Laser Ranging Imager for Planetary Exploration

by

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Future space exploration missions will rely upon "smart" autonomous systems that require highly sophisticated vision systems. Presently, lidar (laser radar) instruments with a range accuracy of about 1 cm over a range of up to several kilometers, combined with high-accuracy rapid scanning, are capable of outputting highly precise 3-D topographic images of scanned objects. This paper describes lidar technology as it applies to space exploration.

Planned sample return missions in the future may likely consist of a larger orbiting spacecraft seeking a smaller vehicle/capsule for rendezvous. In such a scenario the main function of the laser imaging system will be to provide navigation, guidance and control data to the seeker spacecraft. An extension of the sample return application is orbit acquisition and rendezvous/docking for on-orbit servicing.

Planetary landing of spacecraft is another area where the special attributes of laser ranging offer a number of new advances. In this application, the desirable spatial resolution requirements are in the centimeter range in order to avoid small rocks, cavities, untenable slopes and other surface discontinuities. During the approach phase laser ranging can quickly provide a large area map of the intended landing area. As the spacecraft descends, the laser ranging system provides increasingly resolved spatial information to identify a desirable landing site and feedback of critical information to the guidance system.

Initially, exploration of the solar system will have to be conducted robotically. More particularly, the value of being able to return high-resolution 3-D spatial information about the landscape and its specific features needs to be assessed. One practical approach to achieve this is to equip rovers with a sophisticated vision system. In the summer of 2001 a field test of time-of-flight lidar technique in crater geology has taken place. An ILRIS-3D instrument was deployed at the Haughton impact structure on Devon Island in Canada's high Arctic where it generated 3-dimensional optical images of various geological sites. This paper presents the current advances in laser range imaging as they apply to space exploration.

Table 1. ILRIS-3D and RELAVIS Performance Specifications

Parameter/Feature	**ILRIS-3D Commercial Survey Instrument**	**RELAVIS (Goals) Rendezvous Laser Vision System**
Range	1.5 km	500 m – 5 km
Range Resolution	3 mm	3 mm
Range Accuracy	1 cm	1 cm
FOV	40° x 40°	30° x 20°
Programmable Spot Spacing @100m	2.6 mm to 266 mm	1.5 mm to 150 mm
Data Rate	2000 points/s	10000 - 50000 points/s
Volume	20 L	6 - 10 L
Mass	12 kg	6 - 8 kg
Power	75 W	35 W
Laser (Eye- safety)	Class 1	Class 3B

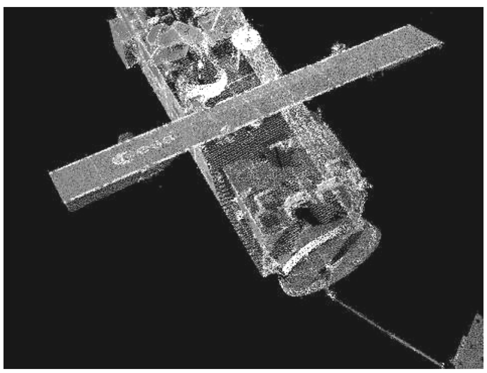

Figure 1. Point cloud image of ENVISAT

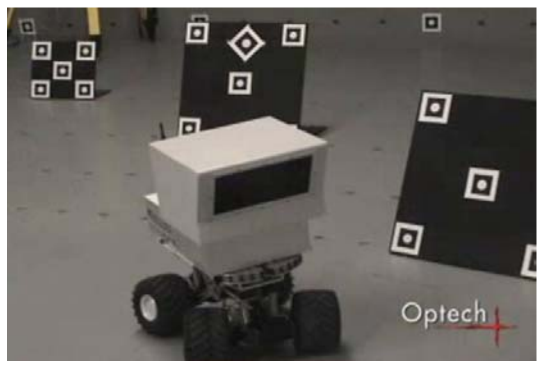

Figure 2: Rover tests, ILRIS-3D mounted atop a University of Toronto Institute of Aerospace Studies (UTIAS) rover.

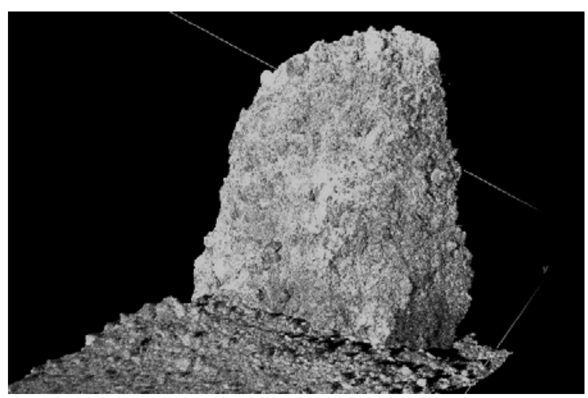

Figure 3: Left: Photograph of ejecta block. Right: ILRIS scan of same ejecta block. (range 20m, spot spacing 3mm).