3D Laser Scanning for Asteroids and Comets. I. N. Gorkavyi, Greenwich Institute for Science and Technology, P.O.Box 797, Haymarket, VA, 20168, agorkavyi@gist.us

Introduction: Surface of asteroids and comets is covered by craters and debris. Analysis of 3D shape and surface details of minor bodies is useful for understanding evolution of asteroids and comets. We propose to use high frequency (~ 10^5 measurements per sec) LIDAR for spacecraft scanning of minor bodies of Solar system.

Papers [1-3] present results of airborne 3D laser scanning and methods used for processing and classification of LIDAR data and generation of 2 m – 30 cm resolution digital terrain models (DTM). The Virtual Surfaces Method (VSM) for DTM generation and noise/foliage filtering from LIDAR data integrate the process of filtering with interpolation in filtered pixels. The VSM possesses the benefits of popular methods for DTM generation, such as the Vosselman-Sithole and Kraus-Pfeifer techniques; however, VSM avoids most of the problems associated with these approaches. The advantages of the VSM, including greater accuracy, were tested during processing of LIDAR and IFSAR data and DTM generation for areas more than 40,000 km², including 15 counties of Maryland (height of airborne LIDAR collection ~ 1 km; horizontal resolution of 3D model - 2 m and vertical accuracy ~ 15 cm). LIDAR data after processing can be converted into accurate 3D model of asteroids and, in the same time, into high quality 2D IR-image of surface without shadows. Our practice shows that IR-image from LIDAR data has better resolution (1 m) than 3D-model. The laser reflection depends from albedo and other surface properties, such as roughness.

Fly-by scanning: During fly-by of spacecraft near minor body (fig.1A) modern LIDAR can cover almost whole surface of asteroids by 10^5 - 10^6 measured points from a distance ~ 1-10 km.

This dataset after processing can provide following models and results for asteroid:

1. 3D model of surface up to sub-meter resolution.
2. IR-map of surface with similar or better resolution.
3. Determination of density of asteroids from known mass.
4. Size distribution of craters and debris larger than ~ 1 m.
5. Depth of craters with accuracy up to ~ 10 cm.
6. Determination of steepness of mountains and regolith strength.

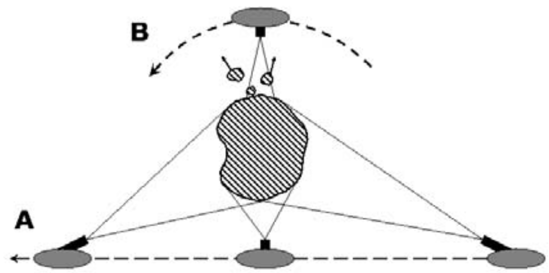

Fig.1 Scheme of fly-by (A) and orbital (B) 3D laser scanning for asteroids or comets.

Orbital scanning: Accumulation of laser measurements from low orbits around a minor body provides best opportunity for high quality 3D-model and IR-map for asteroids or comets (Fig.1B). Orbital scanning is especially useful for cometary body. Most interesting comets are active, covered by cloud of gas and dust. Good penetrating capability of a laser beam and registration of different (for example, first and last) reflections of laser radiation from small obstacles and surface can be very useful for investigation of such active comets.

Orbital LIDAR data after processing give us additional information about comets:

7. Size and 3D shape of the nucleus and how they change with time.
8. Variability of IR-map of surface after eruptions.
9. Density and dynamics of dust structures in coma.
10. Motion and size of ejected debris.
11. Scale of temporary variations of processes up to ten microseconds.

Conclusion: Laser rangefinder is typical equipment for many interplanetary spacecrafts (NEAR, Falcon, DAWN), but it is used basically for navigation during approaching and landing. We propose to change laser rangefinder for high frequency LIDAR. Navigation of spacecraft will be more robust and spectrum of important scientific problems will be solved.

References: [1] Snyder G. et al. (2005) Proc. "Enabling Technologies for Simulation Science IX". SPIE, 5805, 349-361. [2] Gorkavyi I.N. (2006) Proc. “Modern Inform. Tech. and IT-education”. Moscow Univ. 367-377. [3] Gorkavyi I.N. (2007) Geodesy and aerophotography. Izvestia vuzov, 5, 148-162.