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SIMULATING THE CONSTRUCTION OF CONCEPTUAL SPACE STRUCTURES TO EXPLORE THE POTENTIAL OF COMBINED ASTEROID MINING AND SPACE-BASED 3D MANUFACTURING

Abstract

Space-based manufacturing is considered a crucial next step for the further development of human settlement in space. There are vast quantities of building resources distributed throughout space, with asteroids among the most apparent candidates for large-scale mining and resource provision. In this presentation, we present a hybrid simulation model in which building materials extracted from asteroids are used in a differential 3D manufacturing process to create expanding modular space architecture. This work is part of the larger research programme E|A|S (Evolving Asteroid Starships) in which concepts for self-developing and evolvable interstellar spacecraft are being investigated by the DSTART team at Delft University of Technology. A high-level 'factory model' has been created that simulates the different steps of an entire production chain. The functions of the core disjunct components of the model range from mining, processing, storage, and 3D printing to biological life support and habitation. The model's backbone consists of a heuristic based on a decision tree that handles multiple incoming production requests. Production of architectural modules is needed to cope with (1) population growth of the inhabitants, and (2) the need for module replacement due to space weathering caused by particle bombardment and structural fatigue caused by high-energy cosmic radiation. The simulation model combines DEVS (discrete event system specification) and DESS (differential equation system specification) approaches and includes an abstract animated visualization. The model allows the user to keep track of material flows, bottlenecks and production efficiencies. In a series of simulation experiments three parameters are varied: (1) system properties (including e.g. processing speed and storage capacity), (2) resource availability (by varying the chemical composition of the asteroids), and (3) production demand (which depends on population dynamics and the need for module replacement). These experiments are designed to increase understanding of the performance of the envisioned system under different conditions. In this paper, the results of these different simulation experiments will be compared. The relevance for

the larger project goals of E|A|S will be discussed, and conclusions will be drawn for future research on evolvable space architecture concepts.