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A preliminary result of precise positioning of the interplanetary spacecraft using differential VLBI measurements

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The precise and quasi-realtime navigation of the interplanetary spacecraft using VLBI technique is currently under development at NICT(National Institute of Information and Communications [former CRL]). We performed more than 30 VLBI experiments for the Japan's NOZOMI Mars probe from September 2002 until June 2003. The fringe products of group delays were successfully detected from these VLBI experiments in spite of weak and narrow-bandwidth NOZOMI signal. The group delays were used to validate the operational orbit determination based on the range and range rate (R&RR) data sets by ISAS/JAXA.

Though the rms scatter of the group delays of VLBI data from the R&RR results are relatively large up to several tens nanoseconds, the both results are consistent with each other. We also detected phase delay fringes using updated correlation software. The estimated position based on the phase delays are consistent with the R&RR results within several tens of milli-arc second. In particular, the declinations determined by phase delay signals are identical with those obtained by R&RR values.

We perform another VLBI experiments for tracking HAYABUSA spacecraft. HAYABUSA, which means "Falcon" in Japanese, was launched on May 9 2003, and has been flying steadily towards an asteroid named "Itokawa", after the late Dr. Hideo

Itokawa, the father of Japan's space development program. HAYABUSA is traveling through space using an ion engine. It will orbit the asteroid, land on it, and bring back a sample from its surface.

The first HAYABUSA VLBI experiment was performed at X-band(8.4 GHz) using six VLBI stations in Japan on November 26, 2003. We could detect group delay fringes of HAYABUSA range and telemetry signals for the Kashima-Usuda baseline. According to the comparison between group delays and R&RR results, average of residuals are larger than 100 nanoseconds. The large scattering of the group delays are shown at the several epochs. On the other hand, the relatively small scattering less than 10 nanoseconds are shown during the period between 05:00UT and about 07:30UT. It is considered that the difference between them is caused by the characteristic of the radio signals transmitted from HAYABUSA.

We also performed HAYABUSA VLBI experiment on October 16 and 18, 2004 in order to evaluate reducing propagation delays due to the ionosphere and neutral atmosphere using differential VLBI technique. In this experiment, we acquire the VLBI data using both the K5 system and the state-of-art PC/VSI Gigabit system. The hybrid correlation processing based on the Gigabit system and the DBBC (Digital Baseband Converter) filtering technique is significantly efficient to detect fringes of weak radio sources which have small separation angle from the spacecraft.