Paper ID: 88706
student

IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – missions current and future (3A)

Author: Mr. Guillaume Brault
Team Tumbleweed, France

Mr. Rami Amer
Team Tumbleweed, The Netherlands
Mr. Rohit Roy Chowdhury
Team Tumbleweed, The Netherlands
Mr. Lucas Cohen
Team Tumbleweed, The Netherlands
Ms. Celestie Gladys
Team Tumbleweed, The Netherlands
Ms. Alizée Le Goff
Team Tumbleweed, The Netherlands
Mr. Thijs Van Den Heuvel
Team Tumbleweed, The Netherlands
Mr. Sabin Illegitim
Team Tumbleweed, The Netherlands
Mr. Nils Neumeister
Team Tumbleweed, Austria
Mr. Arun Osman
Team Tumbleweed, The Netherlands
Mr. Jakov Ostrouska
Team Tumbleweed, The Netherlands
Mr. Darius Vicovan
Team Tumbleweed, The Netherlands
Mr. Ben Placke
Team Tumbleweed, Austria
Mr. Simon Schwob
Team Tumbleweed, The Netherlands
Mr. Julian Rothenbuchner
Team Tumbleweed, The Netherlands

SUBORBITAL FLIGHT DEMONSTRATION FOR DE-RISKING THE ENTRY, DESCENT, AND LANDING SEQUENCE OF A TUMBLEWEED MARS ROVER

Abstract

Several Mars exploration missions have failed during the entry, descent, and landing (EDL) phase, which commonly requires precise and time-critical operations executed autonomously by relatively unproven systems. The high risk associated with this mission phase also drives mission cost and timeline for Mars missions. An affordable way of testing such systems in realistic flight conditions creates opportunities for a significant reduction of the risks and costs associated with EDL. The current toolbox

available to engineers is limited mainly to numerical simulation and ground testing. To improve this, we are preparing a representative demonstration flight using a scaled prototype of a Tumbleweed rover flown on a sounding rocket.

The Tumbleweed rover represents a promising new approach for lowering the cost of Mars exploration missions by implementing a novel EDL paradigm for reaching the Martian surface. Deployment of a Tumbleweed rover poses a unique challenge in the unfolding of compliant mechanisms during supersonic freefall, immediately following atmospheric entry. To increase the maturity of this solution towards TRL 6 and de-risk a future Mars mission, we are designing a flight prototype that will demonstrate rover deployment in realistic conditions. Development of flight hardware is ongoing, with launch slated for early 2026.

To achieve this, we evaluate the essential aerodynamic parameters that define the flight environment experienced by our Mars rover during deployment, such as Mach and Reynolds numbers. We then design a demonstration-specific entry vehicle capable of being launched by a sounding rocket. The ballistics of this vehicle are tuned in order to carry a scaled rover prototype to a deployment point matching these conditions. The design of the entry vehicle is studied using numerical simulation and wind tunnel testing, and takes into account uncertainties regarding the real trajectory of the rocket. We also consider challenges in scaling down the Tumbleweed rover itself to fit inside the demonstration entry vehicle, and the limits of reproducing Mars EDL in Earth's atmosphere.

Through this demonstration flight, we are seeking to verify and refine our understanding of the dynamics of the Tumbleweed rover durign deployment. We are also building organizational experience by executing the complete lifecycle of a space mission in preparation of future Mars missions. Such an approach may prove highly beneficial for the development of future radical solutions for Mars exploration, as well as demonstrating the viability of the Tumbleweed rover concept.