

**Critical Strategies for Return to the Moon:
Altair Dust Mitigation and Real Time Teleoperations Concepts**

M. Thangavelu
Astronautics and Space Technology Division
USC Viterbi School of Engineering and
USC School of Architecture
Los Angeles, CA 90089

Abstract

Natural, unimproved lunar terrain will present a direct challenge for the Altair lunar landers. They will produce energetic regolith debris during approach, touchdown and blast-off. We can expect severe ballistic debris effects over a radial range of 5-10km depending on terrain, approach trajectories and landing and lift-off modes.

Such effects can have serious implications and deadly consequences for lunar base buildup in the south polar region. It will not be possible to reliably place equipment or situate habitable lunar base components within this range. It will severely restrict crew activity in the region. While regolith shielding prescribed primarily for radiation protection in most habitat concepts explored to date would ameliorate debris effects, we cannot expect them to be in place during the first several sortie missions. Also, it is not considered efficient to have landing zones several km from base because of initial transportation infrastructure constraints.

For these reasons, it is desirable to quickly deploy systems that will ameliorate, curtail or eliminate debris production from repeated lunar landings and lift offs, especially in the region before sortie missions leading up to lunar settlement activities commence in earnest. Some system concepts and allied elements are presented.

As a crucial system of primary activities for astronaut crew, the lunar surface Cabin for Teleoperations(C-TOPS) is proposed as an integral part of the first Altair lunar lander mission. The main function of C-TOPS is to quickly provide the crew with an efficient and productive habitable volume and platform from which to command and control a variety of robots which are needed to build, operate and service the critical components of the initial operational capability(IOC) lunar base. This system concept provides an alternative in order to circumvent the >2.77 sec time delay associated with Earth-based lunar teleoperation systems and associated latency, especially for several tasks involving multiple, simultaneously moving components, equipment and crew during assembly operations. By relegating certain tasks, the C-TOPS system will also help to minimize EVAs, thereby enhancing astronaut safety at the settlement.