Mission Status for Earth Science Constellation MOWG Meeting @ KSC

December 6, 2017

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Topics

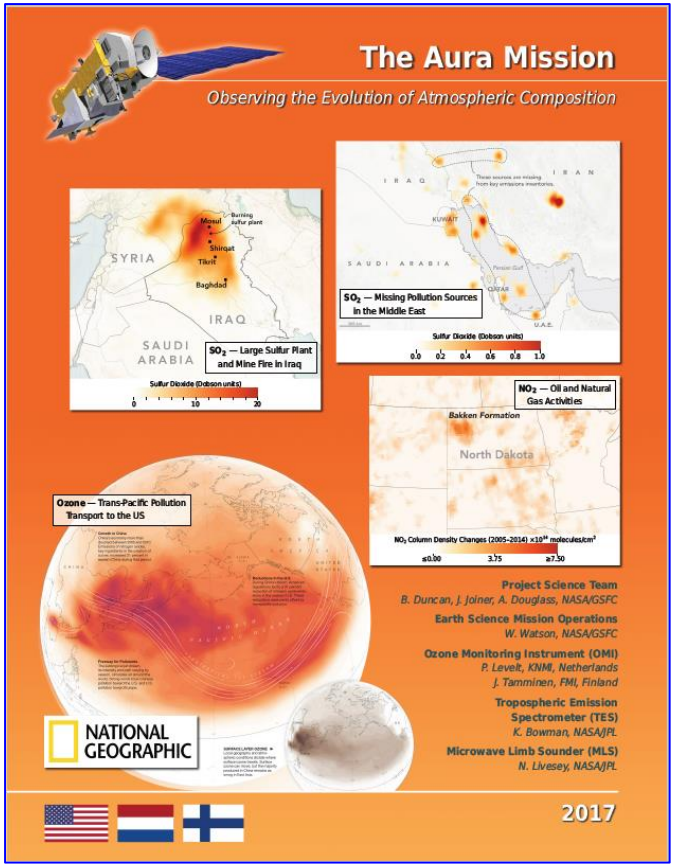
- **Mission Summary**
- **Spacecraft Subsystems Summary**
- **Recent Activities**
- **Planned Activities**
- **Propellant Usage & Lifetime Estimates**
- **Overall Summary**

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

EOS Aura Mission Summary

(Updates since June 2017 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
- 01/25/2017: ESMO Annual Review #10
- 03/03/2017: 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
  - Recommendation to continue with reduction (extend Aura with MLS and OMI, but cease TES operations)
- 07/15/17: Aura 13-Year Anniversary



Aura Spacecraft Subsystems

(Updates since June 2017 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 – October 17-21, 2017 - Yellow limit violations**
- **Electrical Power System (EPS) – Nominal**
  - ***Array Regulator Electronics (ARE) Anomalies:***
    - » ***Solar Panel Connector Anomaly – ARE-3C (January 12, 2005) – loss of ~11 strings***
    - » ***MMOD Strike – ARE-5A (March 12, 2010 & April 25, 2013) – loss of ~6 strings***
  - ***ARE Degradation due to aging – each occurrence is a loss of ~ 1 string: ARE-5C (9/27/12, 2/4/13), ARE-1A (3/12/10, 11/5/11), ARE-6A (9/14/13), ARE-4A (12/8/14), ARE-1C (7/14/17), ARE-2C (8/28/17)***
    - » ***Estimated that Aura has lost 26 strings of solar cells out of a total of 132 strings (~19.7%)***
    - » ***Aura continues to have significant power margin where the life limiting item is fuel***
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
  - **Reaction Wheel Assembly (RWA) #3 Anomaly (12/03/2016) – Recovered on 12/13/16**
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**

All subsystems configured to primary hardware

Recent Activities

(June 2017 – November 2017)

- **6 CARA High Interest Orbital Debris Events (Tiers 1-4) (As of 10/30/17)**
  - 1 required significant action (T3 / T4)
  - 07/21/2017: DMU replanned to reduce risk of post-maneuver conjunction (T4)
- **1 Spacecraft Bus Anomalies**
  - COMM: Transmitter-B Reflected Power Anomaly (10/17/17 – 10/21/17) – Not active
- **1 Instrument Anomalies**
  - TES: 1 ICS Stall (07/29/17) – resumed science collection on 09/17/17
- **5 Spacecraft Maneuvers**
  - **5 Drag Make-up Maneuvers (DMUMs # 103 – 107)**
    - » (4) Routine: 06/21/17, 08/16/17, 09/13/17, 10/25/17
    - » (1) Affected by CA: 07/21/17 (replanned due to post-maneuver CA concern)

- **July 2017:** Draft 'EOS FDS Updated Analysis for Aura Decommissioning' delivered
- **August 2017:** EOS Automation (EA) Phase II (Monitoring & Alerting) ORR
- **September 2017:** OMI Science Team Meeting
- **October 2017:** EA Phase III CDR
  Final 'EOS FDS Updated Analysis for Aura Decommissioning' delivered
  TES Decommissioning Planning – End of Life Test / Global Survey

Planned Activities

- **December 2017:** Aura Reaction Wheel (RW) Slew Maneuver Test (#1)
- **January 2018:** Aura RW Slew Maneuver Test (#2); ESMO Annual Review #11
- **February 2018:** TES Decommissioning (Date TBD)
- **Spring 2018: Annual Inclination Adjust Maneuvers**
  - 2/28/18 (#53), 3/7/18 (#54), 3/14/18 (#55), 3/28/18 (#56)*, & 4/11/18 (#57)
  - * Targeting Aura IAM #56 to be performed using RW to slew out and slew back
- **Spring 2018: Aura Decommissioning Review (DRAFT)**
  - Document Phase F spacecraft activities, any new products to be developed for spacecraft / instrument calibration, proposed Engineering Tests, and Passivation Sequence
- **June 2018: Earth Science Constellation (ESC) MOWG (06/05/17 @ Sioux Falls, SD)**
  - Update propellant budget, decommissioning analysis, reliability predictions, etc.
- **Mid-to-Long-Term Plans**
  - **Aqua/Aura Maneuver Working Group**
    - » Perform Aura RW Slew Maneuver Test (#3) after Spring 2018 IAM Series
    - » Use Slew Maneuver Test data to validate a retrograde maneuver capability (Summer 2018)
  - **EOS Automation (EA) – automation of routine operations**
    - » EA Phase III – ORR Summer 2018
  - **Continue to improve RMM / DAM execution**
    - » CA automation (CRMS) in the following slide

Planned Activities
(TES Decommissioning)

- **As the result of predicted budget constraints and initial 2017 Senior Review evaluations, the Aura FOT and TES IOT have been preparing for instrument decommissioning since August 2017**
- **FOT / IOT have held regular bi-weekly meetings to define the final instrument, spacecraft, and ground system configurations**
  - Instrument will be transitioned to a modified safe state (IEM & Op Heaters ON)
  - Spacecraft will have unnecessary telemetry monitors (TMONs) disabled and fault management will be updated to match the final instrument safe state
  - Ground System will have various proc and database updates
- **No power or thermal concerns with the instrument in modified safe state**
- **During end of life testing TES resumed Global Survey (GS) observations on 10/23/17**
- **Open Items:**
  - Fault Management update (FOT working with AFM to deliver SCS)
  - CDH proc updates (current procs still able to function in the interim)
  - Alarm setup updates; Database updates
  - Auto Ops (SCS) update (able to utilize Auto Log mode in the interim)
- **Timeline:**
  - TES Decommissioning Review @ JPL – Tentatively two weeks prior to decommissioning date
  - TES Decommissioning Date – 90-days from when guidance is given by NASA HQ (SMD/ESD)

Planned Activities
(Aqua/Aura Maneuver Development)

- **Initial focus was to develop a retrograde maneuver capability that could be utilized to exit the constellation, lower the orbit at the end of mission, and/or for control box excursion recovery**
- **Development evolved to investigate the potential of performing Inclination Adjust Maneuvers (IAMs) using reaction wheels instead of thrusters to slew (yaw)**
- **IAMs using Reaction Wheels**
  - **Goal is to save fuel and mission life**
    - » Typical thruster only IAMs use ~10kg of fuel per series; Currently have ~75 kg
  - **Plan to demonstrate slews on wheels during a series of tests (no-burn)**
    - » 3 test maneuvers of increasing complexity have been devised
      - – Test Maneuver #1 – slew angle = -25°
      - – Test Maneuver #2 – slew angle = -76.5°
      - – Test Maneuver #3 – slew angle = -88°
    - » Allow the FOT and FDS team use products and procedures that would be used for the RWA IAM
    - » Use the same abort scenarios and fault management (FM) that would also be developed for the RWA IAM
  - **Goal is to perform 1 IAM with RWs in March 2018**
    - » Targeting Aura IAM #56 (03/28/18) (4th IAM of the series, week break before and after for assessment)
  - **Serves as an incremental step towards retrograde maneuver capability**
    - » Test Maneuver #3 – will verify RWA max slew rate (0.179 °/s)
    - » Retrograde Maneuver would slew to 180° orientation

Planned Activities
(Aqua/Aura Maneuver Development)

- **Retrograde Maneuvers**
  - **Will be used to lower orbit during constellation exit and decommissioning**
    - » Aqua currently planned for early 2022
    - » Aura currently planned for early 2023
  - **Potential to correct orbit after large Debris Avoidance Maneuvers (DAM) (i.e., large excursions from control box)**
    - » Potential challenge to maintain orbit with larger debris catalogue when Space Fence comes online (~2019)
  - **Plan to show retrograde maneuver capability by similarity / simulation**
    - » ESMO Management goal is to show this capability by Summer 2018
    - » No intention to perform on orbit retrograde maneuver test
    - » Data from the slew on wheel test maneuvers will be used to correlate the simulations
- **Open Items:**
  - Test AFM FM patch and finalize FM management procedures
  - Complete EOSSIM and ETSF simulations to aid in analysis work
  - Follow-up with IOTs on Test Maneuver details and any concerns
- **Timeline:**
  - 12/12/17: Test Maneuver #1
  - January 2018: Test Maneuver #2
  - 03/28/18: Aura IAM #56 (using RWs)
  - May 2018: Test Maneuver #3

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

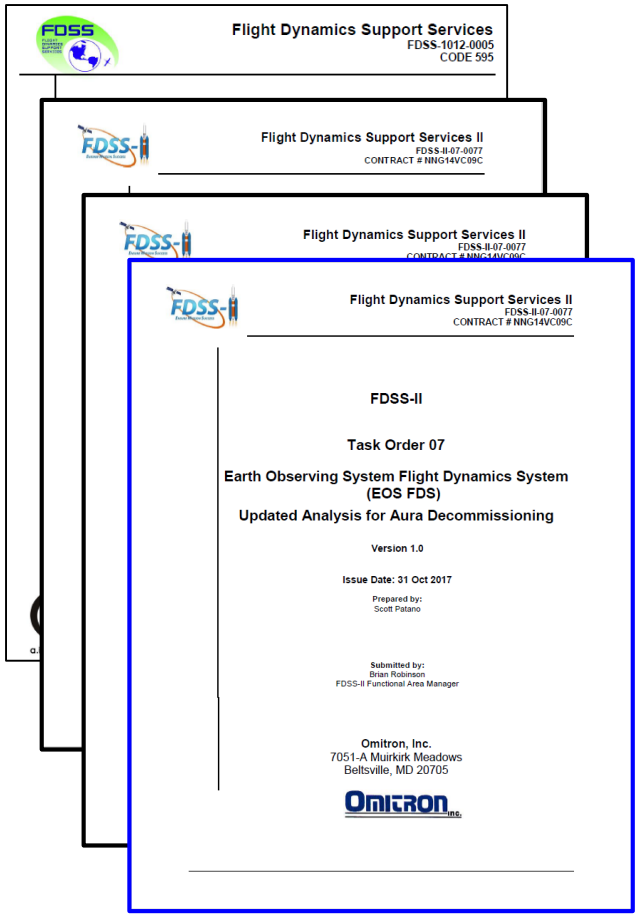
- **EOC is currently operating with CRMS Release 5.2 (ORR 06/22/17)**
  - Patch allows for data retrieval of JSpOC and/or CARA generated CDMs

Spring 2018
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**	1March **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**	23	24
25	26	27 **Aura ID**	28 **Aura IAM #56** **(Goal is to use RWAs)**	29 **Aqua IAM #59**	30	31 **Aqua ID**
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					

Aura Propellant Usage
(Analysis Updated October 2017)

- **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**
  - Updated Lifetime Estimates
- **2013 (August): Updated Decommissioning Plan**
  - Updated propellant trends for IAMs & DMUMs
  - Updated definitive fuel usage and predicted solar flux levels
  - Updated Constellation Exit Plan
- **2014 (September): Updated Decommissioning Plan**
  - Updated propellant trends for IAMs & DMUMs
  - Updated definitive fuel usage and predicted solar flux levels
- **2015 (September): Decommission Plan Update Postponed**
  - Postponed to evaluate long-term plan and decommissioning maneuvers
- **2016 (January): Updated Decommission Plan (v1.2)**
  - Updated definitive fuel usage & predicted solar flux levels
  - Updated propellant estimates for IAMs & DMUs
  - Included hypothetical MLT drift analysis with LS-8
- **2017 (October): Updated Decommission Plan (v1.0)**
  - Updated definitive fuel usage & predicted solar flux levels
  - Updated propellant estimates for IAMs & DMUs

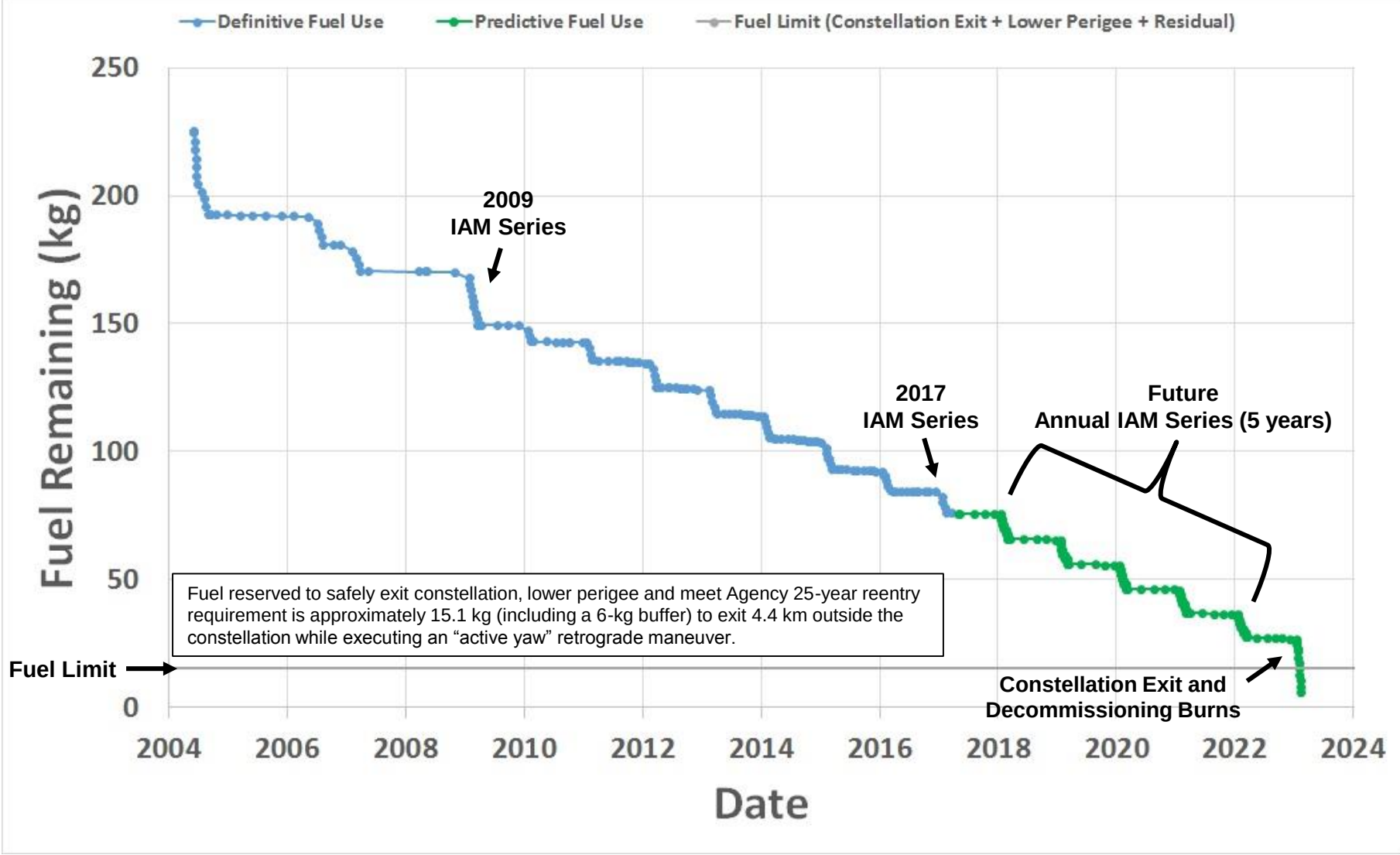


- **Annual updates will be provided each July (starting in 2017)**
  - Final will be produced 60 days before start of decommissioning

Remaining Fuel Estimate
(Analysis Updated October 2017)

- **Long-term orbit simulations were run for Aura through Feb 2023**
  - **Used mean nominal Schatten solar flux predictions (March 2017)**
  - **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 (25 IAMs through 2023)**
  - **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 Aura shows that the spacecraft will have sufficient fuel to maintain its current orbit within the Afternoon Constellation through 2022 (before 2023 IAM series).**
- **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**

Fuel Usage: Actual & Predicted
(Analysis Updated October 2017)



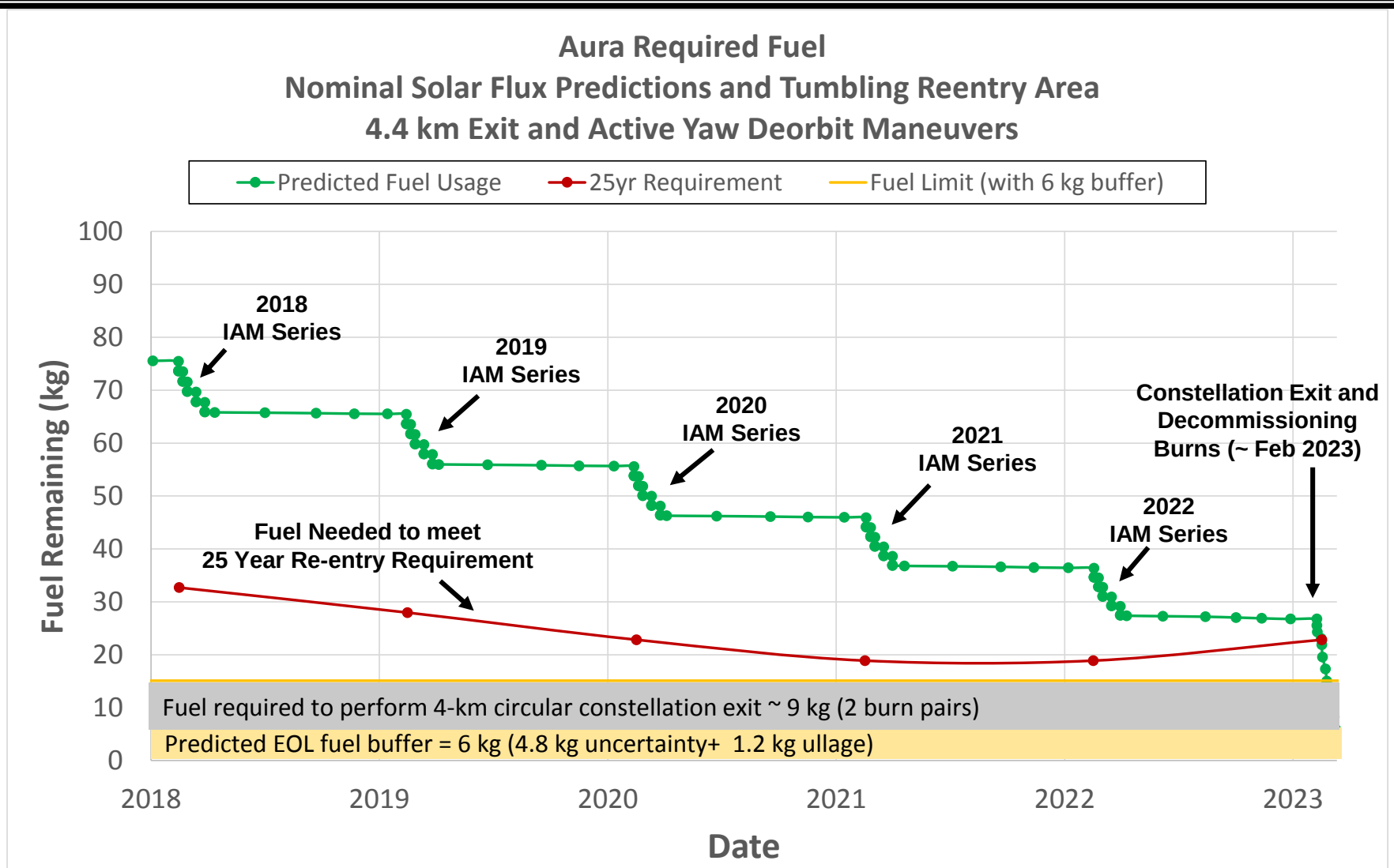
Debris Assessment Software

(Analysis Updated October 2017)

- **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)**
- **DAS requires several inputs describing the spacecraft's mission:**
  - Start apogee = Average Height = ~696 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**

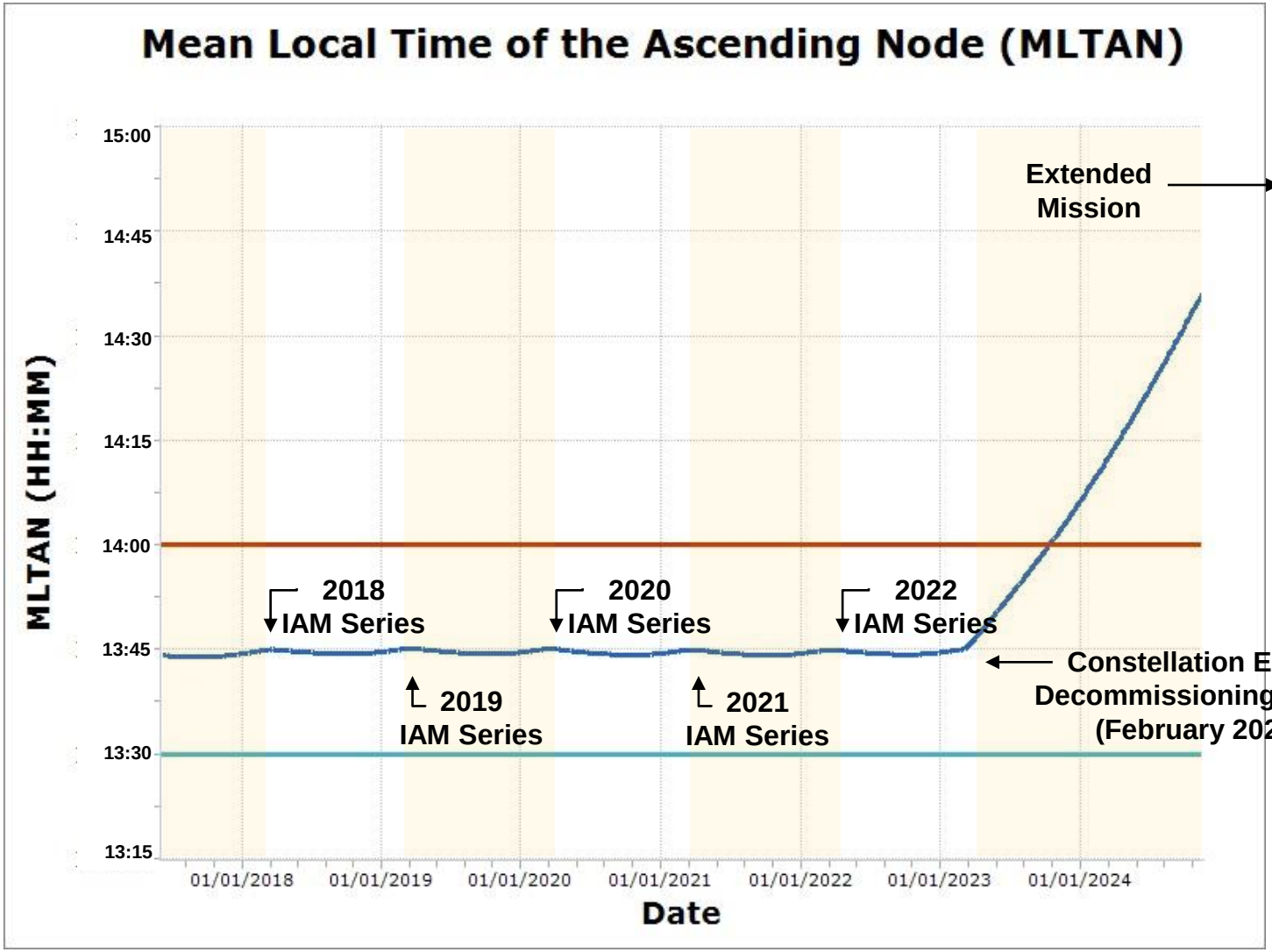
Aura DAS End of Life Predictions

(Same Baseline Plan – Analysis Updated October 2017)



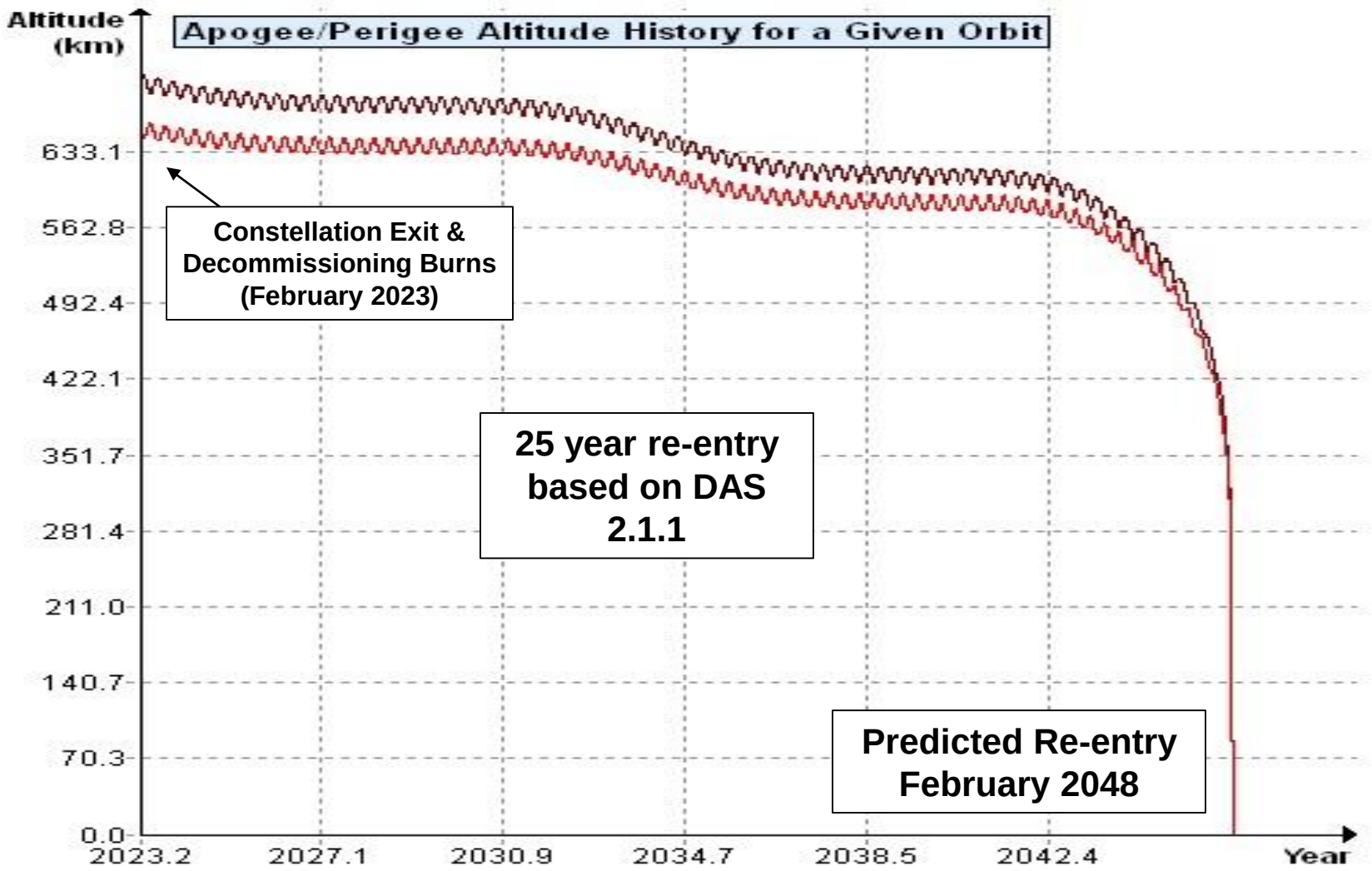
Aura Predicted Mean Local Time

(Same Baseline Plan – Analysis Updated October 2017)



Aura Predicted Re-entry

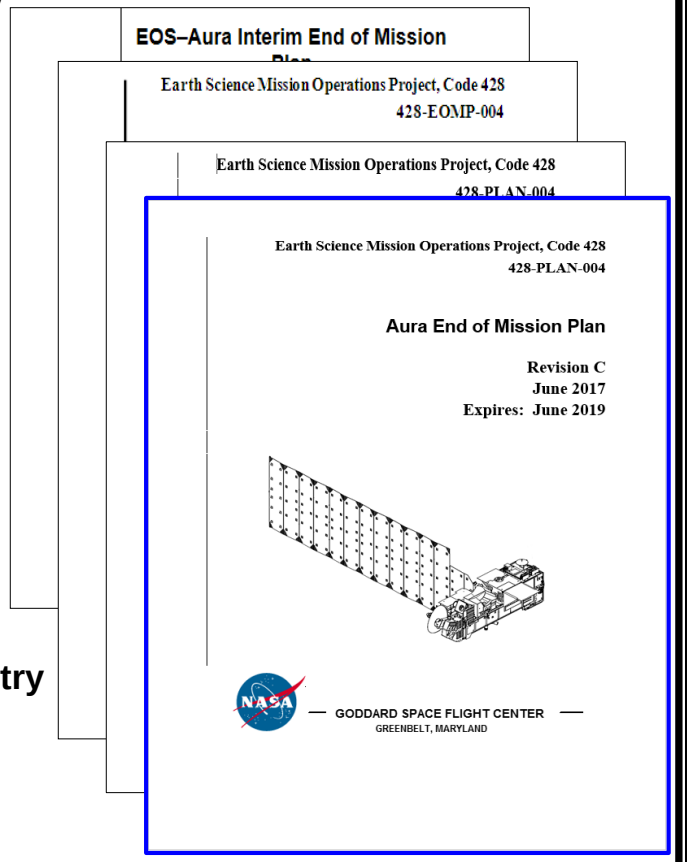
(Same Baseline Plan – Analysis Updated October 2017)



Aura End of Mission Plan (EOMP)

(Plan 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 (09/2012)
  - Added Small Object Collision Assessment
- Produced EoMP Rev B: February 2015
  - Updated Lifetime Estimate (09/2014)
- **Produced EoMP Rev C: June 2017 (in signature cycle)**
  - **Updated Lifetime (12/2016) & Reliability estimates**
- Final will be produced 60 days before End of Mission
- 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)
    - » Re-entry Risk (Un-controlled)
  - Waivers were approved in May 2013



Summary

- **Spacecraft Status – GREEN**
  - **COMM: Transmitter-B Reflected Power Anomaly (10/17/17 – 10/21/17)**
- **Instrument Status - GREEN**
  - **HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data**
  - **MLS: Operating Normally – Only periodic Band 13 measurements**
    - » **08/06/13: Band 12 Shut down (reached end of useful life – 2-year design)**
    - » **02/25/17: R2 Lock Status Yellow Alarms (due to aging, voltage fine-tuned 03/08/17)**
    - » **THz module in Standby Mode – Potential for one final measurement – Date TBD**
  - **OMI: Operating Normally**
    - » **Field-of-View Anomaly started in September 2007 – currently stable**
    - » **03/12/17: OMI Survival Mode Transition (Recovered 03/16/17)**
  - **TES: Operating Normally (Planning for Decommissioning in early 2018)**
    - » **07/29/17: TES ICS Stall #16 – resumed science observations on 09/17/17**
    - » **10/23/17: Resumed Global Survey observations during End of Life test (first since 2012)**
- **Data Capture/L0 Processing Status – GREEN**
  - **SSR Data Capture to 10/31/17: 99.99586202%**
- **Ground Systems – GREEN**
  - **08/03/17: EOS Automation (EA) Phase II ORR**
  - **04/11/2017: MMS Build 24.2.0 (RHEL7) Transition for Aura**

Questions

Additional Charts

Maneuvers & Ground Track History
Orbital Trends

Aura Conjunction Assessment
High Interest Events (HIEs)

Data Capture & Operations Errors

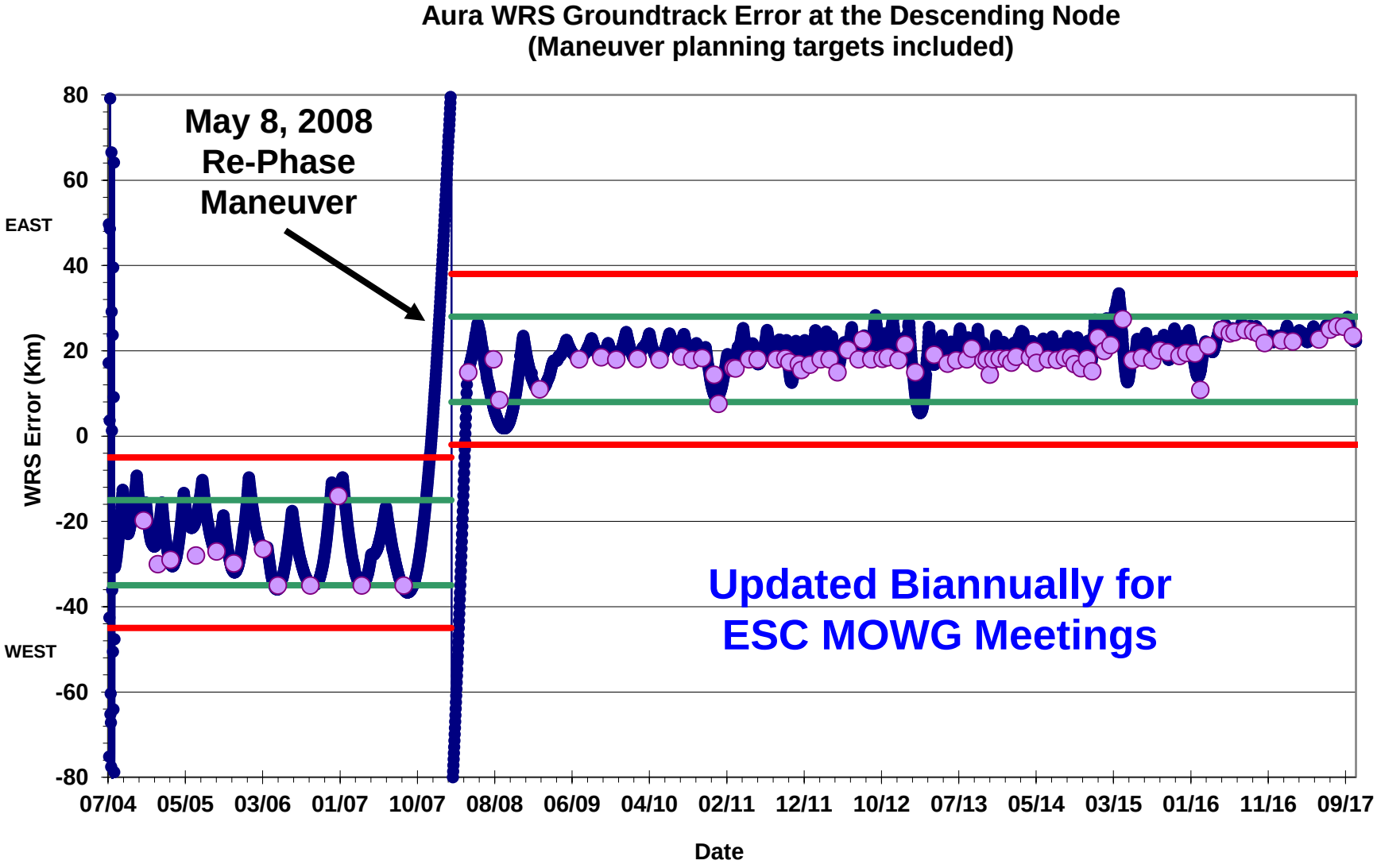
Extended Mission Plans
(Analysis Updates)

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 107 routine DMUMs have been performed**
  - **07/19/2012: DMUM # 43 No Yaw Slew Maneuver (NYS) #1 – NYS Maneuvers (37)**
  - **Last maneuver 10/25/2017 (#107) – Next planned maneuver 12/06/2017 (#108)**
  - **Variation in performance from –3.5% (cold) to +3.3% (hot)**
- **Conducted 12 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)**
  - **Variation in performance from -4.5% (cold) to +1.9% (hot)**

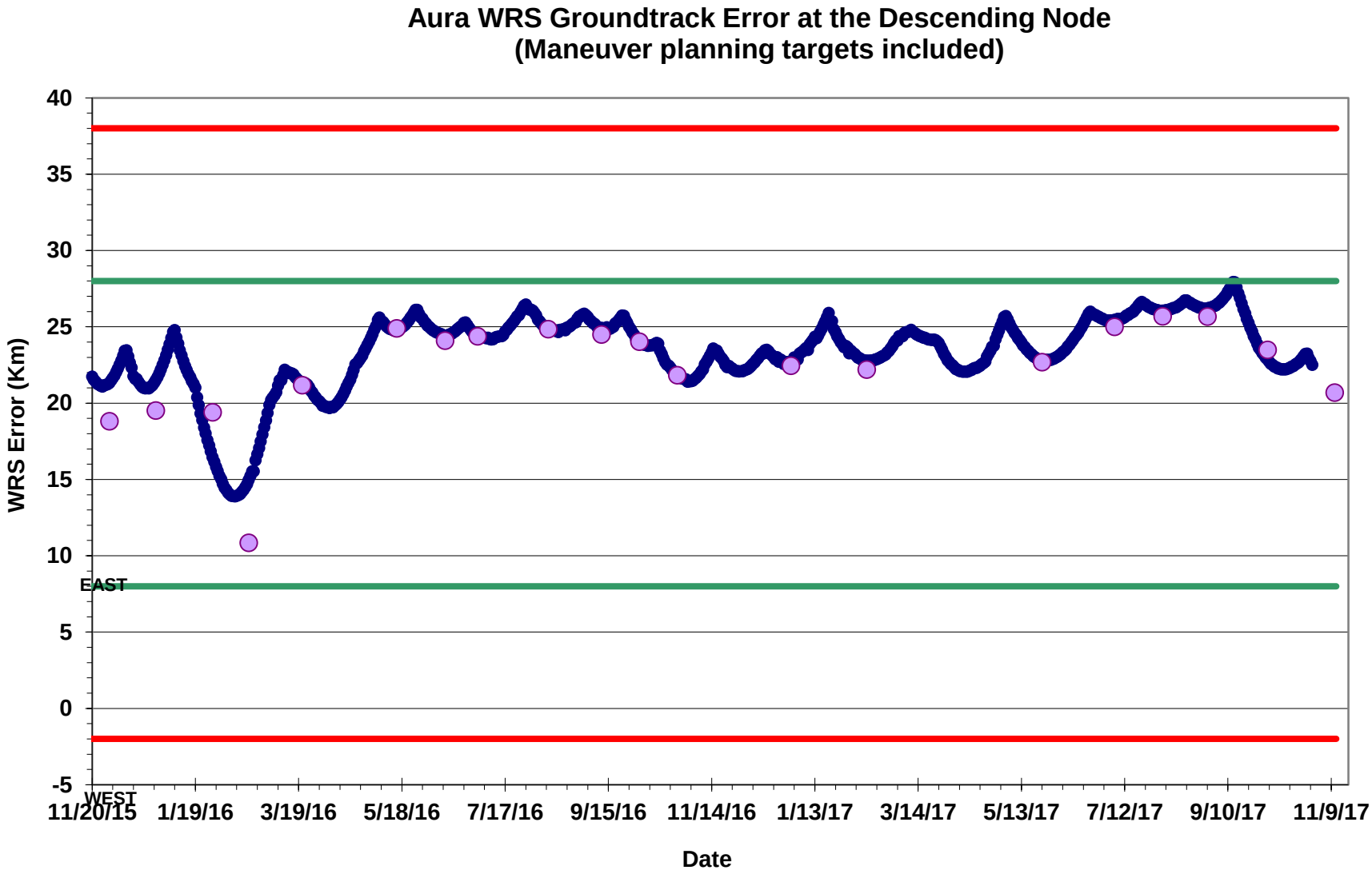
WRS Ground Track Error (GTE)

(As of October 29, 2017)



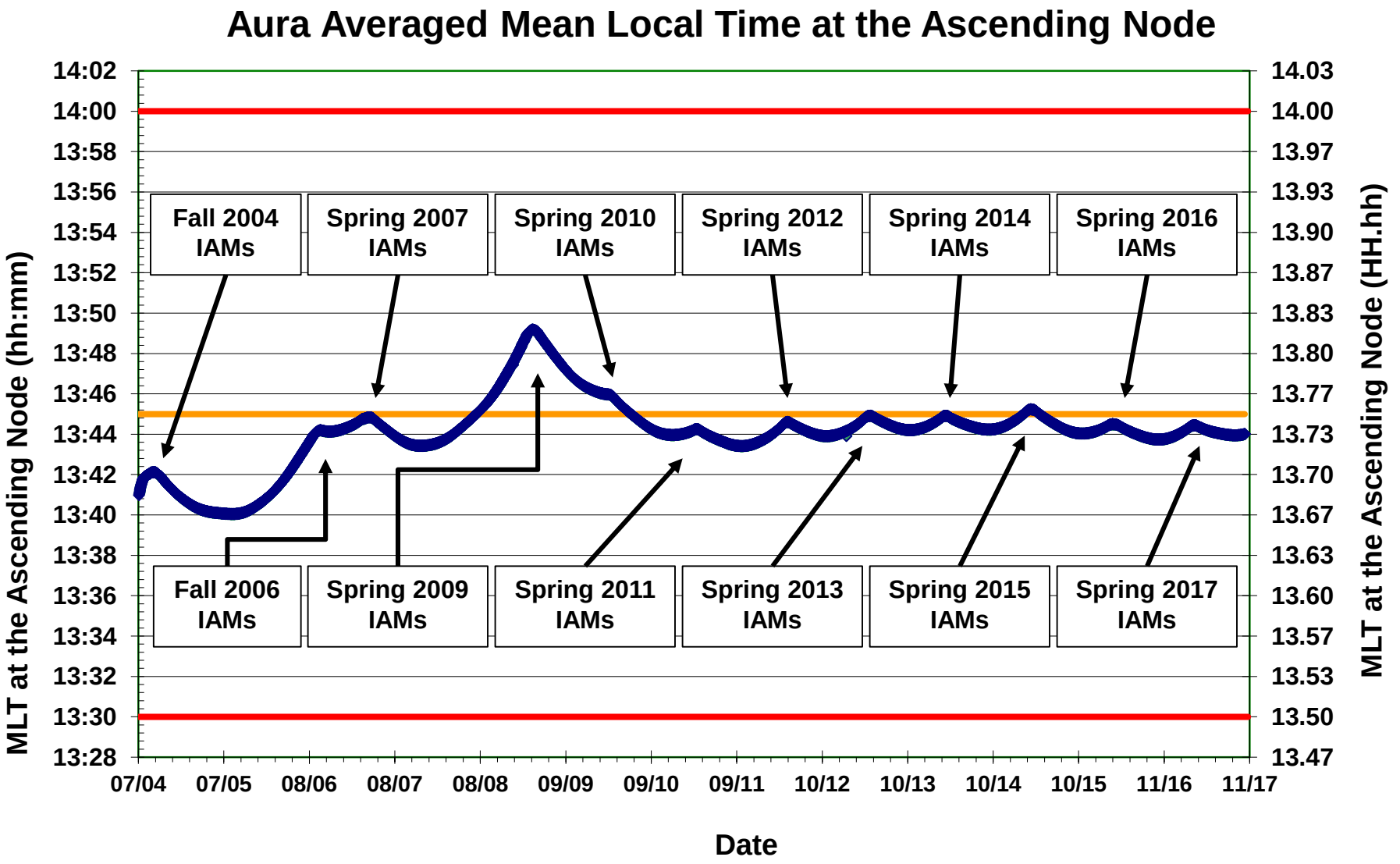
WRS Ground Track Error (GTE)

(As of October 29, 2017)

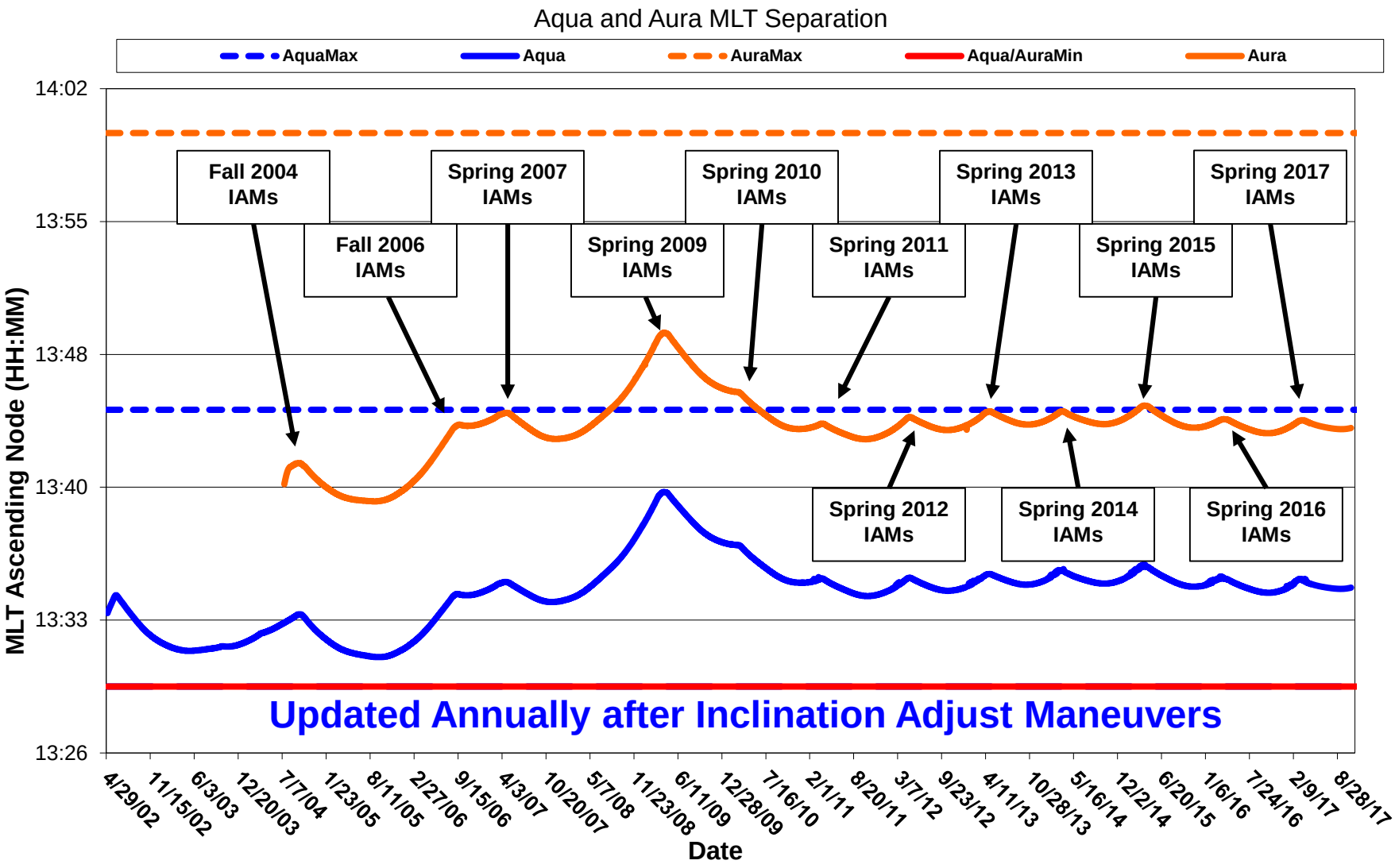


Aura Averaged MLT @ Ascending Node

(As of October 29, 2017)

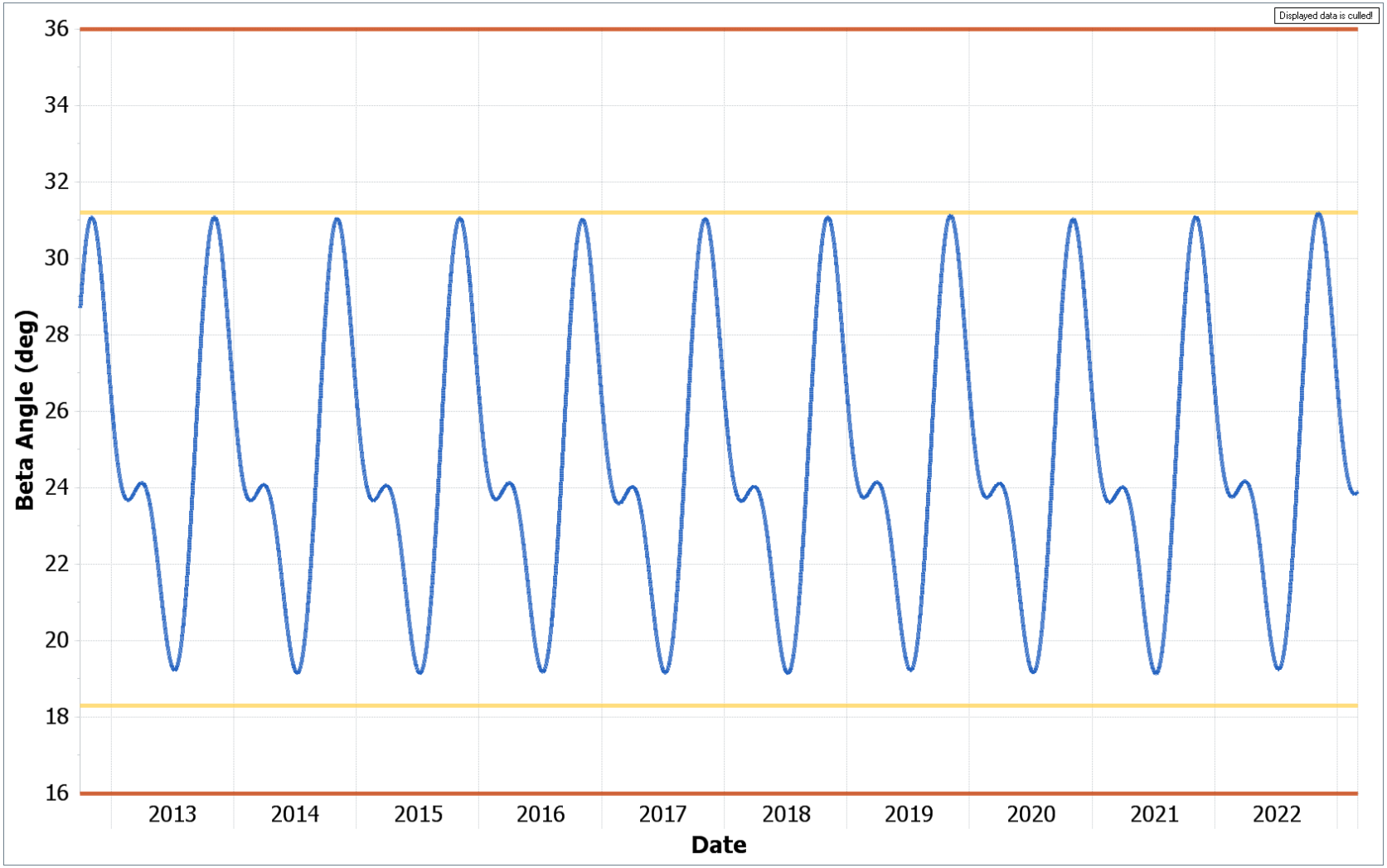


Aqua/Aura Mean Local Time (MLT)
@ Ascending Node (As of October 29, 2017)



Aura Predicted Beta Angle

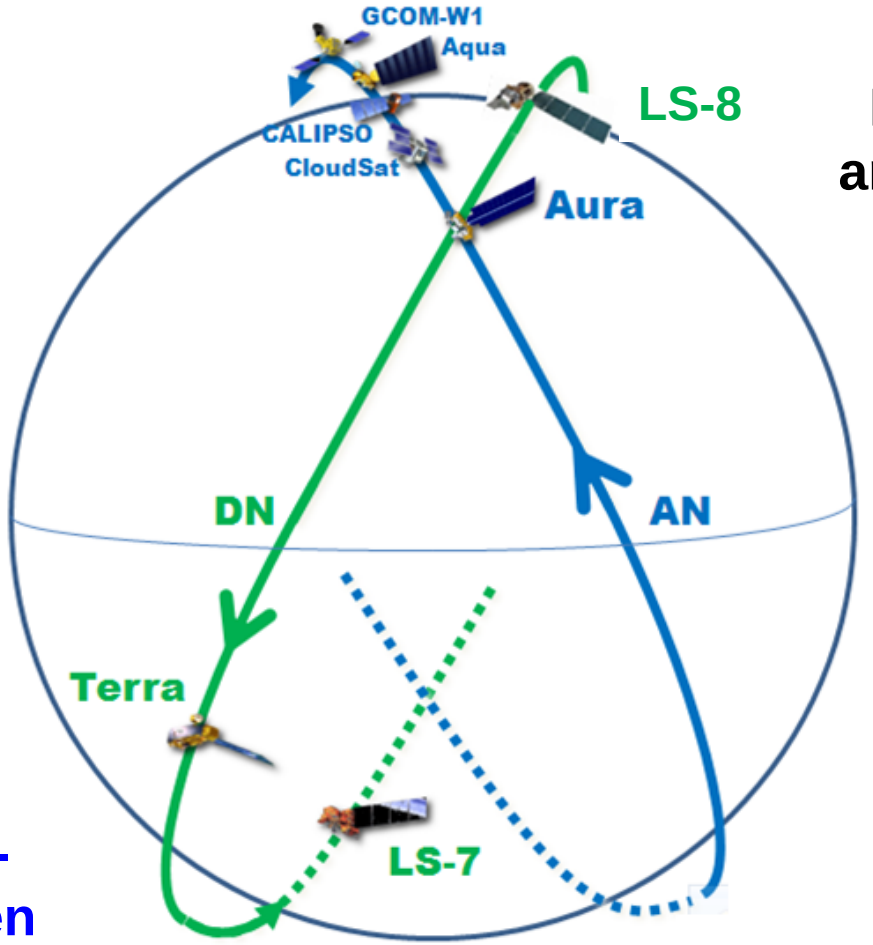
(With Yearly Inclination Maneuvers) (No Change)



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

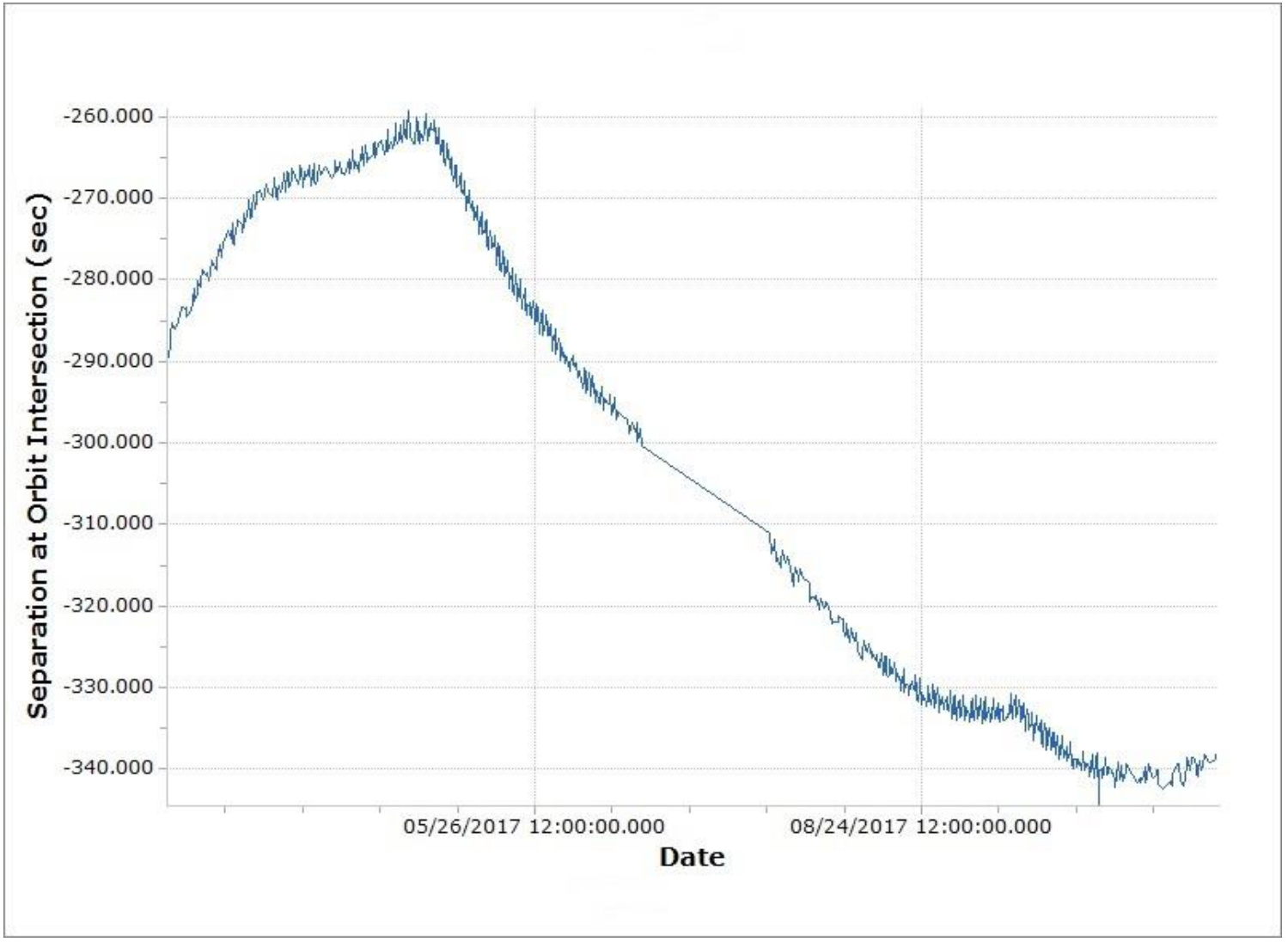
Over the past 8 months (Mar-Nov) there has been 260-340 seconds between Aura and LS-8

Terra ~ 30 min behind LS-7

1 Orbit = ~ 100 minutes

LS-8/Aura Phasing at Poles

@ Northern Intersection Point (as of October 29, 2017)



Aura Conjunction Assessment

High Interest Events (HIEs)

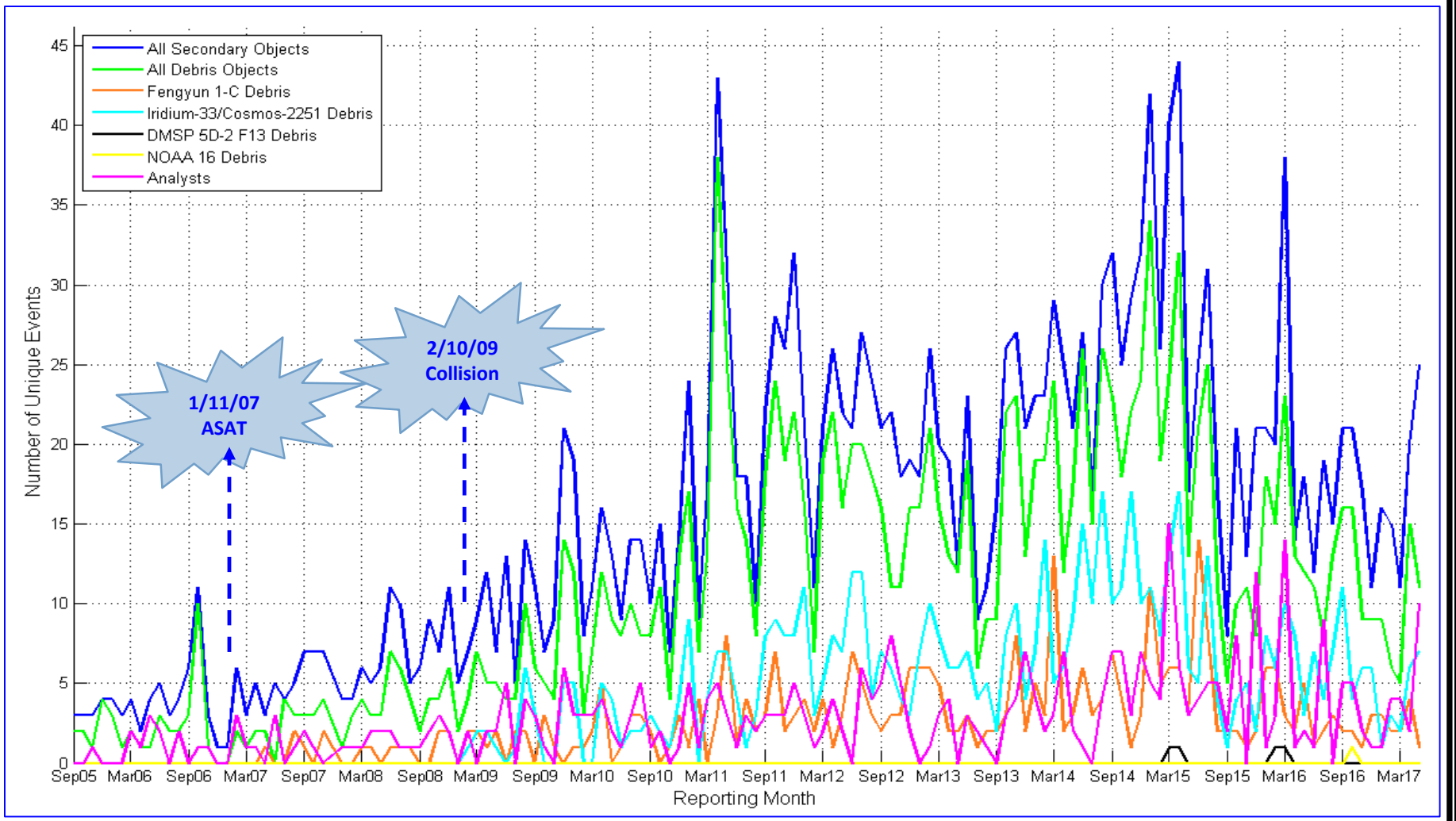
	Jun `17	Jul `17	Aug `17	Sep `17	Oct `17	Nov `17	Total
Tier 1	0	0	0	1	0		1
Tier 2	1	1	1	1	0		4
Tier 3	0	0	0	0	0		0
Tier 4	0	1	0	0	0		1
Total	1	2	1	2	0		6

2013: 29 CARA HIEs – 14 required significant action (T2-T4)
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: 15 CARA HIEs (thru 10/30/2017) – 12 required significant monitoring and/or actions (T2-T4)

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

1. 02/01/2017: CA vs. 13482 on 02/03 at 04:53:36 GMT – HIE briefing but Pc dropped off, continued to monitor (T2)
2. 02/13/2017: CA vs. 35863 on 02/15 at 21:34:48 GMT – DAM planned but conjunction Pc rolled off (T3)
3. 03/08/2017: CA vs. 23547 on 03/12 at 01:36:07 GMT – Post-IAM HIE, screened hot and cold burn cases (T3)
4. 03/11/2017: CA vs. 34363 on 03/13 at 03:24:52 GMT – MTS plots generated but Pc dropped off (T2)
5. 03/26/2017: CA vs. 25759 on 03/26 at 13:39:58 GMT – Executed DAM for HIE with very small miss distance (T4)
6. 04/26/2017: CA vs. 18908 on 04/28 at 17:27:28 GMT – Rescheduled planned DMU due to post-maneuver conjunction (T4)
7. 05/25/2017: CA vs. 28366 on 05/25 at 19:01:09 GMT – Planned DAM for HIE with small miss distance (T3)
8. 06/05/2017: CA vs. 38728 on 06/06 at 21:52:04 GMT – MTS plots generated but Pc dropped off (T2)
9. 07/12/2017: CA vs. 36706 on 07/15 at 13:00:10 GMT – Monitored but no action required (T2)
10. 07/21/2017: CA vs. 26093 on 07/22 at 08:36:57 GMT – DMU replanned to reduce risk of post-maneuver conjunction (T4)
11. 08/13/2017: CA vs. 36712 on 08/17 at 15:20:54 GMT – Monitored planned DMU but no replanning required (T2)
12. 09/16/2017: CA vs. 40993 on 09/19 at 20:15:25 GMT – Monitored but no action required (T2)

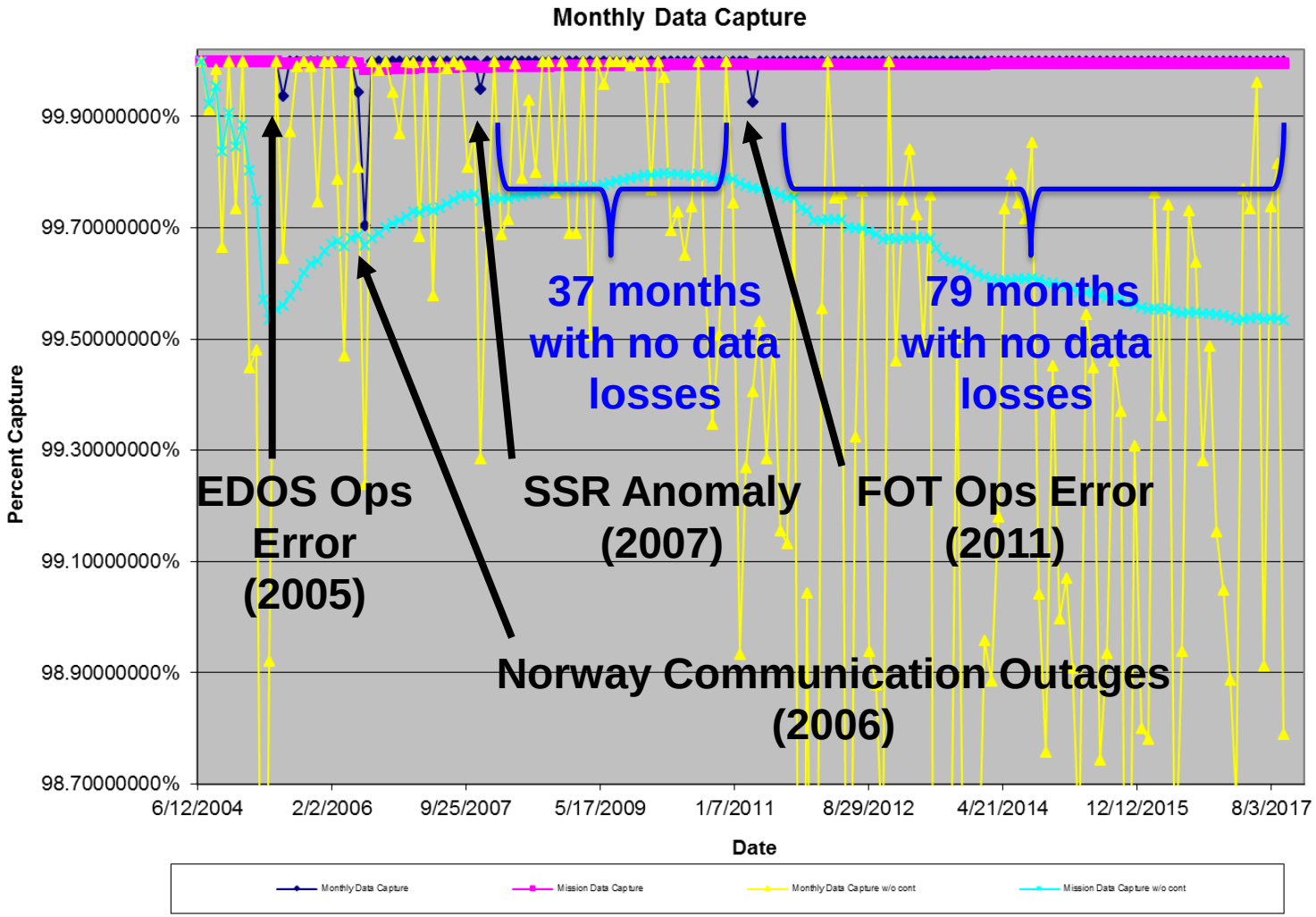
Aura Conjunction Assessment
(September 2005 thru June 2017)



Credit: NASA CARA Team

Aura Monthly Data Capture

SSR Data Capture to 10/31/2017: 99.99586202%

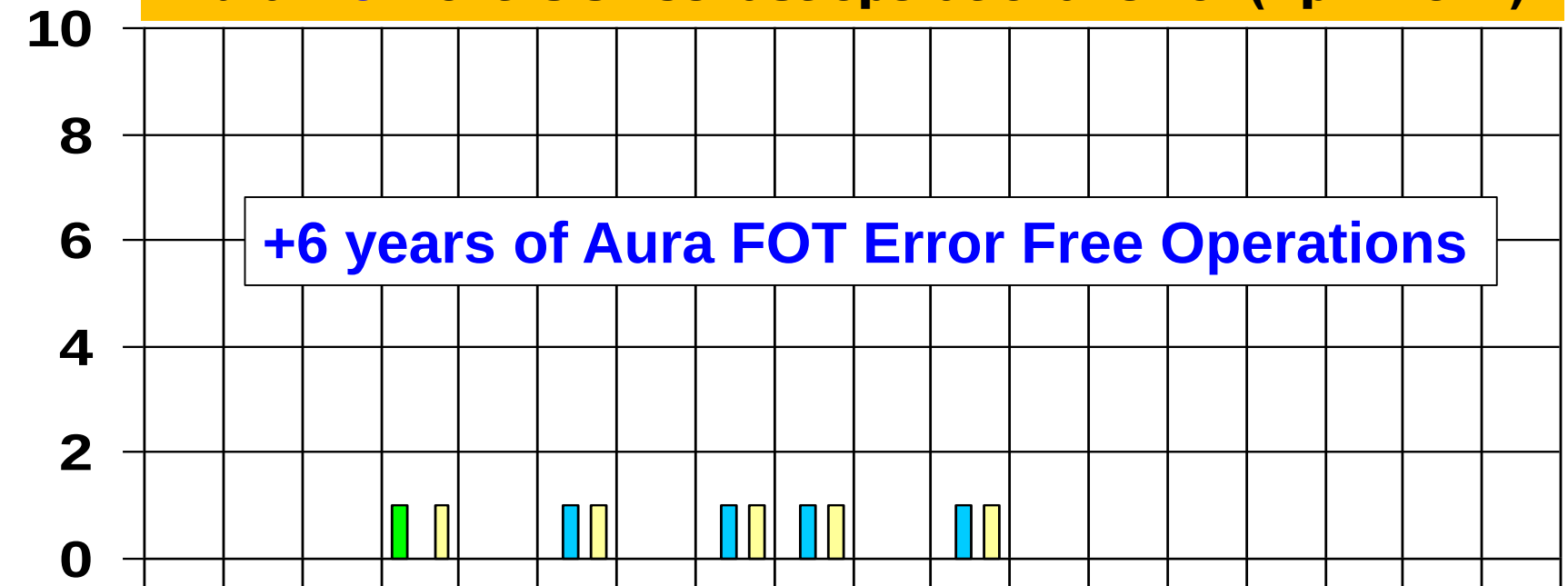


Mission Capture Req. = 95%

Operational Errors

(18-Months: May 2016 – October 2017)

Aura: 79 Months since last operational error (April 2011)



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

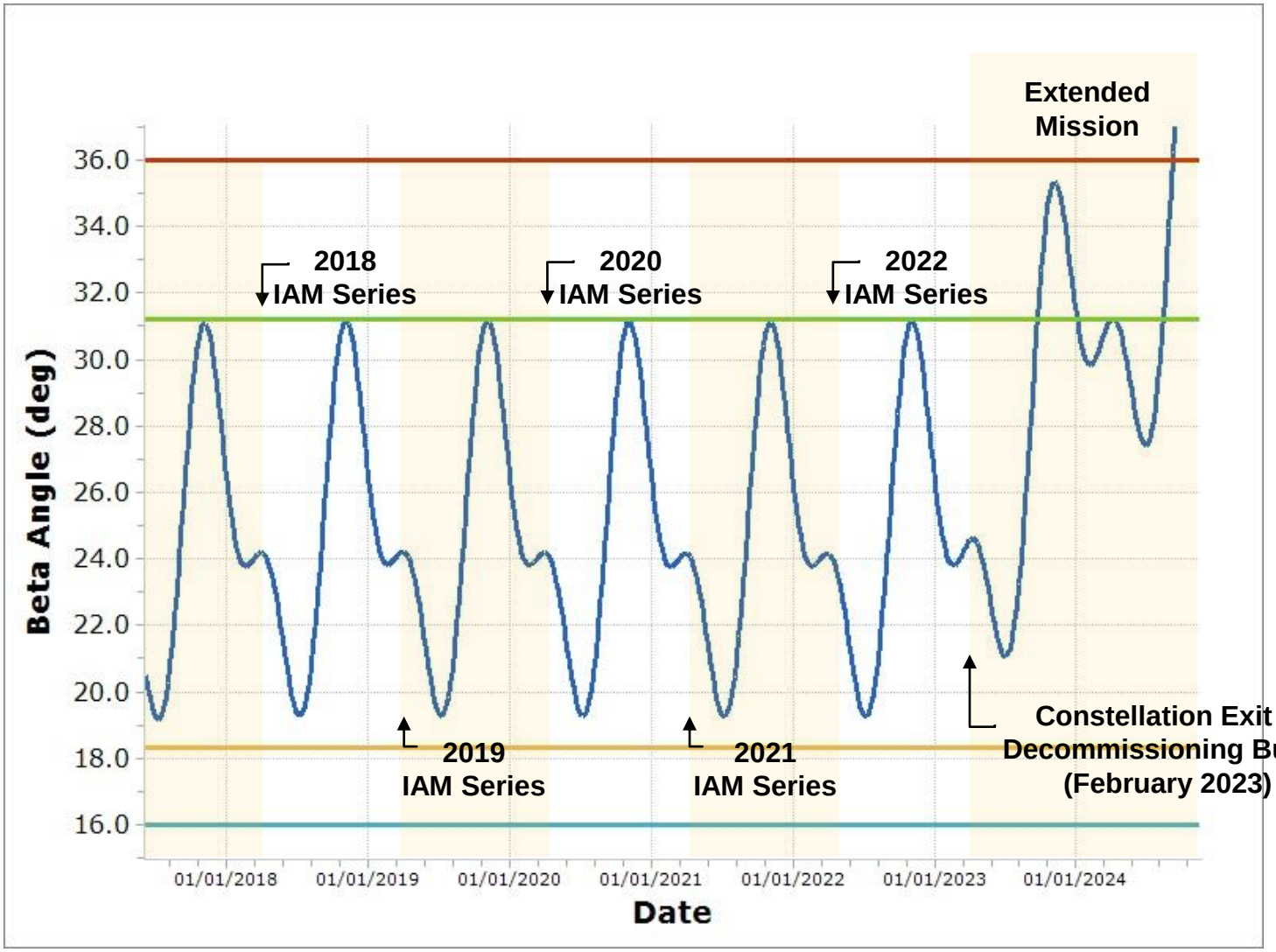
Aura Baseline Decommissioning Plan
(Same Baseline Plan – No Change)

- **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

Documented in final 'EOS FDS Updated Analysis for Aura Decommissioning' (v1.0, 10/31/17)

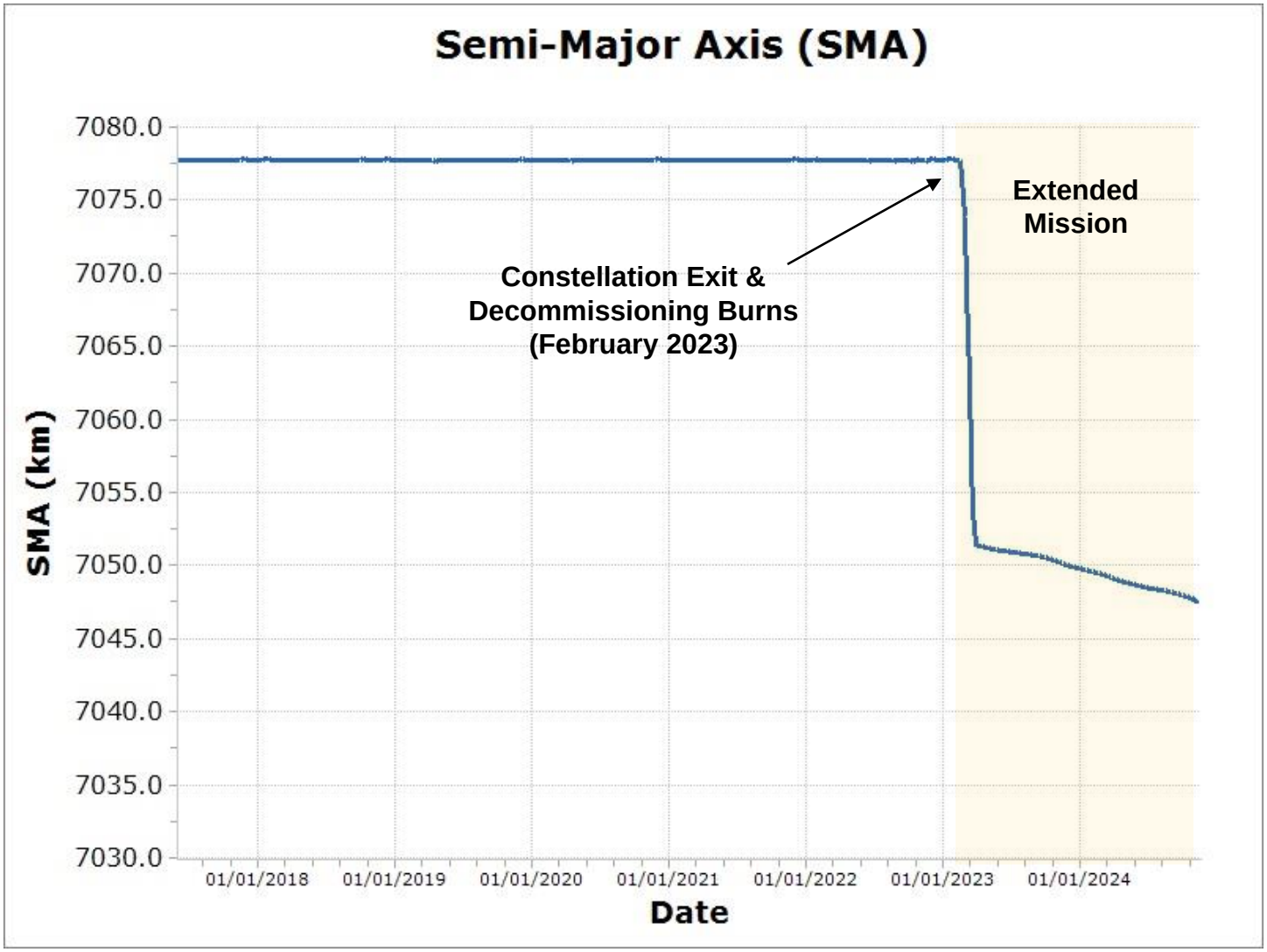
Aura Predicted Beta Angle

(Same Baseline Plan – Analysis Updated October 2017)



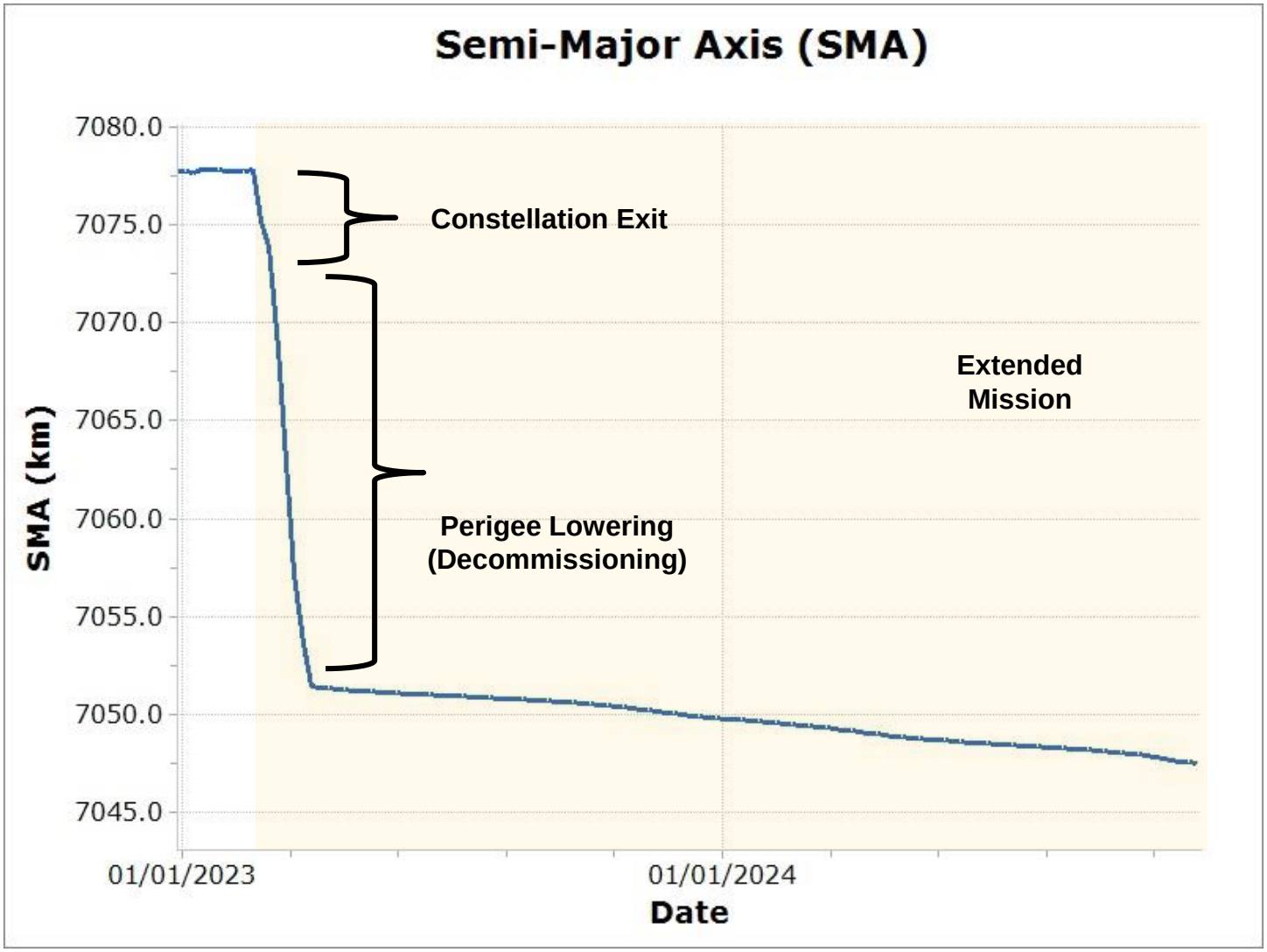
Aura Predicted Semi-Major Axis

(Same Baseline Plan – Analysis Updated October 2017)



Aura Predicted Semi-Major Axis

(Same Baseline Plan – Analysis Updated October 2017)



Aura Alternate Decommissioning Plan

(Same Alternate Plan – Analysis Updated October 2017)

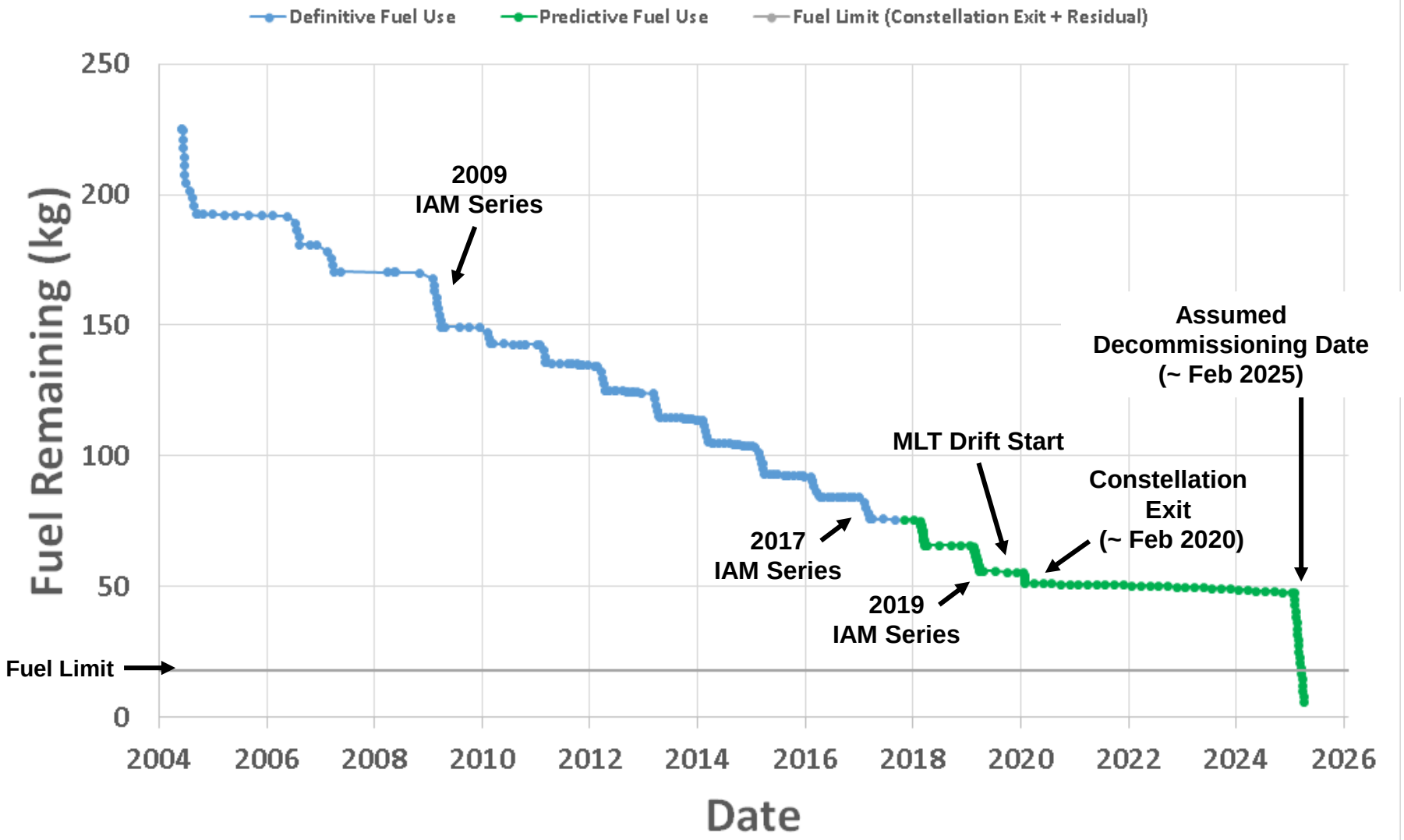
- **Alternate Decommissioning Plan Rationale:**
  - After the OMI / TROPOMI 2-year overlap period ends, currently late 2019, fuel saving orbital maintenance schemes may be a consideration

  (Successful Sentinel-5P launch on 10/13/17, TROPOMI undergoing check out)

- **Alternate Decommissioning Plan Assumptions:**
  - Full IAM Series through 2019
    - Exit A-Train in February 2020 (4.4 km lower in SMA)
  - Stop performing annual IAMs after the 2019 series
    - Allow MLT and Solar Beta Angle to drift until 2025 (or beyond)
  - Perform periodic DMUs until 2025 (or beyond)
    - Maintain WRS-2 ground track and frozen orbit

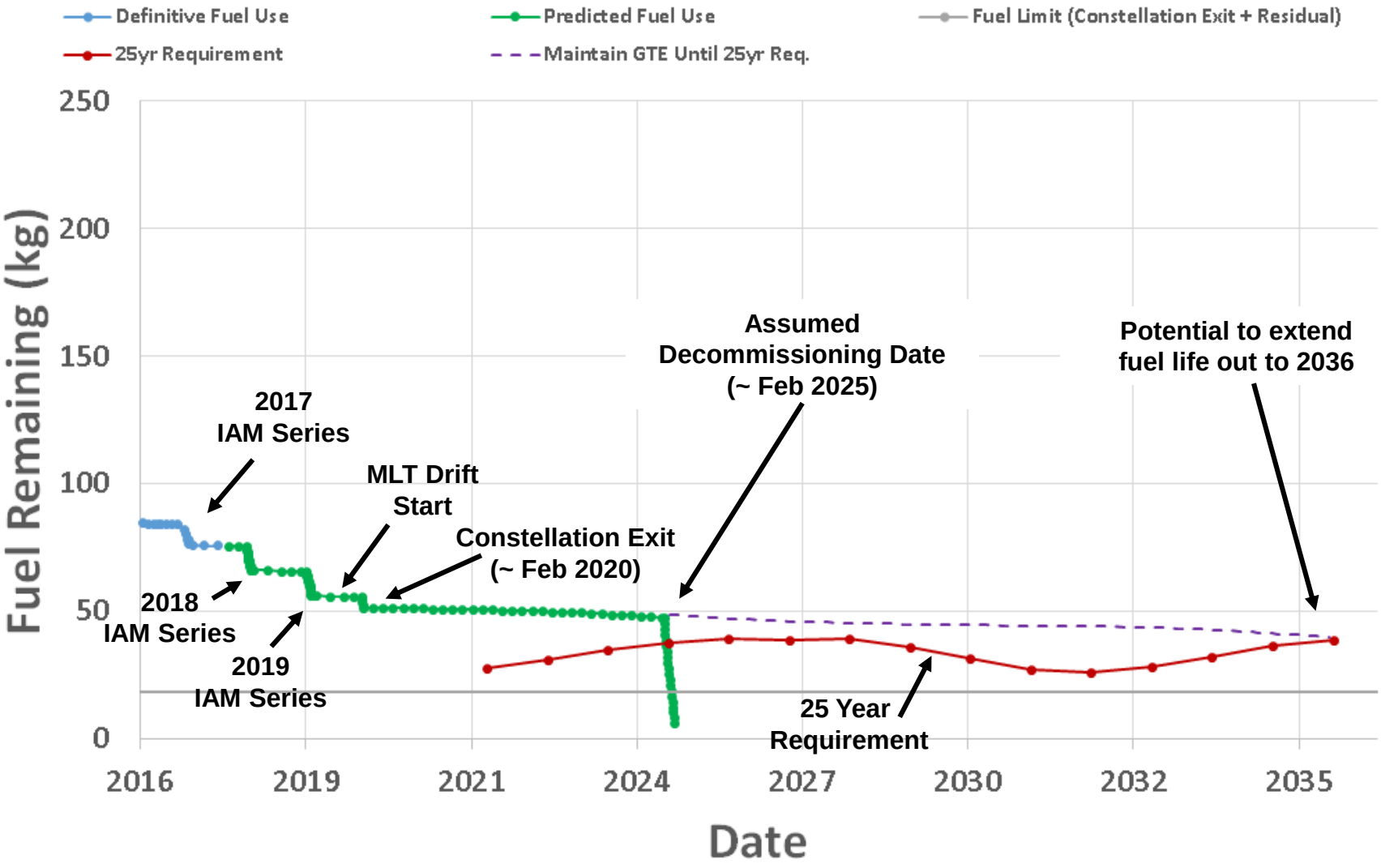
Documented in final 'EOS FDS Updated Analysis for Aura Decommissioning' (v1.0, 10/31/17, Appendix B)

Aura Fuel Usage: Actual & Predicted
(Same Alternate Plan – Analysis Updated October 2017)



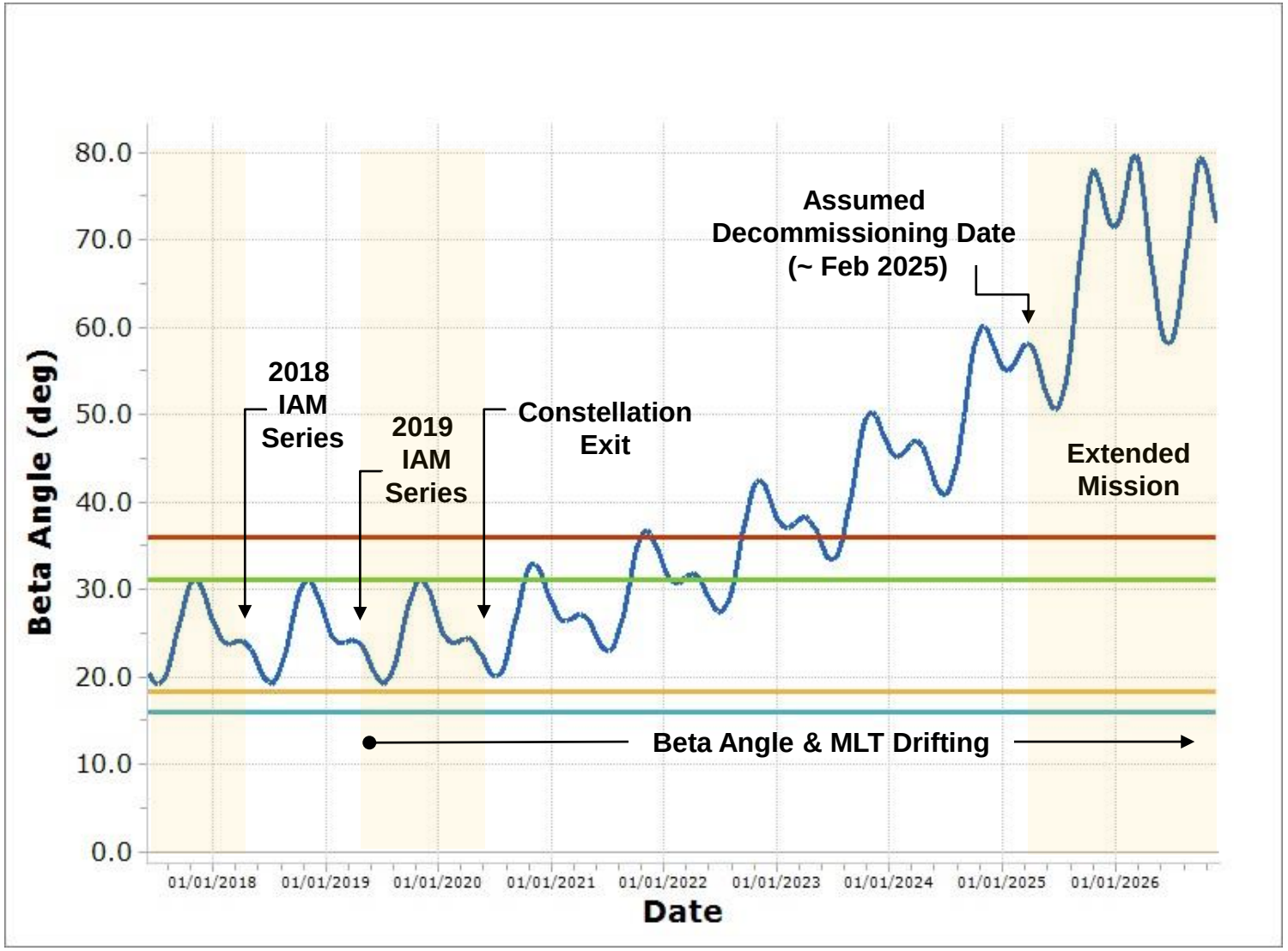
Aura Predicted Fuel Usage

(Same Alternate Plan – Analysis Updated October 2017)



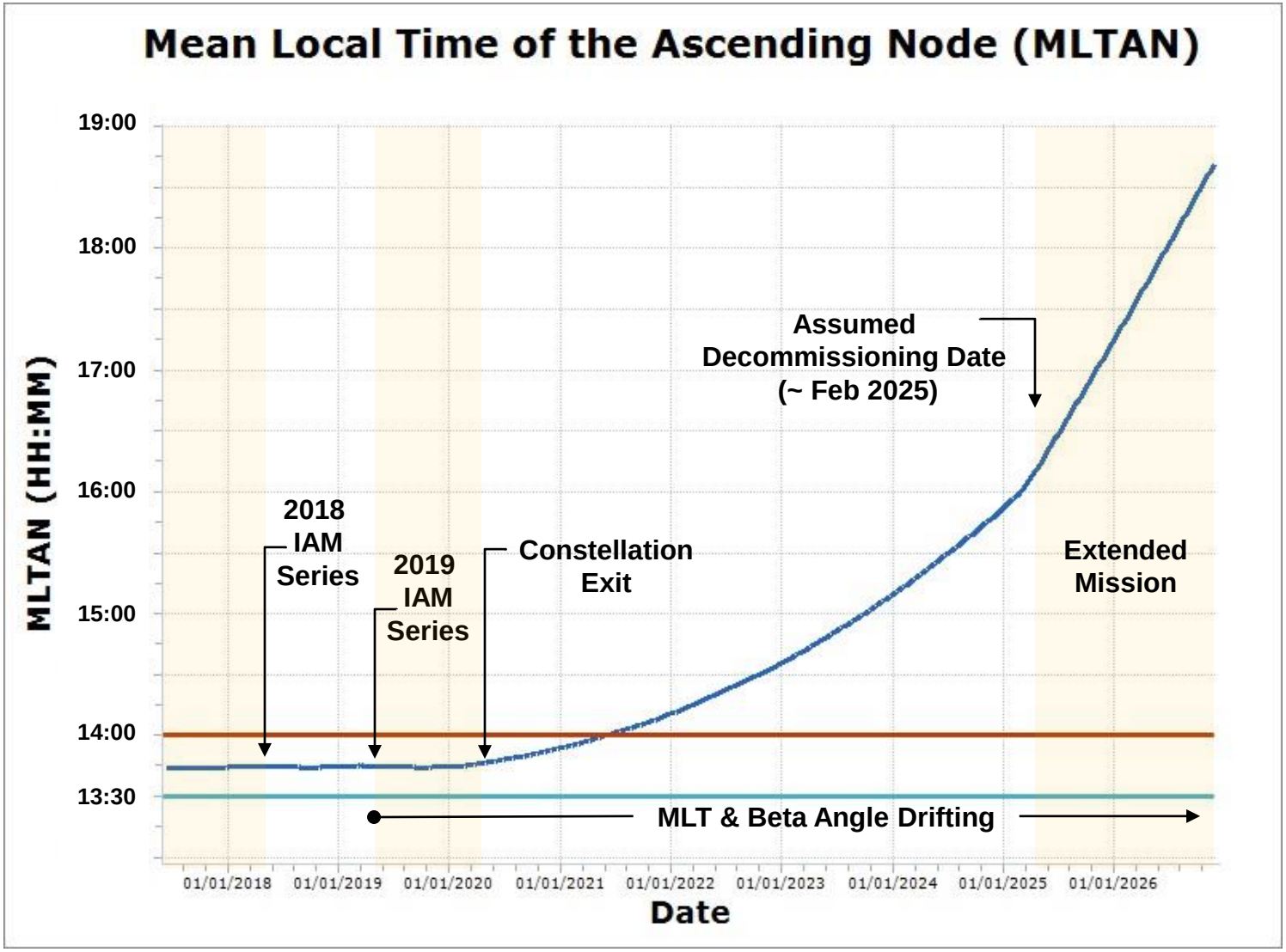
Aura Predicted Beta Angle

(Same Alternate Plan – Analysis Updated October 2017)



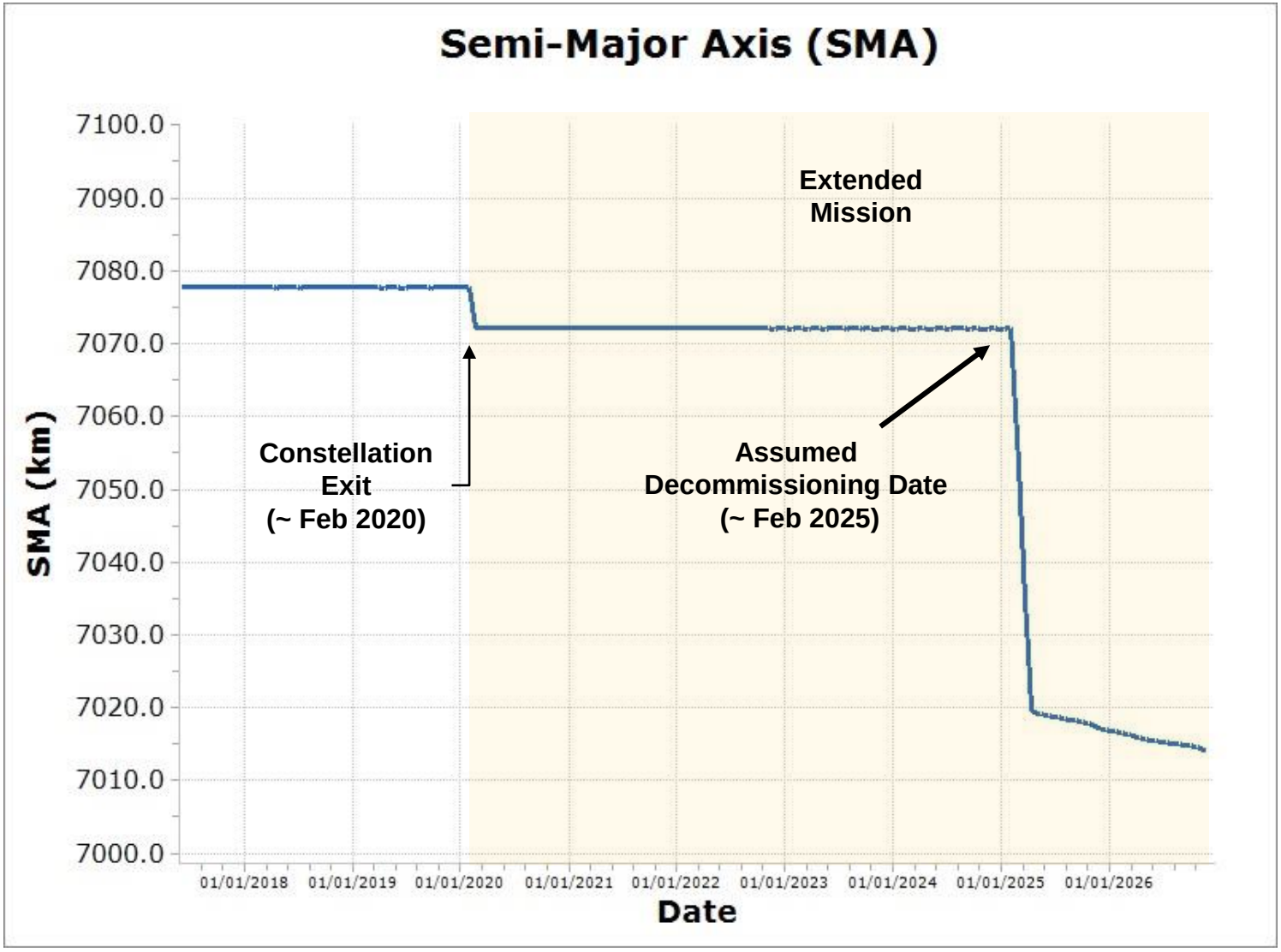
Aura Predicted Mean Local Time

(Same Alternate Plan – Analysis Updated October 2017)



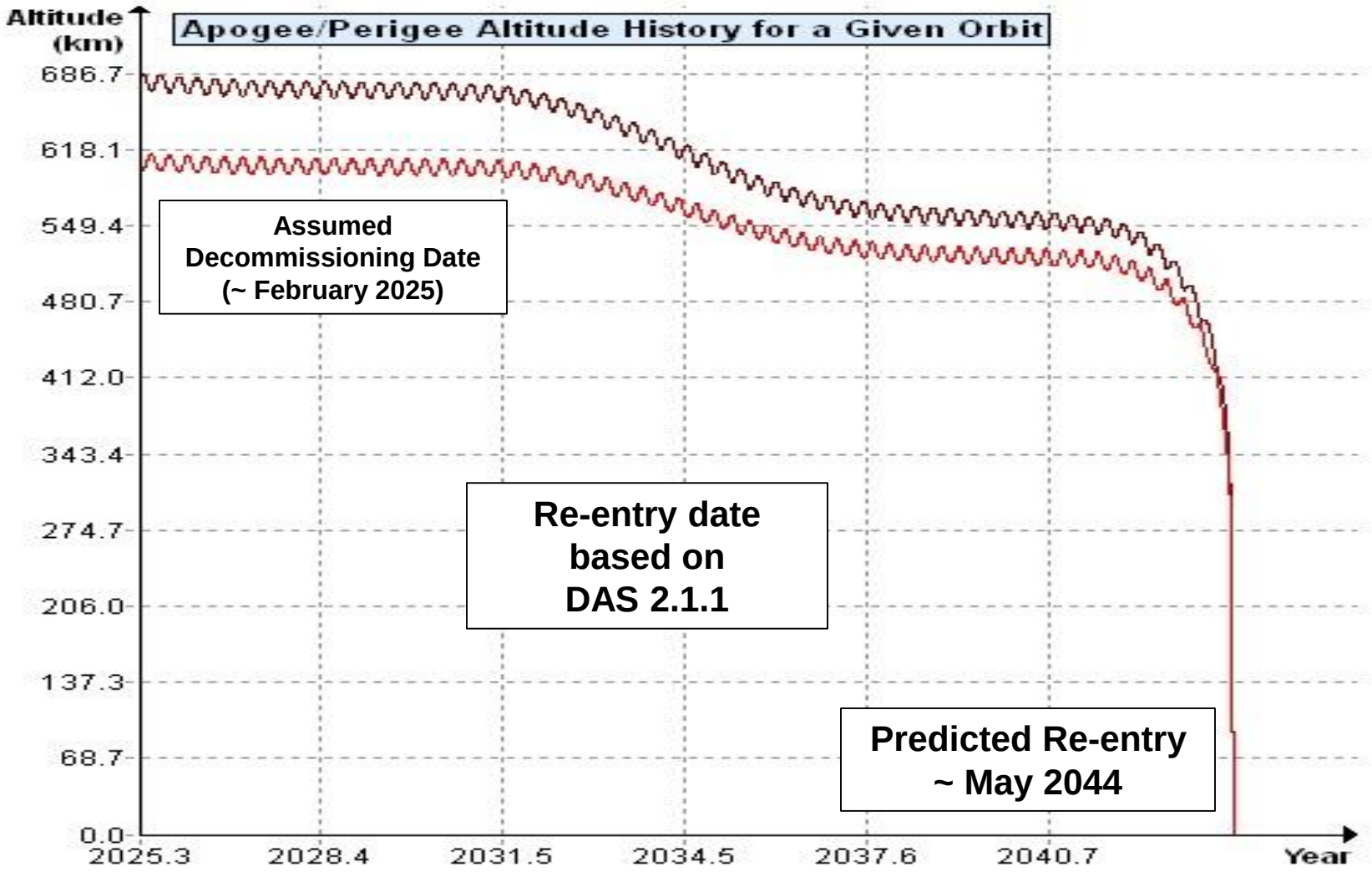
Aura Predicted Semi-Major Axis

(Same Alternate Plan – Analysis Updated October 2017)



Aura Predicted Re-entry

(Same Alternate Plan – Analysis Updated October 2017)



Abbreviations / Acronyms List

AFM –	Aqua/Aura FSW Maintenance
AN –	Ascending Node
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
CDR –	Critical Design Review
CDM –	Conjunction Data Message
COMM –	Communications
CRMS –	Collision Risk Management System
DAM –	Debris Avoidance Maneuver
DAS –	Debris Assessment Software
DMSP –	Defense Meteorological Satellite Program
DN –	Descending Node
DMUM –	Drag Make-up Maneuver
EA –	EOS Automation
EDOS –	EOS Data Operations System
EOC –	EOS Operations Center
EOL –	End of Life
EOMP –	End of Mission Plan
EOS –	Earth Observing System
EOSSIM –	EOS Simulator
EPS –	Electrical Power System
ESC –	Earth Science Constellation
ESD –	Earth Science Division
ESMO –	Earth Science Mission Operations
ETSF –	EOC Training Simulator Facility
FDS –	Flight Dynamics System
FM –	Fault Management
FMU –	Formatter Multiplexer Unit
FOT –	Flight Operations Team
FSW –	Flight Software
GCOM-W –	Global Change Observation Mission- Water
GMT –	Greenwich Mean Time
GNC –	Guidance Navigation & Control
GS –	Global Survey
GSFC –	Goddard Space Flight Center
GTE –	Ground Track Error
HIE –	High Interest Event
HIRDLS –	High Resolution Dynamics Limb Sounder
HK -	Housekeeping
HQ -	Headquarters
IAM –	Inclination Adjustment Maneuver
ICS –	Interferometer Control System
ID –	Ideal Date
IEM –	Integrated Electronics Module
IOT –	Instrument Operations Team
JPL –	Jet Propulsion Lab
JSpOC –	Joint Space Operations Center
kg -	kilogram
km –	kilometer
KSC –	Kennedy Space Center
L0 –	Level-Zero
LS -	Landsat
MLS –	Microwave Limb Sounder
MLT –	Mean Local Time
MLTAN –	MLT of the Ascending Node
MMOD –	Micrometeorite Orbital Debris
MMS –	Mission Management System
MOWG –	Mission Operations Working Group
MTS –	Maneuver Trade Space
NASA –	National Aeronautics & Space Administration
NOAA –	National Oceanic and Atmospheric Administration
NYS –	No Yaw Slew
Ops –	Operations
OMI –	Ozone Monitoring Instrument
ORR –	Operational Readiness Review
PROP -	Propulsion
Pc –	Probability of Collision
R2 –	Receiver 2
RHEL –	Red Hat Enterprise Linux
RMM –	Risk Mitigation Maneuver
RW –	Reaction Wheel
RWA –	Reaction Wheel Assembly
SC -	Spacecraft
SCS –	Stored Command Sequence
SD –	South Dakota
SMA –	Semi-Major Axis
SMD –	Science Mission Directorate
SSR –	Solid State Recorder
TBD –	To Be Determined
TCS –	Thermal Control System
TES –	Tropospheric Emissions Spectrometer
THz -	Terahertz
TMON –	Telemetry Monitor
TROPOMI –	Troposphere Measuring Instrument
WRS –	World Reference System