16th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

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BENEFITS AND APPROACHES OF ARTIFICIALLY INDUCING GRAVITY IN DEEP-SPACE HABITATS UTILIZING TORPOR

Abstract

The human body is not naturally adapted and designed for survival in the space environment. Microgravity, exposure to solar and galactic radiation, and long-term social isolation all present difficult medical challenges for the design of deep-space missions. Many of these challenges could be mitigated by spacecraft designs that feature artificial gravity. Unfortunately, the practical engineering aspects that require revolving massive structures with large radii, extensive on-orbit assembly, and complex dynamic modeling for these rotating systems has prevented any usage or even demonstration of them in space.

Recent research and development activities have been advancing the idea and technology to place astronauts in a medically-induced hypothermic state during the transit phases of deep-space missions. This capability offers multiple mission-level advantages from both an engineering and medical perspective. To date, the crew has primarily been assumed to reside in a microgravity environment for the duration of the mission. However, with the crew in an inactive state, the use of artificial-gravity can be enabled as many of the design constraints that have been established for these systems are eliminated. Feasibility is primarily achieved through the ability to use significantly smaller rotation radii, for an equivalent G-level (e.g. Mars), without causing any detrimental effects on the crew.

This paper will review "traditional" artificial-gravity mission designs based on human-factor criteria required an active crew and compare them against various novel design concepts incorporating inactive, torpor crews. The engineering impacts, in terms of total mission mass and on-orbit assembly, will be addressed and quantified. An assessment of the attitude control system options, either chemical and/or electric, for spin-up and spin-down, with considerations for emergency scenarios, will also be conducted. Lastly, the life-cycle cost impacts of this technology and capability will be presented.