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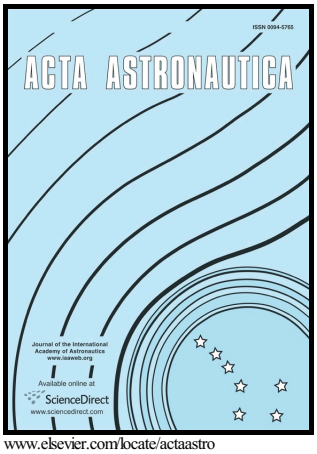

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ROSETTA MISSION OPERATIONS FOR LANDING

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The International Rosetta Mission of the European Space Agency (ESA) was launched on 2nd March 2004 on its 10 year journey to comet Churyumov-Gerasimenko and has reached it early August 2014. The main mission objectives were to perform close observations of the comet nucleus throughout its orbit around the Sun and deliver the lander Philae to its surface. This paper describers the activities at mission operations level that allowed the landing of Philae.

The landing preparation phase was mainly characterised by the definition of the landing selection process, to which several parties contributed, and by the definition of the strategy for comet characterisation, the orbital strategy for lander delivery, and the definition and validation of the operations timeline.

The definition of the landing site selection process involved almost all components of the mission team; Rosetta has been the first, and so far only mission, that could not rely on data collected by previous missions for the landing site selection. This forced the teams to include an intensive observation campaign as a mandatory part of the process; several science teams actively contributed to this campaign thus making results from science observations part of the mandatory operational products. The time allocated to the comet characterisation phase was in the order of a few weeks and all the processes, tools, and interfaces required an extensive planning an validation. Being the descent of Philae purely ballistic, the main driver for the orbital strategy was the capability to accurately control the position and velocity of Rosetta at Philae's separation. The resulting operations timeline had to merge this need of frequent orbit determination and control with the complexity of the ground segment and the inherent risk of problems when doing critical activities in short times.

This paper describes the contribution of the Mission Control Centre (MOC) at the European Space Operations Centre (ESOC) to this mission phase and the lessons learned that can be derived from this experience.

I. INTRODUCTION

Rosetta is a cornerstone scientific mission of the European Space Agency[1,2,3], launched on 2nd March 2004 on an Ariane 5G+ rocket. In order to achieve its main scientific objectives[17], i.e. observation of the nucleus and come for an extended period of time, remote and in-situ measureements, etc. – Rosetta had to rendezvous with the nucleus of comet 67P/Churyumov-Gerasimenko in 2014, to orbit it for about 1.5 years and to deliver onto the nucleus' surface a landing module named Philae. Seven years of active cruise, in which several planet gravity assist swing-bys and two asteroid fly-bys were carried out[4,5,6,7,8,9,10], were followed by the final part of the cruise, where Rosetta (Fig. 1 – Note: manoeuvres are not necessarily represented as actually done in flight, rather as a single event and with the size resulting from a specific trajectory optimisation run) had to fly at distances from the Sun that had never been reached before by a solar-powered spacecraft (aphelion was reached on 3 October 2012 at about 5.3 AU distance)[11]. Notwithstanding the large solar array (64 m^2), in order to survive at such Sun distances the spacecraft had to be almost fully deactivated already in June 2011, to preserve the little available power for the thermostatic heaters and a few other vital electronic units.

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