THE CLASS PLANETARY LANDING TEAM. D. T. Britt[1], P. Metzger[2], and K. M. Cannon[1] [1]University of Central Florida, Department of Physics, 4111 Libra Drive, Orlando FL 32816 (dbritt@ucf.edu). [2]University of Central Florida, Florida Space Institute, 12354 Research Parkway, Orlando, FL 32826.

Introduction: When exploration missions interact with the surfaces of moons, planets, and asteroids, the rocket exhaust will produce dramatically different effects depending on the gravity and size of the object, the mechanical strength and porosity of the soil, and the density (or lack thereof) of the atmosphere. In lunar landings, a spacecraft the size of the Apollo Lunar Module will blow away more than a ton of soil, dust, and rocks at high velocity. For human-class landers on Mars, the supersonic jet will dig a deep, narrow crater that redirects a jet of gas carrying rocks and sand back up at the landing spacecraft at high velocity.

We need to understand the physics of these effects, so we can predict and control them. The Apollo 12 Lunar Module landed on the Moon just 160 m away from the Surveyor 3 spacecraft, and the spray of sand and dust from the Lunar Module thoroughly scoured and pitted the Surveyor's surface. This kind of sandblasting can ruin optics and thermal control surfaces. The impact of rocks can destroy hardware. The chemicals in the rocket exhaust can disturb scientific measurements in the landing zone.

Strategies to mitigate these effects include building landing pads and berms on the Moon or Mars. To do so, we need to develop the robotics with technologies that use the planets' local resources as building materials. We also need to develop the artificial intelligence, so these robots can function autonomously, escaping limitations of the speed-of-light communications delay back to Earth.

The CLASS Planetary Landing Team includes world-leading experts in these topic areas. We have already made significant progress developing the science and technology to enable safe, effective landings on other planets, and we are ready to support the lunar and Martian landings of the future.

Example-Plume Effects on the Moon: On the Moon, the rocket exhaust blows soil and dust in a horizontal sheet along the surface away from the lander. This sheet can be so opaque that it blocks the view of boulders or craters, creating a hazardous condition for landing. In Apollo 16, the crew did not see that they were descending onto the rim of a broad crater. After shutting off the engine, the Lunar Module rocked backwards about 12 degrees into the crater until the rear footpad contacted the ground. The front footpad was then off the ground, bearing no weight. This 12 degree tilt was near the design limits for the Lunar Module. This illustrates the dangers of not being able to see what you are landing on.

The spraying sand and dust will also sandblast any surrounding hardware. This is especially bad for a lunar outpost, because repeatedly landing nearby will cumulatively degrade all the sandblasted surfaces. An example was in Apollo 12, when the Lunar Module landed 160 m from the Surveyor 3 spacecraft, which had sat on the Moon for 2 1/2 years. The Apollo 12 mission was visiting it to cut pieces off and return them to Earth for analysis, to see what 2 1/2 years exposure to the lunar environment did to the various materials. When the hardware was examined on Earth, it was found to have permanent shadows etched into its surfaces from the sandblasting. Members of our team analyzed the materials and found lunar soil particles embedded in the cracked and damaged surfaces.

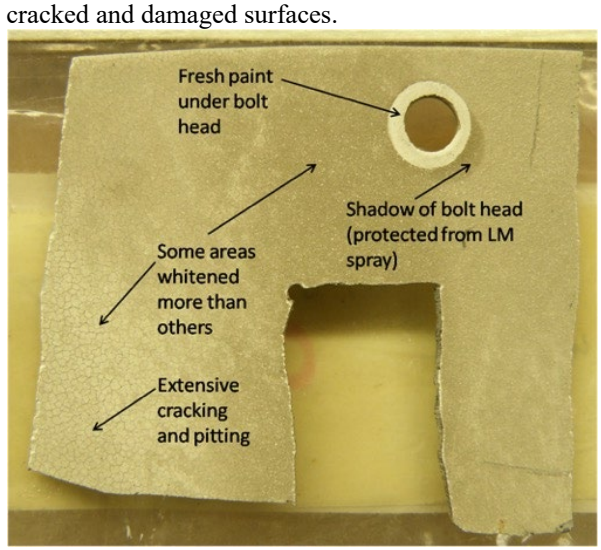

Fig. 1. Piece of Surveyor 3, cut from the spacecraft by Apollo 12 astronauts and returned to Earth. It shows evidence of the sandblasting by the Apollo 12 Lunar Module landing.

For More Information: If you have interests in plume effects and the Landing Team please contact Phil Metzger (Philip.Metzger@ucf.edu) or Dan Britt (dbritt@ucf.edu).
The Landing Team web pages can be accessed at https://sciences.ucf.edu/class/landing-team/.