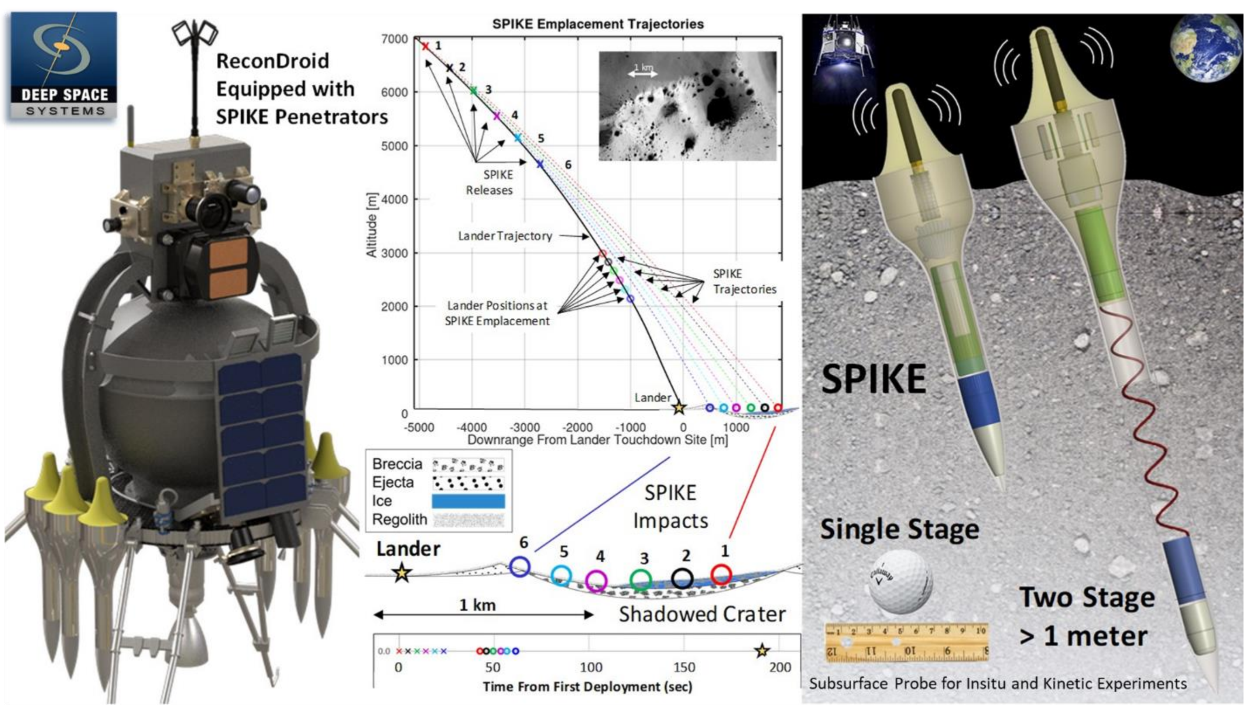
**SPIKE for Artemis-3, Steve Bailey & David Paige**

New tools are needed for Lunar Science for Artemis-3. Although the Apollo tool set was expanded and refined from the Apollo 11 Eagle to the Apollo 17 Challenger, a great deal of miniature sensors, electronics, computing, communications, and battery technology development since then has enabled completely new types of tools to be introduced for Artemis-3. The Subsurface Probe for In-situ and Kinetic Experiments (SPIKE) miniature regolith penetrator is one such tool. SPIKE penetrators bring together a set of innovative technologies and mission con ops to enable cost-effective, near-term investigations of the distribution and geotechnical properties of the Moon's ice-bearing regolith for ISRU prospecting.

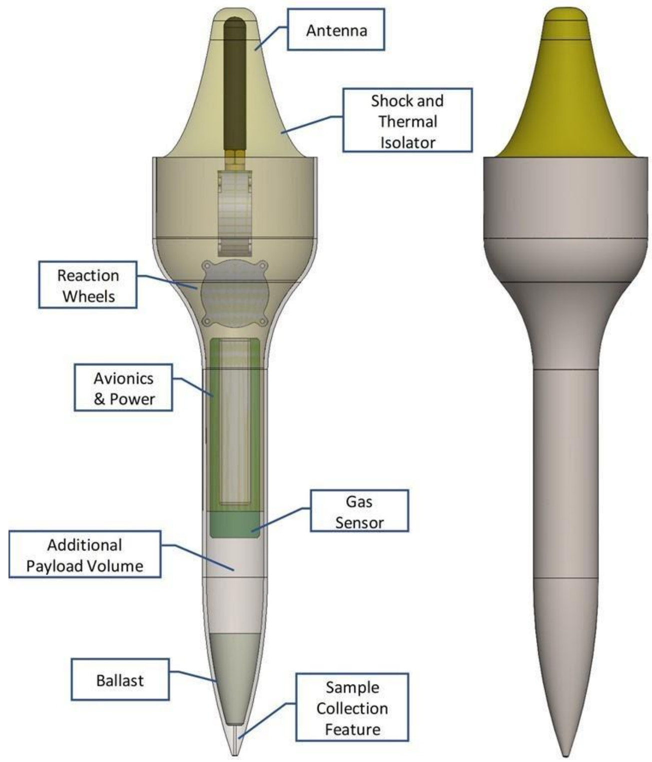
SPIKE consists of a lunar lander hosted control node and a set of ~12 small, short-lived autonomous battery-powered probes deployed by the lander during its terminal descent phase. A self-controlled probe release sequence during the lander terminal descent will enable precision ballistic targeting to multiple points of scientific interest up to 2 km downrange from the lander. The probes reach terminal velocities of 100-200 m/sec and embed themselves ~25 cm into the lunar regolith where they will measure key near-surface regolith properties including soil density, seismic p-wave velocity, and volatile abundance and composition. The SPIKE probes will use rugged, miniaturized instrumentation to provide a comprehensive picture of the nature and spatial variability of the ice distribution and geotechnical properties of unexplored permanently shadowed regions of the Moon, and pave the way for the next generation of in-situ human and robotic exploration of these important regions.

At less than 1 kg each, in addition to Artemis Landers, SPIKE probes should be deployed from CLPS Landers and from reusable and refuellable Droids that accompany Crew Landing Missions.



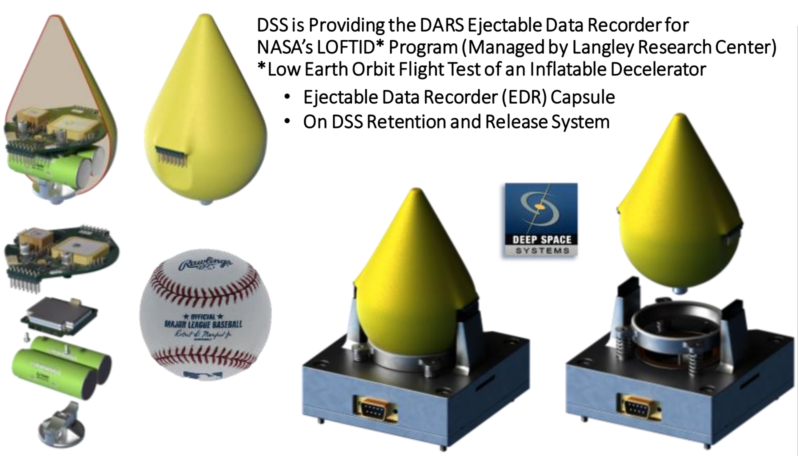

We strongly suspect that widespread ice is present on the moon, but we don't know exactly how much exists, nor do we know exactly where it is. Plans are in place for limited in-situ exploration of polar sites, but not in deep permanent shadow or in rugged terrain. The new capability that SPIKE represents to make first assessments of the geotechnical properties and volatile abundances in deep permanent shadow and rugged terrain is exactly the kind of tool needed for a modern science-driven exploration program. SPIKE provides the potential to characterize the true and full global diversity of lunar cold trap regions and be a prospector for usable and economically viable deposits of volatiles for In Situ Resource Utilization.

SPIKE measurements are acquired immediately after impact. A two-way LoRa radio system allows remote command and data exchange from SPIKE probes to the decelerating Landers for over a minute before they touch down. The probes have sufficient battery life to transmit all data directly to Earth or to high Lunar orbit.




SPIKE will directly measure icy regolith mechanical properties, gases evolved from heating the icy regolith, and perform geoseismic sounding of the local area to further characterize the local vertical and lateral distribution of ice in the regolith. Thanks to other investments in microminiature instruments, including neutron and gamma ray spectrometers, other important measurement types are possible with SPIKE technology. New technology requires new patterns of thought.

These kinds of miniature, rugged, releasable systems are not only possible, they are in active production for NASA flight programs such as LOFTID and are proposed in NASA programs such as Lunar Surface Technology Research (LuSTR), as shown below.





For Artemis-3, with limited mobility and surface stay time, it is especially important to find new ways to extend the reach of Crew members on the Surface and in orbit. Please join us in recommending these exciting new tools to NASA for the Artemis-3 mission.