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SATELLITE ORBIT DETERMINATION: A FIRST-HAND EXPERIENCE WITH THE FIRST BRAZILIAN SATELLITE SCD1

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Under the Complete Brazilian Space Mission (MECB) project, the first Brazilian satellite SCD1 was lofted on 9th February 1993 at 14:42:20 UTC, by a Pegasus rocket of Orbital Sciences Corporation of USA. This weather data collection satellite was injected into a near-circular orbit of approximately 760 km altitude with an orbital inclination of 25°. Since there were available only two Brazilian ground tracking stations, Alcantara and Cuiabá, the European Space Agency (ESA) kindly agreed to use their ground station facilities at Mas Palomas, Spain, to give tracking assistance to Brazil in the very first orbit of the satellite. However due to the failure of the clock in the launch vehicle, the Flight Mechanics group of INPE, Brazil, responsible for the flight dynamics software preparation and operation, had a great difficulty in determining the orbit at the injection point. This paper aims at describing what were the difficulties faced by the group during that early phase, which critical decisions had to be taken, how the hurdles were overcome, and how a very quick and good early orbit determination was achieved using the minimum data available.

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Tracking and Orbit Determination Problem in Japanese Deepspace Missions

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The Institute of Space and Astronautical Science (ISAS) has launched four deepspace probes already. They are Sakigake and Suisei for observation of Halley's comet, Hiten for the lunar swing-by mission,and Geotail for observing interaction between the geomagnetic field and solar plasma under the international cooperation.

Sakigake,which was launched on January 8, 1985, came back to the neighborhood of the Earth, after the successful encounter with the Halley's comet in March,1986 and several revoulutions around the Sun.

It approached to 90,000km from the Earth on January 8, 1992. The communication link with this probe has been reestsbilished since July 1991 and the tracking and orbit determination have been successfuly carried out using two-way range and range-rate data.

Hiten, on the other hand, was launched on January 24, 1990 and several lunar swing-by operations have been conducted, which were supported by the precise orbit determination (OD) using both S and X band signals.

The integrated operations covering The USUDA Deep-Space Center (UDSC), having a 64m ø antenna as well as the Sagamihara Space Operation Center (SSOC) will be described in this paper and numerical results of orbit determination of these probes will be presented in detail.

Moreover, the strategy leading to the injection of Hiten into an elliptical orbit around the Moon in February, 1992 and the requirement on OD precision in achieving this goal, as well as tracking results after injection will be discussed.

Finally, Geotail was successfully launched from the Kennedy Space Center on July 24, 1992 by means of the Delta II rocket of U.S.A..

Since then, tracking of Geotail has been carried out by the Usuda Deep Space Center as well as by the tracking stations of the Deep Space Network of NASA, and successful operations for twelve months after the launch will be reported in this paper.

At the end, the precisions of orbit determination and the tracking capability in deepspace missions of ISAS will be evaluated.

Significant improvement in OD precision has been achieved for Geotail mission, compared to the preceeding missions, such as Hiten.

Various modifications both in hardware and in software may be attributed to this improvement, thanks to the precious experiences of Hiten mission, and the successful tracking throughout the Geotail mission can be expected.

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A POSSIBLESCHEME FOR THE CRUCIAL EXPERIMENT ON CHECKING EQUALITY OR UNQALITY OF TO-AND-FRO LIGHT PATHS BETWEEN TWO MOVING OBJECTS

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Possibility and feasibility to conduct a crucial experiment on checking equality or unequality of to-and-fro light paths between two objects in relative motion is investigated in this paper. A possible scheme to compare the one way range measured by GLONASS system versus the two way average range measured by a laser system is discussed and measurement accuracy is estimated.

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On Making Use of Lunar and Solar Gravity Assists in LUNAR-A, PLANET-B Missions

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Abstract

ISAS (Institute of Space and Astronautical Science) is currently planning to launch PLANET-B spacecraft toward Mars in 1996 and LUNAR-A to Moon in 1997. With increase in scientific payload on those spacecraft, design of M-V that is ISAS's new generation launch vehicle has been intensively reexamined so that spacecraft mass is to commensurate with mass capability of it. In spite of those efforts, those two spacecraft have been facing at mass budget hurdles. Since they are unmanned scientific spacecraft, flight period and arrival time are not so constrained strongly in comparison with either manned or practical spacecraft. In this context, ISAS has been studying how to make good use of lunar and solar gravity effect in order to cope with such mass budget austerity.

As for the lunar gravity assists, ISAS launched two spacecraft HITEN in 1990 as well as GEOTAIL in 1992, both of which did demonstrate double lunar swing-by orbits so that geomagnetic tail coverage may have been assured. They took the same trans-lunar sequences which utilized four and a half revolution scheme that was proved quite robust and promising. Besides, what HITEN demonstrated in 1992 showed solar gravity assist around boundary of SOI (Sphere Of Influence) did save fuel amount at insertion around the Moon by reducing relative velocity to the Moon. These facts ISAS so far experienced were evidences which future trajectory planning can take the advantages of.

LUNAR-A mission is planting three penetrators on the surface of the Moon so that seismic network be built which discloses interior structure of the Moon. Seismic data are relayed via communication orbiter that should be the mother ship carrying penetrators. Up to one third of spacecraft was directed to fuel amount and saving fuel leads to increase in scientific and bass system in turn. And even in this lunar orbiter mission, current orbital sequence spells use of one lunar swing-by via which spacecraft can be thrown away toward SOI boundary for the purpose of acquiring solar gravity assist. This sequence enables approach velocity to Moon to be diminished drastically. PLANET-B spacecraft is the Martian orbiter mission that leaves Earth with C3 of approximately 9km2/s2. Even in such interplanetary mission, use of lunar and solar gravity assist can help in boosting velocity increase and saving fuel amount. Sequence discussed here involves two lunar swingbys to accelerate spacecraft enough to exceed escape velocity.

This paper focuses its attention on how such gravity assist trajectory is designed and stresses significance of such utilization in both missions.