# The role of Synthetic Aperture Radar in Extraterrestrial Mapping

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Most of the surfaces of Mercury, the Moon and Mars are covered by regolith, a large part of which has been generated by repeated hypervelocity impact resulting in the widespread redistribution of materials. On some planets (Mars), aeolian effects have further redistributed the finer particulates. As a result, the solid *in situ* bedrock of these planetary bodies is obscured. Yet for geologists, determining the solid geology of a given planet is key to establishing its geological evolution and for selecting landing sites for bedrock sampling. Unfortunately, details of the solid surface beneath the regolith are not revealed by optical techniques, although the latter help tremendously with regard to understanding a planet's morphology, from which aspects of the underlying solid geology can be inferred. The true nature and thickness of the regolith, and the proximity of bedrock and sub-surface ice or liquid water can only be detected and mapped by an instrument capable of probing at different penetration depths beneath the surface. This includes identifying ice, or features that reveal the presence of ice. Synthetic Aperture Radar (SAR), especially at lower microwave frequencies, is suited for such an endeavour.

The lower the frequency the greater is the penetrating capability of the radar pulses. ESA's Mars Express and NASA's Mars Reconnaissance Orbiter will use radar sounders to probe below the Martian surface at a very low frequency (less than 20 MHz), to detect the presence of sub-surface water or ice. A SAR operating at P-Band (400 MHz) and L-Band (1.25 GHz), as discussed here, has a different purpose. An L-Band SAR could penetrate the unconsolidated dust/sand layers and potentially provide images of the underlying regolith and buried bedrock topography. This could result in production of a high-resolution planetary map that more closely approaches a "solid geology" map typically obtained on Earth. On Mars, such a map could help to identify ancient river beds, "ocean shorelines", or other features carved by water erosion, thus pointing to the most probable locations of subsurface water or ice deposits. P-Band SAR will penetrate to about 10 m below solid surface features, and also reach the surface underneath 70 m of polar ice cap. These data would identify buried channels, near-surface ice or water deposits, and many other geological features of the upper layers of the Martian crust. Besides gathering information about water-related features, other practical uses of these data would be, for instance, identification of the best landing sites for future missions and for optimizing site selection for a drilling program.

Spaceborne SARs are an area of Canadian expertise, due to the experience gained from the RADARSAT programs at C-Band, as well as from many R&D programs aimed at other frequency bands (L and P-Bands) and targeting low-mass and low-cost solutions. The novel technologies proposed could greatly reduce the cost and mass of the P and L-Band SAR antennas, when compared against more conventional implementations. In fact, they make it possible to baseline a relatively large aperture size, which would otherwise not be achievable without significant cost and mass penalties. Most conventional concepts would, for the sake of limiting mass and costs, use a smaller antenna aperture and accept the resulting inferior SAR data. The concept proposed here would offer significant benefits to future exploration programs, such as the Mars Scout Radar (proposed for a 2007, or possibly 2009, launch). Examples of SAR applied to revealing subsurface conditions are cited from different climate regimes on Earth.