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ADAPTIVE VARIABLE - GEOMETRY ROTATIONAL ARTIFICIAL GRAVITY HABITAT : A MODULAR APPROACH FOR DYNAMIC GRAVITY CONTROL IN LONG DURATION SPACE MISSIONS.

Abstract

Prolonged exposure to microgravity in space leads to severe physiological challenges, including muscle atrophy, bone density loss, and vestibular dysfunction. Conventional rotating artificial gravity habitats utilize fixed-radius toroidal designs, which often result in high Coriolis forces, astronaut disorientation, and inefficient adaptation. This research proposes a novel adaptive variable-geometry rotational artificial gravity habitat, designed to dynamically adjust its radius and angular velocity to optimize astronaut adaptation and minimize physiological stress. The system incorporates modular telescopic arms, allowing the habitat to expand or contract based on mission needs, creating a customizable gravity environment. Additionally, distributed electromagnetic braking systems are explored to fine-tune rotational speeds without excessive mechanical wear, ensuring long-term operational efficiency. Computational simulations, including Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD), are conducted to assess the structural integrity and rotational stability of the habitat under variable configurations. Experimental validation through scaled prototypes and centrifuge-based testing will provide real-world performance data. This research introduces a scalable, reconfigurable artificial gravity system that enhances astronaut health and mission feasibility, paving the way for next-generation space habitats suitable for lunar, Martian, and deep-space exploration.

Keywords: Rotational Artificial Gravity, Variable-Geometry Space Habitat, Astronaut Adaptation, Computational Simulations (FEA CFD), Deep-Space Exploration