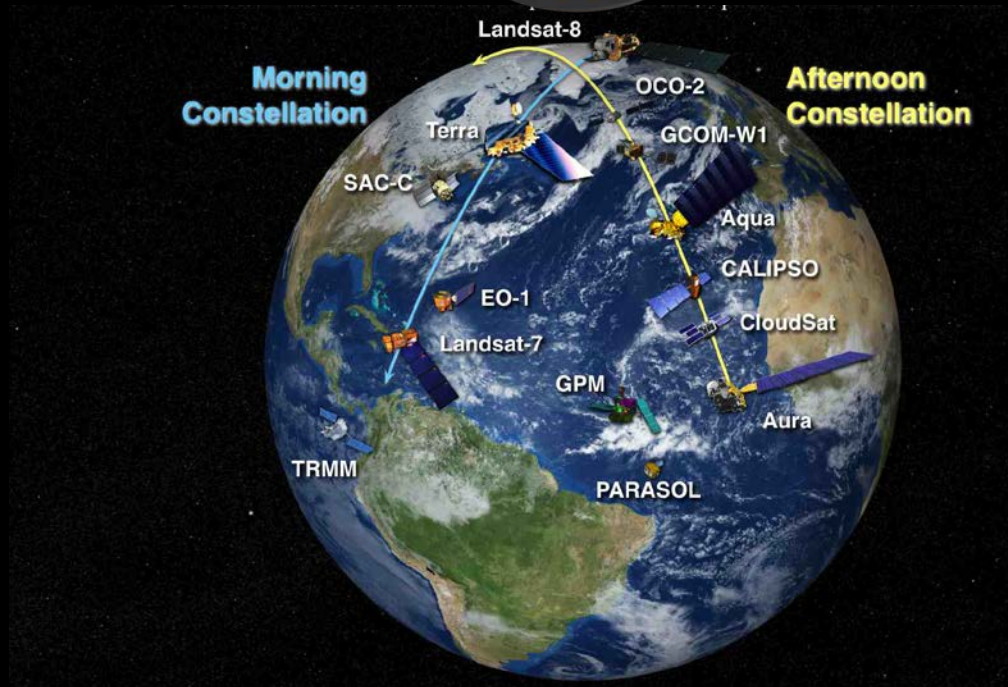


United States Brazil Canada Finland France Japan Netherlands United Kingdom

International Earth Science Constellation Mission Operations Working Group (MOWG)

June 5-7, 2019

Aqua Spring 2019 IAM Series Results

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Agenda

- Recap Aqua 2019 Inclination Adjust Maneuver (IAM) Campaign
  - Series Summary
  - Maneuver Results
  - Post-2019 IAM Mean Local Time (MLT) Evolution
- Aqua's Recent IAM Performance
- 2020 IAM Campaign Dates and Planning
- Summary

Aqua Spring 2019 Series Summary

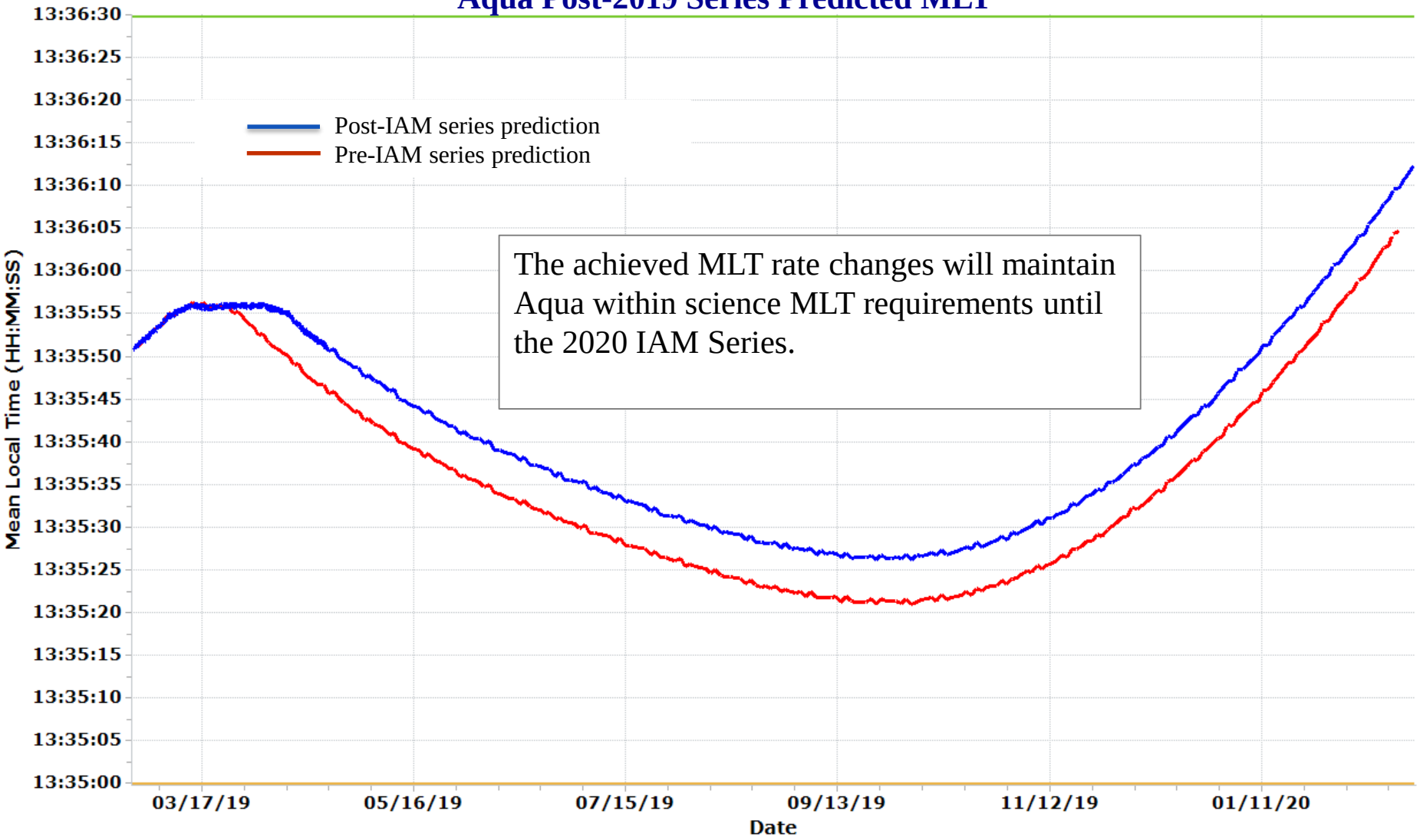
- Aqua performed 4 inclination maneuvers between March 7st and April 11th
- The last two IAMs had to be delayed two weeks to avoid high risk conjunctions
- All 4 IAMs used the 560 second burn duration set in 2018
  - Would keep Aqua within the “mission goal” MLT constraints
- Aqua yaw offset continues to grow
  - Largest achieved offset yet of -3.053 degrees
- The total IAM series performance was 0.33% cold

Aqua Series Results

Inc #	Date	Commanded Yaw (deg)	Achieved Yaw (deg)		Delta Velocity (m/s)		Delta Inclination (deg)		Delta RAAN* (deg)	
			Predicted	Definitive	Predicted	Definitive	Predicted	Definitive	Predicted	Definitive
62	Mar 07	-90.50	-87.90	-87.89	1.23	1.25	-0.00772	-0.00776	0.0238	0.0238
63	Mar 15	-91.40	-88.74	-88.76	1.23	1.24	-0.00770	-0.00765	0.0234	0.0234
64	Apr 04	-93.00	-90.31	-90.29	1.22	1.23	-0.00748	-0.00753	0.0224	0.0224
65	Apr 11	-93.00	-90.28	-89.95	1.21	1.21	-0.00738	-0.00740	0.0.223	0.0223
							Total:	**-0.03035**		
*Right Ascension of the Ascending Node (RAAN)							**% Error**	**-0.33 (Cold)**		

- Final % Error based on advertised series delta inclination from the Dec 2018 MOWG (-0.03043 deg)

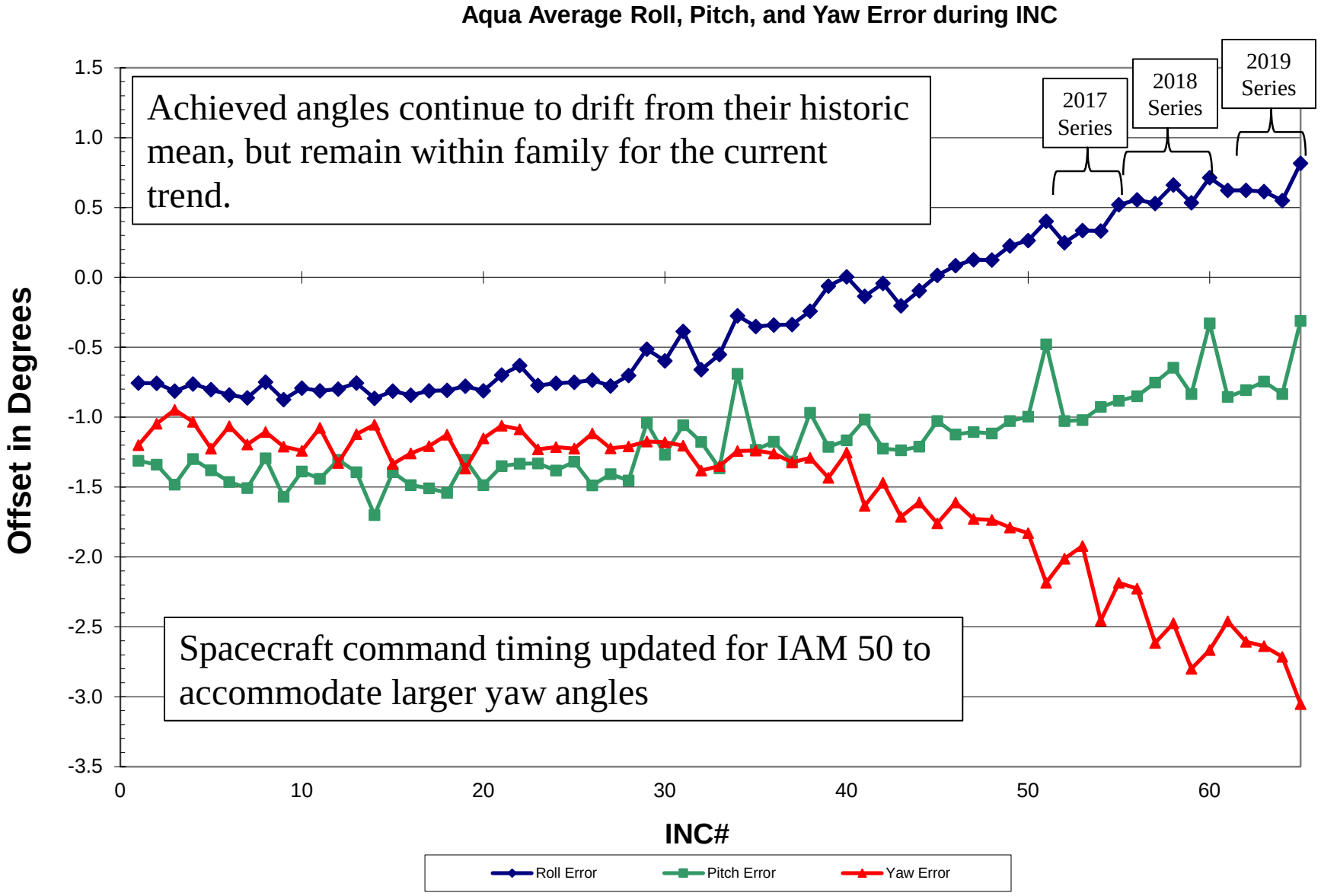
Aqua Post-2019 Series Predicted MLT



Aqua's IAM Performance

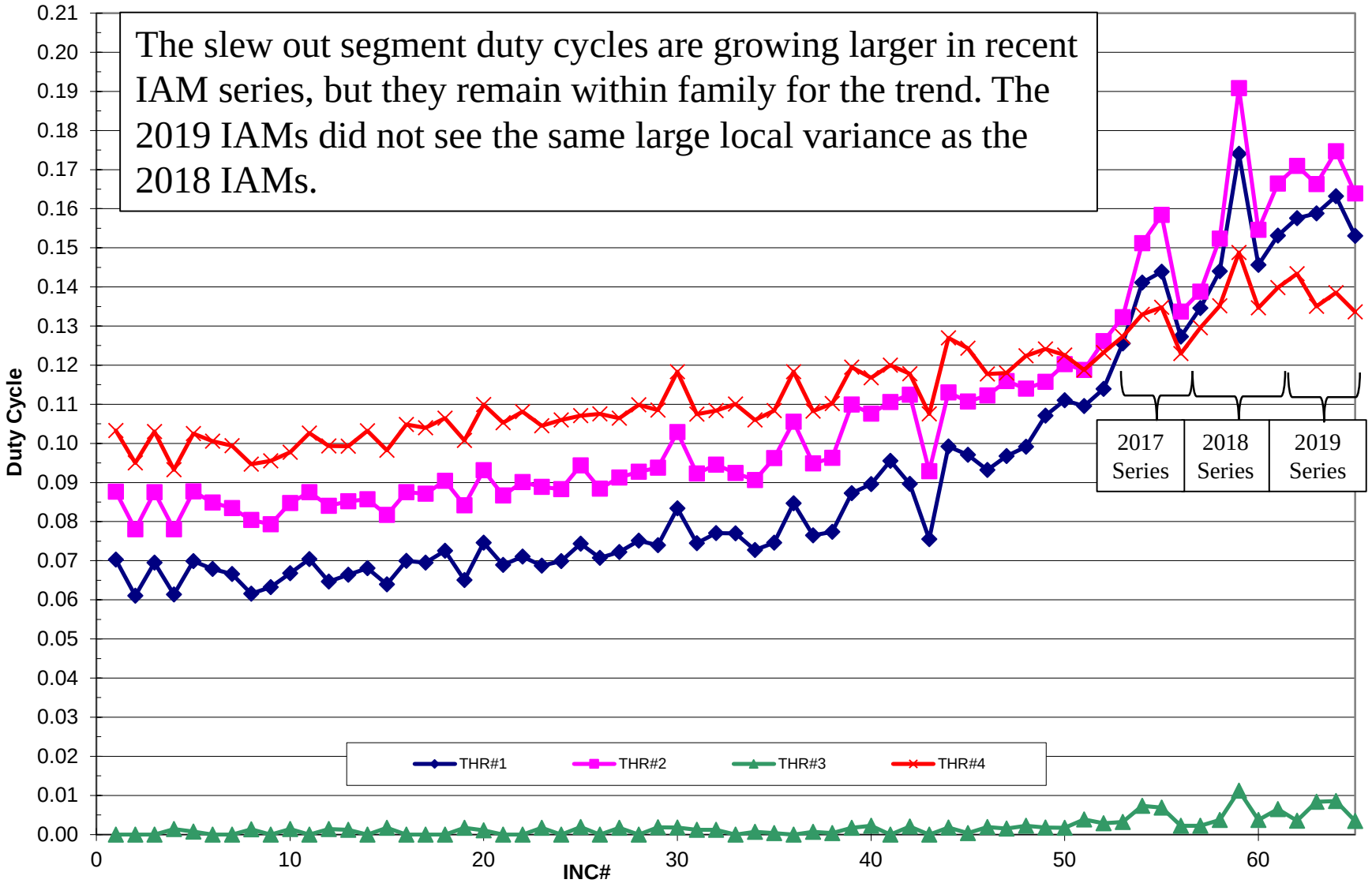
- Aqua's series performance, while in family with previous series performance, was slightly colder than predicted, and continues to show signs of degrading performance.
  - Teams are working to identify which factors may be contributing to the degrading maneuver performance
  - May allow Flight Dynamics (FDS) to better predict maneuver and lifetime performance
- While no definitive cause has yet been identified, there are some interesting trends
  - Attitude errors at the time of the inclination burn segment appear to be growing, in family with the previous IAM trends
  - Slew-out duty cycles continue to trend, but did not exhibit the sharp variance observed in the 2018 IAM series

Aqua's IAM Performance



Aqua's IAM Performance

The slew out segment duty cycles are growing larger in recent IAM series, but they remain within family for the trend. The 2019 IAMs did not see the same large local variance as the 2018 IAMs.



Aqua Spring 2020 IAM Campaign Planning

- The Aqua Spring 2020 IAM plan consists of 6 inclination maneuvers
- Aqua's predicted ideal burn date occurs around March 22, 2020
- Proposed plan has 4 maneuvers occurring before the ideal burn date, and 2 after
  - February 27 (IAM #66)
  - March 5 (IAM #67)
  - March 12 (IAM #68)
  - March 19 (IAM #69)
  - March 26 (IAM #70)
  - April 2 (IAM #71)
- To increase the series efficiency, there are no planned gaps or breaks. Any maneuvers that need to be re-planned will be moved to the end of the series
  - Currently investigating the possibility of a Fall 2019 IAM to reduce the maneuver volume in Spring 2020.

Mission Operations Working Group

June 5-7, 2019

Proposed Aqua/Aura 2020 Maneuver Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
February 23	24	25	26 Aura IAM#63	27 Aqua IAM#66	28	29
March 1	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*	21
22***	23	24	25 Aura IAM#67	26 Aqua IAM#70	27	28
29	30	31	**April** 1 Aura IAM#68	2 Aqua IAM#71	3	4
5	6	7	8 Aura Back-up	9 Aqua Back-up	10	11
12	13	14	15	16	17	18

*Spring Equinox on March 20
**Aura Ideal Date on March 12
***Aqua Ideal Date on March 22
Note: Golden Week in Japan starts April 28

Aqua Predicted 2020 Maneuver Performance

Inc #	Date	Commanded Yaw* (deg)	Duration (sec)	Delta SMA** (m)	Delta Inclination (deg)	Delta RAAN (deg)	Delta Velocity (m/s)
66	Feb 27	-92.59	560	-18.66	-0.00740	0.00137	1.2191
67	Mar 05	-92.59		-8.96	-0.00737	0.00097	1.2085
68	Mar 12	-92.59		1.12	-0.00733	0.00057	1.1974
69	Mar 19	-92.59		12.92	-0.00725	0.00017	1.1852
70	Mar 26	-92.59		15.85	-0.00717	-0.00022	1.1761
71	Apr 02	-92.59		28.20	-0.00705	-0.00059	1.1629
				Total:	**-0.04357**		

*Preliminary angles
**Semi-Major Axis (SMA)

- Utilized trending equations that were updated after the 2019 series was completed

Summary

- The 2019 IAM series requires some additional analysis to better understand the degrading performance
- Aqua is predicted to remain within the “mission goal” MLT constraint up to and during the 2020 IAM series
- The 2020 IAM series will have 6 maneuvers and is predicted to push Aqua low in its MLT box prior to the 2021 series
- The predicted 2020 IAM series performance may be updated after further analysis of the observed 2019 IAM series performance
  - Fall 2019 IAM is in consideration for scheduling purposes to reduce the length of the Spring 2020 IAM series

Special Thanks To

- Michael Von Hendy
  - Michael's careful planning and analysis throughout the series helped the FDS team adjust so Aqua maintained ground track error throughout the series
- The FDS Team
  - The entire team worked very hard to support both Aura and Aqua throughout the series.