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PERFORMANCE-BASED FRAMEWORK FOR THE DESIGN OF LUNAR STRUCTURES

Abstract

We examine the risk and reliability issues surrounding the establishment of structures for human habitation on the Moon from a performance-based framework. Human safety and the minimization of risk to acceptable levels is always a top consideration, and the Moon offers new challenges to the designer. Minimization of risk implies in particular structural redundancy, and when all else fails, easy escape to safety for the inhabitants. The key word is acceptable. It is a subjective deliberation, deeply rooted in economic considerations and societal norms. What is an acceptable level of safety and reliability for a lunar site, one that must be considered highly hazardous? Such questions go beyond engineering considerations and must include policy considerations: Can we afford to fail?

Reliability is a specialized term for the analysis and design of systems where certain aspects of the environment and system have associated uncertainties. Thus, design requires an explicit accounting of the evolutionary processes that are inherently nondeterministic. This fact makes the estimation of risk and reliability complex.

The defining issues in a reliability design for the lunar surface are the environment, which requires consideration of the low gravity, vacuum effects, shielding requirements due to radiation and meteorites, regolith dust, internal pressurization, and lunar construction requirements that demand ease of construction, eventual use of local materials, future expandability of the facility, easy maintenance and inspectability. Coupled with these considerations are the human factors issues.

A performance-based framework is one in which a design approach that links the structural design to its end-user, where the outputs are the decision variables of use to the end-user. System-level performance is linked to the risk of significant events, fatalities, repair costs, and post-event loss of function. The design process is structured to meet specific performance expectations of the structure's occupants, the owner and the public, possibly using the conceptual groupings: Hazard Analysis; Structural Analysis; Damage Analysis; Loss Analysis. Risk-management decisions can now be made based on the loss analysis.