

International Direct Readout Meeting

June 21-24, 2016

EOS Mission Update

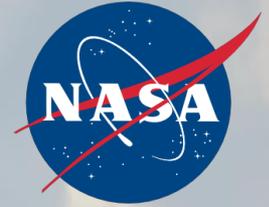
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Earth Science Mission Operations
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Direct Readout Systems Engineer
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Direct Broadcast/Direct Readout Overview



- **The Terra, Aqua, Aura Observatories downlink Direct Broadcast (DB) data in real-time to EOS Direct Readout (DR) Stations at 13/15/15 Mbps via X-Band, respectively**
 - Near Continuous Terra and Aqua DB
 - Terra and Aqua DB turned off when configured for a 150 Mbps X-Band Downlink to the Ground Network (GN).
 - » Aqua/Aura – 14.5 Polar GN Contacts (10-12 minutes) per day
 - » Terra: 2 Polar GN contacts per week
 - Terra DB is turned off when within Deep Space Network interference zones
- **Instruments providing Direct Broadcast data:**
 - **Terra: MODIS Instrument**
 - » Note: ASTER 105 Mbps High Rate data via Direct Downlink (DDL) has been tested, but is not in operational use.
 - **Aqua: AIRS, AMSU, CERES, and MODIS instruments**
 - **Aura: OMI instrument (only to the Finnish Ground station in Sodankyla, Finland)**



Terra Spacecraft Subsystem

(as of June 2016)



- Nominal Operations (Excellent Health)
- All Components remain on primary hardware with following exception:
 - Direct Access Modulator (X-Band) primary side failed in 2008. No impact to Nominal Operations
 - Battery Cell Failure (1 of 108). No impact to Nominal Operations
 - Battery Heater Control failure (effects 4 of 18 Heater Groups). No impact to Nominal Operations
 - Solar Array Panel Failure (1 of 24) in Sept 2000. No impact to Nominal Operations
 - Solid State Recorder Print Wire Assembly (PWA) Anomalies (10 of 59 PWA are offline)
 - Operationally able to manage ASTER Buffer by reducing ASTER data captured
 - Operationally able to manage MODIS/MISR buffer by increasing playback opportunities. Reaching operational limitation. 1-2 more PWA losses will result in intermittent data losses
 - Recycle of Memory Unit likely to recover all PWAs however not warranted at this time



Terra Instrument Summary

(as of June 2016)

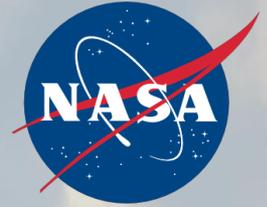


- **MODIS** – Nominal Operations (Excellent Health – loss of redundancy)
 - Power Supply Failure (June 2001). Switched to redundant. Single point of failure
 - Formatter Degradation (Sept 2002). Switched to redundant. Single point of failure
 - Screen Door Failure (May 2003). Remains permanently closed
 - Redundancy allows for Nominal Science
- **MISR** – Nominal Operations – (Excellent Health)
- **ASTER** – Nominal Operations (TIR and VNIR – Excellent Health, **SWIR – Failed**)
 - **SWIR – Compressor unable to maintain detector temperature after April 2008. No Science Data**
 - VNIR – Nominal Operation
 - TIR – Nominal Operation
- **CERES-FORE and AFT (FM-1 & FM-2)** – Nominal Operations (Excellent Health)
 - Cross-Track and Biaxial Modes fully functioning
 - All channels remain operational
- **MOPITT** – Nominal Operations. (Good Health – loss of redundancy)
 - Displacer-B Failure (May 2001). Operating Compressor B at reduced speed to minimize s/c disturbance
 - Chopper motor failure (August 2001)



Aqua Summary (Part 1 of 2)

(as of June 2016)

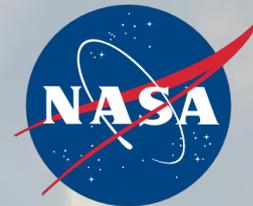


- **Spacecraft Bus – Nominal Operations (Excellent Health)**
 - All Components remain on primary hardware
 - 13 of 132 Solar Array Strings appear to have failed. Significant power generation margin remains
- **MODIS – Nominal Operations (Excellent Health)**
 - All voltages, currents, and temperatures as expected
 - All Components remain on primary hardware
- **AIRS – Nominal Operations (<5% of Channels degraded) – (Excellent Health)**
 - Cooler A Telemetry is frozen since March 28, 2014 to last known value. Not impacting Science
 - All other voltages, currents, and temperatures as expected
 - ~200 of 2378 channels are degraded due to radiation, however they are still useful
- **AMSU-A – Nominal Operations for 12 of 15 Channels (Good Health)**
 - All voltages, currents, and temperatures as expected
 - 3 of 15 channels have been removed from Level 2 processing



Aqua Summary (Part 2 of 2)

(as of June 2016)



- **CERES-AFT (FM-3) – Nominal Operations (Excellent Health)**
 - All voltages, currents, and temperatures as expected
 - Cross-Track and Biaxial Modes fully functioning
 - All channels remain operational
- **CERES-FORE (FM-4) – Nominal Operations (Good Health)**
 - All voltages, currents, and temperatures as expected
 - Cross-Track is Nominal. Biaxial Mode is Nominal when used
 - The Shortwave channel failed on March 30, 2005; the other two channels remain operational
- **AMSR-E – Configured for Survival Mode; (No Science)**
 - Antenna was spun down from 2 rpm to 0 rpm due to stall indications on December 4, 2015
 - Configured the instrument to Survival Mode on December 8, 2015
 - Turned off Instrument on March 3, 2016
- **HSB – Non-operational since February 2003 anomaly**



Aura Summary (Part 1 of 2)

(as of June 2016)

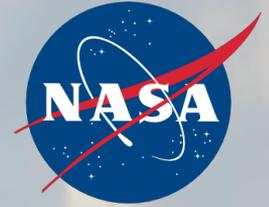


- **Spacecraft Bus** – Nominal Operations (Excellent Health)
 - 25 of 132 Solar Array Strings appear to have failed. No impact to operations
 - 11 strings failed during a Solar Array Panel disconnect anomaly
 - 6 strings failed during a Solar Array anomaly (possible Micro Meteoroid Orbital Debris)
 - 8 individual string failures
 - Formatter introduces noise. Currently accepted as is. Could reset or switch to redundant side
 - All Components remain on primary hardware
- **MLS** – Nominal Operations – (Excellent Health)
 - Band 12 and 13 turned off due to degradation
 - THz is only turned on for target of opportunity or performance checkout.
- **OMI** – Nominal Operations for 12 of 15 Channels (Good Health)
 - OMI Row anomaly (possible blockage?)



Aura Summary (Part 2 of 2)

(as of June 2016)

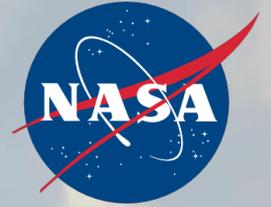


- **Tropospheric Emission Spectrometer (TES) – Degraded Operations (Poor Health)**
 - Mechanical wear on ICS Translator
 - ICS Translator has stalled on 6 occasions (Dec 2011, May 2015, twice in Aug 2015, Nov 2015 and Jan 2016)
 - Toroid bearing separator wear, bearing degradation & debris a likely cause
 - Stall will likely happen again
 - No longer perform Global Survey. Only perform Special Observations collecting up to 300 scans/day.
 - Laser A failed in July 2014
 - Laser B performance issues were causing data quality issues since July 2015.
 - Continue to adjust Laser B crystal temperature to stabilize frequency
 - Continue to adjust Laser B diode current to extend useful laser life
 - Laser life limited (less than 4 months)
 - Evaluating data collection using a simulated clock

- **HIRDLS – Failed**
 - Chopper Motor failure



Fuel Lifetime Estimates



Terra:

Flight Dynamics analysis indicates that Terra can continue science operations through ~ 2020 at current 705km orbit; through 2025 at lower orbit. Continuing to evaluate how to maximize science with remaining fuel.

Aqua:

Flight Dynamics analysis indicates Aqua can continue science operations through ~ 2021 at current 705km orbit; Continuing to evaluate how to maximize science with remaining fuel and analyzing what operations will look like beyond 2021.



EOS Direct Broadcast (DB) Operations

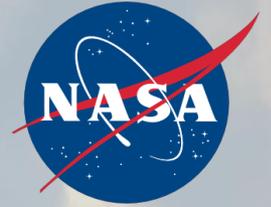


- **Scheduling Guidelines and Constraints for Direct Broadcast :**
 - Aqua does not schedule Wallops GN – This provides U.S. East Coast DB stations with Direct Broadcast data.
 - Aura does not schedule Norway GN contacts from 10:30:00-14:00:00 GMT – This provides the Finland (Sodankylä) DB station with OMI Direct Broadcast data.
 - Terra turns off Direct Broadcast for Deep Space Network (DSN) Blackout periods.
- **A daily contact schedule is posted with the Aqua and Terra scheduled Direct Broadcast turnoff times:**
 - The turnoff schedules for X-Band Playbacks are published at:
<ftp://is.sci.gsfc.nasa.gov/ancillary/ephemeris/schedule/aqua/download/>
<ftp://is.sci.gsfc.nasa.gov/ancillary/ephemeris/schedule/terra/download/>
 - The Terra turnoff schedules for Deep Space Network are published at:
<ftp://is.sci.gsfc.nasa.gov/ancillary/ephemeris/schedule/terra/dsn/>



EOS Direct Broadcast Contacts

(Communication with the DB/DR Community)



For Questions Regarding the Direct Readout Laboratory (DRL); Ground Station Capabilities; and Software Availability	Patrick Coronado patrick.l.coronado@nasa.gov
DRL Website	http://directreadout.sci.gsfc.nasa.gov/
For Questions Regarding EOS Satellite Status/Mission Operations	Eric Moyer eric.m.moyer@nasa.gov



Overall Summary

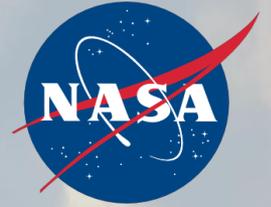


- All EOS missions are older but continuing to provide great science data
 - Missions continue to operate well
 - Terra (16+ years), Aqua (14+ years), Aura (12+ years)
- EOS missions are projected to last for many more years
Estimates are ~ another 6 to 9 years
- EOS Direct Broadcast/Direct Readout operations are considered an important part of the world-wide EOS Ground System

With Great Appreciation to the Direct Broadcast Users:

- For providing feedback while Operations Team investigates spacecraft anomalies by providing Direct Broadcast data receipt/quality/images
- For helping to fill data gaps in our long term archives

THANK YOU!!!



Back-up Slides



Terra Maneuvers



Drag Makeup Maneuvers (DMUs)

- Performed to maintain ground track error (GTE) with respect to the World Reference System (WRS-2) within +/-10 Km as measured at the descending Node

Risk Mitigation Maneuvers

- Performed to avoid a conjunction with another spacecraft or orbital debris

Inclination Adjust Maneuvers

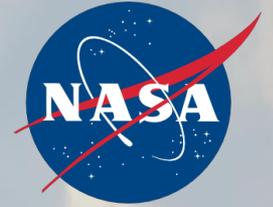
- Performed to maintain nominal spacecraft mean local time (descending node) at 10:30 a.m.

MODIS Roll Maneuvers

- Performed approximately once/month to calibrate MODIS sensors on lunar illumination
 - No Maneuver performed when the required angle for calibration exceeds maneuver capability of -20 degrees.



Aqua Maneuvers



Drag Make-up Maneuvers (DMUs)

- Performed to maintain Aqua's ground track error (GTE) with respect to the World Reference System (WRS-2) within +/-10 Km

Risk Mitigation Maneuvers

- Performed to avoid a conjunction with another spacecraft or orbital debris

Inclination Adjust Maneuvers (IAMs)

- Performed to maintain the Mean Local Time (MLT) as measured at the Ascending Node between 1:30 and 1:45 MLT

MODIS Lunar Calibration Maneuvers

- Performed approximately once/month to calibrate MODIS sensors on lunar illumination



Aura Maneuvers



Drag Make-up Maneuvers (DMUs)

- Performed to maintain Aqua's ground track error (GTE) with respect to the World Reference System (WRS-2) within +/-10 Km

Risk Mitigation Maneuvers

- Performed to avoid a conjunction with another spacecraft or orbital debris

Inclination Adjust Maneuvers (IAMs)

- Performed to maintain the Mean Local Time (MLT) as measured at the Ascending Node between 1:30 and 1:45 MLT