1. Introduction

At GMT 2018-12-27, 361/03:05, the International Space Station (ISS) began a ~3-minute reboost using Progress 71P thrusters. The visiting vehicles graphic of Figure 1 shows the location and alignment of the Progress 71P during the reboost. Newton's 3rd law in action (and reaction) here with Progress thrusters firing in the aft direction to accelerate the ISS in the forward direction. An increase in velocity in the forward/flight direction is the orbital mechanics way to increase the altitude of the space station.

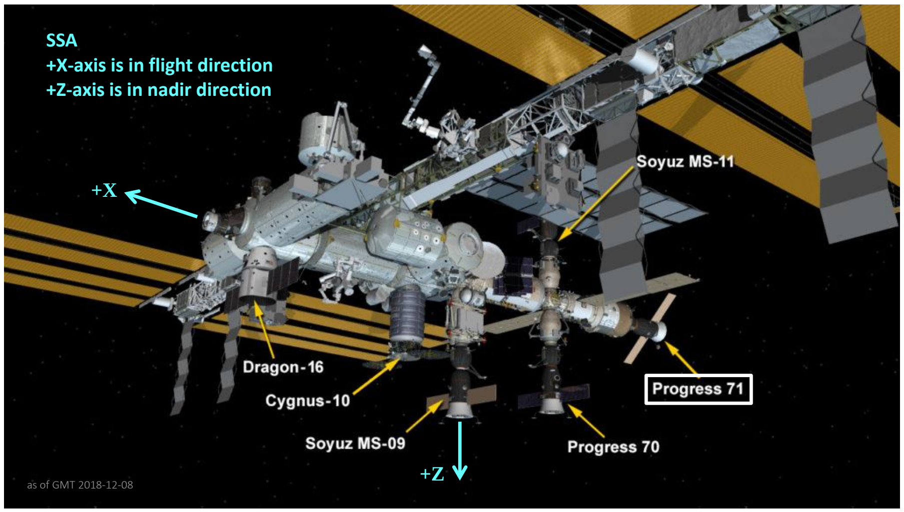

Fig. 1: Progress 71P's location & alignment during reboost.

2. Qualify

An excerpt from the as-flown timeline shown in Figure 3 on page 3 indicates a burn duration of just under 5.67 minutes. Analysis of Space Acceleration Measurement System (SAMS) data recordings made during the reboost shows that features of the acceleration measurements closely match this duration. For example, the middle arrow in the color spectrogram of Figure 2 shows the start of reboost at GMT 03:05, which begins excitation of space station structural modes. These excitations are manifest as bright yellow/orange/red horizontal streaks (i.e. narrowband spectral peaks) primarily below about 2 Hz. These streaks of excitation continue for the duration of the reboost.

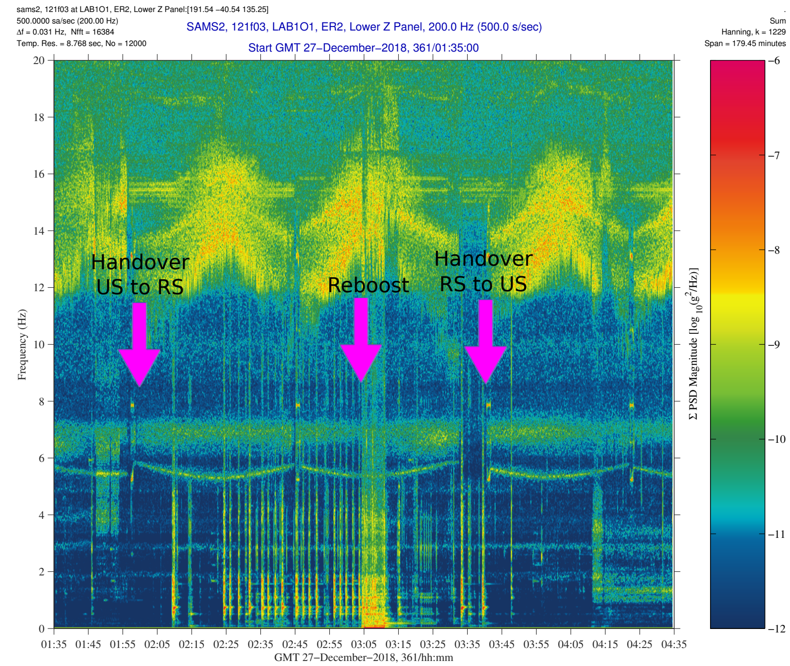

Fig. 2: Spectrogram showing Progress 71P Reboost on GMT 2018-12-27.

The spectral information of figure 2 was computed from SAMS sensor 121f03 measurements made in the US Laboratory (LAB). This figure has arrow and text annotations at the following times to capture the main events related to this reboost:

(1) GMT 02:00 handover from the US to Russian Segment (RS)
(2) GMT 03:05 start reboost
(3) GMT 03:40 handover back to US for station keeping

Note that the transient & vibratory environment (primarily below about 10 Hz or so) is impacted not only during the reboost itself, but also during the span of Russian Segment attitude control.

3. QUANTIFY

Five 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 4. 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 flip issue inherent in SAMS transducers. A crude quantification of the reboost as measured by the 5 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	0.194	JPM1A6 (RMS Console)
121f03	0.195	LAB1O1 (ER2)
121f04	0.195	LAB1P2 (ER7)
121f05	0.197	JPM1F1 (ER5)
121f08	0.195	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 crude acceleration step of reboost as demonstrated here. These independent sensors all agreed that the X-axis step during the Progress 71P reboost stood at just about 0.2 mg. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 in the US LAB indicate a ΔV of about 0.62 meters/second was achieved. This is in close agreement with the predicted value, $\Delta V = 0.65$ meters/second.

More Info

#	Maneuver Start-Stop GMT	S-Band?	Beta Angle	Attitude Name	Ref. Frame	YPR	F/T Cfg.	Event	Remarks
71P Reboost (M18_361_A_08.UAF)									12/27/2018
9	361/02:00:00 —	Y	-46	+XVV +ZLV TEA	LVLH	+356.000 +359.500 +0.700	MMT THR	Handover US to RS	
10	361/02:05:00 361/02:10:00	Y	-46	+XVV +ZLV TEA	LVLH	+356.000 +359.500 +0.700	THR THR	Quaternion Update for Reboost in TEA (Prog on SM Aft)	TIG 03:05:00 DUR 00:05:37
11	361/03:10:37 361/03:15:37	Y	-46	+XVV +ZLV TEA	LVLH	+356.000 +359.500 +0.700	THR THR	Quaternion Update	
12	361/03:40:00 —	Y	-46	+XVV +ZLV TEA	LVLH	+356.000 +359.500 +0.700	THR MMT	Handover RS to US Momentum Management	TEA for VV#2z_N1nCN2nDzefe, PSARJ auto, SSARJ auto

Fig. 3: As-flown timeline entry for GMT 2018-12-27.

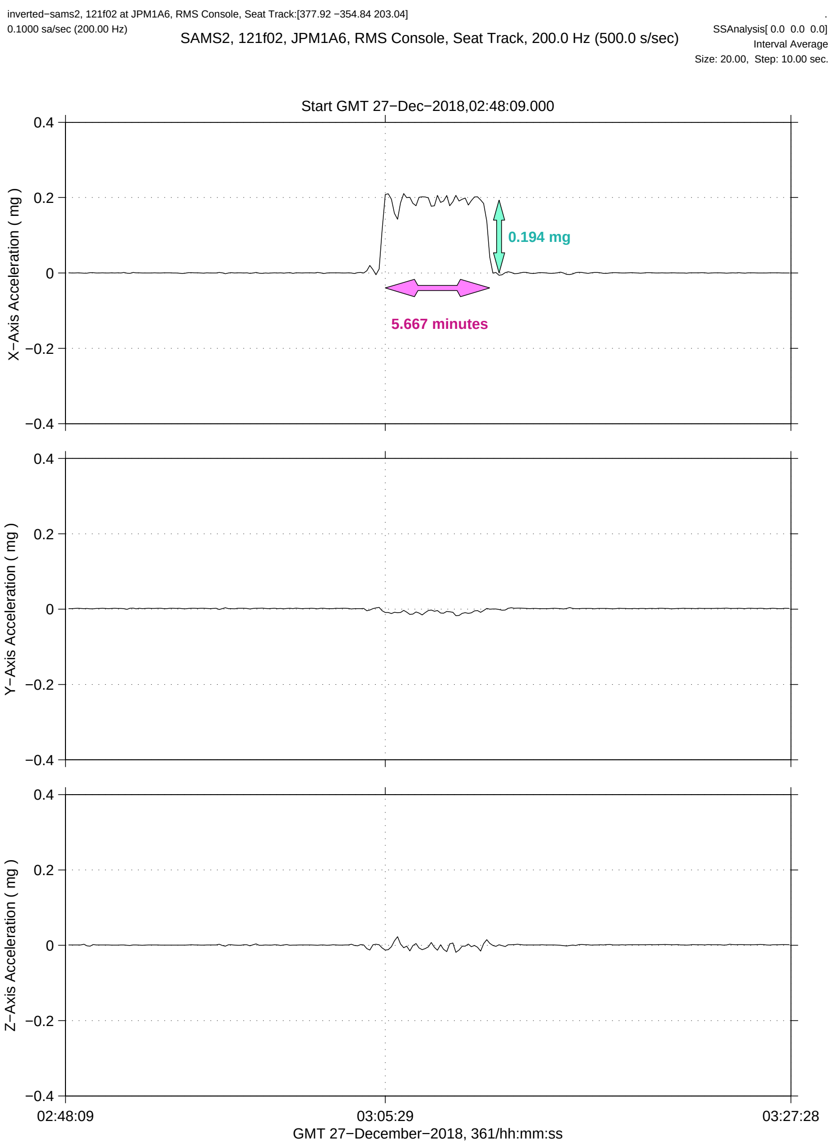

Fig. 4: 60-sec interval average for SAMS 121f02 sensor in the JEM.

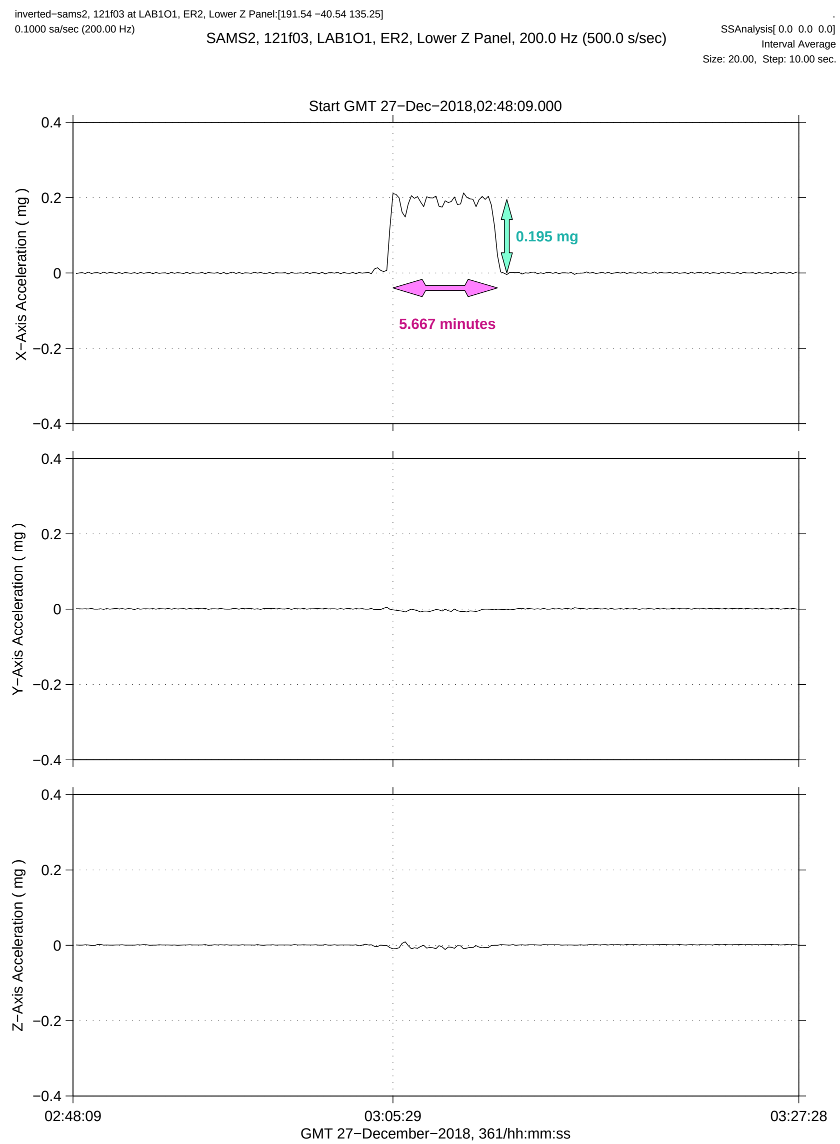

Fig. 5: 60-sec interval average for SAMS 121f03 sensor in the LAB.

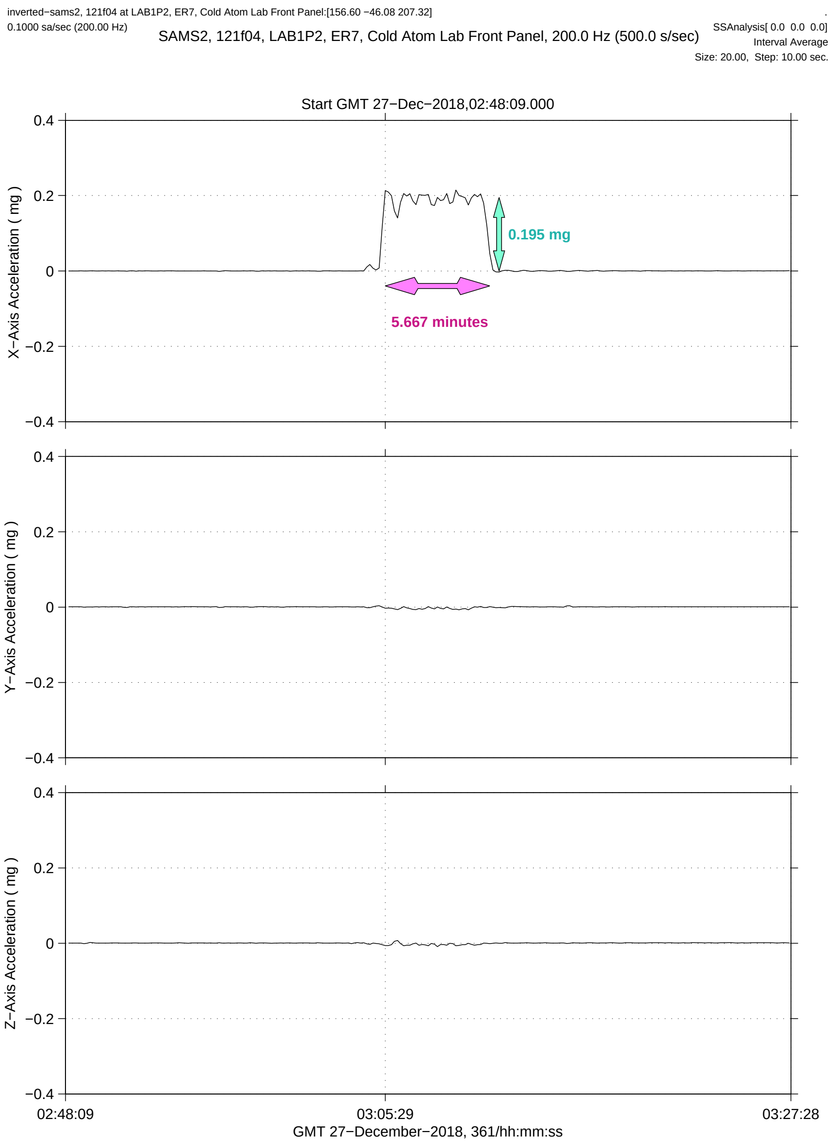

Fig. 6: 60-sec interval average for SAMS 121f04 sensor in the LAB.

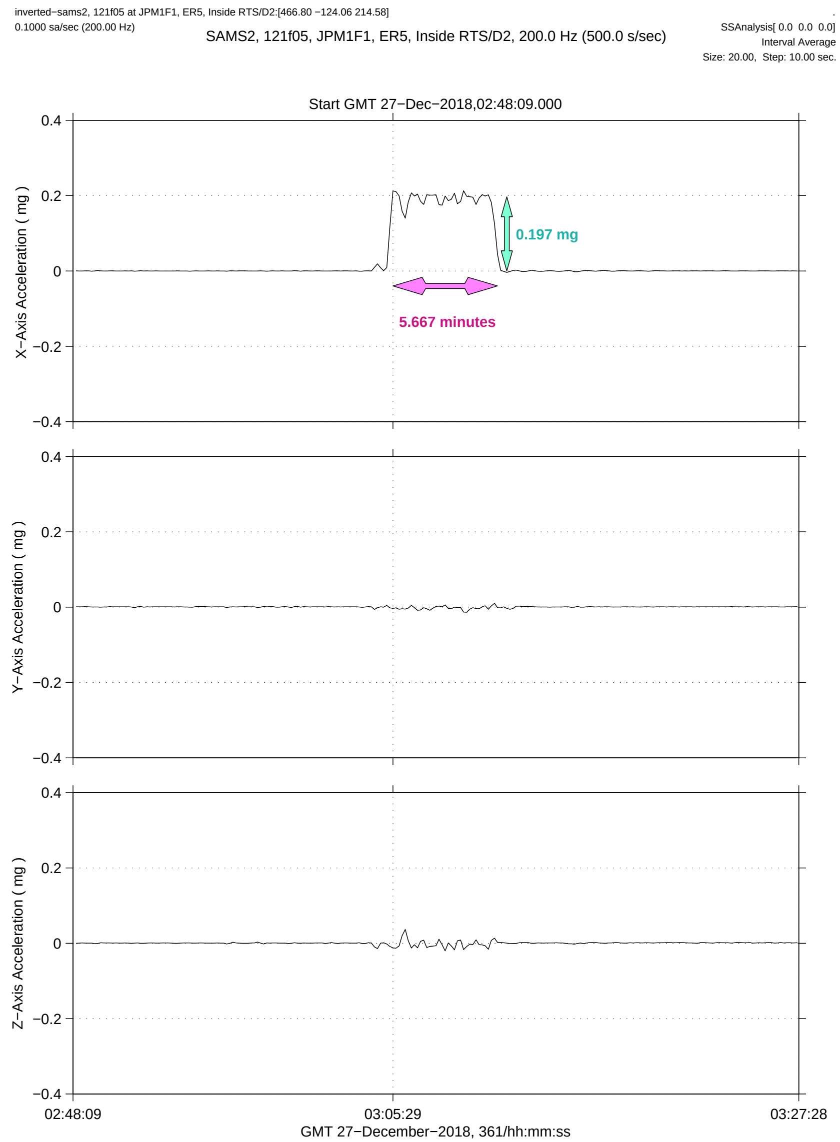

Fig. 7: 60-sec interval average for SAMS 121f05 sensor in the JEM.

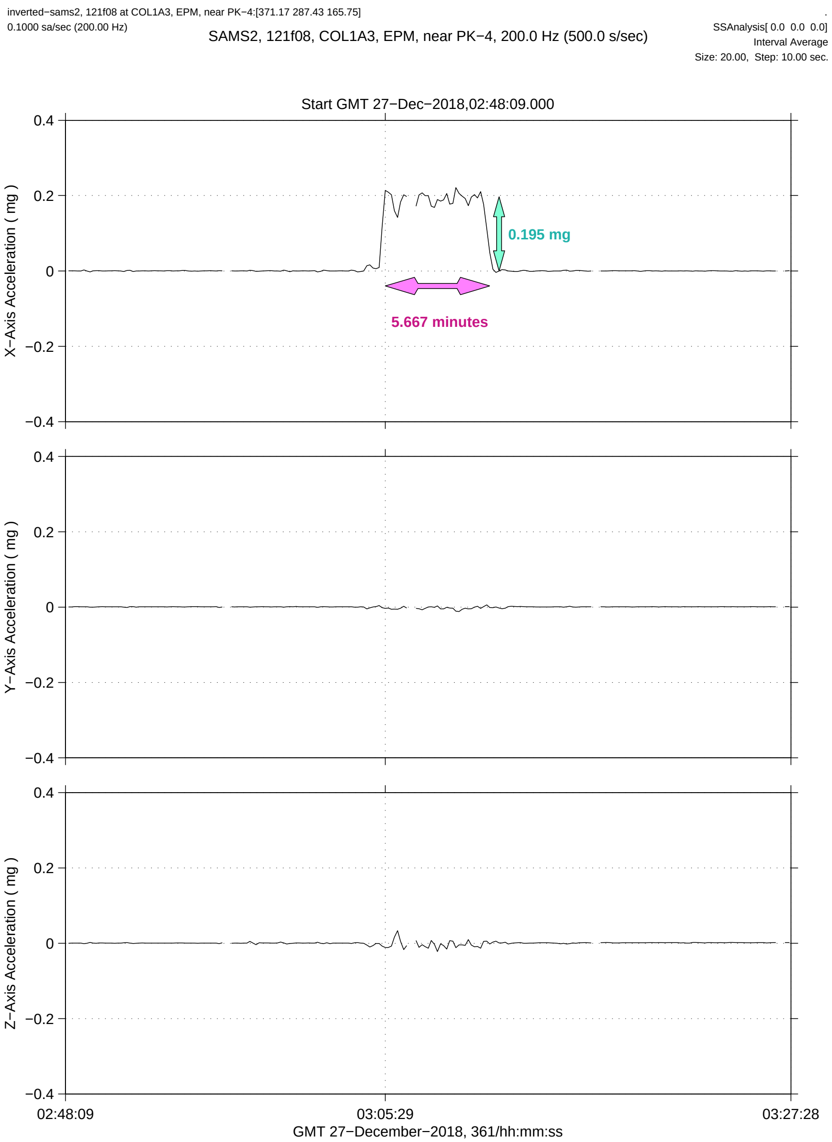

Fig. 8: 60-sec interval average for SAMS 121f08 sensor in the COL.