Paper ID: 52839

IAF SPACE POWER SYMPOSIUM (C3)
Space Power System for Ambitious Missions (4)

Author: Dr. Daniel White
Embry-Riddle Astronautical University, United States, whited78@erau.edu

DESIGN CONSIDERATIONS FOR THE DEVELOPMENT OF A SURFACE POWER INFRASTRUCTURE TO FACILITATE HUMAN EXPLORATION OF TITAN

Abstract

Titan is the largest moon of Saturn. It is the only moon known to possess a dense atmosphere, dynamic weather patterns and liquids on its surface. These characteristics make Titan an attractive destination for future human exploration. Due to its distance from the sun, solar power to support human activities is unsuitable. This makes power production one of the key hurdles to sustainable, long-duration human exploration of the Saturn system and Titan in particular.

In this work, the viability and implementation of a surface power infrastructure and details of an energy economy on the surface of Titan are explored. This discussion will include an exploration of five (5) essential features of the Titan energy economy: power sources, energy storage, energy carriers, power distribution and energy consumption characteristics. In addition to these, human interactions with the energy infrastructure will also be detailed, including asset emplacement, astronaut safety, and intermittency issues associated with grid availability.

In the absence of abundant solar power, several unconventional candidate power sources unique to Titan are detailed, including surface wind power, loft wind power, and sources associated with flow of liquid methane on the surface including tidal power. Conventional power sources are also examined including nuclear power generation, with special attention to salient features of the Titan surface environment and their impacts on nuclear power generation.

The problem of energy storage for a large long-term crewed surface mission to Titan is also examined in detail. Candidate energy storage technologies are outlined, including the storage of in-situ produced liquid oxygen at ambient temperatures and modest storage pressures. The suitability of liquid oxygen as an energy carrier for surface mobility, and as a medium of local power distribution are detailed. Finally, this work explores several facets of crew interaction with the power infrastructure. Topics explored include power production and energy storage infrastructure emplacement, astronaut safety concerns and possible mitigation strategies, as well as design for inherent power infrastructure robustness and operability.

Titan represents an attractive medium-term destination for human exploration. Unique aspects of the Titan surface environment, its composition and dynamic weather patterns work in concert to produce an elegant solution to viable energy economics for long-term crewed missions to explore the surface of Titan.