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The HERA GNC subsystem, the State of the Art Autonomy for Planetary Exploration

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ABSTRACT

HERA is a planetary defence mission currently being developed by the European Space Agency. Its main aims are to fully characterize the Didymos binary asteroid and to measure in-depth detail the aftereffect of the successful impact of NASA's DART (Double Asteroid Redirection Test) mission. Together with ground telescope observations, it will produce the most accurate knowledge possible from the first demonstration of an asteroid deflection technology. Thanks to the international collaboration of NASA and ESA and to the work of scientists and researchers that share their findings, the synergies between HERA and DART are enhanced and the scientific return is maximized.
The HERA GNC (Guidance, Navigation and Control) Subsystem under development by GMV, is one of the most challenging subsystems of the HERA mission, as it implements state of the art autonomous vision-based technologies that will allow spacecraft operations very close to a binary asteroid. The GNC of HERA has been

designed to operate the spacecraft without ground intervention. In the first part of the mission, the autonomy will be limited to the spacecraft attitude in order not to lose the target from the field of view of the HERA payloads. Towards the end of the nominal operations, there will be an experimental phase where the GNC will become fully autonomous and will compute and execute autonomous maneuvers to correct the trajectory to safely reduce the minimum distance to the asteroids, permitting to increment the resolution of the data about the system.

The design of the GNC includes the whole cycle of navigation guidance and control for both attitude and translational states. The GNC is organized into two main blocks, the high priority block where the functions related to the attitude guidance, determination and control are managed, together with the actuation manager function, and the low priority block where the orbit determination, translational guidance, and translational control are executed. The GNC Mode Manager, part of the High Priority block, is the key function that controls and select the execution of the different algorithms. This selection is based on predefined GNC modes of operation that are tailored to the different phases of the mission, including contingency modes to operate in case of an anomaly is detected. Together with these two blocks, GMV has also designed the Image processing block, which translates the optical images coming from the Asteroid Framing Camera into usable measurements for the orbit determination algorithms. The image processing algorithms are implemented in the on-board computer and also in the Image processing Unit (an FPGA based unit, also manufactured by GMV). Along the execution of these blocks, FDIR (Failure Detection, Isolation and Recovery) routines monitor the proper functioning of the algorithms, having the capability of inhibiting the execution of certain blocks or even triggering the request of autonomous Collision Avoidance Maneuvers with the asteroids based on the Collision Risk Estimator calculations. The HERA GNC subsystem is also composed by a set of GNC units, procured by GMV: gyros used in hot redundancy, sun sensors, reaction wheels and star trackers.

This paper will focus on providing a general overview of HERA GNC subsystem and its modes, highlighting the key challenges faced during the design and the key technologies developed to overcome those challenges. HERA is currently in its phase C and the GNC baseline is well consolidated.

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