MARCO POLO: AN ASTEROID SAMPLE RETURNS TO EARTH (IPPW-7)

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ABSTRACT

Marco Polo is a candidate mission for ESA's Cosmic Vision programme, aiming to obtain a sample of asteroid surface material and return it safely to the Earth. Asteroids are very primitive objects, of great interest to scientists, having recorded the history and formation of our solar system. Near-Earth asteroids also represent a potential Earth impact threat. Greater knowledge would help us understand: the processes of solar system and planetary formation; the physical properties and evolution of the building blocks of terrestrial planets; the nature and origin of any organics or pre-solar material in asteroids; and also how to deflect an asteroid. An asteroid sample must be returned to the Earth to discover this information, by analysis in ground-based laboratory instrumentation with exceptionally high precision and sensitivity.

The Marco Polo mission consists of a single spacecraft launching in 2018 on a Soyuz-Fregat 2B, and transferring to the asteroid 1999 JU3 with a bipropellant propulsion system. After rendezvous with the asteroid, the spacecraft would complete a remote sensing phase to map the surface and select a sampling site. Descent to the surface of the asteroid would be performed using visual navigation, a touchdown performed on three landing legs, and thrusters fired to hold the spacecraft on the surface while a robot arm reaches down to obtain a sample of pristine asteroid material using a rotating corer mechanism. Once successfully obtained, the sample would be transferred to the Earth Re-entry Capsule (ERC) using the robot arm, and sealed inside the ERC compartment.

The ERC would return to Earth in December 2024. The asteroid sample must be brought back in such a manner that it remains in good condition. For this reason, overheating, high mechanical loads, and leakage of the sample container are prohibited. The 26 kg ERC must withstand extreme thermal loads (about 250 MJ/m^2, ballistic coefficient 90 kg/m^2) when entering the Earth's atmosphere at 12.1 km/s. High performance heat shields with low density ablators as thermal protection are required to minimise mass. The ERC for Marco Polo has a half cone angle of 45°, a diameter of 600 mm and a height of 320mm, with a centre of gravity located 216 mm behind the nose. The mechanical loads when entering the atmosphere are limited by maintaining a flat entry with a Flight Path Angle below -9°, whilst the ERC shape and architecture are trimmed in a manner to ensure it remains aerodynamically stable during the entry phase, until the parachute system triggers. The parachute decelerates the ERC, allowing a "smooth" impact on the ground at about 5 m/s.

Once the ERC has returned to Earth, the beacons would be activated to allow detection and recovery. The asteroid sample would then be extracted in a sample curation facility, for analysis in laboratories across the world. This paper will outline the Marco Polo mission and it's Earth Re-entry Capsule in detail.