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APPLICATION OF TETHER TECHNOLOGY TO GENERATE ARTIFICIAL GRAVITY IN A SLOWLY-SPINNING SYSTEM FOR HUMAN EXPLORATION MISSIONS

Abstract

The future of human exploration of other celestial bodies in the solar system, particularly Mars, is closely tied to the development of systems and infrastructures that can ensure sustainable and comfortable travel for astronauts. Problems such as bone density loss, impaired vision, muscle atrophy, cardiovascular deconditioning, and changes in the immune system are prevalent among astronauts after spending considerable time in space. In this context, the necessity to develop systems capable of reproducing Earth-like environments in space becomes evident. This can be achieved through the generation of acceleration by means of centripetal forces to reproduce gravity (a concept known as Artificial Gravity). In fact, the human body cannot distinguish between the effects of accelerations generated by gravitation or by centrifugation, though the effects of the Coriolis acceleration must be considered when moving an object in the radial direction of a spinning system. Consequently, the body responds identically to both accelerations at the cellular, systemic, and behavioral levels. A promising technology for addressing this challenge during interplanetary missions is the use of tethers in a slowly-spinning, low-mass binary space system. Conceptually, the system is composed of two modules (one service module and one habitation module) connected to each other by means of tethers. In such systems, the generation of a gravitational-like environment is achieved through the control of the rotational rate and the distance between the modules. The use of tethers makes possible the construction of a system with a length of a few hundreds of meters that can spin slowly at 1-2 rpm thus creating acceleration conditions that are optimal for habitation and on-board mobility. Moreover, once the initial artificial-gravity level is attained by setting the tethered system to spin, different levels of artificial gravity can be achieved by using a motor to reel in or out the tether, without consuming any propellant, but rather exploiting the conservation of angular momentum. As an example, the slowly-spinning system can aid astronauts in transitioning from terrestrial gravity to Martian gravity during the space journey. This paper presents a preliminary definition and optimization of the critical parameters to reproduce gravity through using tether technology in a manned mission from Earth to Mars. Moreover, the paper focuses on key aspects of the mission and presents possible solutions to be developed further in order to move this technology forward.