ORBIT DETERMINATION DEMONSTRATION FOR AKATSUKI (PLANET-C) MISSION

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ABSTRACT

Venus Climate Orbiter, Planet-C known as "Akatsuki", has been launched on May 21, 2010 on H-IIA booster from Tanegashima Space Center (TSC), Kagoshima, Japan. And arrived at Venus in December 6, 2010 without trouble after the cruising interplanetary approximately seven months. The main engine (OME: Orbit Maneuver Engine) failed to complete the Venus orbit insertion (VOI: Venus Orbit Insertion) maneuver required to insertion Venus orbiter.Currently, a spacecraft cruising heliocentric orbit and has been communicated at ground station with telemetry, command, and observation of Earth-based radiometric data. This spacecraft spacecraft is in communication with the ground from a 203-day heliocentric orbit while plans for a return to Venus are being considered. Assessment of the health of the spacecraft main engine (OME) is in progress.
This mission, which now rotates about the Sun, will approach to Venus again in 2015.

It carried out two times of examination trajectory control maneuver (TCM1,TCM2) in September, 2011 to evaluate usability of orbit control engine (OME) which failed in Venus orbiter injection. As a result, it was decided that the orbit control in the near perihelion by using the thruster control system to the attitude (RCS:Reaction Control System) because it could not use OME for trajectory control.
It is carried out three times of trajectory control using RCS in a perihelion November, 2011. As a result, this spacecraft cruising interplanetary for Venus re-encounter without trouble. By these trajectory controls, the orbital period was reduced from 203 days to 199 days.
And this mission design, which now plane to rotate about the Sun, will approach to Venus again in 2015.

The operation sequence specifies four phases for different parts of the mission, (1) Launch, separation and initial health check, (2) Cruise trajectory to Venus after midcourse navigation and final course adjustment, (3)VOI by burning on OME, (4) Nominal Venus Observation by mission instruments. However, a major anomaly occurred on December, 2010 as the spacecraft attempted to enter Venus orbit. Then the stage (3) and (4) failed.

The main engine (OME) failed to complete the VOI maneuver required to slow the craft enough to be captured by the gravity of Venus after stage (3). Then the spacecraft fly-by Venus and cruise heliocentric orbit.

In this paper, we introduce the orbit determination and navigation for two focuses as following.

1) Orbit maneuver estimation analysis and result at three times of trajectory control on November,2011
2) Orbit determination by using new ranging system with on-board on April-May,2012

Basically,the orbit estimation configuration for mapping operations uses a single batch, weighted least squares, square-root information algorithm. The characteristic of a spacecraft product very small maneuvers. These maneuvers were estimated using achievement simple solar radiation dynamics and observation data. The orbit estimation error will be expected to reduce by consider the solar radiation model. And the maneuver is more precise estimated by using recursive Kalman type filter.

In relation 2), "Akatsuki" invesigated new transponder with on-bord. It have a characteristic that the new transponder is regenerative pseudo-noise (PN) ranging scheme using synchronouse integration of long period PN signals whose compatibility are excellent with equipments in the deep space stations.

In the past ranging, transponder aboard explorers simply returned the radio wave. But, we adopt the new method that transponder in space regenerates the signal, restores its quality, and re-modulates the signal. And, then, it sends the ranging signal to the ground. In the conventional method, quality of the ranging signal on the radio wave is deteriorated over its round trip, up and down links. In the new method, the signal degradation occurs only in one way.