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Analysis of landing mission phases for robotic exploration on phobos mar's moon

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Abstract. Landing phase is one of the crucial and most important phases during robotic aerospace explorations. It concerns the impact of the landing module of a spacecraft on a celestial body. Risks and uncertainties of landing are mainly due to the morphology of the surface, the possible presence of rocks and other obstacles or subsidence. The present work quotes results of a computational analysis direct to investigate the stability during the landing phase of a lander on Phobos, a Mars Moon. The present study makes use of available software tools for the simulation analyses and results processing. Due to the nature of the system under consideration (i.e., large displacements and interaction between several systems), multibody simulations were performed to analyze the lander's behavior after the impact with the celestial body. The landing scenario was chosen as a result of a DOE (Design of Experiments) analysis in terms of lander velocity and position, or ground slope. In order to verify the reliability of the present multibody methodology for this particular aerospace issue, two different software tools were employed in order to emphasize two different ways to simulate the crash-box, a particular component of the system used to cushion the impact. The results show the most important frames of the simulations so as to provide a general idea about how lander behaves in its descent and some trends of the main characteristics of the system. In conclusion, the success of the approach is demonstrated by highlighting that the results (crash-box shortening trend and lander's kinetic energy) are comparable between the two tools and that the stability is ensured.

Keywords: landing stability; DOE analysis; crash-box; multibody simulation

1. Introduction

In the last 40 years, many robotic explorations were coordinated by the most popular aerospace companies: for example, Viking 1 in 1975 by NASA (the results of which are shown by Briggs *et al*. 1977 and Carr *et al*. 1977); Venera 13 in 1982 by the Russian space agency (which made possible to study the composition of rocks on Venus, as described by Surkov *et al*. 1982); Near Earth Asteroid Rendezvous in 2001 by NASA (Acuña *et al*. 1997, described this mission, which concerns about the study of 433 Eros, a near-Earth asteroid, and Miller *et al*. (2002) showed the results); Hayabusa in 2003 by JAXA, (which was the first sample return mission, as described by

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software and from the simulation approach performed, can be considered reliable.

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