

# NASA SBIR/STTR Technologies

T4.03-9945 - Particle Flow Physics Modeling for Extreme Environments



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## Identification and Significance of Innovation

Advanced computer modeling software required to predict flow of granular materials in extra-terrestrial environments (spacecraft landing).

Soil particle erosion/cratering occurs in "extreme environments" that combine low gravity, little or no atmosphere, supersonic and partially rarefied rocket exhaust gas, unusual properties of highly irregular regolith, complex particle shape and size dispersions.

Expand existing advanced simulation technology :

- CFDRC developed multi-phase gas-granular CFD code
- UF granular flow 3-D Discrete Element Modeling (DEM) with unique modeling for irregular particle shape and distributed particle size effect

Estimated TRL at beginning and end of contract: ( Begin: 3 End: 5 )

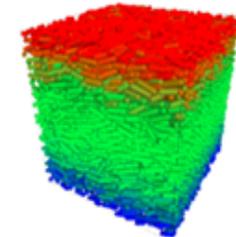
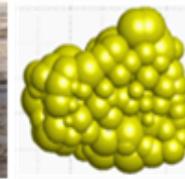
## Technical Objectives and Work Plan

Technical Objectives

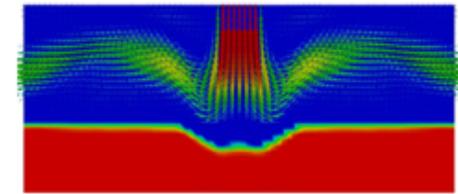
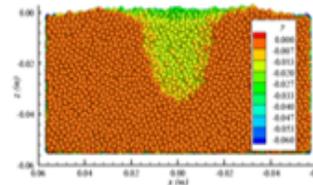
- Develop accurate constituent physics modeling for gas-soil erosion/mixing and implement in application oriented simulation tool
- Develop integrated CFD model for liberation/cratering of realistic granular material compositions in extreme extra-terrestrial environments

Work Plan

- Identify improvements to multi-phase flow CFD solver numerical modeling framework for extreme gas-granular simulations
- Demonstrate and validate multi-phase flow solver for cratering simulations
- Develop granular mechanics constituent models to capture irregular particle shapes and realistic particle size dispersion effects
- Develop macro-scale granular flow CFD model of combined irregular shaped, distributed size particle effects
- Integrate granular phase models, gas-granular multiphase CFD, and continuum-rarefied environments modeling in unified CFD code



Innovative DEM Modeling Irregular Particle Shape And Size Dispersion Effects



DEM Particle Sim. => Granular Constituent Model => Gas-Granular Flow CFD

## NASA Applications

The debris simulation tool will offer a powerful simulation capability of first order importance to the Space Exploration Program for robotic and human mission architecture definition to the Moon, Mars, and other destinations. The granular flow modeling capability will be equally important for modeling regolith material manipulation for In-situ Resource Utilization such as pneumatic transport and processing of regolith in reactors for resource extraction.

## Non-NASA Applications

Many potential non-NASA commercial applications exist in civil and military industries. Dust, sand and snow stir-up during helicopter landing and take-off in a desert or arctic environment result in severe visibility impairment (brown-out) and danger of debris ingestion. Manipulation and mixing of granular materials is an extremely important technology in pharmaceutical and chemical industry.

## Firm Contacts

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NON-PROPRIETARY DATA