SysNova SEALS

BEAST (Binary Asteroid Orbit Modification)

Challenge Analysis Executive Summary

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SysNova Technology Reference Study No.: 12/X03
Contract Number: 4000106980/12/F/MOS

This contract was carried out within ESA's General Studies Programme and funded by the European Space Agency. The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency

BEAST: CHALLENGE ANALYSIS EXECUTIVE SUMMARY

SYSNOVA: BINARY ASTEROID ORBIT MODIFICATION (BEAST)

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Authorized by: Pablo Colmenarejo

Code: GMV-BEAST-ES

Version: 1.0

Date: 14/02/2013

Internal code: GMV 20428/13 V1/13

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PICTURE

MOTIVATION

BEAST aims to modify the orbital period of the small secondary object of a binary asteroid by kinetic impact. BEAST analyses a commercial LEO platform accommodating as payload the impactor and GNC system with total mission cost below 150 M€.

METHODOLOGY

- CDF and industry assessments of kinetic impact asteroid missions were considered to identify feasible concepts and major trade-offs.
- Analyses of existing binaries were complemented with further analyses to identify potential binary systems among currently assumed single asteroids.
- A preliminary identification of different platforms led to define initial mission envelopes (cost, delta-V, Sun distance).
- Systematic search of trajectories led to selection of asteroid candidates for each platform.
- Parametric analyses led to sizing of GNC system (sensors, procedure, strategy, constraints).
- Closed loop Monte Carlo simulations were performed to assess the GNC performances and limitations.
- A detailed technology roadmap were analysed and harmonized with platform development.

RESULTS

- Identification of feasible method with existing resources on-board to estimate the change in orbital period of the secondary, including expected performances.
- Feasibility of performing a low-cost mission using a commercial LEO platform (Iridium-NEXT) in which the GNC sensors and the impactor and separation mechanism are integrated as payload.
- Availability of an envelope of platforms with different level of modifications (and cost) that is able to reach different targets. This envelope provides a flexible and scalable mission concept that can measure the deflection of different secondary objects.
- Detailed roadmap analyses identifying the critical technologies and their components. This permits harmonization of the platform AIV process with the technology development and demonstrates launch before the end of the decade.

PUBLICATIONS

- J. Gil-Fernandez, F. Cabral, D. Escorial, B. Amata, M. Lavagna, D. Filipetto, E. Luraschi, A. Galvez, " BEAST: Low-Cost Demonstration Mission for Binary Asteroid Orbit Modification", 3rd Planetary Defense Conference, Flagstaff, AZ, USA, 15-19 April 2013.

HIGHLIGHTS

Demonstration (via closed-loop, model-in-the-loop, Monte Carlo simulation) of the capability to impact a very small secondary using standard GNC equipment mounted on a commercial platform, to perform a safe collision avoidance manoeuvre and to measure the deflection using the on-board resources (only camera). Demonstration of the GNC system performances in case of hypervelocity impacts (~10 km/s) in end-to-end simulations could be performed with moderate effort. Detailed simulations of the performances of deflection measurement methods are needed to consolidate the kinetic impact design.

END OF DOCUMENT

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COBRa (Contactless Earth-bound object orbit modification system)

Challenge Analysis Executive Summary

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SysNova Technology Reference Study No.: 12/X01
Contract Number: 4000106980/12/F/MOS

This contract was carried out within ESA's General Studies Programme and funded by the European Space Agency. The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency

COBRA: CHALLENGE ANALYSIS EXECUTIVE SUMMARY

SYSNOVA: CONTACTLESS EARTH-BOUND ORBIT MODIFICATION (COBRA)

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Authorized by:	Pablo Colmenarejo
Code:	GMV-COBRA-ES
Version:	1.0
Date:	15/02/2013
Internal code:	GMV 20463/13 V1/13

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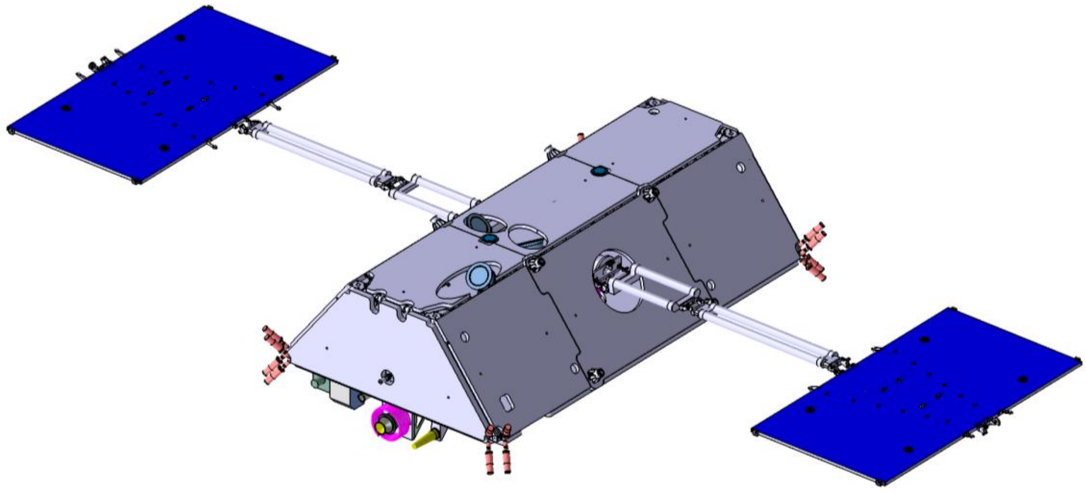
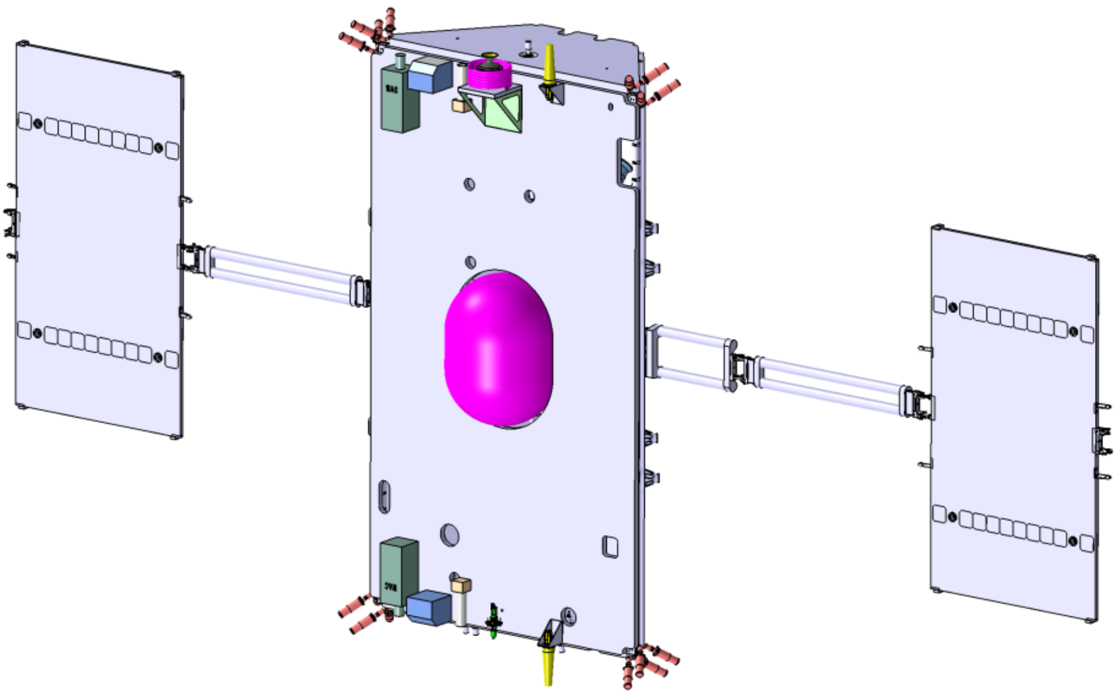
PICTURE





MOTIVATION

The objective of the Cobra mission is to use a conventional chemical thruster to modify the orbit of a man-made object through plume impingement. The proposed concept uses a standard satellite platform with a modified payload to suit mission needs.

METHODOLOGY

Cobra uses a chemical engine to modify the orbit of an uncooperative space debris object with a mass of 100 kg in an 800 km Sun synchronous, low Earth orbit. The orbital velocity of the target object needs to be modified by 50 m/s in less than 3 years.

The main research topics were the momentum exchange, mission analysis and mission design. Work on the momentum exchange included a literature review of methods and models for plume impingement and the development of a Monte Carlo plume impingement model. Mission analysis involved an analytical evaluation of the ΔV required to cover all mission phases. Mission design focused on adapting the payload module of the Elite bus for rendezvous and debris pushing operations. In addition an operational concept, a mission timeline and a preliminary design of the GNC system were generated.

RESULTS

- The demonstration mission can be performed at low cost using a modified payload module on an otherwise standard satellite platform.
- In the current mission design it is feasible to impart a ΔV of 50 m/s by means of momentum transfer exchange using a monopropellant hydrazine thruster.
- The momentum transfer efficiency needs to be better than 5%. In worst case conditions (20° plume divergence angle and inelastic collisions of the gas molecules on the debris surface) the distance between the thruster and the debris surface needs to be 5 m or less.

PUBLICATIONS

- Peters, T. V., Pellacani, A., Lavagna, M., Attina, P., Luraschi, E., Galvez, A. "Space Debris Orbit Modification using Chemical Propulsion Shepherding", Proceedings of the Sixth European Conference on Space Debris, Darmstadt, 2013.
- Lavagna, M., Benvenuto, R., De Luca, L., Maggi, F., Tadini, P., Graziano, M., Peters, T., "Contact-less Active Debris Removal: the Hybrid Propulsion Alternative", Proceedings of the 5th European Conference for Aerospace Sciences, Munich, 2013

HIGHLIGHTS

The use of a standard platform means that the mission is feasible in the near-term. The main technology development needs lie in the development and testing of a high-fidelity plume impingement model and the on-board GNC software for performing the rendezvous and proximity operations, including the debris pushing. Technology readiness level 6 can be achieved by developing and testing the GNC software in a hardware-in-the-loop simulator that includes the plume impingement model in its real-world dynamics software.

END OF DOCUMENT