1- Observatory Assessment

2- Orbit Dynamics Assessment
1- Observatory Assessment

2- Orbit Dynamics Assessment
## Observatory Current Status

<table>
<thead>
<tr>
<th>OBSERVATORY</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVICE PLATFORM</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>AQUARIUS</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>MWR</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>HSC</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>DCS</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>TDP</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>CARMEN-1</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>ROSA</td>
<td>Working Nominally</td>
</tr>
<tr>
<td>NIRST</td>
<td>Mirror Calibration Pending</td>
</tr>
<tr>
<td></td>
<td>Working Stable (w/4 Formats per week)</td>
</tr>
</tbody>
</table>
Observatory Commissioning Assessment

During Commissioning Phase:

1) All the Service Platform Subsystem were commissioned Successfully.

2) Aquarius Instrument was commissioned Successfully.

3) All the SAC-D Instruments were turned on, tested and started operations.

4) The Orbit was acquired successfully (full compliant with requirements).

5) The process to execute the CSC (Clod Sky Calibration) was validated successfully.

6) The process to upload a software patch was executed successfully (AQ case)
7) The Operations scheme demonstrated enough robustness to deal with the intense level of activity that was needed during the commissioning phase (we attend approx. 1700 passes in the first four months, around 110% of what is needed in a whole year of nominal operations).

8) The FOT have been able to deal safely with all occurred S/P flight anomalies and to adjust the S/P configuration in order to accomplish the S/P commissioning objectives.

9) GS systems and its Operations performed nominally meeting all requirements and with no open liens.
Observatory Nominal Operations Assessment

Nominal Operations:

1) We move to this phase on October 24\textsuperscript{th} (2011).

2) From that day we are operating nominally using ETC and IMT for the nominal operations and NEN only for maneuvers, CSC and emergencies.

3) We are performing periodically orbit maintenance maneuver activities. Approximately one every 45 days.

4) We are performing periodically CSC maneuvers.
Observatory Nominal Operations Assessment

During Nominal Operation Nominally we are performing approximately the following Activities on a weekly basis:

1) 29 X-Band Downloads (Science Downloads)

2) 28 S-Band Contacts for Activities Upload and Status verification

3) Aquarius, MWR, CARMEN-1 and ROSA are continuously acquiring data

4) TDP is continuously acquiring data without its GPS data

5) NIRST 56, DCS 14 and HSC 12 Acquisitions
1- Observatory Assessment

2- Orbit Dynamics Assessment
## Nominal Orbit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equatorial altitude</td>
<td>657 km</td>
<td>+/- 1.5 km</td>
</tr>
<tr>
<td>Groundtrack kept within Equator Grid</td>
<td>Equator Grid</td>
<td>+/- 20 km</td>
</tr>
<tr>
<td>Mean Semi-major axis</td>
<td>7028.871 km</td>
<td>+/- 1.5 km</td>
</tr>
<tr>
<td>Mean Eccentricity</td>
<td>0.0012</td>
<td>+/- 0.0001</td>
</tr>
<tr>
<td>Mean Inclination</td>
<td>98.0126 deg</td>
<td>+/- 0.001 deg</td>
</tr>
<tr>
<td>Mean Local Mean Time of Ascending Node</td>
<td>06:00:00 PM</td>
<td>+/- 5 min</td>
</tr>
</tbody>
</table>
Orbit Maneuvers

- Orbit Acquisition
  - Maneuver Calibration
  - Removal of Launcher injection errors

- Orbit Maintenance
  - Keep orbit within established limits
Orbit Acquisition Phases

- Orbit Acquisition divided in three phases in relation to Instruments Commissioning:

  - **First Phase** – Initial Tests & Calibrations
    - Collision Avoidance Calibration

  - **Second Phase** – Prior to Instruments Commissioning
    - Launcher Height Injection Errors Correction

  - **Third Phase** – Post Instruments Commissioning
    - Launcher Inclination Injection Errors Correction
First Phase – Initial Tests & Calibrations

- Short Burn to test on the Propulsion System Performance
- Collision Avoidance Maneuvers Calibration
  » Posigrade & Retrograde
- Total of 7 Burns

<table>
<thead>
<tr>
<th>Burn Start</th>
<th>Duration [s]</th>
<th>Type</th>
<th>DV[m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-07-24</td>
<td>3</td>
<td>Posigrade</td>
<td>0.00815</td>
</tr>
<tr>
<td>2011-07-26</td>
<td>5</td>
<td>CAM Posigrade</td>
<td>0.01018</td>
</tr>
<tr>
<td>2011-07-26</td>
<td>5</td>
<td>CAM Posigrade</td>
<td>0.01018</td>
</tr>
<tr>
<td>2011-07-28</td>
<td>5</td>
<td>CAM Posigrade</td>
<td>0.01018</td>
</tr>
<tr>
<td>2011-07-28</td>
<td>5</td>
<td>CAM Posigrade</td>
<td>0.01018</td>
</tr>
<tr>
<td>2011-07-30</td>
<td>5</td>
<td>CAM Retrograde</td>
<td>0.01018</td>
</tr>
<tr>
<td>2011-07-30</td>
<td>5</td>
<td>CAM Retrograde</td>
<td>0.01018</td>
</tr>
</tbody>
</table>
Orb. Acq. 2\textsuperscript{nd} Phase: Height Adjustment

- Second Phase – Prior to Instruments Commissioning
  - Correction of Launcher Height Injection Errors
  - Reduction of the ground track drift rate
  - Ground Track inside nominal deadband
  - Approach to Frozen Orbit conditions
  - Short Out of Plane Burn Test for System Performance
  - Total of 3 Burns

<table>
<thead>
<tr>
<th>Burn Start</th>
<th>Duration [s]</th>
<th>Type</th>
<th>DV [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-08-05</td>
<td>42</td>
<td>Retrograde</td>
<td>0.08553</td>
</tr>
<tr>
<td>2011-08-07</td>
<td>116</td>
<td>Retrograde</td>
<td>0.24038</td>
</tr>
<tr>
<td>2011-08-09</td>
<td>8</td>
<td>Out of Plane</td>
<td>0.01659</td>
</tr>
</tbody>
</table>
Orb. Acq. 3\textsuperscript{rd} Phase: Inclination & Final Acquisition

- Third Phase – Post Instruments Commissioning
  - Height fine tuning
  - Keep Ground Track inside longitude deadband
  - Correction of Launcher Inclination Injection Errors
  - Collision Avoidance Maneuvers Re-calibration after Aquarius Boom Deployment
  - Frozen Orbit Conditions
  - Total of 7 Burns

<table>
<thead>
<tr>
<th>Burn Start</th>
<th>Duration [s]</th>
<th>Type</th>
<th>DV[m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-09-17</td>
<td>10</td>
<td>Retrograde</td>
<td>0.02444</td>
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<tr>
<td>2011-09-21</td>
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<td>Out of Plane</td>
<td>0.09775</td>
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<tr>
<td>2011-09-27</td>
<td>46</td>
<td>Out of Plane</td>
<td>0.11241</td>
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<tr>
<td>2011-10-01</td>
<td>17</td>
<td>Out of Plane</td>
<td>0.04155</td>
</tr>
<tr>
<td>2011-10-07</td>
<td>4</td>
<td>CAM Posigrade</td>
<td>0.00978</td>
</tr>
<tr>
<td>2011-10-12</td>
<td>4</td>
<td>CAM Retrograde</td>
<td>0.00978</td>
</tr>
<tr>
<td>2011-10-15</td>
<td>17</td>
<td>Posigrade</td>
<td>0.04155</td>
</tr>
</tbody>
</table>
Orbit Maintenance

- Goals
  - Keep orbit parameters within margins
    - Ground Track
    - Descending Node Height
    - Eccentricity
    - Argument of Perigee
    - Mean Local Time at Ascending Node
  - Perform Conjunction Avoidance Maneuvers if needed
- Performed so far: 5 Burns

<table>
<thead>
<tr>
<th>Burn Start</th>
<th>Duration [s]</th>
<th>Type</th>
<th>DV[m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-11-11</td>
<td>40</td>
<td>Maintenance</td>
<td>0.09776</td>
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<tr>
<td>2011-11-16</td>
<td>26</td>
<td>Maintenance</td>
<td>0.06354</td>
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<tr>
<td>2011-12-14</td>
<td>43</td>
<td>Maintenance</td>
<td>0.10509</td>
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<tr>
<td>2012-03-02</td>
<td>42</td>
<td>Maintenance</td>
<td>0.10264</td>
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<tr>
<td>2012-03-25</td>
<td>8</td>
<td>Maintenance/CAM</td>
<td>0.01955</td>
</tr>
</tbody>
</table>
Orbit Maint. Burns Assessment

• Maneuver Assessment
  • Performed after each Burn
  • Based on SAC-D Precise Orbit Determination
  • Observed performance is very close to nominal

<table>
<thead>
<tr>
<th>Burn Start</th>
<th>Planned [m]</th>
<th>Observed [m]</th>
<th>Performance %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-11-11</td>
<td>182</td>
<td>184</td>
<td>100.9</td>
</tr>
<tr>
<td>2011-11-16</td>
<td>119</td>
<td>120</td>
<td>100.9</td>
</tr>
<tr>
<td>2011-12-14</td>
<td>196</td>
<td>202</td>
<td>102.8</td>
</tr>
<tr>
<td>2012-03-02</td>
<td>192</td>
<td>194</td>
<td>101.4</td>
</tr>
<tr>
<td>2012-03-25</td>
<td>36</td>
<td>36</td>
<td>99.8</td>
</tr>
</tbody>
</table>
Delta V Evolution

**SAC-D/Aquarius**
Delta Velocity

Based on Predicted Thrust

**Total DV Allocation:** 73.85 m/s

Accumulated Delta Velocity [m/s]

Time

17 Apr 11  06 Jun 11  26 Jul 11  14 Sep 11  03 Nov 11  23 Dec 11  11 Feb 12  01 Apr 12  21 May 12
Fuel Consumption

SAC-D/Aquarius
Fuel Consumption

Based on Predicted Thrust

Fuel Mass
@ Launch:
65 kg

Accumulated Consumed Fuel [g]

17Apr11 06Jun11 26Jul11 14Sep11 03Nov11 23Dec11 11Feb12 01Apr12 21May12

Time
Orbit Evolution

SAC-D/Aquarius
Descending Node Ground Track

Ground Track – Daily Average [Km]

01Aug11  20Sep11  09Nov11  29Dec11  17Feb12  07Apr12  27May12
Orbit Evolution

SAC-D/Aquarius
Argument of Perigee

Argumet of Perigee – Daily Average [deg]

Time

17 Apr 11 26 Jul 11 03 Nov 11 11 Feb 12 01 Apr 12

06 Jun 11 14 Sep 11 23 Dec 11 21 May 12
Orbit Evolution

SAC-D/Aquarius Inclination

Inclination - Daily Average [deg]

17Apr11  26Jul11  03Nov11  11Feb12  21May12
06Jun11  14Sep11  23Dec11  01Apr12

Time

98.017
98.016
98.015
98.014
98.013
98.012
98.011
98.010
98.009
98.008
• CONAE Orbit Dynamics Services – CODS
  • responsible for the overall operations (f.i. products generation, maneuvers definitions) regarding the orbit of the CONAE satellites, including SAC-D

• CODS Daily Products include:
  • TLE, Ground Station Contacts, Orbit Events
  • Ephemeris (J2K, TOD, ECF)
    – Post Facto & Predicted, Dense
  • Interpolated Quaternions
  • Nodal Crossing Times

• CODS Maneuver Products include:
  • Maneuver definition
  • Maneuver Ephemeris
  • Maneuver Assessment
Orbit Dynamics Conclusions

- Orbit Acquisition Sequence Successfully Performed
  - Correction of Launcher Injection Errors
  - Total of 17 Burns performed
  - Nominal ground track achieved on Aug 7th
  - Inclination & Fine adjustment Burns completed Oct 15th
  - Induced 1st Maintenance Cycle

- Orbit Maintenance Operations Successful
  - Ground Track Longitude and Descending Node Height kept within margins
  - Frozen Orbit maintained within margins
  - Descending node MLT kept well within margins, with only a few seconds dispersion
  - Inclination kept in very close agreement to the nominal margins
  - Total of 5 burns performed so far

- CODS services operational