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BEAST: LOW-COST DEMONSTRATION MISSION FOR BINARY ASTEROID ORBIT MODIFICATION

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ABSTRACT

The BEAST mission has been studied within ESA's Sysnova approach. The mission scenario specified by ESA intends to demonstrate the capability of modifying the orbit of the secondary body of a binary asteroid. More specifically, the mission shall change the relative velocity by 0.8 mm/s of the binary object by means of a direct contact (kinetic impact). The target object shall be a natural (i.e. metallic, silicate or carbonaceous) irregular object characterized by an overall mass of 250 tons, with a minimum diameter of 5 meters. The ROM cost of the overall mission (including launcher) shall be less than 150 ME. The total duration shall be less than 3 years.

Given the above mentioned mission requirements, in particular the cost limit, the mission concept was analysed and different options traded. The main strategy to maintain low cost for a deep space mission is re-use an existing commercial platform as much as possible, define an operation timeline compatible with reduced operational costs and minimise the technology development costs. The BEAST mission consists of a single spacecraft that carries a small impactor. The vehicle is based on the commercial Iridium platform by TAS. The direct launch with Soyuz inserts the vehicle in interplanetary trajectory towards the target. After detection and approach, the proximity operations are intended to characterize the binary system. Later, the spacecraft performs the terminal impact phase autonomously. The GNC controls this phase with the same system that was developed for hypervelocity impact. After release of the impactor towards the secondary body, the spacecraft performs a collision avoidance manoeuvre and observes the impact. Then, the SC

achieves a safe haven to characterize the effect of the impact, namely the orbital period variation.

As the currently known binaries do not have the characteristics specified by the requirements, three different groups of asteroids have been investigated as targets for BEAST, 1) known binaries, 2) asteroids that might host a small secondary from disruption theory, 3) small asteroids that may host a small secondary based on the diameter correlation from known binaries. All these groups of potential asteroids have been analysed from the point of view of mission analysis (direct transfers and with one Earth gravity assists). The candidates that might be reached with the different platforms that have been traded have been selected (delta-V budget, power generation, Earth communication link).

A stepwise approach is followed in the design of the mission. Different configurations, from the cheapest to the most expensive within mission limit, have been analysed. The basic configuration is the Iridium platform with minimum variations to withstand interplanetary flight, the major change is a high-gain antenna. From that version, deltas are introduced to increase solar power, and then propellant (delta-V). The final step is to switch to TAS Proteus Mark II platform that permits higher delta-V budget and still is a commercial platform. The mission capability of each version permits to assess the effectiveness of the extra cost, within the total boundary. For instance, some metrics are the number of candidate targets reachable with each platform or the additional science payloads that could be accommodated.
The terminal GNC system is the most critical technology. Given the small impact velocities needed to achieve the required 0.8 mm/s velocity change in the small secondary, the kinetic impact science will not be fully representative of deflection of a larger asteroid (requires hypervelocity ~10 km/s). However, this mission concept will validate the GNC terminal impact mode of a real deflection mission. In addition, it can validate some GNC modes and operation procedures for characterization, and descend & landing (rehearsal until very low altitude on the primary), all needed in sample-return missions as Marco Polo-R.

The preliminary design of the ground segment is based on reuse of existing facilities at ESOC for interplanetary missions, like ROSETTA and BepiColombo. Some approaches are also presented to minimise the development cost and the operational cost. The autonomy level has been traded against the cost of operations in order to minimize the overall cost (ground segment against space segment) and maximize the demonstration of technologies. The overall cost of the different versions gives several options to the mission manager in order to perform a low-cost demonstration mission to deflect the secondary object of wider candidate sets.

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Comments:
Oral Presentation