MASCOT ON BOARD OF HAYABUSA-2: THE QUEST FOR THE ORIGINS OF THE SOLAR SYSTEM

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ABSTRACT

Mascot is a German-French lander to be placed on board of the Japanese mission Hayabusa-2. This JAXA space probe is an asteroid explorer and sample return mission as its predecessor. The target of Hayabusa-2 is the Near Earth Asteroid 1999JU3, which is believed to have remained essentially unchanged since the early days of the Solar System and can therefore provide valuable clues on its origins and the formation of our planet. Hayabusa-2 will be launched in December 2014 and will arrive at the vicinity of the asteroid in summer 2018.

As thrilling as the exploration of small bodies of the Solar System is, Mascot mission offers additional challenges. On the one hand, the current knowledge about the characteristics of asteroids is still very limited. So, placing a lander on their surface is not an easy task. Essential information such as the precise shape and density of the target body, or the regolith size and distribution on the surface, are barely known and difficult to predict within a reasonable level of confidence due to the small number of previous missions dedicated to asteroids. On the other hand, Mascot is a small lander (approximately 10 kg) with no propulsive system, so its descent to the surface of 1999JU3 will be passive. Therefore, the delivery strategy does not focus on the descent trajectory itself, but on aspects such as the mother-ship altitude over the surface, the release attitude, as well as the separation time and delta-v provided by the separation mechanism. Furthermore, there is no way for Mascot to be anchored on the surface after touch-down. This will result in a bouncing trajectory of unknown duration, that has to be simulated as a part of the descent trajectory analysis.

Mission analysis studies regarding Mascot descent trajectories to 1999JU3 are performed at CNES, in the frame of the collaboration between DLR and the French agency. There are two main objectives related to these studies. Firstly, to prove the feasibility of Mascot's mission under given hypothesis and determine the validity of such feasibility when the environment and the constraints change. Secondly, to develop the tools and the engineering feeling which will allow us to be operationally prepared for what will happen around the asteroid. In particular, scientific models for the shape and estimated density of the asteroid are used, in addition to assumptions for the unknown quantities such as the bouncing coefficients. Then the constraints coming both from the lander and from Hayabusa-2 are taken into account in the computations. Dispersion analysis is applied only to the trajectories satisfying the constraints. As a result of these studies, quantities such as the size of the dispersion ellipses or the expected bouncing duration can be predicted and used in the landing site selection. Once Hayabusa-2 is in the asteroid phase, this selection process will most probably

come down to a separation time selection process. For given asteroid models and fixed Hayabusa-2 approach and delivery strategy, the only parameter that allows flexibility on descent trajectory analysis is the separation time. In other words, once the current unknowns start becoming precisely defined and JAXA freezes the operational separation position and attitude, each separation time will lead to a nominal landing trajectory and a nominal touch-down point. The bouncing and the dispersion analysis will convert this touch-down point into a predicted 3-sigma landing ellipse. The global constraint satisfaction level over the points of the ellipse, together with the suitability of the area for the desired scientific experiments will provide the key elements for the choice.

This international collaboration is expected to enlighten the scientific community on topics such as the characteristics of small primitive bodies and the origin of the planets, in addition to continue preparing the way for future missions to asteroids.