IMPROVING SCIENCE/ENGINEERING COMMUNICATION. L. Kerber[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109 (kerber@jpl.nasa.gov)

Introduction: Research scientists at the Jet Propulsion Laboratory (JPL) and similar institutions sit at the intersection between science and engineering. In addition to pursuing pure research, their role is frequently as a representative of the planetary science community among engineers and technologists developing technology for future missions. In this role, scientists must serve as a bridge: developing a wide breadth of scientific knowledge, building a network of relationships and trust with technologists, cultivating an interest in planetary science among engineers so that they become advocates for planetary science in their own right; and preserving a large network of contacts in the scientific community to serve as subject matter experts, collaborators, and potential technology champions and mission principal investigators. To maximize the usefulness of technology developments for planetary science, it is necessary for scientists to have a close working relationship with engineers, and for each to be mutually knowledgeable and engaged in each other's fields as they evolve.

In this abstract, I discuss several activities designed to improve scientist/engineering communication at JPL that have been enabled by a recent NASA Early Career Award.

Background: Early career engineers enter JPL from a variety of disparate disciplines, including mechanical engineering, civil engineering, robotics, and computer science. In a significant number of cases their arrival at JPL is their first introduction to space and planetary science. For this reason, many are eager to understand what motivates planetary scientists to explore space and what engineering challenges are associated with each planetary target as a function of its unique environment.

As they progress in their careers and start developing technologies, understanding planetary mission instrumentation becomes increasingly important, as small details about the requirements and placement of instruments can become top-level drivers when designing robotic and sample-handling systems.

In addition, many early career engineers developing in-situ surface space technologies are not familiar with how science is done in the field, what kinds of data are useful, how scientists think and operate, as well as the realities of the unpredictable geological environments that their devices and technologies will face. Contrariwise, geologists are often not familiar with types of terrain data, images, and observations that would be useful for designers of mobility systems.

Activities:

Lecture Series: Two lecture series are being developed to provide early career engineers an introduction to useful knowledge required for planetary exploration. First, a series called "Tour of the Planets" steps through each planetary environment from Mercury to the Oort Cloud. These lectures discuss classic "Introduction to Planetary Science" topics, but with an added focus on remaining unanswered questions and highlighting the aspects of each environment that make it a challenging engineering problem, such as the pressure, high and low temperatures, caustic chemicals and dust, operations lag time, available solar energy, etc. The second series is called "The Secret Requirements of Planetary Instruments". It goes through the electromagnetic spectrum from gamma rays to radio waves, discussing how each type of radiation is used to explore planetary processes, and then finishes with geophysical techniques. For this series there is an added focus on what these types of instruments usually need from a spacecraft, such as a controlled thermal environment, stable mounting, ground placement, or electromagnetic cleanliness.

Instrument Database: As a part of the 2016 3rd International Workshop on Instrumentation for Planetary Missions, we made an instrument database available that catalogued public information on a variety of instrument types (including best estimates of mass, volume, and power). As part of this initiative, this database will be updated to serve as a resource for mission developers looking for types of instruments that may fit their proposed payload allocations. https://ipmdatabase.webnode.com

Field Excursions: One of the most tried-and-true ways of improving scientist-engineer communications is to go out into the field together. Early career engineers often have a strong desire to go out into the field, but lack the opportunities that are open to scientists. This makes it difficult for scientists and engineers to develop a shared understanding of the challenges of target terrains. As an example, many lava-tube-exploring robots are built to navigate ideal, flat-floored tubes with smooth walls that are commonly featured in online image searches of lava tubes, but are not necessarily capable of entering the cave, navigating floors covered in ceiling collapse blocks, carrying desirable instruments, or even making it to the cave entrance from the parking lot (**Fig 1**). To meet this need, several trips are being organized to take engineers out into the field alongside scientists and immerse them in common terrains expected on planetary bodies. The first trip is to Pisgah Volcano in the Mojave Desert (**Fig 2**), where participants learn about basaltic volcanism and explore a lava flow field, including a maze of intact and collapsed lava tubes. The second trip is to Ocotillo Wells, California, where participants learn about the formation of the Salton Sea, observe a Mars-like desert environment within the off-road vehicle park, and visit a large erg (the Algodones Dunes). In each case, participants make the long drive to the field site together to ensure abundant time for conversation.

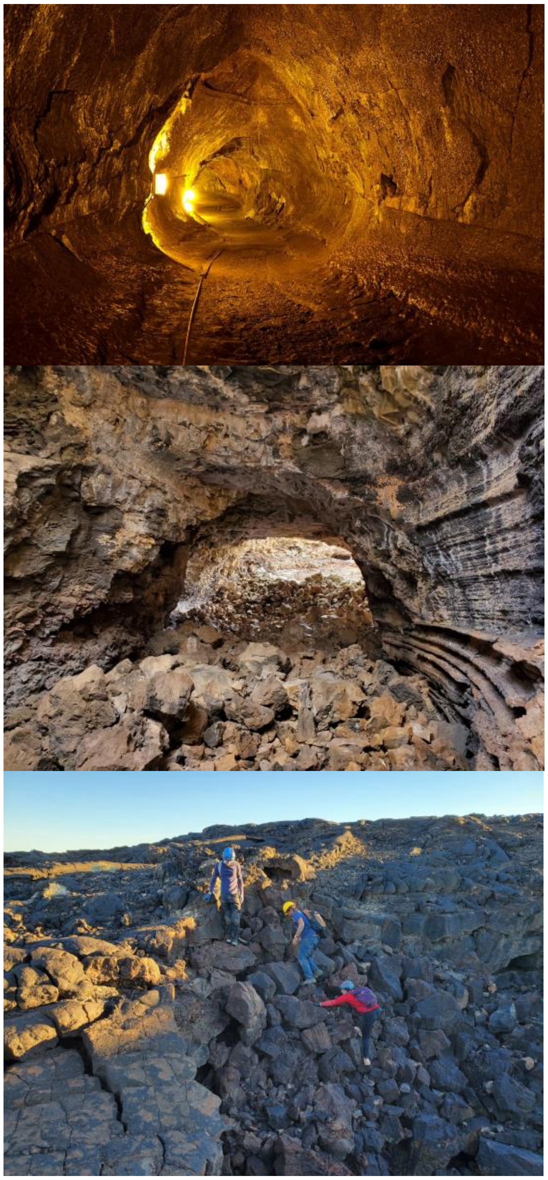

Fig 1. (top) Thurston Lava tube, Hawaii, featured prominently in Google search results and on Wikipedia, presents an easy mobility environment for robotic systems, as do many commercialized lava tubes. Picture by Frank Schulenburg. (middle) Many lava tubes are considerably more difficult to access and navigate, particularly in the event of a ceiling collapse, as in this case for a tube at El Malpais, New Mexico. (bottom) JPL Early Career participants getting first-hand experience in the mobility challenges of typical volcanic block fields.

Field Databases: Even when engineers cannot accompany scientists into the field, scientists can help by collecting field data that is relevant to their challenges. For example, geologists almost always take field pictures that include a scale, but technologists doing machine learning may prefer pictures without scales (lest their machine learning algorithm becomes an algorithm for identifying rock hammers). As another example, rovers in development need terrain roughness data at different scales depending on the size and wheel base of the rover. We have been creating databases of “typical planetary field sites” including the approach from the parking lot to the feature, many images of similar features (to show the range of possibilities), and terrain from LiDAR or photogrammetric mapping.

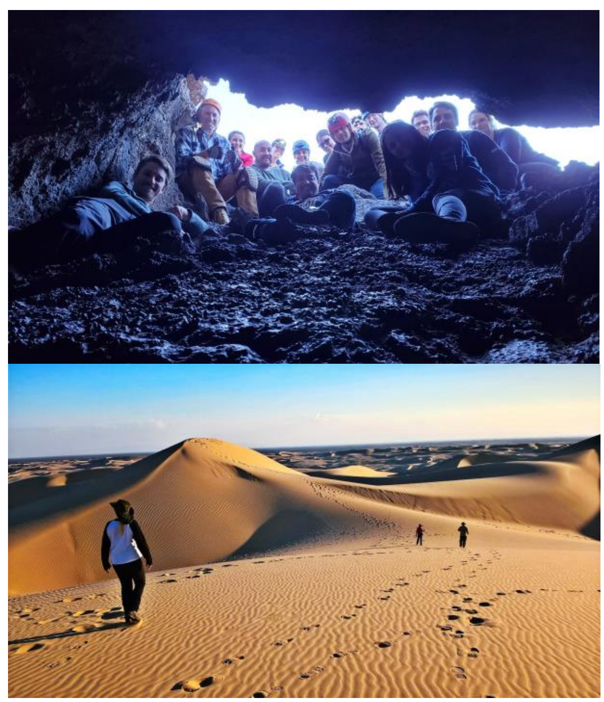

Figure 2. (top) Trip to lava tubes in the Pisgah lava field, in the Mojave Desert, California, in November 2022. The group included scientists, engineers, and spacecraft operators. (bottom) Previous science/engineering trip to Algodones Dunes. Picture by Adi Khuller.