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Mars Probe Soft Landing Test in the Earth Conditions

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Abstract: Presented paper informs about the FP7 project SPARTAN (SPAce exploration Research for Throttleable Advanced eNgine) that is mainly dedicated to design and develop high efficient and green propellant propulsion technology based on using hybrid fuel rocket engines. This technology is needed for further space exploration and precise landing on any planet surface in the solar system. This article pays particular attention to the SPARTAN Lander, which demonstrates developed technology capability in the Earth conditions. The article contains aerodynamic shape study, subscale model free fall testing and ballistic recovery system design and testing.

Introduction

Soft landing ability, with the payload that cannot withstand heavy impact load and should be smoothly delivered onto precisely selected place on the extraterrestrial bodies without or with low atmosphere density, is the key technology for future manned and unmanned missions.

European Space Agency established the project "View on The Long-Term International Scenario for Space Exploration" [1]. There is disclosed an intention for manned and future early robotic preparatory exploring missions towards the Moon and the Mars. In response to ESA exploration plans, the FP7 project SPARTAN (SPACE exploration Research for Throttleable Advanced eNgine, SPACE SPA.2010.2.1-04 GA n. 262837) was established. The main aim of the project is to design fully throttleable engines for soft planetary landing by using the hybrid fuel rocket engines technology. It allows smoother and wider throttle range in comparison to solid rocket engines, which are intrinsically simpler, safer and able to use green propellants in comparison to liquid powered rocket engines.

Since 2010, when project started, Lander demonstrator structure has been designed and manufactured as well as its internal structure and driving systems. During autumn 2014 the project reached the final phase and recently is facing the last challenge, i.e. the full scale test. The full scale soft landing test serves as verification of the development process of the entire series of preparatory tests. The whole system has to work as one unit which contains the newly designed engines commanded by On Board Computer (OBC) algorithms according to data from the Guidance and Navigation Center (GNC) in order to smoothly touch down on the ground by Landing gear.

The full scale test conditions are derived from the planet Mars requirements and adjusted by the Earth and the Mars mass ratio. The test is dedicated to the last phase of landing, when Lander has already passed Mars upper atmosphere layers, pilot parachute has deployed and Lander is steadily descending towards the ground. Lander releases the main parachute and decelerates to 30 m/s (for atmosphere average density on the ground ~0.020 kg/m3 [2] and Lander weight 1000 kg). In precise altitude, above the ground, the thrusters are fired and decelerate the Lander up to zero velocity at 0.5 m above the ground where they are turned off.

Full scale test starts with Helicopter hovering when demonstrator hangs in altitude 220 m above the ground and is subsequently released. Lander descents 50 m by free fall and reaches velocity 30 m/s. At this moment the thrusters are fired and throttled due to the GNC and OBC commands. Lander decelerates up to 0.2 m above the ground and engines are turned off. Impact energy is damped by landing gear.

Lander demonstrator

Lander demonstrator was designed with respect to planned mission. Its shape and overall design is based on mechanical and aerodynamic study and corresponds with ordinary designs of extraterrestrial probes and satellites. Lander body has a shape of octagon truncated pyramid where each vertex contains landing gear hinge.

Designed shape was carefully analyzed by CFD. The main purpose was to check an aerodynamic derivation what shows lander free fall phase stability or possibility of spin and fail. This critical topic was further investigated and subscale model was tested in free fall phase.

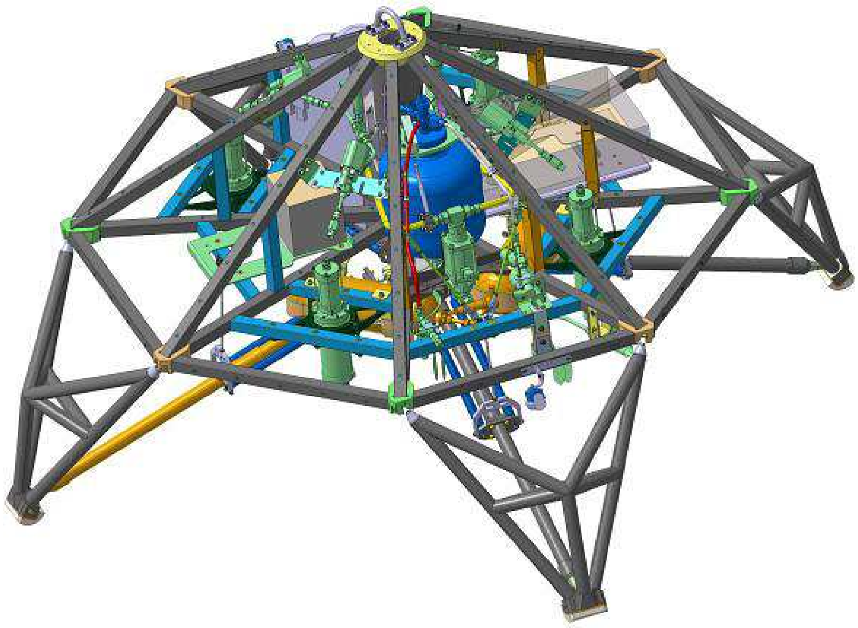

Fig. 1: Lander demonstrator design

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