Service Module (SM) Reboost on GMT 2019-07-03

1. Introduction

At GMT 2019-07-03, 184/00:18:15, the International Space Station (ISS) began a ~38-second reboost using Service Module (SM) main engines. The purpose of the reboost was to set up proper phasing for 4-Orbit Soyuz 59S launch on July 20th and 2-Orbit Progress 73P launch on July 31st. The visiting vehicles graphic of Figure 1 shows the location and alignment of those vehicles during this reboost. We see Newton's 3rd law is in action (and reaction) here with SM main engine thrusters firing in the aft direction to accelerate the ISS in the opposite, forward direction. It is this increase in velocity in the forward/flight direction that puts orbital mechanics in play to increase the altitude of the space station. During this reboost, the ISS climbed nearly 1 km in altitude above the Earth.

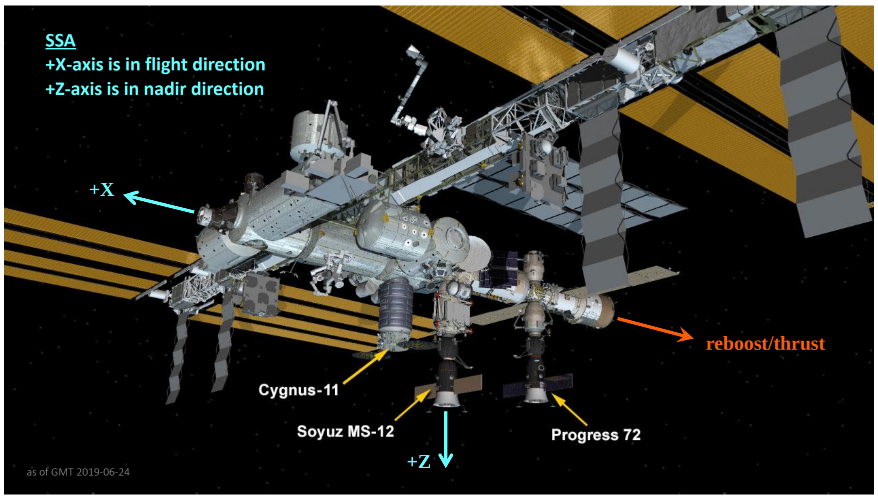

Fig. 1: Service Module's location and alignment during reboost.

2. Qualify

The information shown in Figure 2 was calculated from SAMS sensor 121f03 measurements made in the US Laboratory. This plot shows increased structural vibration excitation, especially around GMT 184/00:18. We can attribute some of this increase to Russian Segment (RS) attitude control. RS control took place for a span before, during and some time after the reboost event. The increased structural vibrations are evident as more noticeable horizontal streaks (structural/spectral peaks) that change from quieter (greenish) to more energetic (yellow/orange/red) sporadically during this period of RS control. For science operations and general situational awareness, it is good to be aware that the transient and vibratory environment (primarily below about 10 Hz or so) is impacted not only during the reboost event itself – this one lasting about half a minute – but also during the much longer span of Russian Segment attitude control as displayed here.

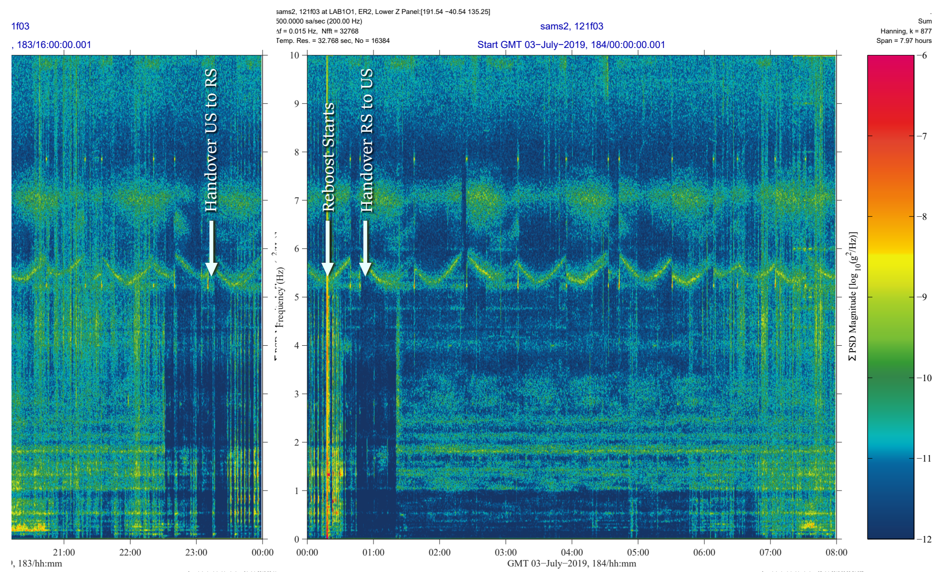

Fig. 2: Spectrogram showing Service Module Reboost on GMT 2019-07-03.

3. Quantify

The as-flown timeline for this event indicated the reboost would start at GMT 18:00 and have a burn duration of about 34 seconds. Analysis of Space Acceleration Measurement System (SAMS) data recordings made during the reboost shows the tell-tale X-axis step that nearly matches the start time and the duration as seen in Figure 3.

Four more plots of 5-second interval average acceleration versus time for SAMS sensors distributed throughout the ISS are shown at the end of this document, starting with Figure 4 on page 3. The interval average processing effectively low-pass filtered the data so as to help emphasize the acceleration step that occurs on the X-axis during the reboost event. It should also be noted that we flipped the polarity of (inverted) each axis in the SAMS plots owing to a polarity inversion issue inherent in SAMS. A crude quantification of the reboost as measured by the distributed SAMS sensors is given in Table 1.

Table 1. X-axis step values during reboost event for 5 SAMS sensors.

Sensor	X-Axis Step (mg)	Location
121f02	1.557	JPM1A6 (RMS Console)
121f03	1.586	LAB1O1 (ER2)
121f04	1.590	LAB1P2 (ER7)
121f05	1.587	JPM1F1 (ER5)
121f08	1.591	COL1A3 (EPM)

4. CONCLUSION

While SAMS sensors were designed to characterize the vibratory environment of the ISS, and not so much the quasi-steady environment, they perform well for capturing the relatively large X-axis step induced by reboost events. Despite the underlying low-frequency & low-magnitude baseline being obscured by transducer bias/offset, SAMS sensors easily detect the gross acceleration step of reboost as demonstrated here. The SAMS sensor data analyzed showed an X-axis step during the Service Module reboost of about 1.5 mg. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 in the US LAB indicate a ΔV of about 0.51 meters/second was achieved, and matched flight controllers' pre-planned value.

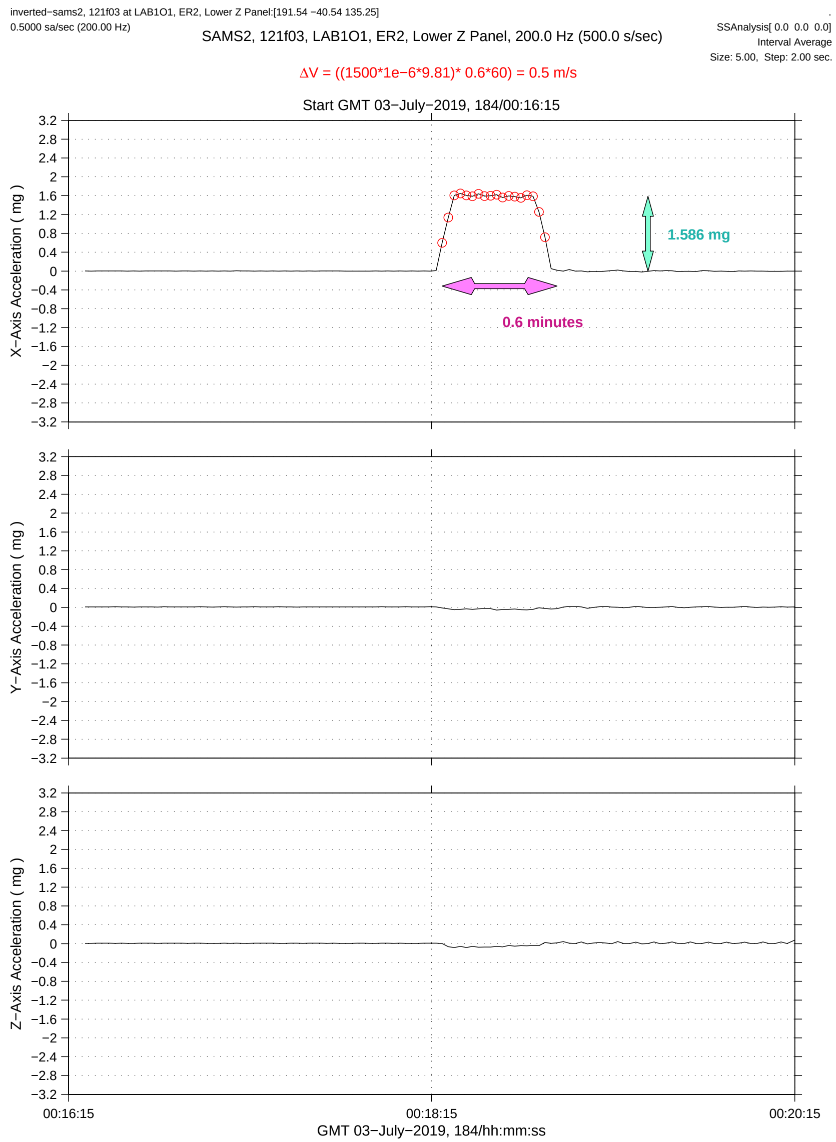

Fig. 3: Interval average of SAMS 121f03 sensor data shows SM reboost.

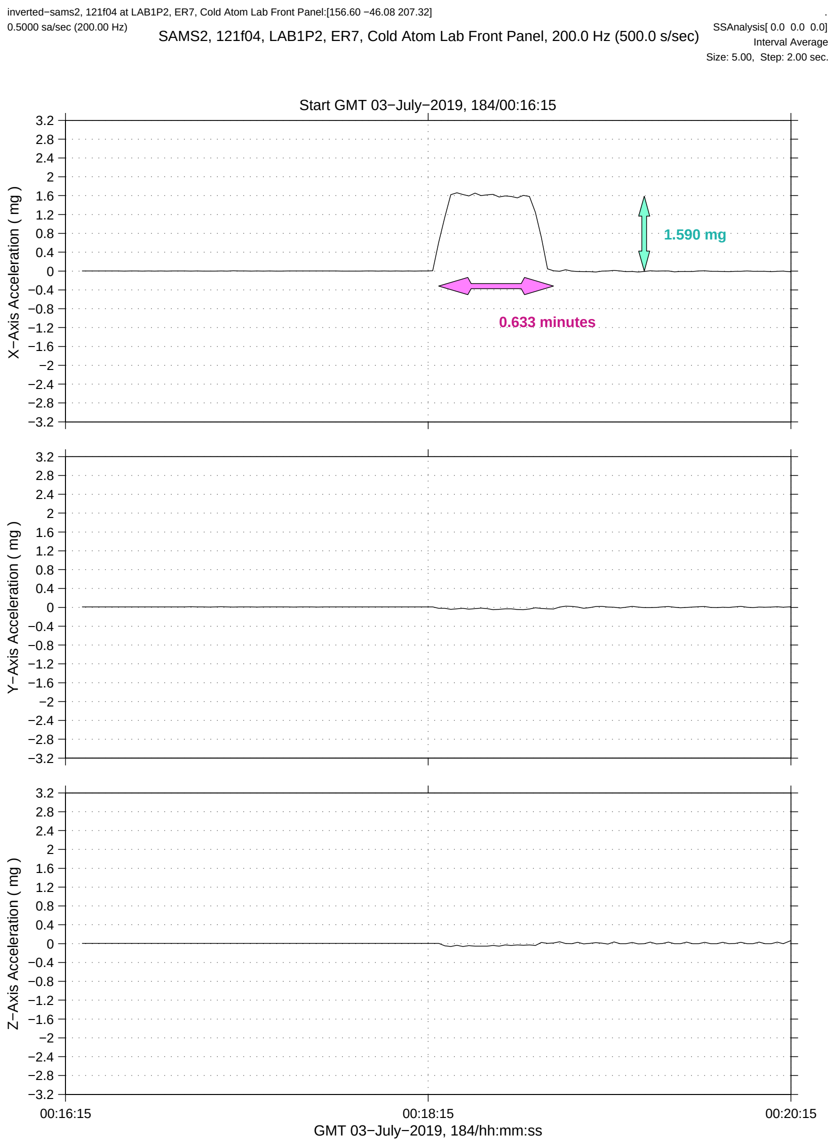

Fig. 4: 5-sec interval average for SAMS 121f04 sensor in the LAB.

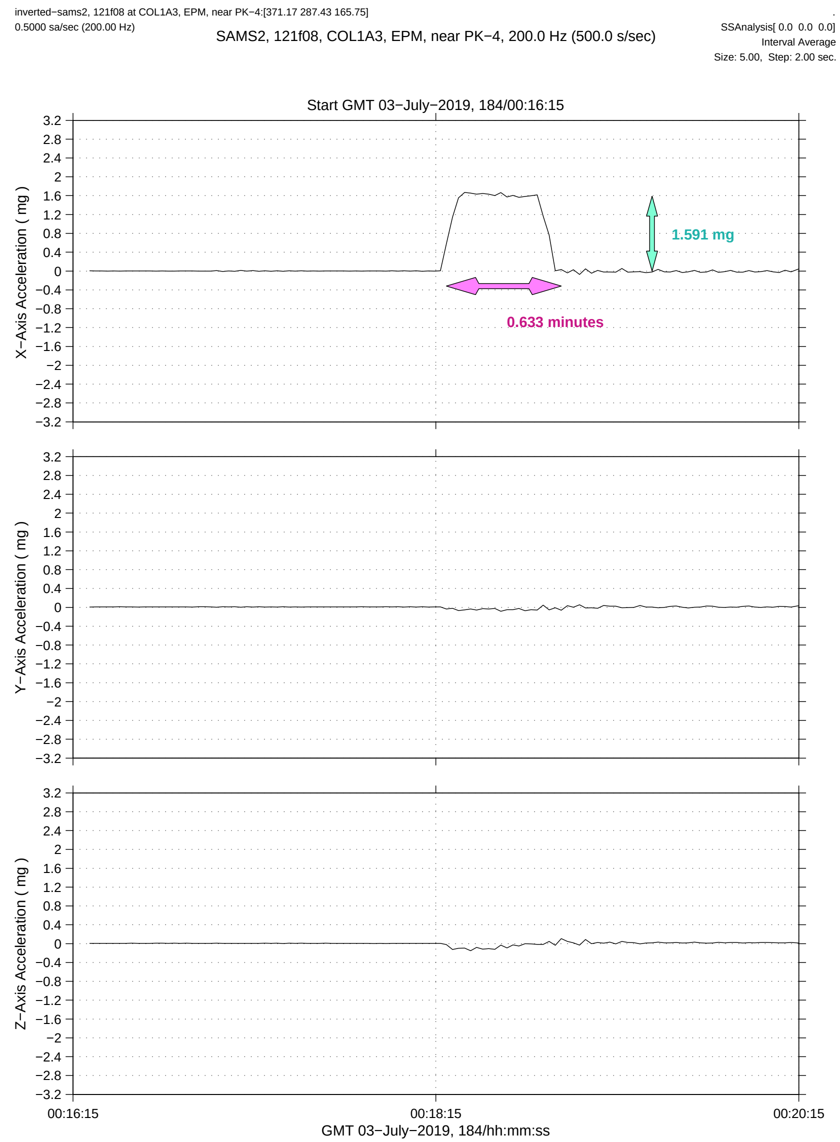

Fig. 5: 5-sec interval average for SAMS 121f08 sensor in the COL.

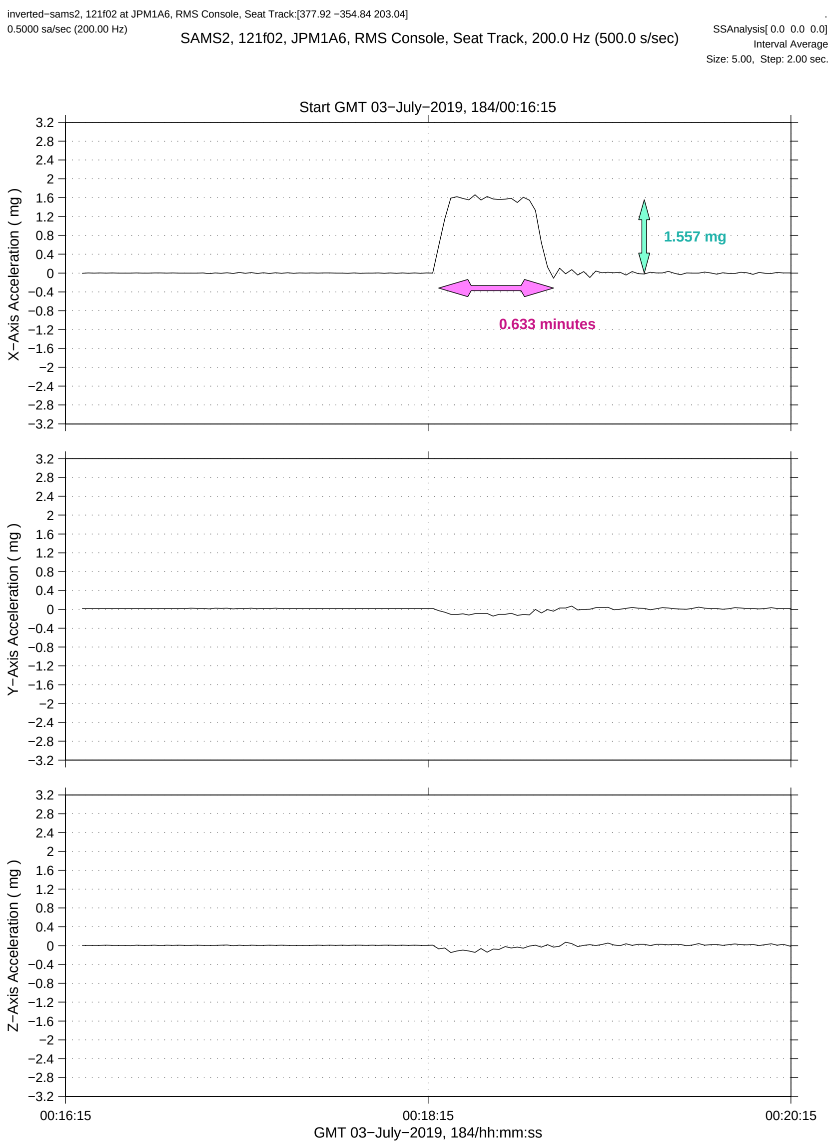

Fig. 6: 5-sec interval average for SAMS 121f02 sensor in the JEM.

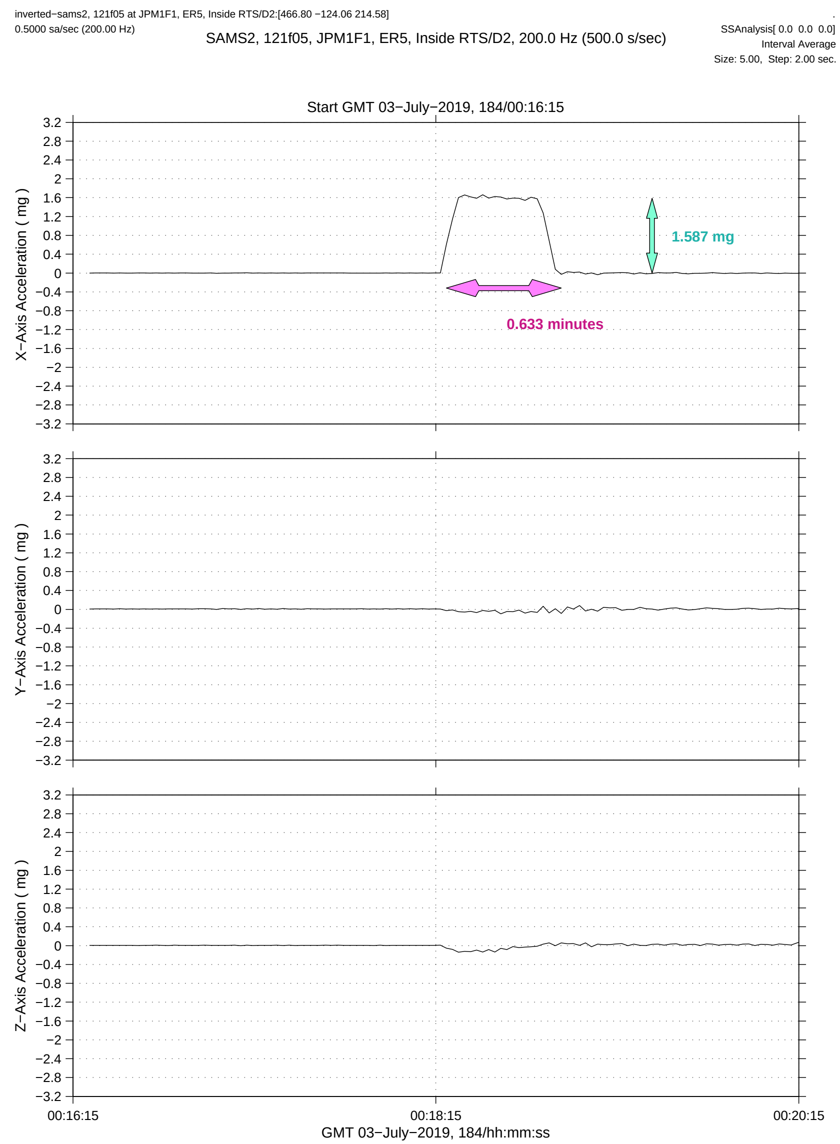

Fig. 7: 5-sec interval average for SAMS 121f05 sensor in the JEM.