

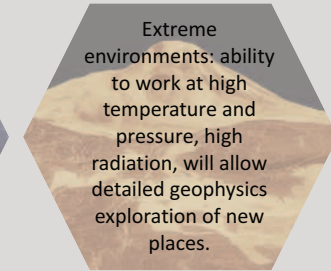
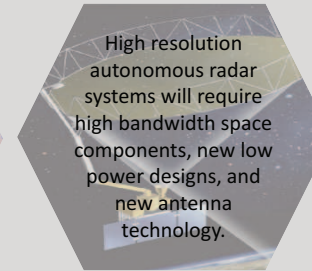
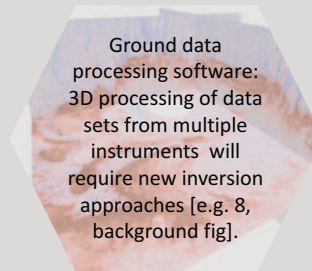
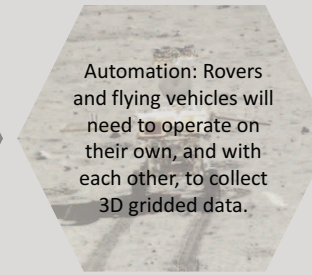
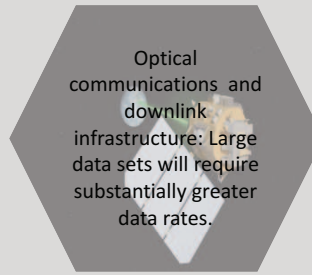
Exploring Below the Surface at Human Scales: Adding a Third Dimension to our Knowledge of Planets

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In the next 30 years, advances in instrument technology, automation, data downlink capacity and analysis software could provide the opportunity to create 3D maps of the upper hundred meters of the subsurface that seamlessly integrate with optical images and mineralogy.

Key Enabling Technologies

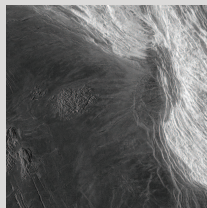


Near surface geophysics

- includes the upper tens of meters to a couple hundred meters; orbiters and landed systems.
- provides information about the structure and composition of the subsurface at vertical resolutions of cm to tens of meters.
- Is an important tool for resource prospecting and can greatly reduce the risk associated with human exploration of the Moon and Mars.
- techniques include ground penetrating radar, seismic studies, magnetics, electromagnetics methods like TEM (transient electromagnetism), high-resolution gravity and radar imaging of the subsurface at long wavelengths
- can map stratigraphy and compositional differences that are produced by processes such as regolith development, volcanism, aeolian deposition, cementation, impact cratering, and fluvial and lacustrine processes.

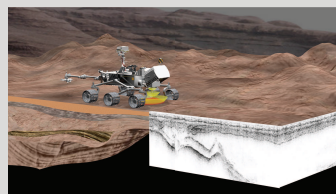
Venus

- In order to understand the provenance of continent-like tesserae regions, geophysical remote sensing is needed to determine their density, internal structure, and relationship to the plains.
- A Venus seismic package would finally provide information about the nature of the crust.



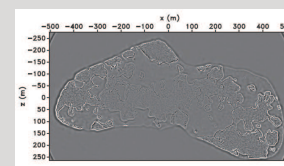
Moon/Mars

- Orbital radars and multiple autonomous rovers could be used to measure the distribution of ice/water resources, and to map buried features such as lava tubes, fluvial channels, and stratigraphic boundaries [1 (fig),2,3].
- Future human missions need safe shelter from radiation events, and geophysical techniques can be used to find buried caves that be used in case of emergencies.
- High-res. topography and advanced processing will allow a 3D model of the surface in high-clutter situations [4].
- Surface or airplane systems will provide higher resolution ground truth comparison with orbital data.



Small bodies

- Geophysical remote sensing will also be key to exploring asteroids and comets, including searching for and mapping ice and other resources[5,6].
- Tomography can be used to image the interior of comets and km-sized asteroids [9 (fig)].
- Gravity plus radar imaging can be used to investigate rubble-pile interior geometry.



Ocean Worlds

- The near surface structure of these objects is currently unknown but is critical to understanding the observed surface features [e.g. 7], assessing the habitability of the different icy moons and providing information for future landers that may have drills or sampling systems.

