Space Tether Technology – Verification in Space and Future

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Abstract— ***Space verification of advantageous performance of tether technology is much demanding for space development. Two projects are introduced in this paper to verify the performance of space tether technology. A sounding rocket will be launched in the summer of 2009 to deploy a bare electro-dynamic tape tether having a length of 300m. The other project to verify the space tether technology is a small satellite to deploy a bare 25km electro-dynamic tape tether, and the launch is expected in 2013 with employing a new solid motor rocket. These verifications of tether technology will lead to a large numbers of applications of space tether technology and some future projects are also introduced.***

1. Verifications of Tether Technology in Space

THE space tether technology is indispensable in constructing and also maintaining large space structures, which are designed for future space development including the solar power satellite and deep space exploration. Tether technology has such many advantages as simple structure, compact package, very long lightweight structure, autonomous construction with little help of the astronauts, and also active electro-dynamic artificial driver. It is thus necessary for tether technology to verify in space those performances expected as elements of space structures.

A verification of tether technology will be conducted for an electro-dynamic tether (EDT) deployed from a sounding rocket, S520 as shown in Fig.1. The S520-25, 25^{th} of S520, will be launched to an altitude of 300km (velocity about 0.5km/s) at a dawn in August of 2009 by ISAS/JAXA from Uchinoura site in Japan to southwest direction (Ref.1). The EDT is deployed to the flight direction in order to cross with the direction of the earth magnetic field by almost 45 degrees, which is not controlled but is measured by a magnetometer. The objective of the projects is to verify experimentally the performances of a bare EDT in space from both scientific and engineering aspects including 1) swift and high reliability deployment of long tether, 2) fast ignition of a hollow cathode to provide electricity to electro-dynamic tether, 3) demonstration of EDT in collection of electrons, 4) vilification of electron collection theories including OML (Orbit Motion Limit) theory, 5) atmospheric entry of tape tether, and 6) space robot motion control. The tether is a bare EDT, which is a reinforced aluminum with width 25mm and thickness 0.05mm, and the science experiments employs the Langmuir tube as a main measurement device. The tether will be deployed in its length through 300m in 120 seconds (Fig.2) in order to afford sufficient time periods for science experiments for about 300 seconds in space.

Figure 1: S520 Sounding rocket

The two objectives studied in this proposal are apparently two major indispensable technologies both in the scientific and engineering aspects and will play important roles in the course of space development. The present proposal is to verify the fundamental technology for such important tether applications as deployment and use of bare conductive tethers in space. The other of the two objectives of the present proposal is the scientific study to incorporate the conductive tether by employing an Aluminum bare tape tether. A conductive tether opens unique opportunities for science that are not limited to testing OML collection under orbital conditions and generating convenient electron beams. The project is a European/ American/ Australian/ Japanese International Campaign. Main

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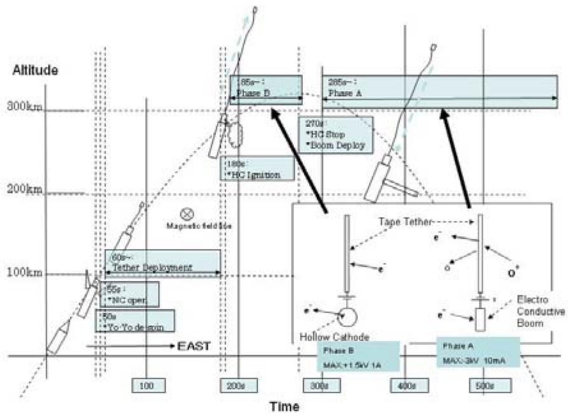

Figure 2: Experimental Sequence of the Sounding Rocket

The sounding rocket experiment could be extended to a low cost LEO mission of a small satellite with an electro-dynamic tether. These demonstrations will extend many useful methods of employment of the bare electro-dynamic tether including engine to increase/decrease orbit, supplier of electricity, spring-shot, and lifter for payloads. The objective is to verify the two fundamental and important aspects of the tether technology: One is a scientific experiment of the Alfven wave (Fig.3), and the other is an engineering demonstration to elevate and/or descend the orbit without using fuel as shown in Fig.4. A tether could generate controllable nonlinear Alfven wave fronts artificially in space and we can study many interesting physical features in relation to fronts of the solar wind with Earth, Jupiter, or comets. In the engineering mission, the electro-dynamic tether on space structures could apply thrust or drag without using any fuel mass, as well as achieving orbit elevation without any fuel, which could provide much effective and economic means for aerospace engineering.

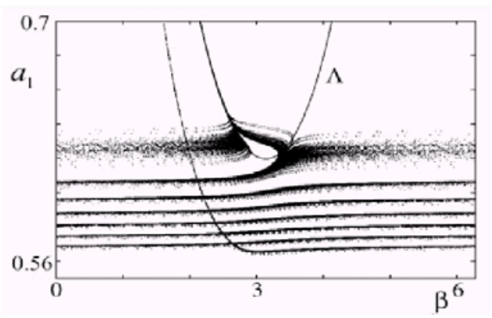

Figure 3: Nonlinear Alfven wave

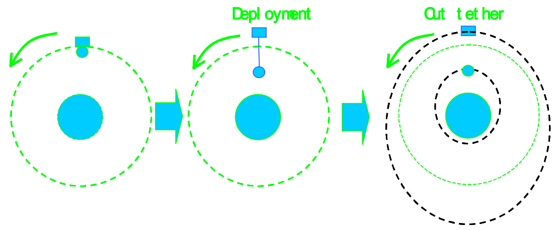

Figure 4: Orbit elevation/decent without fuel

2. APPLICATIONS OF SPACE TETHER TECHNOLOGY IN FUTURE

The drivers for the electro-dynamic tether are underlies in the low cost, simple mission concept, and fast realization possibility. The application includes a number of interesting and useful operations of space tether technology, including elevation of orbit of the International Space Station without consumption of, fuel and the solar power satellite.

The demonstration will also be very effective to examine the possibility of the rotating electro-dynamic tether to Jupiter mission application to enable simple entry into the atmosphere of Jupiter, or lunch free tour to Saturn satellites (Fig.5). It may be noted that de-orbiting of defunct satellites is indispensable for our future space missions to reduce the numbers of debris, and constitutes one of the main and relevant commercial applications of the technology. These demonstrations will extend many useful current applications of the bare electro-dynamic tether.

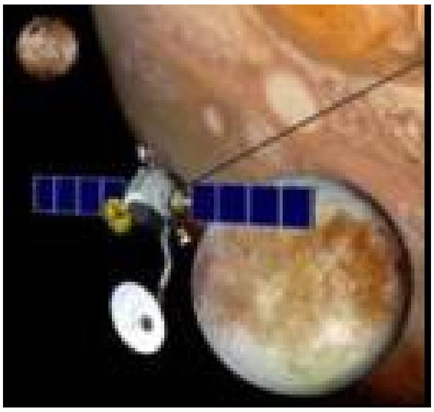

Figure 5: Lunch Free Tour Satellites

3. SUMMARY

The success of the two proposed international campaigns by Europe, United States, Australia and Japan on space tether experimental projects will herald a new era of the electro-dynamic tether technology to a number of innovative and useful space applications in our near future.

References

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