

SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration - Part 2 (2B)

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CONCEPTUAL LUNAR BASE DESIGN - MODELLING AND SIMULATION

Abstract

The Space Station Design Workshop (SSDW) has been developed for over ten years at the Institute of Space Systems of the Universität Stuttgart, providing exceptional methodology and sophisticated software tools for space systems engineering. Current activities are expanding and enhancing the capabilities of this design environment towards new exploration destinations, particularly Moon and Mars.

This paper focuses on the modelling and simulation of the surface environment and surface installations on the Moon. Modelling and visualization tools for the lunar topography in combination with Sun, Earth and Moon orbital motions have been developed at the IRS and allows for the calculation of solar irradiation and Earth visibility. These tools enable the analysis and optimization of the energy management of a lunar base, i.e. power generation and storage, thermal control by energy absorption and dissipation, base configuration and energy distribution as well as the analysis of communication windows to Earth and operational constraints for surface activities. In the next step, a modelling approach to the conceptual design of lunar surface elements including habitats, laboratories, power plants, ISRU plants and surface transportation vehicles is implemented based on parametric relations. It describes first order estimates of lunar module sizing depending on high level inputs such as crew size, surface location, loop closure of the life support system, stay time and others, while also considering cross-connections in terms of mass and energy flows between the different element types. Finally, the base system configuration is combined with transportation aspects to allow for the generation of assembly and operations timelines as well as a comparative cost analysis of different scenarios. It then provides a full lunar base system and environment modelling and simulation environment with the necessary depth to provide quick turn-around assessment of possible lunar surface infrastructure.

These tools are used for a conceptual lunar base design in the Space Station Design Workshop 2009 in July with an interdisciplinary group of students and young professionals in order to generate and compare different base concepts. A summary of the results from two competitive teams will be presented. An outlook will be given as to merge the design concepts with similar work performed at the IRS in order to generate a reference scenario for the assembly and operation of a lunar base and to support the discussion of technical, environmental and programmatic aspects.