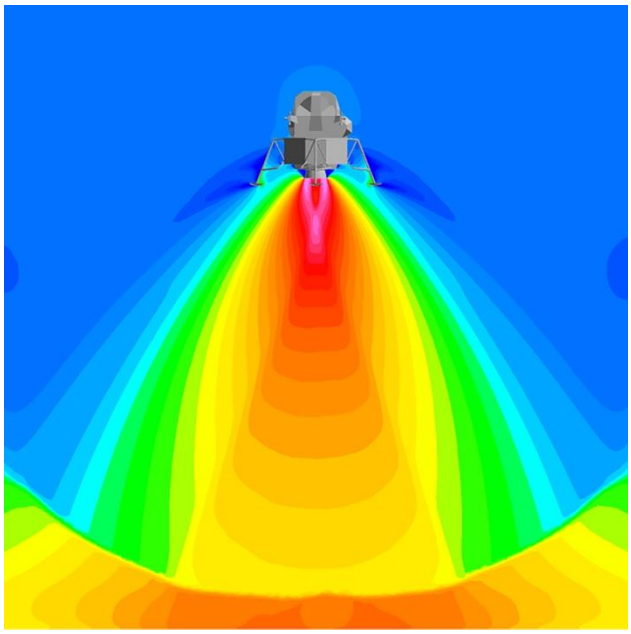
Thruster Plume-surface Modeling



Name of Technology:
Predict Plume-surface Interaction

Participating NASA Centers:
KSC (Lead); GSFC, JSC, LaRC,

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

Vision for the Technology:
Lander design, surface operations and equipment are affected by the plume-surface interactions. NASA needs the ability to predict the effects of propulsive landing vehicles (i.e. inducted plume), as a function of vehicle scale and configuration, and landing site characteristics.

Challenges:
Analysis from the limited Apollo mission photos/videos indicates huge regolith excavation rates. Current tools are unvalidated with test data from a relevant environment. Since the moon and Mars have different environments, the physics of plume-surface interaction will be different. Without a predictive plume tool, the lander's design may be over or under designed yielding unanticipated damage to sensors, critical equipment, and nearby assets.

NASA Seeks to Meet the Following Specs:
Successful validation of models with ground test and flight data. Acceptable uncertainties vary with parameter; most are on the order of 25%.

The analysis tools need to predict:

(1) Site alteration dimensions

(2) Lander induced environments

(3) Ejecta size, velocity, and distance

Overview of Student Project:
NASA seeks innovative image sensor technology solutions for situational awareness on long duration missions. Solutions may include new technologies as well as improving current with radiation protection.

Innovative Areas Student Projects Can Address:

- Develop predictive software tool
- Computational Fluid Dynamics modeling of plume
- Combining current CFD data along with gaming engines, such as Unity, Unreal, etc. for predictive modeling.

Project Phases

I. Analytical critical analysis and characteristics

II. Computational Predictive modeling

Research Funded by NASA on this Topic:
Proposal Number: 22-1- Z7.04-1934
Wall Shear Measurement Technology for Plume Surface Interactions

Proposal Number: 22-1- Z7.04-1530
Rapid Parametric Sensitivity Analysis for Plume-Surface Interaction Simulations

Proposal Number: 19-2- Z7.04-2726
Measurement and Modeling of High Speed Polydisperse Granular Flow Under Plume/Surface Interaction Conditions

Proposal Number: 18-2- T9.01-6552
A Scalable Gas-Particle Flow Simulation Tool for Lander Plume-Surface Interaction and Debris Prediction

References:

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

T6.02 Predictive Numerical Simulation of Rocket Exhaust Interactions with Lunar Soil

Z7.04 Lander Systems Technologies (2019)

Z7.04 Landing Systems Technologies (2022)

NASA - Plume Surface Interaction (PSI)

The Science of Plume Effects