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International Earth Science Constellation Mission Operations Working Group

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Aqua/Aura Inclination Adjust Maneuver Series Spring 2018 Planning

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Agenda

- 2017 Drag Make-Up (DMU) Maneuver Strategy
- 2018 Inclination Adjust Maneuver (IAM) Campaign Planning
 - Spring 2017 Mission Operations Working Group (MOWG) Summary
 - New Trending Overview
 - Aqua and Aura Maneuver Schedule
 - Predicted Aqua and Aura Maneuver Performance
- Aqua/Aura 2018-2019 Mean Local Time (MLT) Predictions
- 2018 IAM Campaign Summary

Green text is values for current plan.

Red text is values from previous plans.

2017 Drag Make-up Maneuver Strategy

- Aqua and Aura continue to operate using a hybrid maneuver scheme
- Aqua's hybrid maneuver scheme (mirror pole and frozen orbit)
 - April – Sept: DMU maneuvers performed at alternating pole locations
 - Oct. – 2018 IAM series: DMU maneuvers performed at argument of latitude that best maintains frozen orbit requirements
- Aura's hybrid maneuver scheme (descending node and frozen orbit)
 - Maneuvers performed at the descending node to improve MLT phasing
 - Nov. – 2018 IAM series: frozen orbit maintenance maneuvers performed
- With the current low-drag environment, both are using a modified targeting scheme now:
 - A four-week DMU cadence is being utilized for maneuver planning
 - GTE controlled near the top quarter of the control box
 - Allows room to execute Risk Mitigation Maneuvers (RMM) and remain in the control box
- RMM locations are dictated by conjunction timing and geometry

Recap of Spring 2017 MOWG

- At the Spring 2017 MOWG presented (1) change in burn duration for Aqua and (2) Aqua/Aura burn order switched
 - Predicted change in inclination (ΔI) would be less than presented at 2016 MOWG (-0.04089°)
 - Burn duration needed to increase to 565.0 seconds from 550.0 seconds
 - Predicted ΔI presented: -0.04083°
 - Schedule: $3-1-1$ cadence
 - Each mission performs a maneuver a week for three weeks, then one week off, another week of one maneuver each, a week off, and a final week of one maneuver each
 - Upward Aqua-Aura phasing spikes caused the upper phasing limit to be briefly violated soon after 2018 IAM series
 - Burn order: **Aura before Aqua** (originally Aqua then Aura)
 - Helps push phasing in the desired direction

Trending Methodology Update

- Previous two IAM series (2016 and 2017), the change in semi-major axis (Δ SMA) and Δ I predictions were less accurate than desired
- Analysis was performed to determine ways to improve our current prediction method
- A new method was developed which identifies the best (statistically significant) parameter combinations to create trends
 - Methodology discussed more thoroughly in separate presentation
- Implemented in latest Lifetime and Decommissioning Analysis Report for each mission and used in predicted performance in this presentation
 - Aqua's predicted Δ I would increase to **-0.04120°**
 - Burn duration decreased to **560.0** seconds to better match previous value
 - Predicted Δ I: **-0.04086°**
 - Duty cycles trended from 550.0 second burn duration
 - Burn duration may change to meet advertised Δ I

Aqua Spring 2018 IAM Campaign Planning

- The Aqua Spring 2018 IAM plan consists of five inclination maneuvers performed on **Thursdays**
- Burn duration: **560.0** seconds
- Aqua's predicted ideal burn date occurs around March 22, 2018
- Proposed plan has three maneuvers occurring before the ideal burn date and two after
 - March 1, 2018 (IAM #56)
 - March 8, 2018 (IAM #57)
 - March 15, 2018 (IAM #58)
 - March 29, 2018 (IAM #59)
 - April 12, 2018 (IAM #60)

Note: Performing maneuvers off of the ideal date slightly decreases burn efficiency

Aura Spring 2018 IAM Campaign Planning

- The Aura Spring 2018 IAM plan consists of five inclination maneuvers performed on **Wednesdays**
- Burn duration: **398.0** seconds
- Aura's predicted ideal burn date occurs around March 27, 2018
- Proposed plan has three maneuvers occurring before the ideal burn date and two after
 - February 28, 2018 (IAM #53)
 - March 7, 2018 (IAM #54)
 - March 14, 2018 (IAM #55)
 - March 28, 2018 (IAM #56)*
 - April 11, 2018 (IAM #57)

*ESMO is currently evaluating the execution of an IAM using wheels and may execute IAM#56 in this manner.

Note: Performing maneuvers off of the ideal date slightly decreases burn efficiency

Aura Spring 2018 IAM Campaign Planning – IAM#56 on Wheels

- Aura IAM#56 (fourth in the series) may be executed using wheels to slew out to the burn attitude and slew back to nominal pointing
- These slews will not contribute to the overall inclination change or contribute to the SMA changes
- Therefore the maneuver duration and slew angle will be adjusted to achieve the desired ΔI (for the phasing relative to Aqua) and altitude change (to maintain the ground track)
- The fourth burn was chosen because of the additional time both before and after for additional preparations and/or re-planning for the final burn.

Proposed Aqua/Aura 2018 Maneuver Schedule

Aqua/Aura 2018 Inclination Maneuver Series Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			February 28 Aura IAM#53	March 1 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	22 Aqua Ideal Date	23	24
25	26	27 Aura Ideal Date	28 Aura IAM#56	29 Aqua IAM#59	30	31
April 1 Easter Sunday	2	3	4	5	6	7
8	9	10	11 Aura IAM#57	12 Aqua IAM#60	13	14
15	16	17	18	19	20	21*

*Japan Golden Week starts April 29

2018 Predicted Maneuver Performance*

AQUA

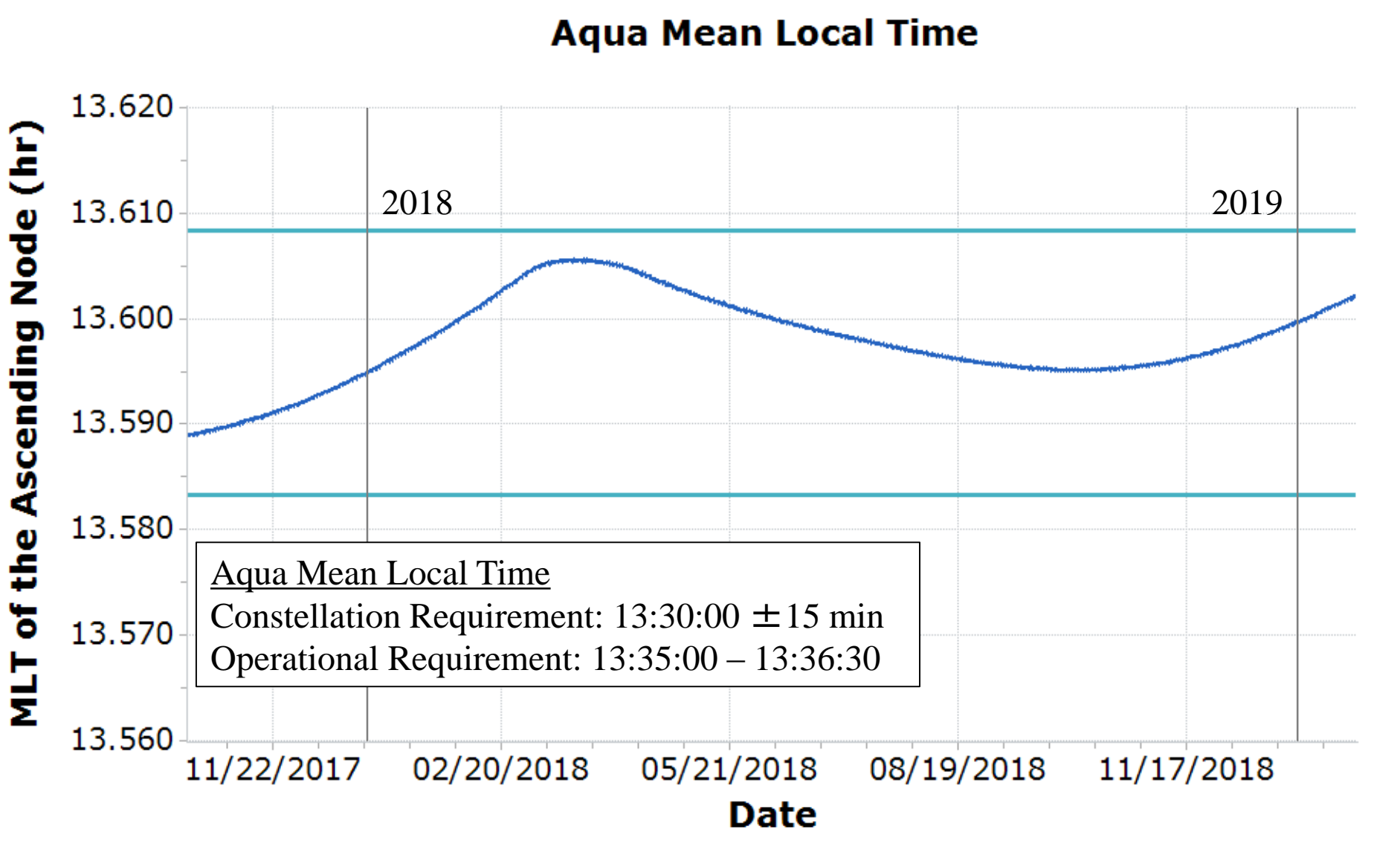
IAM #	Date	Target Yaw Angle (deg)	Burn Duration (sec)	Delta-V (m/sec)	Delta-SMA (m)	Delta-Inc (deg)	Delta-RAAN (deg)
56	March 1, 2018	-86.67	560.00	1.298347	-10.800	-0.00822	0.001350
57	March 8, 2018	-86.58	560.00	1.290616	4.394	-0.00821	0.000905
58	March 15, 2018	-86.51	560.00	1.284150	16.540	-0.00819	0.000462
59	March 29, 2018	-86.49	560.00	1.280921	21.684	-0.00816	-0.000414
60	April 12, 2018	-86.50	560.00	1.281771	18.913	-0.00808	-0.001256
					Total Delta-Inc (deg)	-0.04086	0.001047

AURA

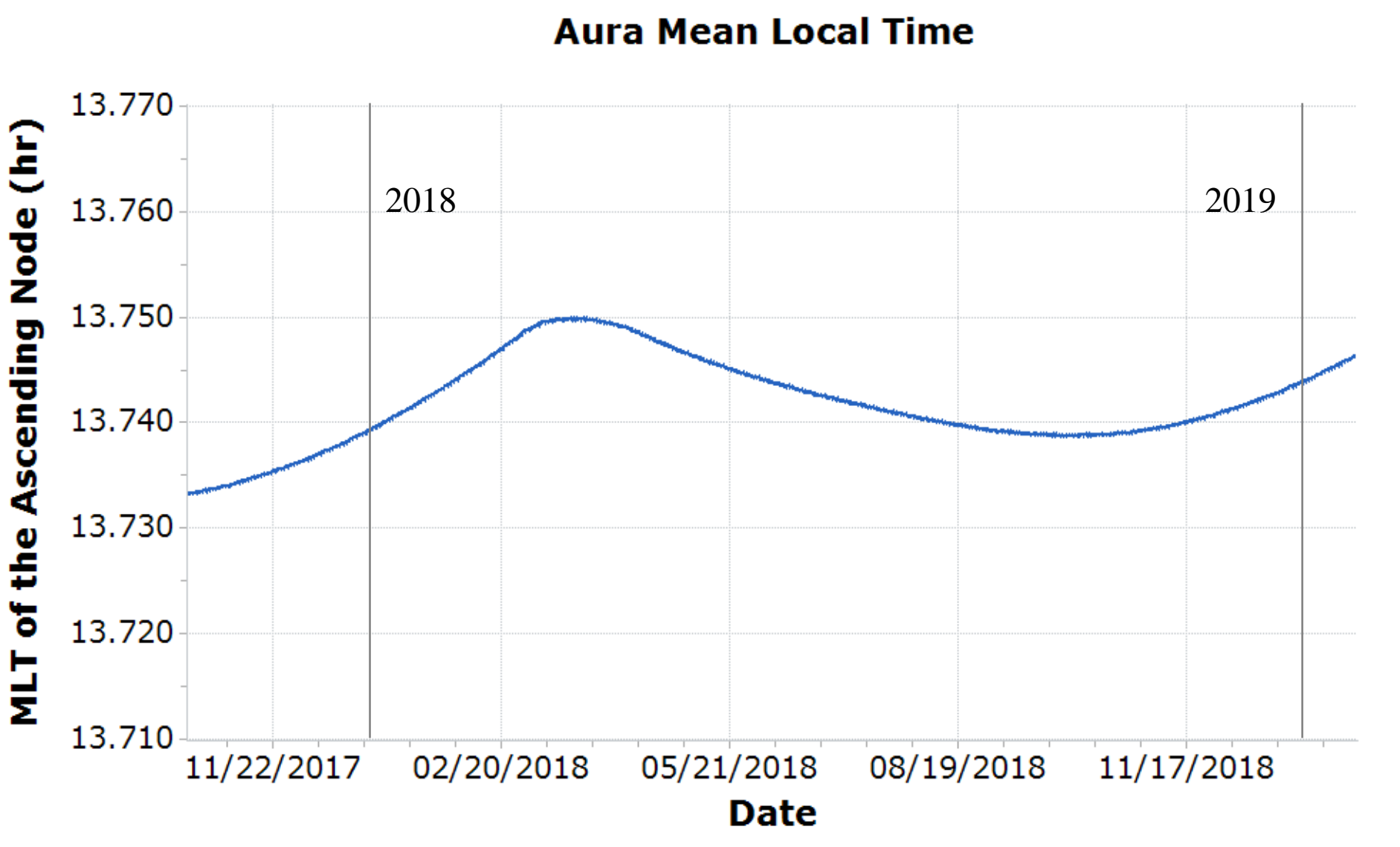
IAM #	Date	Target Yaw Angle (deg)	Burn Duration (sec)	Delta-V (m/sec)	Delta-SMA (m)	Delta-Inc (deg)	Delta-RAAN (deg)
53	February 28, 2018	-82.77	398.00	1.141633	0.046	-0.00852	0.001795
54	March 7, 2018	-82.80	398.00	1.135571	0.169	-0.00856	0.001338
55	March 14, 2018	-82.83	398.00	1.130478	0.049	-0.00857	0.000861
56	March 28, 2018	-82.86	398.00	1.124416	0.084	-0.00858	-0.000078
57	April 11, 2018	-82.89	398.00	1.119324	0.218	-0.00848	-0.000971
					Total Delta-Inc (deg)	-0.04271	0.002945

* Source: Aqua and Aura Lifetime Analysis, October 27, 2017, Spencer Boone and Scott Patano

Aqua Predicted Pre- and Post-2018 IAM MLT

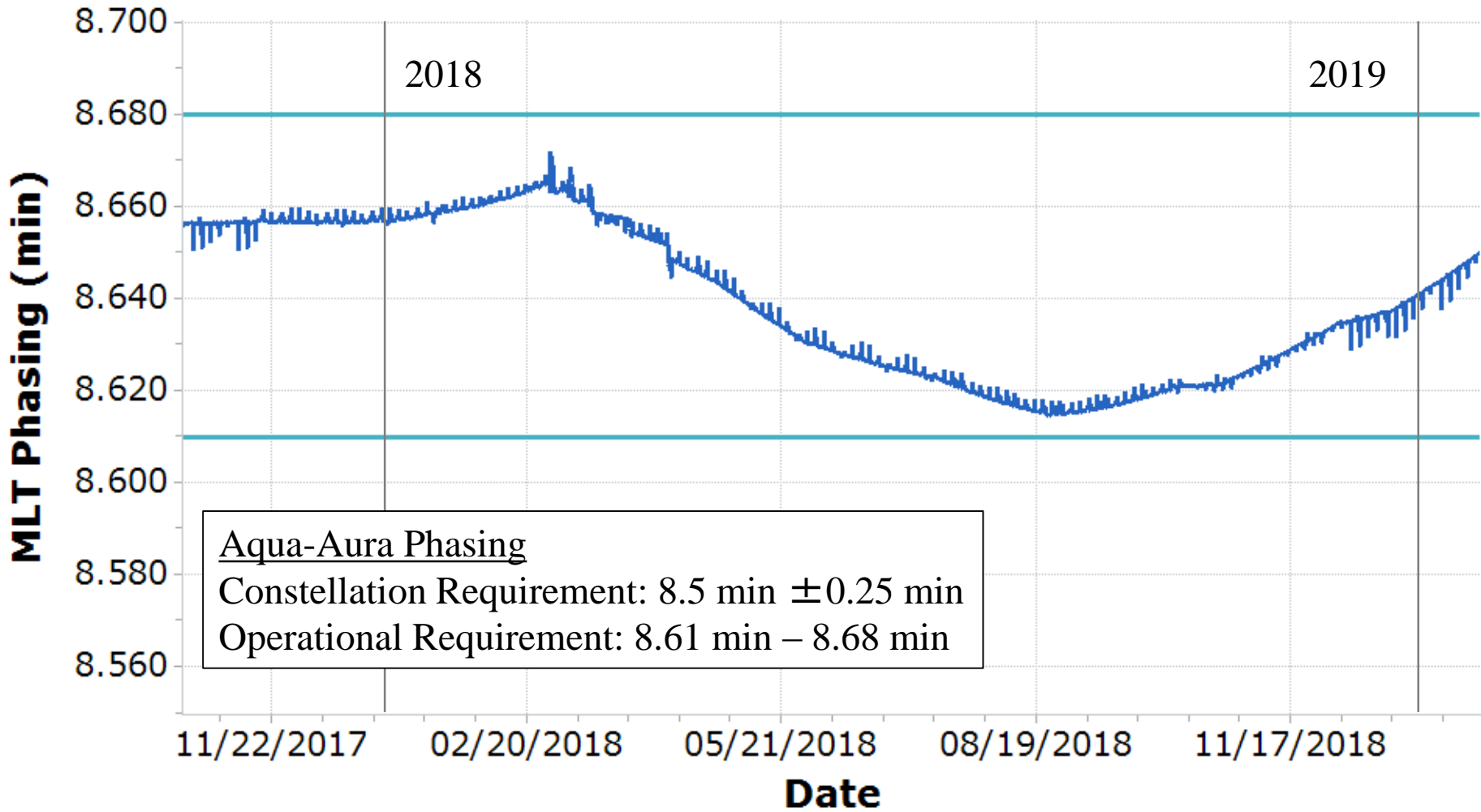


Aura Predicted Pre- and Post-2018 IAM MLT



Aqua-Aura Lifetime MLT Phasing Based on Planned IAM Strategy

Aqua-Aura Phasing



Aqua/Aura Spring 2018 Series Planning Summary

- Maintain the Aqua MLT box of 13:35:00 - 13:36:30 and Aqua-Aura MLT relative phasing box of 8.61 - 8.68 minutes in 2019
- The Aqua and Aura Spring 2018 IAM series will consist of five inclination maneuvers for each mission
- Kept changes presented at Spring 2017 MOWG
 - Aqua and Aura burn schedule now 3-1-1, beginning Feb. 28, 2018
 - Aura will burn on Wednesdays
 - Aqua will burn on Thursdays
- Aqua burn duration: 560.0 seconds
- Aura burn duration: 398.0 seconds
- New trending implemented for predicted performance
- Planned Aqua ΔI of -0.04086° is **slightly more** than Spring 2017 prediction of -0.04083°