## 1. INTRODUCTION

At GMT 2020-09-22, 266/21:19:10, the International Space Station (ISS) began a ~2-minute 45-second reboost using eight Progress 75P aft thrusters. This reboost was an unplanned posigrade debris avoidance maneuver (PDAM), which had the crew sheltering in place in the Service Module during the reboost. Ultimately, this maneuver was used to clear a conjunction with Object 46477 (H-2A Debris). The visiting vehicles graphic of Figure 1 shows the location and alignment of the Progress 75P vehicle during this reboost. Newton's 3rd law is in action (and reaction) here with Progress thrusters firing in the aft direction to accelerate the ISS in the 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 about 0.5 km.

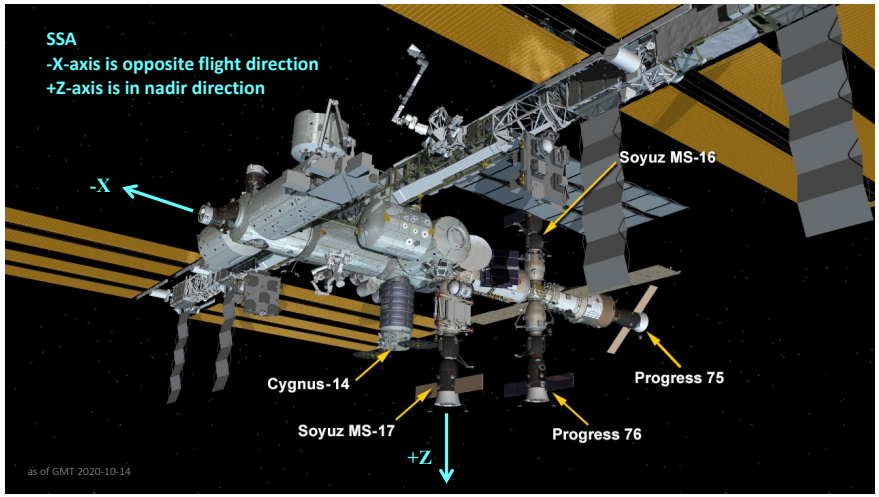


Fig. 1: Progress 75P's location and alignment during reboost.

## 2. QUALIFY

The information shown in Figure 2 was calculated from SAMS sensor 121f03 measurements made in the US Laboratory module. This plot shows increased structural vibration excitation contained between about GMT 20:09 to 23:00. We can attribute some of this increase to Russian Segment (RS) attitude control since the as-flown timeline shows that is the period that RS control was in 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 (green/yellow) to more energetic (orange/red) sporadically during this period of RS control spanning nearly 3 hours. The actual reboost activity itself lasted about 2 minutes 45 seconds evidenced by slight more pronounced, vertical orange-red streaks in Figure 2 around GMT 21:19:10. For science operations and general situational awareness, it is prudent 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 3 minutes – but also during the much longer span of Russian Segment attitude control too.

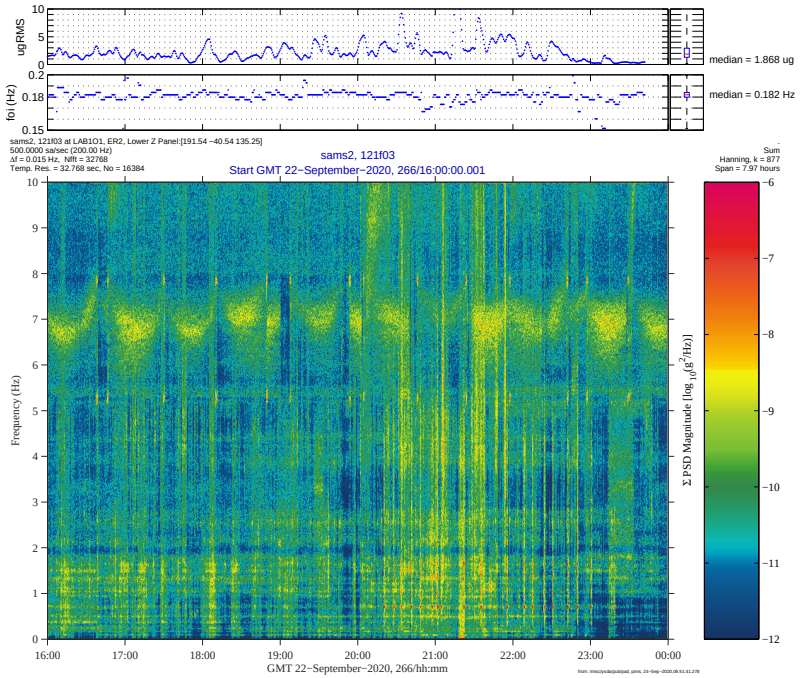


Fig. 2: Spectrogram showing Progress 75P PDAM Reboost on GMT 2020-09-22.

## 3. QUANTIFY

The as-flown timeline for this event indicated the reboost would start at GMT 21:19:00 and have a duration of 165 seconds. Analysis of Space Acceleration Measurement System (SAMS) data recordings shows the tell-tale X-axis step that was about 10 seconds later than planned and the duration as seen in the top subplot of Figure 4 was about 2 minutes 45 seconds (a bit shorter than planned).

Four 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 the X-axis during the reboost 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 reboost as measured by the 5 distributed SAMS sensors is given in Table 1.

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

| Sensor | X-Axis | Location |
|---|---|---|
| 121f02 | 0.185 | JPM1A6 (RMS Console) |
| 121f03 | 0.185 | LAB1O1 (ER2) |
| 121f04 | 0.185 | LAB1P2 (ER7) |
| 121f05 | 0.185 | JPM1F1 (ER5) |
| 121f08 | 0.186 | COL1A3 (EPM) |

## 4. CONCLUSION

The SAMS sensors were designed to characterize the higher-frequency vibratory environment of the ISS, but not the lower-frequency, quasi-steady environment. However, they perform well for capturing the relatively large steps induced by reboost events. The SAMS sensor data analyzed showed an **X-axis** step during the Progress 75P reboost of about 0.2 mg. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 in the US LAB indicate a $\Delta V$ of about 0.3 meters/second was achieved. This value matched the planned value of $\Delta V = 0.30$ meters/second. Flight controllers reported that this reboost elevated the space station's altitude by 0.488 km.

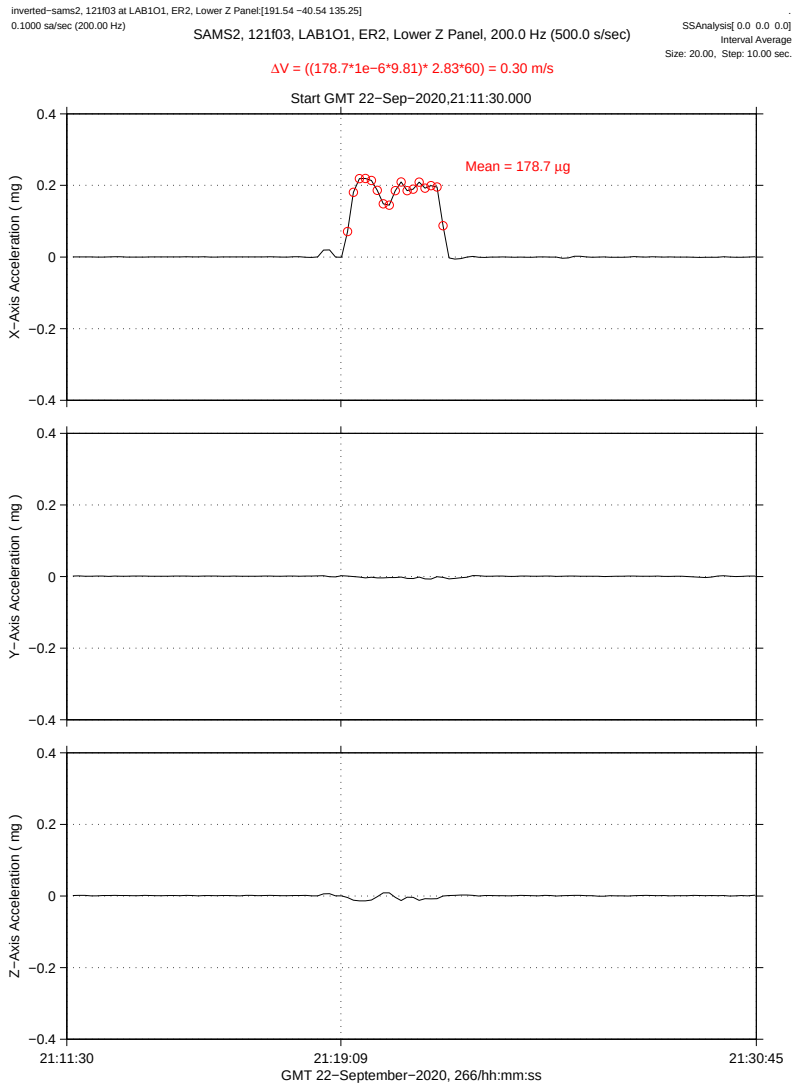


Fig. 3: Interval average of SAMS 121f03 sensor data shows Progress 75P reboost.

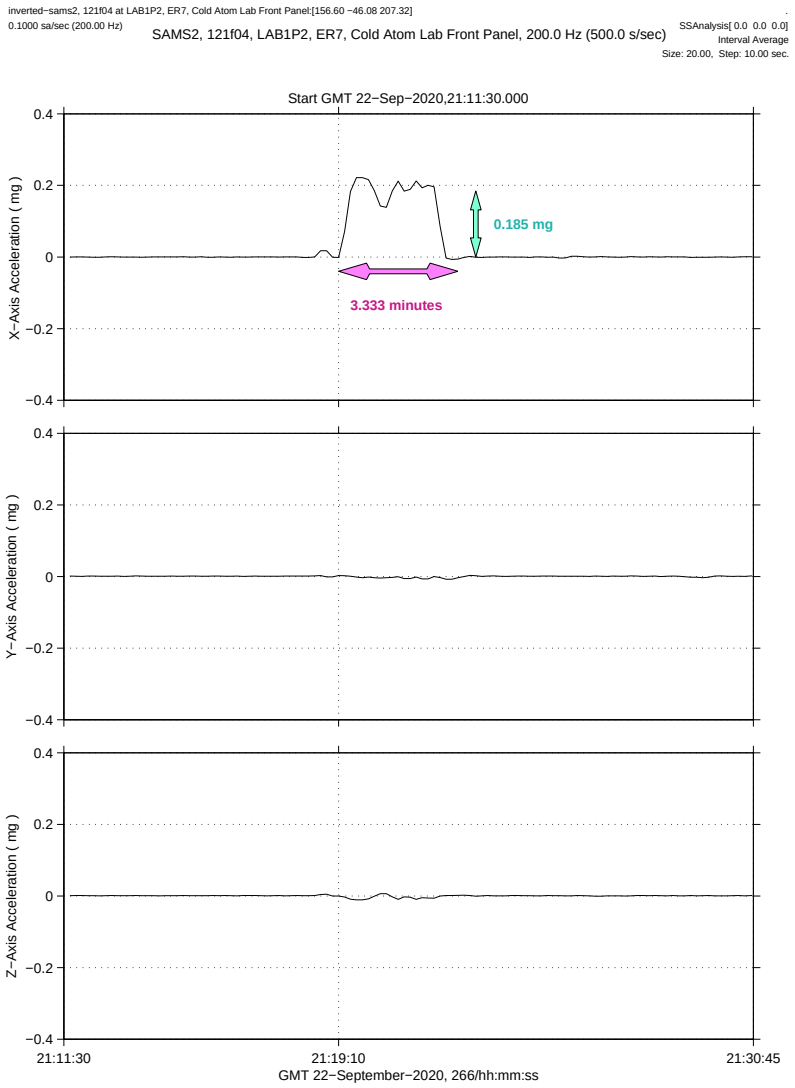


Fig. 4: 20-sec interval average for SAMS 121f04 sensor in the LAB.

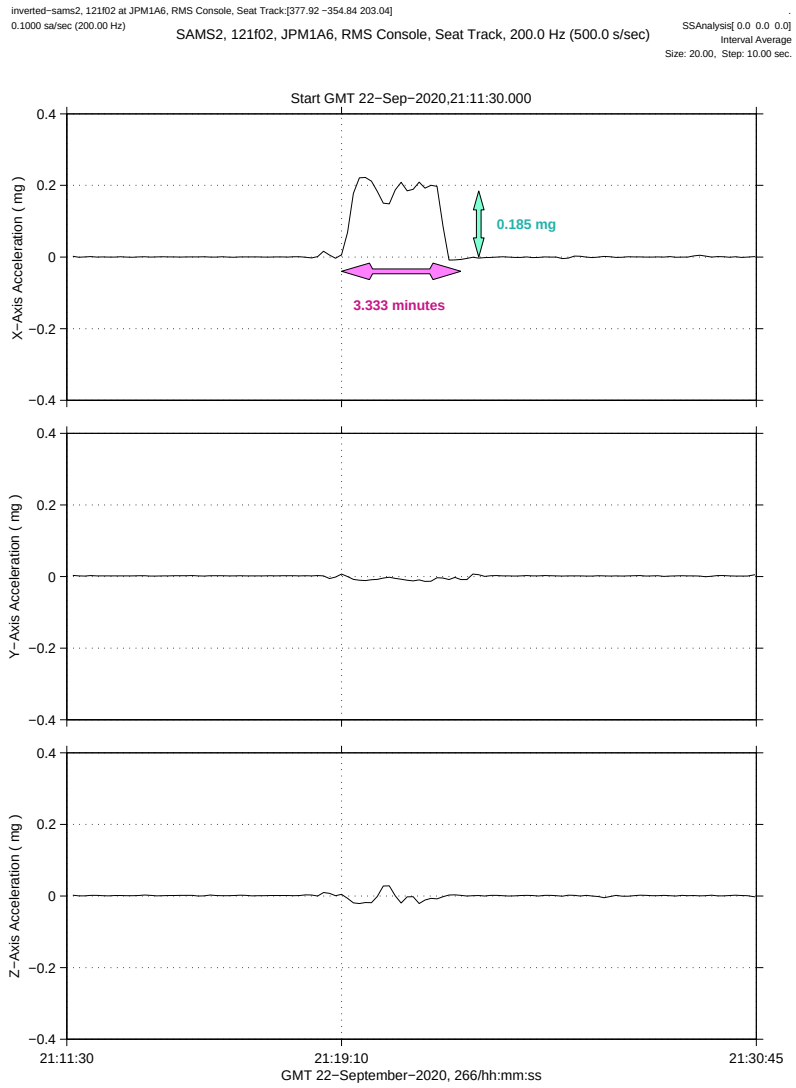


Fig. 5: 20-sec interval average for SAMS 121f02 sensor in the JEM.

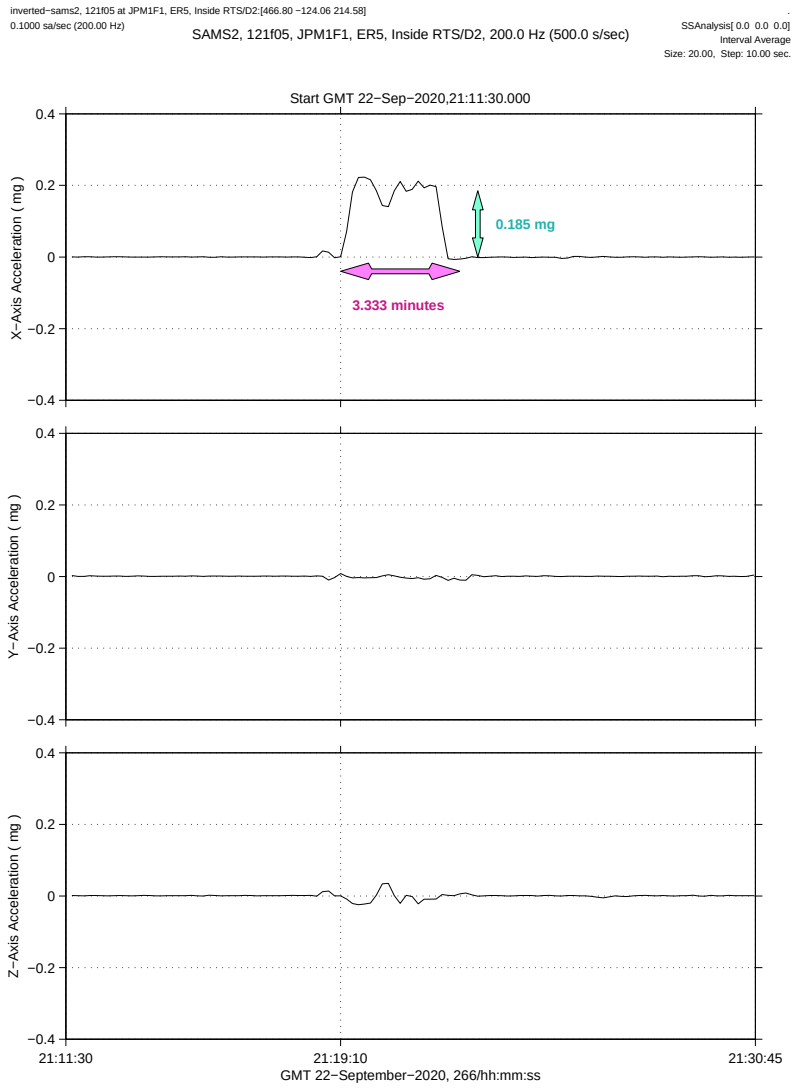


Fig. 6: 20-sec interval average for SAMS 121f05 sensor in the JEM.

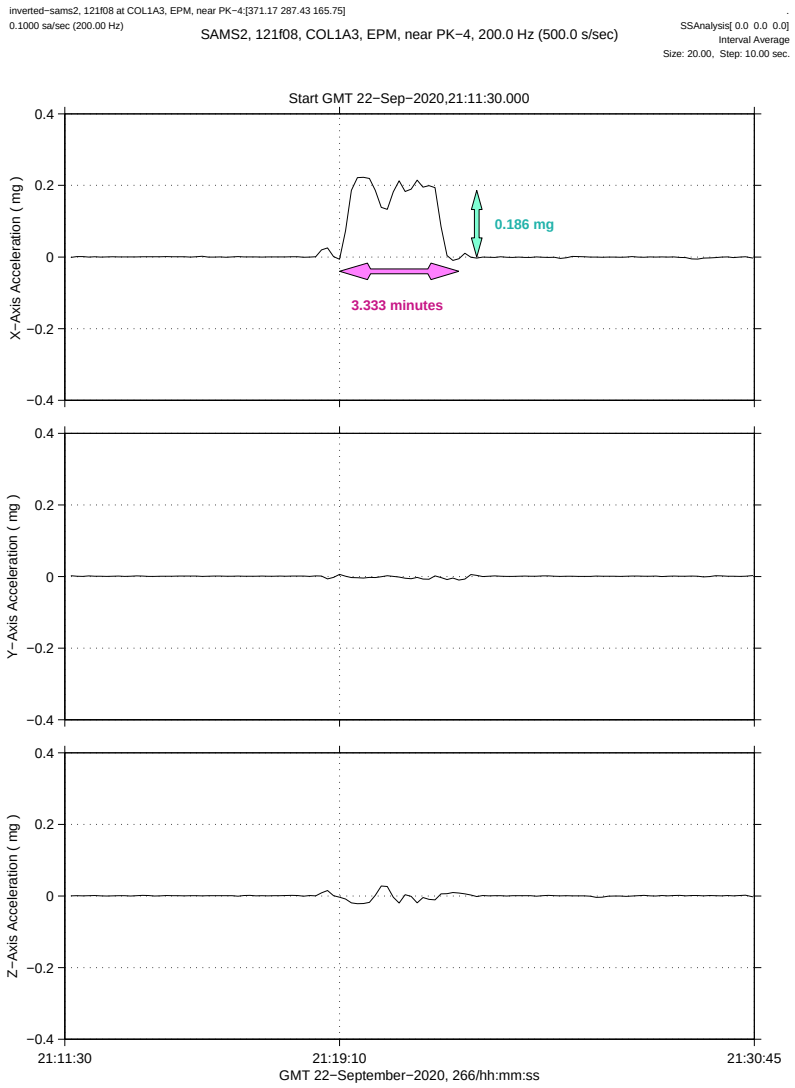


Fig. 7: 20-sec interval average for SAMS 121f08 sensor in the COL.