LOW-COST TACTILE INTERFACES FOR NON-VISUAL EXPLORATION OF PLANETARY DATASETS
A. H. Parker* and the Project ESPRESSO Team. *Southwest Research Institute, 1050 Walnut St. Suite 300, Boulder, CO, 80302 (aparker@boulder.swri.edu).

Introduction: Interaction with planetary exploration efforts need not be confined to visual media, and inclusive public engagement efforts in particular can benefit from the adoption of non-visual methods for interacting with planetary science data. These technologies can enhance interactions with planetary exploration efforts for individuals with visual impairments or blindness. 3D printed materials — such as models of small bodies and planetary topography — provide excellent reproducible means to interact with planetary datasets in a non-visual manner. However, the lead time for a 3D print is typically 30 minutes to many hours, limiting the responsiveness of this medium to new inquiry. Thermal expansion machines create bump-map images on a special paper substrate. The expansion process is very rapid (on the order of seconds), resulting in potential for more responsive interactivity with datasets. However, the expansion is binary, resulting in a lower-fidelity tactile reproduction than a 3D printed surface. Images or terrain models must be pre-processed (e.g., as halftone maps, see Figure 1) to render in an intuitively informative way once printed. Tactile displays (e.g., Spirkovska 2005) present an attractive means of enabling real-time responsive interaction with a variety of types of information. Information is presented to the user through stimulation of the skin via a variety of means. At present, the technologies are typically expensive (e.g., the Manus VR Prime Haptic glove interface currently retails for €4990), placing them out of reach of most public engagement and education efforts.

Low-Cost Haptic Interface Glove: The Project ESPRESSO Accessible Exploration Initiative is developing a low-cost (~$150 USD), open-source haptic feedback glove. The proof-of-concept prototype is illustrated in Figure 2. The system consists of a glove with uniquely colored fingertip pads with embedded vibration motors, a fingertip-tracking camera, and a control computer. We use a low-cost (~$60) Pixy2 camera that performs on-board color-based object tracking to drive software on a Raspberry Pi 3 B+ single-board computer (~$30). This software independently controls each of the finger-pad vibration motors. When the glove is held above the camera, the (x,y) location of each fingertip is mapped onto an (x,y) location in the dataset to be explored (in preliminary efforts, these were monochromatic lunar images). The amplitude of the vibration driven in each fingertip is set by the data value at this location (e.g., the image level). In early testing, glove users can easily distinguish the lunar phase by sensing the periphery of visible illumination, and discern a degree of terrain texture. The Project ESPRESSO Accessible Exploration Initiative is developing a “Tactile Telescope System” to enable tactile interactions with data acquired by a telescope in near real time. A pair of portable 11” Celestron telescopes are equipped with CMOS cameras that drive both a laser projector as well as a thermal expansion machine for generating persistent tactile prints of any region of the moon chosen by the user. In 2020, the haptic glove interface will be refined and incorporated into the Tactile Telescope System to enable even more direct, real-time non-visual interaction with telescopic data of the moon, planets, and the deep sky.