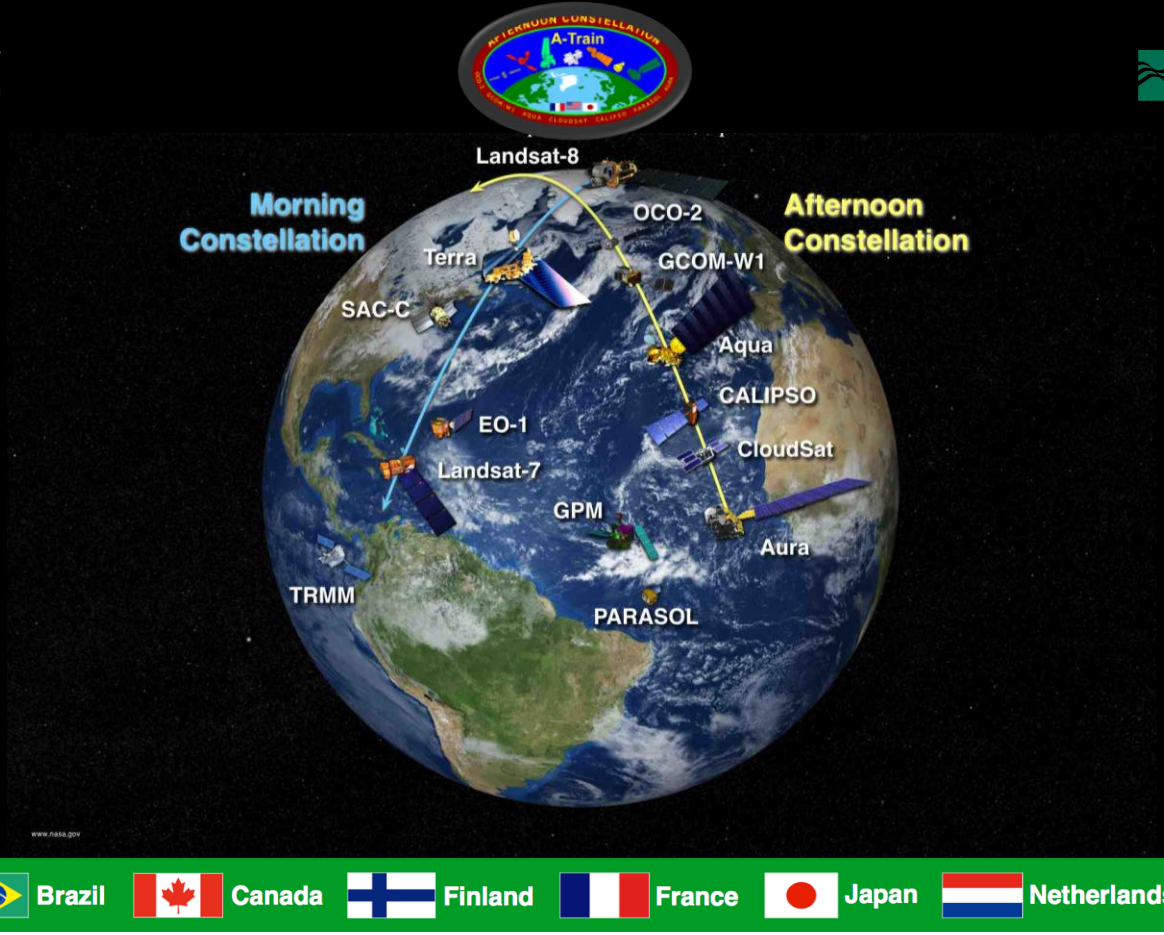

United States Brazil Canada Finland France Japan Netherlands United Kingdom

International Earth Science Constellation Mission Operations Working Group

December 6 - 8, 2017

Aqua vs TanSat: A Long-Term Analysis

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Agenda

- Background
- Assumptions
- Solar Flux Predictions
- Frozen Orbit Comparison
- Six-year Comparison
- Phasing Over next 6 Years
- Orbit Element Comparison for Next Two Predicted Crossings
  - Feb 22 2018
  - Aug 04 2018
- Mean Local Time (MLT) Crossing
- Multiple Drag Profiles for Next Two Predicted Crossings
  - Semi-Major Axis
  - Radial/In-track/Cross-track Separation

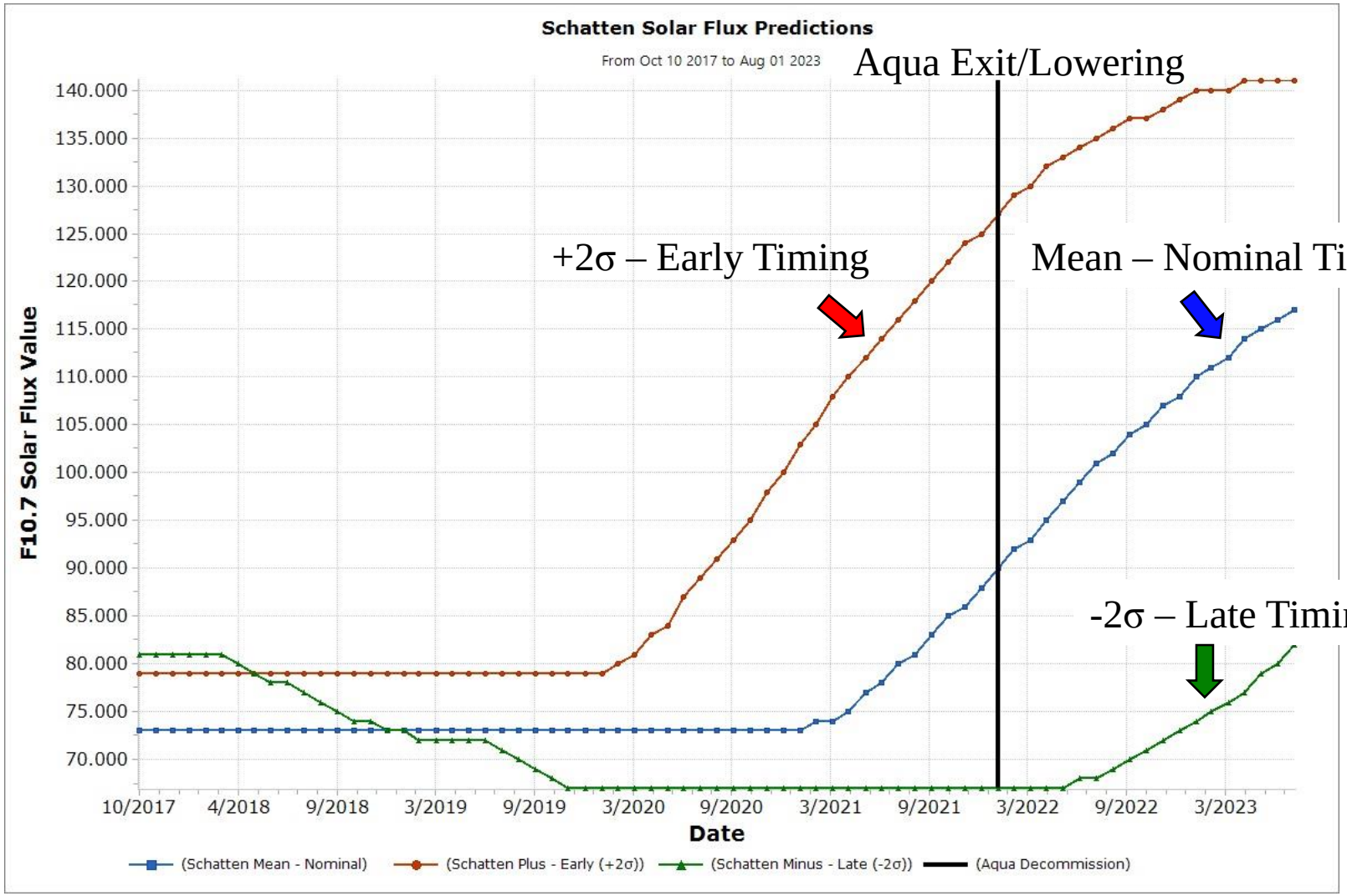
Background

- An analysis comparing TanSat and Aqua
- TanSat Ephemerides
  - Generated through an existing mission plan by parsing state file
    - State file from Oct 10 2017
    - Propagated out for 7 years
    - Three different drag profiles
  - Timespan: Oct 10 2017 to Oct 09 2024
- Aqua Lifetime Ephemeris (from the November 3rd 2017 final Aqua lifetime decommissioning report)
  - Timespan: Mar 30 2017 to Apr 01 2023
    - Note: Aqua exit/lowering date is Feb 01 2022
  - Burns per Inclination Adjust Maneuver (IAM) Series: 5
  - Burn Duration for all IAMs: 560 sec

Assumptions

- Three Schatten drag profiles used for both satellites in order to create a range of dates and potential geometries for individual crossing
  - Plus 2-σ, Early (+2-σ of uncertainty, early timing for next solar maximum)
  - Mean, Nominal (mean uncertainty with nominal timing for next solar maximum)
  - Minus 2-σ, Late (-2-σ of uncertainty, late timing for next solar maximum)
- Aqua: Nominal lifetime activities
  - Ground Track Error and Mean Local Time maintenance
- TanSat: No maneuvers
- Comparison Span: 6 years

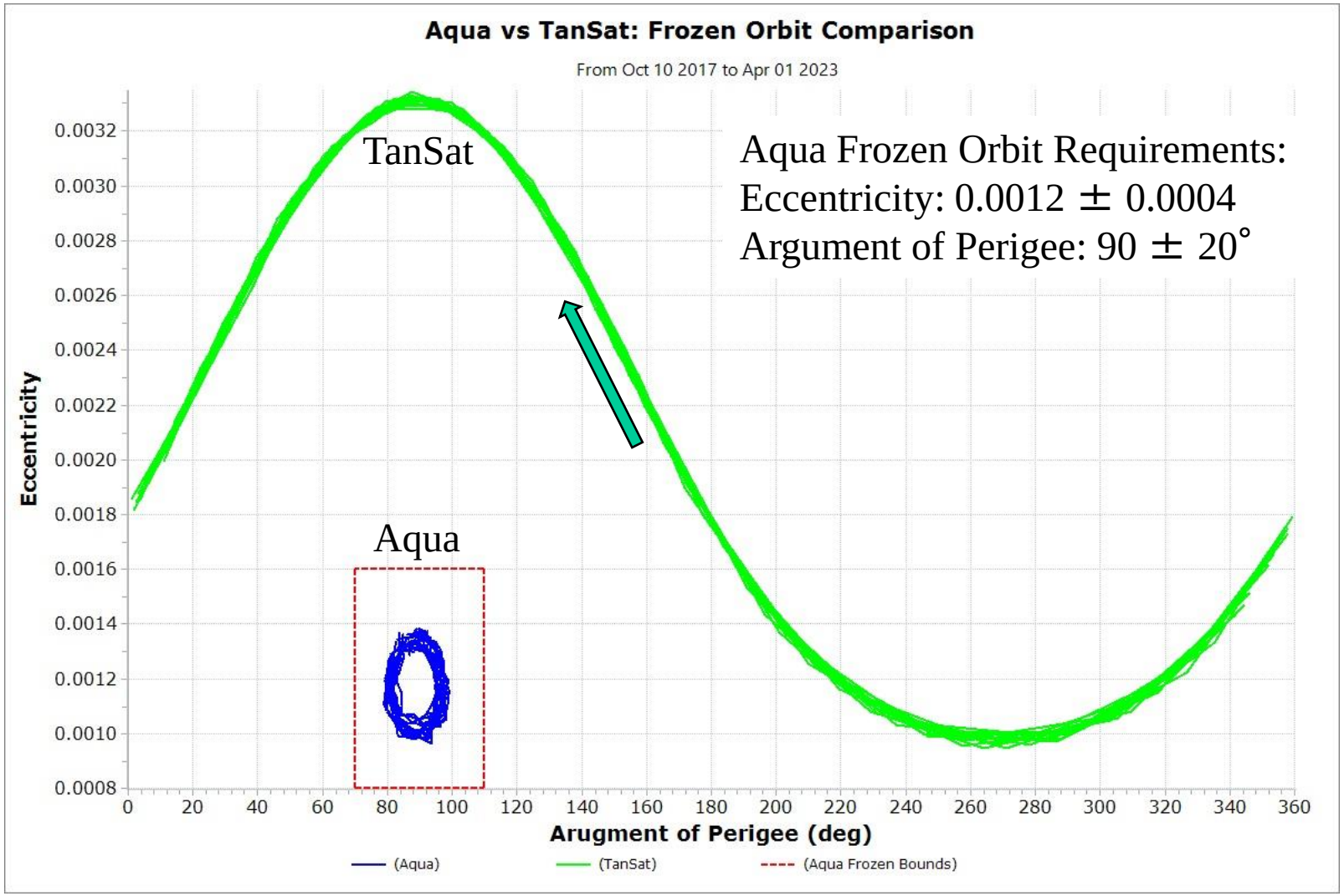
Schatten Drag Predictions



Six - Year Comparison

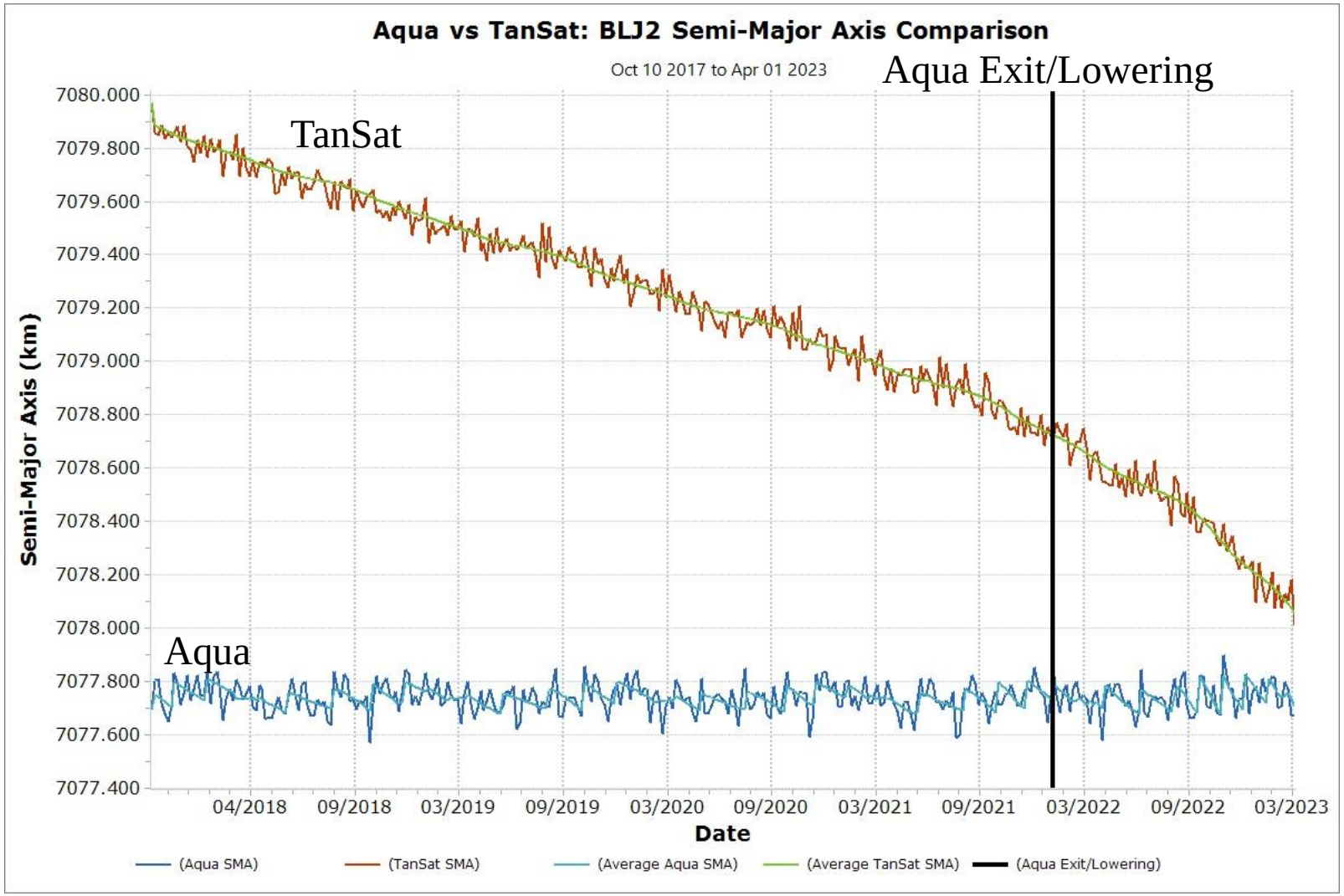
Mean Drag, Nominal Timing

Frozen Orbit Comparison



TanSat Argument of Perigee Period: ~115 days

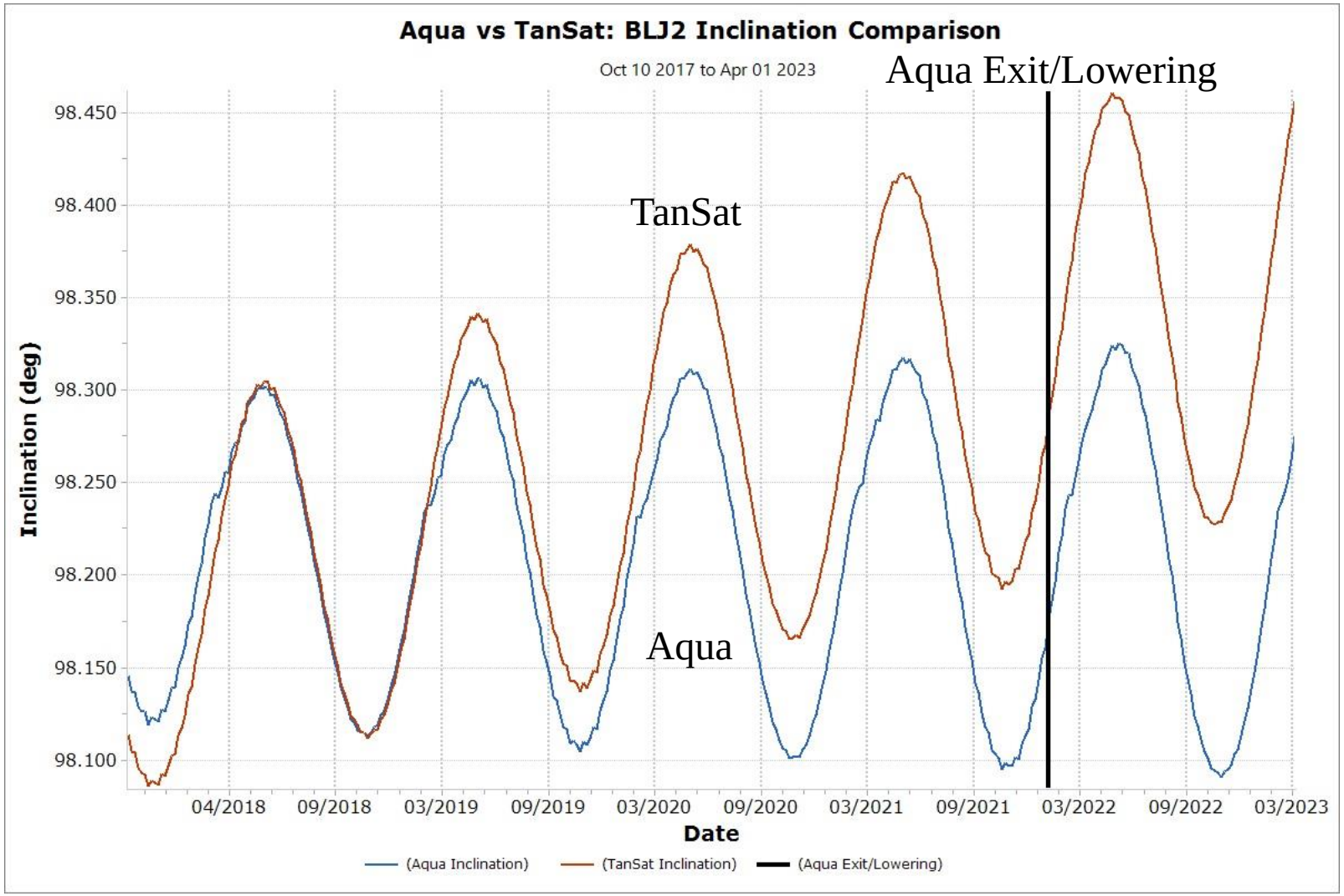
Six-Year Semi-Major Axis



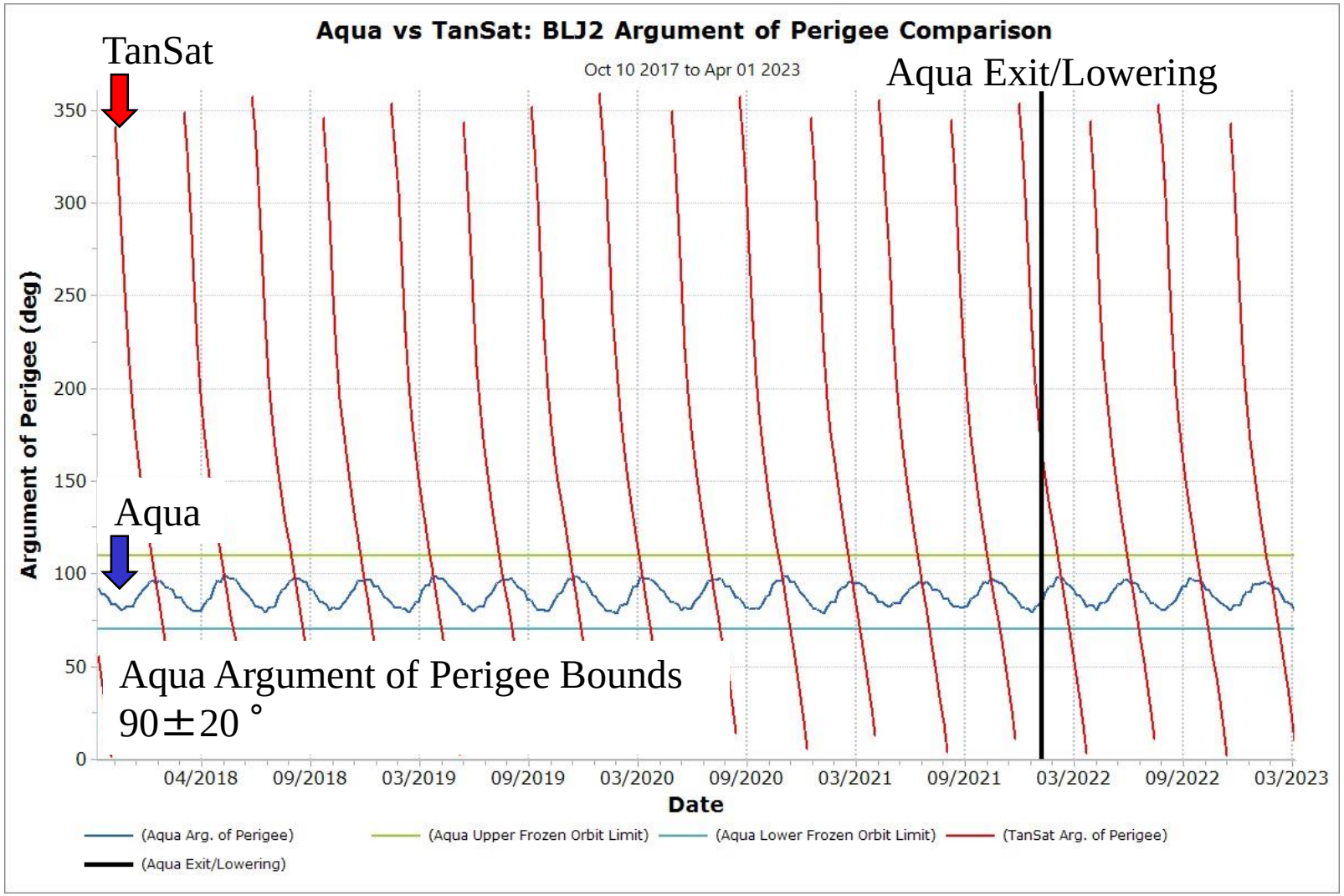
BLJ2 = Brouwer-Lyddane J2

TanSat SMA Decay Rate: 0.9702 m/day

Six-Year Inclination

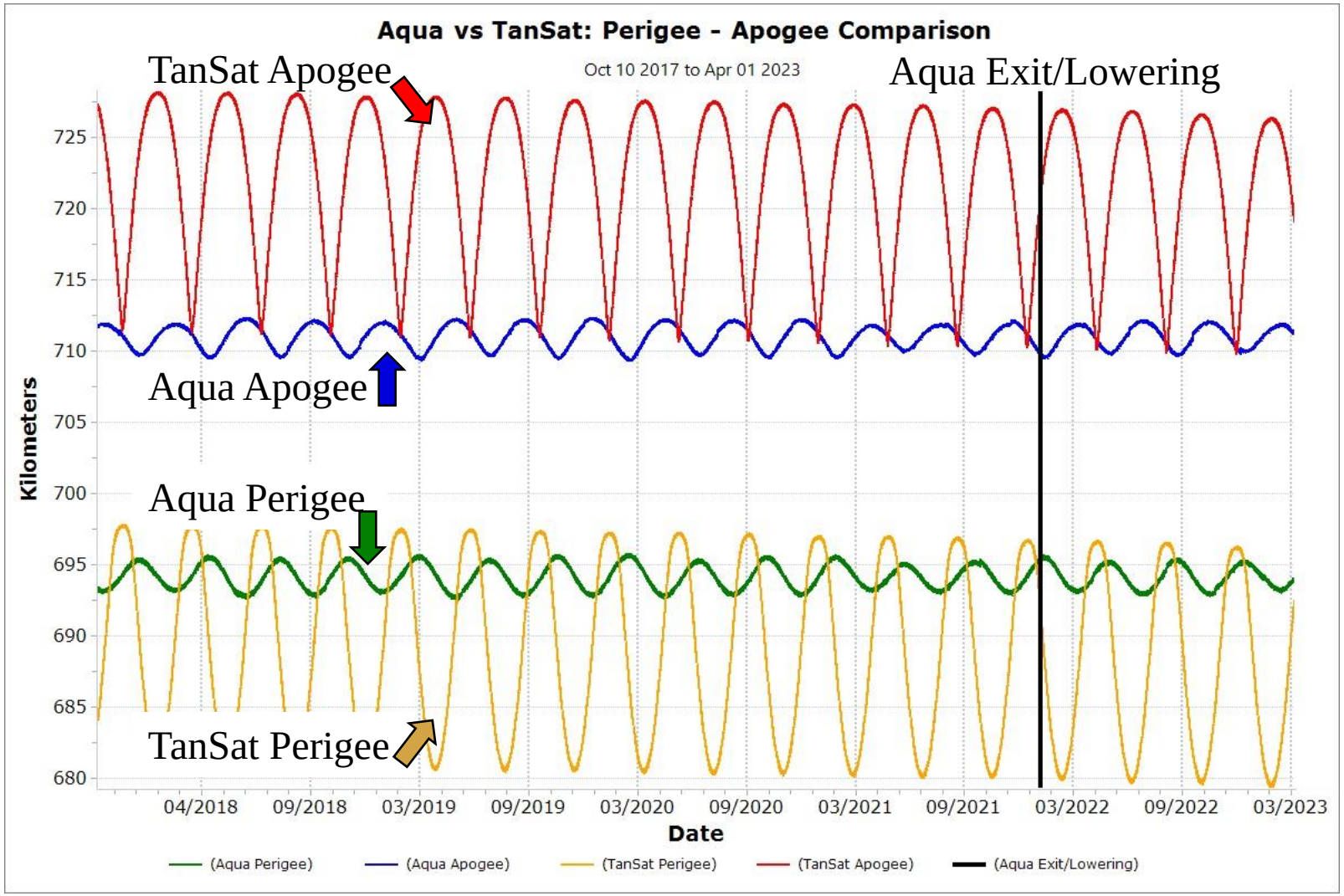


Six-Year Argument of Perigee

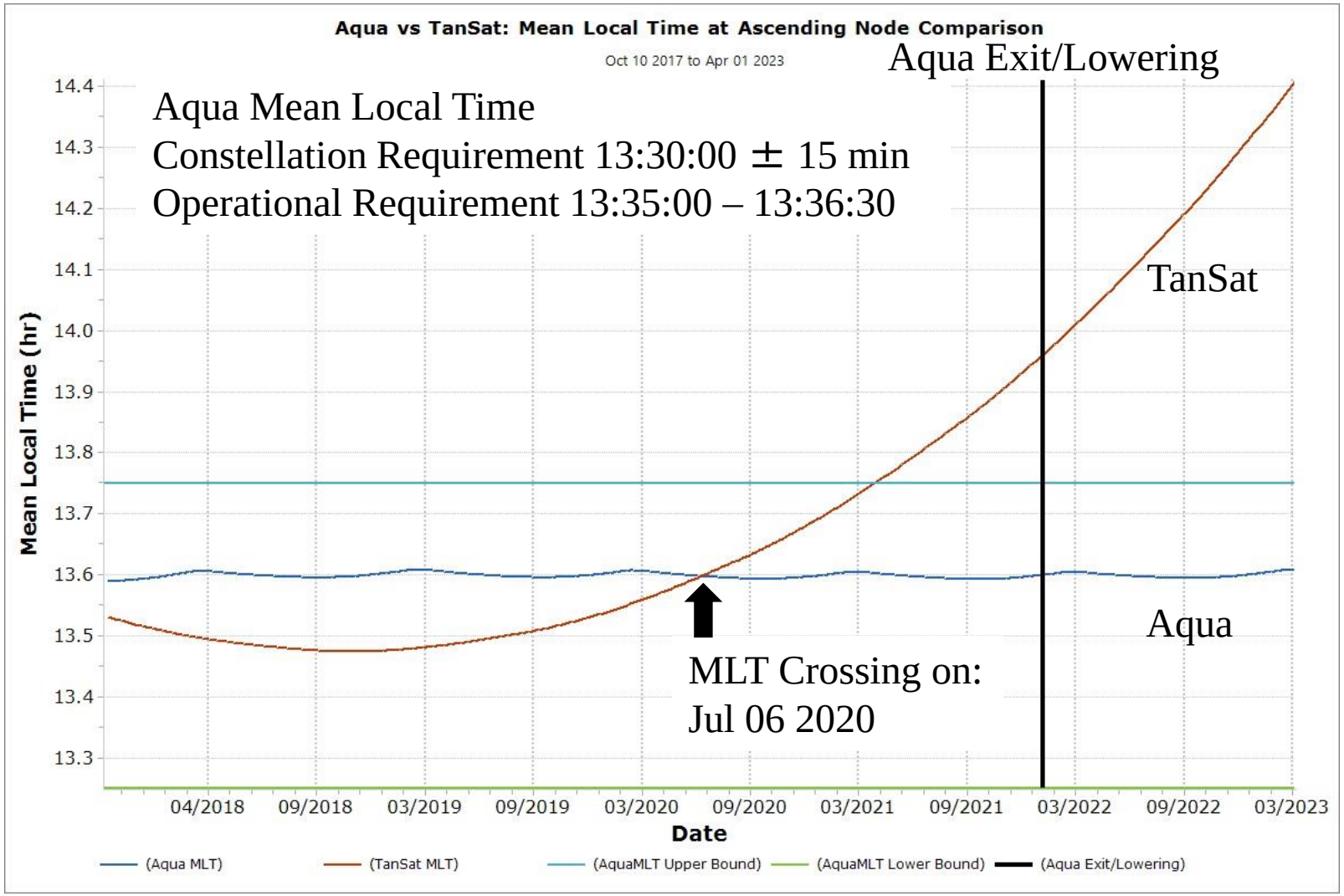


TanSat Argument of Perigee Period: ~115 days

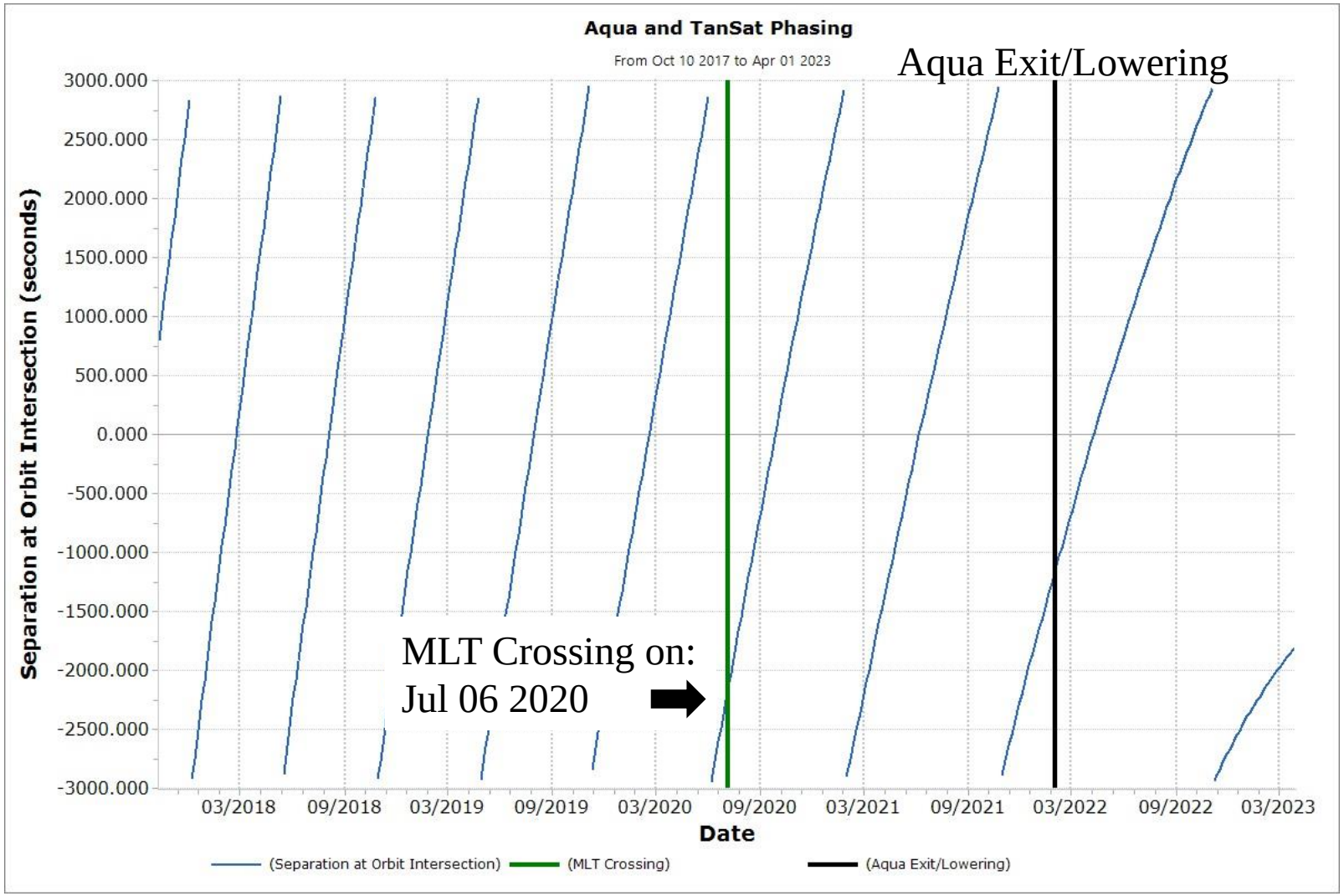
Six-Year Perigee - Apogee



Six-Year Mean Local Time at the Ascending Node



Aqua vs. TanSat: Phasing



Phasing: Predicted Crossings

- Eight total predicted crossings in the analysis span

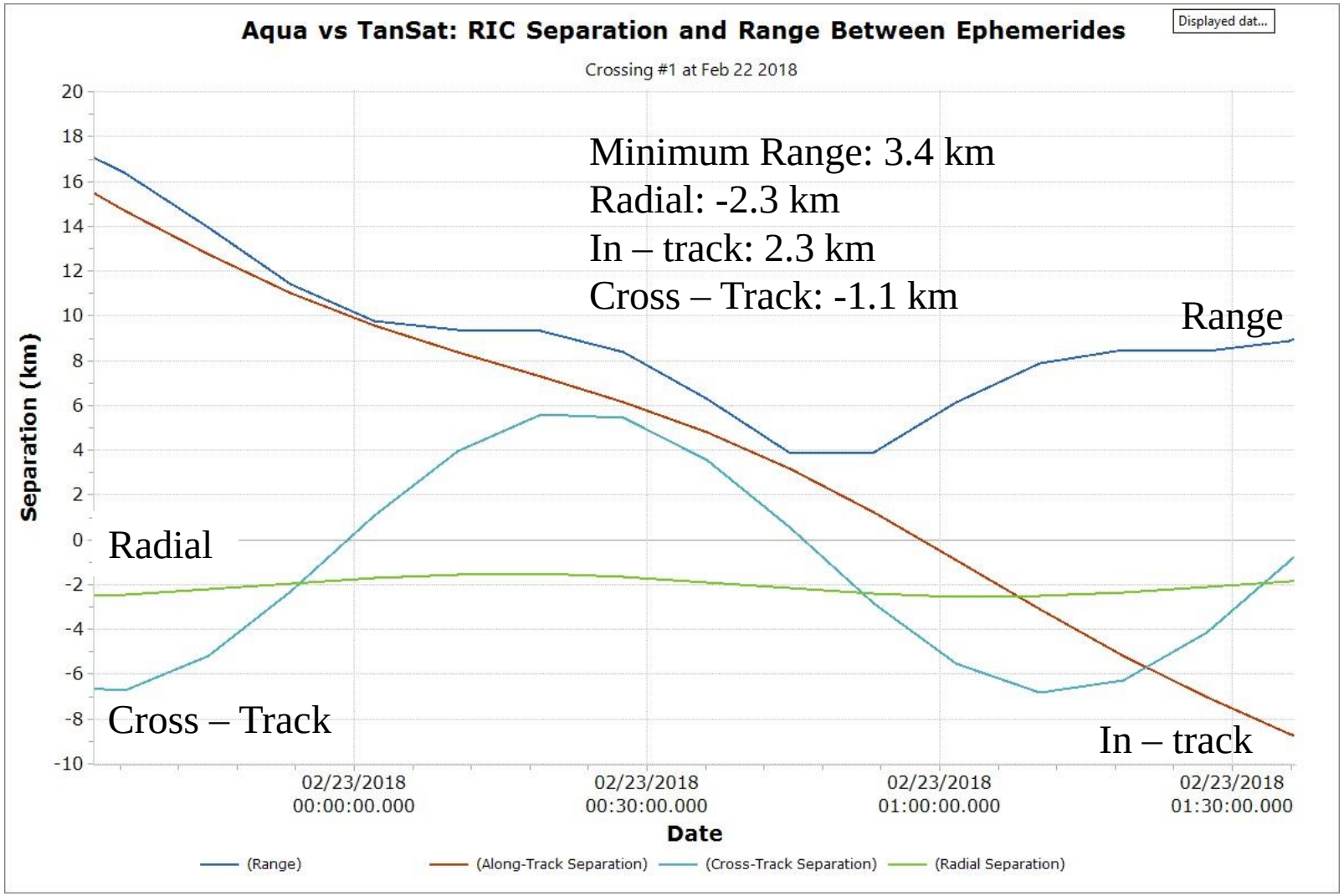
Past Crossings : ■ Future Predicted Crossings: ■

Crossing Epochs	Days Since Last Crossing
April 29 2017	-
Sept 19 2017	144
Feb 22 2018	157
Aug 04 2018	164
Jan 25 2019	175
Jul 30 2019	187
Feb 17 2020	203
Jul 06 2020 (MLT Crossing)	N/A
Sep 26 2020	223
Jun 06 2021	254
Apr 09 2022	308

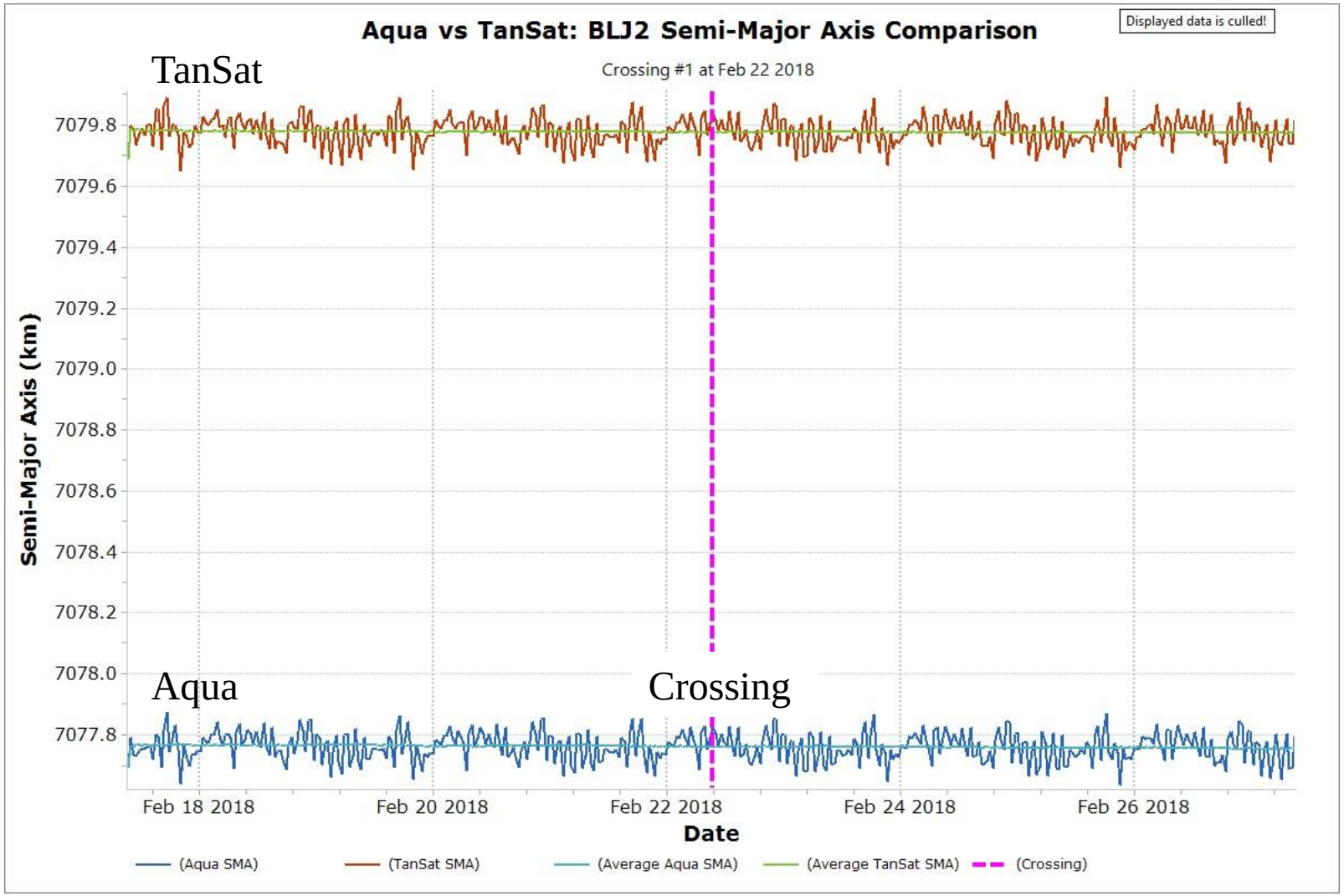
Crossing #1: Feb 22 2018

Mean Drag, Nominal Timing

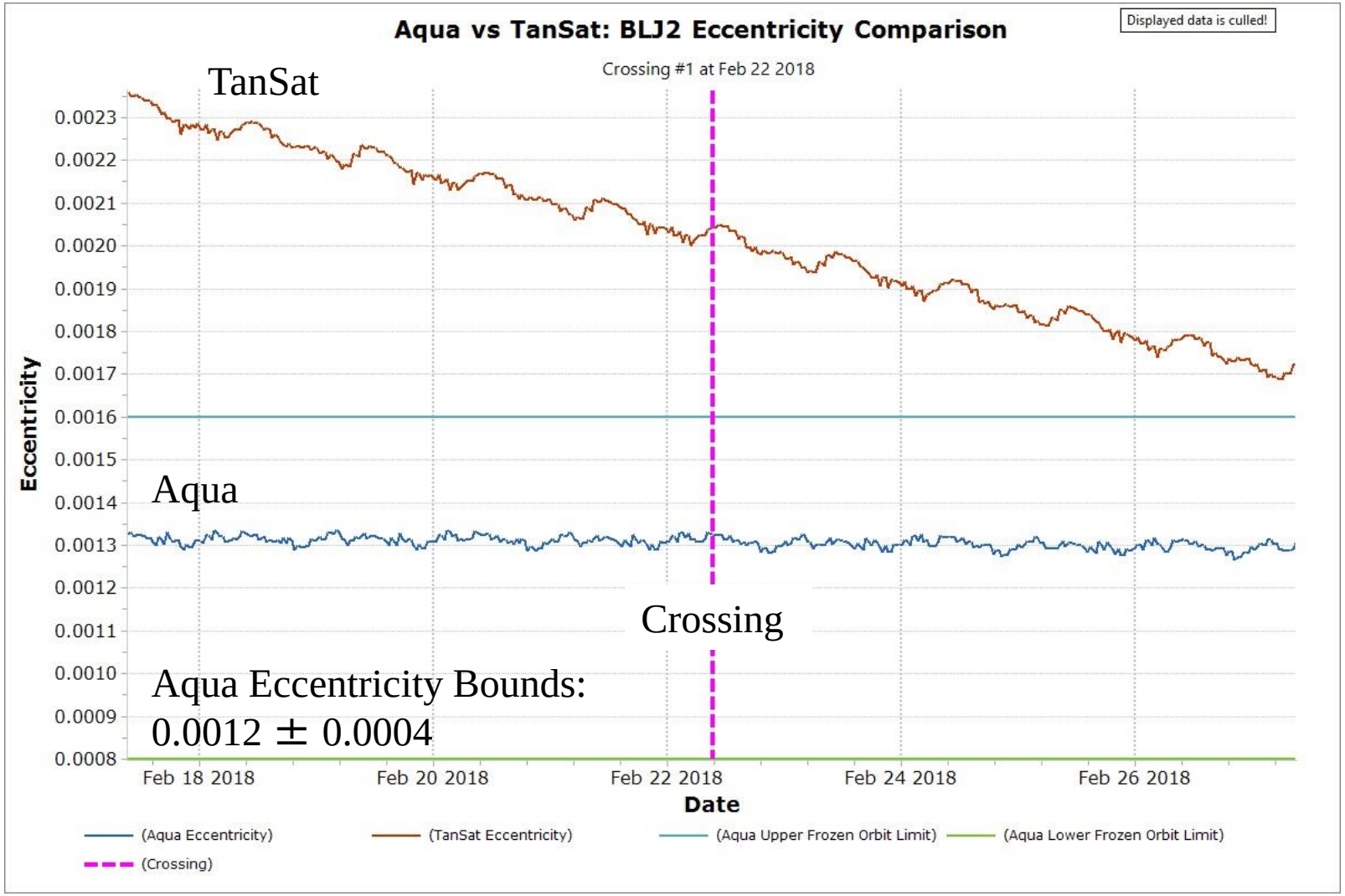
Feb 22 2018 – RIC



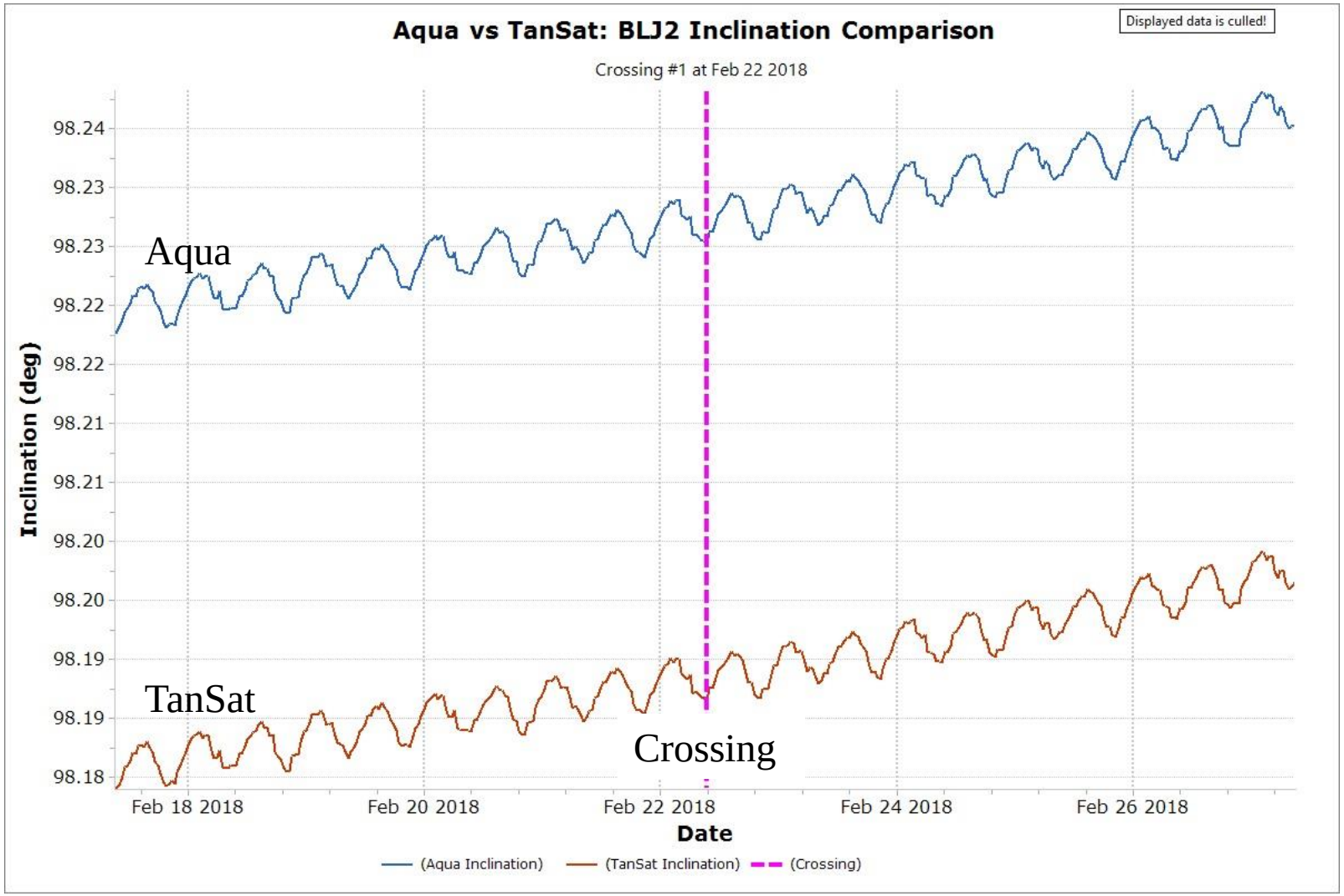
Feb 22 2018 - Semi - Major Axis



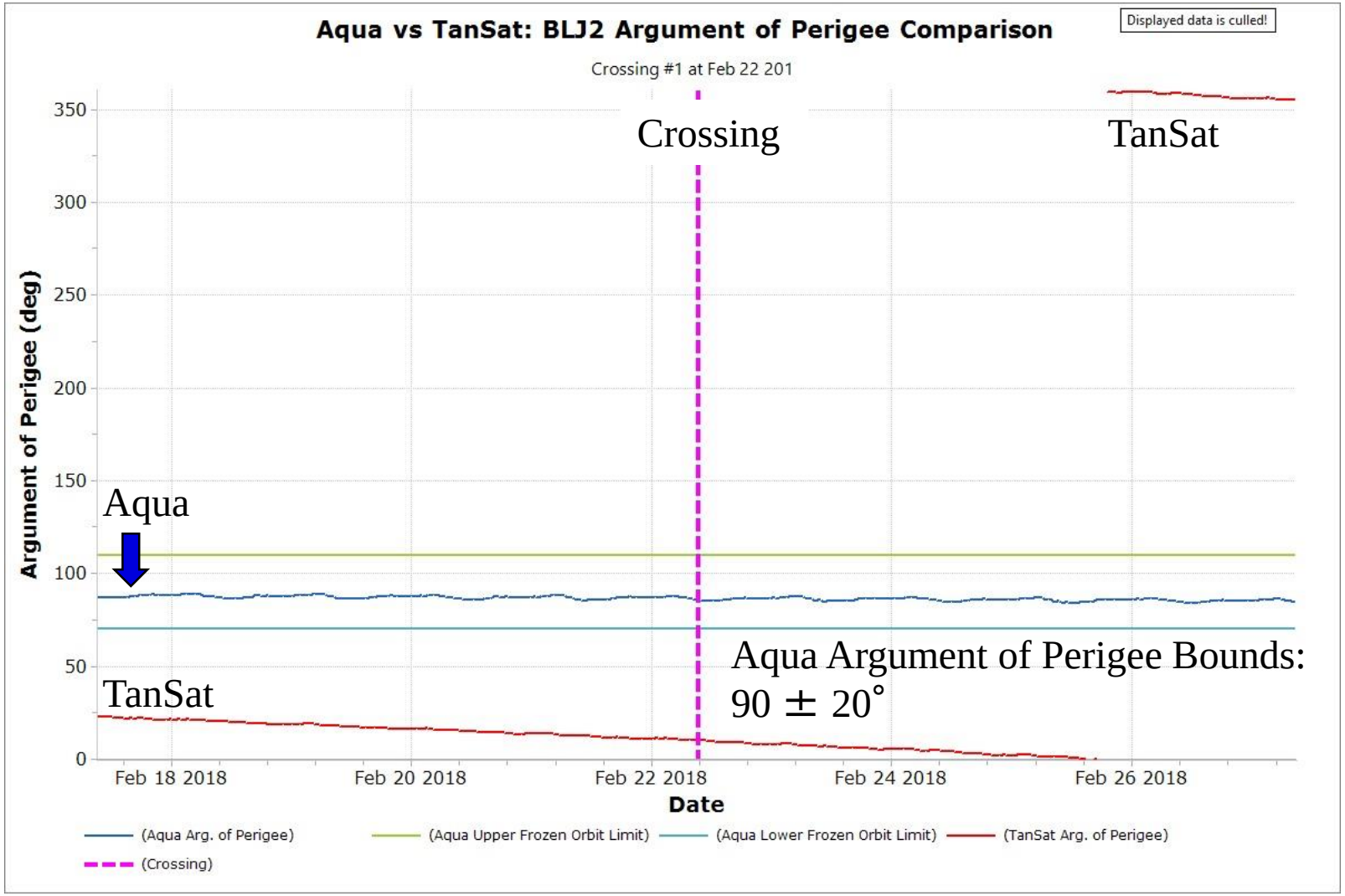
Feb 22 2018 - Eccentricity



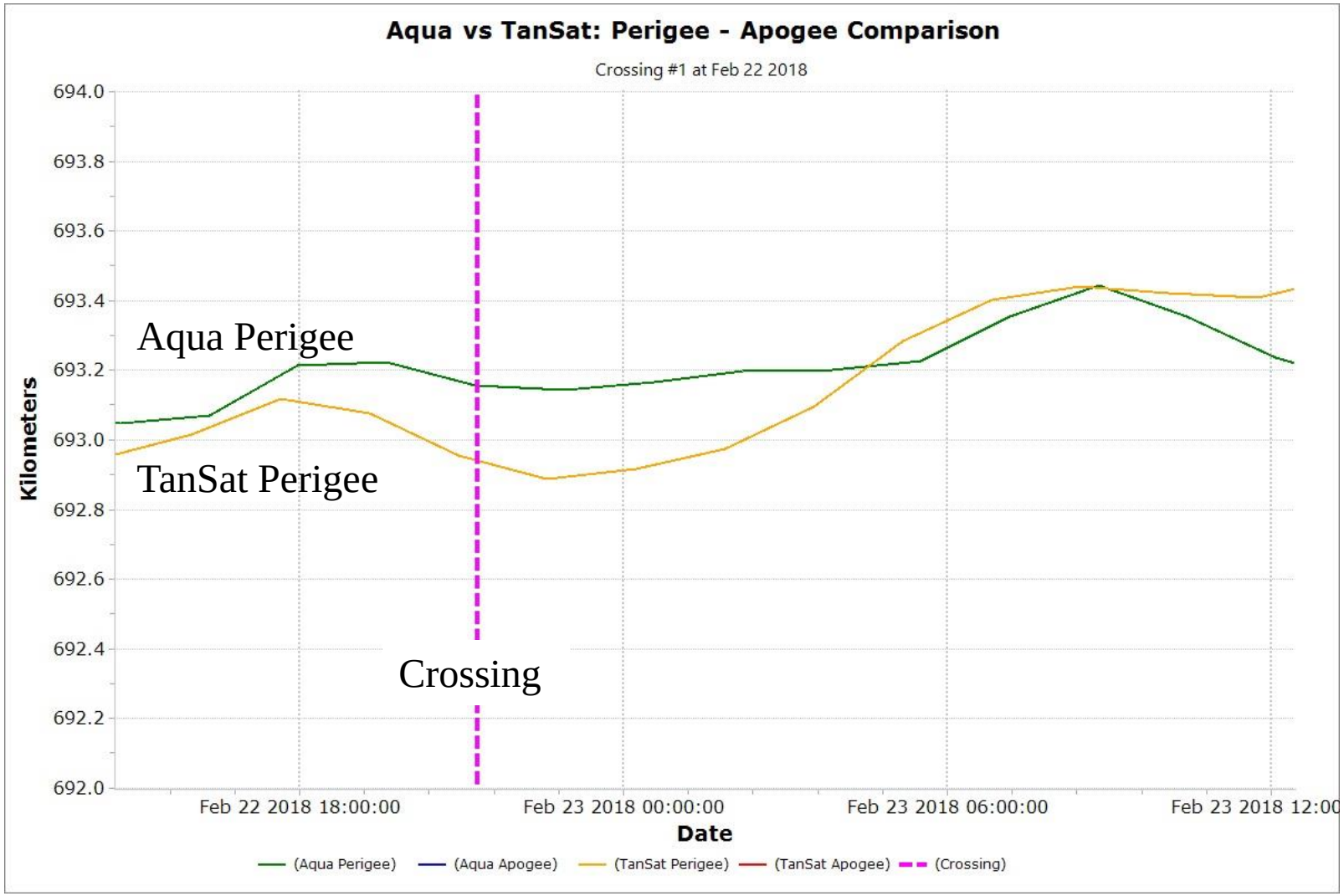
Feb 22 2018 - Inclination



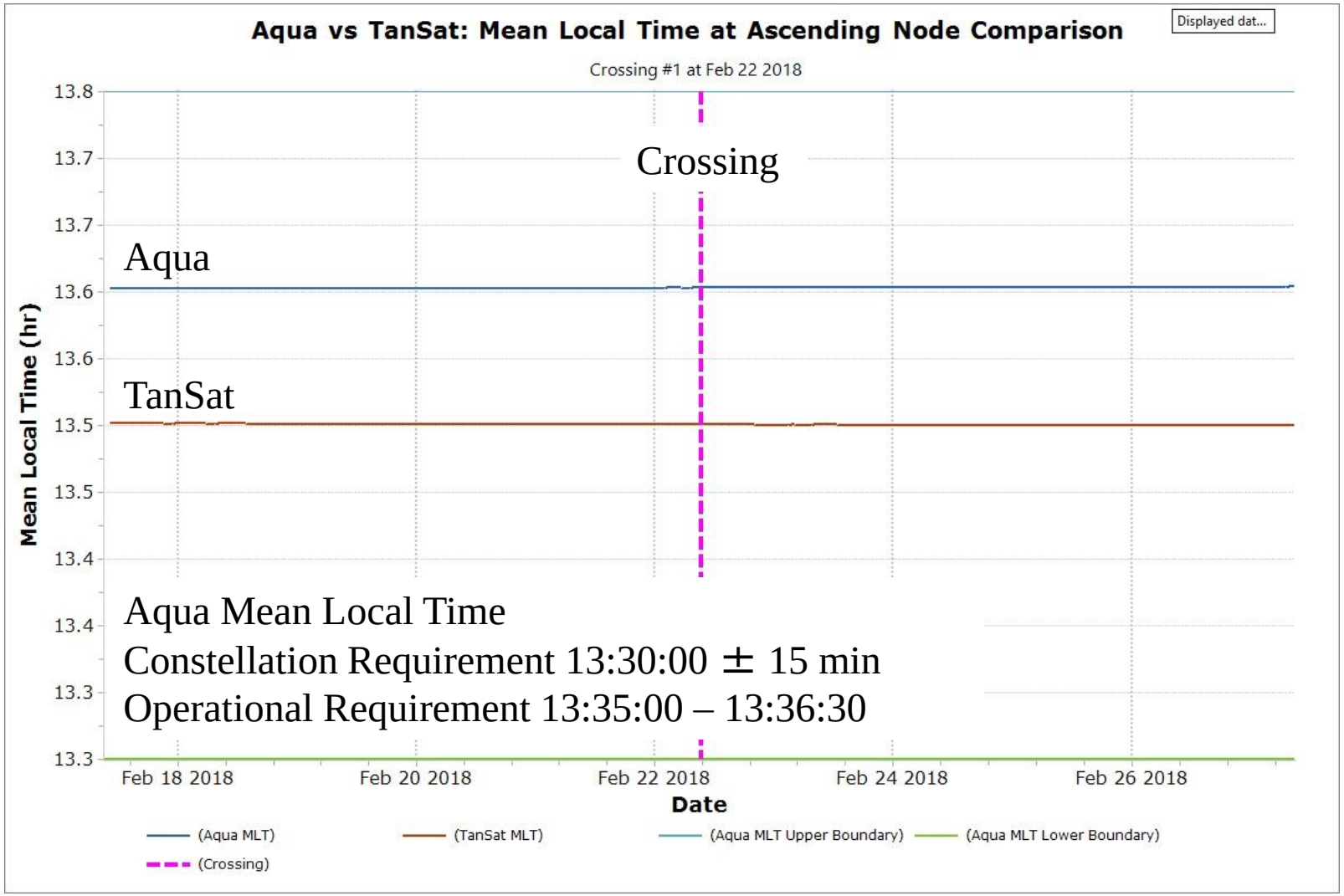
Feb 22 2018 - Argument of Perigee



Feb 22 2018 - Perigee - Apogee



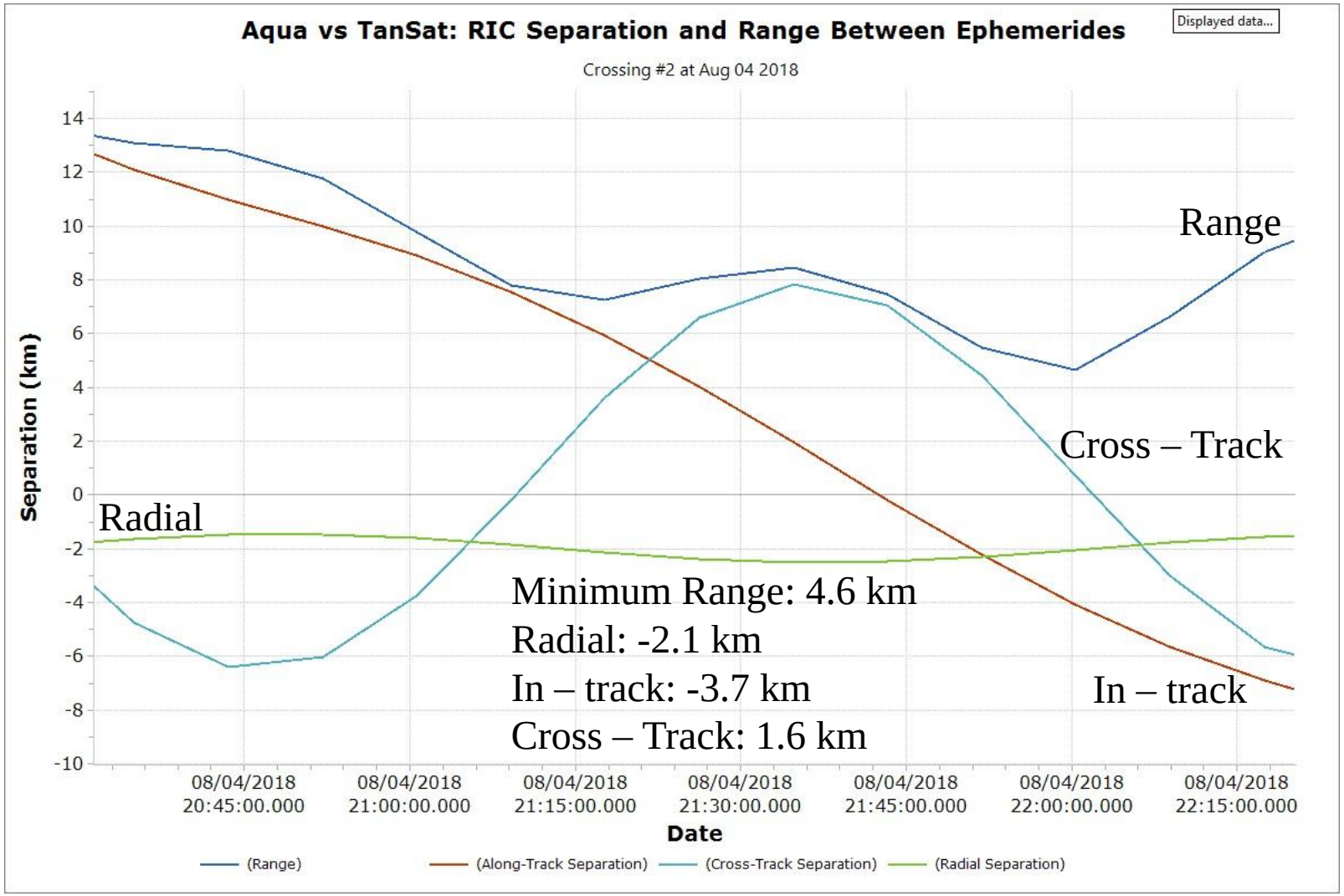
Feb 22 2018 - Mean Local Time at the Ascending Node



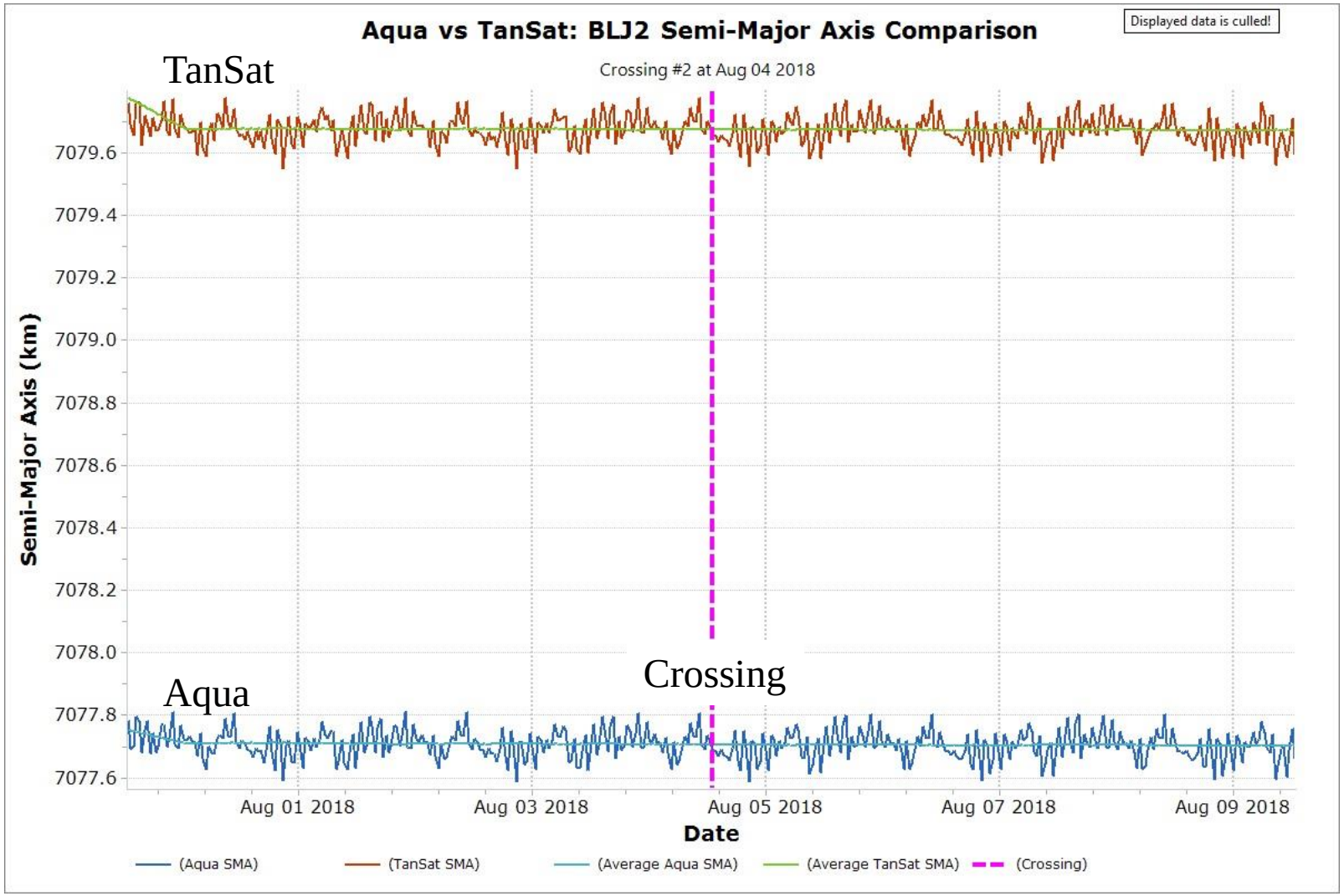
Crossing #2: Aug 04 2018

Mean Drag, Nominal Timing

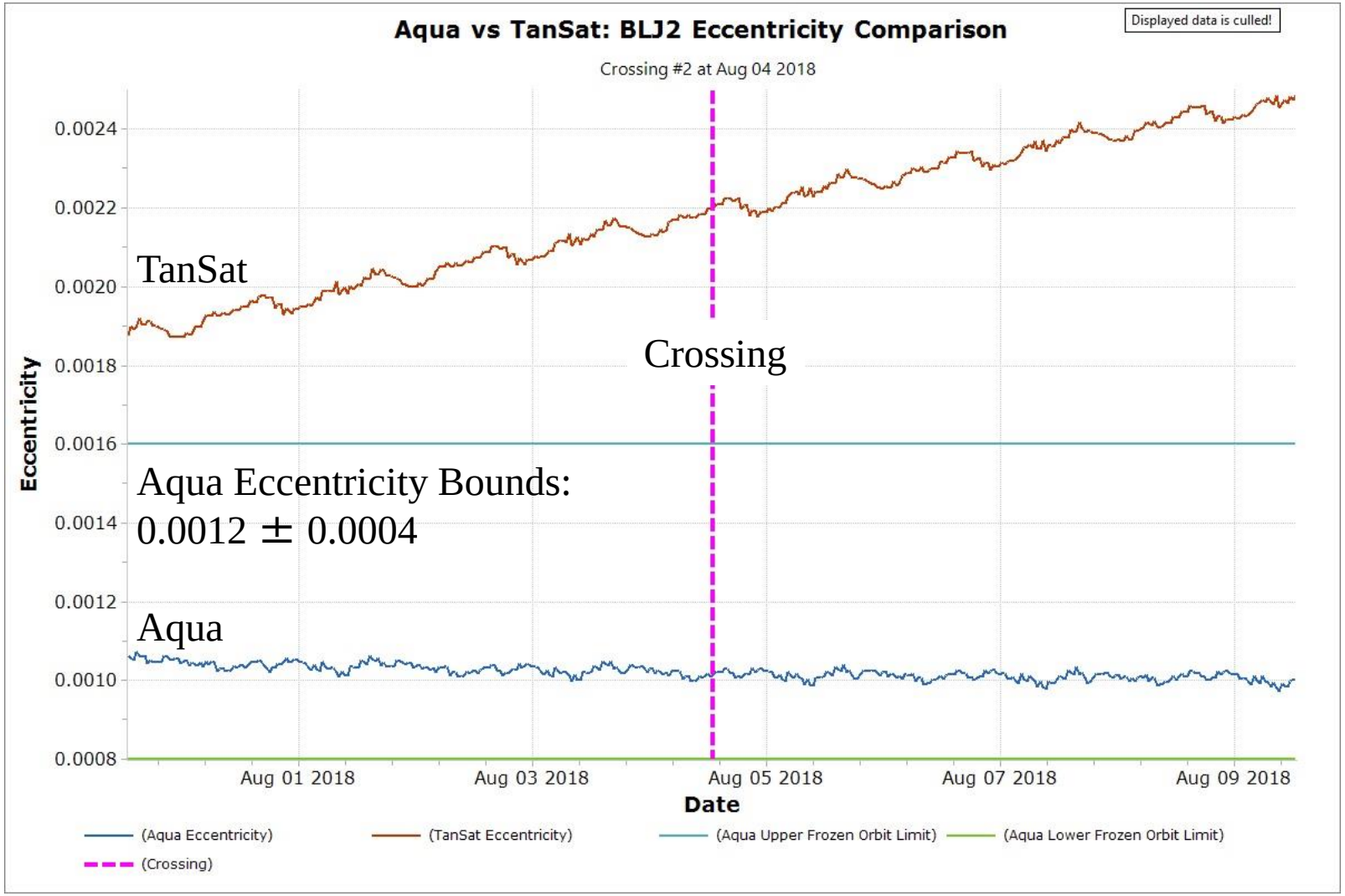
Aug 04 2018 – RIC



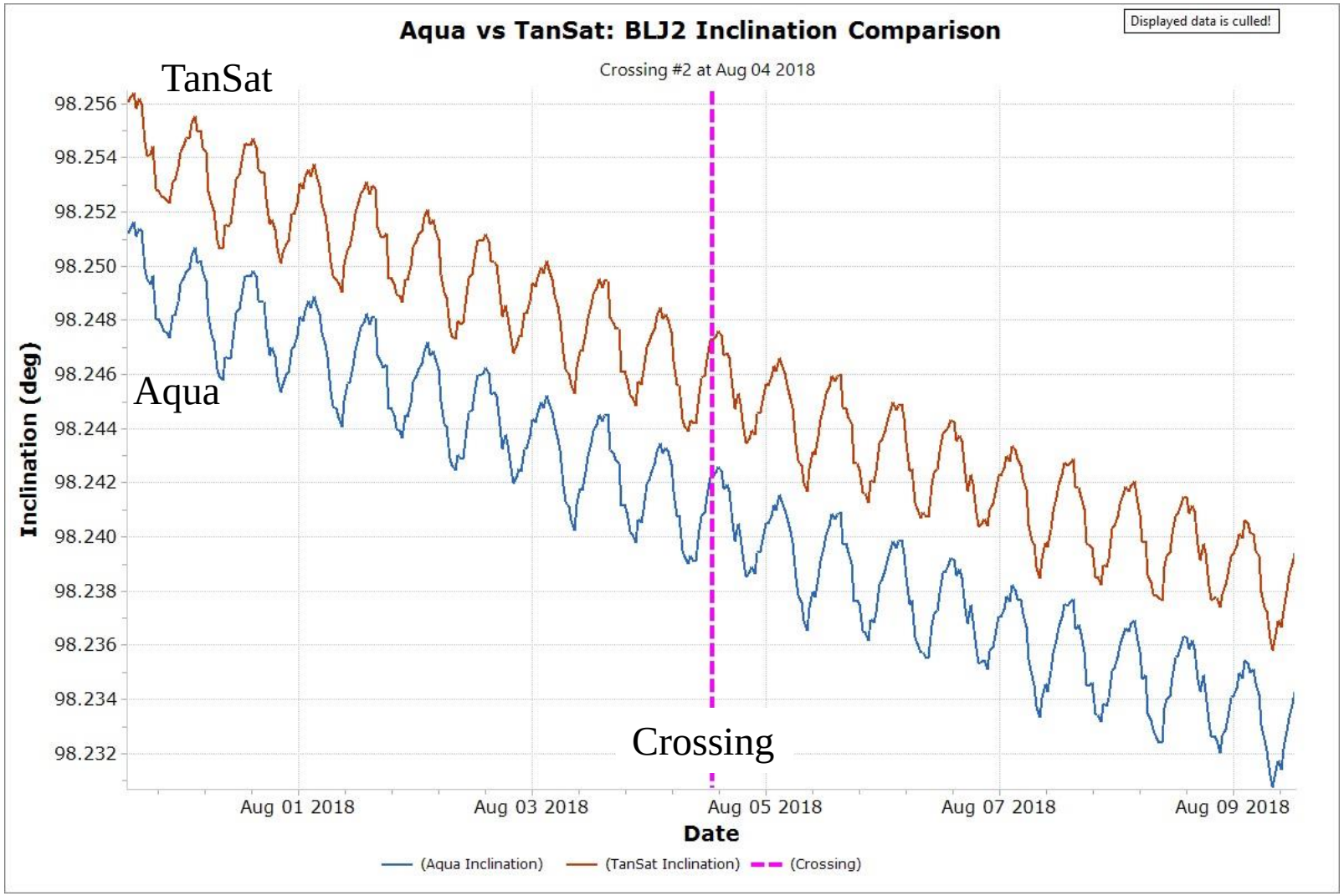
Aug 04 2018 - Semi-Major Axis



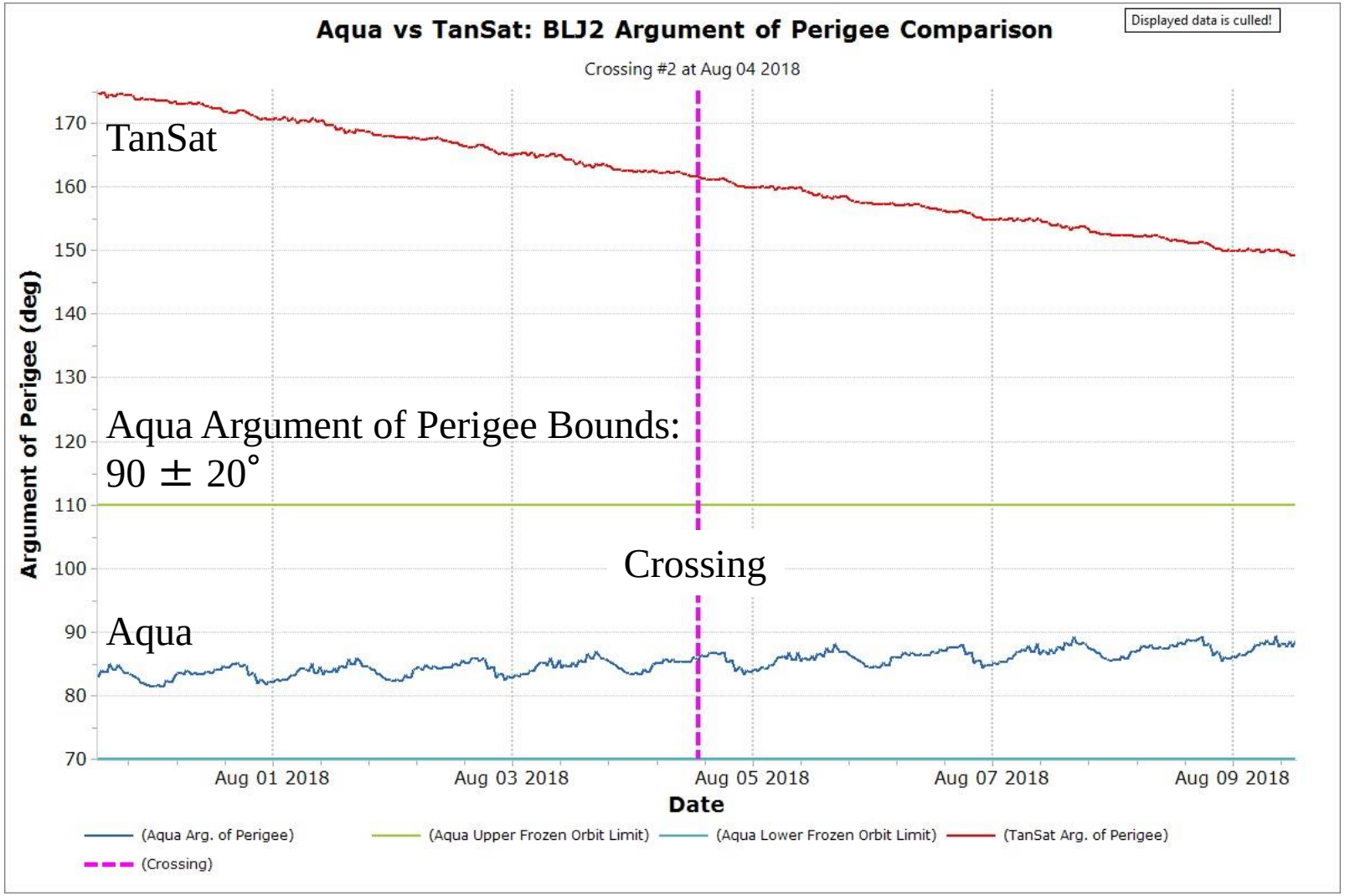
Aug 04 2018 - Eccentricity



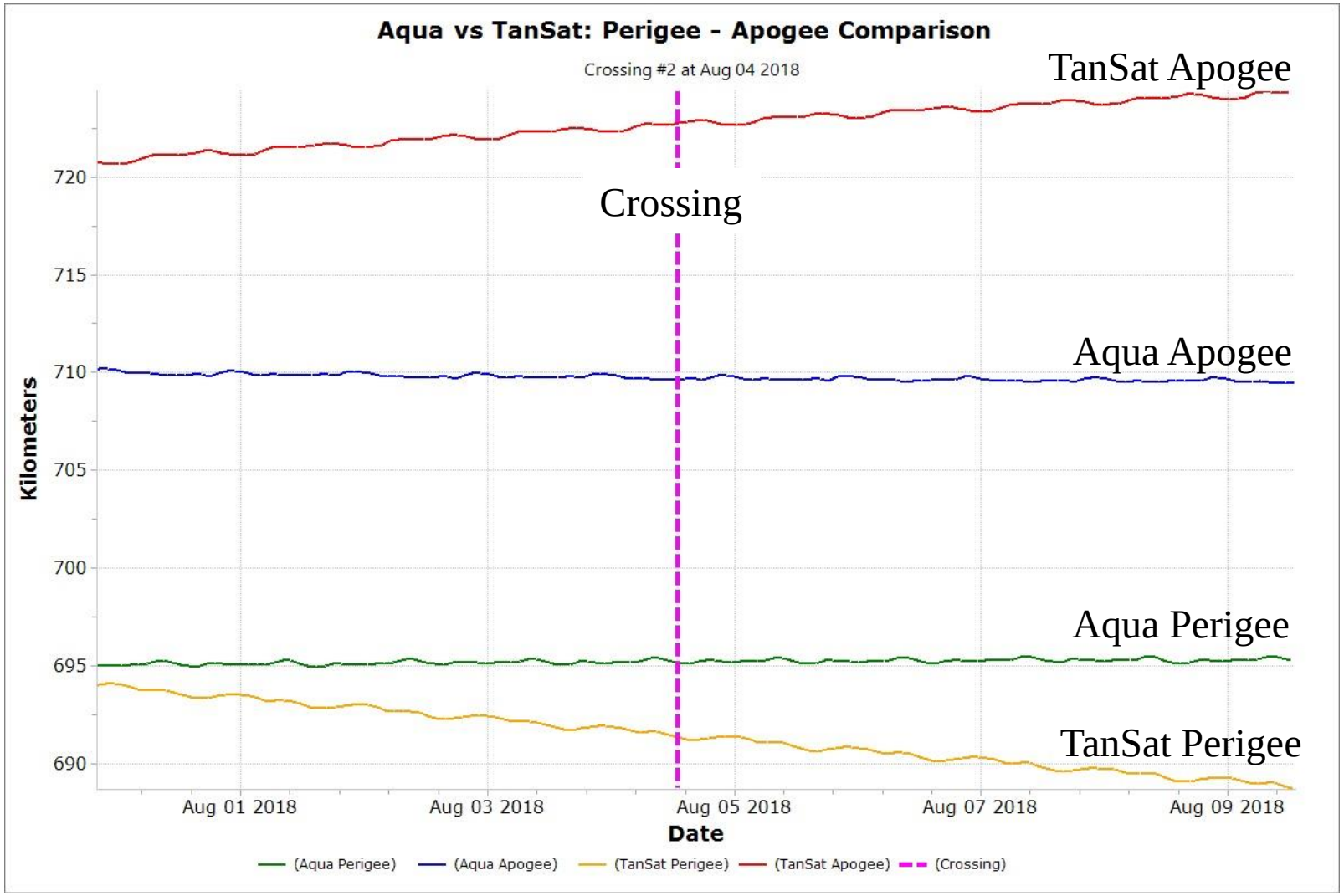
Aug 04 2018 - Inclination



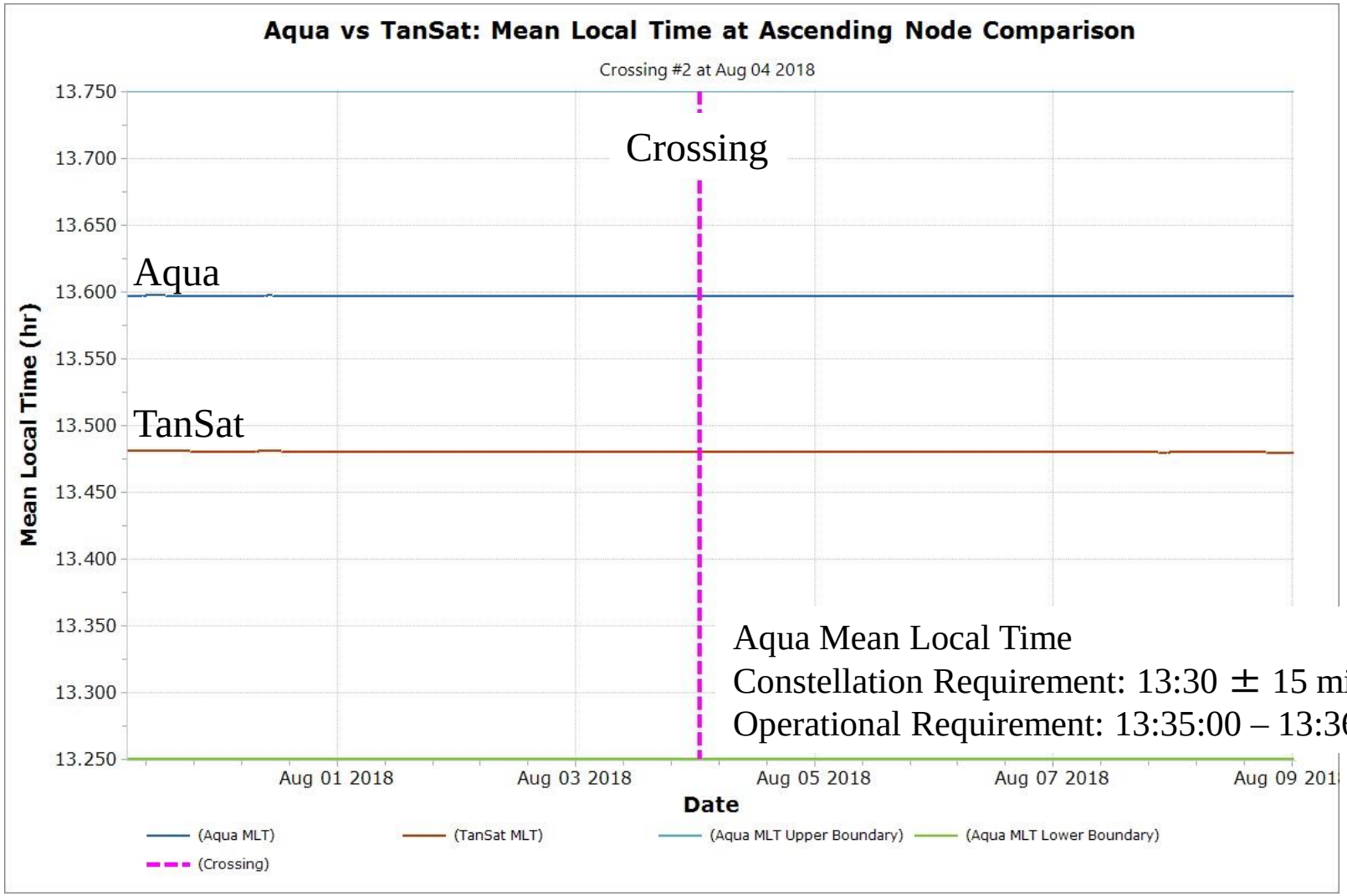
Aug 04 2018 - Argument of Perigee



Aug 04 2018 - Perigee - Apogee



Aug 04 2018 - Mean Local Time at the Ascending Node

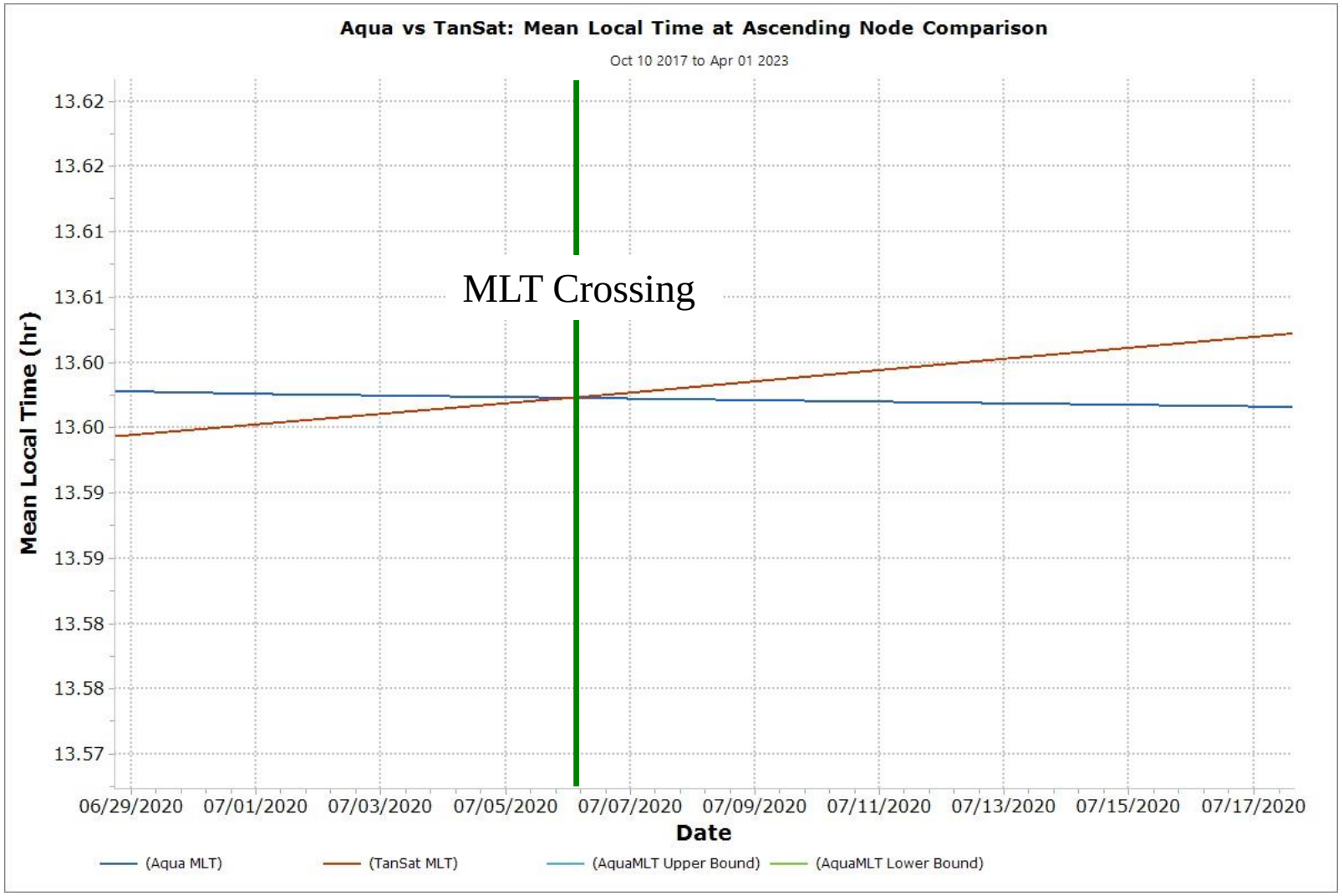


Aqua Mean Local Time
Constellation Requirement: 13:30 ± 15 min
Operational Requirement: 13:35:00 – 13:36:30

MLT Crossing: Jul 06 2020

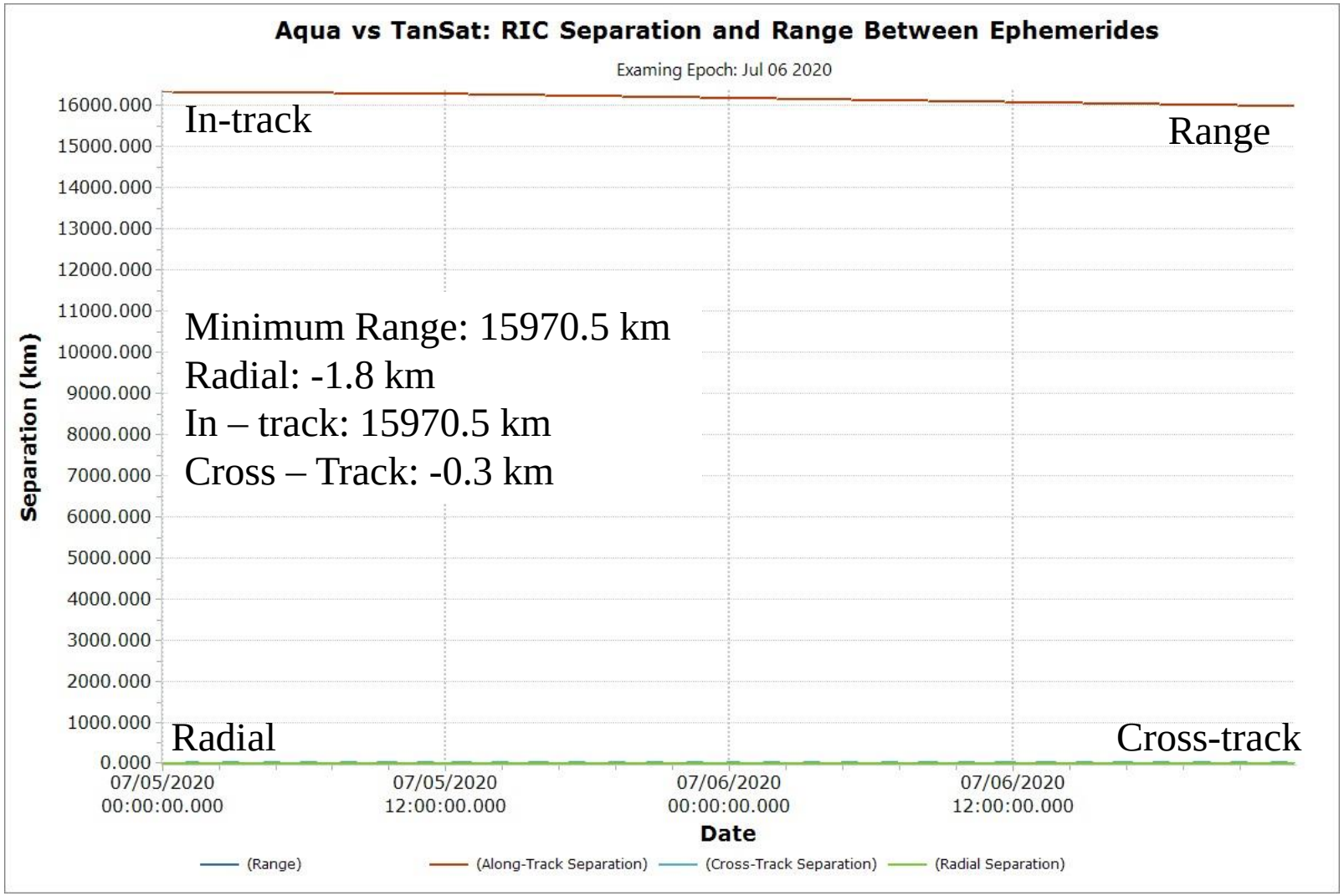
Mean Drag, Nominal Timing

Jul 06 2020 MLT Crossing: MLT Comparison



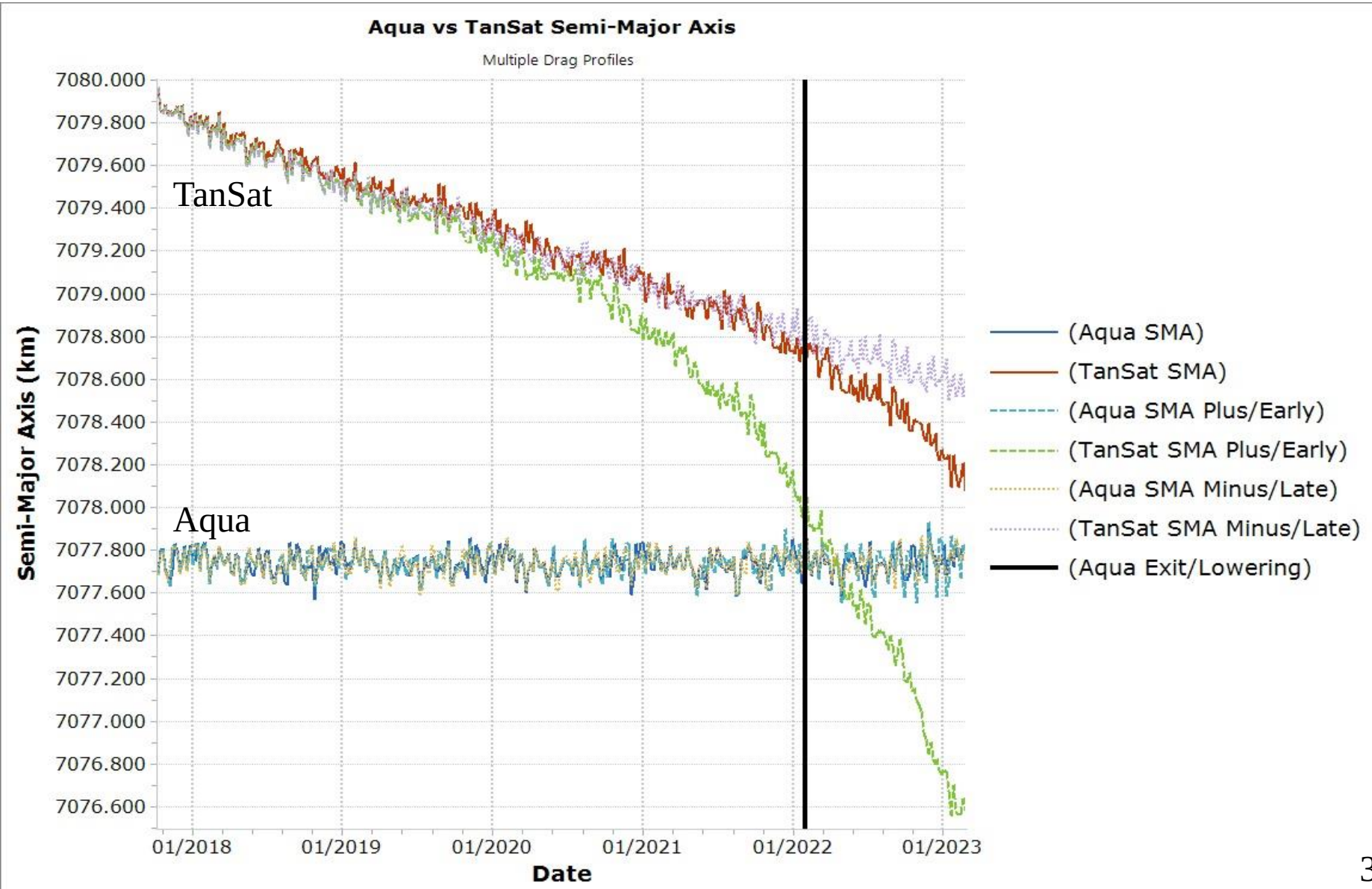
Jul 06 2020 MLT Crossing: Phasing

Jul 06 2020 MLT Crossing: RIC



Alternative Drag Profiles

Semi-Major Axis Drag Profile Comparison



Alternative Drag Profile Phasing Crossing Dates

Past Crossings : ■ Future Predicted Crossings: ■

Crossing Epochs		
Plus/Early	Mean/Nom	Minus/Late
-	April 29 2017	-
-	Sept 19 2017	-
Feb 23 2018	Feb 22 2018	Feb 23 2018
Aug 07 2018	Aug 04 2018	Aug 08 2018
Feb 01 2019	Jan 25 2019	Feb 02 2019
Aug 14 2019	Jul 30 2019	Aug 13 2019
Mar 17 2020	Feb 17 2020	Mar 09 2020
Nov 18 2020	Sep 26 2020	Oct 21 2020
Dec 03 2021	Jun 06 2021	Jul 05 2021
Aug 22 2022	Apr 09 2022	Apr 28 2022

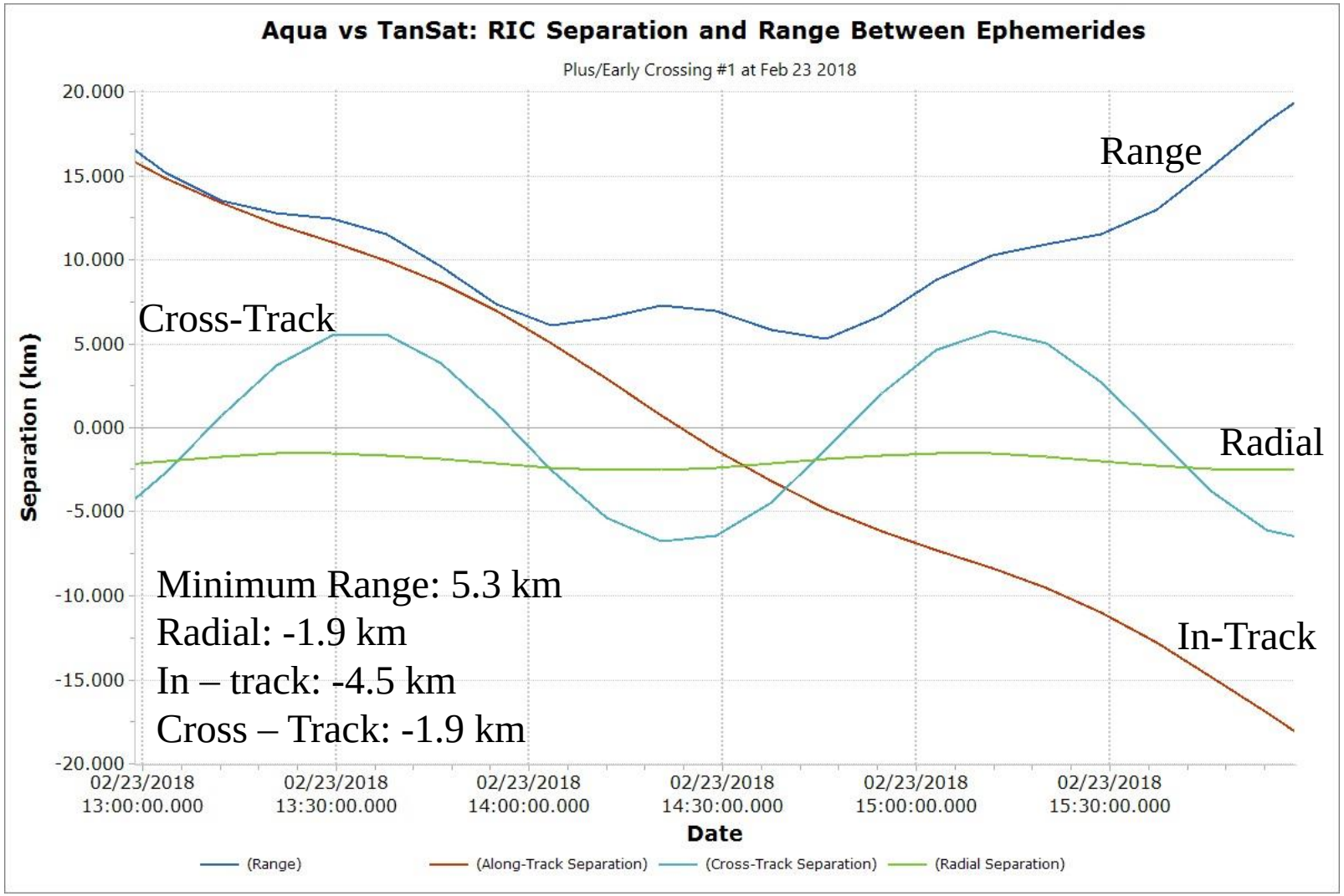
Conclusions

- TanSat is predicted to cross Aqua 7 times prior to Aqua predicted exit/lowering in February 2022
- The next three crossing dates vary from 1 - 7 days depending on TanSat orbit decay rate; remainder have larger variations
- Crossing geometry is generally favorable at any crossing due to the TanSat orbit eccentricity
- MLT Crossing on Jul 05, 2020
  - Not a concern due to large phasing; as above, the TanSat eccentric orbit drives crossing in-track separation values

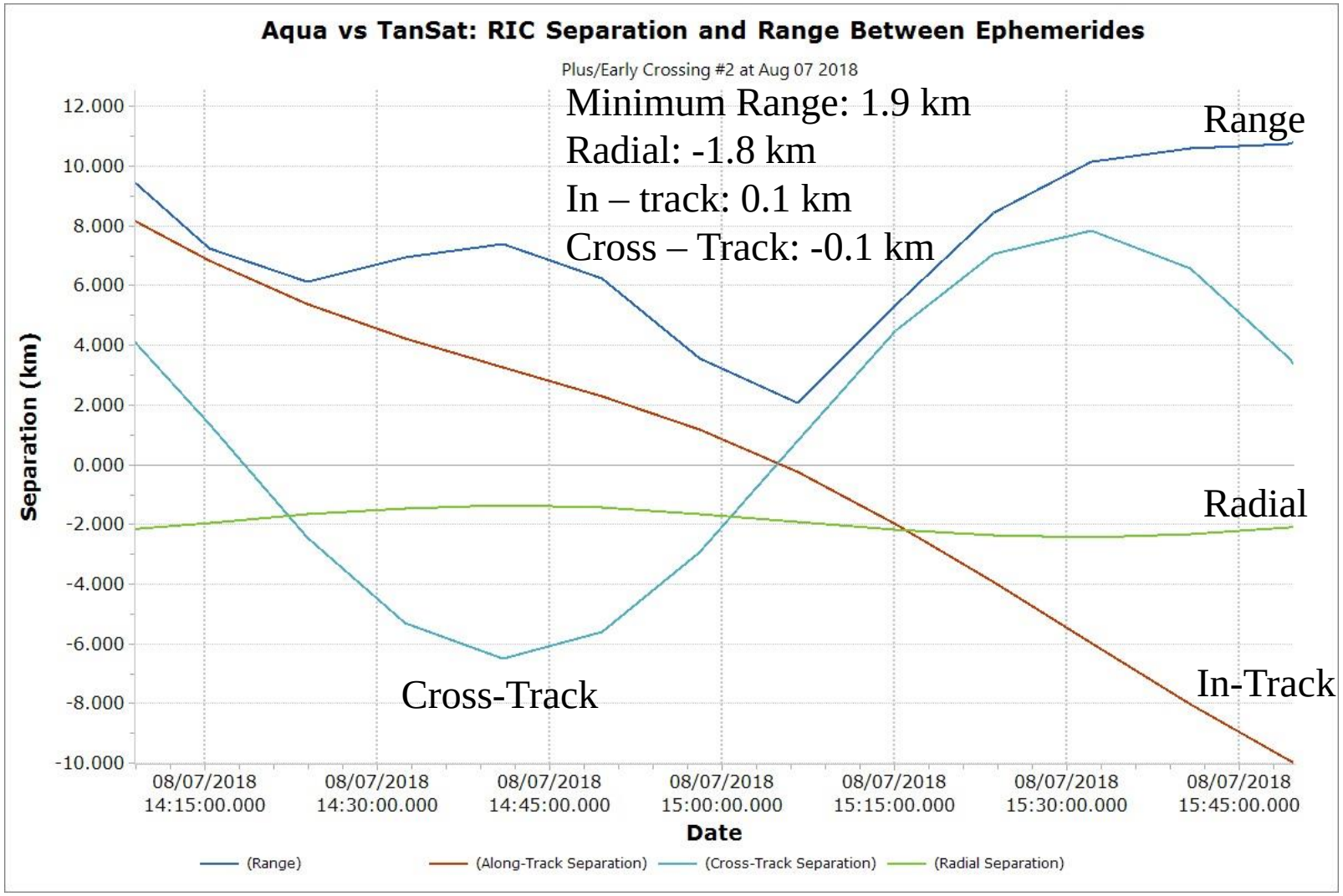
BACK UP

Plus/Early Crossings

Crossing #1 RIC for Plus/Early Drag Profile: Feb 23 2018

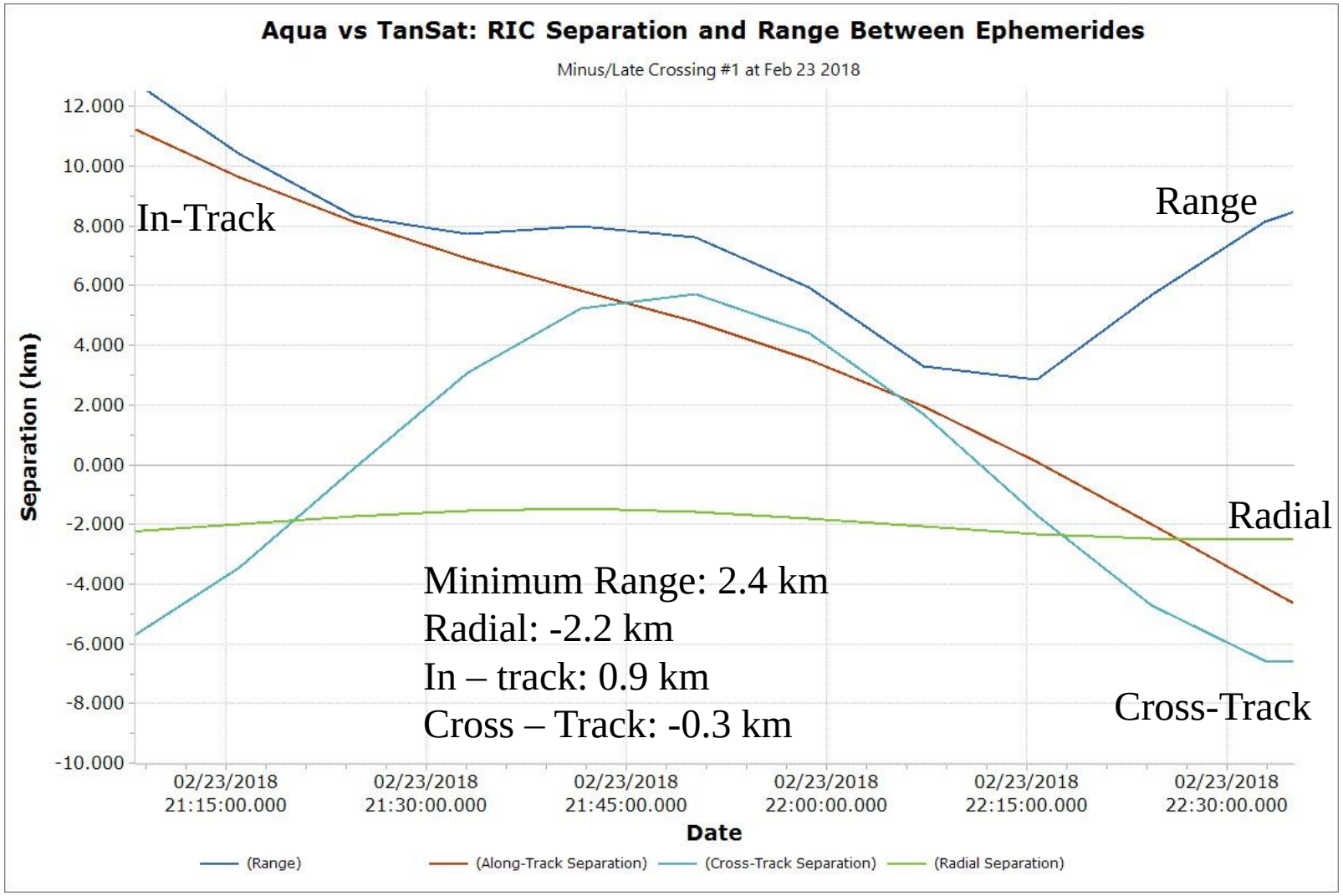


Crossing #2 RIC for Plus/Early Drag Profile: Aug 07 2018



Minus/Late Crossings

Crossing #1 RIC for Minus/Late Drag Profile: Feb 23 2018



Crossing #2 RIC for Minus/Late Drag Profile: Aug 08 2018