Title

Physics-based Modeling and Tool Development for the Characterization and Uncertainty Quantification of Crater Formation and Ejecta Dynamics due to Plume-surface Interaction

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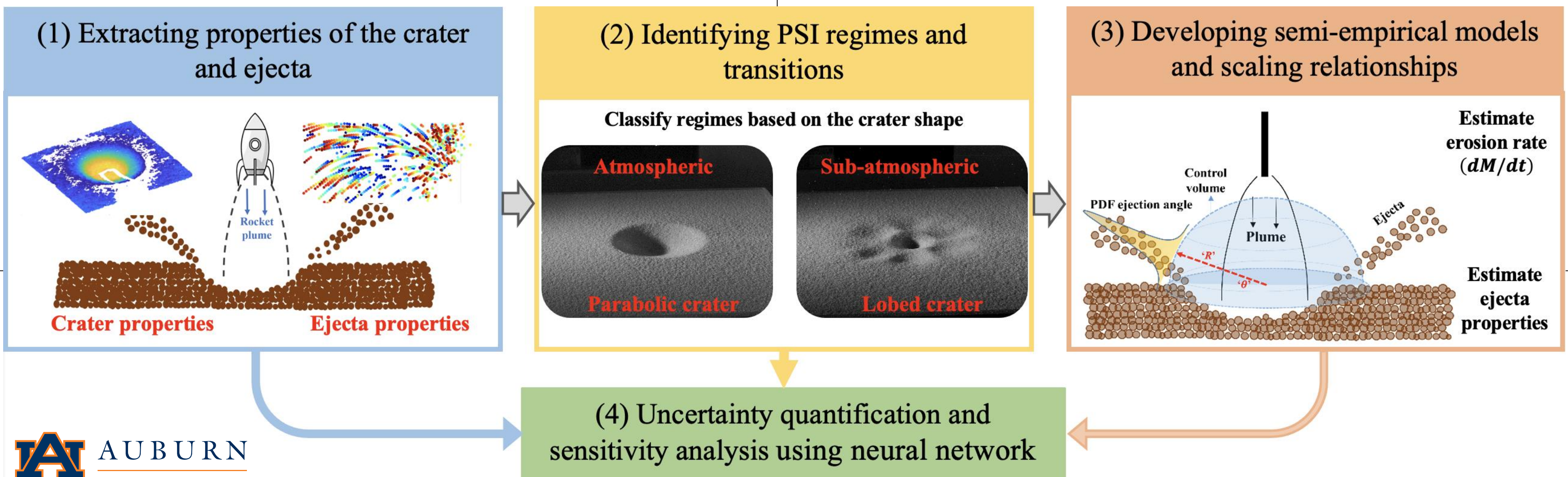
Topic 2 – Advancements in Predicting Plume-Surface Interaction Environments During Propulsive Landings

Research Objectives

1) Extract critical crater and ejecta properties from crater and flow field images.
2) Develop tools to identify PSI regimes and the associated mechanisms
3) Formulate novel physics-based, reduced-order, semi-empirical models for predicting crater formation and ejecta properties.
4) Identify and quantify sources of experimental uncertainties by implementing neural network models.
   - Proposed objectives will advance the methods currently in use, from TRL2 at the start to TRL3 at the end of the project.



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Approach

- Implement edge/ boundary-identification and stereo-photogrammetry to extract crater geometry, and 2D particle-tracking velocimetry for ejecta dynamics.
- Develop image-processing techniques coupled with classical Machine Learning models to identify patterns and transitions in crater geometry and ejecta properties.
- Develop and validate physics-based, reduced-order, semi-empirical models informed by cratering and ejecta dynamics regimes.
- Devise and mature Neural Network (NN) based sensitivity analysis tools to quantify the effect of identified experimental uncertainty parameters on cratering and ejecta dynamics.

Potential Impact

- Novel tools developed will facilitate rapid efficient extraction of critical mechanisms of crater and ejecta dynamics.
- Methods will advance the capability to efficiently process PSI data, identify regimes and transitions, and estimate risks due to PSI in extra-planetary environments.
- Physics-based, reduced-order models will allow for rapid prediction of ejecta dynamics from real-time measurements of crater dynamics from SCALPSS cameras.
- Proposed neural network based uncertainty analysis tools will provide a new capability to quantify the effect of measurement uncertainties on cratering and ejecta dynamics for experimental investigations and operational landers.