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Space Architecture: Habitats, Habitability, and Bases (1)

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FEASIBILITY STUDY OF NOVEL CREW WELLBEING AND ALTERNATIVE COUNTERMEASURES SOLUTIONS FOR RECREATIONAL SPACES IN FUTURE LUNAR PERMANENT SETTLEMENTS

Abstract

With the recent successful conclusion of the Artemis I mission, a new era of human and robotic exploration has just started with the aim to pave the way for humans to return to the Moon. It is therefore of paramount importance to develop sustainable and architecturally sound solutions for permanent outposts, with a special focus on habitability, ergonomics, and long-term usability for hypogravity environments such as the lunar surface. By focusing on crew psychophysiological wellbeing, this work revolves around the design of innovative recreational spaces that combine fitness and fun activities. It is well known that by introducing game components into exercise routines, user engagement and commitment can be significantly elevated. Thus, the present study seeks to demonstrate in a proof-of-concept evaluation if tennis, which has many proven health benefits, could theoretically be played under lunar gravity conditions and the related architectural implications for optimal lunar surface habitat design. Despite its evolution in the last century, tennis still features unchanged characteristics: the playing area is delimited and divided by a net, the use of rackets and balls, and scoring as a system of evaluation. This feasibility study seeks to investigate how the game would change under lunar gravity conditions and if certain rules, space, or equipment adjustments would be required to play it on the lunar surface. The present proof-of-concept study has also several implications for current digital hypogravity simulation modelling applications. The proposed modelling approach starts from a technical analysis and systematic evaluation of “tennis-relevant variables” that will differ in a lunar habitat compared to Earth such as: gravity, changed atmosphere, static cling, dimensions of the playing field, as well as features of balls and racquets. Additionally, qualitative assessments were conducted to better adapt rules and playing conditions starting from the existing terrestrial ones used for all the racket-ball sports. Finally, an actual tennis rally on the lunar surface using a motion capture system and anybody® movement analysis software has been simulated to investigate the kinematics and kinetics of tennis players, balls and rackets. These key factors related to human kinematic and kinetic data are essential for any digital model aimed to better understand human movement and ergonomics. Staring with architectural evaluations and following a disruptive modelling approach, this paper could benefit several stakeholders in the field of human spaceflight for habitat design, surface EVA planning and preparation, countermeasures and hardware design for sustained human lunar mission operations.