

ACORN: the Advanced Compact Orbiting Radar for luNar sounding

Orbital radar sounding at meters-scale wavelength is a unique geophysical tool that can address many objectives in lunar science and exploration by probing the subsurface to depths and resolutions that prior imaging and sounding radars cannot reach, with global-scale coverage that landed platforms cannot achieve. These objectives include the distribution of ice in the subsurface to hundreds of meters of depth, the nature and depth of regolith and megaregolith, the characterization of mare basalts and detections of lava tubes, and three-dimensional context for landed missions with in-situ instrumentation. The number of flight-proven instruments for radar sounding is currently limited to a few examples based on conventional technologies with inherent limitations, both in terms of mass/power/volume and performance.

There is a need for compact radar sounder technology that can be deployed from a small volume - suitable for both dedicated CubeSat/SmallSat missions and as part of an instrument suite on a larger spacecraft. Such a radar must provide fully polarimetric information for the identification of subsurface ice and have directivity to determine the source of echoes. This helps prevent the misidentification of off-nadir surface echoes as true subsurface echoes. Conventional technology requires very large antennas precluding a small form factor and limiting the options for mission scenarios.

The Advanced Compact Orbiting Radar for luNar sounding (ACORN) will be based on a vector sensor antenna (VSA), a transformative solution for radar sounding with the potential to address many limitations of current technology. This is due to its measurement of all components of both the electric and magnetic fields of electromagnetic wave echoes. These data enable determination of polarization and angle-of-arrival for multiple discrete sources using just a single small payload. These are key aspects in the ability to generate a fully-polarimetric, high-resolution subsurface mapping radar that operates across wide frequency bandwidths.

ACORN and its VSA are compact and deployable from a 4U volume, enabling the possibility of a complete radar in a small package. It is a novel approach to providing spatial resolution and penetration that provides a new alternative to distributed arrays of elements or large directive apertures for radars. Leveraging heritage from NASA's AERO-VISTA mission to develop and launch a Cubesat VSA for passive (receive-only) study of the radio aurora, our VSA technology is now sufficiently mature to develop an active VSA-based radar with a small form factor and performance that addresses a range of planetary radar applications. VSA-based radars can now address a wide variety of NASA's strategic goals and key investigations across the entire Solar System delineated in the Planetary Science Decadal Survey. For example, the very small form factor, mass, and power requirement make sounding of outer Solar System targets (e.g., the Uranus and Neptune systems) possible.