



International Earth Science Constellation Mission Operations Working Group (MOWG) December 3-5, 2019

Aqua 2019 Fall IAM Series Results and Spring 2020 Planning

Michael Von Hendy, a.i. solutions

EOS FDS, esmo-eos-fds@lists.nasa.gov, +1.301.614.5050

Agenda

- Aqua Fall 2019 Inclination Adjust Maneuver (IAM) Campaign
 - Series Summary
 - Maneuver Results
 - Post-2019 IAM Mean Local Time (MLT) Evolution
- Aqua's Recent IAM Performance
- Aqua Spring 2020 IAM Campaign Dates and Planning
 - Reaction Wheel Slew Plan
 - Thruster Slew Plan
- Summary

Aqua Fall 2019 Series Summary

- Aqua performed 1 inclination maneuver on October 2nd
- The IAM used the 560-second burn duration set in 2018
 - Keeps Aqua within the “mission goal” MLT constraints
- Aqua yaw offset trend is maintained
 - Largest achieved offset yet of -3.053 degrees with IAM#65
 - Yaw offset achieved of -2.965 with October 2019 IAM#66
- The total IAM series performance was 0.41% cold

Aqua Fall 2019 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
66	Oct 02	-93.00	-90.09	-90.06	1.204	1.211	-0.00740	-0.00737	0.00040	0.00025
							Total:	-0.00737		
							% Error	-0.41 (Cold)		

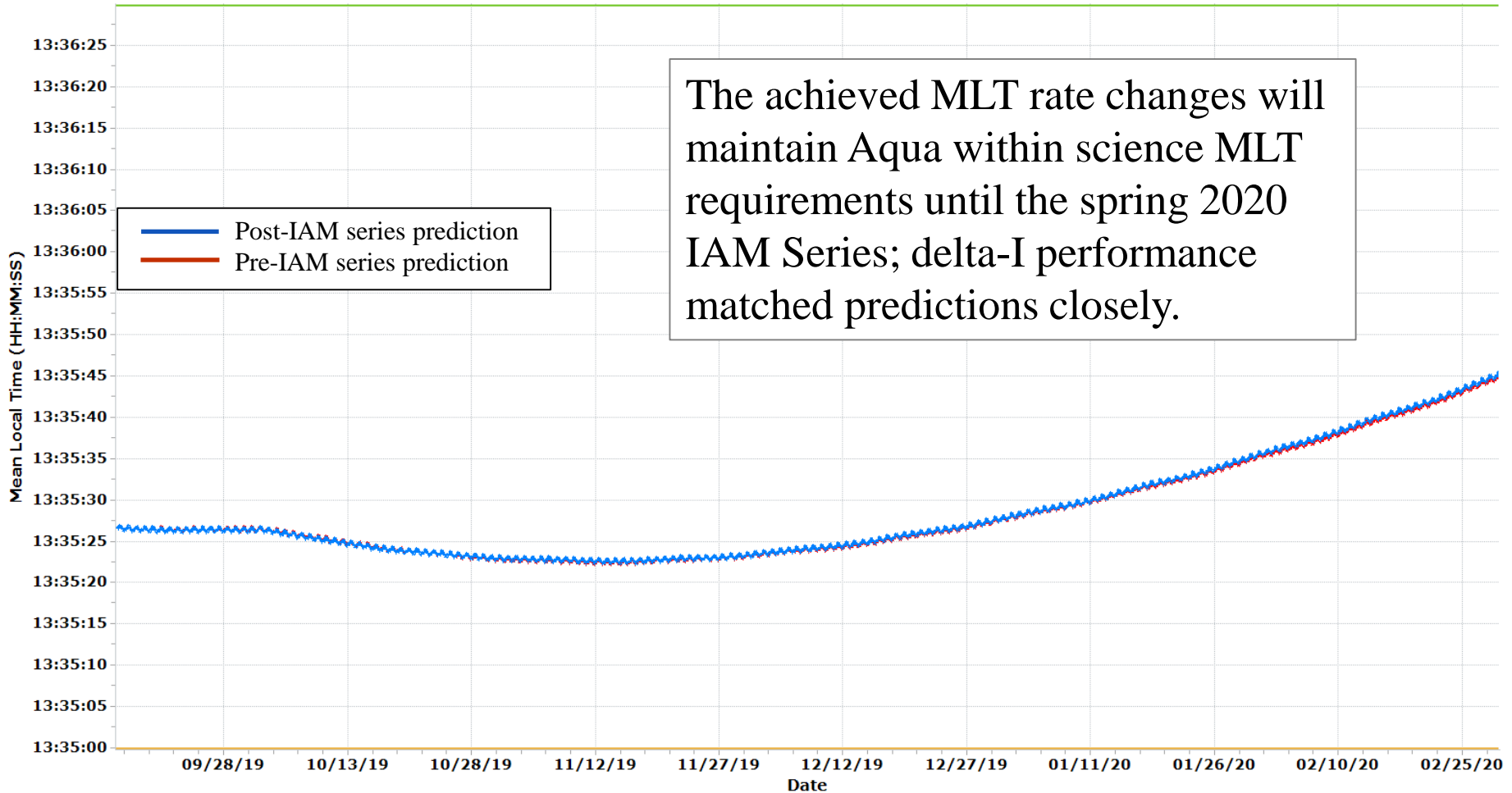
*Right Ascension of the Ascending Node (RAAN)

- Final % Error based on advertised series delta inclination from the Constellation Coordinated Plan (-0.00740 deg)

Aqua Post-2019 Series Predicted MLT

Aqua: Mean Local Time at Ascending Node

10/15/2019

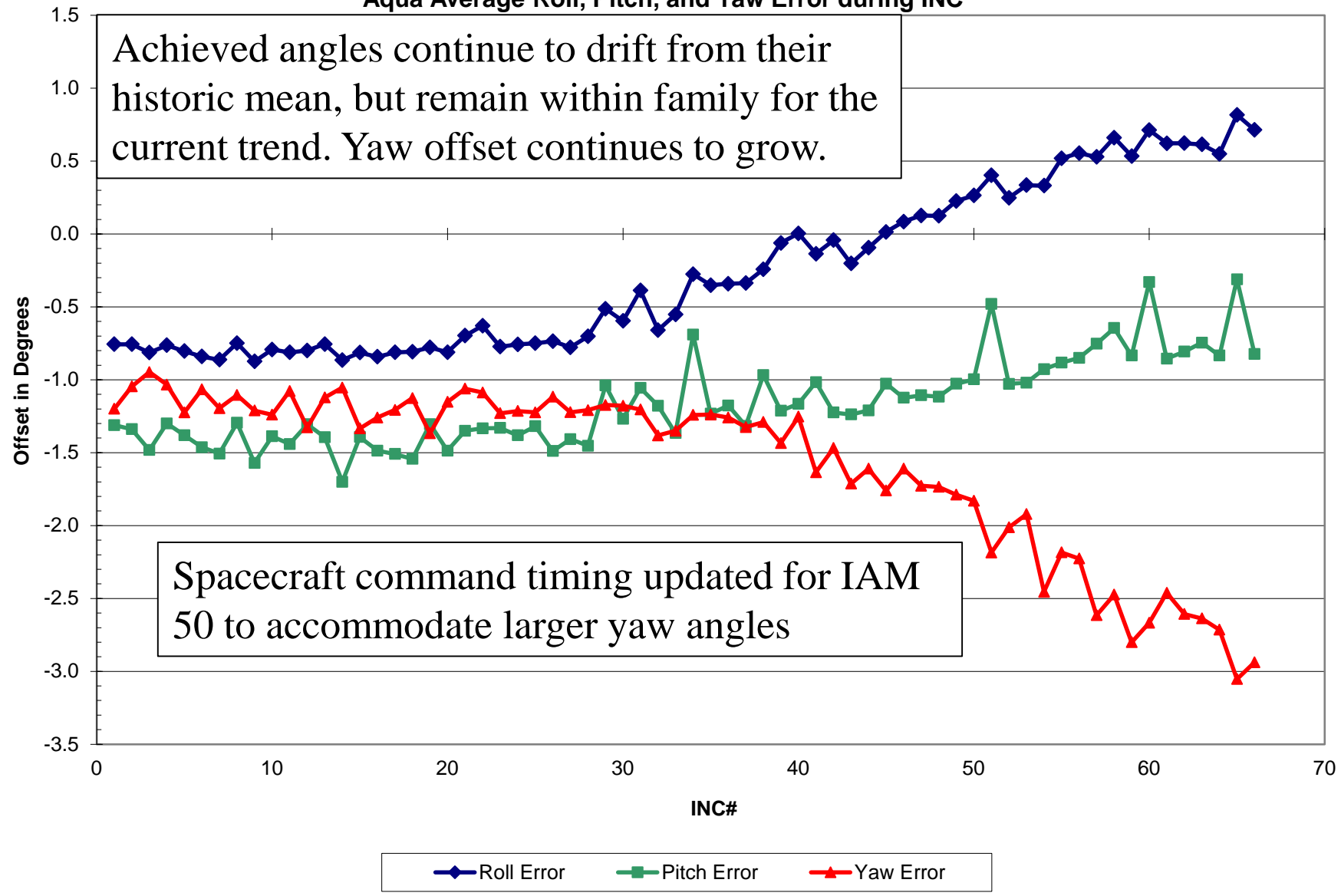


Aqua's IAM Performance

- 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 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 although large pitch error contributed to higher duty cycles than predicted.

Aqua's IAM Performance

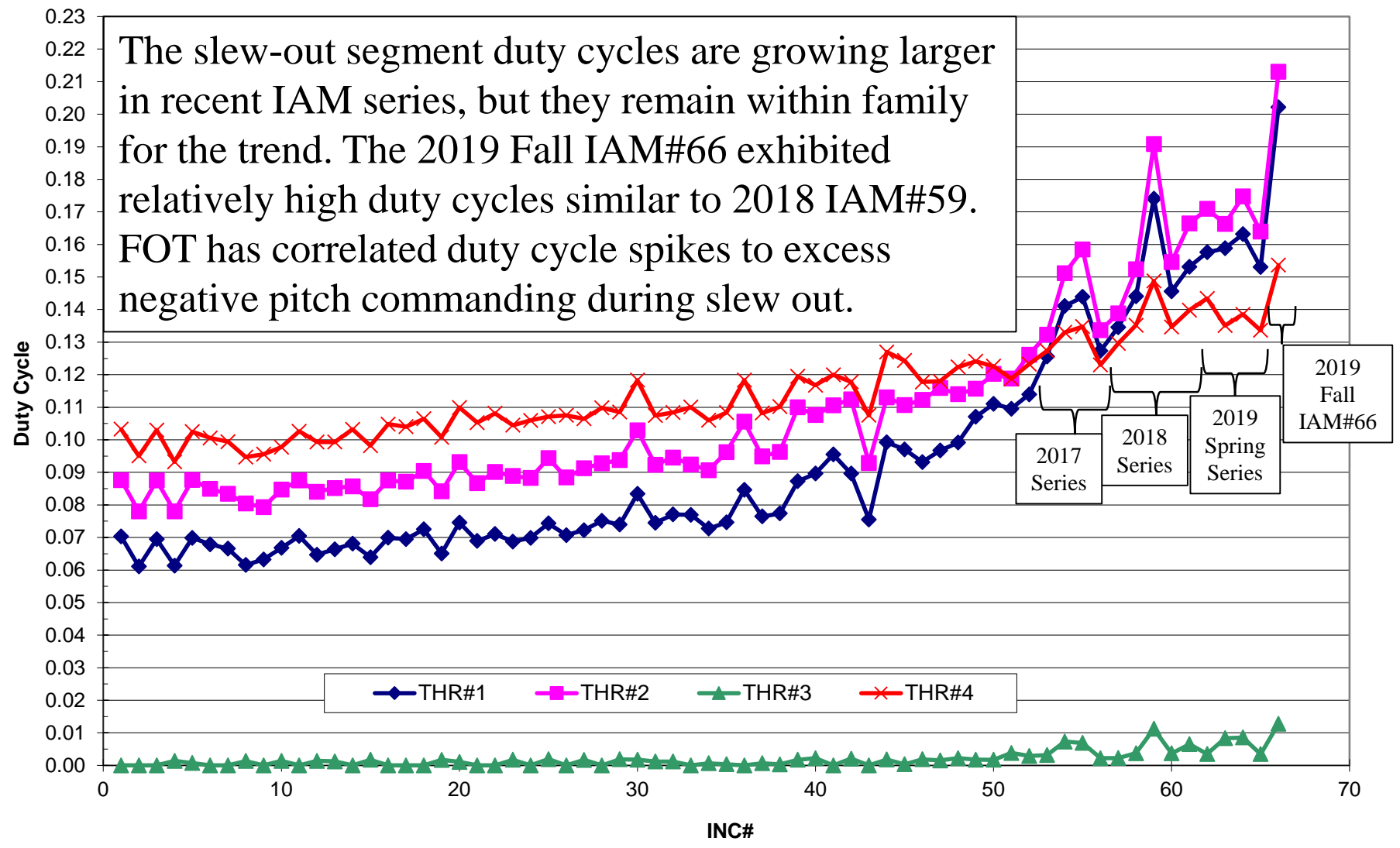
Aqua Average Roll, Pitch, and Yaw Error during INC



Aqua's IAM Performance

Aqua Half Slew Out Thruster Duty Cycle

The slew-out segment duty cycles are growing larger in recent IAM series, but they remain within family for the trend. The 2019 Fall IAM#66 exhibited relatively high duty cycles similar to 2018 IAM#59. FOT has correlated duty cycle spikes to excess negative pitch commanding during slew out.



Aqua Spring 2020 IAM Campaign Planning (1/2)

- The Aqua Spring 2020 IAM plan consists of 4 inclination maneuvers
- Aqua's predicted ideal burn date occurs around March 12, 2020
- Proposed plan has 1 maneuver occurring before the ideal burn date, 1 on the ideal date, and 2 after
 - March 5 (IAM #67)
 - March 12 (IAM #68)
 - March 19 (IAM #69)
 - March 26 (IAM #70)
- The updated campaign plan reduces the number of Spring 2020 IAMs from 6 to 4 to accommodate the new bi-annual inclination maneuver schedule.
 - Two maneuvers are planned for the Fall 2020 IAM campaign in addition to the Spring 2020 IAMs.

Aqua Spring 2020 IAM Campaign Planning (2/2)

- Aqua plans to transition from thruster slewed inclination maneuvers to using the reaction wheel assembly (RWA) to slew for the 2020 series.
 - Aura successfully transitioned to using wheel slewed maneuvers in the Spring 2019 series.
 - Analysis, simulations, and testing is currently ongoing.
 - A reaction wheel slewed test was executed on November 14, 2019
 - An alternate plan was generated using all thruster slewed maneuvers as contingency.

Proposed Aqua/Aura 2020 Maneuver Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
February 23	24	25	26	27	28	29
March 1	2	3	4 Aura IAM#64	5 Aqua RWA slewed IAM#67	6	7
8	9	10	11 Aura IAM#65	12* Aqua RWA slewed IAM#68	13	14
15	16	17	18 Aura IAM#66	19 Aqua RWA slewed IAM#69	20**	21
22	23	24	25 Aura IAM#67	26 Aqua RWA slewed IAM#70	27	28
29	30	31	April 1 Aura Back-up	2 Aqua Back-up	3	4
5	6	7	8	9	10	11

* Aqua ideal RWA slewed date on March 12

** Spring Equinox on March 20

*** Golden Week in Japan starts April 29

Predicted Maneuver Performance – Reaction Wheel Slewed

Inc #	Date	Commanded Yaw* (deg)	Duration (sec)	Delta SMA** (m)	Delta Inclination (deg)	Delta RAAN (deg)	Delta Velocity (m/s)
67	Mar 05	-75.65	560	-10.21793	-0.00637	-0.00001	0.84870
68	Mar 12	-75.65		-8.65430	-0.00631	-0.00001	0.84057
69	Mar 19	-75.65		-7.37410	-0.00624	-0.00001	0.83136
70	Mar 26	-75.65		-6.55405	-0.00617	-0.00001	0.82181
				Total:	-0.02509		

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

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

Proposed Aqua/Aura 2020 Thruster Contingency Maneuver Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
February 23	24	25	26 Aura IAM#64	27 Aqua thruster slewed IAM#67	28	29
March 1	2	3	4 Break week	5	6	7
8	9	10	11 Aura IAM#65	12 Aqua thruster slewed IAM#68	13	14
15	16	17	18 Aura IAM#66	19 Aqua thruster slewed IAM#69	20*	21**
22	23	24	25 Aura IAM#67	26 Aqua thruster slewed IAM#70	27	28
29	30	31	April 1 Aura Back-up	2 Aqua Back-up	3	4
5	6	7	8	9	10	11

* Spring Equinox on March 20
 ** Aqua ideal thruster slewed date on March 21
 *** Golden Week in Japan starts April 29

Predicted Maneuver Performance – Thruster Slew

Inc #	Date	Commanded Yaw* (deg)	Duration (sec)	Delta SMA** (m)	Delta Inclination (deg)	Delta RAAN (deg)	Delta Velocity (m/s)
67	Feb 27	-93.50	560	-16.72029	-0.00728	0.00135	1.20587
68	Mar 12	-93.50		-0.92205	-0.00730	0.00058	1.19853
69	Mar 19	-94.00		-4.13246	-0.00722	0.00018	1.18841
70	Mar 26	-94.00		0.18716	-0.00716	-0.00020	1.18025
				Total:	-0.02896		

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

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

Summary

- The 2019 Fall IAM series exhibited the same degrading performance observed in the Spring IAM series.
 - Further investigation by FDS and FOT is underway
- 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 (4 Spring, 2 Fall) and is predicted to push Aqua low in its MLT box prior to the 2021 series.
- The predicted 2020 IAM series may be updated after further analysis of the observed 2019 Fall IAM series performance.
 - FDS is currently investigating options to keep Aqua in constellation through May 2022.