

Modeling and Analyzing Itokawa Topography for Hayabusa Touchdown and Sample Collection

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Introduction: Asteroid sample collection is the major mission of Hayabusa spacecraft and modeling and analyzing the target Itokawa is the essential step to achieve the goal. Before the Hayabusa's approach to the Itokawa, Ostro model was obtained from radar observation from the Earth. However the detailed mapping is required for sampling site selection and navigation and guidance of Hayabusa touchdown. A detailed 3-D model of Itokawa is built using the Hayabusa's proximity observation data. Four global mapping teams are involved in the Hayabusa project: Guidance and navigation team, AMICA team, LIDAR team, and JPL team. This paper describes the global mapping results of the Guidance and navigation team.

3-D Shape of Itokawa: The optical navigation camera (ONC) images taken at the distance of 7 km are used to construct a 3-D shape of Itokawa (Fig.1). Several Ground Control Points are set on the ONC images and the spin axis orientation and the spacecraft position are estimated by GCP tracking. Two kinds of methods are applied to construct the shape model; a limb profile method and a stereo image analysis method. And the scale of the 3-D model is defined by using the light detection and ranging sensor (LIDAR) data. The obtained 3-D model is shown in Fig.2 and Fig.3. The estimated size and volume of is as follows.

Size:

- X 540 m (major axis on the equatorial plane)
- Y 246 m
- Z 216 m (spin axis)

Bounding Box Size:

- X 562 m
- Y 293 m
- Z 239 m

Volume: 1.74×10^7 (m³)

Analyzing Itokawa Topography for Touchdown Site Selection: Because Itokawa has irregular and unique shape, the process of touchdown site selection is

complex. This section describes the topographical aspect of site selection for safe touchdown. Therefore two factors, boulders and surface gradient are considered. Firstly, boulders greater than 1 meter should be avoided. So, the regolith expanse area in the middle of Itokawa, known as MUSES-SEA, where the terrain is broad and flat, is the first candidate. Secondly, the surface gradient should be less than 30 degrees to keep the solar panels toward the sun and also to keep the communication link to the earth during the touchdown process. Figure 4 shows the gradient map of Itokawa, which is calculated from the 3-D model. This shows the most of MUSES-SEA area is too steep to touchdown, though small safe areas exist near the equatorial plane. Thus the touchdown site is selected as shown in Fig.4. From the viewpoint of guidance and navigation, the pin-point landing and touchdown technique is established by Hayabusa mission.

References: [1] Makoto Maruya, *et al.* (1999) *ISSFD*. [2] Ostro, S.J. *et al.* (2004) *Meteoritics & Planetary Science* 39:407-424. [3] S.Kobayashi *et al.* (2005) *Lunar and Planetary Science XXXVI*. 1982.pdf [4] Robert W.Gaskell (2005) *AAS/AIAA Astrodynamics Specialist Conference*.



Figure 1. Itokawa image taken by HayabusaONC.

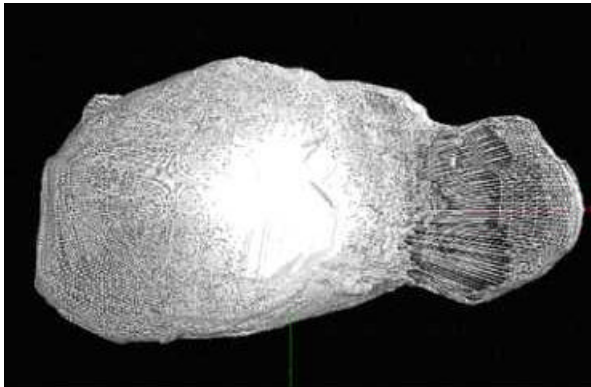
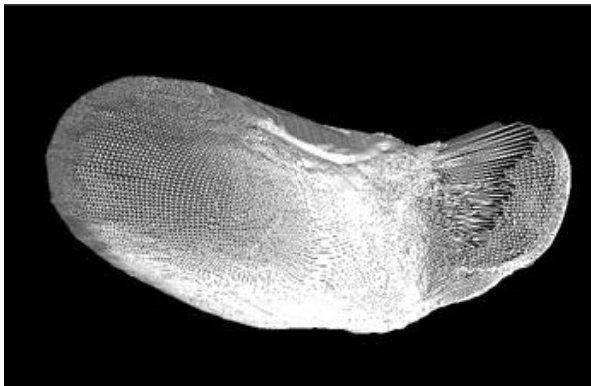
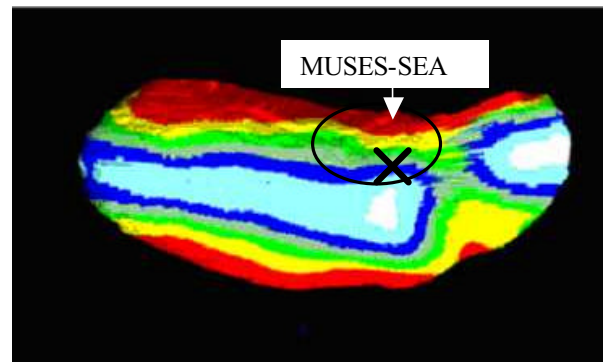
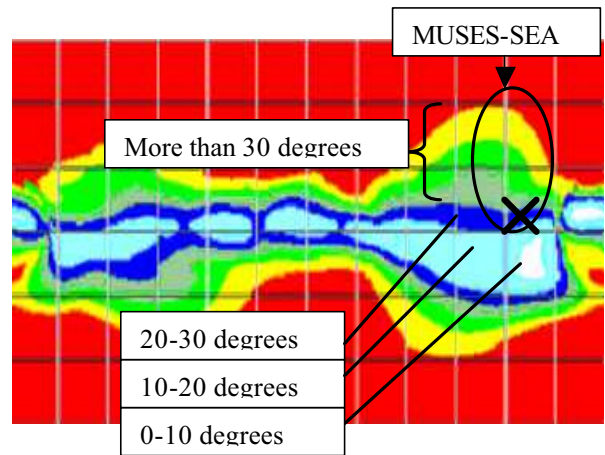


Figure 2. Wire frame representation of Itokawa 3-D Model



Figure 3. Texture Mapped model of Itokawa



X indicates the selected touchdown site.

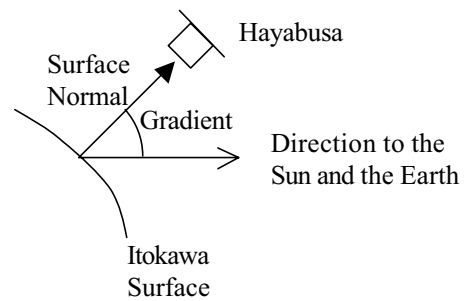


Figure 4. Surface Gradient Map (top) and the 3-D model textured with the map (middle).