Aura Extended Mission Plans

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Topics

- Background
- Aura Key Facts
- Summary of Efforts in 2016 / 2017
- Baseline Extended Mission Plan
- Alternate Extended Mission Plan
- Backup

Aura Key Facts

- **Required to hold sufficient fuel in reserve to:**
  - Safely exit the constellation envelope
  - Lower perigee to meet the NASA 25-year reentry requirement
- **Required to use the NASA's Debris Assessment Software (DAS) for end-of-mission life analyses**
  - Created by NASA's Orbital Debris Office at Johnson Space Center
  - DAS is the Agency standard for end-of-mission life analyses and lifetime estimations
  - DAS Solar Flux model is updated twice per year
    - » Newest Version 2.1.1 (November 2016)
    - » Version 2.0.2 used in latest FDS analysis (very minor differences to 2.1.1)
- **Goal: Maximize mission science objectives with remaining fuel while still meeting the Constellation Exit and NASA's and International 25-year re-entry requirements**
  - Current plan is to perform full Inclination adjustments in 2018 thru 2022 time frame
  - Exit Constellation/A-Train in March 2023 (circularly lower orbit by 4+ km)
  - Find a way to operate Aura out into the 2025-2027 time frame
  - Investigating more fuel-efficient inclination adjust and retrograde maneuvers

Aura Key Facts

- **Required to meet the Solar Beta Angle constraint**
  - Spacecraft Solar Beta Angle maintenance requirement is 16° to 36°
  - OMI requests that Aura maintain its Beta Angle between 18.3° to 31.2° in order to maintain science within previously calibrated region
- **Request to meet coincident viewing between MLS-CALIPSO**
  - 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
- **Request to maintain tighter Ascending Node Crossing time**
  - Reduced MLTAN to 13:38-13:45 for MLS cross correlation with Aqua and CloudSat
- **Goal: Once TROPOMI is operational, maintain OMI science data capture for a minimum of 2-years of overlap**
  - TROPOMI will be on ESA's Sentinel 5 Precursor (S5P)
    - » **Scheduled Launch Date = August 16, 2017**
  - TROPOMI is intended to provide data continuity with OMI
    - » Both operated by the Royal Netherlands Meteorological Institute (KNMI)
  - FDS analysis performed to explore the effects of halting IAMs after the two year overlap period
    - » Alternate scheme would mean stopping IAMs after the 2019 series

Summary of Efforts 2016 / 2017

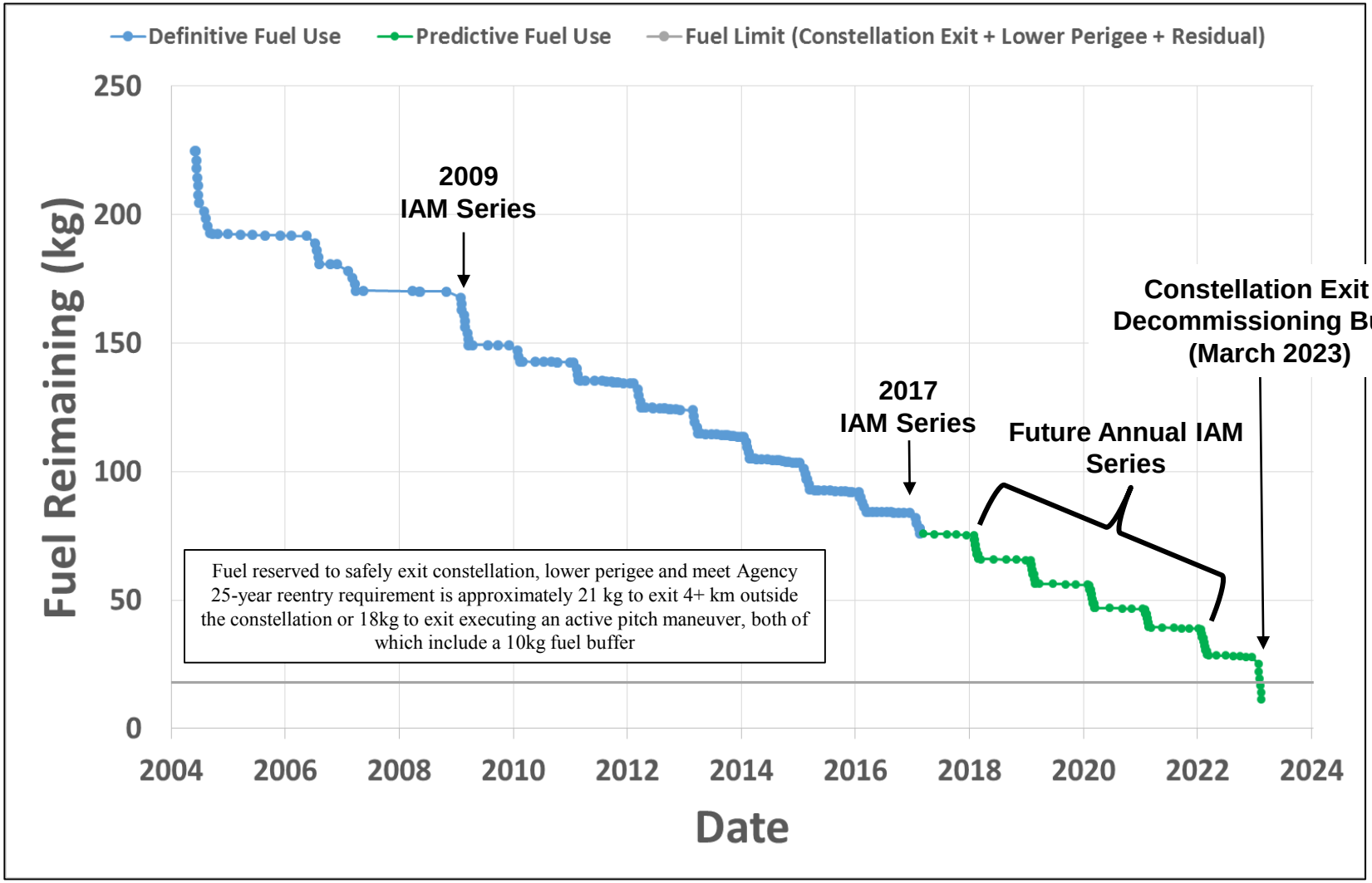
- **2016 (December): Updated Decommission Plan (v1.1)**
  - Long-term orbit simulations were run for Aura through February 2023
    - **Predictions show sufficient fuel to maintain current orbit through 2022 (exit March 2023)**
  - Used mean nominal Schatten solar flux predictions from November 2016
  - Estimated the frequency of DMUMs to maintain Aura's WRS-2 ground track requirements
  - Estimated the required number of annual IAMs for Aura to maintain it's MLT requirement
    - **25 IAMs needed 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

- **2017 (January): Updated Decommission Plan (v1.2)**
  - Update included how drifting Aura's MLT would interact with the Landsat-8 orbit

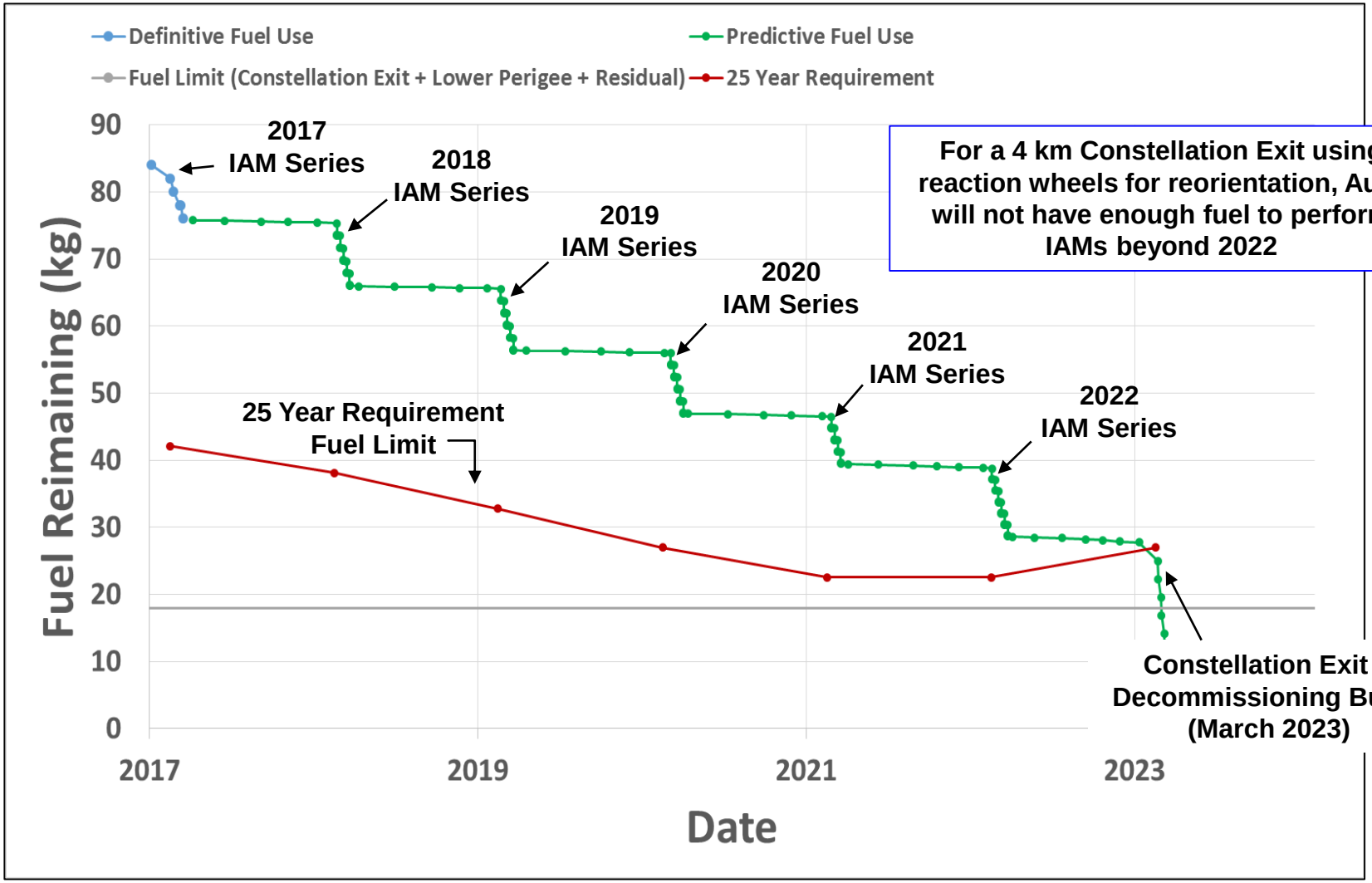
Aura Baseline Decommissioning Plan

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

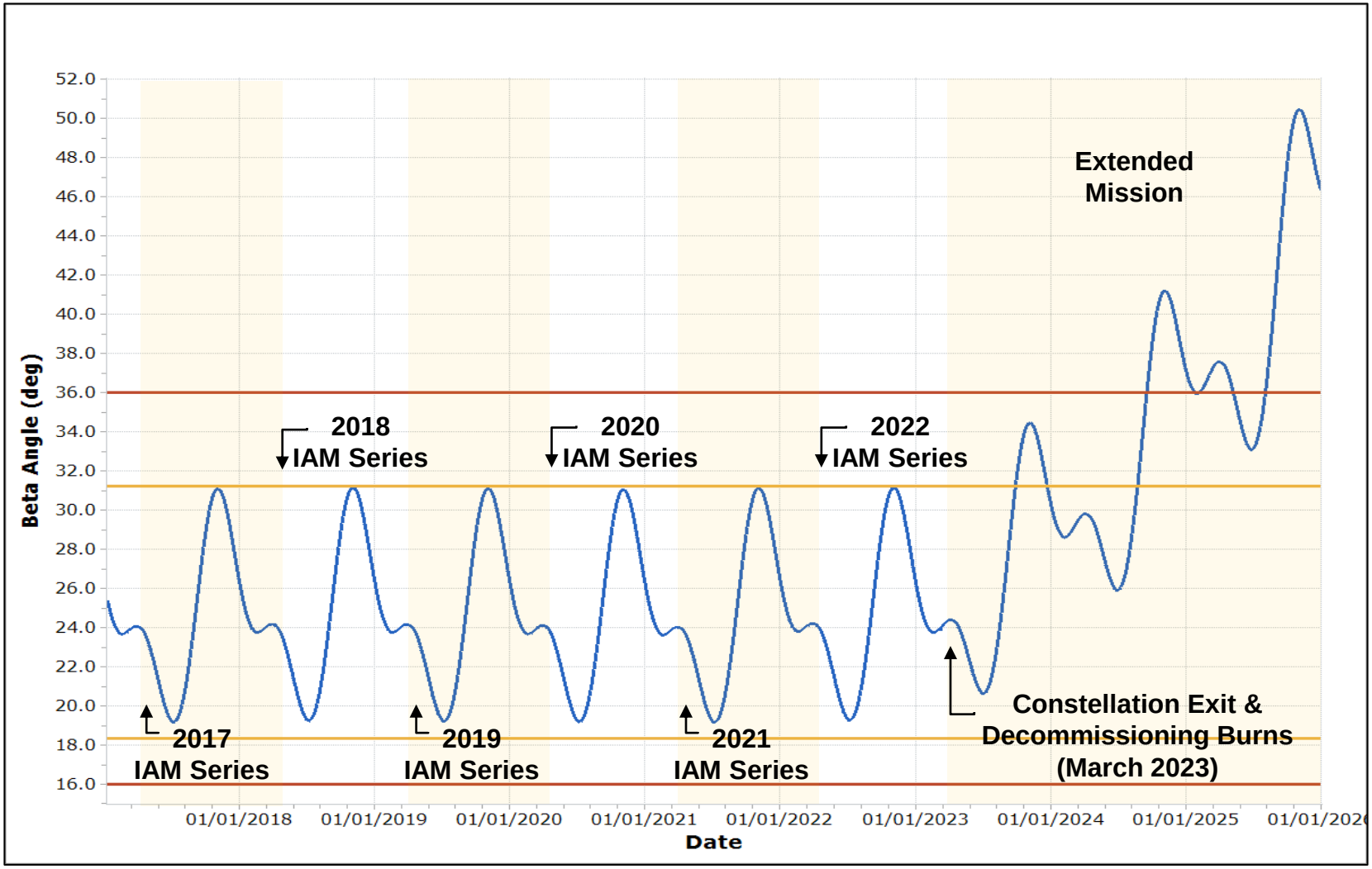
Aura Fuel Usage: Actual & Predicted
(Baseline Plan)



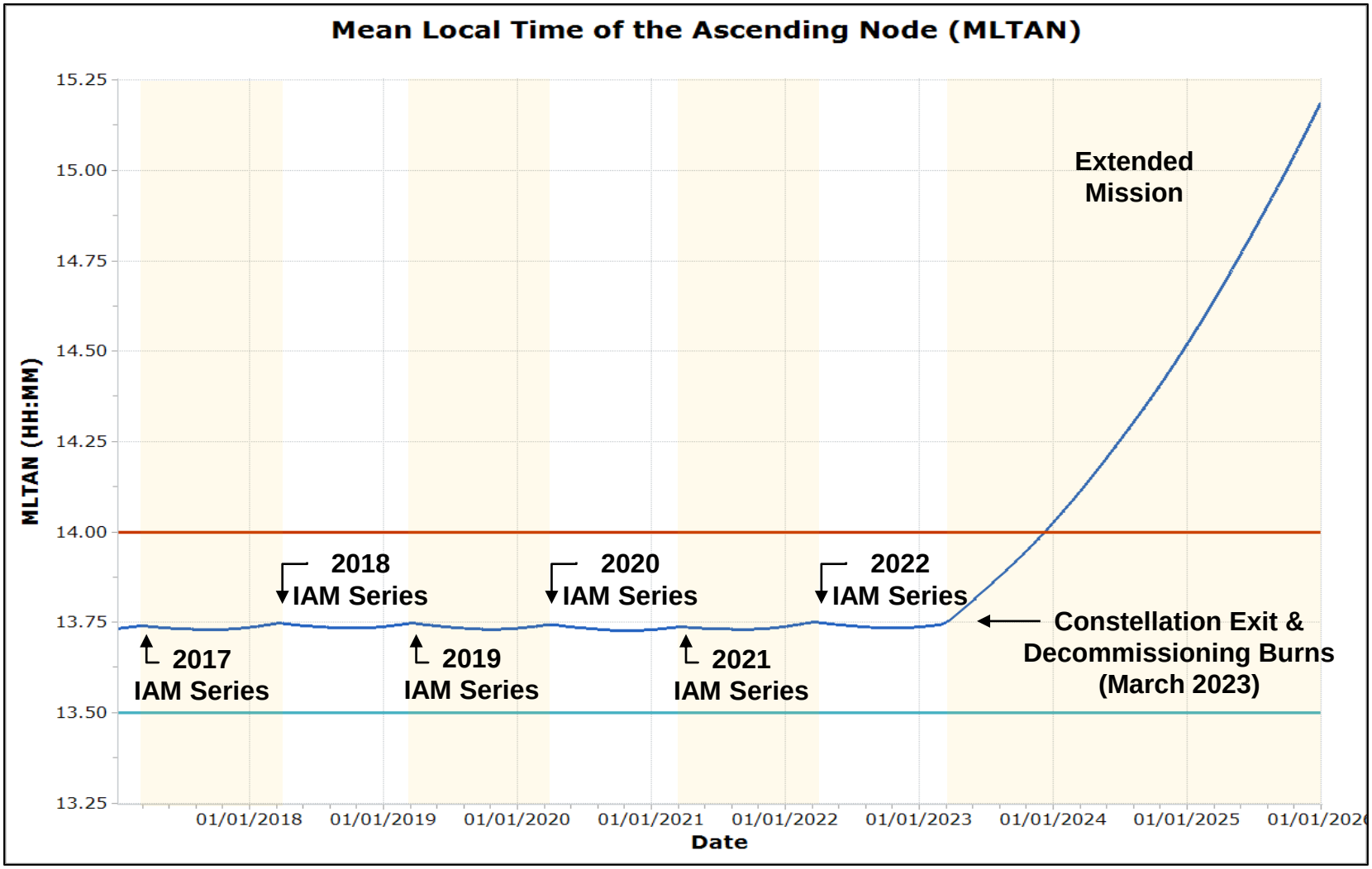
Aura Predicted Fuel Usage
(Baseline Plan)



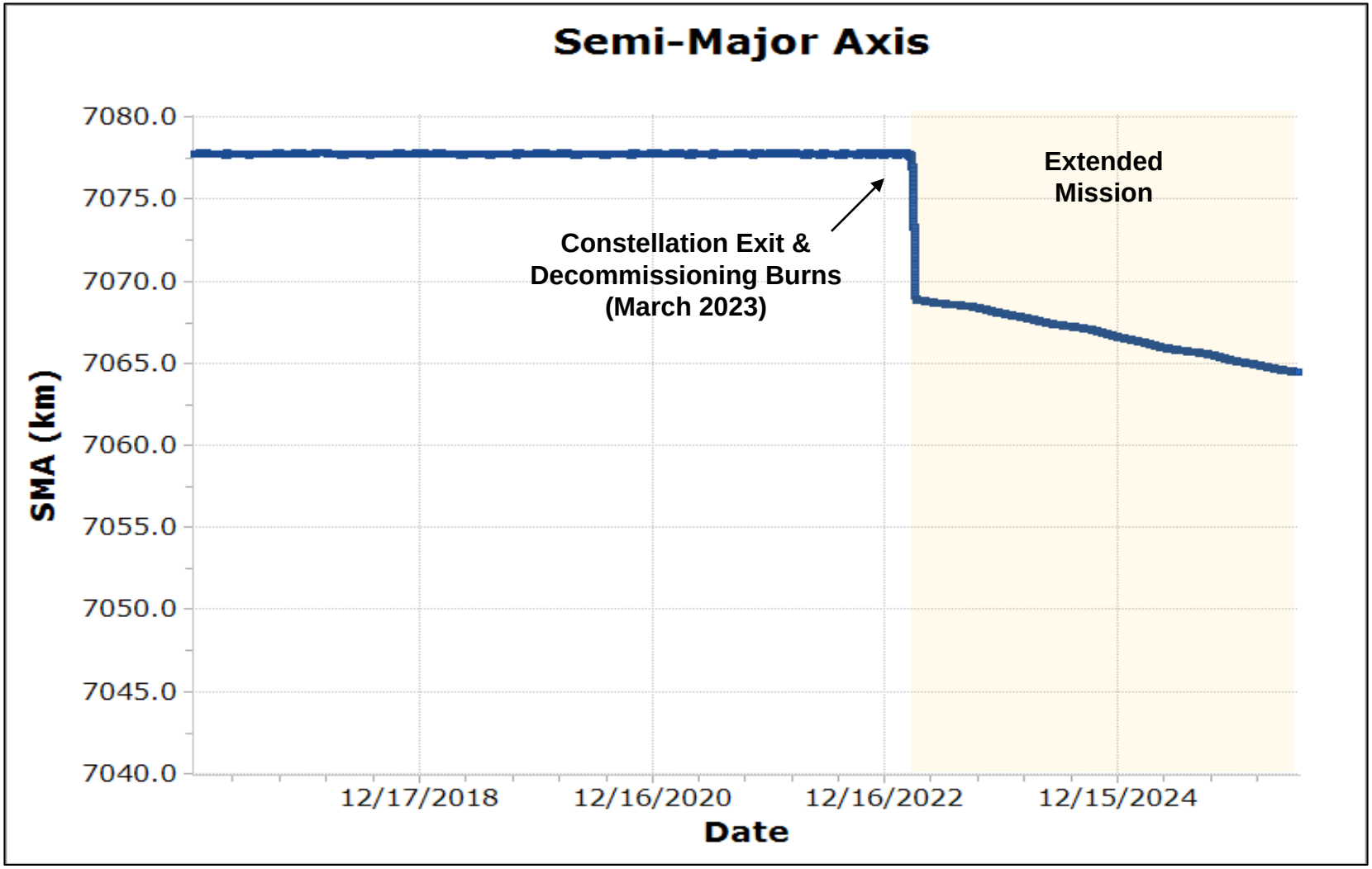
Aura Predicted Beta Angle
(Baseline Plan)



Aura Predicted Mean Local Time
(Baseline Plan)



Aura Predicted Semi-Major Axis
(Baseline Plan)



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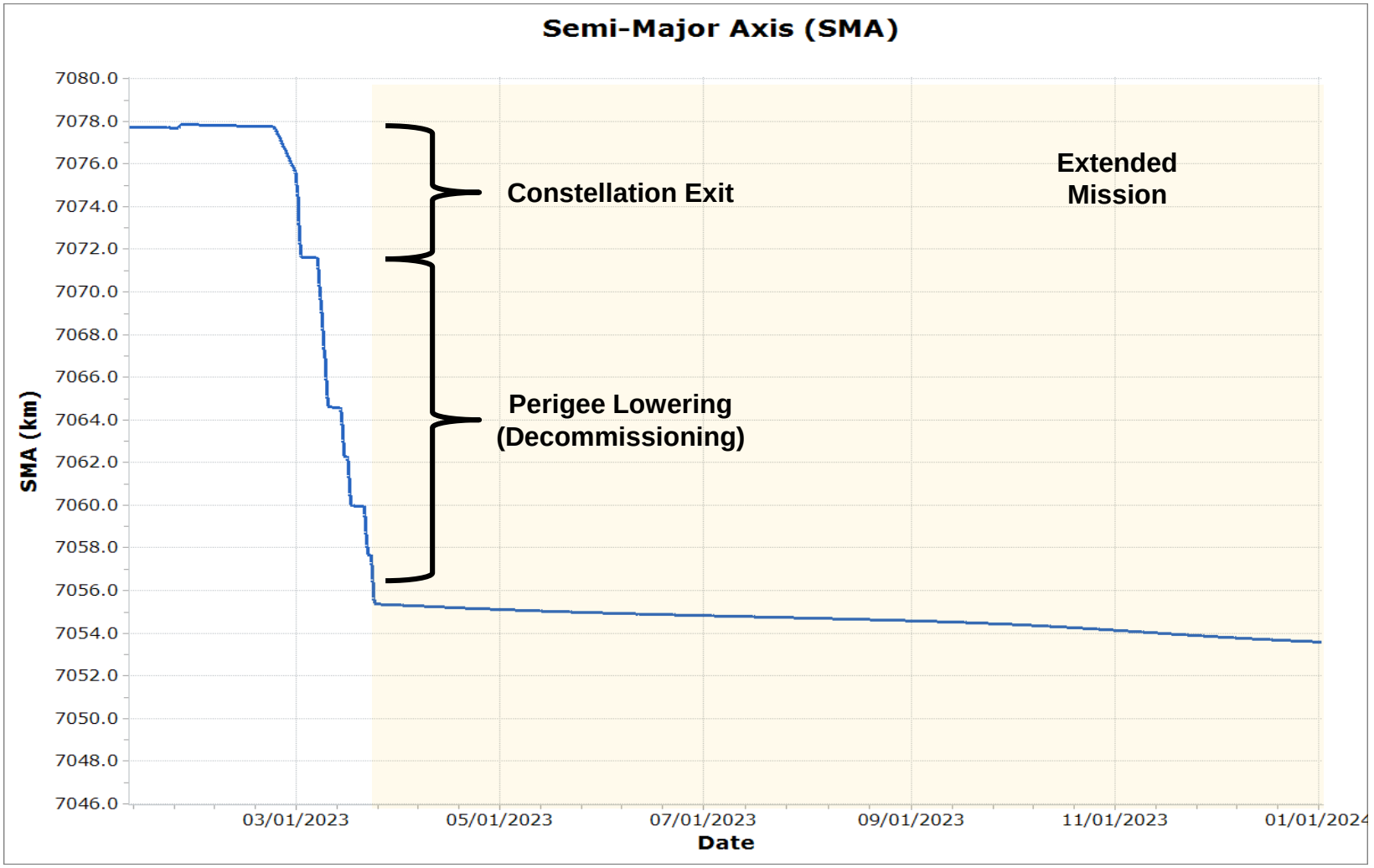
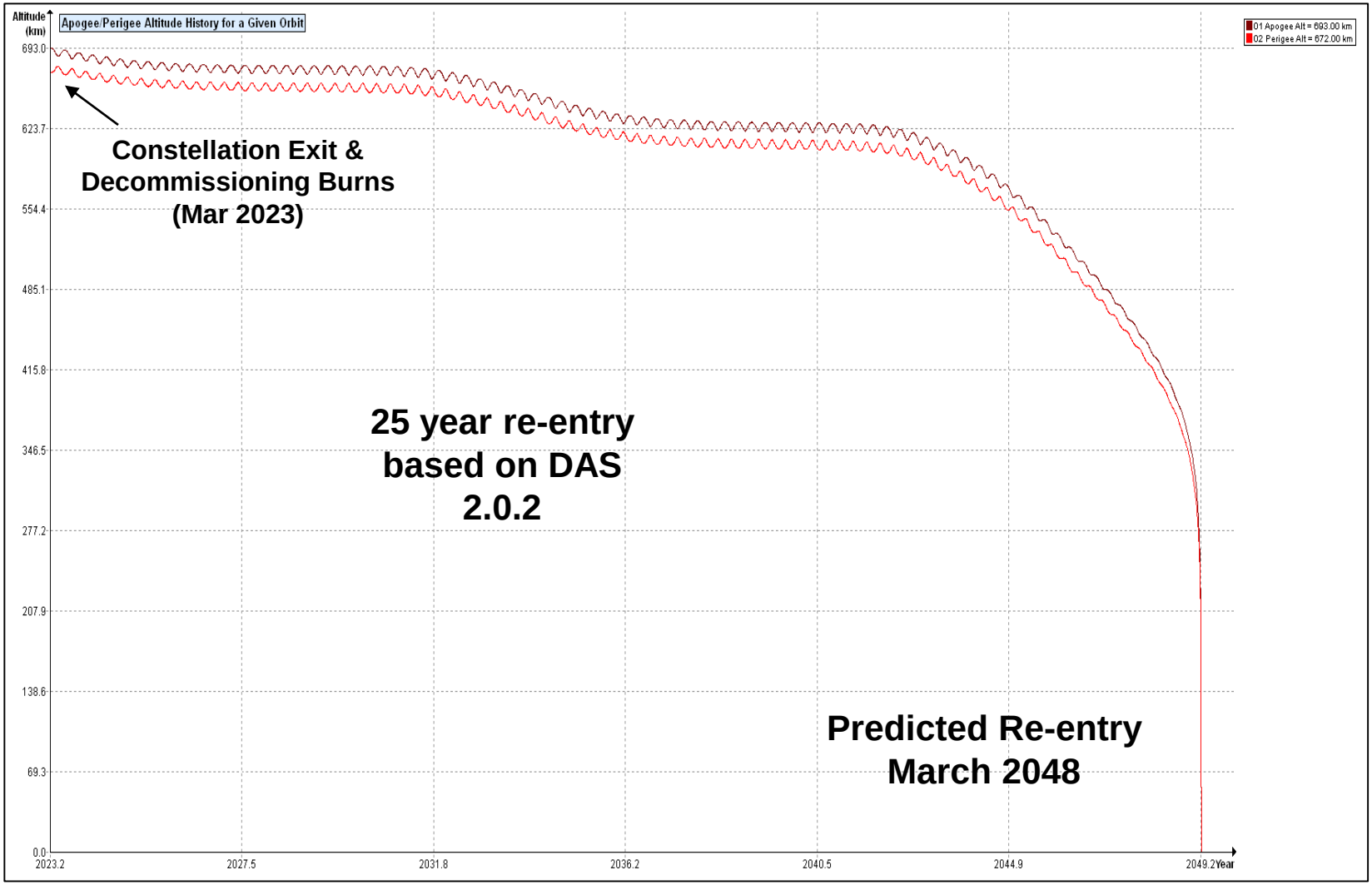


Aura Predicted Re-entry
(Baseline Plan)



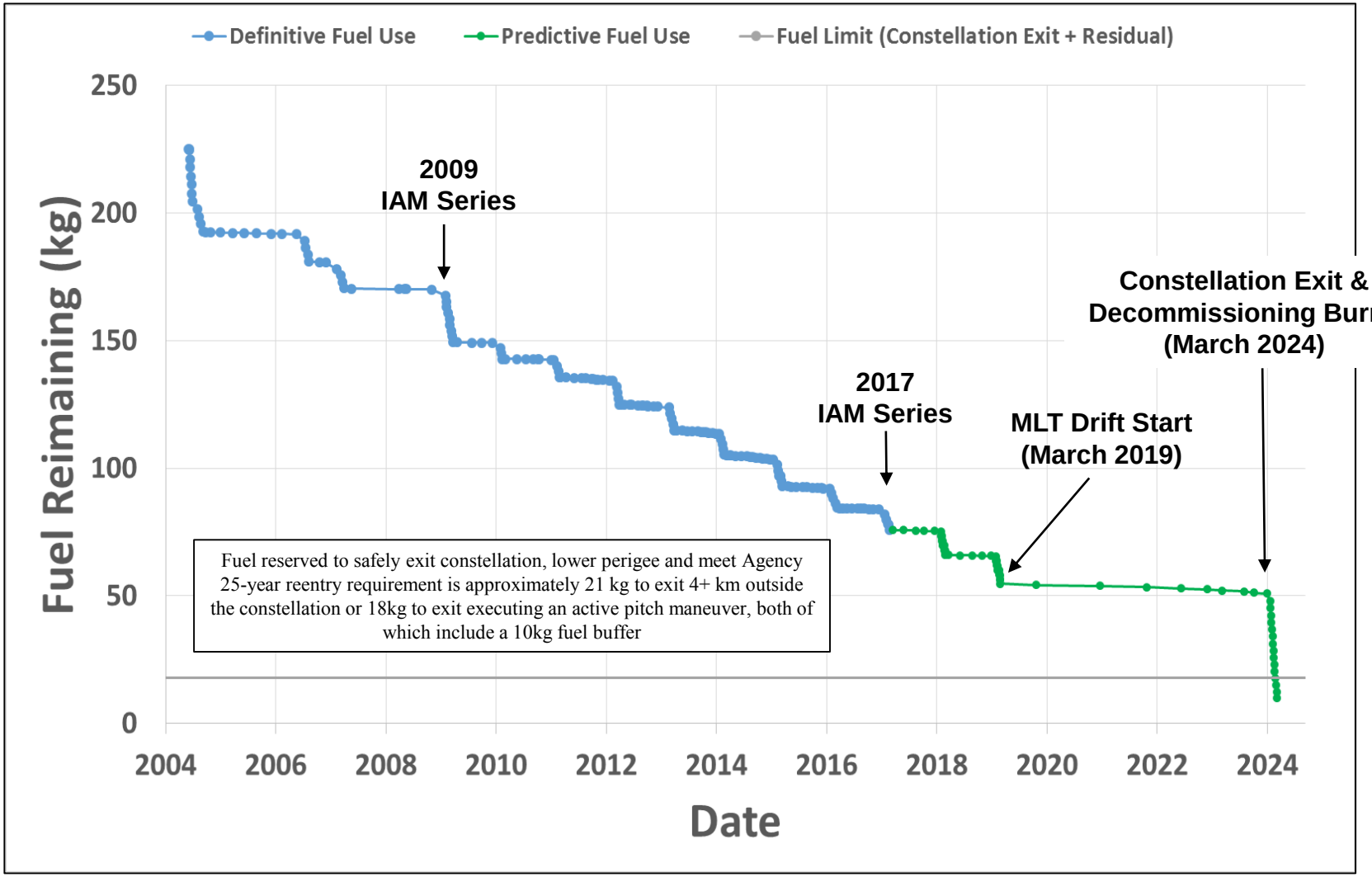
Aura Alternate Decommissioning Plan

- **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

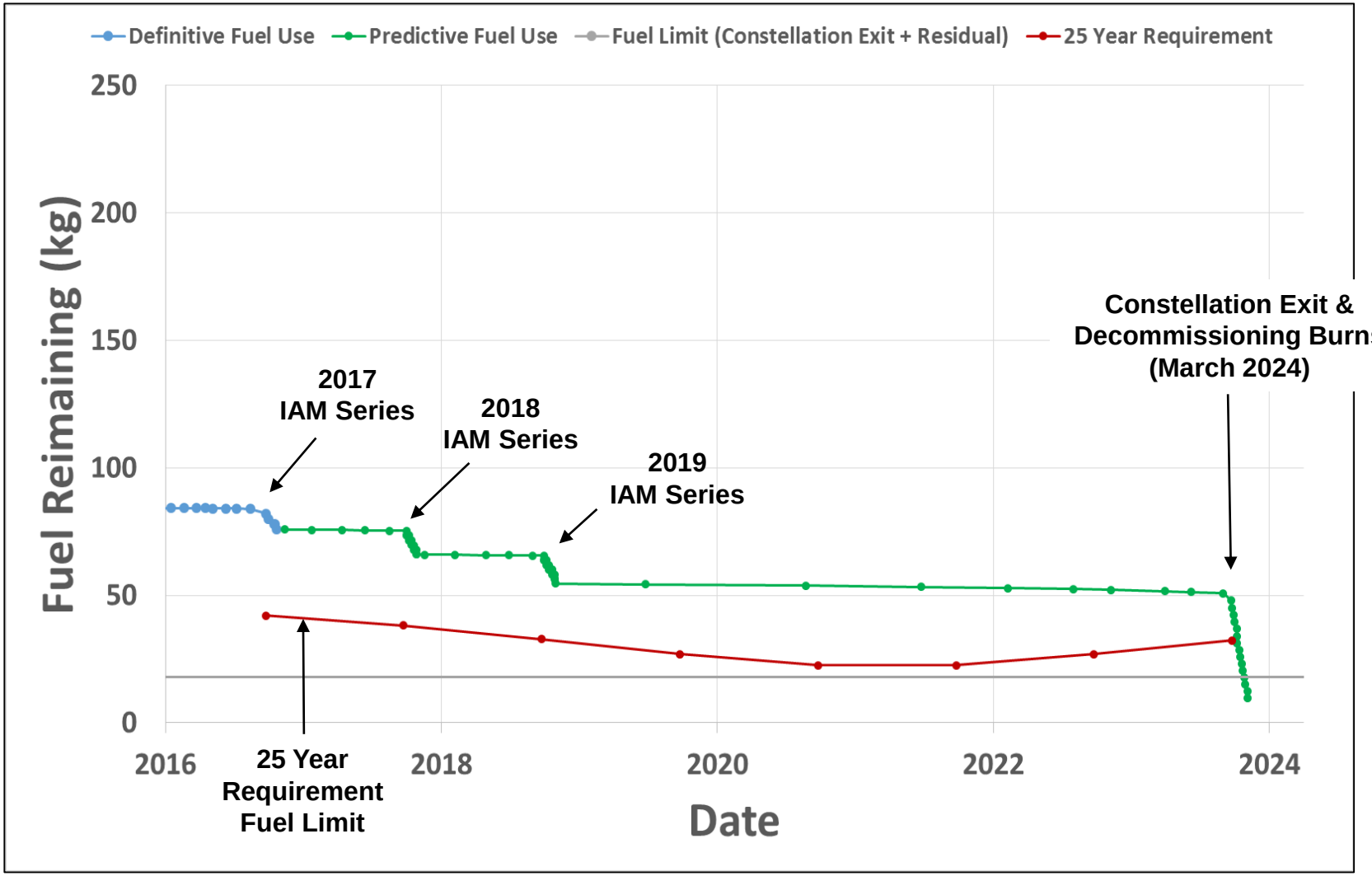
- **In this alternate decommissioning case:**
  - Allow MLT and Solar Beta Angle to drift
    - Stop performing annual IAMs after the 2019 series
  - Maintain WRS-2 Ground Track
    - Perform periodic DMUs to maintain WRS-2 Ground Track Error

Note: Further investigations with the spacecraft manufacturer (NGAS) and the instrument teams need to examine the effects of the Solar Beta Angle on hardware and science collection

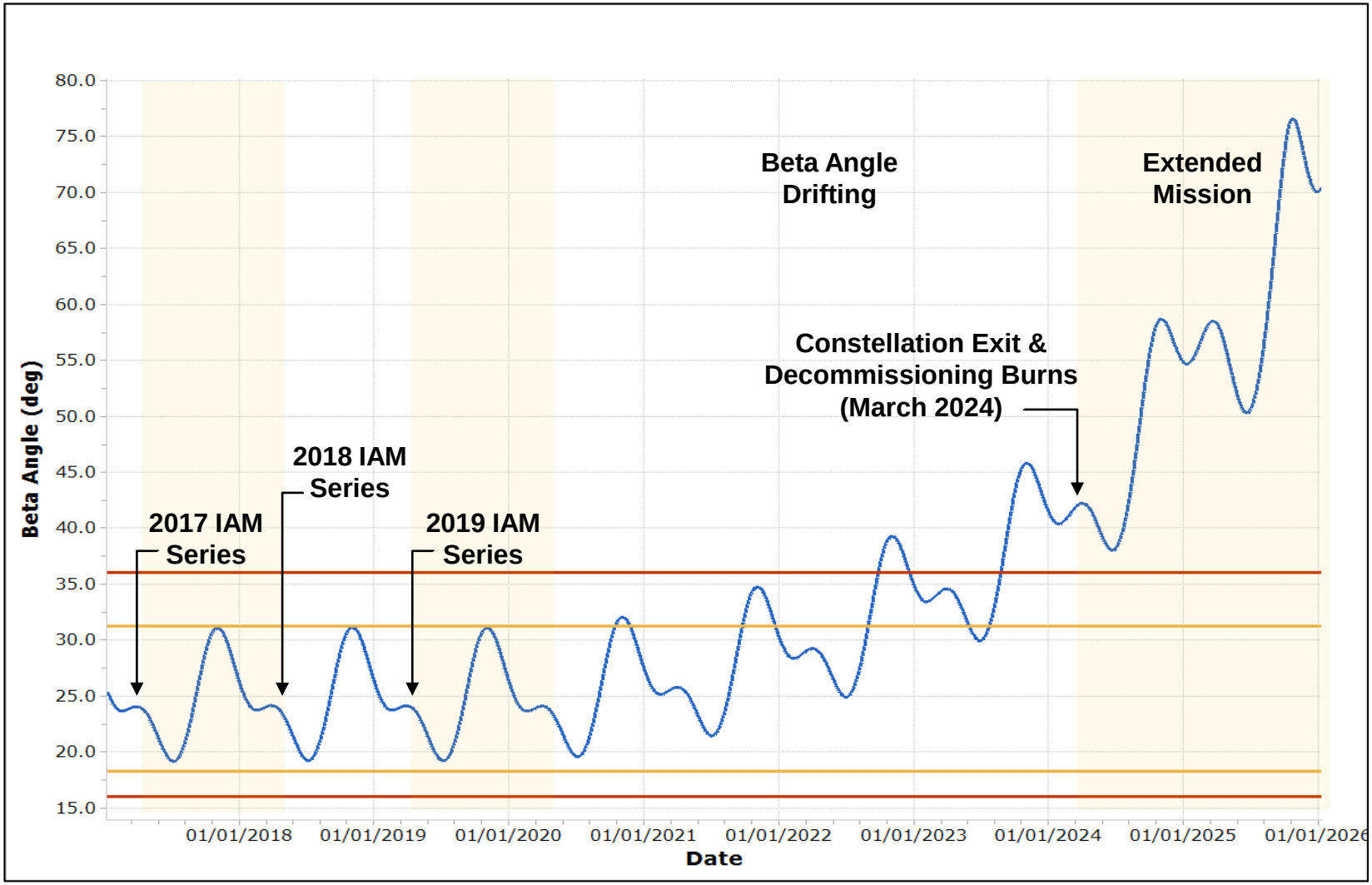
Aura Fuel Usage: Actual & Predicted
(Alternate Plan)



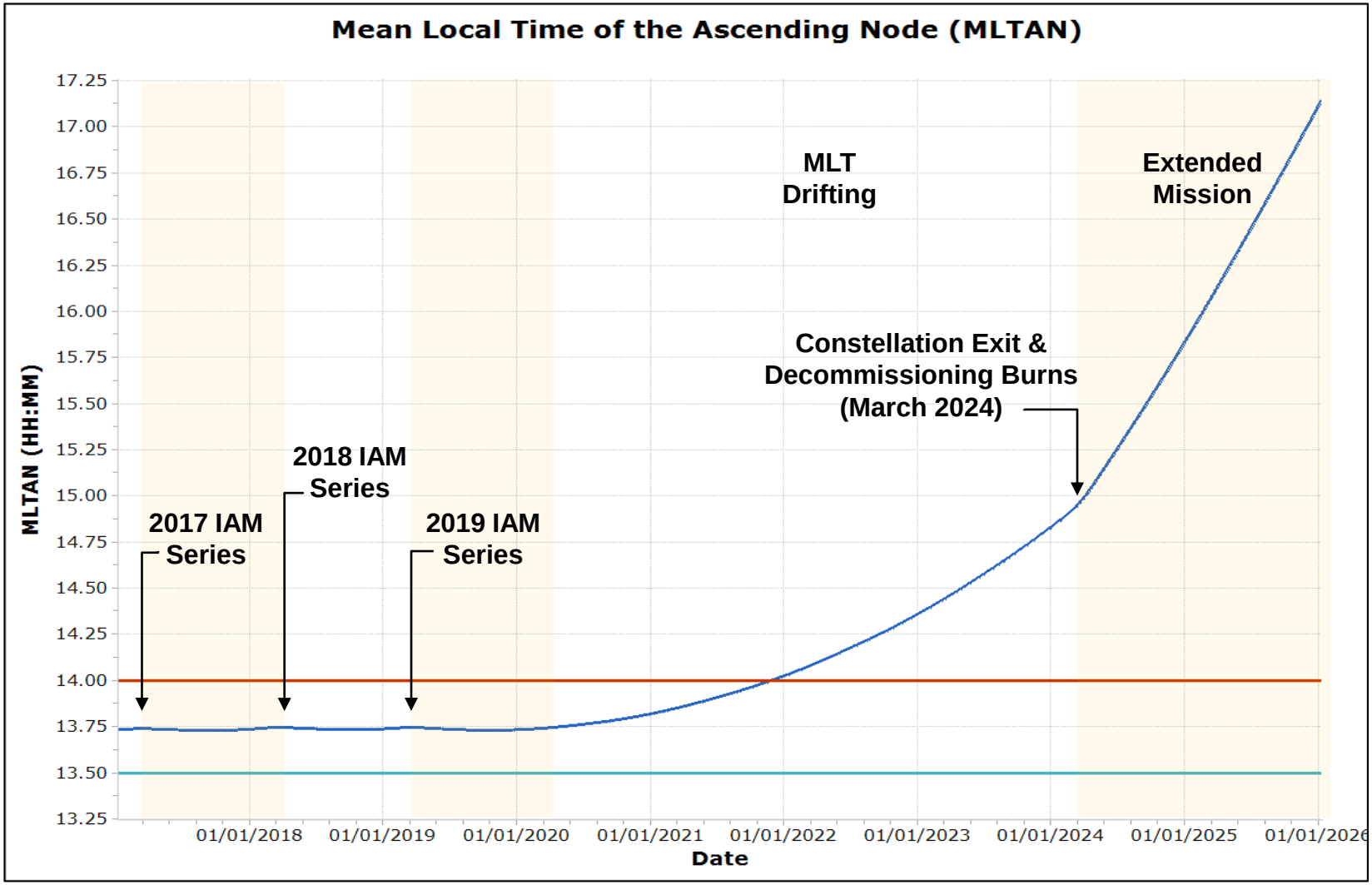
Aura Predicted Fuel Usage
(Alternate Plan)



Aura Predicted Beta Angle
(Alternate Plan)



Aura Predicted Mean Local Time
(Alternate Plan)



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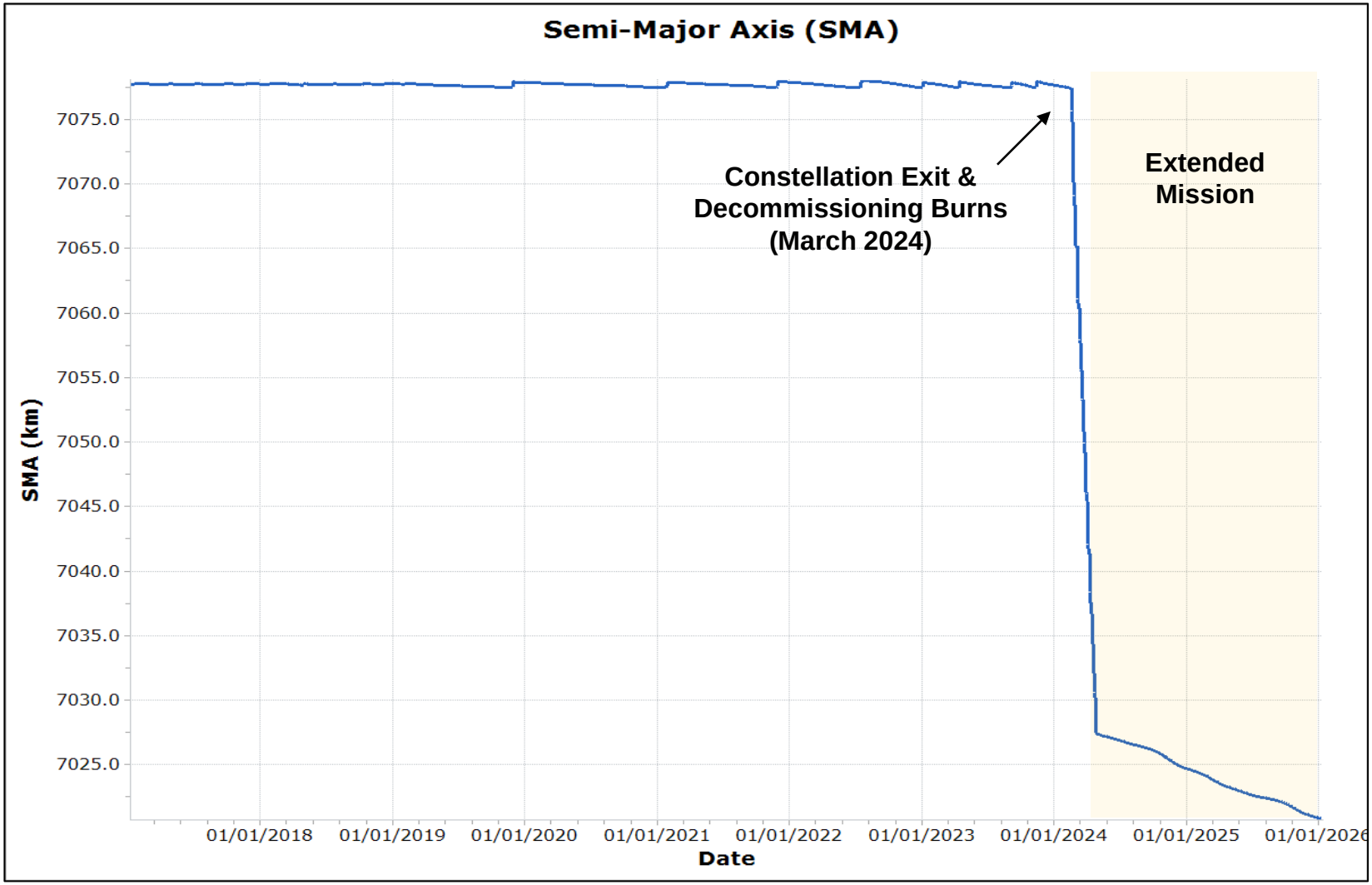
(Alternate Plan)



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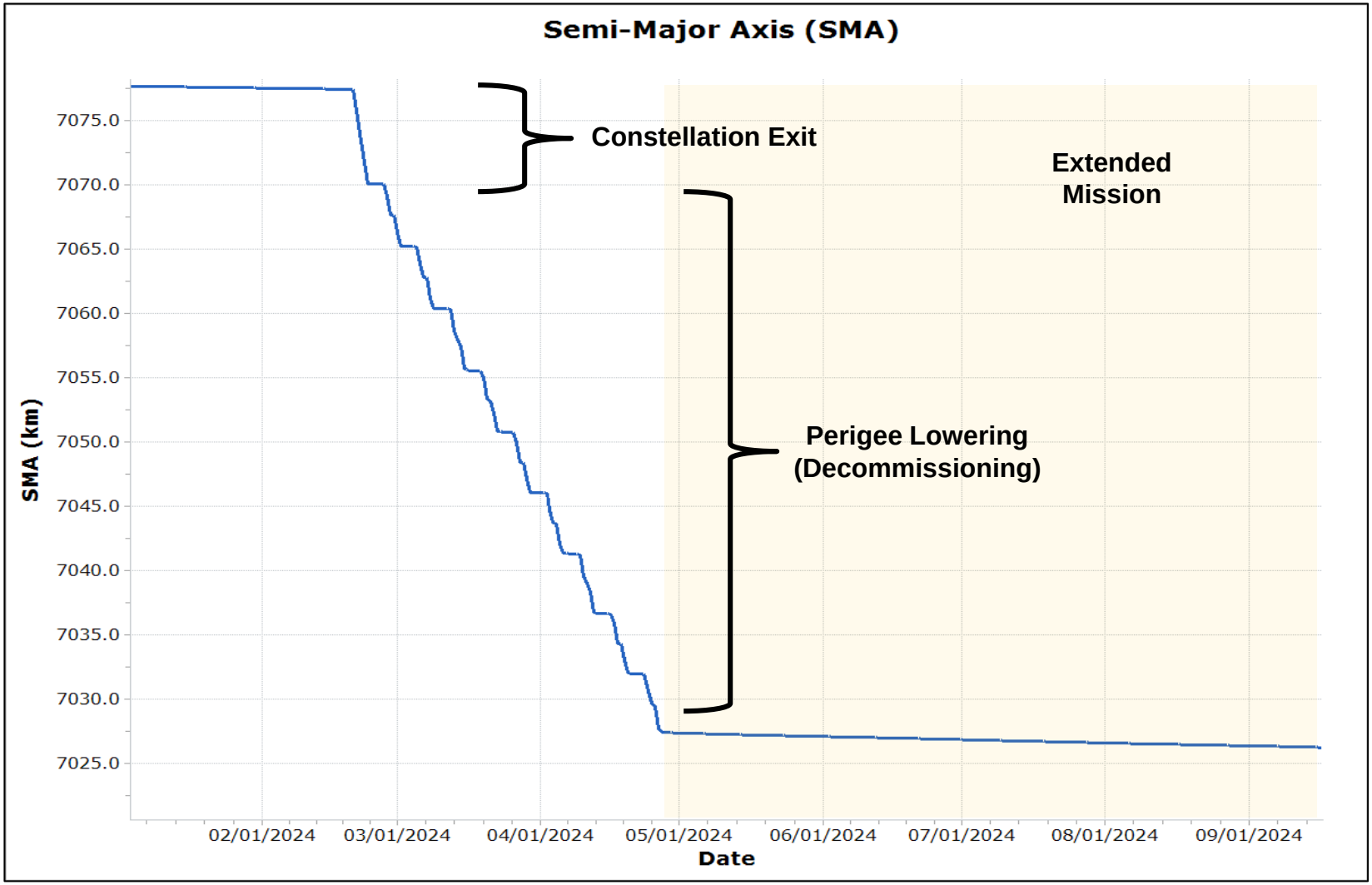
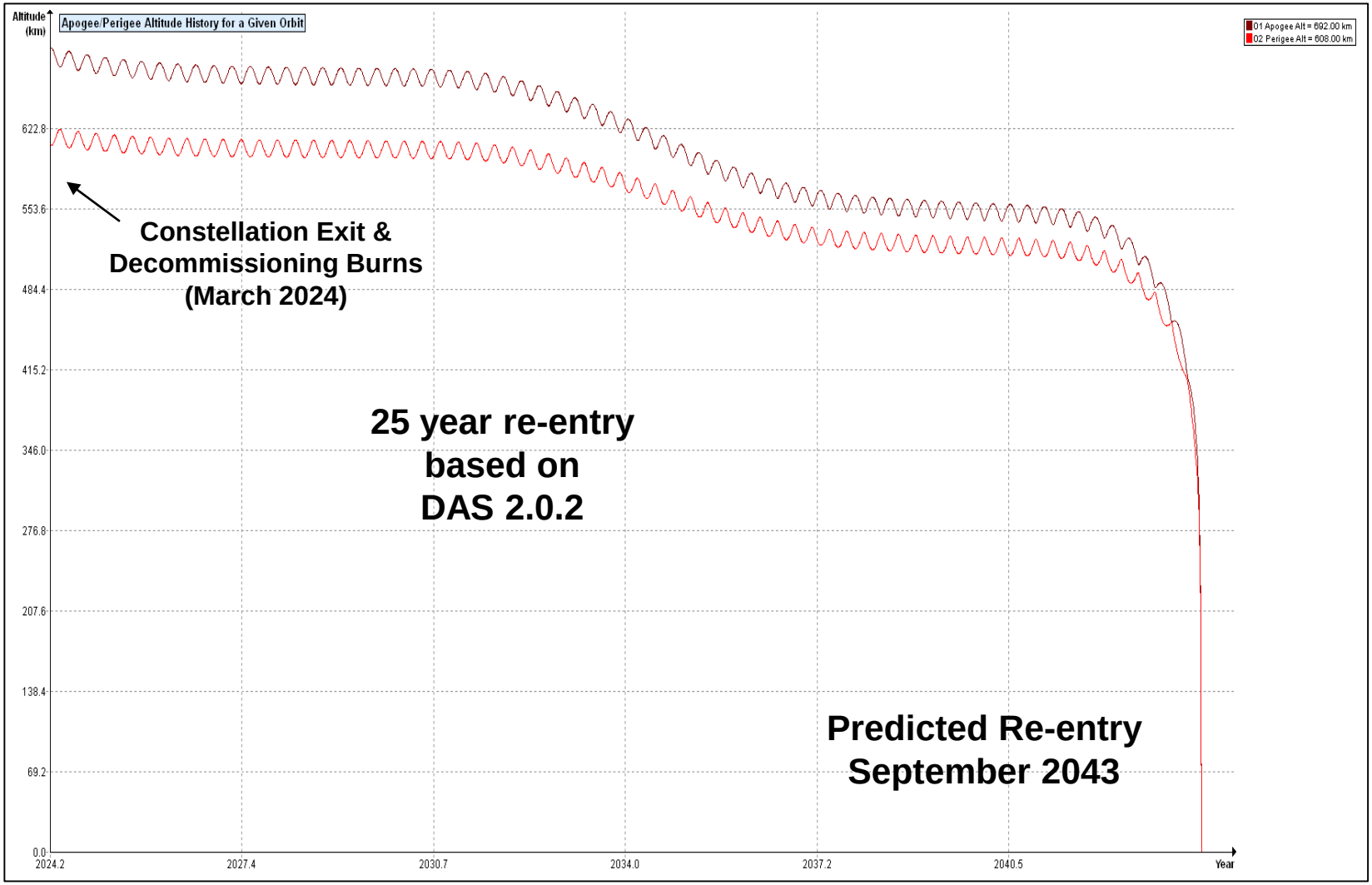
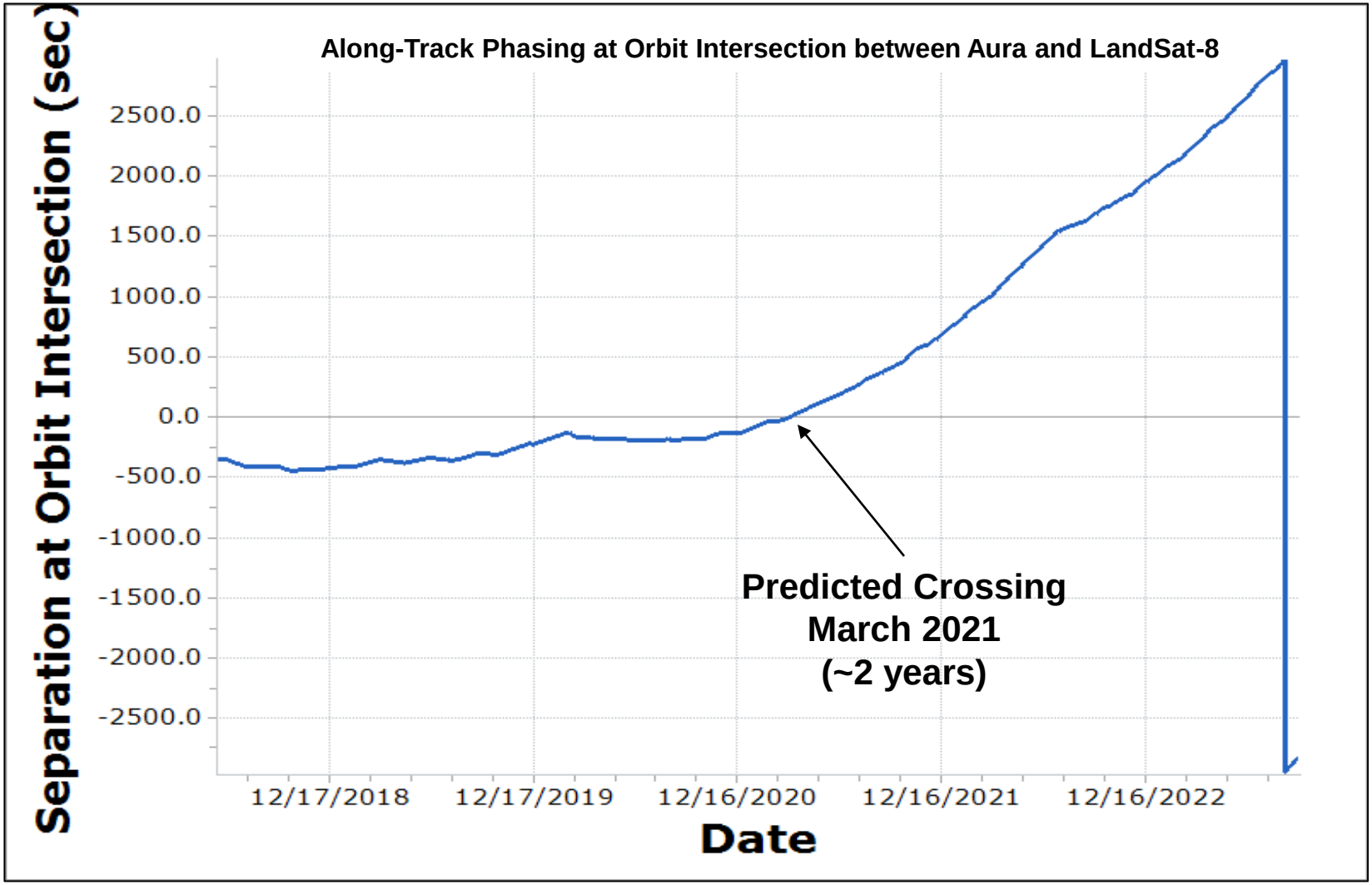


Aura Predicted Re-entry
(Alternate Plan)



Aura Predicted Landsat-8 Crossing
(Alternate Plan)



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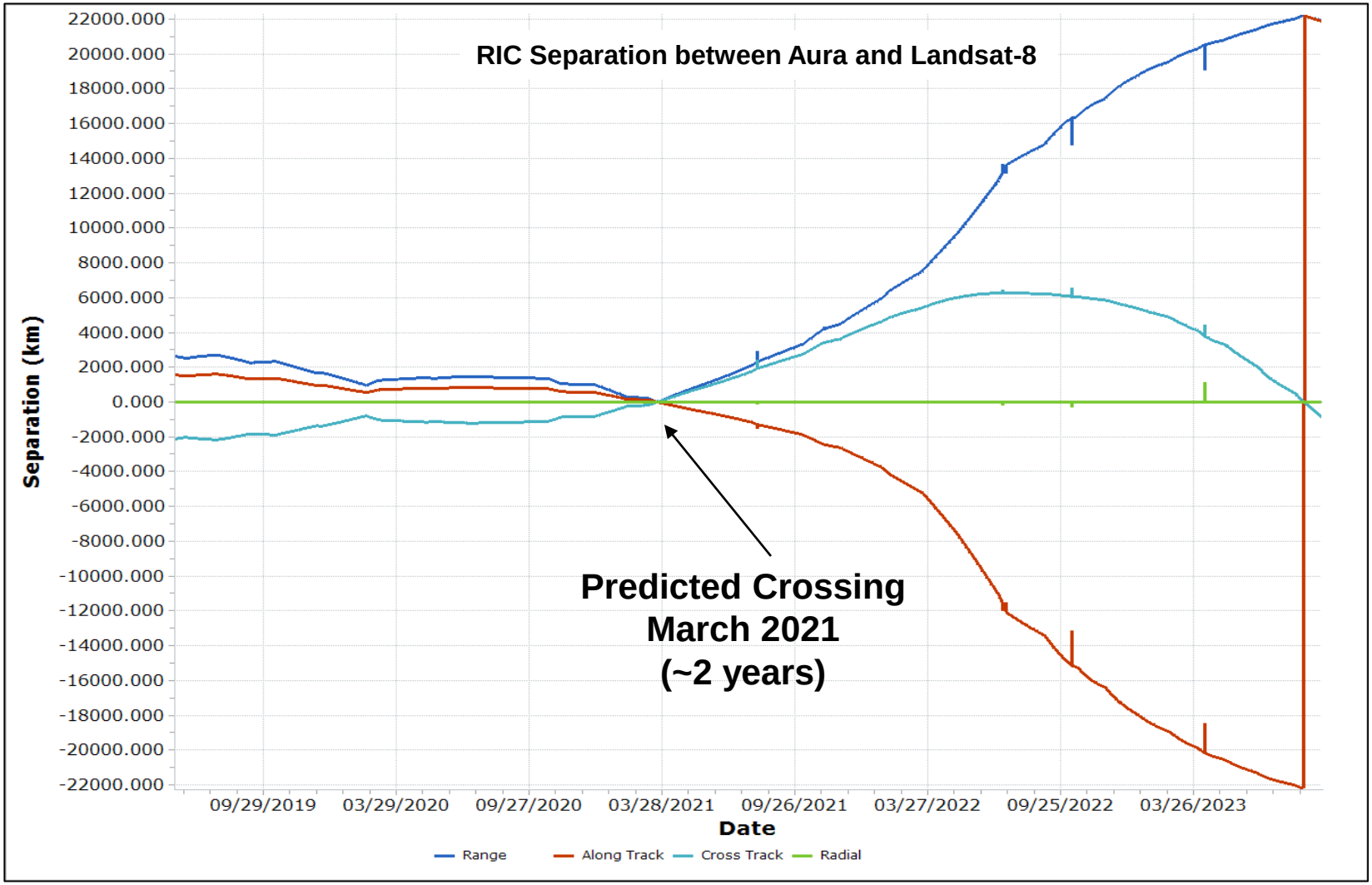

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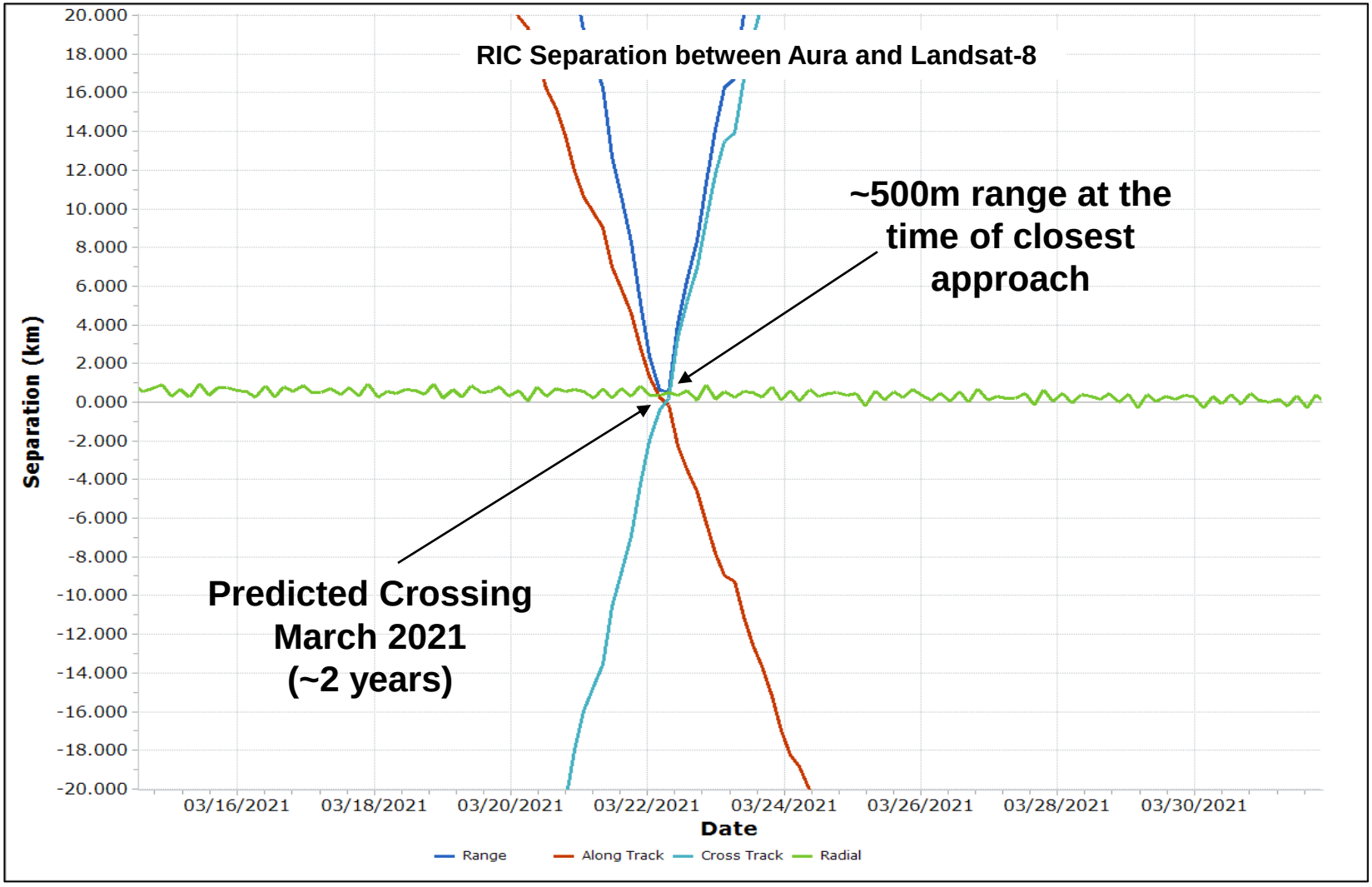
(Alternate Plan)



Questions

Backup Slides

Abbreviations / Acronyms List

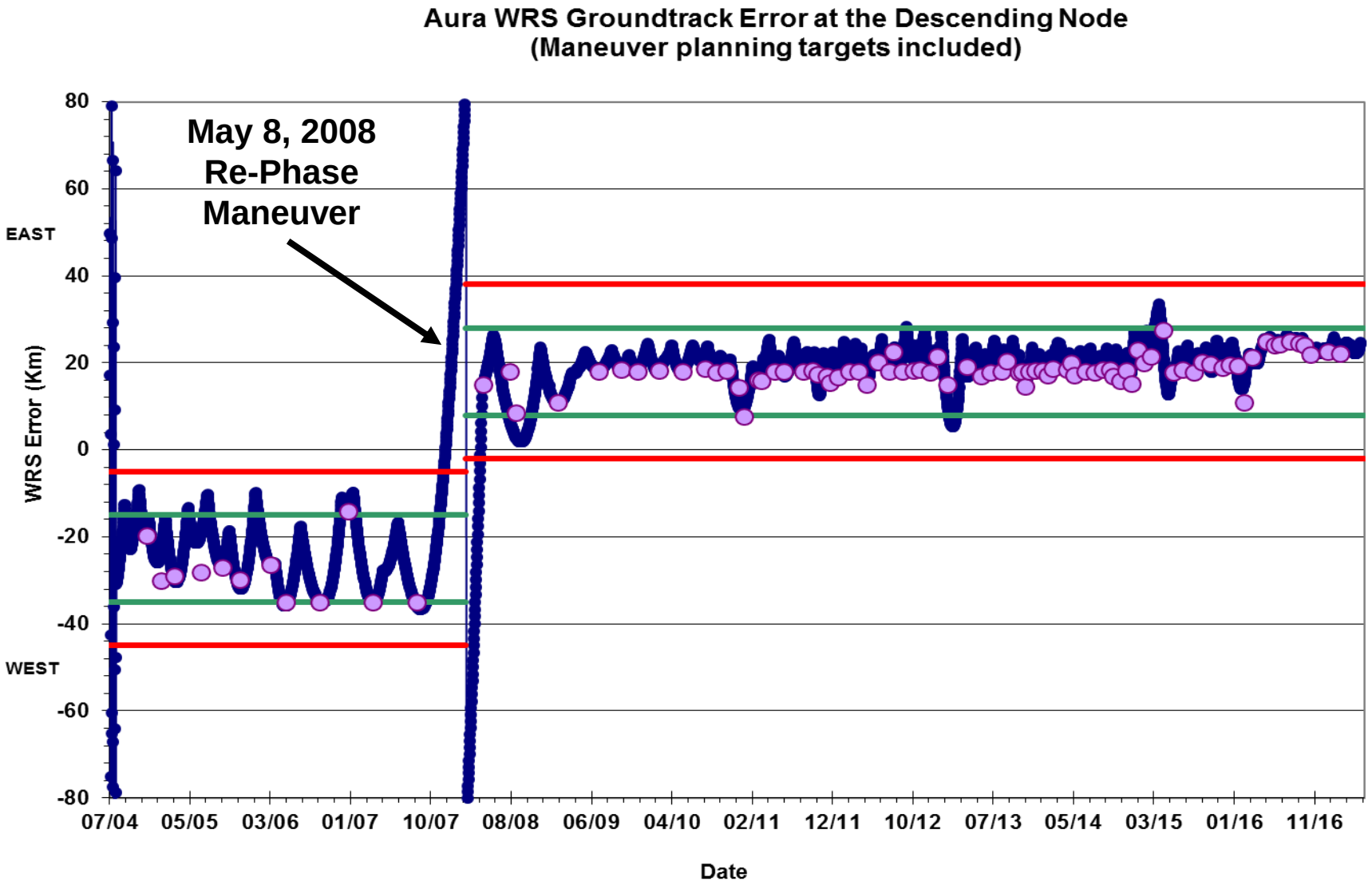
DAS –	Debris Assessment Software
DMUM –	Drag Make-up Maneuver
ESA –	European Space Agency
FDS –	Flight Dynamics System
GTE –	Ground Track Error
IAM –	Inclination Adjustment Maneuver
kg -	kilogram
km –	kilometer
KNMI –	Royal Netherlands Meterological Institute
LS -	Landsat
MLS –	Microwave Limb Sounder
MLT –	Mean Local Time
MLTAN –	Mean Local Time of Ascending Node
NASA –	National Aeronautics & Space Administration
NGAS –	Northrop Grumman Aerospace Systems
OMI –	Ozone Monitoring Instrument
SMA –	Semi-Major Axis
WRS –	World Reference System

Debris Assessment Software
(Updated December 2016)

- **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 2.0.2)**
- **DAS requires several inputs describing the spacecraft's mission:**
  - Start apogee – Average Height (~691 km, at constellation exit)
  - Spacecraft dry mass (2796.546 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**

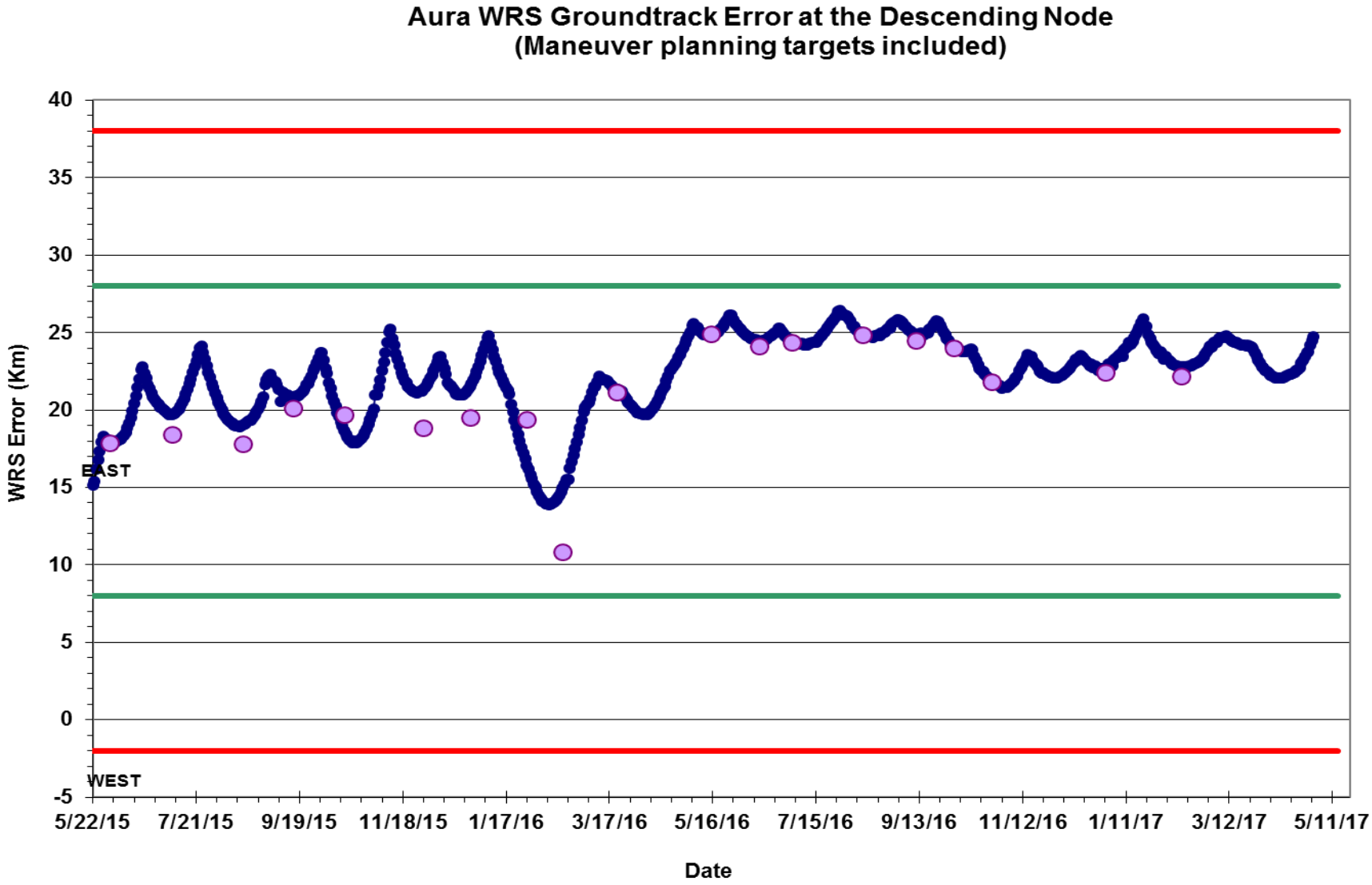
WRS Ground Track Error (GTE)

(As of May 1, 2017)



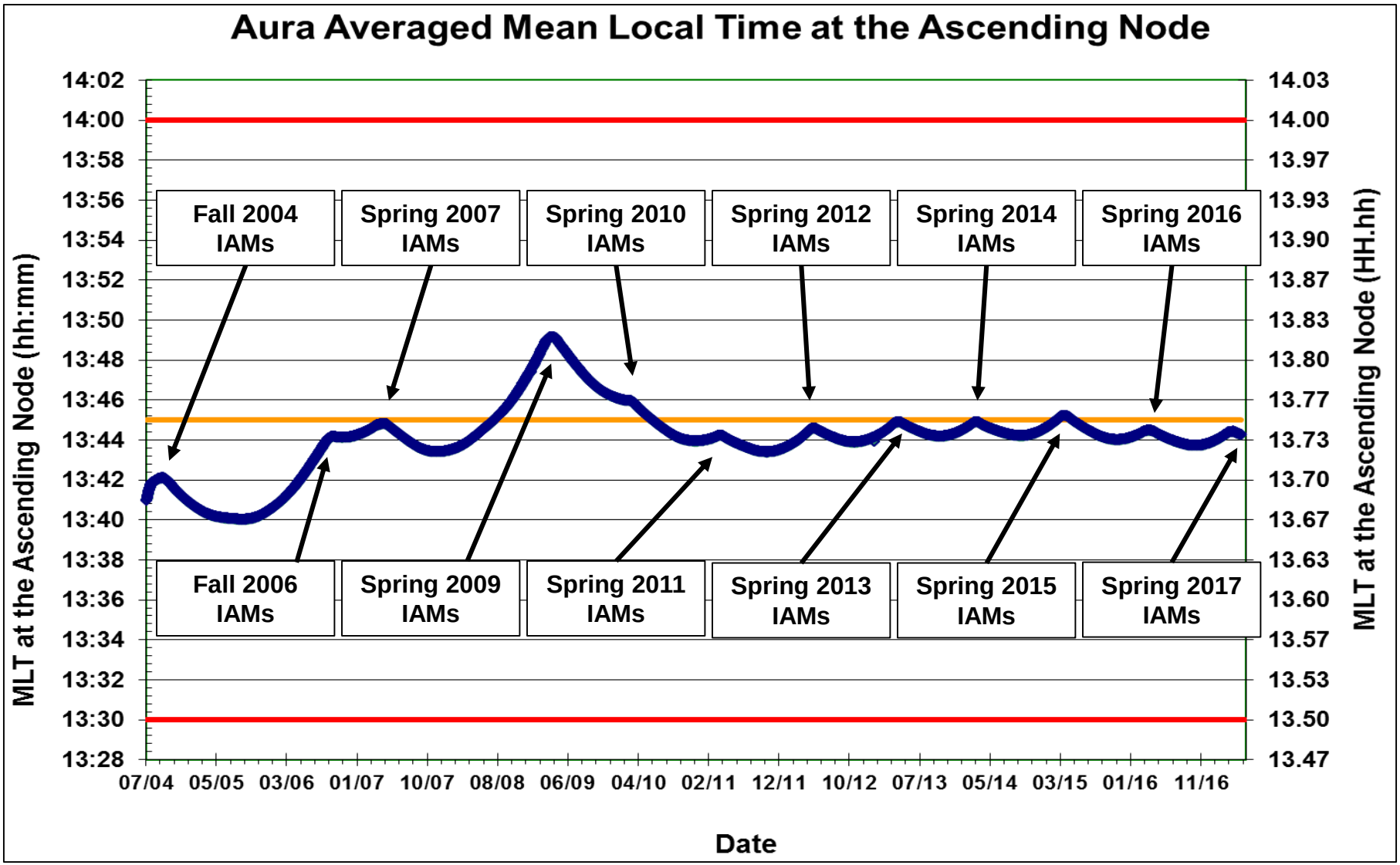
WRS Ground Track Error (GTE)

(As of May 1, 2017) Past 18+ months



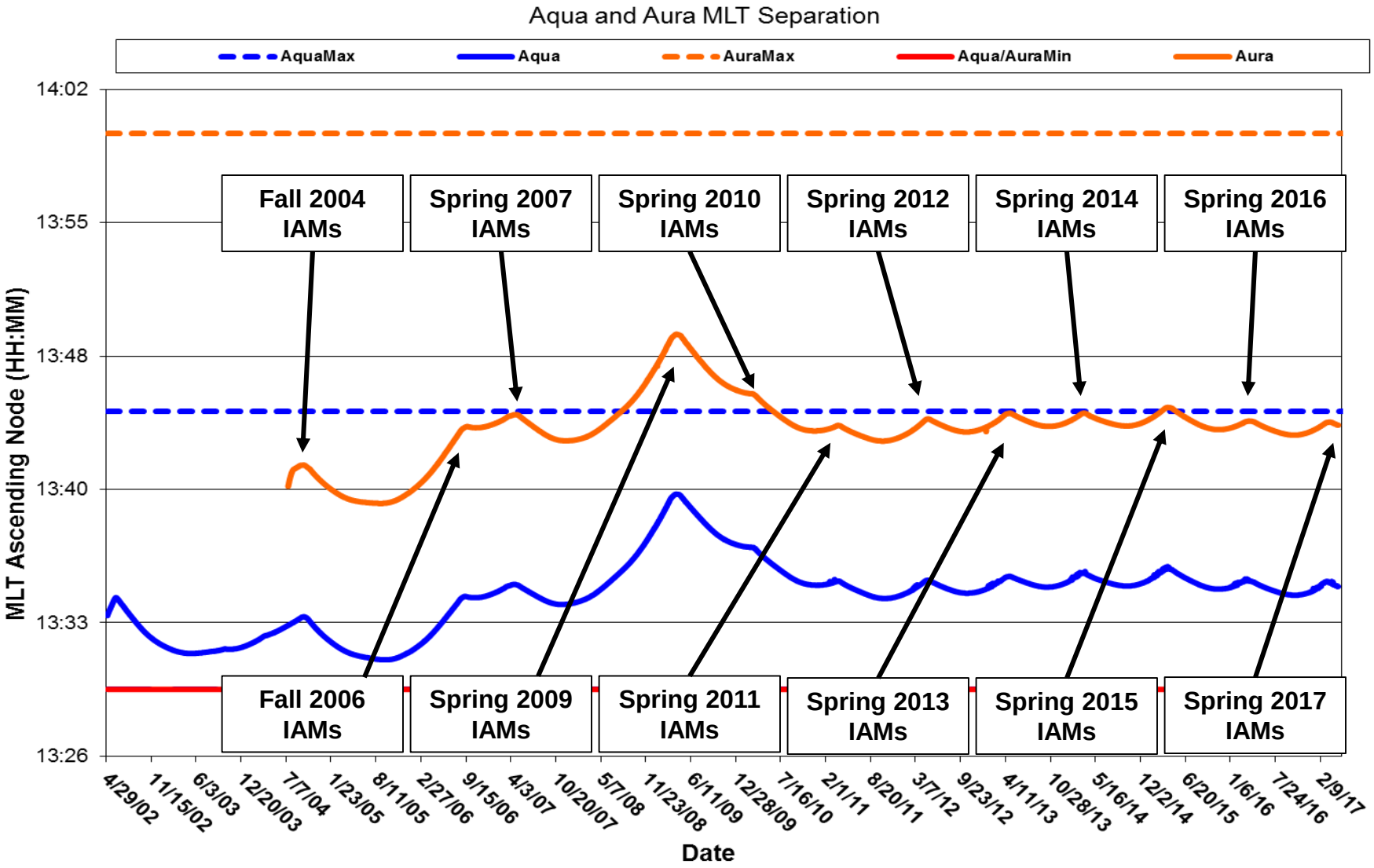
Aura Averaged MLT @ Ascending Node

(As of May 1, 2017)



Aqua/Aura Mean Local Time (MLT)

@ Ascending Node (as of May 1, 2017)

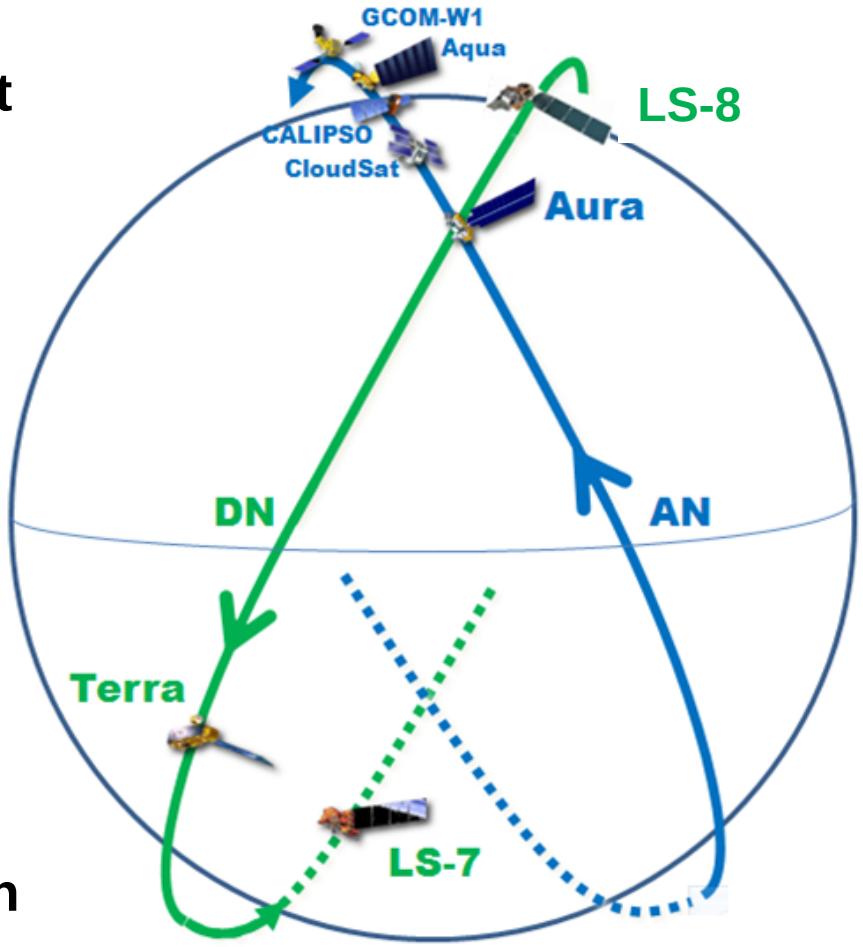


Aura and Landsat-8 (LS-8)
Orbit Phasing

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

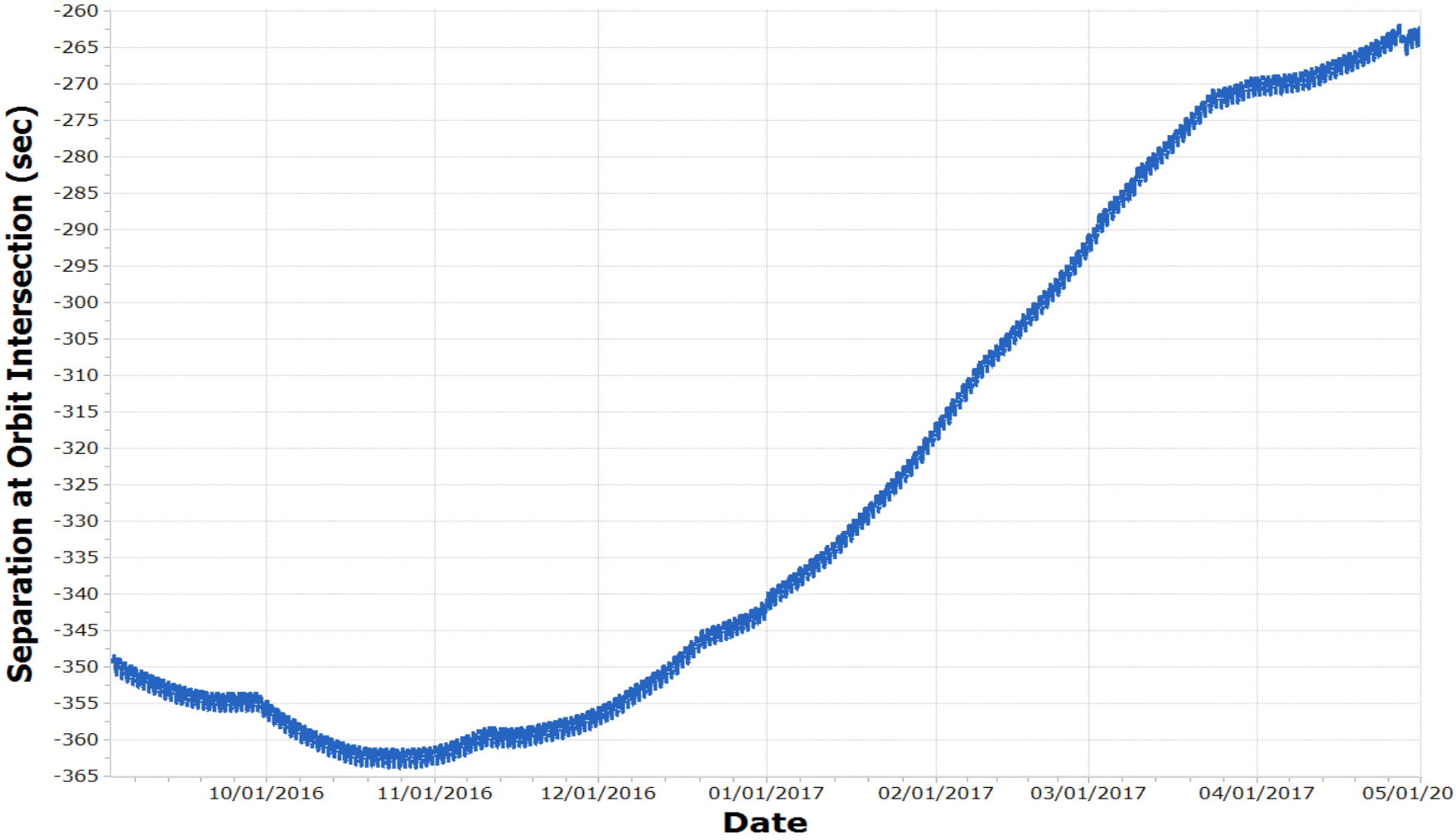
Typically 265 – 365 seconds

Terra ~ 30 min behind LS-7



1 Orbit = ~ 100 minutes

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

LS-8/Aura Phasing at Poles

@ Northern Intersection Point (as of May 1, 2016)