International Earth Science Constellation
Mission Operations Working Group
December 6-8, 2017
Aqua/Aura Inclination Adjust Maneuver Series
Spring 2018 Planning
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Mission Operations Working Group
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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 ($\Delta$SMA) and $\Delta$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 $\Delta$I would increase to $-0.04120^\circ$
  - Burn duration decreased to 560.0 seconds to better match previous value
    - Predicted $\Delta$I: $-0.04086^\circ$
    - Duty cycles trended from 550.0 second burn duration
      - Burn duration may change to meet advertised $\Delta$I
• 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
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 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 $\Delta I$ (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

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
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<td>20 Equinox</td>
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<td>Aura Ideal Date</td>
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<td>April 1</td>
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*Japan Golden Week starts April 29*
### 2018 Predicted Maneuver Performance*

<table>
<thead>
<tr>
<th>IAM #</th>
<th>Date</th>
<th>Target Yaw Angle (deg)</th>
<th>Burn Duration (sec)</th>
<th>Delta-V (m/sec)</th>
<th>Delta-SMA (m)</th>
<th>Delta-Inc (deg)</th>
<th>Delta-RAAN (deg)</th>
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<td>-86.58</td>
<td>560.00</td>
<td>1.290616</td>
<td>4.394</td>
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<td>1.281771</td>
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**Total Delta-**

**Inc (deg)**

-0.04086, 0.001047

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<tr>
<th>IAM #</th>
<th>Date</th>
<th>Target Yaw Angle (deg)</th>
<th>Burn Duration (sec)</th>
<th>Delta-V (m/sec)</th>
<th>Delta-SMA (m)</th>
<th>Delta-Inc (deg)</th>
<th>Delta-RAAN (deg)</th>
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**Total Delta-**

**Inc (deg)**

-0.04271, 0.002945

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

Constellation Requirement: 13:30:00 ± 15 min
Operational Requirement: 13:35:00 – 13:36:30
Aura Predicted Pre- and Post-2018 IAM MLT

Aura Mean Local Time

MLT of the Ascending Node (hr)

Date

11/22/2017  02/20/2018  05/21/2018  08/19/2018  11/17/2018

2018

2019
Aqua-Aura Lifetime MLT Phasing Based on Planned IAM Strategy

Aqua-Aura Phasing

Constellation Requirement: 8.5 min ±0.25 min
Operational Requirement: 8.61 min – 8.68 min
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 $\Delta I$ of $-0.04086^\circ$ is slightly more than Spring 2017 prediction of $-0.04083^\circ$