

Analyzing JAVAD TR-G2 GPS Receiver's Sensitivities to SLS Trajectory

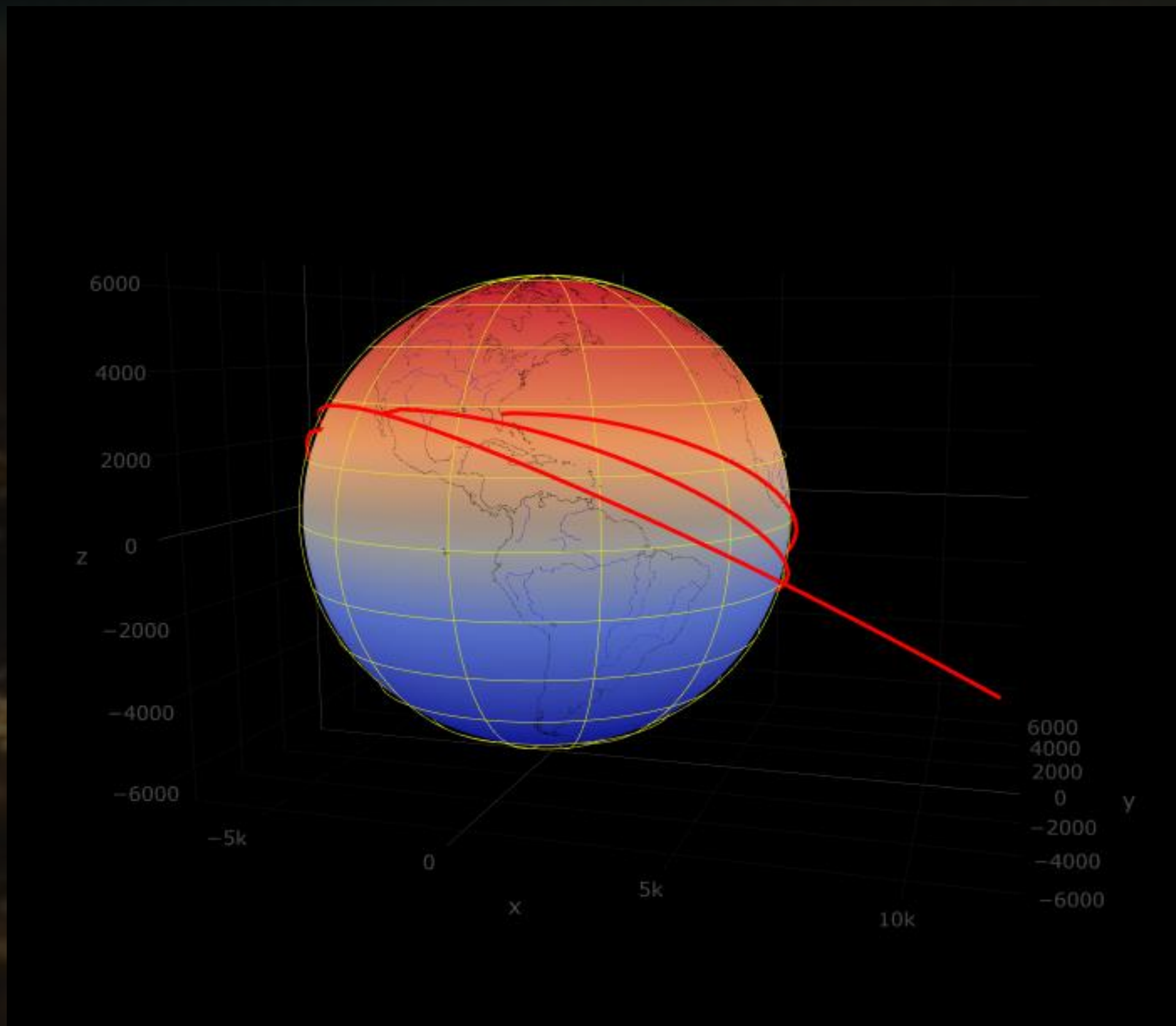
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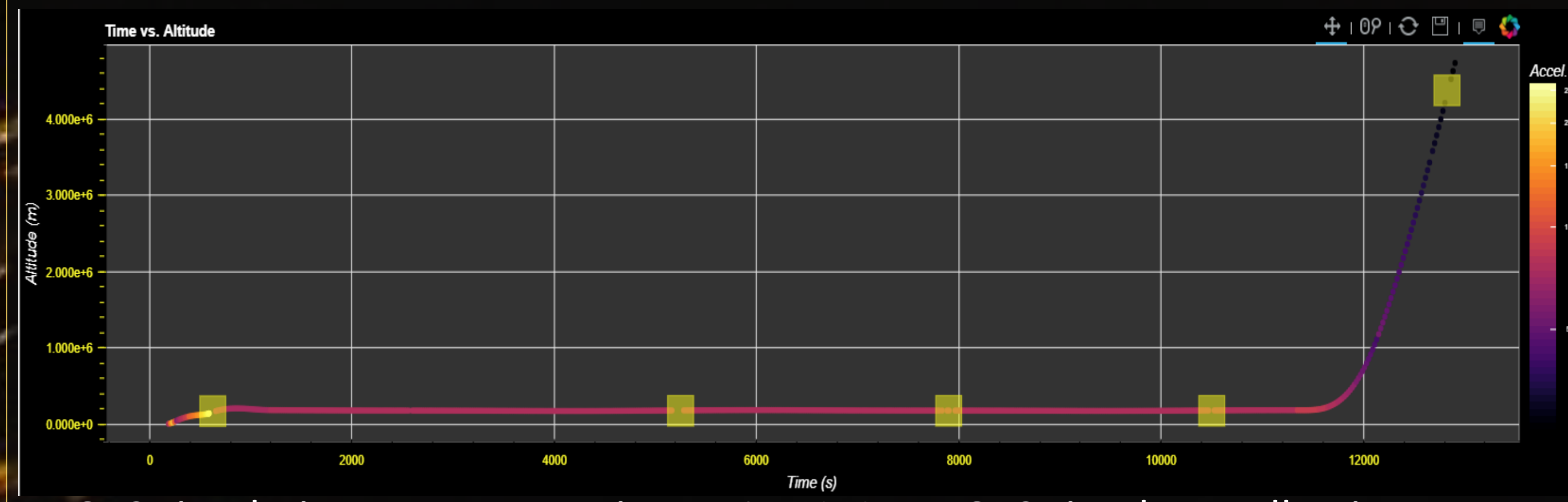
ABSTRACT

Automated guidance and navigation systems are an integral part to successful space missions. Previous researchers created Python tools to receive and parse data from a JAVAD TR-G2 space-capable GPS receiver. I improved the tool by customizing the output for plotting and comparing several simulations. I analyzed position errors, data loss, and signal loss by comparing simulated receiver data from an IFEN GPS simulator to 'truth data' from a proposed trajectory. By adjusting the trajectory simulation's gain, attitude, and start time, NASA can assess the best time to launch the SLS, where to position the antennas on the Block 1-B, and which filter to use. Some additional testing has begun with the Novatel SpaceQuest GPS receiver as well as a GNSS SDR receiver.

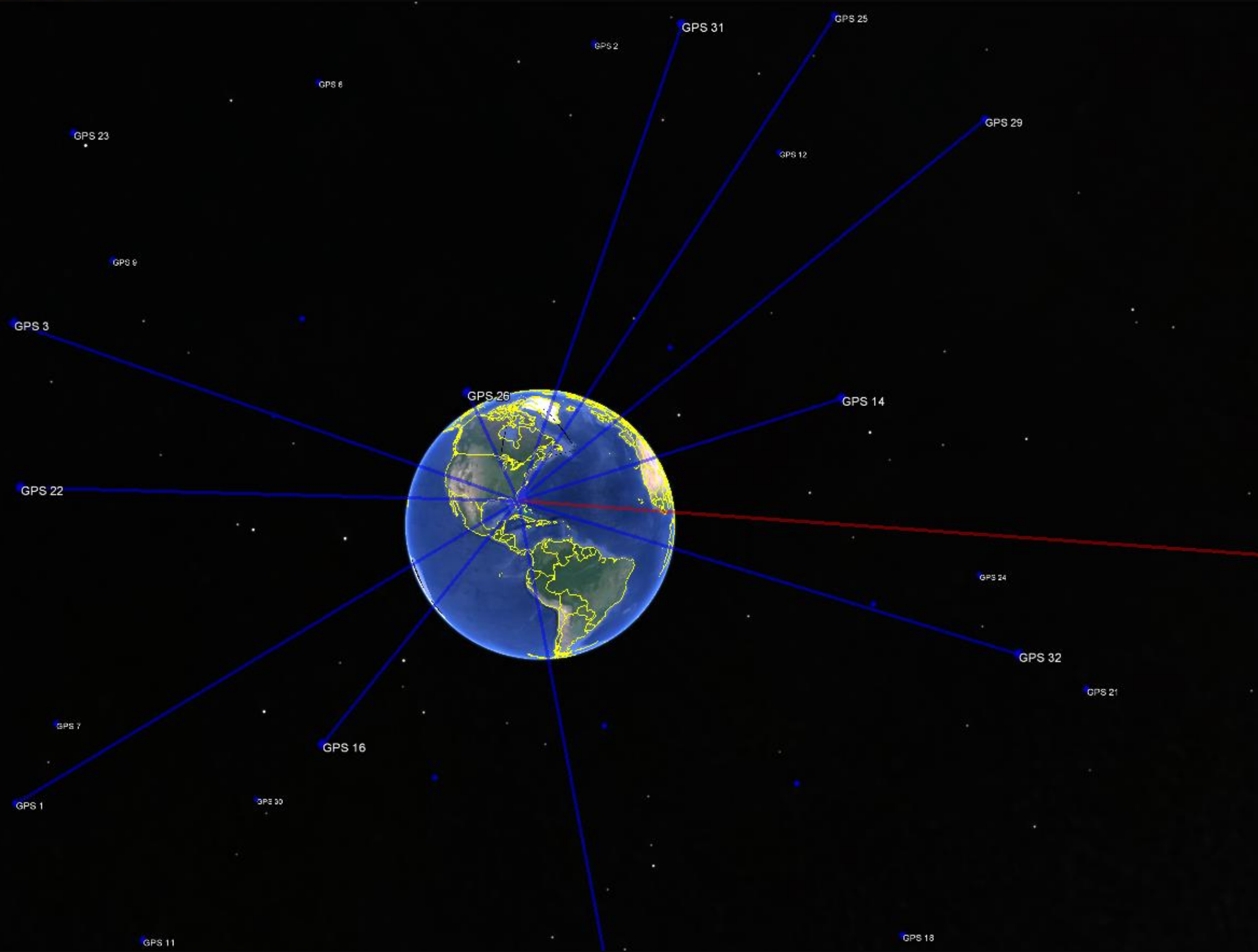
BACKGROUND



- NASA's Space Launch System (SLS) will take a few Low Earth Orbits (LEO) around the Earth before completing a TLI (Tran-Lunar Insertion) burn to the moon.
- GPS data from the JAVAD TR-G2 receiver will provide information on the vehicles position and velocity.
- The receiver requires signals from at least four satellites in the GPS constellation in order to acquire a position lock.
- The geometry of signals at higher altitudes above the GPS constellation primarily result in seeing satellites from the other side of the earth



- GPS simulations were run using an IFEN Nav-x GPS simulator, allowing us to test different variables such as satellite power levels, attitude, time of day, and date of a launch.



ACKNOWLEDGMENT

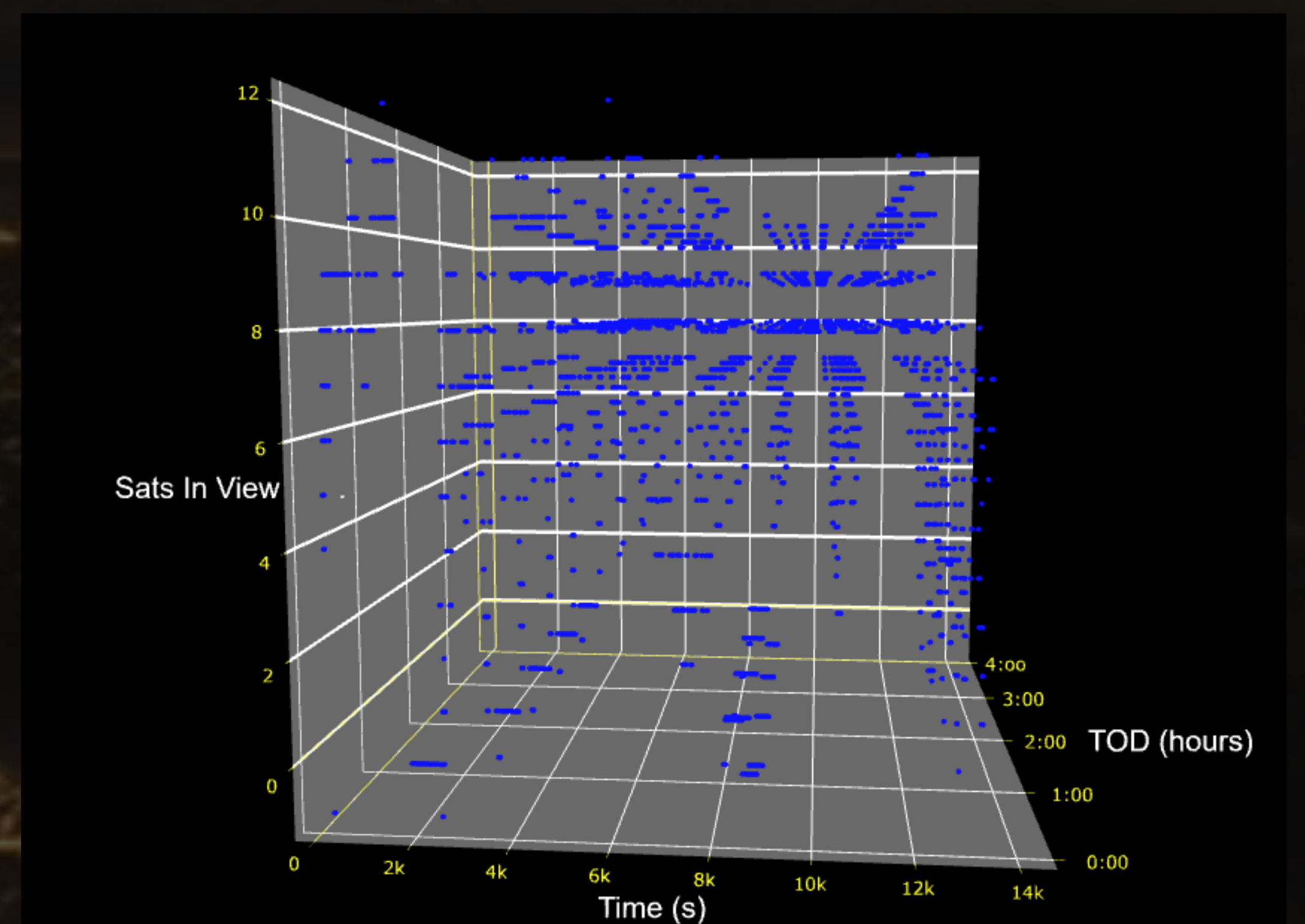
Special thanks to Evan Anzalone, EV42, for his guidance and mentorship on this project. Thank you also to NASA and the USRA for making this research opportunity possible



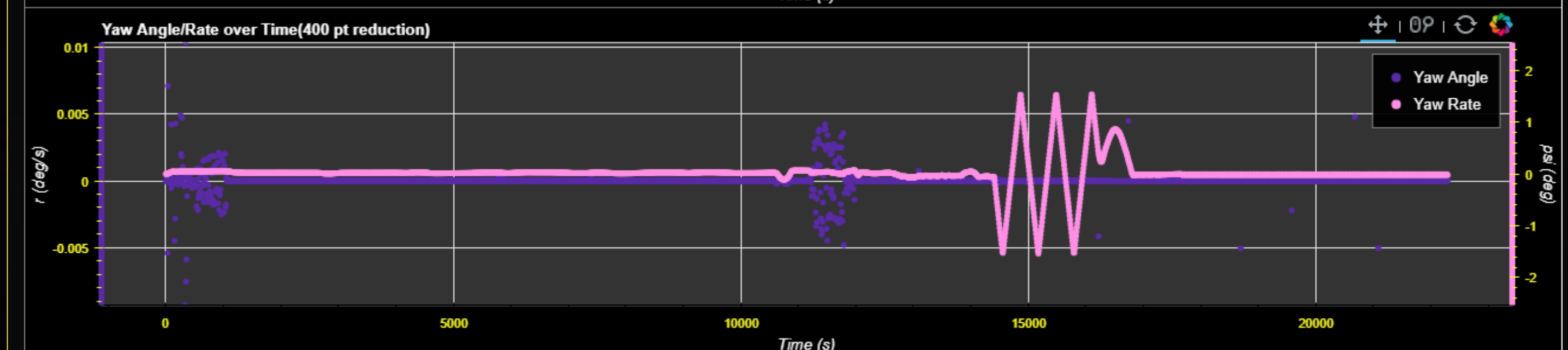
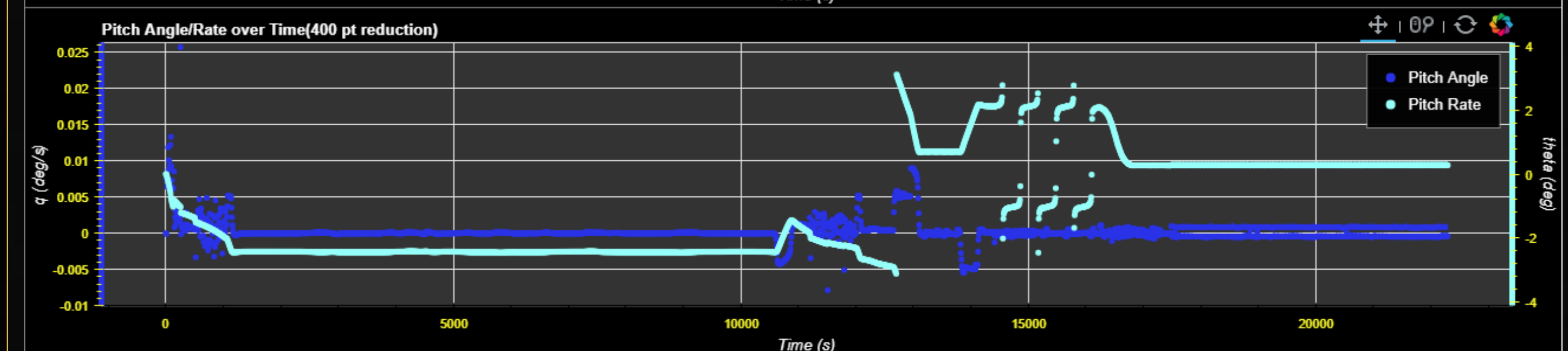
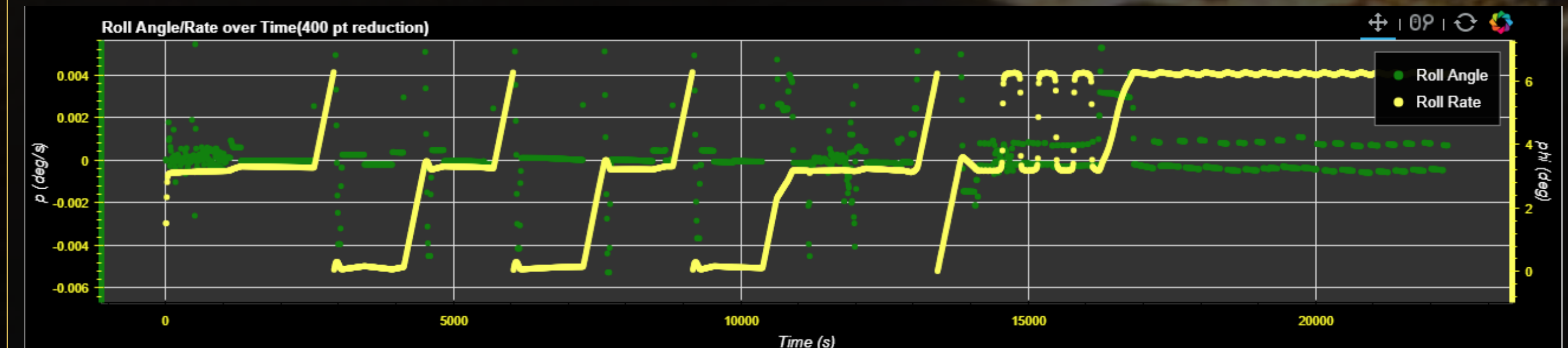
METHODOLOGY

- Improved a tool to parse incoming JAVAD TR-G2 receiver data packets and output the information to a csv file for analyzing and plotting the data. This script also accounted for data loss and errors in the data stream.
 - A variation of this program was also converted into C for t
- Developed a script to merge and manipulate data between the receiver and the "true" proposed SLS trajectory to determine position and velocity errors from the receiver
- Developed a script to plot interactive graphs of pitch roll and yaw, as well as angular rates and acceleration for the SLS trajectory
- SLS trajectory files contain over six hours of data at a 50Hz interval however, the receiver loses satellite lock after about four hours. I designed a batch processing program to run simulations back to back in four hour intervals so multiple simulations could run at night and over weekends.

RESULTS



- The graph above shows the number of satellites the JAVAD received during a flight simulation of the SLS for different start times. The resulting data is fairly constant.
- An important result shows that the receiver cuts out for 1-2 minutes (as seen by the yellow squares in the Time vs. Altitude under Background) several times in the trajectory for any attitude, or time of day adjustment.



- Upon further analysis, I determined the signal loss directly corresponds with angular rate changes of the SLS in the x-direction.

CONCLUSION

Several hypotheses for the cause of the signal dropouts:

- signal interference issues tracking the same satellite with two different antennas.
- Onboard tracking loops may not operate well under rotational motion due to changes in observables induced by the motion of the Block 1-B.
- The receiver does not have enough time to lock onto the new satellites in view to generate position/velocity data.

FUTURE GOALS

Additional Hardware in the Loop testing with additional receivers and GPS simulators are needed to verify that the signal losses due to angular rate changes are accurate.