NASA SBIR/STTR Technologies

High-Fidelity Gas and Granular Flow Physics Models for Rocket Exhaust Interaction with Lunar Soil

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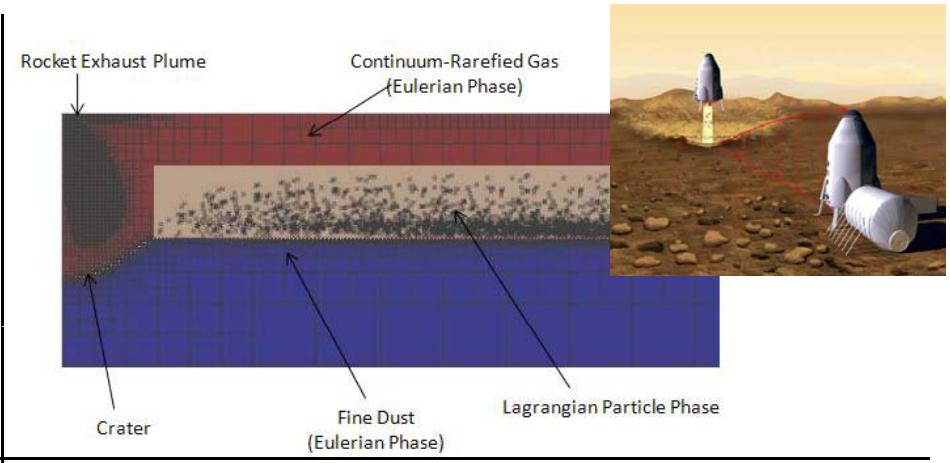
Identification and Significance of Innovation

- Current modeling of Lunar/Martian rocket plume driven soil erosion and debris transport lacks essential physics peculiar to soil grain composition and extra-terrestrial flow environment
- Granular mechanics models based on mono-disperse spherical particles empiricism; ignore poly-disperse irregular grain mechanics
- Strong interaction of dense particle cloud with rarefied-continuum plume gas surface layer flow; turbulent kinetic erosion and mixing
- Large modeling uncertainties must be reduced by deriving first principle physics sub-models for lunar and Mars environment

Expected TRL Range at the End of Contract (1-9): 5-6



Technical Objectives

- Develop accurate constituent physics models for gas-soil erosion/mixing and implement in plume erosion and cratering simulation tool

Work Plan

- Develop regolith granular flow mechanics constituent models from first principle irregular particle interaction modeling (Lagrangian DEM)
- Implement granular constituent flow models in Eulerian multi-phase gas-particle formulation for macroscopic dust and debris cloud simulations
- Integrate Eulerian gas-solid modeling into existing Unified Flow Solver (UFS) with adaptive Cartesian mesh for interface resolution
- Implement turbulence models for surface stress erosion effects (turbulent jet scouring, surface roughness)
- Validate integrated simulation tool against erosion/cratering experiments (sand, lunar/Mars simulants, reduced gravity)
- Technology demonstration for Moon/Mars landing crater formation and debris transport (Eulerian gas-dust flowfield, Lagrangian debris tracking)

NASA and Non-NASA Applications

- Robotic and manned Moon landing
- Robotic and manned Mars landing
- Industrial gas-solid flows (coal gasification, fluidized beds, …)
- Brown-out during desert helicopter and aircraft take-off

Firm Contacts

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NON-PROPRIETARY DATA