –	Probability of Collision
PLM –	Perigee Lowering Maneuver
PROP –	Propulsion
PWG –	Power Working Group
RCCA –	Root Cause and Corrective Action
RFA –	Request for Action
RMM –	Risk Mitigation Maneuver
RWA –	Reaction Wheel Assembly
SAA –	South Atlantic Anomaly
S/C –	Spacecraft
SMA –	Semi-Major Axis
SOH –	State of Health
SORCE –	Solar Radiation and Climate Experiment
SSR –	Solid State Recorder
TBC –	To Be Confirmed
TCS –	Thermal Control System
TES –	Tropospheric Emissions Spectrometer
TM –	Test Maneuver
TMON –	Telemetry Monitor
TROPOMI –	Troposphere Measuring Instrument
TRR –	Test Readiness Review
W –	watts
WG –	Working Group
WRS –	World Reference System