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ECHUSOVERLOOK (EO): OPEN-SOURCE KNOWLEDGE-BASE FOR TECHNO-ECONOMIC ANALYSIS AND SIMULATION OF HUMAN EXPLORATION OPERATIONS

Abstract

Design practices and tools for human exploration missions have evolved in concert with mission complexity over the past half century of the space age. As collective thought turns toward the exploration of Mars and of the Moon, including the Artemis Program, technologies new and old have been proposed to address challenges in astronautics. However, the coordination of these challenges has lagged behind the advances of technologies themselves. This drives our development of echusOverlook (eO), an open-source Python library that captures the explorable mission design space, standardizes the definition of mission components, and democratizes the process of distilling technologies to sustain human exploration.

No existing mission design software allows users to build and simulate technologies of their own design, because they are limited to the space of hard coded options. The open and modular framework of eO attempts to reflect and integrate the collaborative contributions of the community. For a given configuration, eO calculates the exchange of resources between system components using a crewmember model and mass balancing logic. This mission representation is a precursor to computations including inventory generation, techno-economic analysis, and performance assessment of simulated discrete and stochastic behavior. Calculations are benchmarked against and on par with the ALSSAT for inventory generation, and with HabNet for mission simulation.

eO supports both private, local data and the publishing of mission designs to a central public server, where they can be extended by the global community. We use CORAL, a backend framework for creating FAIR data—findable, accessible, interoperable, and reusable—to ensure that data shared through eO conforms to these standards.

Among the many ideas for enabling human exploration of space, emerging biological technologies have been identified as critical in their functionality and in reducing mission cost. Therefore, we reproduce the ALSSAT model of a closed-loop mission with a biomass system, and extend it in eO with the modular addition of a novel bioprocess that produces parathyroid hormone for skeletal anabolism. The expansion of mission technologies beyond abiotic hardware to biotic design is a key motivator for eO's accessibility, which attempts to meet NASA's Space Technology Grand Challenges by bridging the space sciences and biological engineering communities.

Our software, data, and models will be released and maintained on GitHub. We invite participation in their maturation and extension, and we hope to build an engaged private and public community around coordinating and optimizing new technologies for advanced space operations.