OPTICAL MEASUREMENTS FOR ROSETTA NAVIGATION NEAR THE COMET

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ABSTRACT

In July 2014, the ESA interplanetary spacecraft (S/C) Rosetta became the first mission to rendezvous with a comet (67P/ Churyumov-Gerasimenko). The overall trajectory, lasting ten years, contained several planetary swing-bys (Earth and Mars), two asteroid flybys (Steins and Lutetia) and a two and a half years hibernation phase. Finally, after a series of braking maneuvers, Rosetta drew near enough to the comet to take high resolution images of the nucleus.

Optical measurements from on-board navigation cameras were used near the comet to navigate the S/C during the approach, mapping and characterization, landing and escort phases. The resolution at which the surface appeared in the images ranged from ten meters to less than a meter.

The cometary phase was complex and diverse, forcing various scenarios to be envisaged. First, a day-side comet characterization phase took place at 100 km distance with the purpose of determining the rotational state, gravitational potential and approximate shape of the nucleus, and to define a coarse landmark grid. Here the S/C followed a sequence of hyperbolic arcs in a pyramidal shape down to 50km distance. Then, Rosetta progressively descended to circular orbits from 30 km down to 10 km gradually refining the landmark grid as well as the comet shape. Finally, a science phase started including several close flybys.

Pixel positions of landmark observations were determined visually at first, with a graphical user interface, but were automated after a few weeks of operations using the maplet technique. This paper presents an overview of the optical measurements concept used at ESOC for navigating near a small active body. The algorithms and rationale are detailed and explained.

Relevant results and statistics regarding optical measurements and shape reconstruction will be presented for the different phases of the mission previously described along with strategies employed, difficulties encountered and lessons learned.

Currently the optical measurements of 67P are largely automated on-ground achieving sub-pixel accuracy and its shape has been precisely reconstructed validating the overall optical navigation philosophy.