1. INTRODUCTION

For the SpX-17 resupply mission, the Dragon spacecraft's pressurized capsule was loaded with 1,517 kilograms (3,344 lb) of equipment and supplies, while a further 965 kilograms (2,128 lb) of unpressurized cargo was stored in the trunk section, for a total of 2,482 kilograms (5,472 lb).

The pressurized cargo includes 726 kilograms (1,601 lb) of scientific equipment and experiments. Research equipment that SpX-17 delivered to the station includes Tissue Chips in Space, Photobioreactor, the Hermes Facility and equipment needed to augment the Space Acceleration Measurement System (SAMS). This includes:

- 2 sensor heads
- 2 seat track devices
- 4 cable assemblies
- 8 wireless adapters
- 2 USB drives

Along with experiment equipment, the SpX-17 mission delivered 338 kilograms (745 pounds) of supplies and provisions for the space station's crew, 357 kilograms (787 lb) of hardware for the US and International segments of the station, 75 kilograms (165 lb) of computer equipment, 10 kilograms (22 lb) of hardware to support EVAs and 11 kilograms (24 lb) of hardware that is being flown on behalf of the Russian Federal Space Agency.

After the Dragon's cargo was unloaded, the capsule would be filled with equipment to be returned to Earth. Because its capsule is designed to be recovered, Dragon provides NASA and their international partners with the ability to return failed hardware to Earth for investigation, experiments for further analysis, and equipment to be refurbished and reflown.

Dragon's unpressurized Trunk contains hardware that will be mounted on the outside of the space station. This includes the Orbiting Carbon Observatory 3 (OCO-3) payload, which will use three spectrometers to measure the density and distribution of carbon dioxide in Earth's atmosphere.

SpaceX-17 Dragon is scheduled to be docked to the ISS for about one month before its departure and return to Earth. Figure 1 shows a depiction of the visiting vehicle arrangement after the SpX-17 Dragon was berthed to the nadir-facing port of the Node 2 module.

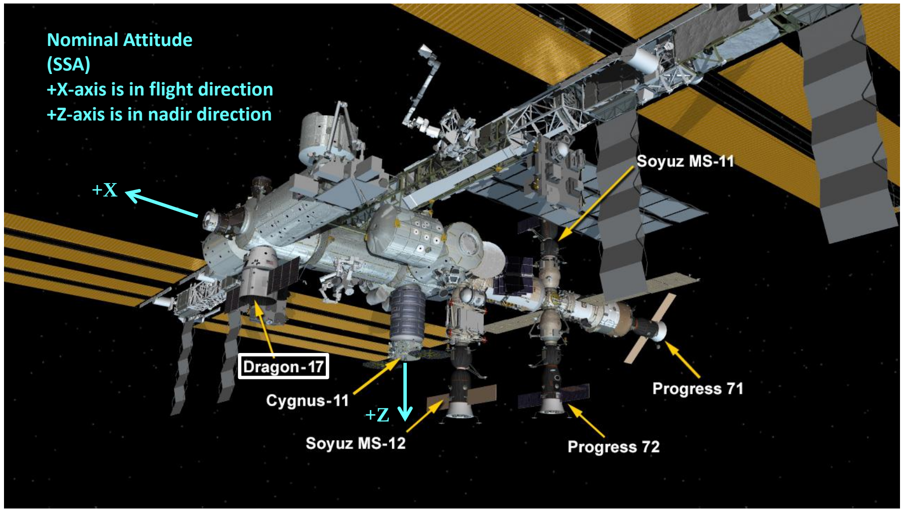

Fig. 1: Visiting vehicle arrangement with Dragon berthed at Node 2 (nadir).

2. QUALIFY

Figure 2 on page 2 is a color spectrogram computed from Space Acceleration Measurement System (SAMS) sensor 121f03 measurements made in the US LAB before, during and after the capture and install activities. The white text annotations show some of the pertinent activities that impact the vibratory environment. Most notably, at GMT 09:24, attitude control was transitioned to US-only thruster (USTO) mode of operation resulting in a series of thruster firings intended to adjust or maintain the space station's attitude during the rendezvous.

Thruster firings, being impulsive accelerations, tend to excite structural modes below about 2 Hz. These vibrations show up initially as vertical, yellowish streaks on the spectrogram followed by brief orange/red horizontal streaks until the excitation settles down. Attitude is held leading up to Dragon capture at ~GMT 11:00, then USTO pattern mentioned earlier is resumes starting at GMT 11:07 and then dies down around GMT 12:46 with transition to momentum management for attitude control.

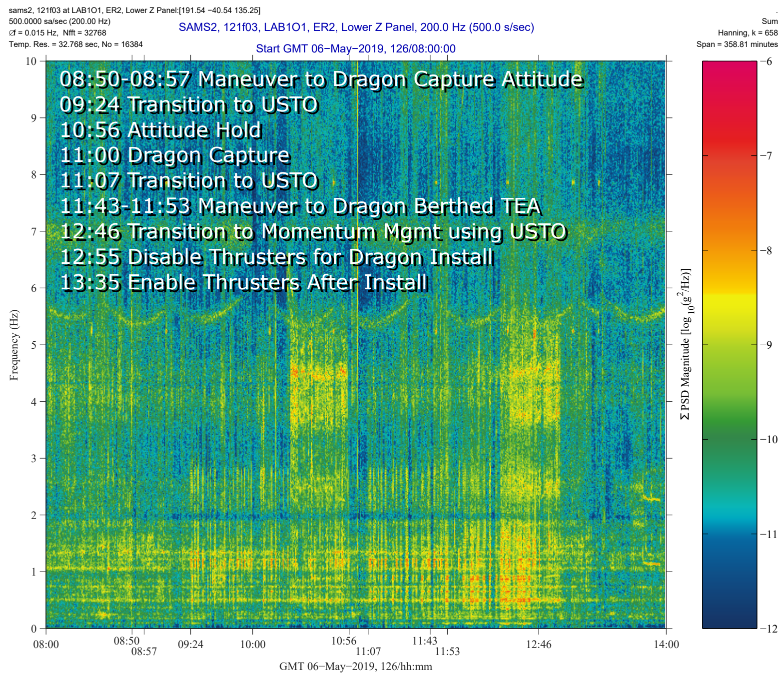

Fig. 2: Spectrogram during Dragon capture/install activities on GMT 2019-05-06.

3. Quantify

The Microgravity Acceleraion Measurement System (MAMS) would have been the instrument to best measure the quasi-steady effects of the capture/install of Dragon and the shift of overall ISS center of mass. However, the MAMS was out of service during these events, so here we take a look at RMS acceleration below 2 Hz to quantify the vibratory impact.

Figure 3 on page 3 shows acceleration Root-Mean-Square (RMS) values versus time. These RMS values (below 2 Hz) were computed from SAMS sensor 121f03 measurements made in the US LAB during the same span as the spectrogram of Figure 2. As the annotations on this plot show, there were notably large RMS impacts during the period when USTO was used to control attitude before and after Dragon capture/install. The capture and install events themselves do not show up as impactful to the transient/vibratory environment. Instead, the maneuvering and attitude control required to orchestrate a clean and safe rendezvous are where we focus for transient and vibratory impacts as shown in Figure 3 through Figure 5 for SAMS sensors in the US Lab and Columbus modules.

RMS values below 2 Hz in the Columbus module topped out just over 500 µg during USTO control as seen in Figure 5. On the other hand, the RMS magnitudes in the US Lab came in at a bit under 200 µg. This disparity comes about due to the structural mode response at the Columbus measurement location relative to the US Lab measurement location. In Columbus, we see larger accelerations stemming from larger displacements.

4. Conclusion

The RMS results presented here reinforce the fact that SAMS sensor the Columbus tend to experience higher magnitude structural mode excitation than those in the US LAB due to the layout, structure and nature of the ISS. In the case of a Dragon capture/install as described in this document, the driving force and source of excitation were thrusters (USTO) needed to change or maintain the space station's attitude, primarily before and after the actual Dragon capture/install events.

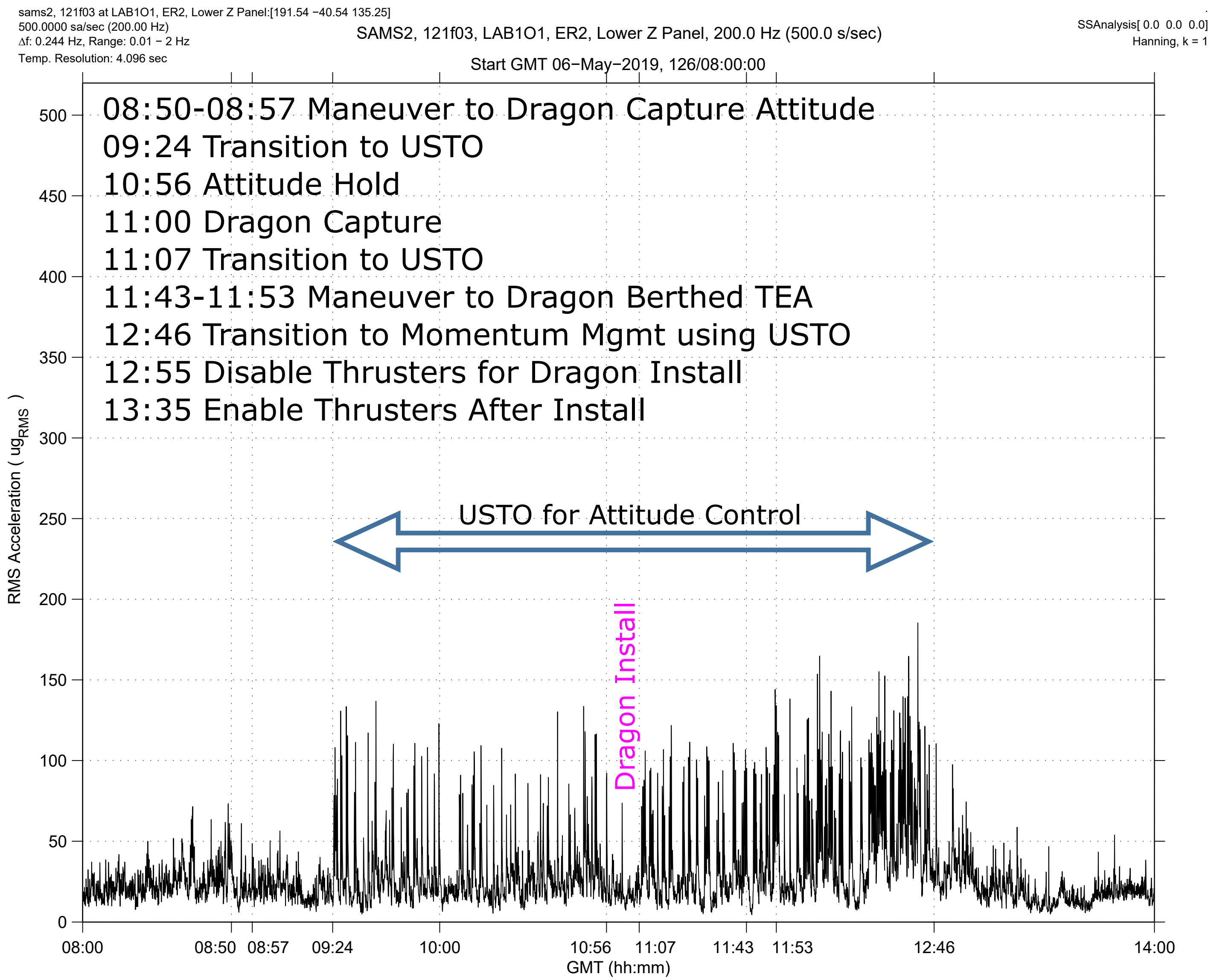

Fig. 3: RMS below 2 Hz for Dragon capture time frame with SAMS sensor (121f03) in JEM.

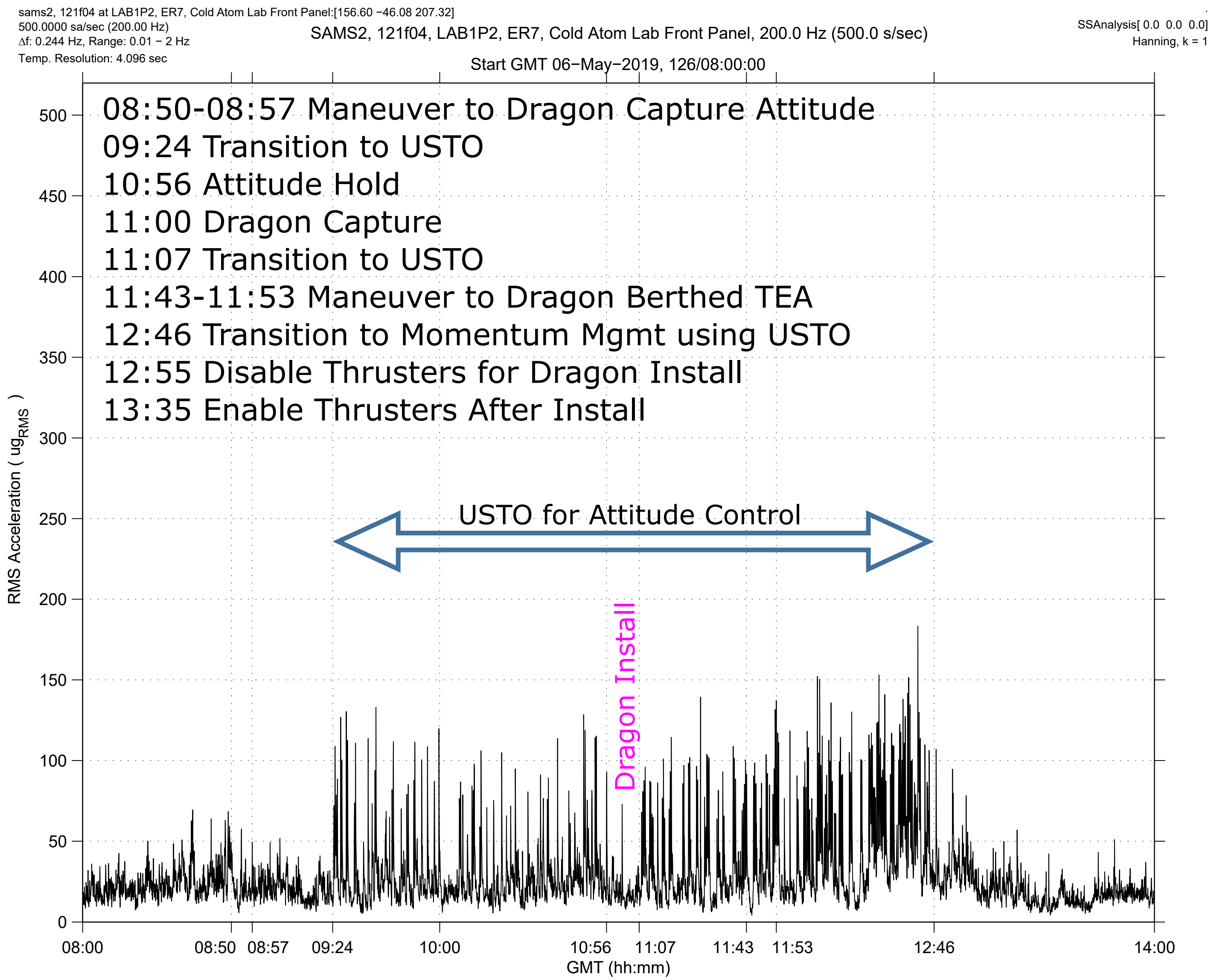

Fig. 4: RMS below 2 Hz for Dragon capture time frame with SAMS sensor (121f04) in US LAB.

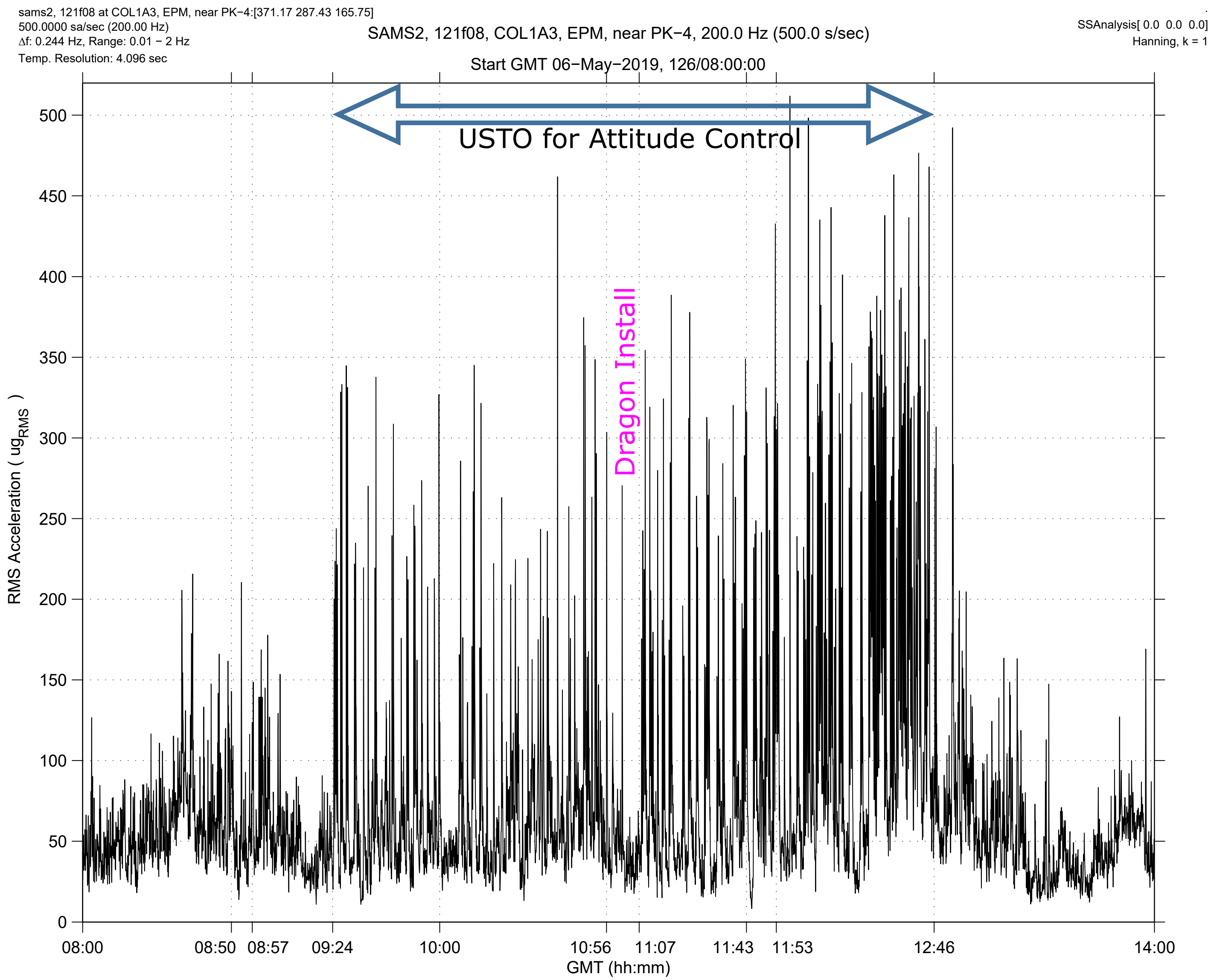

Fig. 5: RMS below 2 Hz for Dragon capture time frame with SAMS sensor (121f08) in COL.