NASA Develops Lidar Backpack Technology for Moon Explorers

NASA researchers and their industry partners have developed a remote sensing mapping system to aid explorers in the most isolated wilderness imaginable: the airless wastes at the South Pole of the Moon. Now the astronauts, who are like 'hikers on a mountaineering expedition' in a wholly uncharted environment, will be able to generate a real-time 3D map of the terrain.

The Kinematic Navigation and Cartography Knapsack (KNaCK) is a mobile Lidar scanner – a remote sensing method that uses light detection and ranging laser light to measure range. Worn like a hiker's backpack, it makes use of an innovative type of Lidar called frequency modulated continuous wave (FMCW) Lidar in order to provide Doppler velocity and range for millions of measurement points per second. These measurement points instantly create a real-time navigation system, delivering to the explorer a 3D point cloud or high-resolution map of the surrounding terrain.

Superpowered Version of Laser Range Finders

"Think of it as a superpowered version of laser range finders used by surveyors or the highly sensitive proximity alarms that help smart cars avoid collisions," said planetary scientist Dr Michael Zanetti, who leads the KNaCK project at NASA's Marshall Space Flight Center in Huntsville, Alabama.

"Basically, the sensor is a surveying tool for both navigation and science mapping, able to create ultra-high-resolution 3D maps at centimetre-level precision and give them a rich scientific context," Zanetti said. "It will also help ensure the safety of astronauts and rover vehicles in a GPS-denied environment such as the Moon, identifying actual distances to far-off landmarks and showing explorers in real time how far they've come and how far is left to go to reach their destination."

That's a key challenge as Artemis-era explorers prepare to undertake the first modern missions to the Moon, and the first ever to its South Pole. The Sun never rises more than 3 degrees above the lunar horizon there, leaving much of the terrain in deep shadow. That makes distances to various points of interest difficult to assess.

Michael Zanetti, a NASA planetary scientist at NASAâ€™s Marshall Space Flight Center in Huntsville, Alabama, hikes the Cinder cone in Potrillo volcanic field in New Mexico in late 2021, testing the backpack-sized prototype for NASAâ€™s Kinematic Navigational and Cartography Knapsack (KNaCK), a mobile Lidar scanner now in development to support lunar exploration and science missions. (Courtesy: NASA/Michael Zanetti)

Accurate Mapping without GPS

Initiated in 2020 with funding by NASA's Early Career Initiative, the KNaCK project has partnered with Torch Technologies to develop the backpack prototype and associated navigation algorithms that permit accurate mapping without GPS. The project's commercial vendor, Aeva Inc. of Mountain View, California, is supplying FMCW-Lidar sensors and support, working with NASA to enhance the backpack's Lidar sensing system for use on the Moon and other extraplanetary human excursions.

Using KNaCK during rover excursions and when traveling on foot, explorers could precisely map the topography of the landscape, including deep ravines, mountains, and caves. Lidar even works in pitch blackness, relieving astronauts of the need to haul cumbersome lighting rigs everywhere they go.

"As human beings, we tend to orient ourselves based on landmarks – a specific building, a grove of trees," Zanetti said. "Those things don't exist on the Moon. KNaCK will continuously enable explorers traversing the surface to determine their movement, direction, and orientation to distant peaks or to their base of operations. They can even mark specific sites where they found some unique mineral or rock formation, so others can easily return for further study."

That's vital for astronauts on a clock, their excursions limited by the oxygen supply in their suits. KNaCK's ultra-high-resolution precision – an order of magnitude greater than conventional lunar topography maps and elevation models – makes it a vital resource for conducting science and mission operations 238,900 miles away from mission control, Zanetti said.

This video of a UAV drone landing in the dusty New Mexico desert demonstrates how the KNaCK technology – leveraging 4D FMCW-Lidar data from NASA vendor Aeva of Mountain View, California – combines live, real-time high-definition video imaging, as seen at upper left panel; Lidar ranging data, at upper right; and Lidar Doppler velocity data. The latter tracks the speed and direction of dust particles kicked up by the descending drone, with red indicating particles moving away from the scanner and blue indicating those moving toward it. Such capabilities, now in development by researchers at NASA's Marshall Space Flight Center in Huntsville, Alabama, could benefit future science missions on other worlds in addition to enabling real-time topographical mapping by explorers.
(Courtesy: NASA/Michael Zanetti)

Miniaturization of the Hardware

The hardware got another major field test in April 2022 at NASA's Solar System Exploration Research Virtual Institute (SSERVI) in Kilbourne Hole, New Mexico. The team previously put the KNaCK system through its paces at that ancient volcanic crater – estimated to be 25,000-80,000 years old – in November 2021. They also used it recently to conduct a 3D reconstruction of the 6-mile-long sea barrier dunes at NASA's Kennedy Space Center in Florida, which protect its primary rocket launch pads. Kennedy and Marshall engineers will continue to use KNaCK to assess the impact of storms on dune erosion, ensuring the safety of future flight missions as they further refine the system.

Next, the KNaCK team will work to miniaturize the hardware – the backpack prototype weighs about 40 pounds – and harden the sensitive electronics against the punishing effects of microgravity and solar radiation.

"Taking advantage of the latest advancements in Lidar technology from Aeva, our next-generation space-hardened unit with support from Torch Technologies will be about the size of a soda can and could enable lunar surface operations like never before," Zanetti said. He envisions mounting it on a rover or on the side of an astronaut's helmet – which should leave plenty of room in future lunar mountaineers' all-purpose backpacks.

Source: NASA.

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