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A QUANTITATIVE HUMAN SPACECRAFT DESIGN EVALUATION MODEL FOR ASSESSING CREW ACCOMMODATION AND UTILIZATION

Abstract

Crew performance, including both accommodation and utilization factors, is an integral part of every human spaceflight mission, from commercial space tourism to the demanding journey to Mars and beyond. Spacecraft were historically built by engineers and technologists trying to adapt the vehicle into cutting-edge rocketry with the assumption that the astronauts could be trained and will adapt to the design. By and large, that is still the current state of the art. It is recognized, however, that poor human-machine design integration can lead to catastrophic and deadly mishaps. The premise of this work relies on the idea that if an accurate predictive model exists to forecast crew performance issues as a result of spacecraft design and operations, it can help designers and managers make better decisions throughout the design process and ensure that the crew members are well-integrated with the system from the very start. The result should be a high-quality, user-friendly spacecraft that optimizes the utilization of the crew while keeping them alive, healthy, and happy during the course of the mission. Therefore, the goal of this work was to develop an integrative framework to quantitatively evaluate a spacecraft design from the crew performance perspective. The approach presented here is done at a very fundamental level starting with identifying and defining basic terminology, and then builds up important axioms of human spaceflight that lay the foundation for how such a framework can be developed. With the framework established, a methodology for characterizing the outcome using a mathematical model was developed by pulling from existing metrics and data collected on human performance in space. Representative test scenarios were run to show what information could be garnered and how it could be applied as a useful, understandable metric for future spacecraft design. While the model is the primary tangible product from this research, the more interesting outcome of this work is the structure of the framework and what it tells future researchers in terms of where the gaps and limitations exist for developing a better framework. It also identifies metrics that can now be collected as part of future validation efforts for the model.