University of Stuttgart
Institute of Space Systems

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Task Description Master's Thesis

Assessment of Delta-V Potential in Life Support System By-Products

Motivation:

Environmental control and life support systems (ECLSS) have been continuously under development by the world's space faring nations since the early 1960s. As progress has marched on, the degree of loop closure has steadily increased, to the point where today it is possible to have, for example, a water-positive life support system. This is due to the fact that the water recovery systems have become so efficient, that almost 99 % of the water expelled by the crew, via respiration, perspiration and urination, can be recovered and recycled. In combination with the water content of the food launched from Earth and the fact that the human body produces additional water when burning the carbohydrates in the food, the overall water balance of a space station in low Earth orbit can be positive. A life support system also has other by-products, such as methane from CO_2 reduction and other combustible gases from waste processing.

The research group on electric propulsion systems at IRS has been researching air-breathing propulsion systems for low-flying spacecraft since 2015. These systems collect oxygen and nitrogen from the Earth's exosphere and use them as propellants for orbital maneuvering. The strength of these thrusters is the absence of electrodes leading to a very high propellant flexibility. Correspondingly, they can be used with chemically reactive gases, such as oxygen or iodine, propellant blends and even water. Hence, the excess water of ECLSS and gases from solid wastes can also be used as propellant.

This thesis aims to analytically quantify the potential synergies between the ECLSS and the propulsion system of a crewed spacecraft, like the Starlab space station. The life support system is modeled using the Virtual Habitat (V-HAB), an analysis tool under development at IRS. The ultimate goal of the thesis is to develop a framework where the delta-v potential for a given spacecraft can be calculated based on parameters of the propulsion and life support systems.

Task Description:

- Familiarization with propellant flexible electric propulsion and life support systems,
- Familiarization with V-HAB
- Identification of requirements and boundary conditions for the analysis
- Development of an analysis framework, preferably in MATLAB
- System analyses for relevant test cases such as crewed flight to Mars (INPPS), etc.
- Documentation

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