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MarcoPolo-R: Mission and Spacecraft Design

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Abstract

The MarcoPolo-R mission is a candidate for the European Space Agency's medium-class Cosmic Vision programme, with the aim to obtain a 100 g sample of asteroid surface material and return it safely to the Earth. Astrium is one of two industrial contractors currently studying the mission to Phase A level, and the team has been working on the mission and spacecraft design since January 2012.

Asteroids are some of the most primitive bodies in our solar system and are key to understanding the formation of the Earth, Sun and other planetary bodies. A returned sample would allow extensive analyses in the large laboratory-sized instruments here on Earth that are not possible with in-situ instruments. This analysis would also increase our understanding of the composition and structure of asteroids, and aid in plans for asteroid deflection techniques. In addition, the mission would be a valuable precursor for missions such as Mars Sample Return, demonstrating a high speed Earth re-entry and hard landing of an entry capsule.

Following extensive mission analysis of both the baseline asteroid target 1996 FG3 and alternatives, a particularly favourable trajectory was found to the asteroid 2008 EV5 resulting in a mission duration of 4.5 to 6 years. In October 2012, the MarcoPolo-R baseline target was changed to 2008 EV5 due to its extremely primitive nature, which may pre-date the Sun. This change has a number of advantages: reduced DeltaV requirements, an orbit with a more benign thermal environment, reduced communications distances, and a reduced complexity propulsion system – all of which simplify the spacecraft design significantly.

The single spacecraft would launch between 2022 and 2024 on a Soyuz-Fregat launch vehicle from Kourou. Solar electric propulsion is necessary for the outward and return transfers due to the DeltaV requirements, to minimise propellant mass. Once rendezvous with the asteroid is achieved, an observation campaign will begin to characterise the asteroid properties and map the surface in detail. Five potential sampling sites will be selected and closely observed in a local characterisation phase, leading to a single preferred sampling site being identified. The baseline instruments are a Narrow Angle Camera, a Mid-Infrared Spectrometer, a Visible Near-Infrared Spectrometer, a Radio Science Experiment, and a Close-up Camera.

For the sampling phase, the spacecraft will perform a touch-and-go manoeuvre. A boom with a sampling mechanism at the end will be deployed, and the spacecraft will descend using visual navigation to touch the asteroid for some seconds. The rotary brush sampling mechanism will be activated on touchdown to obtain a good quality sample comprising regolith dust and pebbles. Low touchdown velocities and collision avoidance are critical at this point to prevent damage to the spacecraft and solar arrays. The spacecraft will then move away, returning to a safe orbit, and the sample will be transferred to an Earth Re-entry Capsule. After a final post-sampling characterisation campaign, the spacecraft will perform the return transfer to Earth.

The Earth Re-entry Capsule will be released to directly enter the Earth's atmosphere, and is designed to survive a hard landing with no parachute deceleration. Once recovered, the asteroid sample would be extracted in a sample curation facility in preparation for the full analysis campaign.

This presentation will describe Astrium's MarcoPolo-R mission and spacecraft design, with a focus on the innovative aspects of the design.