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Maximizing the science return of fly-by missions thanks to ancillary smallsats and cubesats

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Abstract

The multiplication of new targets in the distant reaches of our Solar System will keep the need for "New Horizons"-like fly-by missions alive, requiring innovative architectures to further enhance the science-to-cost ratio. Thales Alenia Space discusses here how a mid-sized spacecraft can be efficiently complemented by ancillary micro-satellites so as to provide for a considerably increased spatial and/or time coverage and probing of the magnetic field, gravitational field, atmosphere or exosphere of the targets.

1. Introduction

Three quarters out of the 100 largest bodies in our Solar System are either transneptunian objects or moons of Uranus and Neptune. In-situ exploration of those full-fledged planetary bodies would be of course best served by orbiters rather than by fly-by but the required advances in performance of propulsion and mainly power generation specific mass place such orbiter missions far beyond the next decade.

For the transneptunian dwarves, a fly-by still represents the most efficient in-situ exploration strategy in the short term. This is de facto true too for the large moons of Uranus or Neptune as capture into orbit around one of these moons would require a very large delta-V.

NASA's New Horizons sets a precedent of a mission to a transneptunian dwarf planet. The large number of targets and their diversity call for many New Horizons-like missions. New Horizons had to battle to exist despite its reasonable size and the study of as many as 4 to 6 unexplored bodies. Increasing the science return–to-cost ratio of a fly-by is therefore vital to get such missions to distant targets approved.

2. Ancillaries as a mission architecture alternative

An innovative architecture can overcome this challenge by complementing a mid-sized New Horizons-class spacecraft with ancillary micro-satellites so as to provide for an increased spatial and/or time coverage and probing of the magnetic field, gravitational field, atmosphere or exosphere of the targets.

The aim is then to cover all physical fields in a comprehensive way while still benefiting from the low cost of a fly-by mission.

3. Parametric mission studies

We have run parametric studies to assess delta-V as a function of the time at which such ancillaries would be released, so as to cope with navigation uncertainties and power supply considerations. The ancillaries are low-cost, low-mass items (50kg typically each) as they have no need for orbit control and can survive their short lifetime as independent items through primary batteries.

We have computed, in the example of a New Horizons-like fly-by of dwarf planet Makemake, the needed delta-V as a function of release time and fly-by altitude in a scenario with two cubesat/microsat ancillaries, as illustrated in figure 1.

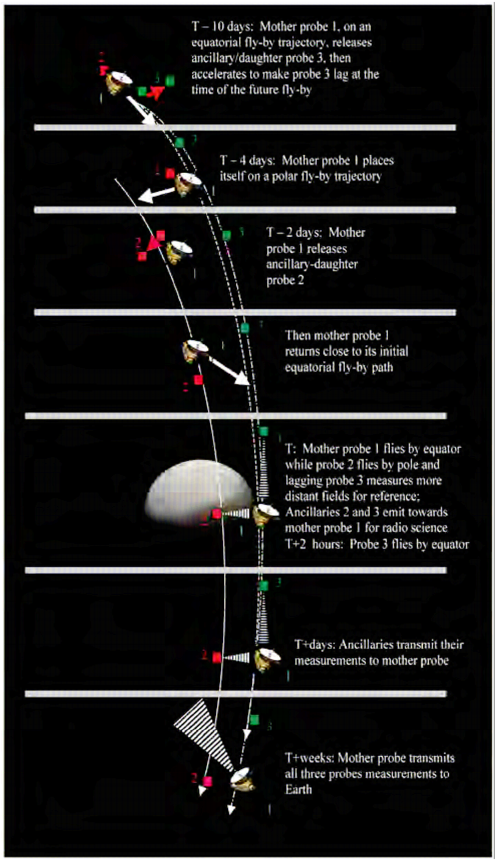

Figure 1: *An example of use of ancillaries: mother probe #1 releases probe #3 so that it trails it on its equatorial fly-by trajectory, places probe #2 on a polar fly-by trajectory and then comes back to an equatorial fly-by path.*

The total delta-V needed to manage the ancillaries is reasonable e.g. for a release of probe #3 ten days prior to the planetary body encounter, and a release of probe #2 two days before the encounter. The amount found is then 150 + 33 = 183 m/s of delta-V to be kept as a chemical reserve on board the mother ship for a New Horizons-like spacecraft design.

4. Summary and Conclusions

The scenario has been found feasible, paving the way a considerable increase of the science-to-cost ratio of fly-by missions. This is not only an enabler for missions to distant objects, but also a source for mission cost reduction for closer unexplored targets in our Solar System.