1. Introduction

At GMT 2020-04-19, 110/05:09:00, the International Space Station (ISS) began a ~one-minute deboost using Service Module main enginer thrusters. The purpose of the deboost was to set up the conditions needed for the upcoming Progress 75P 2-Orbit rendezvous on July 23rd and the Soyuz 63S rendezvous on October 14th. In addition, the deboost served as a Debris Avoidance Maneuver (DAM) to avoid conjunction with Object 31280, Fengyun 1C (FY-1C) orbital debris from a Chinese weather satellite. This Wikipedia page states that "the intentional destruction of FY-1C created 2,841 high-velocity debris items, which is a larger amount of dangerous space junk than any other space mission in history"!

The graphic of Figure 1 shows the location and alignment of the Service Module, and the cyan-colored annotations show nominal flight attitude. To prepare for this deboost, however, the space station was maneuvered on the previous day to what is referred to as a "-XVV" attitude, which means it was "flying backwards" and thereby pointing the Service Module main engine thrusters into the ram direction, or "into the wind". This alignment of the thrust vector to directly oppose the velocity vector (to oppose the direction of flight) gives way to here citing Newton's 3rd law. You remember that..."for every action, there is an equal and opposite reaction". Well, that bit of physics was employed by flight controllers in Houston and Moscow to decelerate the ISS, and slow it down. It was this decrease of velocity in the direction of flight that put orbital mechanics into play to ultimately decrease the altitude of the space station and achieve the intended, lower orbital altitude and thereby steering clear of hazardous debris and achieving proper phasing.

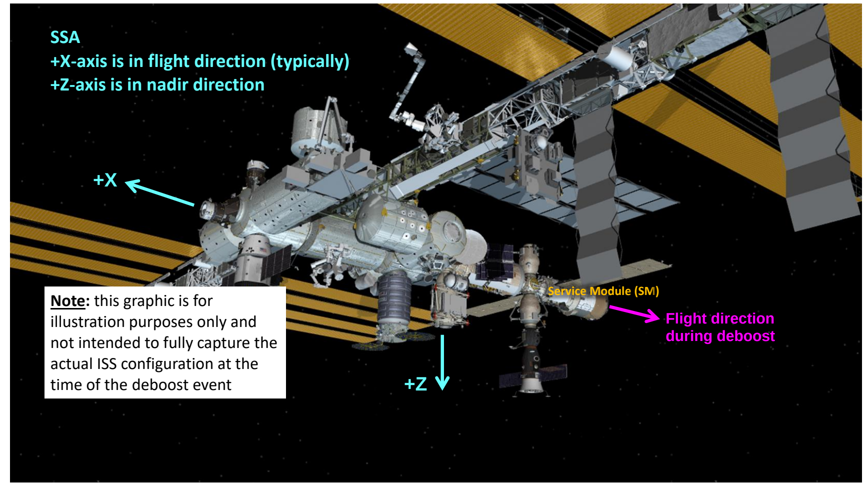

Fig. 1: Service Module's location and alignment during deboost.

2. Qualify

The information shown in Figure 2 was calculated from SAMS sensor 121f03 measurements made in the US Laboratory module. This plot shows increased structural vibration excitation between about 04:10 and 05:55 (see magenta annotation). 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 deboost event. The increased structural vibrations are evident as more noticeable horizontal streaks (structural/spectral peaks) that change from quieter (green/yellow) to more energetic (orange/red) sporadically during this period of RS control spanning over about 2 hours. The actual deboost activity itself lasted just over a minute or so, a minor subset of the span indicated by the magenta arrow of Figure 2. For science operations and general situational awareness, it is wise to be cognizant that the transient and vibratory environment (primarily below about 10 Hz or so) is impacted not only during the deboost event itself – this one lasting just about 1 minute – but also during the span of Russian Segment attitude control, lasting about 2 hours as shown here.

3. Quantify

The as-flown timeline for this event indicated the deboost would start at GMT 05:09 and have a duration of just over 1 minute. Analysis of Space Acceleration Measurement System (SAMS) data recordings shows an obvious X-axis step that nearly matches the start time and the duration as seen in Figure 3. Notice that SAMS registers a +X-axis step during a **deboost** identical in polarity to that of a **reboost** and that is because the SAMS sensors themselves (and thus their polarity) get their attitude adjusted too as they were fixed to the ISS body when it was spun around to point the SM main engine thrusters counterposed to the velocity vector.

Five more plots of 20-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

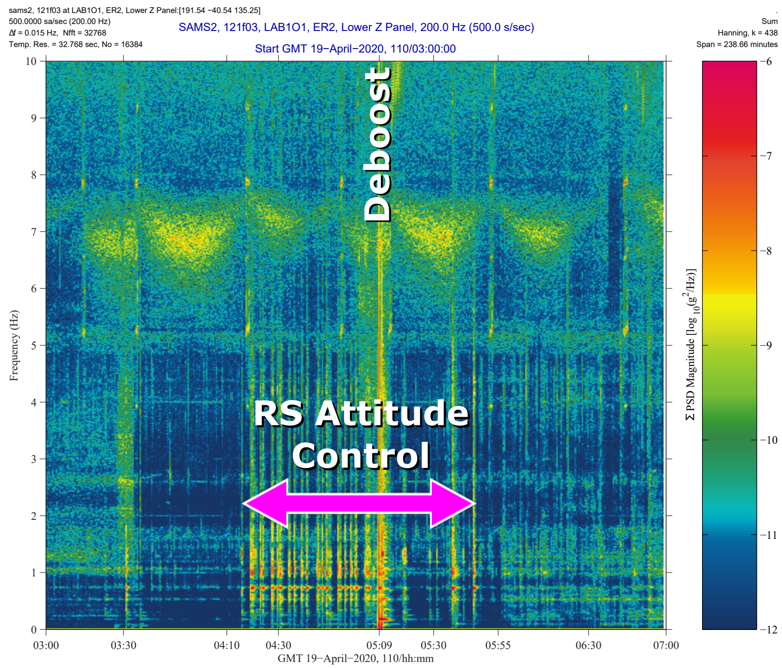

Fig. 2: Spectrogram showing Service Module Deboost on GMT 2020-04-19.

the X-axis during the deboost event. It should also be noted that we flipped the polarity (inverted) of each axis in the SAMS plots owing to a polarity inversion issue inherent in SAMS transducers. A somewhat crude quantification of the deboost as measured by the 5 distributed SAMS sensors is given in Table 1.

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 a deboost. Despite the underlying low-frequency & low-magnitude baseline being obscured by transducer bias/offset, SAMS sensors easily detect the gross acceleration step of deboost as

Table 1. **X-axis step** (mg) during deboost event for 5 SAMS sensors.

Sensor	X-Axis	Location
121f02	1.097	JPM1A6 (RMS Console)
121f03	1.100	LAB1O1 (ER2)
121f04	1.101	LAB1P2 (ER7)
121f05	1.098	JPM1F1 (ER5)
121f08	1.101	COL1A3 (EPM)

demonstrated here. The SAMS sensor data analyzed showed an X-axis step during the Service Module deboost of about 1 mg. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 in the US LAB indicate a ΔV of about 0.97 meters/second was achieved. This value matched the planned value of ΔV = 0.97 meters/second. Also, flight controllers in Houston reported a decrease in the space station's altitude of about 1.7 km for this deboost.

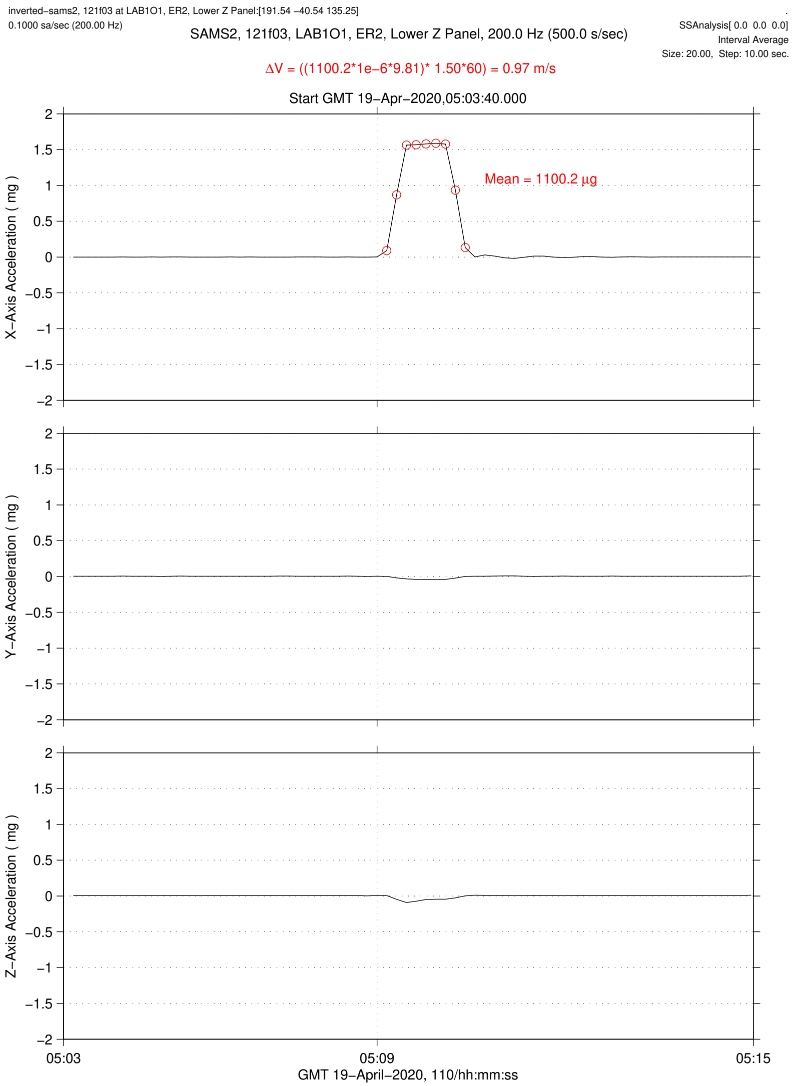

Fig. 3: Interval average of SAMS 121f03 data shows Service Module deboost.

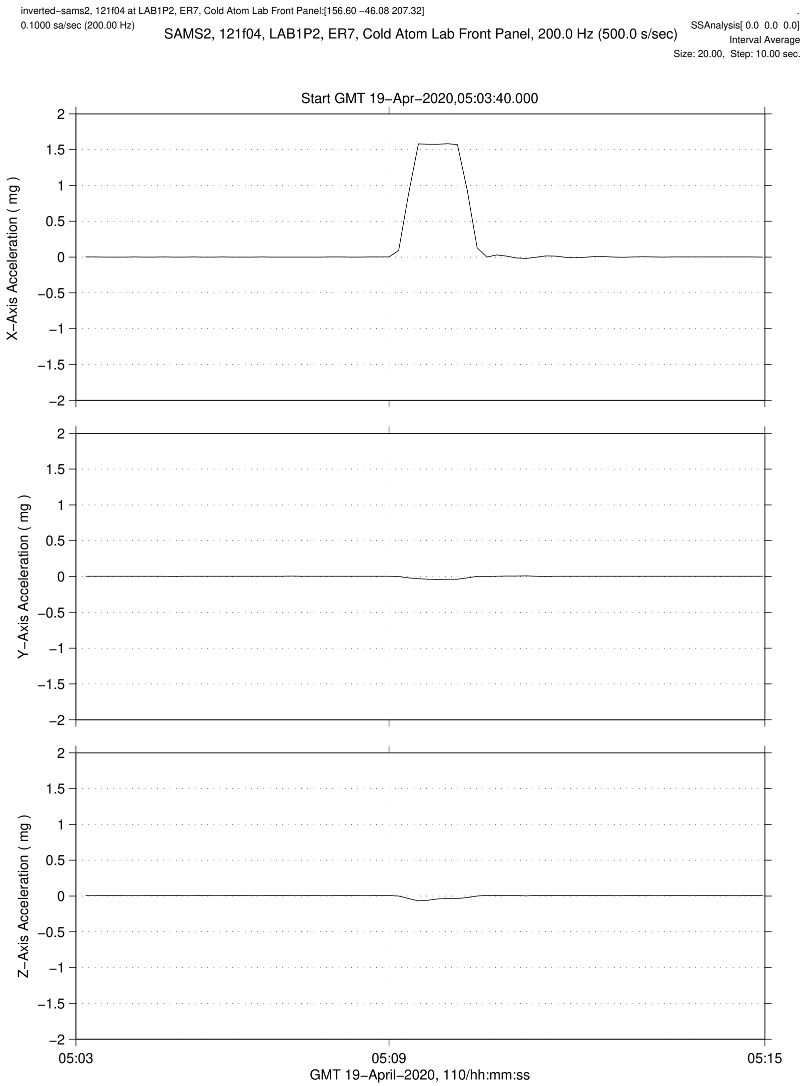

Fig. 4: 20-sec interval average for SAMS 121f04 sensor in the LAB.

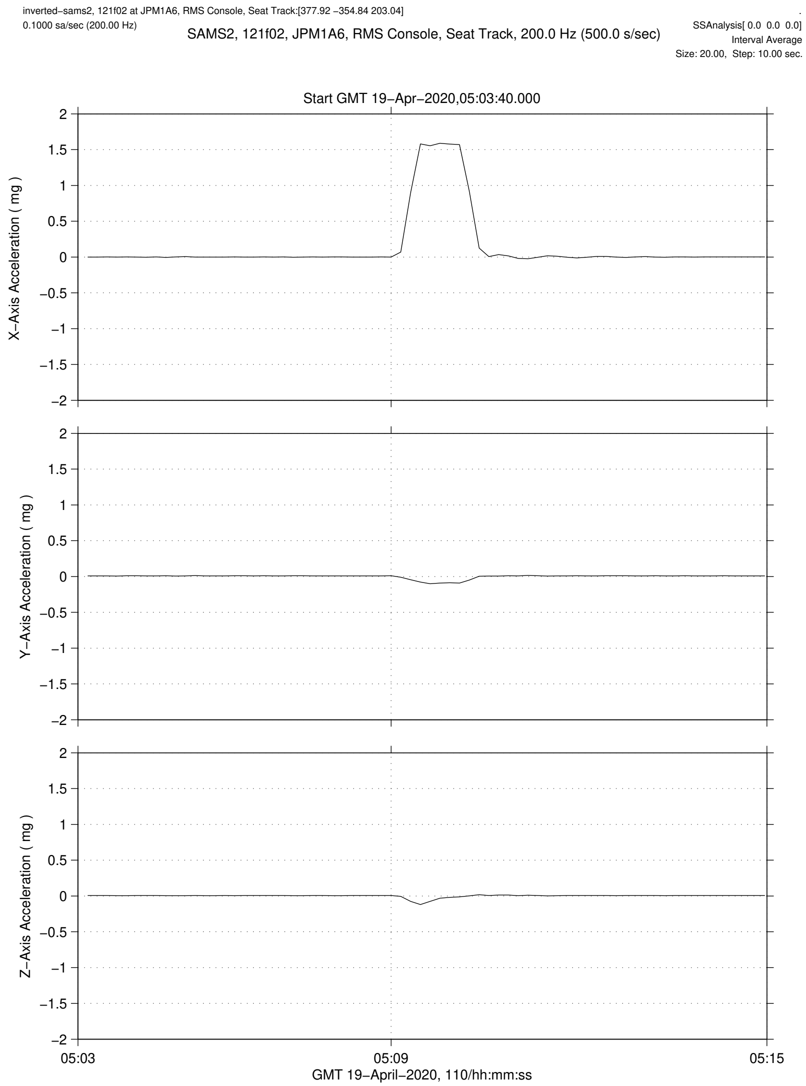

Fig. 5: 20-sec interval average for SAMS 121f02 sensor in the JEM.

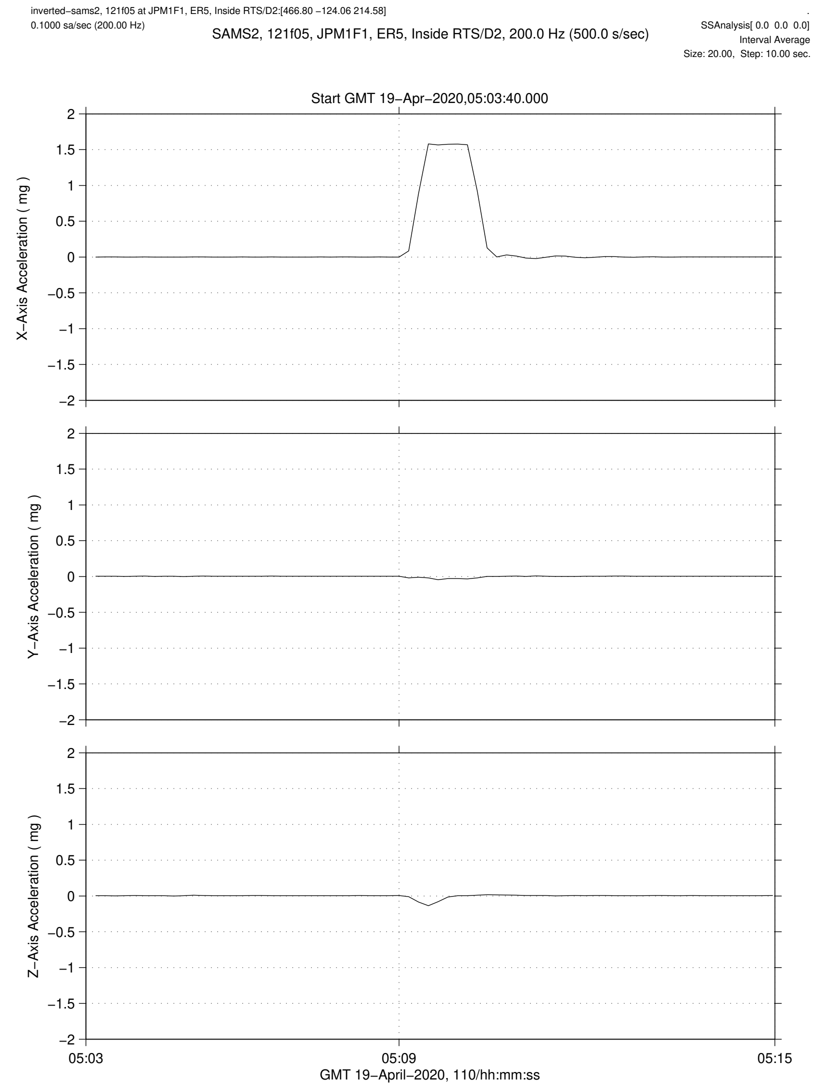

Fig. 6: 20-sec interval average for SAMS 121f05 sensor in the JEM.

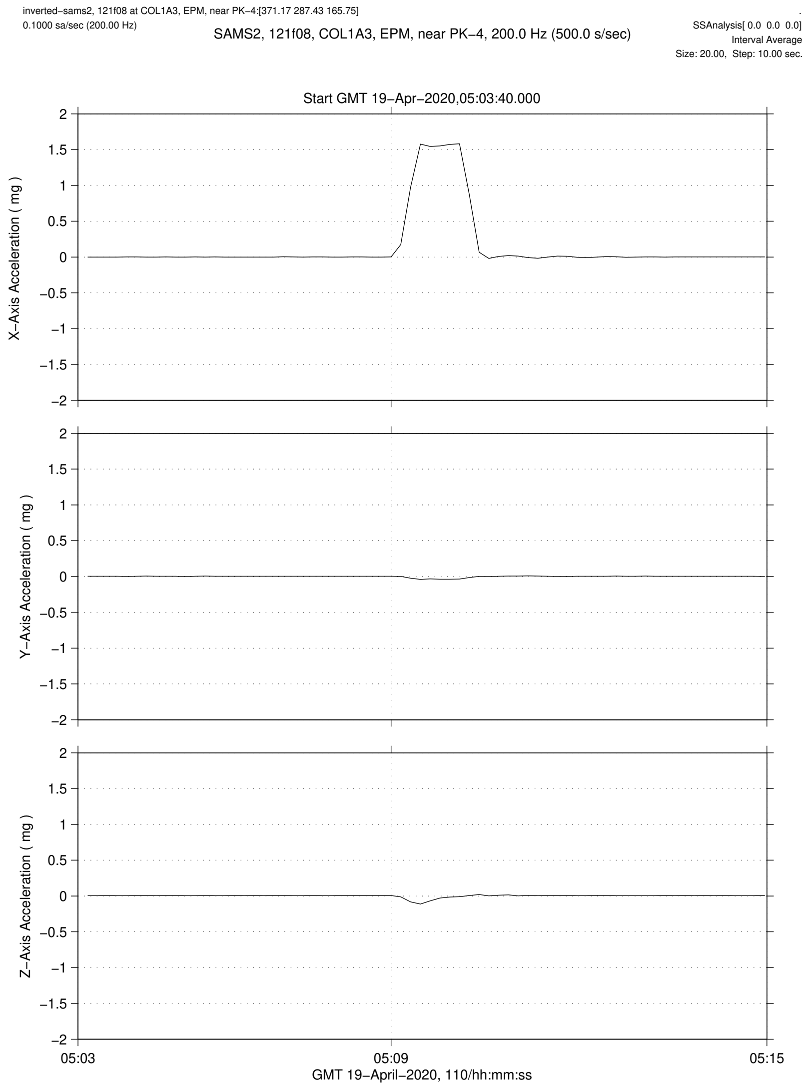

Fig. 7: 20-sec interval average for SAMS 121f08 sensor in the COL.

Fig. 8: Artist rendering of Service Module thruster firing (not actual depiction).