**A MARS ORBITAL LASER ALTIMETER FOR ROVER TRAFFICABILITY: INSTRUMENT CONCEPT AND SCIENCE POTENTIAL;** J.B. Garvin and M.T. Zuber, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

Limited information on the types of geologic hazards (boulders, troughs, craters etc.) that will affect rover trafficability on Mars are available for the two Viking Lander sites, and there are no prospects for increasing this knowledge base in the near future. None of the instrument payloads on the upcoming Mars Observer or Soviet PHOBOS missions can directly measure surface obstacles on the scales of concern for rover safety (a few meters). Candidate instruments for the Soviet Mars 92 orbiter/balloon/rover mission such as balloon-borne stereo imaging, rover panoramic imaging, and orbital synthetic aperature imaging (SAR) are under discussion, but data from this mission may not be available for target areas of interest for the US Mars Rover Sample Return (MRSR) mission. In an effort to determine how to directly measure the topography of surface obstacles that could affect rover trafficability on Mars, we are studying how to design a laser altimeter with extremely high spatial and vertical resolution that would be suitable for a future Mars Orbiter spacecraft (MRSR precursor or MRSR orbiter). This report discusses some of the design issues associated with such an instrument, gives examples of laser altimeter data collected for Mars analogue terrains on Earth, and outlines the scientific potential of data that could be obtained with the system.

In contrast with the design of a Lunar Observer Laser Altimeter (LOLA) intended for global profiling of lunar surface topography at 30 m spatial resolution [1], an orbital system appropriate for directly measuring obstacles no larger than a few meters in scale on the surface of Mars must incorporate an extremely high repetition rate laser transmitter into the basic design. From an orbital height of 350 km (MO altitude), a Mars Orbiter Laser Altimeter for Rover Trafficability (MOLAR-T) containing a CW-pumped, cavity-dumped Nd:YAG laser transmitter operating at a pulse repetition rate of 1000 Hz could provide 15 cm vertical resolution contiguous footprints as small as 2 m in diameter along track. The system would also consist of a 50 cm telescope, data system, and suitable sub-nsec time interval unit and constant fraction discriminator electronics. The laser transmitter would emit in the near infrared, thus providing the additional capability of measuring the relative reflectance of Martian surface materials. The instrument would transmit several mjoules of energy per 1-3 nsec (FWHM) laser pulse when operating in full repetition rate mode (a few minutes per orbit if pre-selected candidate target areas are the focus). An alternative design involving larger footprints (say 30 m) with oversampling by a factor of 15 along track could detect meter scale obstacles if signal processing were invoked.

Airborne laser altimeters in operation and under development at GSFC directly simulate some of the key instrument parameters of MOLAR-T. In order to simulate the type of data expected for this instrument from Martian analogue terrains, a 400 Hz Nitrogen laser altimeter system was flown at low altitude over volcanic landscapes in SW Iceland. The instrument and mission configuration provided 1.5 m diameter footprints along track, with oversampling by a factor of five on the basis of aircraft velocity. Figure 1 is an example of a profile obtained with this system for the southern wall of the collapsed vent crater of Surtur II on the island of Surtsey. The profile demonstrates the type of hazard that even a relatively autonomous rover must avoid. The 6 m "cliff" at the edge of the 100 m diameter pit crater has a local slope of 59 degrees, which would not be easily traversed by any sort of rover. Figure 2 is a profile of a boulder-covered beach on the north shore of Surtsey that illustrates the presence and detectability of individual meter-scale boulders.

Our preliminary study suggests that a very high spatial and vertical resolution profiling system would be capable of directly detecting rover obstacles without resorting to model-dependent analyses such as those required for interpretation of microwave and thermal IR surface scattering observations. Profiles from such an instrument could be used in studies of local geomorphology (e.g. lava flow heights, local gradients, etc.) as well as for obtaining "ground-truth" data on surface roughness useful for calibrating microwave and thermal observations. As currently conceptualized, the MOLAR-T instrument would exceed the severe weight, power, and data-rate limitations imposed for Observer-class spacecraft. More rigorous definition of this proposed instrument concept, and continued analysis of Iceland analogue data in the context of Mars rover trafficability are in progress. (We thank J.B. Abshire and J.L. Bufton for many helpful discussions regarding engineering requirements. This work was indirectly supported by NASA RTOPs 157-03-80-20 and 677-43-24.)

References: [1]Garvin, J.B. et al. (1987), LPSC XVIII, 318-319.

Figure 1. Airborne laser profile (0.25 m effective footprint diameter, 0.3 m vertical resolution, sub-meter after GPS-assisted aircraft motion removal) of the south wall of the vent crater Surtur II on Surtsey, Iceland, obtained from 1200 ft. altitude in the NASA/WFF P-3 aircraft using the 400 Hz AOL laser altimeter.

Figure 2. Laser profile of a boulder-covered beach on the north shore of Surtsey obtained with the same system as in Figure 1. The dotted line shows the local slope of the beach and the solid lines show the positions of meter-scale boulders.