ENSURING ACCURATE COMET SHAPE RECONSTRUCTION TO PREPARE FOR THE ROSETTA LANDER DELIVERY

Michael L. Flegel[(1)], **Jan Essert**[(2)], **and Robin Raus**[(3)]
[(1)] *ESA, ESOC, HSO-GFF, Robert-Bosch-Str. 5, 64293 Darmstadt, Germany, +49 6151 903629, michael.flegel@esa.int*
[(2)] *CGI (Germany) GmbH & Co KG, Robert-Bosch-Str. 5, 64293 Darmstadt, Germany, jan.essert@esa.int*
[(3)] *Telespazio VEGA Deutschland GmbH, Robert-Bosch-Str. 5, 64293 Darmstadt, Germany, robin.raus@esa.int*
Keywords: *Rosetta, Churyumov-Gerasimenko, comet shape reconstruction, lander, validation.*

ABSTRACT

ESA’s Rosetta mission was launched in 2004 with the ultimate purpose of orbiting the comet Churyumov-Gerasimenko and delivering a lander to its surface. On its ten-year cruise, Rosetta has performed three Earth and one Mars swing-by. The trajectory chosen furthermore enabled close proximity fly-bys of the asteroids Steins and Lutetia. After two and a half years in deep-space hibernation, while it receded from the Sun as far as 5.2AU, Rosetta will exit hibernation in January 2014. A series of manoeuvres is scheduled starting in May 2014 to reach orbit around the comet in August 2014. Lander delivery is planned for November 2014.

Arguably the most critical aspect of the Rosetta mission, the lander delivery requires the knowledge of a multitude of parameters about the comet, both absolute and relative to Rosetta. In particular, an accurate 3D shape model of the comet has to be created in order to select a suitable landing site. Shape reconstruction is performed in the three months between arrival at the comet and the lander delivery. The flight dynamics team at ESOC in Darmstadt performs this employing an iterative process using images taken by navigation cameras on board Rosetta. This paper discusses the methodology employed in order to gain confidence in the methods used to reconstruct the shape as well as the accuracy of the shape model. In the search for validation methods, emphasis was put on methods that would lend themselves to also be used operationally when the shape of the real comet is reconstructed.

To this end, realistic comet kinematics, an arbitrary, but representative, comet shape, and relative Rosetta-comet trajectory were chosen. Images were rendered at realistic intervals, accurately modeling camera distortion of the navigation cameras. In total over 700 images were generated.

These were then split into batches and used to exercise the operational, two-pronged, process. Before reconstructing the shape of the comet, the comet state is determined. For this purpose, landmarks on the comet surface are manually selected and correlated between images separated in time. These landmarks are then used to determine the comet kinematic state and relative Rosetta-comet trajectory as a function over time. A by-product of this reconstruction is a landmark database, giving landmark positions in a comet-fixed frame. This step is also performed and validated by the flight dynamics team at ESOC, but is not subject of this paper.

Upon successful reconstruction of the state, the same images are reused to reconstruct the comet shape using the Rosetta attitude and the now-known comet attitude, and relative Rosetta-comet trajectory. This validation of this process is the focus of this paper

Gaining confidence in the shape model and its accuracy is then performed by several means. The novel idea was to select methods which made no use of any a priori knowledge of the simulated comet, and as such could also be used operationally. Such methods augment other validation approaches, which do make use of the a priori knowledge.

Software was developed by the ESOC flight dynamics team for each of these validation steps. Consistency checks on closedness of the 3D mesh are performed. It is checked that the reconstructed landmarks are located on the surface of the shape model. Furthermore, using a raytracer, the shape model is rendered into images at the times of the simulated images. The original simulated images are then compared with the raytraced shape models by various means, automatic as well as visual. Also, due to the method employed in the shape construction, at any given iteration, the shape model is expected to be fully contained in the shape model of the previous iteration. Examples for each of these validation steps are given.

When Rosetta arrives at the comet Churyumov-Gerasimenko in August 2014, images of the real comet will be used to perform the same shape reconstruction as described above. The presented validation concept has the great advantage that it can also be applied to real comet operations. Given that the time between arrival at the comet and lander delivery is extremely short, this is of considerable importance.