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# Enabling technologies and building blocks for large planetary orbiters

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## Abstract

Thales Alenia Space reports how, beyond ExoMars, enabling technologies and their corresponding building blocks for large orbiters and mother ships will play a key-role in the exploration of our System. We first make a census of the targets, of the induced missions for the next decades and of the constraints they place on the physical and functional architecture of the main spacecraft. As a function of the maturity of the related technologies, and of the urgency of scientific and exploration needs, we then introduce the time dimension per target and mission type, as an input for establishing a future comprehensive road map. We conclude by recalling the most urgent developments.

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## 1. Introduction

ExoMars represents a golden opportunity for Europe to enter the age of large planetary orbiters. Future missions will require the entire spectrum of possibilities: fly-by, mere orbiter, orbiter or carrier bringing surface elements and/or atmospheric probes, sample return.

Thales Alenia Space reports how, beyond ExoMars, enabling technologies and their corresponding building blocks for large orbiters and more generally, mother ships will play a key-role in the exploration of our System. Here we focus on the spacecraft. For missions including surface elements like landers, rovers, balloons, we consider here only the delivery means whether carriers or aeroshell, and how the spacecraft manages those surface elements.

## 2. An ever wider set of targets

The rate of discoveries in planetary science in the solar system is accelerating steadily, making the total number of desirable missions expand.

The number of targets with recently discovered phenomena requiring orbiters or surface elements for their proper analysis have been bolstered by missions such as Galileo or Cassini/Huygens, from the subsurface oceans of Europa, Ganymede and Callisto to the plumes of Enceladus to quote some most notorious ones.

Even the number of known planetary bodies in our system has increased, doubling from 35 objects wider than 500km diameter known as of 2000 to 70 as of 2010. The numerical increase is even more pronounced for asteroids. The total number of known bodies, all sizes included has now reached more than half a million.

The consequences for the future missions is that they will require orbiters and/or delivery of surface/probe elements not only around Mars or other inner planets but also around Jupiter, Saturn, Uranus and around some of their major moons. Some asteroids, small or large, in the Main Belt or in the Trojan clouds will also see new missions, after Hayabusa and Dawn. The multiplication of new targets in the distant reaches of our Solar System will also keep the need for "New Horizons"-like fly-by missions alive, requiring innovative architectures to further enhance the science-to-cost ratio.

All types of missions remain thus desirable: fly-by, mere orbiter, orbiter or carrier bringing surface elements and/or atmospheric probes, sample return.

## 3. An ever greater need for more performing technologies

Targets generate challenges through:

- Their distance to the sun
- Their accessibility
- Their environment (e.g. radiation for the moons of Jupiter)

Distance to the sun drives in turn:

- power generation,
- telecommunication,
- mission lifetime.

For all those challenges we review the induced technological needs.

## 4. Induced constraints on spacecraft architecture

We first make a census of the target missions of the next decades, and the constraints they place on the physical and functional architecture of the main spacecraft.

The type of propulsion is a primary influential parameter:

- With chemical propulsion the large wet mass-to-dry mass ratio combined with the need for an efficient structural index determines the physical architecture.
- With electrical propulsion, the staging trade-off is always fundamental with an outcome depending upon the depth of the gravity well of the target.

The science and/or exploration mission constrains as usual the face allocation, directly through the payload accommodation requirements and indirectly through the needs related to power generation needs and communication with Earth.

## 5. Identified building blocks and road map

All in all, the multiplicity of needs makes the case for technology-driven building blocks that minimize non-recurring costs across this vast array of missions: we identify those potential physical and functional building blocks and their level of necessity for each of the potential mission types and targets.

Interplanetary Missions can rely on a common core architecture while some functions remain scalable:

- Power: Battery, PCDU
- Communication: Antennae, amplifiers …
- Reaction Wheels
- Structure, tanks, Thermal control
- Power generation (Solar array or RTG)

As a function of the maturity of the related technologies, and of the urgency of scientific and exploration needs, we then introduce the time dimension per target and mission type, as an input for establishing a future comprehensive road map reported in the presentation.

## 6. Conclusions

We have reviewed for each potential target the challenges to the design of the spacecraft. The subsequent needs for innovative building blocks have been inferred, and put in perspective per mission type and per target. Positioning each mission in time taking into account both scientific urgency and a realistic readiness for the required technologies enables to determine the most urgent needs.

The main challenges for the spacecraft itself, per type of missions, for the next two decades are:

- For Sample Return from “close” targets: Mars, Phobos, Asteroids
    - GNC technologies for RdV, close operation, landing & autonomy
    - High reliability, robustness & bio cleanliness
- For the exploration of far targets with high resolution data (Jovian System and moons)
    - Large Data-volume (data rate, on-board processing to provide high science volume)
- For missions beyond Jupiter: Saturn & Titan, ice giants, dwarf planets
    - Nuclear power generation.