Castalia

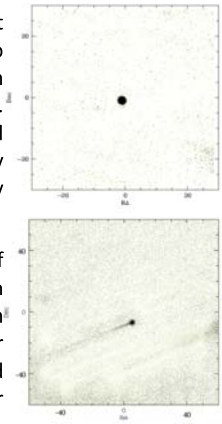
A mission to a Main Belt Comet

EXPLOITING A SCIENCE MISSION FOR ASTEROID DEFLECTION

The Mission

The Castalia mission was recently proposed for the next ESA M4 Medium-class mission. The mission aims to explore and characterise a new class of solar system objects, the Main Belt Comet (MBC) - 1330/Elst-Pizarro. MBCs are objects that reside within the main asteroid belt, but have a comet-like appearance with a dusty comae and tails at certain periods in their orbit. They straddle the divide between asteroids and comets.

Their existence challenges the traditional definition of asteroids and comets, the formation and early evolution of the main asteroid belt, and the origins of water on Earth. The instrument science data is also applicable for an analogue demonstration of low thrust asteroid deflection techniques by solar sublimation or laser ablation. Data will detail the mass flow, expansion, temperature and velocity of the sublimated material.



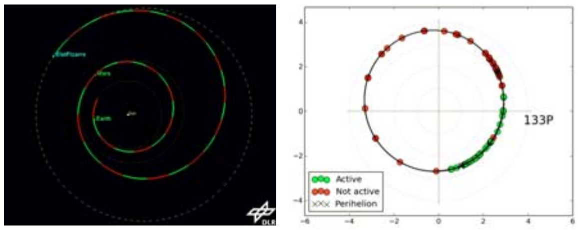
Target Near Aphelion and around Perihelion [ESO, NTT]

1330/Elst-Pizarro

Following a 4.5 year interplanetary cruise the spacecraft would arrive at the target several months before its estimate reactivation. 133P/Elst-Pizarro was selected as it has a proven repetitive and periodically observable level of activity. It has a detectable tail for approximately a year of its five-year orbital period. Activity starts one month before perihelion and has occurred over four revolutions since its discovery. This provides continued evidence of its sublimation driven activity. The target is expected to be a loosely bound rubble-pile asteroid, that has a high rock-to-ice ratio.

Left: Baseline Transfer with One Gravity Assist Manoeuvre at Mars

Right: Top Orbital View of the Target



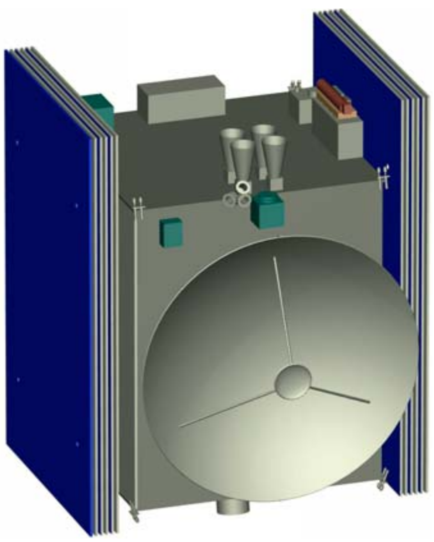
Spacecraft and Payload

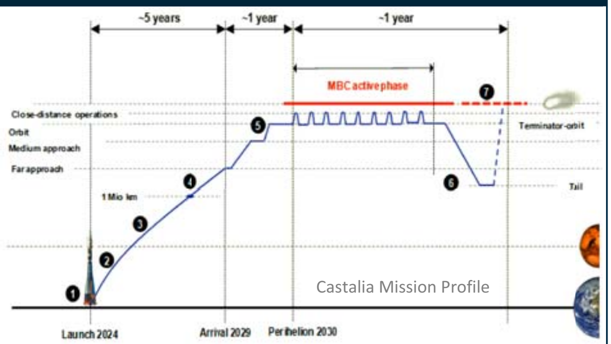
Upon arrival, the spacecraft performs a series of far and close approach manoeuvres; allowing global and local characterisation, as well as in-situ analysis. Core payloads include:

Remote Sensing:
Visible & NIR spectral Imager
Thermal Infrared Imager
Radar - Deep & Shallow Subsurface
Radio Science

In-Situ:
Dust Impact Detector
Dust Composition Analyser
Neutral/Ion Mass Spectrometer
Magnetometer
Plasma Package

An electric and chemical propulsion system is used during the interplanetary transfer and close approach operations. Navigation includes a wide- and narrow- angle camera, LIDAR, IMU, star trackers and sun sensors. X-band is proposed for telemetry up- and down-link, and Ka-band for science data downlink. Active and passive methods are used for thermal control.





Castalia Mission Profile

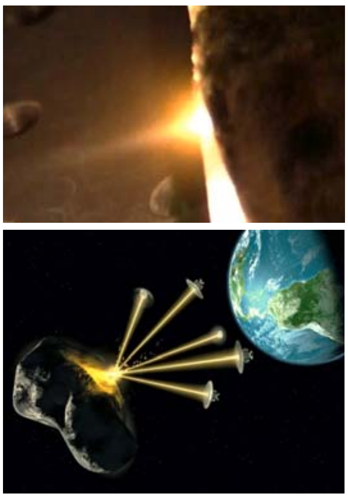
1: Launch on a Soyuz-Fregat from Kourou with direct injection
2: Early phase including commissioning
3: Transfer phase with electric propulsion
4: Near target phase with the start of science activities
5: MBC science phase including orbiting and hovering phases for close investigation of the target and repetitive passage through the emission cone; enabling the direct measurements of the sublimated gas and dust.
6: Tail Phase
7: Landing phase (optional)

Applied to Planetary Defence

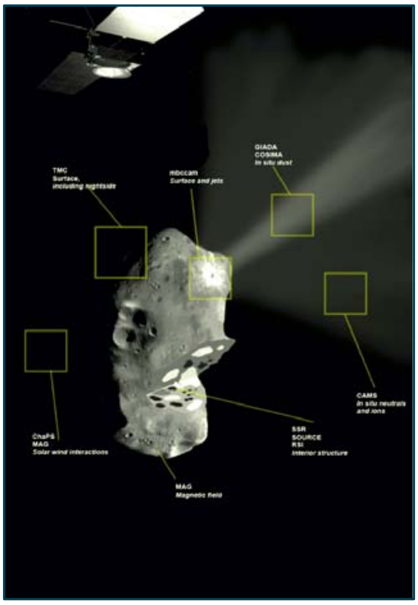
Modelling of cometary sublimation uses similar assumptions for understanding the physical and chemical processes of surface ablation. The formation of the ejecta plume(s) is comparable to the rocket exhaust in standard methods of rocket propulsion. Gas expands from a reservoir, through a nozzle and into the vacuum of space. The ejecta plume acts against the asteroid, providing a low-thrust deflection event.

Results from the visible and near IR camera, dust detector, dust composition analyser and thermal IR imager can be used to validate the ablation and sublimation models in a relevant (space) environment. The impact sensor on the dust detector would also provide essential information on the momentum and rate of deposition of any impinging material. Understanding the ejecta-induced contamination effects is a critical factor in spacecraft design, especially during any close proximity operations with optical payloads, the thermal design of radiators, MLI and solar arrays as a power generating mechanism.

The Castalia mission would increase European competiveness in planetary defence. The mission has a large scientific and technology return, serving several synergic communities. Following Rosetta, it would be the natural next step in cometary physics, planetary science and defense activities.



Ablation-based Investigations for Asteroid Deflection [University of Strathclyde]



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