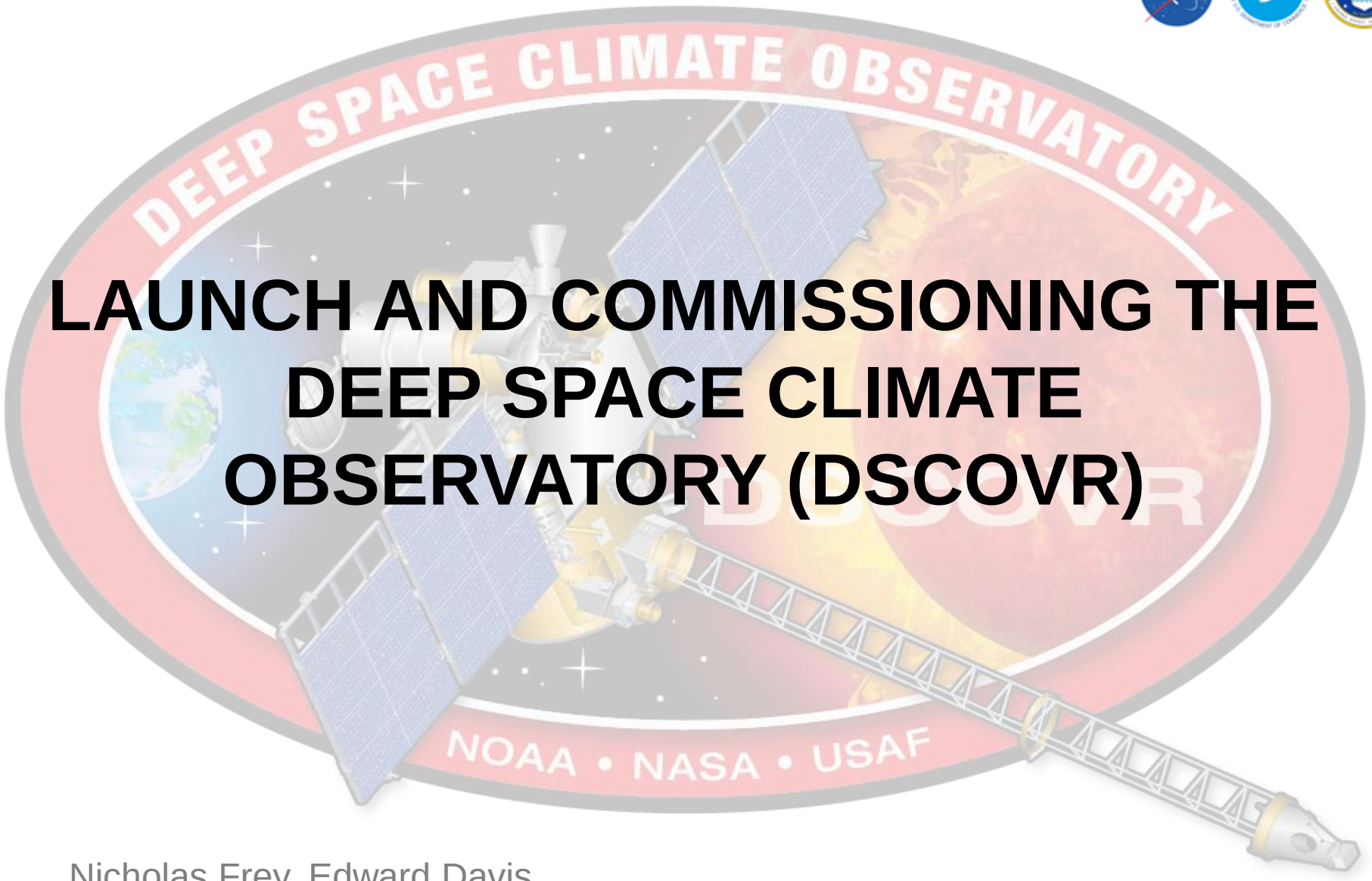


LAUNCH AND COMMISSIONING THE DEEP SPACE CLIMATE OBSERVATORY (DSCOVR)

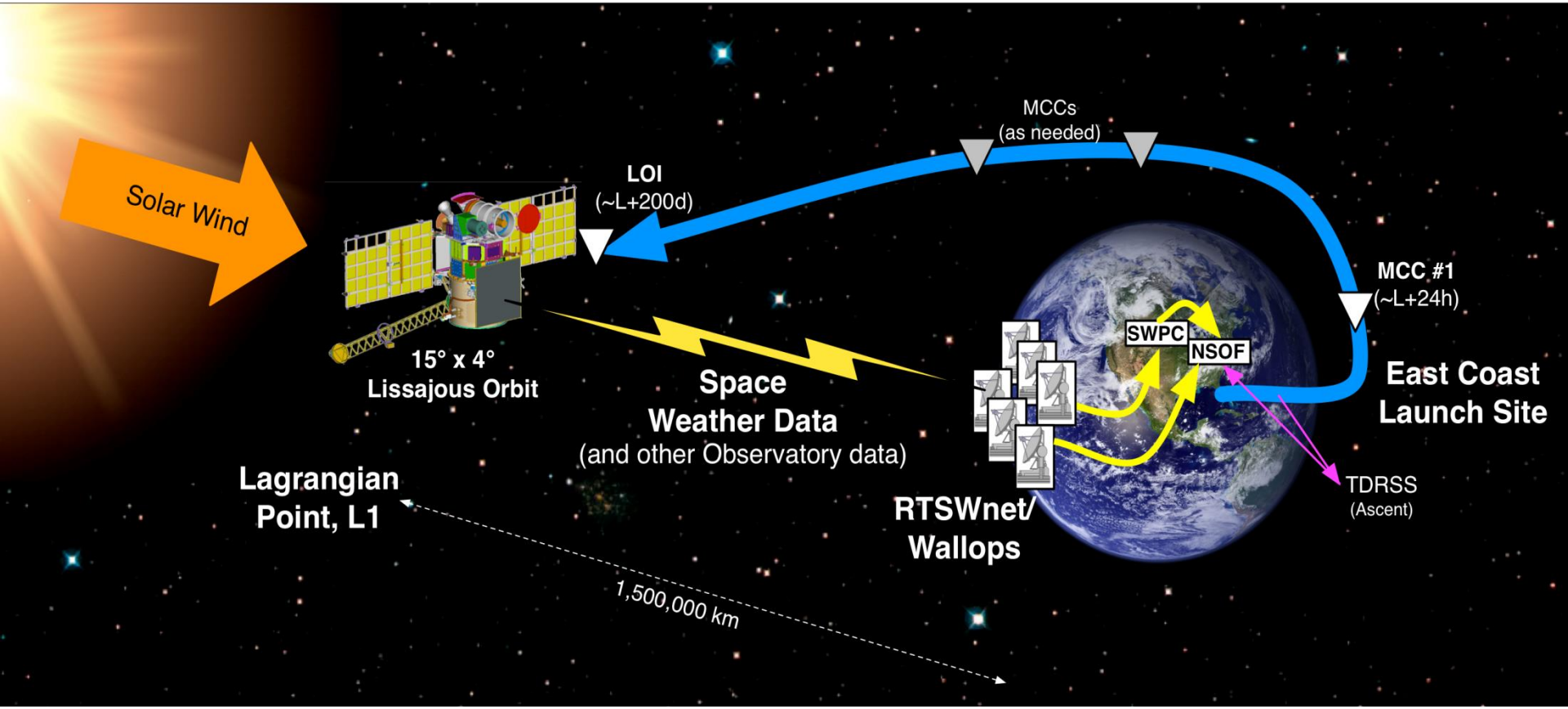
Nicholas Frey, Edward Davis

NASA Goddard Space Flight Center

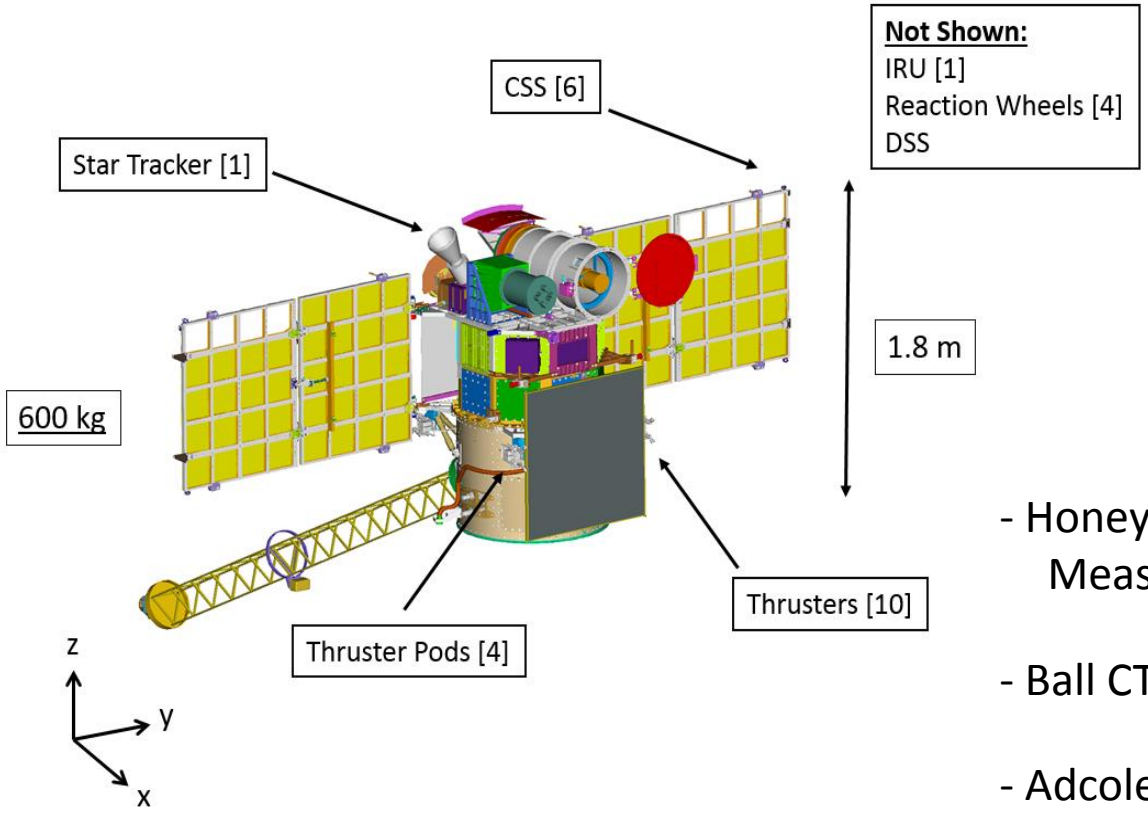
Outline

- Background
- Post-Separation
  - Initial Sun Acquisition
  - Digital Sun Sensor (DSS) Anomaly
- Internal Reference Unit (IRU) Calibration
  - Star Tracker Processing Anomaly
- Boom Deployment
- Plasma Magnetometer (PlasMag) Calibration Slews
- Lissajous Orbit Insertion (LOI)
- Earth Imaging

Mission Overview

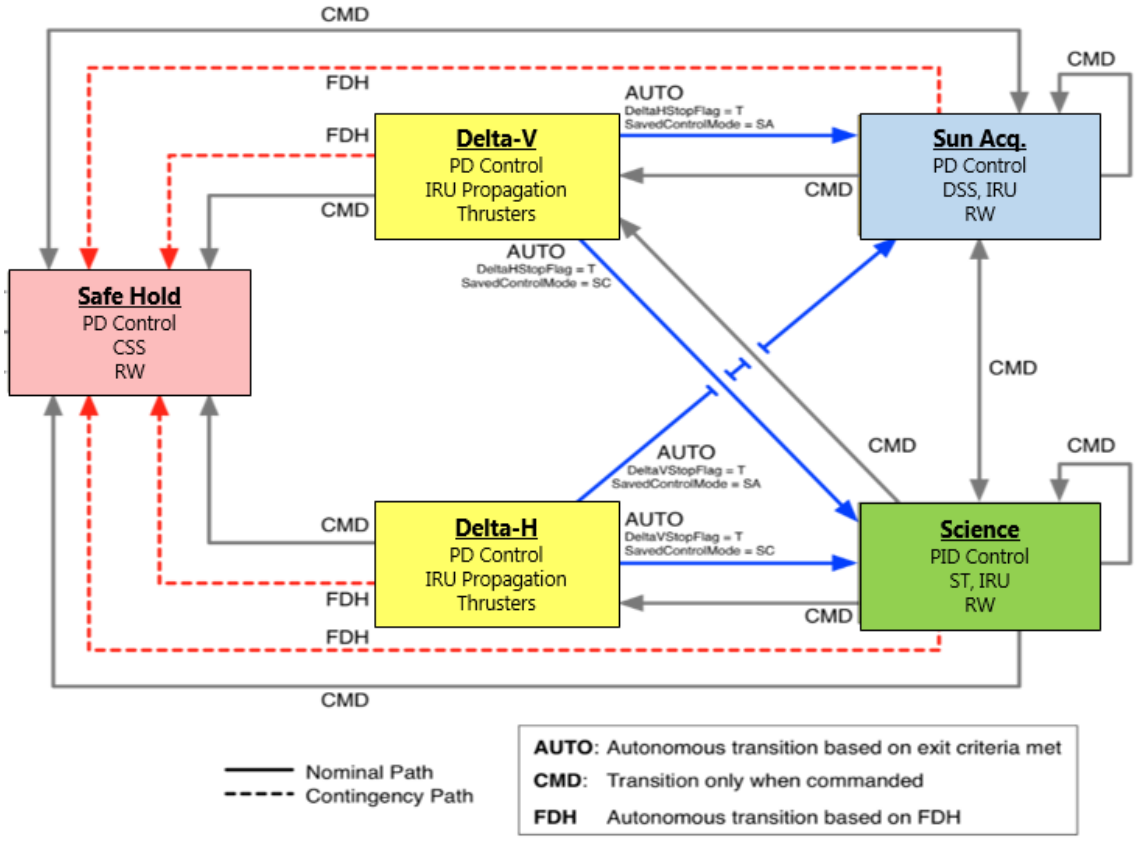


Hardware Overview



- Honeywell Block III Miniature Inertial Measurement Unit
- Ball CT-633 Star Tracker
- Adcole Digital Sun Sensor
- 6 Adcole Coarse Sun Sensors (CSSs)
- In-House Integrated Reaction Wheel Assemblies

ACS Overview



Five primary control modes:

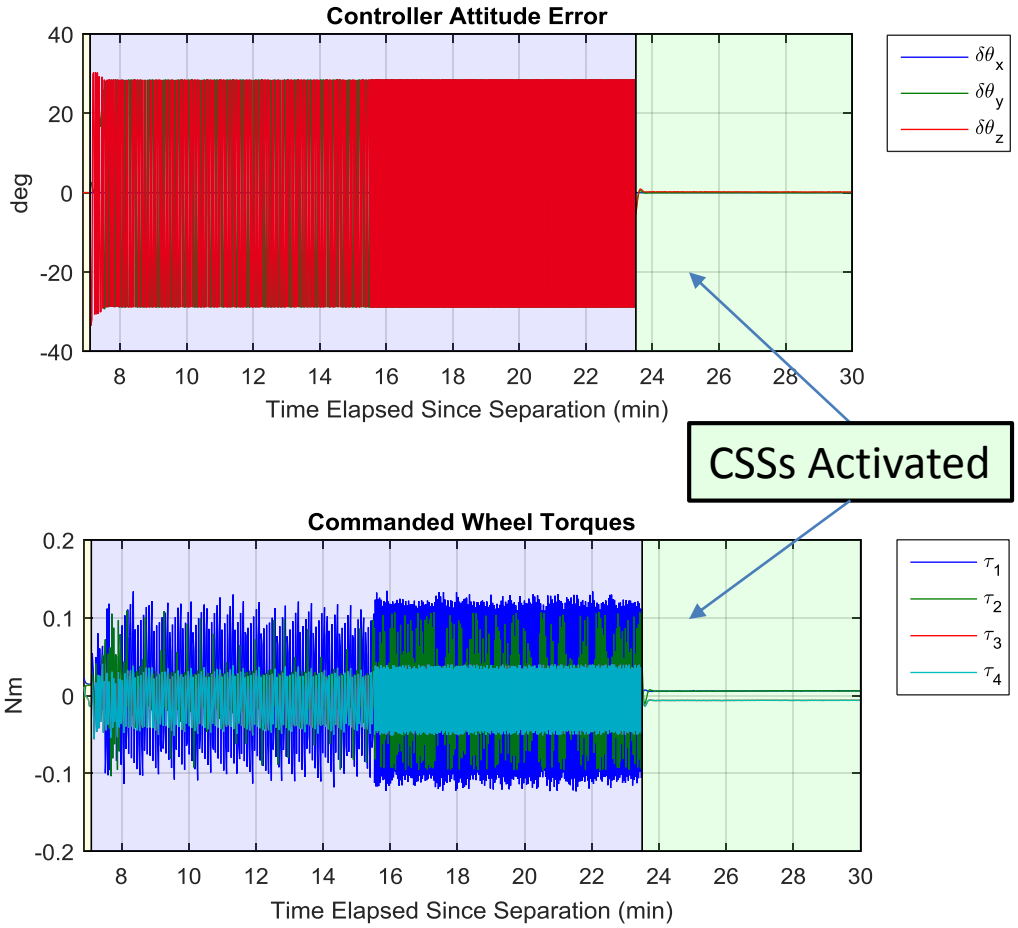
- Science
- Delta-V
- Delta-H
- Sun Acquisition
- Safe Hold

Arrow Key:

- Nominal autonomous transitions
- Commanded transitions
- Failure, detection, and handling triggered

Post-Separation

Day 42 Post-Separation Flight Data:



After autonomously transitioning from Safe Hold to Sun Acquisition post launch, the DSS started providing unphysical measurements.

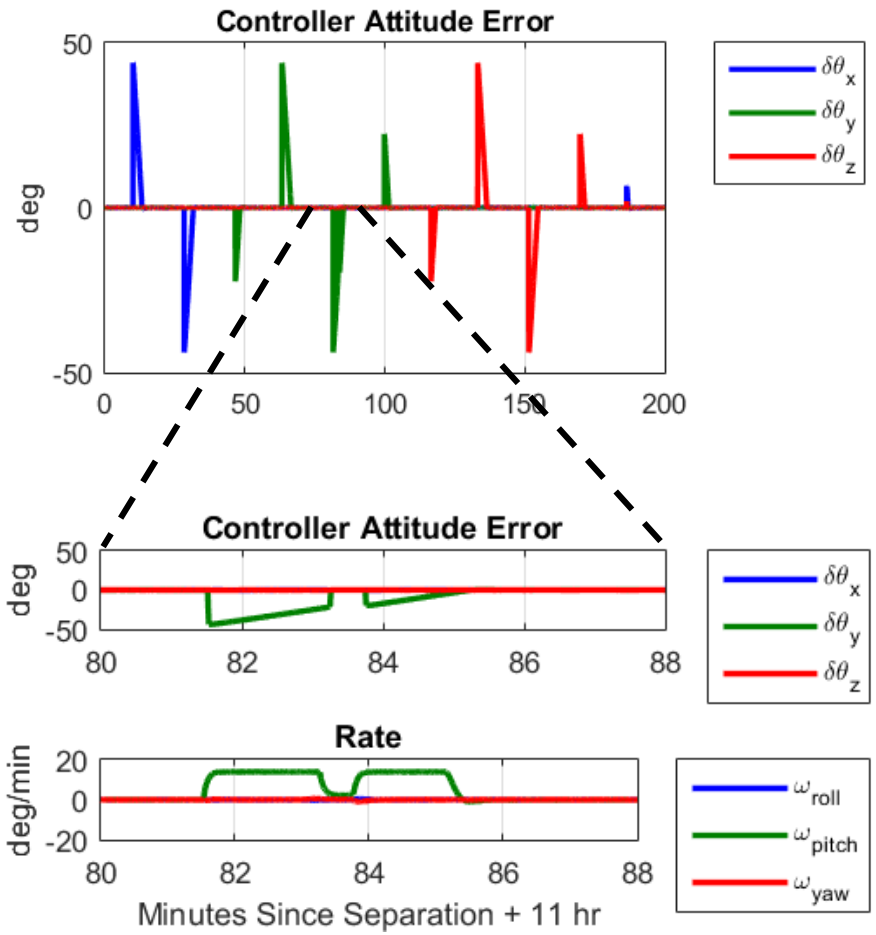
The ACS team immediately commanded the spacecraft to remain in Sun Acquisition mode, but utilize the CSSs for attitude knowledge.

The ACS settled to the appropriate attitude and the cause of the anomaly was traced back to an error in the DSS processing algorithm.

The DSS was outputting inverted Gray code, while the processing algorithm was expecting already converted alpha and beta angles as input. A FSW patch was implemented and resolved the error.

IRU Calibration (L+11 hr)

Day 42 IRU Calibration Flight Data:



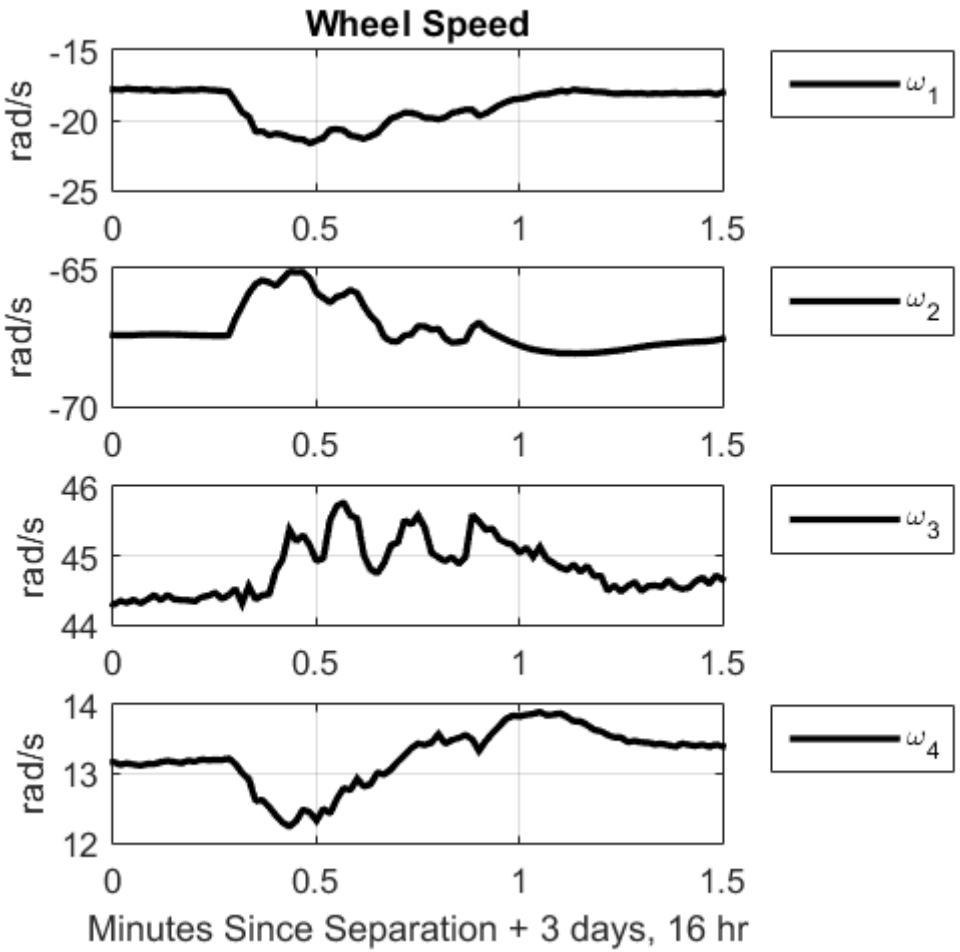
During the pitch portion of the sequence, the spacecraft suddenly reported zero attitude error mid-slew, and the spacecraft halted.

The ACS team determined that the control system was utilizing an incorrect star tracker generated lost-in-space (LIS) flag, which reports a LIS occurrence one control cycle after the null quaternion.

The ACS task of the flight software was altered to point to the correct flag, and the control system has behaved nominally since.

Boom Deployment (L+4 days)

Day 46 Boom Deployment Flight Data:

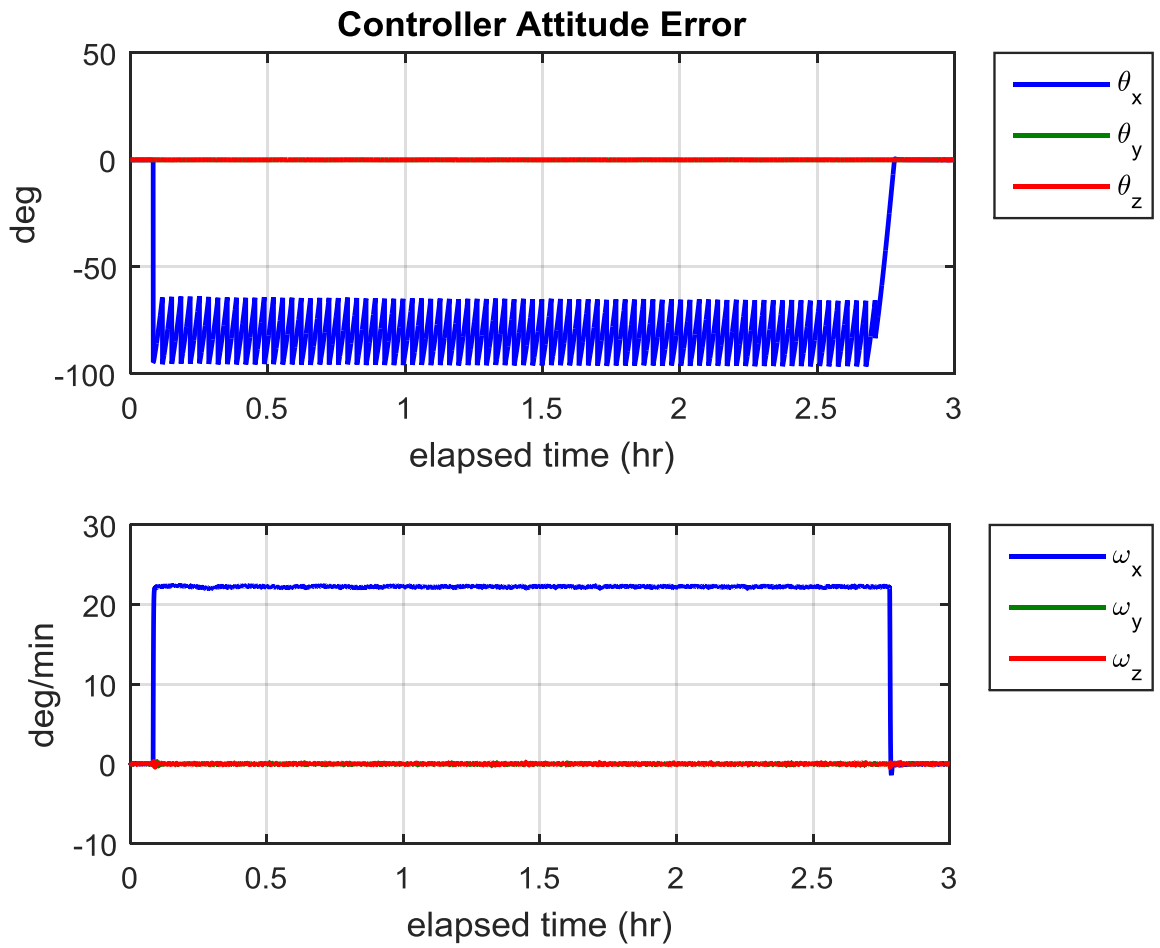


The 4-meter coiled boom telescopes outward in four intervals, completing one co-axial rotation per interval. While the disturbance in attitude and rate were relatively unnoticed, the reaction is clearly visible in the wheel response.

Based on the wheel response, as well as data provided by the magnetometer, the flight team was able to conclude that all four of the magnetometer boom's sections had successfully deployed.

PlasMag X-Roll Sequence (L+27)

Day 69 PlasMag-X Sequence Flight Data:

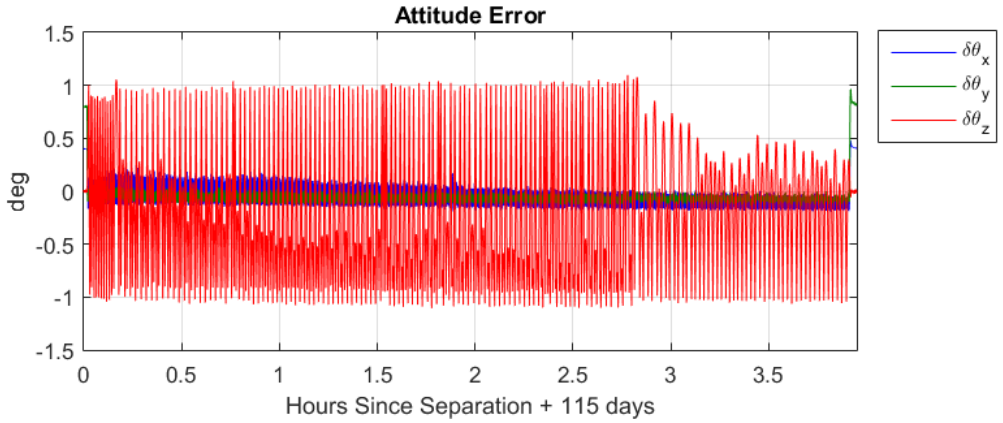


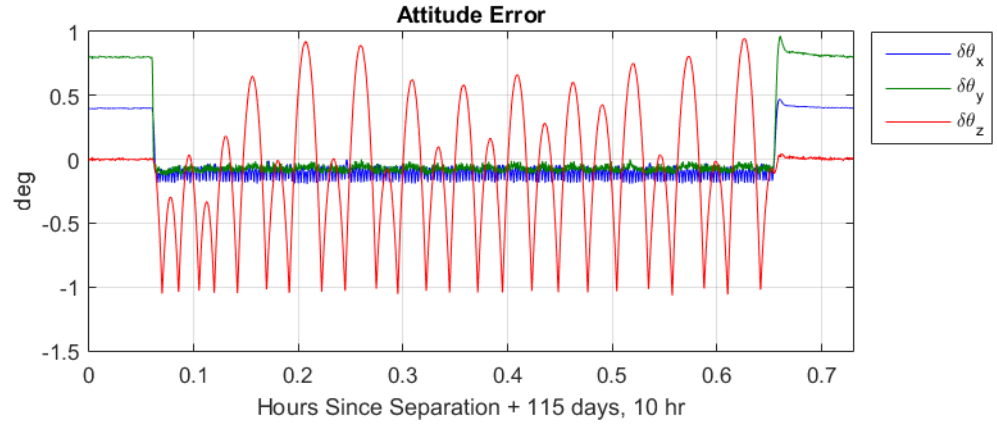
To calibrate the PlasMag, the science team requested 10 revolutions at a constant rate of 22.5 deg/min about the spacecraft's +X axis.

The attitude error shows how the quaternions are commanded such that the target is always ahead of the spacecraft to ensure the spacecraft maintains a continuous angular rate.

Lissajous Orbit Insertion (L+116)

Day 158 Lissajous Orbit Insertion Flight Data:





The LOI maneuver was split into two segments due to concerns over burn efficiency.

Doppler data used from first segment which was utilized to plan second segment.

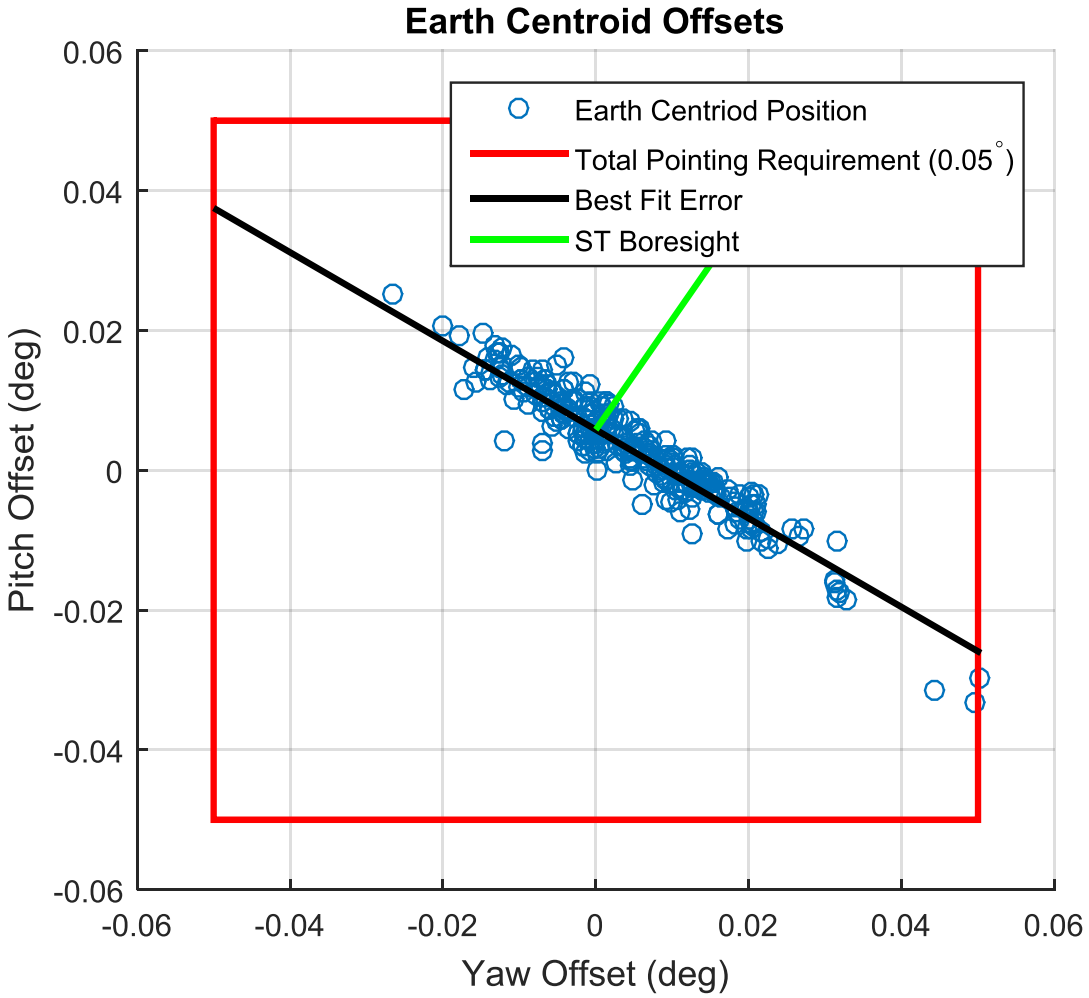
Offset implemented to account for bias introduced by CG/thrust vector offset and pulse width modulator limits.

Popular DSCOVR Earth Images

First Publically Released Image (June 13, 2015):

DSCOVR Captures the "Dark Side" of Earth's moon (July 16, 2015):

EPIC Earth Centroid Errors



After initially downloading multiple images, in order to correct the EPIC pointing, the sole star tracker's alignment parameters were augmented to fix EPIC's boresight on Earth.

Mean Offsets:

Mean Yaw Offset: 0.00850 deg

Mean Pitch Offset: 0.00029 deg

Requirement: (None)

3σ Total Pointing Errors:

3σ Yaw Offset: 0.0354 deg

3σ Pitch Offset: 0.0246 deg

Requirement: 0.0500 deg/axis

Conclusion

- To date, each of the five spacecraft ACS modes have been operating as expected and meeting all guidance, navigation, and control requirements.
- On September 29, 2015 the DSCOVR team successfully completed the Post Launch Acceptance Review.
- NASA handed DSCOVR over to NOAA on October 28, 2015.