EPSC Abstracts
Vol. 5, EPSC2010-539, 2010
European Planetary Science Congress 2010

Data Clippers: A new application for Solar sails and E-sails

J. Poncy (1), P. Couzin (1) and J. Fontdecaba (2)
(1) Thales Alenia Space, Cannes, France (2) Thales Alenia Space, Toulouse, France (joel.poncy@thalesaleniaspace.com / Fax: +33-492926490)

Abstract

Thales Alenia Space proposes and investigates here a novel application of Solar sail or E-sail: carrying large volumes of data back to Earth's neighborhood thanks to multi-mission "Data Clippers". Missions to the distant planetary targets face a drastic limitation in the amount of data that can realistically be transmitted back to Earth. Data Clippers are found to represent a potential solution to bypass this bottleneck, allowing for repatriating huge volumes of scientific data such as the full high resolution maps of the planetary bodies.

1. Introduction

The solar sail technology is now at last in orbit with JAXA's IKAROS. Moreover another way to use the Sun as a propulsion source, the E-sail [1] [2], is now emerging as a potential alternative solution. Both present the considerable advantage to require no propellant on board, and are subsequently not limited by the duration of the mission. This translates into the ability to go from one place to another in the Solar System, as long as the hardware has not aged up to the point that the spacecraft is no longer maneuverable.

They are therefore ideal technologies for missions requiring transportation of items. Sample return is an obvious application. But there is something else of high value that they can return to Earth: data!

2. Why not just send the data?

In this Age of Information, more and more data are generated and processed. Space exploration is no stranger to that general trend as data volumes increase steadily in new missions. In particular, high-resolution imaging is key to the comprehension of planetary bodies and requires considerable resources, both in orbit and on ground, for the transmission of the gigabytes and now terabytes of collected data. Flash memories will very soon allow for the storage of huge quantities, such as the ones needed for the full mapping of a planetary body in high resolution. But downloading a full hi-res map of, say, Ganymede, would take decades for an orbiter even depending on very large antennas on board and on the SKA on Earth. Even for more modest quantities, downloading the data triggers snowball effects on the spacecraft. It leads to a heavy communication subsystem and to large spacecraft dimensions with significant power generation capacities, via respectively antenna size and transmission power, hence significant costs. In the same way, operations costs now take a larger and larger share of the cost at completion of the missions, due to the need for a long use of the major ground facilities. How to download large quantities of data is the major design driver (and limiter) of interplanetary missions, in particular for the Outer Solar System where most planetary bodies lie.

3. Principle of the Data Clipper

The 19th century clippers brought back valuables from across the Globe. Similarly a sail-equipped spacecraft could do the same with large amounts of science data in the Solar System. The principle studied there is to fly "close" to e.g. a planetary orbiter, upload its data when passing by and go back to fly by Earth so as to download tens of terabytes of scientific information to the ground station. Having several such Data Clippers cruising in the Solar System at any time would provide for a considerable support to the entire set of planetary missions, as they would allow for a significant downsizing of the exploration spacecraft combined with a huge science return and a low ground operation cost. The exploring spacecraft would still download some samples of their data to Earth so as to enable

interactivity and a real time re-planning of the science operations depending on their discoveries. But the bulk of the data, which is usually anyway processed by scientists long after the downloading and has a lower degree of urgency, would then be stored in flash memories, transferred to the sail-propelled Data Clipper as it flies by the spacecraft and re-transferred to Earth when flying by our planet. Once the Data Clipper has fallen back into the more sunlit inner system, it then recovers a strong maneuvering capability that allows its use for another mission.

4. Preliminary sizing

Thales Alenia Space has performed a pre-sizing of such a mission. We assess and discuss in a preliminary way the challenges of such a mission, e.g. ultra-high rate transmission, Doppler effects, pointing accuracy needed for the massive data transfer, potential for RF or optical transmission, needs for tracking devices, limitations on the velocity and typical mission profile of the Data Clipper.

5. Summary and Conclusions

The concept of a Data Clipper has been found promising, especially for overcoming the data download bottleneck that missions to the Outer System will face in the next decades. The fly-by conditions should however be carefully designed so as to master in a reliable way the ultra-high rate of transfer when uploading the data to the Data Clipper, and the tracking accuracy on both emitting and receiving vehicles. They deserve attention in the next future with an adequate pre-development effort. Data Clippers would open the way for repatriating full high resolution maps of the planetary bodies as well as other massive scientific data volumes, a key for the comprehensive understanding of our Solar System.

References

[1] Janhunen, P, Electric Sail for producing spacecraft propulsion, United States Patent 7641151, 2010, Priority date Mar 2, 2006

[2] Janhunen P., Increased electric sail thrust through removal of trapped shielding electrons by orbit chaotisation due to spacecraft body, Ann. Geophys., 27, 3089-3100, 2009.