Aqua/Aura
QuickDAM (QDAM) 2.0 Ops Concept

John Nidhiry
Flight Operations Team
June 3, 2015
QDAM Goals

• Reduce work load and dependency on staff and systems.
  – Enhance capabilities so that repetitive processes are not necessary for every option.
  – Streamline process so that unnecessary preparation steps, systems, personnel are not needed.

• Reduce turn-around time and provide emergency last minute capabilities.
  – With Drag Make Up (DMU) and Risk Mitigation Maneuver (RMM) flow, all steps must be completed, in order to execute a burn.
  – Create a streamlined and safe process to be able to prepare for RMMs with minimal time so that the Flight Operations Team (FOT) does not have to ‘gear up’ for every plausible RMM scenario.
  – This would also save the FOT from having to ‘waive off’ RMMs where the threat self-mitigates.

• Increase burn parameter flexibility.
  – Execution time of burn and burn duration are fixed in stored command sequence (SCS).
  – In RMM scenarios, sometimes last minute tracking updates cause a desired change in burn parameters.
Summary of Previous RMM Capability Enhancements

• Manual Instrument Commanding for Aqua
  – SCSs were developed that would allow the FOT to configure two instruments (CERES and AIRS) without having to place the commands in the daily stored command load built two days before the maneuver date.
  – This allowed more flexibility in changing the time of maneuver.
  – This also gave the capability to execute a maneuver with less warning and preparation time.

• No Slew DMUs and RMMs
  – In 2012 the FOT developed a method of conducting DMUs and RMMs without performing the wheel based yaw slew maneuver necessary to align the thrusts with the orbital velocity vector before hand.
  – By eliminating the slew out and slew back, the DMU and RMM sequence was greatly simplified, making it easier to plan multiple options, requiring less contacts and load building.
• QDAM 2.0 is actually the 5th generation operational RMM enhancement implemented.
  – Variable Burn Duration (VBD) Slewed version
  – QDAM 1.0 Slewed version
  – Variable Burn Duration (VBD) No-Slew version
  – QDAM 1.0 No-Slew version
  – QDAM 2.0 (No-Slew)

• QDAM 2.0 Key Enhancements over QDAM 1.0
  – There were 3 critical drawbacks with the QDAM 1.0 No-Slew version presently onboard.
    1 - A communications contact was needed to execute the burn, limiting options, and making obtaining communications contacts a critical step.
    2 - The burn would execute at an imprecise time whenever command was sent real-time.
    3 - Only pre-canned burn durations were available, limiting burn size fidelity.

  – These key drawbacks made QDAM 1.0 an emergency only option and was never utilized.

• QDAM 2.0 Key Enhancements over VBD
  – More flexibility to change the burn duration at time of execution.
  – Reduced the number of SCSs required if many different durations were being at any same start time.
  – Pre-canned options were no longer limited.
SCS Background

- From DMU to DMU, there are only two things in the custom built SCS that vary.

- Absolute time delay, 32-bit unsigned integer in GIRD epoch seconds.

- The burn duration (BD), 32-bit floating point.
QDAM 1.0 Concept

- Replaced the first absolute time delay with a no-op. So SCS runs as soon as its activated.

- Replaced burn duration command with a call to another ‘sub’-SCS. There are multiple versions of this sub-SCS with different burn durations that user can uplink.
Since QDAM 1.0 had the critical flaws that made it an emergency only option, it was desired to make a new concept that can be used for all DAMs.  

- It was proposed that a memory write command could be used to overwrite the absolute time and burn duration memory with whatever the user wants.  

- However memory write commands cannot overwrite “protected memory” areas; such as SCSs, algorithms.  

- In response, the ground system maintenance contractor (Raytheon) created a new ground system command that mimicked a memory load.  

- The FOT has completed testing on these commands.
New vs Old DAM Flows
Past Nominal RMM vs Quick DAM 2.0 Planning Flows

Past Nominal RMM Flow

1. CARA, FDS, FOT, ESMO Decide Burn Options (~1-2 days before RMM)
2. GNC Delivers Maneuver Plan (~1-2 days before RMM)
3. INST Notifies IOTs (~1-2 days before RMM)
4. COMM Requests Critical Contacts (~1-2 days before RMM)
5. COMM Verifies Critical Contacts (~1-2 days before RMM)
6. COMM Verifies MCL Commanding (~1-2 days before RMM)
7. FDS Delivers DMU Products to RMS (~1-2 days before RMM)
8. GNC and CM Build Maneuver SCSs (~1-2 days before RMM)
9. GNC and FSW Verify Maneuver SCSs (~1-2 days before RMM)
10. CM Delivers Maneuver SCSs to Online (~1-2 days before RMM)
11. FOT Prepares DMU Day Plan, CAM & PPCRs (~1 day before RMM)
12. FOT Executes RMM Maneuver

Quick DAM 2.0 Flow

1. CARA, FDS, FOT, ESMO Decide GDAM Burn Options (~2 days before GDAM)
2. GNC Notifies FOT and Delivers Maneuver Plan (~2 days before GDAM)
3. INST Notifies IOTs (~1-2 days before GDAM)
4. COMM Requests Critical Contacts (~1-2 days before GDAM)
5. COMM Verifies Critical Contacts (~1-2 days before GDAM)
6. COMM Verifies MCL Commanding (~1-2 days before GDAM)
7. GDAM Prepares DMU Day Plan, CAM & PPCRs (~1 day before GDAM)
8. GDAM Executes GDAM Maneuver

All burn time options must satisfy instrument and comm constraints.

These 4 steps repeated for each option.

Contacts will not be as critical but should be obtained when possible.
Past Nominal RMM vs Quick DAM 2.0 Execution Flows

Past Nominal RMM Flow

- Step One: FOP 4.901
  - FOP Check "C" from RD to Execute DMR
  - Day before DMR
  - GNC
  - FSW

- Step Two: GNC Evaluates
  - SCS Cleaning PCCP (HR)
  - Step Three: FOP Exercises
    - Maneuver GO PCCP (HR)
    - 2 Contacts before DMR

- Step Four: DMU Maneuver
  - GNC
  - Attitude and Propulsion Performance

- Step Five: GNC Evaluates
  - GNC, Clean up PCCP (HR)
  - Contacts after DMU

- Step Six: FOP Exercises
  - DMU, Carry Out File
  - Contacts after DMU

- Step Seven: SCS Clean up PCCP (HR)
  - Contacts after DMU

- Step Eight: FSD Check up PCCP (HR)
  - Contacts after DMU

Quick DAM 2.0 Flow

- Step One: FOP 4.903
  - FOP Core "GO" from RD to Execute QDAM
  - Day before QDAM
  - GNC
  - FSW

- Step Two: GNC Evaluates
  - Propulsion Setup PCCP (HR)
  - Step Three: FOP Exercises
    - Maneuver GO PCCP (HR)
    - 2 Contacts before QDAM

- Step Four: QDAM Maneuver
  - GNC
  - Attitude and Propulsion Performance

- Step Five: GNC Evaluates
  - GNC, Clean up PCCP (HR)
  - Contacts after QDAM

- Step Six: FOP Exercises
  - DMU, Carry Out File
  - Contacts after QDAM

- Step Seven: GNC and FSW Evaluates QDAM Params
  - Clean up PCCP (HR)
  - Contacts after QDAM

- Step Eight: FSD Check up PCCP (HR)
  - Contacts after QDAM

- Step Nine: GNC and FSW Exercises QDAM Params
  - Carry Out File

- Step Ten: GNC and FSW Exercises QDAM Params
  - Before Change of DIF
  - Contacts after QDAM
Original RMM vs Quick DAM 2.0
Execution Timeline

Original RMM

- Real Time Setup Commanding
- Instruments Configure (Aqua)
- Slew Out to ~14° Yaw
- ~2-20 min

Quick DAM 2.0

- Real Time Setup Commanding
- Instruments Configure (Aqua)
- Change to Thruster Mode and Burn
- ~3 min

Timeline:

- 1-2 hrs
- 2-4 hrs
- ~9 min
- 10 - ~30 min
- 10 - ~30 min
- 10 - ~30 min
- ~1-1.75 hrs
## RMM Capability History

### Past RMM Concepts

<table>
<thead>
<tr>
<th></th>
<th>Pre 2012 (Original RMM)</th>
<th>2012-2014 (Nominal RMM)</th>
<th>2012-2014 (Emergency RMM)</th>
<th>Current (Quick DAM 2.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shortest Turn Around</strong></td>
<td>24-48 Hours</td>
<td>~6-12 hours</td>
<td>~2-6 hours</td>
<td>~2-6 hours</td>
</tr>
<tr>
<td><strong>Burn Parameter Flexibility</strong></td>
<td>~12 hours out, complete fidelity</td>
<td>Last minute, reduced fidelity</td>
<td>Last minute, imprecise start time, reduced fidelity</td>
<td>Last minute, complete fidelity</td>
</tr>
<tr>
<td><strong>Precise Burn Time</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Personnel</strong></td>
<td>FDS, CM, GNC, INST, FSW</td>
<td>FDS, CM, GNC, INST, FSW</td>
<td>GNC, INST, FSW</td>
<td>GNC, INST, FSW</td>
</tr>
<tr>
<td><strong>Systems Required</strong></td>
<td>FDS, MMS, EMOS</td>
<td>FDS, MMS, EMOS</td>
<td>EMOS</td>
<td>EMOS</td>
</tr>
<tr>
<td><strong>SCSs to Build</strong></td>
<td>3 per burn time/duration option</td>
<td>1 per burn time option</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Burn Contact Required</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Total Planning SOP Steps</strong></td>
<td>12 (4 repeated for every option)</td>
<td>12 (4 repeated for every burn time option)</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

*All turn around times, systems and personnel listed are in reference to FOT operational constraints/requirements.*