1. INTRODUCTION

The Russian Progress 70P cargo ship undocked from the International Space Station (ISS) and was directed to deorbit and destruct over the Pacific Ocean. The Progress 70P resupply vehicle ended its 6½ month stay at the space station when it undocked from the Pirs docking compartment (DC-1) at GMT 2019-01-25/12:55. The friction created by a high-velocity descent through Earth's atmosphere destroyed the cargo ship and its contents of trash and discarded gear. All burned up safely over the southern Pacific Ocean.

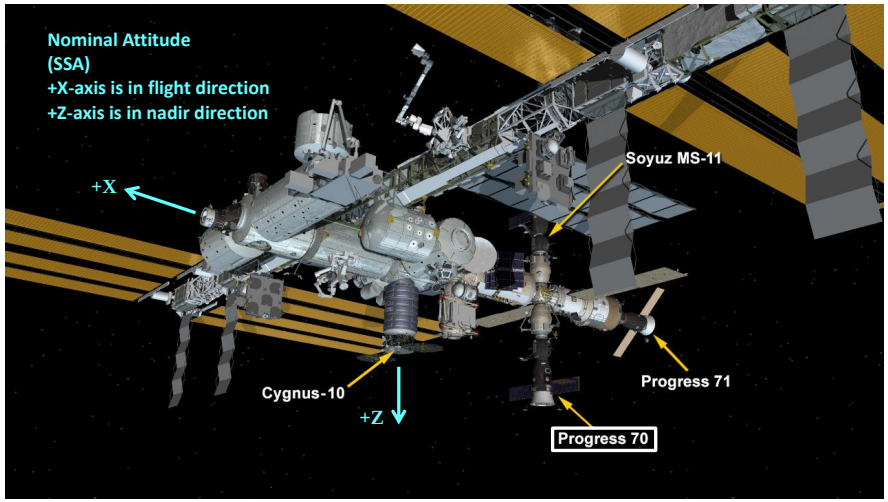

Fig. 1: Progress 70P's location before undocking.

2. QUALIFY

The spectral information shown in Figure 2 was computed from SAMS sensor 121f03 measurements made in the US Laboratory (LAB). This plot shows increased structural vibration excitation (brief ringing) at the 3 time hacks shown in the annotations of that figure. The main activities noted for this undocking from the as-flown timeline include:

1) **GMT 11:55:00** - Transition to US-thruster only (USTO) control.
2) **GMT 11:55:01** - Begin maneuver to +ZVV attitude.
3) **GMT 12:44:00** - Handover from US to RS for attitude control.
4) **GMT 12:52:30** - Free drift for undocking.
5) **GMT 12:55:30** - Physical Separation (undocking).
6) **GMT 12:56:40** - RS snap and hold.
7) **GMT 13:03:20** - Handover RS to US for attitude control.
8) **GMT13:02:21** - Begin maneuver back to nominal +XVV attitude.
9) **GMT 13:42:00** - Transition to momentum management.

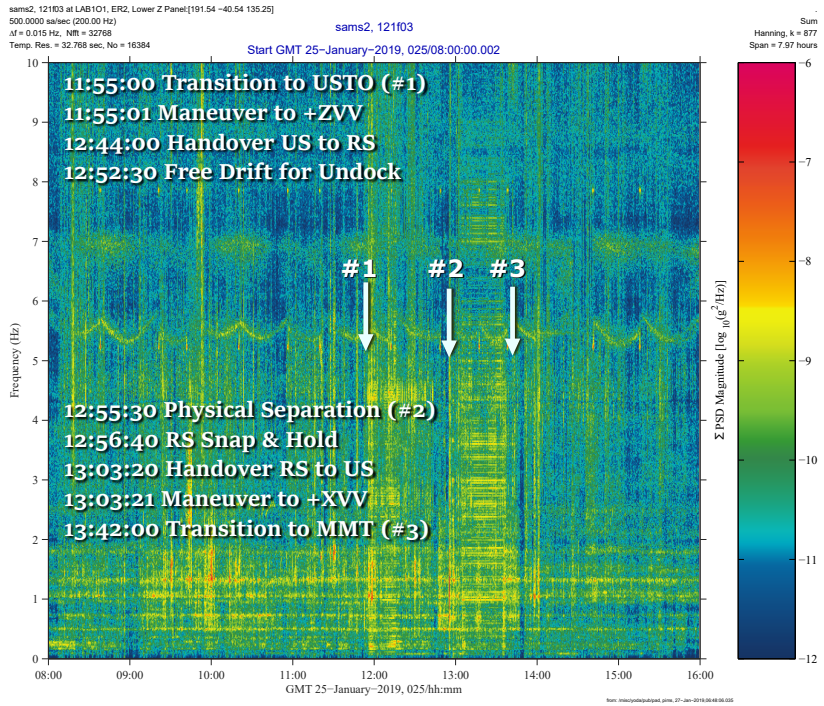

Fig. 2: Spectrogram showing Progress 70P undocking events on GMT 2019-01-25.

ISS propulsive control is managed by Russian Service Module (SM) computers. The primary mode of propulsive operation is under Russian control using software, called the Russian Segment (RS) Motion Control System (RS MCS). However, a US-thruster only (USTO) mode of operation is also possible. This mode puts the

RS thrusters under US command. Under both modes, a wide range of thruster configurations are available for both translation and attitude control. The SM provides control in all three axes, and a Progress or an Automated Transfer Vehicle (ATV) at the SM-Aft docking port can provide control in all three axes as well. Momentum management for attitude control uses a combination of Control Moment Gyroscopes (CMGs) and RS thrusters. During quiescent operations, the momentum management controller uses 4 CMGs to maintain a specific momentum vector while the ISS attitude is allowed to deviate slightly (maybe 3 to 4 degrees).

3. QUANTIFY

The as-flown timeline for the undocking event indicated physical separation of the ISS and the Progress 70P spacecraft occurred at GMT 12:55:30. Analysis of Space Acceleration Measurement System (SAMS) data recordings made during the undocking (low-pass filtered at 6 Hz) shows Z-axis ringing that starts at GMT 12:55:19, see Figure 3 on page 2. The bottom, Z-axis plot in Figure 3 shows a strong 1 Hz response aboard the ISS in the US LAB when the Progress 70P undocked. This same signature shows up in another US LAB SAMS sensor data set seen in Figure 4. Signatures for the Japanese Experiment Module (JEM) are on page 3, and for the Columbus module on page 4.

A broader overview of activities surrounding the undocking's physical separation can be see in Figure 8 on page 5. This is basically a zoom-out of Figure 3.

4. CONCLUSION

All SAMS sensors registered the Progress 70P undocking, but to varying degrees. The largest excursion appeared on the X-axis for the SAMS sensor (121f08) in the Columbus module, with brief ringing peak-to-peak value of about 5 mg.

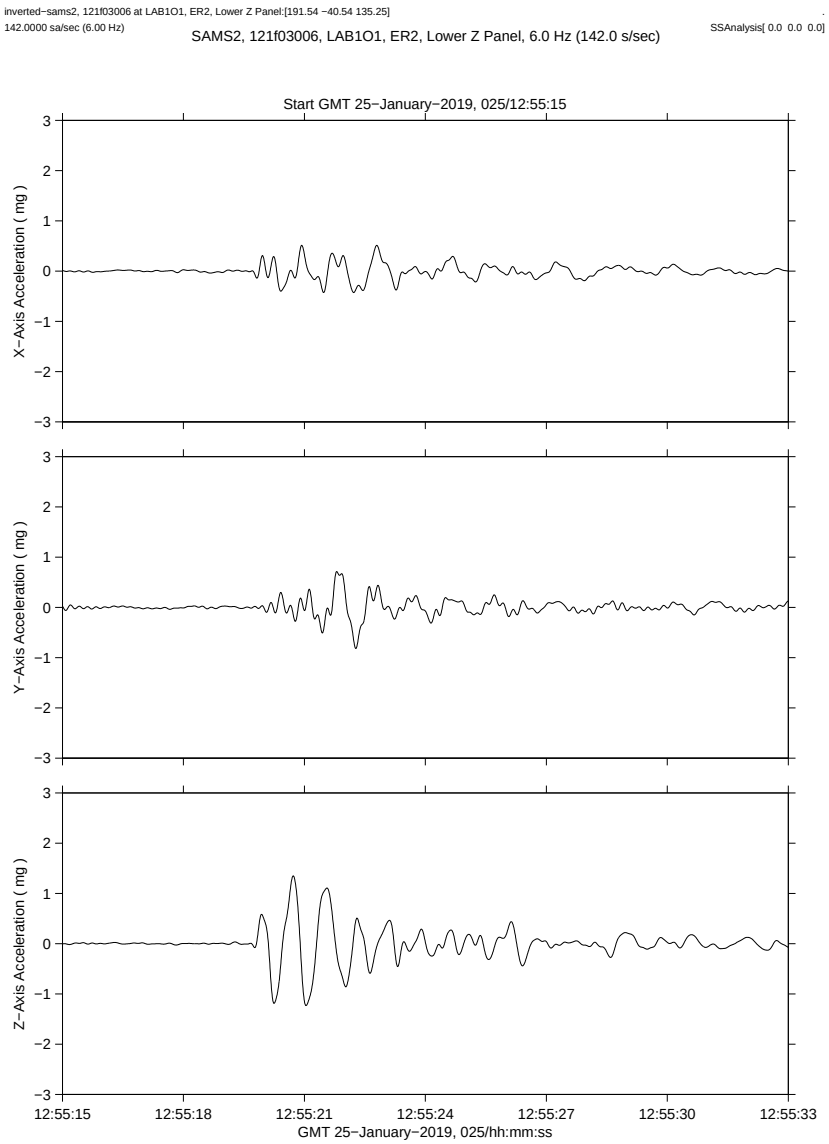

Fig. 3: SAMS 121f03 acceleration data (f < 6 Hz) shows undocking event.

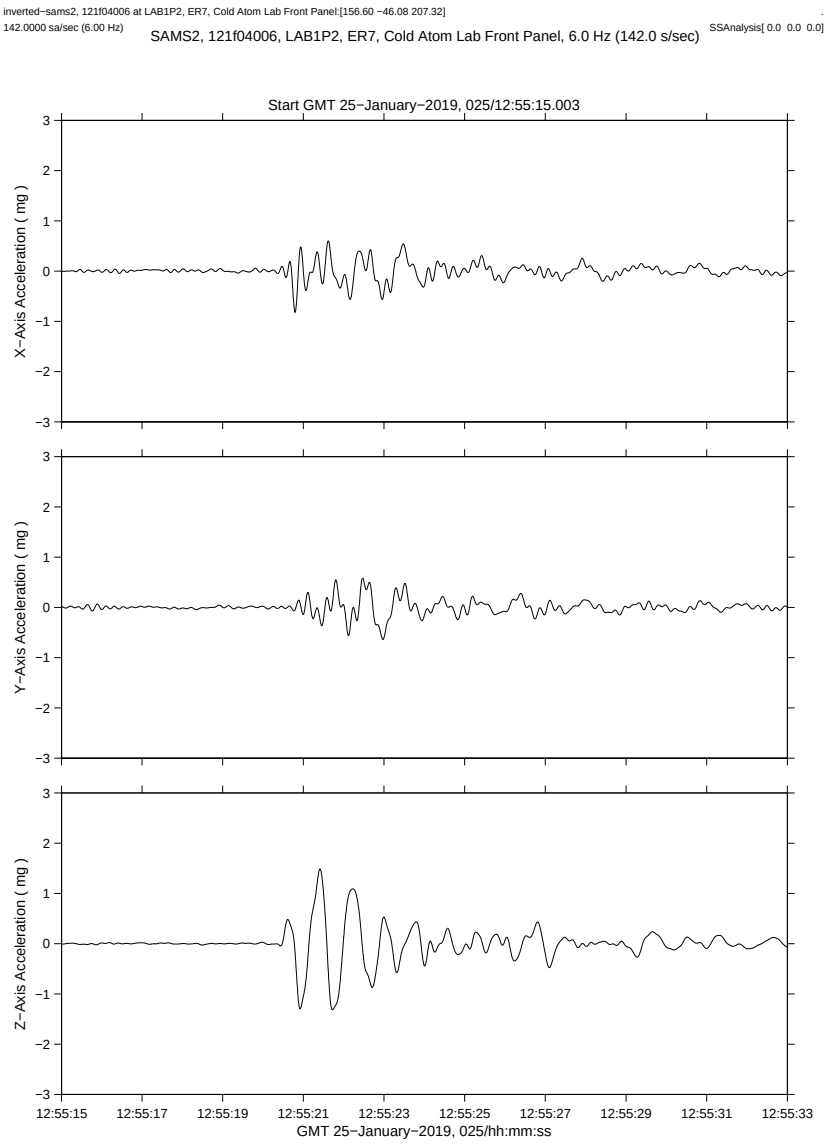

Fig. 4: SAMS 121f04 acceleration data (f < 6 Hz) shows undocking event.

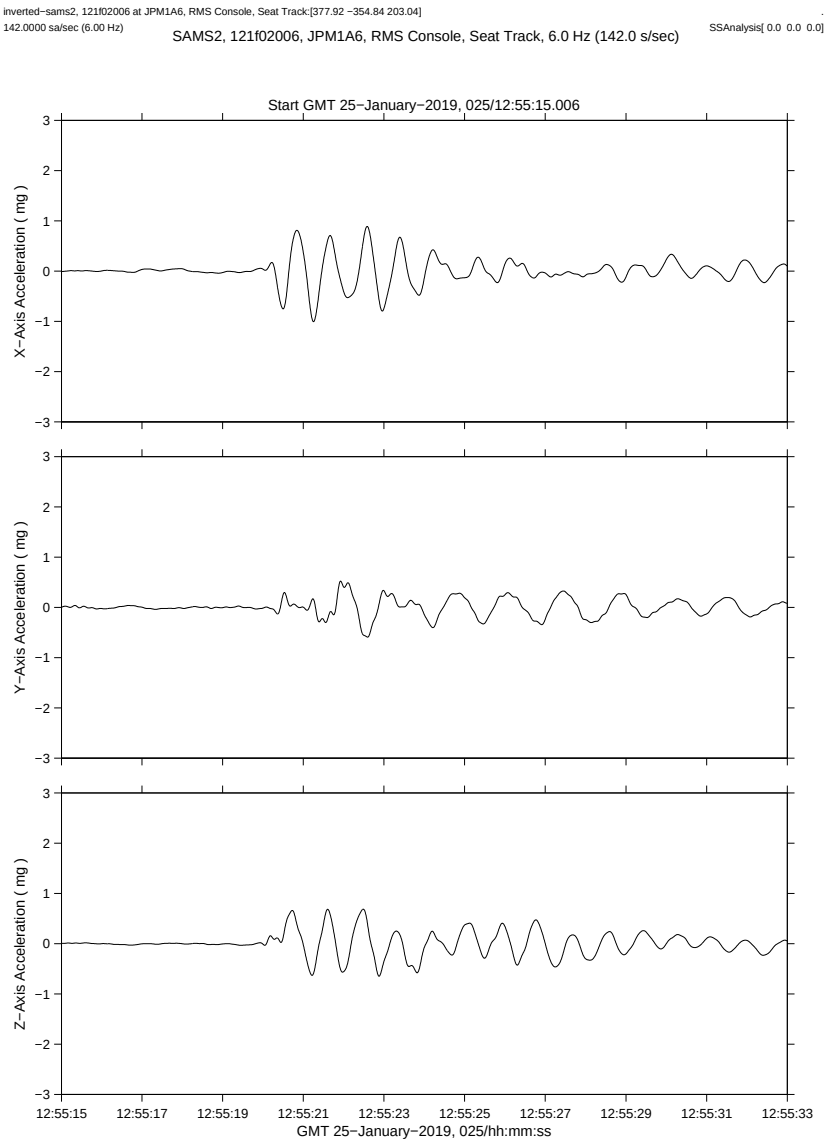

Fig. 5: SAMS 121f02 acceleration data (f < 6 Hz) shows undocking event.

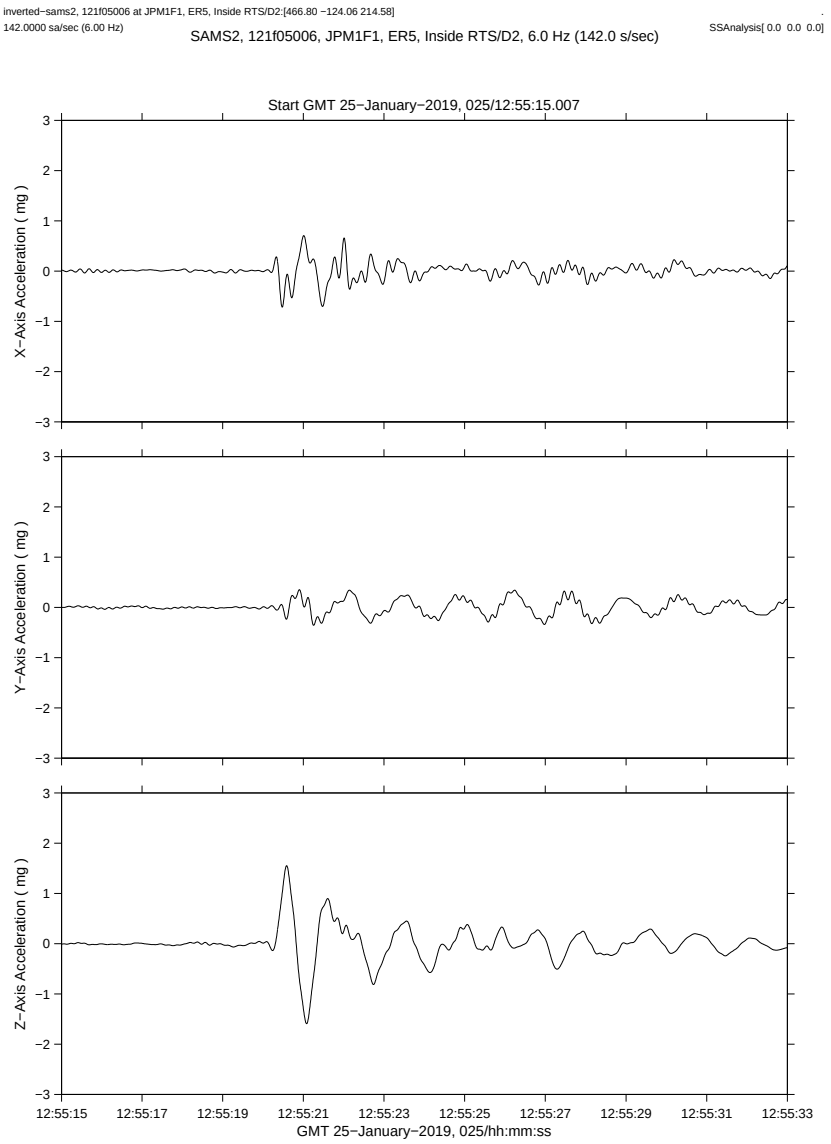

Fig. 6: SAMS 121f05 acceleration data (f < 6 Hz) shows undocking event.

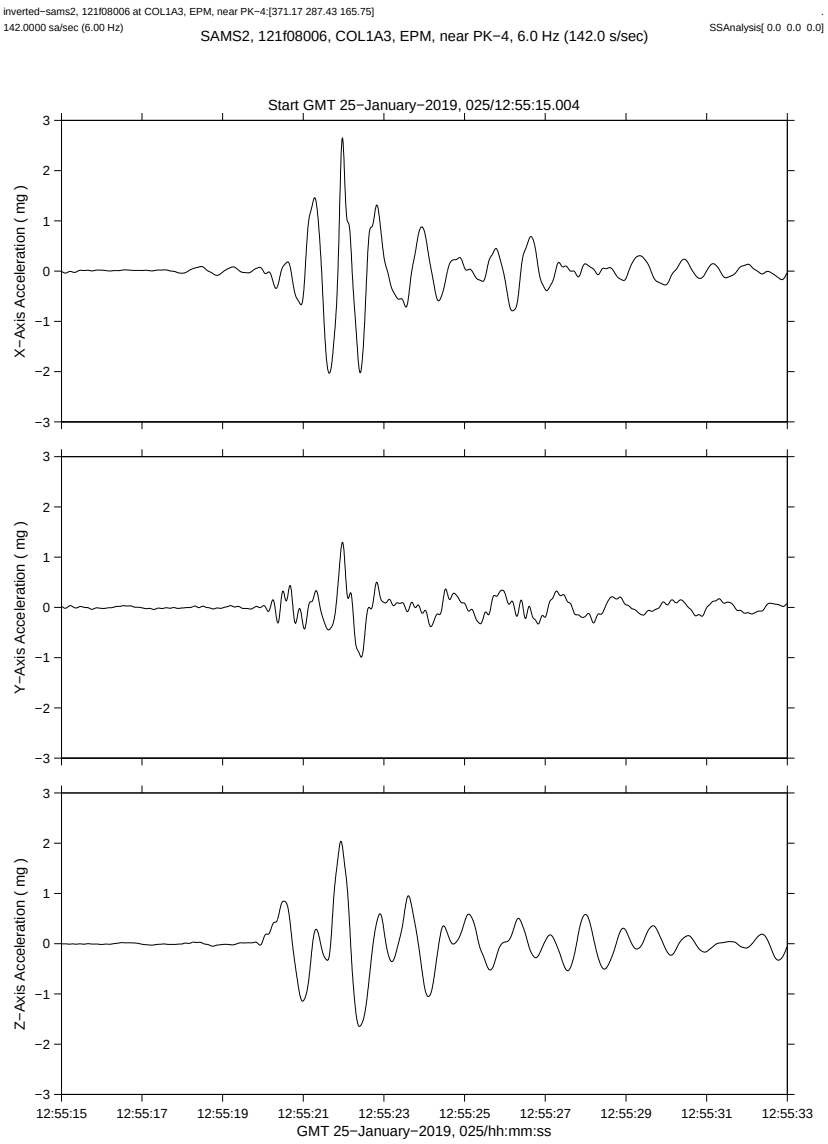

Fig. 7: SAMS 121f08 acceleration data (f < 6 Hz) shows undocking event.

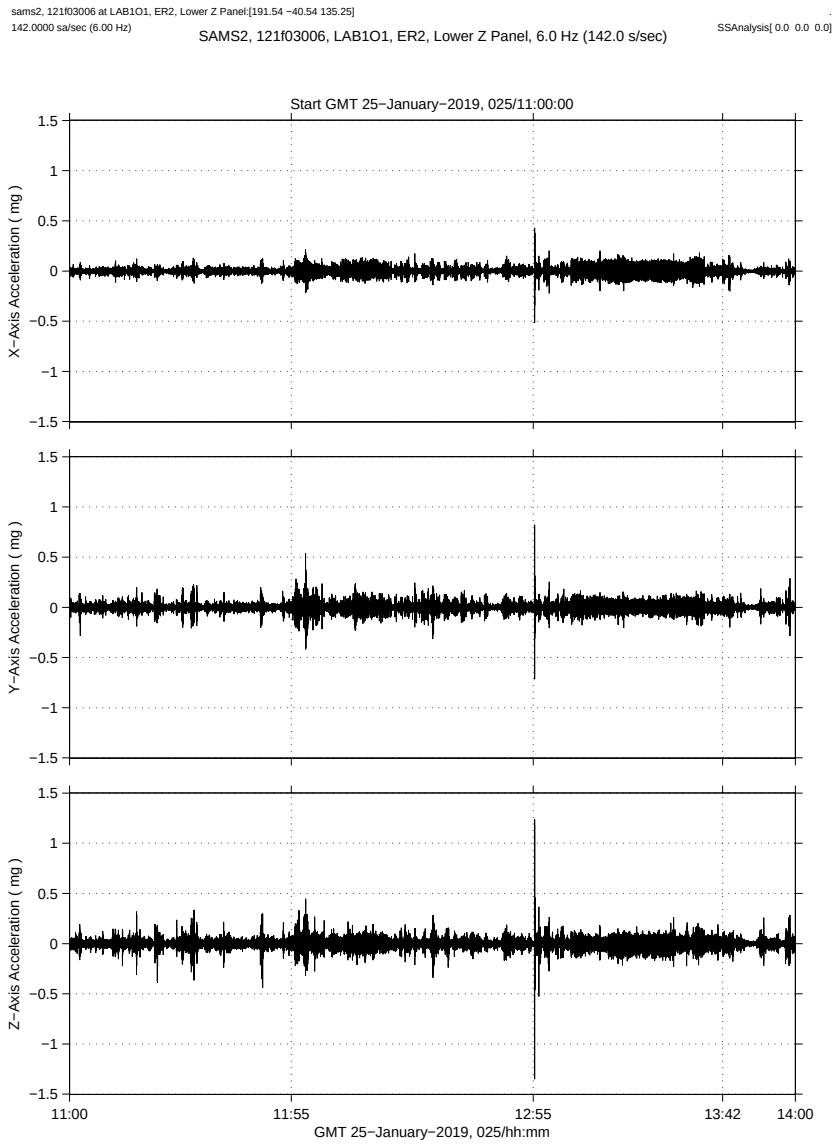

Fig. 8: SAMS 121f03 acceleration data (f < 6 Hz) shows undock activities.