SEISMOLOGY OF TERRESTRIAL SPACE PORT OPERATIONS AS AN ANALOG FOR MONITORING ANTHROPOGENIC SEISMICITY ON THE MOON. Tara L. Sweeney¹, Jose M. Hurtado, Jr., Marianne S. Karplus, Aaron A. Velasco. Department of Earth, Environmental, and Resource Sciences, The University of Texas at El Paso, El Paso, TX 79968, tsweeney@miners.utep.edu

Introduction: The value of seismic data collected during NASA’s Apollo lunar missions [1] and the InSight Mars mission [2] underscores the important role seismic data acquisition will play in future space missions. The recording of anthropogenic and natural seismic signals will be valuable for planetary science research, monitoring surface operations and their environmental effects, as well as conducting fundamental geological and geophysical characterization of the subsurface of planetary operations targets. Future seismic missions to both the Moon and Europa are currently under development from various space agencies. However, relatively few seismic studies have been performed around Earth-based space ports [3].

Project Overview: Processing publicly available seismic data around space ports can serve as an analog for similar investigations on the Moon or other planetary bodies. Our project addresses the following goals: (1) monitor seismic signals generated during launch, landing, engine test, and other ground operations; (2) use seismic data to produce geophysical models of the subsurface geology in the vicinity of the space port; and (3) monitor naturally-occurring background seismicity using the space port seismic infrastructure. Each of these goals has the potential to support operations and engineering as well as to advance scientific discovery.

Methodology: To conduct our work, we access free, real-time data from the Incorporated Research Institutions for Seismology (IRIS) Data Management Center (DMC). We use MATLAB to query the IRIS DMC database to obtain miniSEED data records applicable to the designated space port operations events.

As an example, we have downloaded seismic data for the Blue Origin New Shepard (NS) missions that occurred from Launch Site One (LS1) outside of Van Horn, TX, on 13 October 2020 (NS-13), 14 January 2021 (NS-14), and 14 April 2021 (NS-15). Data have been acquired from four nearby Texas Seismological Network (TexNet) [4] and Advanced National Seismic System (ANSS) stations: PB28 (36.55 km from LS1), PB29 (43.29 km from LS1), VHRN (74.35 km from LS1), and MNTX (75.15 km from LS1). Fig. 1 shows vertical component seismograms obtained by the closest station, PB28, starting three minutes before NS launch to approximately 2 minutes after crew capsule landing. The timing and similarity of signals observed for all three missions suggest that, even at this distance, we can interpret signals associated with the launch, the ascending and descending booster (Doppler-shifted sound waves), two sonic booms, booster landing, and crew capsule landing (within red boxes in Fig. 1).

In addition to reviewing data associated with Blue Origin operations at LS1, we will use the existing seismic network of monitoring stations to obtain data associated with other operational rocket launch organizations. These organizations have been selected because of the differing operational tempos, engine types/thrust capacities, and geologically diverse operational locations. These organizations include: U.S. Space Force at Vandenberg Space Force Base, CA; SpaceX at Boca Chica, TX; Masten Space Systems at Mojave Air and Space Port, CA; United Launch Alliance at Cape Canaveral Space Force Station, FL; and Northrup Grumman at the NASA Wallops Island Flight Facility, VA.

Figure 1. Vertical component seismograms for three NS missions recorded by TexNet station PB28, located 36.55 km from LS1. (a) NS-13 on Oct. 13, 2020 at 13:37 UTC. (b) NS-14 on Jan. 14, 2021 at 17:18 UTC. (c) NS-15 on April 14, 2021 at 16:50 UTC. All records are shown from 3 minutes before launch to 2 minutes after crew capsule landing. Red boxes indicate approximate flight operations windows for each mission.

Implications: Our project will demonstrate the value of using seismic data and instrumentation to support space port operations and science goals on and off the Earth. We hope it will also spur the next phase of our operations, which will include the deployment of dedicated seismic arrays around a space port using 3-component seismic instruments.