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SUNSHADE PRODUCTION IN SPACE: INITIAL ASSESSMENTS FOR A MODULAR AND SCALABLE IN-SPACE MANUFACTURING AND ASSEMBLY FACILITY

Abstract

Space-based sunshades hold promise in temporarily limiting the rise in global warming, affording time for the required energy transition. The concept entails placing large, lightweight structures, preferably utilizing space resources, at the L1 Lagrange point between the Sun and Earth to intercept a fraction of sunlight before it reaches Earth. In-Space Manufacturing and Assembly (ISMA) could enable the production of large, load-optimized structures for sunshades using materials and resources available in space, such as lunar or asteroidal material, rather than launching fully assembled sunshades from Earth. The International Planetary Sunshade (IPSS) concept focuses on an evolutionary design for sunshades manufactured and assembled in space, aiming for a sustainable design through the progressive integration of space resources and innovative technologies. These sunshades are to be positioned in specific configurations to achieve a complex shading pattern, allowing a controlled reduction of solar radiation while considering regional and seasonal variations. A logistical network including robot-assisted and autonomous systems collects the processed raw materials and transports them to logistics hubs to supply the ISMA facility manufacturing sunshade structures. The flexible facility design uses the novel manufacturing environment enabling a more efficient, scalable and modular sunshade architecture. This in turn can be tailored to specific use cases, such as a modular architecture for space-based solar power satellites supporting both terrestrial and lunar applications. Given the complexity of the overall system, a comprehensive analysis of technological, logistical, and manufacturing challenges is performed. The current analysis of the static performance parameters of the ISMA facility concept is enhanced by utilizing discrete-event simulation. This allows the modeling of dynamic events such as bottlenecks and failures that could significantly impact the production process. In addition, an initial cost and risk assessment for the ISMA facility has been conducted, enriching the comprehensive evaluation of the current facility concept. The detailed characterization of the ISMA facility concept is a key element enabling a modular sunshade architecture. Future work will address the environmental and financial challenges by conducting detailed coupled analyses for the purpose of creating a viable, long-term strategy for climate intervention including the IPSS system.