#07 - Space Transportation Segment for a Martian Autarkic Research and Colonization Habitat

Currently, TU Delft is performing a feasibility study for ESA on building a habitat on Mars. This study is being conducted across faculties within TU Delft. As a part of their final bachelor thesis, 10 students from the Aerospace faculty have been given the task of designing a space transportation segment that should support the construction of a habitat on Mars, and bring humans safely to Mars and back to Earth again. The so called 'Rhizome' habitat will be built mainly with in-situ materials on Mars and for this, several types of robots will be used, including scouting, mining and 3-D printing robots.

Mission Objective

The objective of this project is to design a re-usable, sustainable and easily re-configurable space transportation segment serving a Martian research and colonisation habitat, with the option of (partially) refuelling at a permanent Moon station. This means that the vehicle shall be able to transport from and to the Mars habitat repeatedly with different types of cargo and/or crew. The habitat should be up and running within 10-years of the maiden flight and will have a lifetime of at least 20 years.

System Design

The space transportation segment is designed to be able to perform 10 round trips to Mars and will consist of a main interplanetary spacecraft named MARCO and a lander called POLO. 10 round trips will add up to around a 40 year life cycle for MARCO-POLO. The objective is to have an easily re-configurable spacecraft which can deal with different types of missions, both manned and unmanned. Therefore, two landers have been designed: POLO cargo and POLO crew. POLO cargo is an expendable lander that can transport up to 45t of payload to the Martian surface, whereas POLO crew can house 5 crew members and can bring in total 16 t of payload to Mars and back to Earth again.

Similar to the landers, the propellant tanks and habitation module of MARCO are also easily removable. Depending on the mission, the tanks and habitation module can be added or removed so no dead weight is carried all the way to Mars and back again.

The main design of MARCO-POLO is to support the 'Rhizome' habitat, and there will be three cargo missions in the construction phase. Once the habitat is up and running, the crewed missions will begin and the habitation module and reusable lander will connect to MARCO. For the following 20 years, MARCO-POLO will ensure the operation of the 'Rhizome' habitat by transporting crew and materials between Earth and Mars. In case the habitat lifetime is shorter than the lifetime of MARCO, other future missions can be supported, since MARCO is designed to be easily re-configurable.

The main focus for this DSE was on MARCO, which will consist of a control module, up to 10 propellant tanks, bi-modal nuclear engines, and solar arrays. A habitation module will also be included for manned missions.

The technology required to refuel on the Moon is still in the early phases of development and the cost is much higher compared to refuelling in low Earth orbit (LEO). However, should the prices for lunar refuelling drop to near Earth prices, this will become a viable option and MARCO will refuel at the Moon instead of in LEO. As of now, MARCO will travel between LEO and low Mars orbit, and the landers will bring the required payload to and from the surface of Mars.