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PHASE A STUDY OF AN INNOVATIVE, LOW-COST DEMONSTRATION MISSION OF TUMBLEWEED MOBILE IMPACTORS ON MARS

Abstract

Mars science is currently being characterized by large, high-value spacecraft, flown in low numbers. This makes deep space inaccessible due to prohibitively high costs, mission risk, complex operations, and long timelines. In order to enable widespread and inclusive participation in space exploration, all these factors must be addressed. The Tumbleweed Mission, consisting of a swarm of wind-driven, circularly symmetrical mobile impactors offers an order-of-magnitude reduction in costs per observable while enabling the direct participation of a large number of individual actors. However, this novel mission architecture requires novel technologies and operational concepts to be de-risked for deep space application.

An in-situ demonstration of the technology on Mars is a critical step in the maturation of the technology. While these de-risking efforts are critical to ensuring mission success, they are also time- and cost-intensive. Furthermore, they make little use of opportunities afforded by the decreased cost of space launches. In order to mature Tumbleweed Rover technology to TRL9, a low-cost Tumbleweed Mars Demonstrator Mission must be developed and integrated into preceding de-risking measures. Through conducting a Phase A-level study on the mission, we derive mission objectives, mission- and system-level solutions. Furthermore, key operational concepts and programmatic aspects of such a mission are defined.

Thereby, we derive a mission architecture featuring a highly simplified prototype Tumbleweed Rover and a dedicated entry vehicle. With a total mission mass of less than 12 kg, it can be brought along as a payload of opportunity on a wide variety of science mission profiles. To that end, we investigate integration with potential parent missions. Furthermore, we show how the Tumbleweed Mars Demonstrator Mission de-risks all critical phases and technologies of a Tumbleweed Mission architecture. Lastly, we present a cohesive set of precursory technology demonstration missions, including a suborbital deployment demonstrator, an Earth demonstrator to test operations and validate performance, and an in-orbit demonstrator to test critical electronic hardware in an applicable radiation environment.

Ultimately, the demonstrator missions de-risk a promising future space technology, increase the scientific return of planned Mars missions, and overall represent a hallmark mission in the development of

miniaturized deep space missions.