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International Earth Science Constellation

Mission Operations Working Group

September 27-29, 2016

Aqua Spring 2017 IAM Series

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Agenda

- Recap Aqua 2016 IAM Campaign
 - Maneuver Results
 - Post-2016 IAM MLT Evolution
- Current DMU Strategy
- 2017 IAM Campaign Dates and Planning
- Aqua Latest Lifetime MLT Term Predictions

Aqua Spring 2016 Series Summary

- Aqua performed four (4) inclination maneuvers on March 9th to April 19th
- The maneuvers were re-planned to adjust the slew angles to account for changes in the solar flux predictions seen closer to the start of the IAM series.
 - There was a 30-40% decrease in predicted average atmospheric density between May 2015 Meannom Schatten predict (used for original planning) and Nov 2015 Meannom Schatten predict (used to re-plan)
 - Large slew angles were required; these provided a larger decrease in semimajor axis so the ground track error could be maintained within limits during and after the INC series
 - There was little/no change in the delta-i values
- The larger yaw angles required some adjustments to the timing of the commanding; the flight operations team was able to adjust the commanded timing to accommodate the longer slew times.

Initial Plan; Re-plan; Actual*

Inc #	Date	Commanded Yaw Angle (deg)	Delta SMA (m)	Burn Dur. (sec)	Delta - Inc (deg)	Delta - RAAN (deg)
48	9-Mar-16	-84.4	47.40	550	-0.00845	0.00150
49	16-Mar-16	-84.5	46.93	550	-0.00847	0.00105
50	6-Apr-16	-84.2	60.40	550	-0.00849	-0.00031
51	20-Apr-16	-84.8	42.56	550	-0.00839	-0.00112
				Totals:	-0.033805	0.00111

Inc #	Date	Commanded Yaw Angle (deg)	Delta SMA (m)	Burn Dur. (sec)	Delta - Inc (deg)	Delta - RAAN (deg)
48	9-Mar-16	-85.0	41.2550	550	-0.008627	0.001388
49	16-Mar-16	-85.0	44.5000	550	-0.008509	0.000999
50	6-Apr-16	-88.0	-55.4000	550	-0.008509	-0.000596
51	19-Apr-16	-89.5	-64.29	550	-0.008163	-0.001224
				Totals:	-0.033808	0.000567

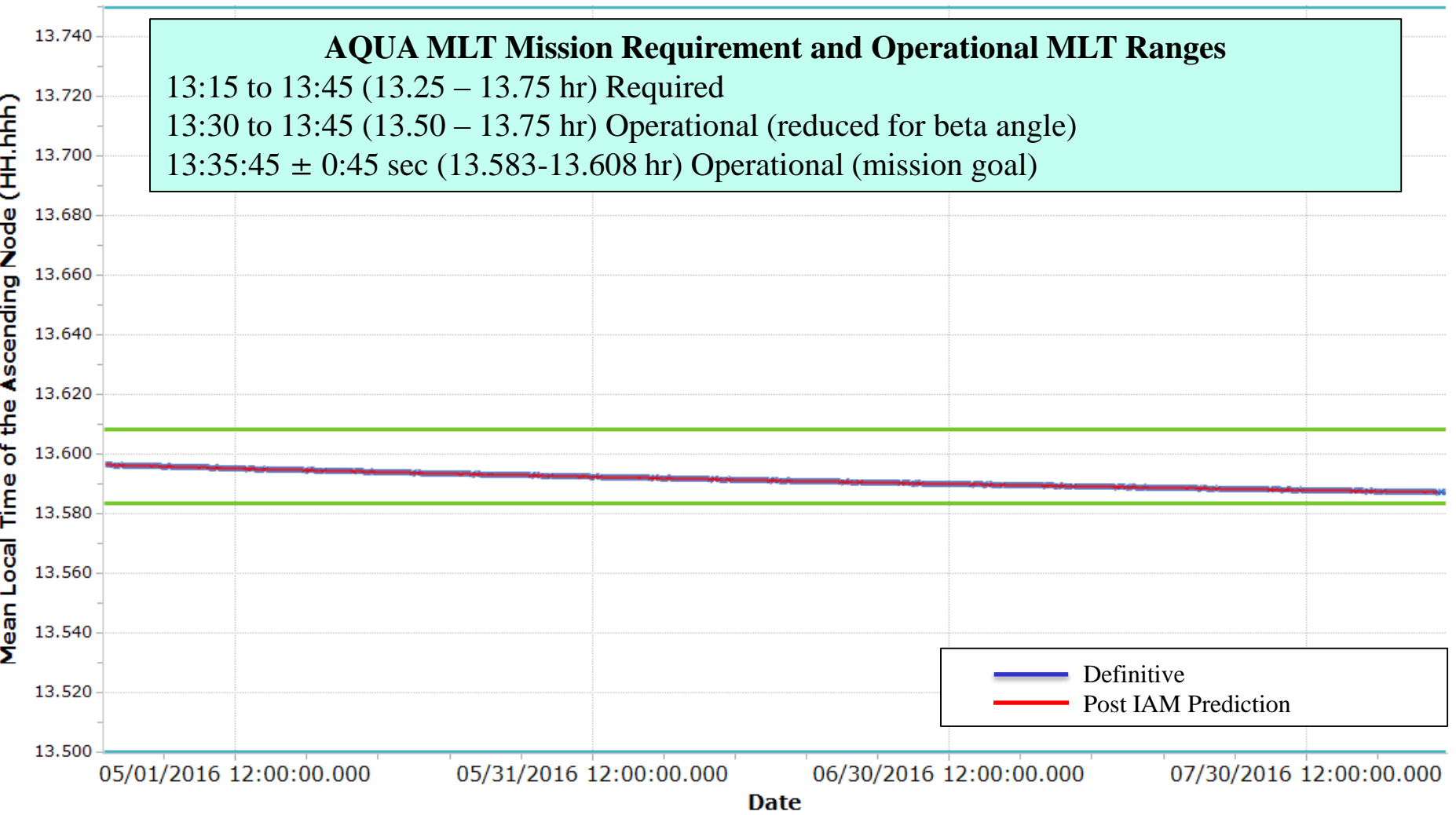
Inc #	Date	Commanded Yaw Angle (deg)	Delta SMA (m)	Burn Dur. (sec)	Delta - Inc (deg)	Delta - RAAN (deg)
48	9-Mar-16	-85.0	38.8000	550	-0.0085375	0.00129
49	16-Mar-16	-85.0	51.3000	550	-0.0084830	0.00100
50	6-Apr-16	-88.0	-10.2500	550	-0.0084325	-0.00097
51	19-Apr-16	-89.5	-69.50	550	-0.0083600	-0.00174
				Totals:	-0.033813	-0.00042
				Diff from Orig.	-0.023665138%	
				Diff from Exp.	-0.014789399%	

* Source: Performance Analysis, Ryan Moore

Aqua Post-2016 Series Predicted and Definitive MLT

Aqua Mean Local Time: Predicted vs Definitive

Displayed data is culled!

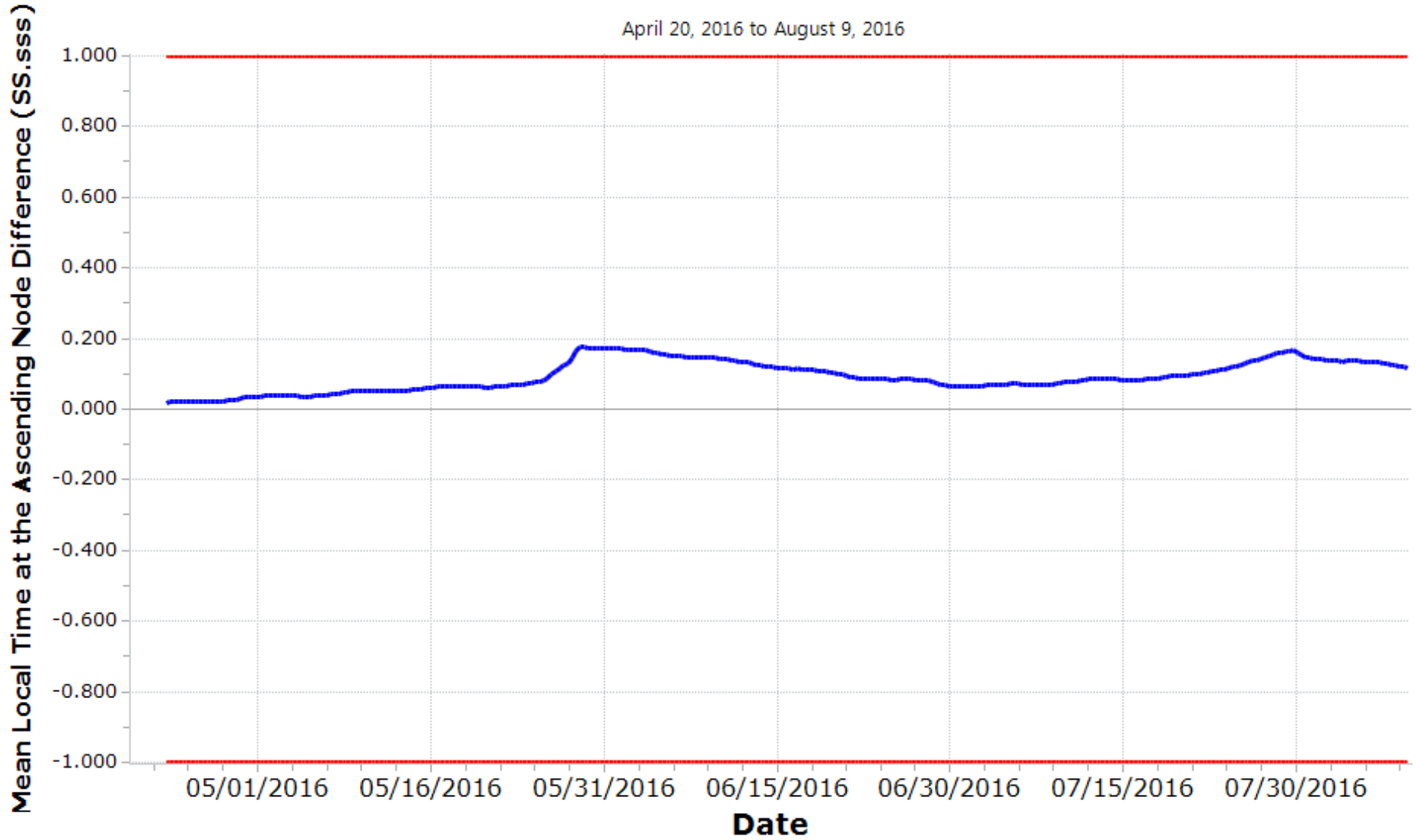


Aqua Predicted and Definitive MLT Difference

Post-2016 IAM Series MLT: Predicted minus Definitive

Displayed data is culled!

April 20, 2016 to August 9, 2016



Post-INC Series DMU Strategy

- Aqua (and Aura) continue to perform no-slew maneuvers using the mirror pole strategy.
- They operate using a hybrid maneuver scheme
 - DMU maneuvers are nominally performed at alternating pole locations
 - RMM locations are dictated by conjunction timing and geometry
 - 1 (or more) frozen orbit maneuvers are added per year (near the end of the calendar year) to maintain frozen orbit requirements
- With the current low-drag environment, they are using a modified targeting scheme now:
 - a four week DMU tempo is being utilized for maneuver planning
 - GTE controlled near the top of the control box
 - allows room to execute RMMs and remain in the control box



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Post INC Series Aqua DMUs to Date



DMU #	DMU Maneuver Type	Date
107	No-Slew Mirror Pole – South	May 25, 2016
108	No-Slew Mirror Pole – North	June 29, 2016
109	No-Slew Mirror Pole – South	July 21, 2016
110	No-Slew Mirror Pole – North (planned)	August 25, 2016

Aqua Spring 2017 IAM Campaign Planning

- The Aqua Spring 2017 IAM plan consists of four (4) inclination maneuvers
- Proposed plan has 3 maneuvers occurring before the ideal burn date and 1 after
 - March 1
 - March 8
 - March 22
 - March 29
- Aqua's predicted ideal burn date occurs around March 24, 2017
- Gap between burns 2 and 3 provides buffer for re-planning, contingencies, etc.

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

Proposed Aqua/Aura 2017 Maneuver Schedule

Aqua/Aura 2017 Inclination Maneuver Series Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			March 1 Aqua IAM#52	2 Aura IAM#49	3	4
5	6	7	8 Aqua IAM#53	9 Aura IAM#50	10	11
12 Full Moon*	13	14	15	16	17	18
19	20 Equinox	21	22 Aqua IAM#54	23 Aura IAM#51	24 Ideal date (delta-i centered at node crossing)	25
26	27	28	29 Aqua IAM#55	30 Aura IAM#52	31	April 1
2	3	4	5 Aqua Backup	6 Aura Backup	7	8
9	10	11	12	13	14	15
16 Easter Sunday	17	18	19 [-----]	20 A-Train Science Symposium	21 [-----]	22**

*Aura MLS Moon Scan to be scheduled

**Japan Golden Week starts April 29

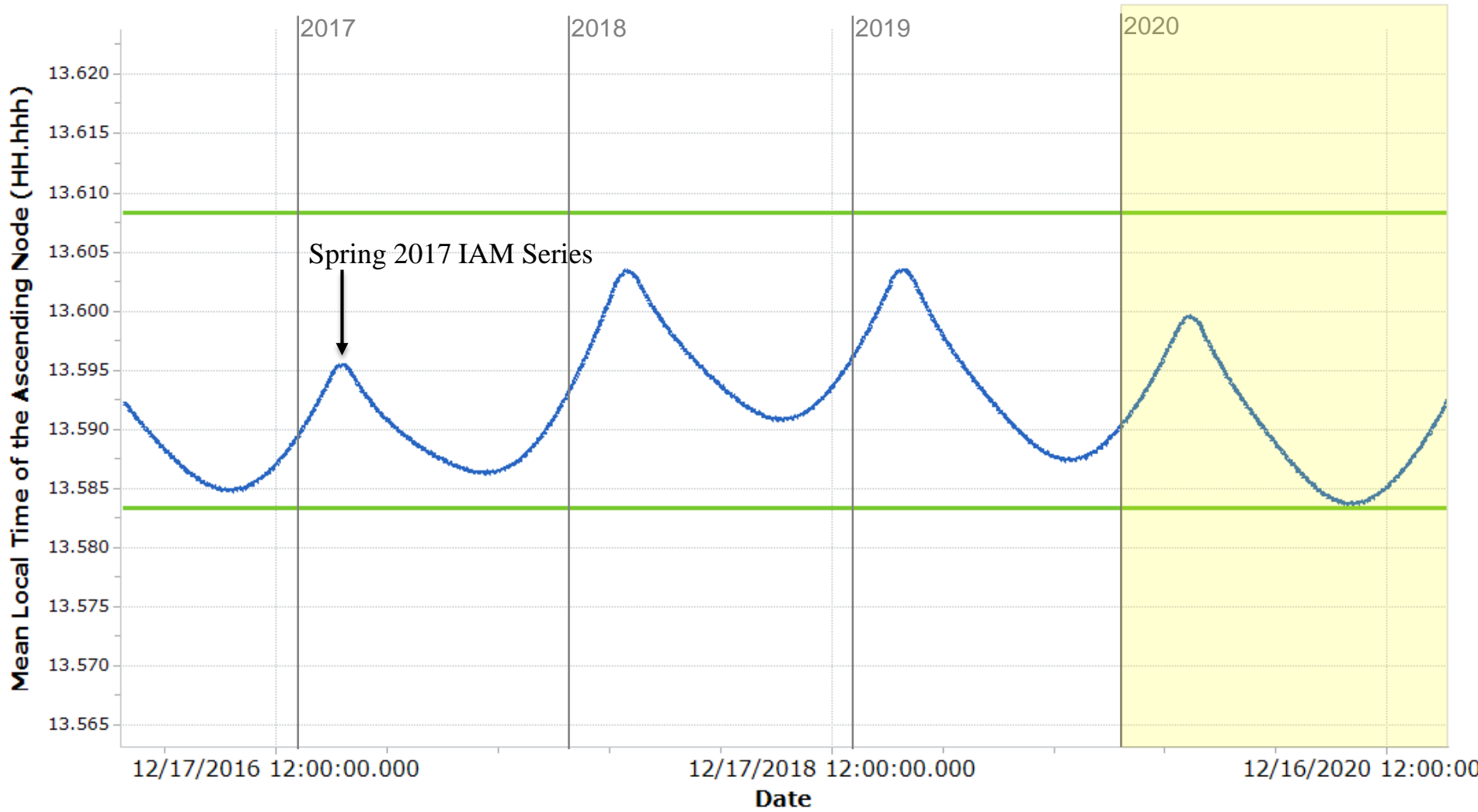
Predicted Pre- and Post-2017 IAM MLT



Lifetime MLT Based on Planned INC Strategy*

Aqua Mean Local Time

Displayed data is culled!



* Source: Lifetime Results, Draft Aqua Decommissioning Analysis, 30-Jun-2016, Juan Ojedo Romero and Waqar Zaidi

Backup

- Results for Alternate Planning Dates for the 2017 Campaign

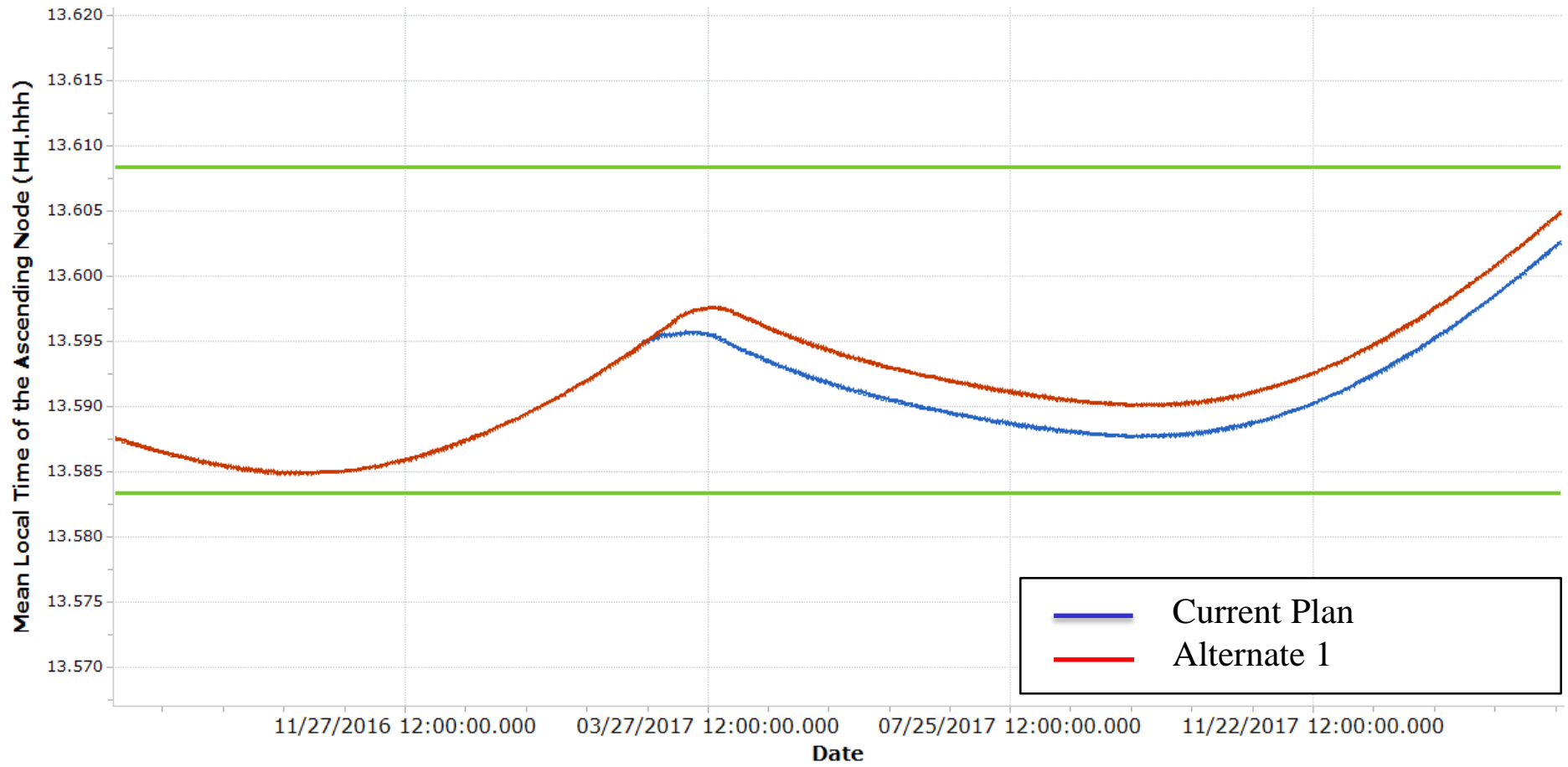
Comparison of Alternate Planning Dates

Plan	Maneuver Date	Duration (sec)	Delta-i (deg)	Total Inclination Change (deg)	Percent Difference
Current Plan	March 1, 2016	550	-0.008289		
	March 8, 2016	550	-0.008311		
	March 22, 2016	550	-0.008325		
	March 29, 2016	550	-0.008278	-0.033203	n/a
Alternate 1 (burns slightly more centered relative to ideal date)	March 15, 2016	550	-0.008394		
	March 22, 2016	550	-0.008370		
	March 29, 2016	550	-0.008319		
	April 05, 2016	550	-0.008249	-0.033332	+0.4%
Alternate 2 (no gap; all burns prior to ideal date)	March 1, 2016	550	-0.008289		
	March 8, 2016	550	-0.008311		
	March 15, 2016	550	-0.008307		
	March 22, 2016	550	-0.008284	-0.033191	-0.04%

Current Plan vs. Alternate 1

Aqua Mean Local Time

Displayed data is culled!



Current Plan vs. Alternate 2

Aqua Mean Local Time

Displayed data is culled!

