

## HAYABUSA'S SAMPLING SITE COORDINATES ON ITOKAWA: CONNECTING IN-SITU DATA AND RETURNED SAMPLES .

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**Introduction:** Hayabusa performed two touchdown (TD) operations for sample collection at the "MUSES-C Regio" smooth terrain of Itokawa on November 19th and 25<sup>th</sup>, 2005 [1]. Although the emergency descent abort for TD1 and the software problem for TD2 prohibited Hayabusa to shoot Ta projectiles onto the asteroid surface, sub-mm to micron-sized asteroidal samples were collected in two separated chambers of the sample catcher, allowing to distinguish these samples from two different locations, except the smallest end members that might be able to move between the chambers. Thus estimates of these sampling sites will help to combine statistical characteristics of collected samples with geological ground truth at the MUSES-C Regio.

### Reconstructing the Descent Trajectories with HK Data:

The two sampling sites were estimated by reconstructing the orbit/drift motions of Hayabusa's HK data, much more comprehensively than a previous, preliminary attempt [2]. During the initial phase of the decent operation, the spacecraft position relative to the asteroid was determined by the "GCP Navigation" on the asteroid surface as landmarks [3, 4]. In this analysis, the following sensor data were integrated: Attitude Sensor, Range Rate, LIDAR, LRF-S1, LRF-S2, and ONC-W1,2. In addition, the Itokawa 3D model was used as a reference of the surface gradient.

**TD1 Site Estimate:** At 20:40 UTC, the flight sequence was interrupted due to an obstacle detection near the target marker location, then the spacecraft was in drifted motion with the initial velocity. The range data showed that the spacecraft bounced twice after free fall. After the drift motion of ~50 minutes, Hayabusa landed near Itokawa's south pole, at the latitude: -82 ~ -71 deg. and the longitude: +323 ~ +324 deg. There remain some uncertainties in the drift trace but the surface gradient at the estimated TD site gives a good agreement with the final spacecraft attitude: ~25 deg. inclined from the Earth-Itokawa line.

**TD2 Site Estimate:** At the final decent phase of the TD2 on November 25th, the spacecraft attitude was aligned with regard to the surface, and the landing/sampling was performed successfully at ~22:07 UTC. The resulting trace is not as clear as the TD1 but the best estimated sampling site for the TD2 is near the equator at the latitude -10 ~ -1 and the longitude +331 ~ +333 deg.

**Implications to Collected Samples:** The TD1 region is in the middle of the smooth terrain and close to the south pole vortex where global regolith gravels can migrate and accumulate effectively [5]. Thus spectrally matured, eroded microparticles must exist. In contrast, the TD2 equatorial region is right next to the "Shirakami Mountain", one of the steepest geopotential areas on Itokawa. Thus regolith could be admixture between matured, rounded components and spectrally younger, sharper-edged components. This is consistent with the early reports about space weathering and 3D shapes of the samples from this region [6, 7].

**References:** [1] H. Yano, et al. 2006, *Science*, **312**, pp.1350-1353. [2] T. Kubota, et al., 2006, *Proc. AIAA/AAS Astrodynamics Conf.* [3] S. Aida, et al., 2006, *2006 IAC Proc.*, IAC-06-E2.2.03. [4] J. Kawaguchi, et al, 2006, *Proc. AIAA/AAS Astrodynamics Conf.* [5] H. Miyamoto, et al.: 2007, *Science*, **316**, pp.1011-1014. [6] T. Noguchi, et al., 2011, *Science*, **333**, pp. 1121-1125. [7] A. Tsuchiyama, et al., 2011, *Science*, **333**, pp. 1125-1128.