Asteroid Sample Return Mission Architecture Options and Trade-offs

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An Asteroid Sample Return (ASR) mission is being investigated for a European Space Agency Technology Reference Study. Asteroids are currently of great interest to space scientists, and a mission to a Near Earth Object (NEO) is a strong contender to be part of ESA's Cosmic Vision programme. Asteroids can provide invaluable insight into the history and formation of the solar system, largely due to their 'fossil-like' nature that has changed little since the solar system's beginnings. Study and knowledge of their properties is also vital for the mitigation of any Earth impact threat.

Numerous challenges and trade-offs are associated with an ASR mission, and a wide range of possible mission and system conceptual architectures can be found to address these challenges. The purpose of the current industrial activity is to investigate and assess mission alternatives and configuration options to identify the most cost-effective mission baseline for a given set of scientific objectives. Currently, a drill/corer has been selected as the optimal sampling method for a sample return mission. This is mainly due to the drill's ability to obtain a subsurface sample of significant size and depth – highly desired for scientific value. However, the use of a drill will require an element of the spacecraft to land and anchor itself to the asteroid. In addition to the drill, other candidate in-situ science payloads include magnetic, thermal and electrical conductivity sensors, and a scanning microscope.

The remote sensing science payload is likely to include an imager, α-X-ray and IR spectrometers, a radio science experiment, and crucially, a radar tomographer. The latter is highly desired due to its ability to map the asteroid's internal structure – a current knowledge gap in the area of NEO science.

The very large number of possible mission and spacecraft configurations presents a challenge to mission designers. One of the major mission trade-offs is between visiting and sampling a single asteroid, or sampling multiple asteroids for a much increased science return. The spacecraft configuration must also be traded-off, with the two main options being to either land the full spacecraft, similar to the recent Hayabusa mission, or to have a separate orbiter and lander, as in the Rosetta mission.

The key mission and system trade-offs for an Asteroid Sample Return mission are presented in this paper. These include the mission target options and the spacecraft configuration and staging trade-offs. As a result of this investigation, a preliminary baseline design will be presented.