The Kinematic Navigation and Cartography Knapsack (KNaCK) LiDAR System. M. Zanetti[1], B. Robinson[2], P. Bremner[1], K. Miller[1], B. De Leon Santiago[1], E. Hayward[1], J. Jetton[2], [1]NASA Marshall Space Flight Center, Huntsville, AL 35805, [2]Torch-Technologies, Inc, Huntsville. (Michael.R.Zanetti@nasa.gov).

Introduction: Improved terrain characterization and navigation sensors are needed to enhance crew safety, ISRU return, and scientific understanding of future lunar landing sites. Specific to the Artemis Program and sustained exploration at the lunar South Pole, are extreme illumination conditions that will hamper existing photogrammetry-based robotic navigation. Additionally, a major challenge for navigation on the Moon and other planetary surfaces is the lack of Global Positioning and Navigation Systems (GPS/GNSS). Thus, there is a need for an alternative to camera-based navigation that allows for precise and accurate mapping in GPS-denied environments on any planetary body.

The Kinematic Navigation and Cartography Knapsack (KNaCK) LiDAR system is a 2020 NASA STMD Early Career Initiative (ECI) project with the aim of assessing how Velocity-Sensing FMCW-LiDAR sensors and mobile LiDAR con-ops can address challenges in lunar terrain mapping and navigation at the Moon's South Pole, and to advance the TRL of commercial prototype FMCW-LiDAR sensors for extreme-environments and the lunar surface.

The Kinematic Navigation and Cartography Knapsack (KNaCK) LiDAR instrument: The KNaCK is a backpack-mounted, mobile navigation and terrain mapping system that uses scanning *velocity-sensing* coherent light detection and ranging (LiDAR) system based on a frequency modulated continuous wave (FMCW) technique. FMCW-LiDAR is immune to direct solar interference (and other LiDAR sources), with a solid-state LIDAR-on-a-chip architecture with minimal moving parts. The test-article is equipped with FMCW-LIDAR, a time-of-flight LiDAR, 3 inertial measurement units (IMU), GPS, and on-board computing and power. During a traverse, the sensors continually scan the environment to build a three-dimensional point cloud representation of topography, as well as providing real-time mapping and hazard avoidance for rover navigation. The system is modular and is also fitted to a small rover platform for research into autonomous rover mapping.

SLAM Algorithm Development: The KNaCK Project is also developing novel simultaneous localization and mapping (SLAM) algorithms based on the unique velocity data available from FMCW-LiDAR. The concurrent range and velocity information sampled at each of 10^6 points/sec allow for measurement of ego-motion odometry, improved spatial state estimation, and iterative-feedback algorithms to constrain IMU bias propagation errors. These solutions allow cm-scale accurate mapping in GPS-denied environments with respectable (dm-scale) loop-closed scan matching spatial error. Results from field testing and planetary analog science at NASA KSC and SSERVI RISE2 Kilbourne Hole, NM will be presented.

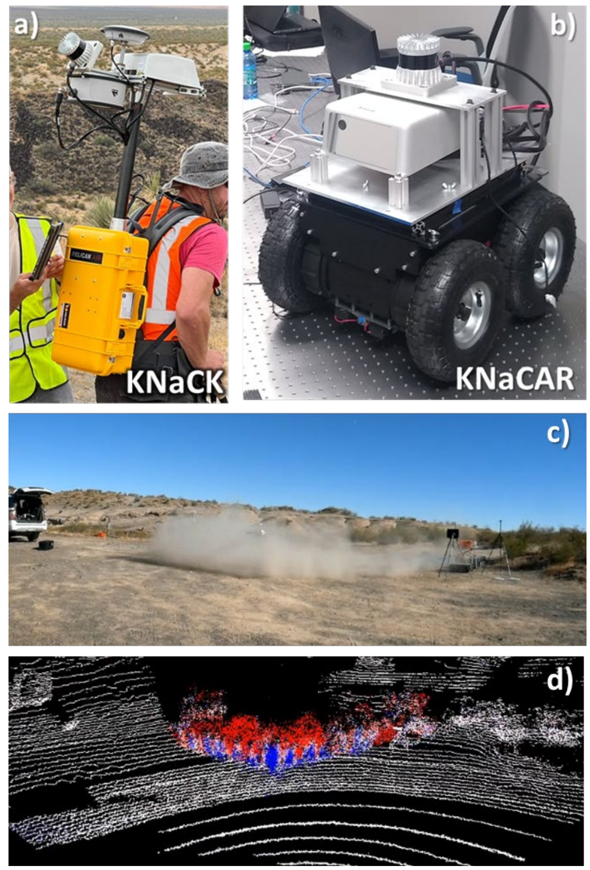

Figure 1: a) The KNaCK backpack mobile LIDAR scanning system in the field in NM. b) The KNaCK autonomous rover platform. c) HD video of a UAV quadcopter drone landing, creating a dust cloud. d) doppler shift (red away, blue toward sensor) instantaneous velocity of lofted dust particles by the UAV. A rotational vortex is visible in real-time data playback

Environmental Testing: Thermal, vacuum, and radiation testing of an FMCW-LiDAR chipset is scheduled for late June 2022.

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