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In-orbit rendezvous: an enabler of ambitious exploration and science missions beyond Earth's orbit

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In-orbit rendezvous has been a critical technology for past human exploration missions like the ISS and the Apollo programs, and will be even more so in the future for robotic or human exploration missions like e.g. for Sun-Earth L2 point, Deimos or Mars. It will also be a key element for future Sample Return missions from the planets (e.g. Mars, Venus) or dwarf planets (e.g. Ceres) of our Solar System.

Thales Alenia Space presents here the different challenges and solutions for in-orbit rendezvous, in view of mid-term and longer-term robotic and human exploration of the Solar System.

We identify three main drivers for the technology:
· the level of autonomy required by the light-travel time delay and ground station availability,
· the navigation support capabilities,
· the level of cooperation of the target vehicle,
and then discuss their consequences.

The first criterion leads to consider a roadmap of progressively increasing autonomy levels: Low Earth Orbit missions such as the ATV, autonomous rendezvous in lunar orbit or in Lagrange L2 point, and finally interplanetary rendezvous (Mars and beyond).

The second criterion leads to distinguish GPS-enabled, LEO missions on the one hand from interplanetary missions on the other. The latter will require building robust navigation solutions without support from the ground, using sensors such as cameras, lidars, and/or RF sensors. Efficient data processing and filtering are the key to this problem.

As far as the level of cooperation of the target vehicle is concerned, human exploration missions will require highly cooperative vehicles with accurate relative positioning using RF or laser metrology, while robotic exploration missions can exploit a cheaper but more challenging architecture with an uncontrolled target vehicle to be captured.

Finally, the rendezvous techniques are reviewed per target and per type, and are placed on a strategic roadmap.