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Author: Ms. Farah Alibay
Massachusetts Institute of Technology (MIT), United States

Mr. Vishnu Desaraju
Aurora Flight Sciences, United States
Dr. Jessica Duda
Aurora Flight Sciences, United States
Prof. Jeffrey Hoffman
Massachusetts Institute of Technology (MIT), United States

# FRACTIONATED ROBOTIC ARCHITECTURES FOR PLANETARY SURFACE MOBILITY SYSTEMS

**Abstract**

The traditional approach to planetary surface exploration is to use a single planetary surface vehicle and consists of a point design approach with limited exploration of the multi-vehicle architecture trade space. While this has led to many successful missions, with the growing complexity emerging from increasingly ambitious mission objectives, the accomplishment of future missions will require more fundamental research on the functional and operational aspects of mission architectures. Consequently, a fractionated approach to the design of planetary surface mobility systems is suggested as a way to increase scientific return and robustness as compared to the monolithic alternative. Fractionated mobility systems are made up of physically independent vehicles, which collaborate to provide additional benefit or value to the beneficiaries or beneficiary stakeholders. Separately, each vehicle may have limited functionality, but together they have at least as much, and often more, functionality than their monolithic counterpart, whilst keeping the overall mass of the system relatively constant.

The paper describes a methodology for generating and exploring a trade space of fractionated robotic architectures, based on a set of mission goals. In this approach, fractionated architectures are compared to each other and to a baseline monolithic architecture using carefully selected metrics and a set of specially designed tools. These tools include an architecture generation and evaluation tool, a set of vehicle mass modeling tools and a path-planning tool for operational modeling. These tools enable the generation and evaluation of fractionated architectures that achieve a better performance than the monolithic baseline. A case study involving the redesign of the Mars Science Laboratory is presented to demonstrate the potential benefits of fractionation.

Results from this work have shown that fractionated systems are particularly advantageous under uncertainty and when the monolithic alternative is very large. In addition, a fractionated approach to robotic planetary surface exploration helps shift complexity later on in the design lifecycle, thus reducing some of the development risks. Although fractionation sometimes leads to increased operational complexity, in general, it is shown to have the potential to address the ever-increasing vehicle complexity and the desire for higher reliability in planetary surface exploration missions, as well as potentially enabling new mission concepts.