



NASA STTR 2008 Phase I Solicitation

T7.01 Predictive Numerical Simulation of Rocket Exhaust Interactions with Soil

Lead Center: KSC

On lunar or martian spaceports, the blast protection infrastructure must be constructed (in part) using in situ materials, such as a berm made with soil or sintered soil to form a landing pad. There are a number of mission scenarios that will be different than the Apollo experience and that cause the erosion problem to be more significant. Thus, this needs to be assessed in hardware and architecture design.

The lunar soil erosion theory developed during the 1940's and 50's did not include some of the relevant physics and as such it does not allow us to quantitatively predict the blast effects (with sufficient confidence) for missions that include multiple spacecraft landing in close vicinity to one another on the Moon or Mars. Without these predictions, it is currently not possible to develop adequate blast mitigation and protection technologies. To obtain better predictions, the Kennedy Space Center desires the development of a software tool that numerically predicts the plume interactions with the soil for rockets landing or launching on the Moon and Mars, including the erosion rates and trajectories of ejected particulate matter.

The difficulties in developing a flow code to predict these effects include the unique lunar environment with the plume expanding into a vacuum, the difficulty in solving flow physics from first principles around discrete particle assemblages, the large spatial scale of the flow features compared to the vast number of lunar soil particles within that region, and the need to parameterize the erosion of soil to produce realistic predictions although realistic benchmarking experiments of lunar erosion are difficult to perform terrestrially. Innovations are sought, resulting in the improvement of software packages to improve the fidelity of predictions for lunar and martian blast dynamics. Examples include but are not limited to the inclusion of particle dynamics models for the eroding soil, greater understanding of the particle aerodynamics including lift and drag in the relevant flow regimes, improvement of turbulence models for the particle laden flow, improved erosion (emission) models to predict the erosion rate with greater confidence as a function of both gas and soil parameters, greater understanding of the structure of the boundary layer on the planet's surface considering the Knudsen and Mach numbers that may occur, and the ability to predict the diffusion of gas into the soil and how that loosens the soil to increase erosion and/or excavation processes.

