MARS EXPLORATION GOALS ACHIEVED BY AN ORBITAL IMAGING RADAR.  B. A. Campbell, Smithsonian Institution, Center for Earth and Planetary Studies, PO Box 37012, Washington, DC 20013-7012, campbellb@si.edu; Jeffrey J. Plaut and Scott Hensley, Jet Propulsion Lab, Pasadena, CA 91109.

Introduction: Mars exploration to date has provided a wealth of information on the geologic history of the planet, the roles of impact cratering and ancient hydrologic processes, and the current nature and inventory of water ice. Our understanding of many of these topics remains incomplete due to both the extensive sediment cover and the limitations of current shallow subsurface investigations. An orbital polarimetric synthetic aperture radar (SAR) can reveal geologic features beneath meters of dust, probe the uppermost layers of the polar deposits, and map shallow reservoirs of ground ice for climate studies and future exploration. SAR systems use proven hardware and analysis methods, and can be accommodated on a Discovery class bus or as part of the instrument suite of a Next Mars Orbiter (NeMO) [1].

The Hidden Face of Mars: Our current best understanding of the shallow subsurface of Mars, and the possibility of widespread ice deposits, comes from the SHARAD instrument on MRO [2-6]. Radar sounders are excellent tools for profiling along a ground track, but they do not form high-resolution two-dimensional surface coverage and cannot characterize the uppermost ~10 m of the terrain. Even an enhanced sounder (e.g., higher frequency, higher bandwidth than SHARAD) will have significant challenges in detecting shallow interfaces.

Fig. 1. Imaging radar viewing geometry.

Orbital imaging radar provides a 2-d image similar to that of a visible/IR camera, but with the capability to probe several meters in dusty material and 10’s of meters in polar ice (Fig. 1). This type of mapping will reveal previously unseen geologic features related to volcanic, impact, fluvial, and other processes. A SAR can also measure the full polarimetric properties of the scattered signal to detect the unique signature of ice layers that are a few meters thick and extend over much of a resolution cell.

A SAR with readily achievable requirements can provide a global map at 75-m resolution of the subsurface geology through 3-5 m or more of mantling dust or sand. Spatial resolution comparable to THEMIS-VIS at 18 m per pixel can be achieved with the same penetration depth, and spotlight SAR processing can provide even finer resolution for targeted sites. Loss properties of materials on Mars have been directly measured using SHARAD [6], and confirm the expected depth of mapping.

Direct support for the success of an orbital SAR comes from Earth-based radar maps of Mars, which reveal stunning details of lava flows and other features hidden by dust (Fig. 2) [7]. An orbital sensor will yield 50-100 fold finer spatial resolution and about 5-fold greater depth of penetration than the Arecibo measurements. These results will transform our understanding of regional geology, ancient habitable settings, and the current inventory of shallow ground ice.

Fig. 2. Arecibo radar view of roughness changes in lava flows beneath dust across Elysium Planitia [7].

Instrument: A SAR optimized for these goals can be accommodated by a Discovery-class spacecraft, or as part of a suite on a larger bus. The radar requires an antenna: a 6-m deployable mesh is adequate for the science described here. The radar wavelength should be 30-60 cm, based on experience with subsurface lunar probing, and fully polarimetric capability is required to allow for flexibility in probing ice and other deposits.