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PHILAE'S FLIGHT DYNAMICS CHALLENGES: REPORT OF THE LANDING ON A COMET

Abstract

The European probe Rosetta reached the comet Churyumov-Gerasimenko in summer 2014. The delivery of Philae, a 100 kg lander on-board of Rosetta, took place on November 12th. The controlled landing of Philae on the comet, accomplished thanks to the joint work of the agencies ESA, DLR and CNES, is one of the most outstanding achievements of last year and it will probably mark the history of space exploration. The French space agency (CNES) contributed to Philae's mission through the Science Operation and Navigation Centre (SONC) located in Toulouse. Within the SONC, our team of flight dynamics engineers was responsible for the design of Philae's descent trajectory as well as the computation of the best delivery conditions. This work was performed in tight collaboration with the scientific teams generating comet models, as well as with the Flight Dynamics engineers of Rosetta (ESA/ESOC) and the Lander control center (DLR). However, until summer 2014 the uncertainties on basic parameters such as the mass of the comet or its shape were so big that the descent trajectory analysis consisted almost exclusively of parametric studies. These studies were aimed at designing a robust operational strategy, which would guarantee a high rate of success even for the worst case scenarios. When ESA put Rosetta in orbit around the comet, the shape, gravity and outgassing models started to become realistic. The landing site selection process was then triggered and the delivery strategy was progressively adapted to the real conditions. Unfortunately, despite the fact that both delivery and descent were executed nominally, Philae spent two hours bouncing on the surface of the comet due to a failure of its anchoring systems. The final site in which the lander stopped does not have the characteristics of solar illumination that would be necessary for recharging its batteries. This fact has so far prevented Philae from continuing with the planned scientific after the first science sequence. In this paper we provide an overview of the process that lead to the selection of the landing site for Philae as well as the design of the nominal descent trajectory, from SONC-Philae's flight dynamics point of view. Furthermore, a summary of the flight dynamics activities performed at CNES after the landing will also be given.