STEREO MOC Status Report
Time Period: 2016:193 - 2016:199

STEREO Ahead (STA) Status:

1. The following Ground System anomalies/events occurred during this reporting period:

   - On day 195, an interface test was successfully conducted with the new 34m BWG station at the Canberra complex, DSS-36. The MOC successfully bound to the station from all three command and control workstations and sent 5 no-op commands from each. Monitor data was successfully received and processed by the MOC.

   - On day 197, during the DSS-24 support, command bind was lost at 1840z due to a transmitter issue. The MOC rebound the command link at 1855z. Later in the support, turbo decoder lock was lost at 2043z, and again at 2245z. This anomaly resulted in the loss of 2 frames of SSR data. See DR# G117309 for more information.

2. The following spacecraft/instrument events occurred during this week. The Ahead observatory operated nominally during this week.

   - On day 198, the Ahead observatory was used to phase calibrate the 8th uplink array, using DSS-24, 25, and 26 for 1.9 hours, to support the array use for STEREO Behind battery recovery. An approximate 12.5 dB gain in uplink AGC was observed in the spacecraft transponder data. No SSR playback was conducted as the phasing of transmitters would have caused periodic dropped frames.

   - On day 199, the Ahead observatory was used again to phase calibrate the 9th uplink array, using DSS-24 and 26 for 1.9 hours, to support the array use for STEREO Behind transmitter carrier recovery. As the transmitter for DSS-25 was declared red, the station was not used for uplink array. With the single 20 kW and 80 kW transmitters, an approximate 8.6 dB gain in uplink AGC was observed in the spacecraft transponder data. No SSR playback was conducted as the phasing of transmitters would have caused periodic dropped frames. See DR# G117314 for more information.

- The average daily science data return for Ahead was 5.9 Gbits during this week.

STEREO Behind (STB) Status:

1. The following Ground System anomalies/events occurred during this reporting period:

   - On day 195, an interface test was successfully conducted with the new 34m BWG station at the Canberra complex, DSS-36. The MOC successfully bound to the station from all three command and control workstations and sent 5 no-op commands from each. Monitor data was successfully received and processed by the MOC.

   - On day 198, the 8th uplink array for STEREO Behind recovery was conducted using DSS-24, 25, and 26. The uplink array was phase calibrated using the Ahead observatory first for 1.9 hours then the arrayed stations were switched to point to the Behind observatory. The configuration consisted of three 34m stations at the Goldstone complex using the 80 kW and two 20 kW transmitters incorporating the frequency segmented acquisition sequence with the MOC sending commands for battery recovery. At 1937z, the DSS-25 transmitter tripped due to a high voltage arc and remained off-line for the remainder of the support. This anomaly resulted in reducing the uplink gain to 9 dB, as compared to a single 34m station, for the remaining 31 frequency segments. 324 commands covering 36 frequency segments were sent for battery state of charge recovery. See DR# G117312 for more information.

   - On day 199, the 9th uplink array for STEREO Behind recovery was conducted using DSS-24 and 26. The uplink array was phase calibrated using the Ahead observatory first for 1.9 hours then the arrayed stations were switched to point to the Behind observatory. As the transmitter for DSS-25 was declared red, the configuration consisted of two 34m stations at the Goldstone complex, using the 80 kW and one 20 kW transmitters incorporating the frequency segmented acquisition sequence with the MOC sending commands for transmitter carrier recovery. At 1919z, the command state did not transition to operational as expected resulting in the loss of commanding one frequency segment. At 1959z, DSS-26 80 kW transmitter tripped off due to fast antenna reflective power. The station was able to bring the

transmitter back online at 2030z; however, the uplink power was lowered to 41 kW in order to keep additional interlocks from occurring. This anomaly resulted in the loss of commanding for 3 frequency segments. With DSS-24 uplinking at 20 kW and DSS-26 uplinking at 41 kW in a two station uplink array, the uplink array gain was reduced to 5.6 dB over a single 34m station. This would be equivalent to a 70m uplink at 20 kW. The Allen Telescope Array and the DSN 70m station, DSS-14, monitored the downlink. JPL Radio Science also configured radio science receivers to aid in the signal detection. 628 commands covering 32 frequency segments were sent. There were 2 occurrences where the DSS-14 declared lock, but correlating these lock times with the signal levels and high carrier residuals seem to indicate these may be false locks. JPL Radio Science also reported there were no indications of a spacecraft signal present in real-time, but a further in-depth look at the open loop data is being conducted. See DR# G117315, G117316, and G117317 for more information.

2. Detailed status of the recovery activities to restore operations from the Behind loss of communication anomaly, which occurred on October 1, 2014, are listed below.

   - The Behind observatory entered superior solar conjunction at the 2.0 degree SPE angle on January 22, 2015. Recovery efforts resumed post solar conjunction on May 4th through June 27, 2015, as the spacecraft had cleared solar interference for LGA communications. The Failure Review Board recommendations were implemented consisting of battery state of charge recovery and powering on the downlink carrier. The Green Bank Radio Telescope and the Arecibo Observatory also observed the carrier recovery tracks. No downlink signal has been detected. Due to Behind's retrograde motion causing it to re-enter the region of solar interference, recovery operations were suspended from June 28th through November 29, 2015. Weekly recovery operations resumed on November 30, 2015. The Green Bank Radio Telescope and the Allen Telescope Array will also observe the carrier recovery tracks depending on availability. While the Arecibo Observatory is willing also assist, the Behind observatory is only in view mid-April through mid-September. To minimize the impact on DSN resources, recovery operations were reduced to every other week beginning on March 21, 2016. Beginning in July, GSFC has directed to reduce Behind recovery operations to monthly, alternating the nominal single station recovery

configuration with the uplink array use. Recovery operations will be suspended in July 2017 and resume in January 2020 when the LGA uplink returns to 125 bps.

- The Failure Review Board's recommended faster frequency segmented acquisition sequence was tested with the Ahead observatory on September 29, 2015. All 18 one kHz frequency steps were tested twice. While stepping down through the 1 kHz segments, on segment #9 going down in frequency, the transponder locked to the BLF and accepted 9 no-op commands as expected. An interesting finding, but not unexpected, was that the transponder continued to follow the moving carrier and accept all commands sent for the remaining 27 segments.

- As commands must be received to recover the Behind observatory, the first use of the newly developed DSN uplink arraying capability for Behind recovery operations occurred on March 17, 2016. The uplink array capability provides four times the uplink received power as a 70m station. The uplink array consists of using an 80 kW and two 20 kW transmitters from three 34m Goldstone stations, DSS-24, 25, and 26, with each uplink being precisely phase shifted to create a constructive interference. From testing with STEREO Ahead, an approximate 12 dBm increase in received uplink power, as compared to a single 34m, has been successfully demonstrated each time. As the Behind observatory may be rotating, a frequency segmented acquisition sequence will be used with the uplink array. For each use of the uplink array, as transponder feedback is required, the Ahead observatory is first used to calibrate the phased uplink array then the three stations are switched to point to the Behind observatory sending commands for recovery. The uplink array will be used twice every other month within a three day period, once for battery recovery and again for carrier recovery. The next use of the uplink array is scheduled for September.

- As time goes by, the ephemeris error increases degrading DSN antenna pointing. However, with time the spacecraft range also decreases improving RF communications and the ability for other assets to acquire data on Behind. Analysis indicates that the total RF gain change is significant and the probability of command success increases with time.

Significant findings to date:

1. Analysis of the three DSN extracted telemetry frames from the carrier signal just before the planned observatory reset/anomaly occurred on October 1, 2014 showed nominal performance of the spacecraft, i.e., no anomalies, IMU off, and the star tracker providing an attitude solution.

2. Post reset, from the very limited telemetry, three packets, extracted from the carrier signal by the DSN, the X-axis gyro on IMU-A had failed. Unfortunately, this telemetry contained only G&C anomaly data and no spacecraft summary data, i.e., the state of the RF, G&C, fault protection and other subsystems is not known at the time of the anomaly. With a failed IMU and the star tracker being off-line for an undetermined duration, the sun sensors will keep the observatory pointed at the Sun, though the G&C will not have any roll knowledge, and cannot roll the observatory as part of the safing configuration to re-establish communications on the LGAs. From analysis of this telemetry and initial G&C simulations, it is highly suspected that the observatory is rotating about the principal axis of inertia due to an autonomous momentum dump initiated by highly biased gyro data flagged good by the IMU, but this has not yet been confirmed.

3. At least two anomalies occurred post reset, the star tracker not promoting to AAD mode and the X-axis gyro failure. Unfortunately, due to the number of possible combinations, the STEREO fault protection system is not designed for simultaneous failures.

Once communications are restored and the anomaly resolved, the Behind observatory will be returned to nominal science data collection as soon as it is safely possible.