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MODULAR ISRU SYSTEMS AS A BUILDING BLOCK FOR SUSTAINABLE SPACE EXPLORATION

Abstract

Leading space agencies and companies identified the utilization of local resources as foundation for the continuous long-term exploration of the solar system within the Global Exploration Roadmap. In-Situ Resource Utilization (ISRU) will be one of the key technologies for sustainable space exploration and habitation missions to moon, mars and beyond. Defined production systems based on hydrogen value chains are utilized as essential building blocks to transform the available resources into valuable elements for energy, propulsion, life support or production systems.

The current research at TU Dresden addresses the engineering of ISRU systems using a modular plant concept of standardized, interchangeable and reusable modules. The development, production and automation processes are defined based on the existing standards on modular process plants (VDI 2776) and modular automation (VDI/VDE/NAMUR 2658) for terrestrial application. Therein, a module called Process Equipment Assembly realizes unit operations which are interconnected to form different plant configurations that enable flexible production paths. These standardized architectures and concepts are adapted to the requirements of space utilization. Compared to currently developed high specialized single use systems, a modular plant approach according to these standards allows the flexible application to different mission requirements and environmental conditions. In advance, modular plants minimize the development effort and risk, lead to a lowered market entry threshold for small and medium-sized enterprises from diverse market sectors and encourage commercial competition between manufacturers.

A major input for the holistic development of modular ISRU plants are top-level mission characteristics and sub-level requirements as input for the plant development process. In order to compile these requirements, representative missions to moon and mars are defined and analyzed. The required level of detail, necessary input- and output parameters and the implementation in an iterative development process are examined. To create a standardized interface for managing the parameters from mission perspective, necessary properties and features of a suitable simulation environment are derived and evaluated.

Different available simulation tools are compared, tested and assessed towards their applicability within an iterative modular plant development process.

The investigation results in an overview of requirements based on the analyzed reference missions that represent a valuable input for the development and utilization process of modular ISRU plants in space applications. The research regarding an accessible simulation environment provides a selection and evaluation of available target-oriented simulation tools. The results are transferred to the development process of the modular ISRU plant.