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Author: Ms. Anne-Marlene Rüede
Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, annemarlene.ruede@yahoo.com

Dr. Claudio Leonardi
Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, claudio.leonardi@epfl.ch
Dr. Anton Ivanov
Skolkovo Institute of Science and Technology, Russian Federation, a.ivanov2@skoltech.ru

DESIGN OF A REUSABLE CRANE SYSTEM FOR MARS SURFACE MISSIONS

Abstract

In order to enable robotic and manned surface exploration of Mars, descent and ascent vehicles are required. This research proposes the design of a crane system with high Technology Readiness Level that can be utilized as such for various Mars surface missions. Indeed, NASA has already used a crane to land Curiosity on Mars. However, this technology has been developed specifically for one mission and there are currently no major plans for a reusable landing and takeoff systems that have been proposed, although they have the potential of facilitating Mars surface exploration. The key features of the proposed technology are that the system is reusable, refuelable with in-situ produced propellant and modular. This crane includes three independent thrusters capable of performing critical maneuvers like braking, landing and orbital insertion, and a reusable thermal protective shield for atmospheric entry. Correction systems allow to maintain the crane's stability during critical phases. The system is designed to be able to attach various payloads under the thermal shield and reservoirs. The "suspended" configuration translates in a low center of gravity and therefore an increased stability during descent and ascent. This configuration also facilitates the capture and release of the payloads. The payload capacity is estimated to reach up to twenty-two metric tons, which is consistent with the payload capacity of launchers such as the Space Launch System or the Falcon Heavy. The crane rendezvous in orbit with the payload, which must bring a light inflatable and replaceable thermal shield and the appropriate amount of propellant, depending on the landing site. The crane then deposits the payload on the surface of Mars and lands a few meters away, where it refuels with Mars in-situ produced propellant in a time frame suitable with the next window for a return to Earth. The in-situ propellant production plant can be included in the crane for single descents or can be left in place considering multiple descents. The impact of this research is to propose a technology that would enable manned Mars mission, as multiple ascents and descent would be required, considering the large mass budget and limited payload capacity. It could also facilitate robotic missions by allowing the development time, the mass and the financial requirements to be reduced.