1. INTRODUCTION

At GMT 2019-05-23, 143/16:08:00, the International Space Station (ISS) began an ~20-minute reboost using Progress 71P aft thrusters. This reboost was intended to meet constraints for the Soyuz 57S undock upcoming on GMT 175 (2019-06-24). The visiting vehicles graphic of Figure 1 shows the location and alignment of the Progress 71P 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 4.4 km.

![Soyuz MS-11, Dragon-17, Cygnus-11, Progress 71P, Progress 72]

Fig. 1: Progress 71P’s location and alignment during reboost.

2. QUALIFY

The information shown in Figure 2 was calculated from SAMS sensor 121f08 measurements made in the Columbus Laboratory module. This plot shows increased structural vibration excitation between about 15:03 and 16:55. 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 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 20 minutes – but also during the span of Russian Segment attitude control as displayed here.

![Spectrogram showing Progress 71P Reboost on GMT 2019-05-23]

Fig. 2: Spectrogram showing Progress 71P Reboost on GMT 2019-05-23.

3. QUANTIFY

The as-flown timeline for this event indicated the reboost would start at GMT 16:08 and have a burn duration of about 20 minutes. 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.

Three 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 ?? on page ???. 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 3 distributed SAMS sensors is given in Table 1.

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

<table>
<thead>
<tr>
<th>Sensor</th>
<th>X-Axis Step (mg)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>121f02</td>
<td>not powered</td>
<td>JPM1A6 (RMS Console)</td>
</tr>
<tr>
<td>121f03</td>
<td>0.218</td>
<td>LAB1O1 (ER2)</td>
</tr>
<tr>
<td>121f04</td>
<td>0.218</td>
<td>LAB1P2 (ER7)</td>
</tr>
<tr>
<td>121f05</td>
<td>not powered</td>
<td>JPM1F1 (ER5)</td>
</tr>
<tr>
<td>121f08</td>
<td>0.218</td>
<td>COL1A3 (EPM)</td>
</tr>
</tbody>
</table>

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 Progress 71P reboost of about 0.2 mg. Furthermore, calculations based on
SAMS sensor (121f03) mounted on EXPRESS Rack 2 in the US LAB indicate a
\[ \Delta V = \frac{(216.5 \times 10^{-6} \times 9.81) \times 19.83 \times 60}{200.0 \text{ Hz} \times 200.0 \text{ Hz}} \approx 2.53 \text{ m/s} \]

This nearly matched the planned value of \( \Delta V = 2.55 \text{ meters/second} \).
Fig. 4: 20-sec interval average for SAMS 121f03 sensor in the LAB.

Fig. 5: 20-sec interval average for SAMS 121f04 sensor in the LAB.
Fig. 6: 20-sec interval average for SAMS 12f08 sensor in the COL.