TANDEM: Tensegrity Rover for Exploration of Venusian Tessera Regions

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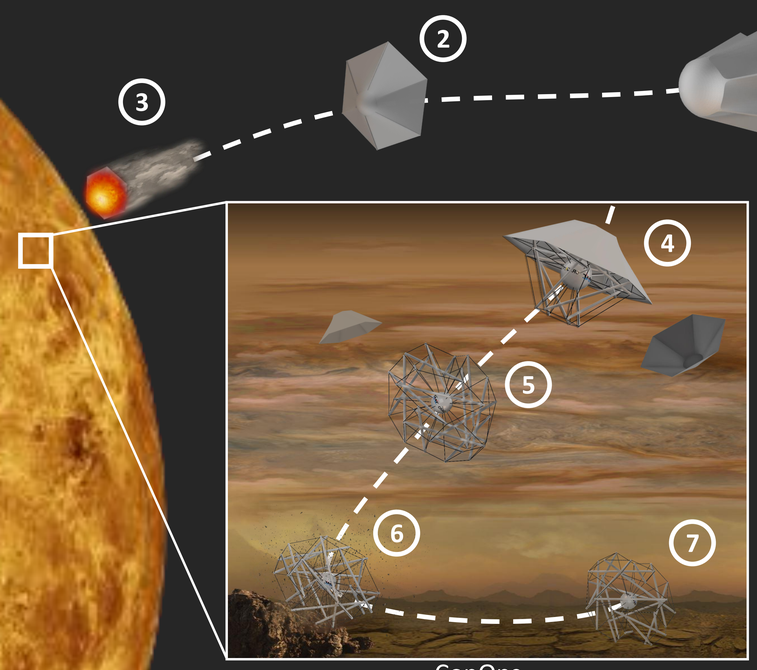
Concept of Operations



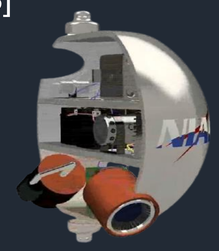
ConOps

1. Vehicle Stowed for Transit to Venus
2. Heat Shield Deployment
3. Entry into Upper Atmosphere
4. Heat Shield Separation/ Back Shell Deployment
5. Back Shell Separation for Freefall Landing
6. Ground Contact/Impact
7. Surface Exploration

Mission Summary & Instrument Candidates

The Tension Adjustable Network for Deploying Entry Membrane (TANDEM) is a unified vehicle concept coupling tensegrity robotics with a mechanically deployable semi-rigid heat shield and drag plate. Through the actively controlled tensegrity frame all aspects of entry, descent, landing, and locomotion are combined into a single, multifunctional system. TANDEM is designed as a secondary or tertiary rideshare mission to land in and explore the hazardous tesserae regions of Venus that have been listed by NASA's decadal survey to be of high scientific interest. [1] – [3]

Candidate Instrumentation	
Pressure Transducer	Batteries
Anemometer	Avionics Unit/Instrument Electronics
Thermocouple	LIBS/Raman
Magnetometer	Neutral Gas Spectrometer
IMU	High Resolution Camera


Payload Cross-Section

Mission Profile

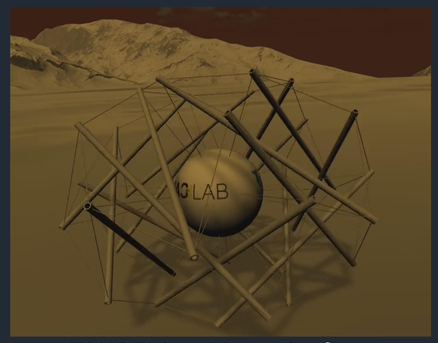
1 2 3 **Launch & Transit:** TANDEM is stowed in its minimum volume configuration for transit to Venus. Upon arrival a semi-rigid heat shield is deployed for entry into the upper atmosphere.

4 5 6 **Entry, Decent, & Landing:** After peak heating the heat shield is dropped. A flexible backshell is deployed and allows for controlled descent. During the final stage of descent the backshell is discarded and TANDEM free-falls to the surface. The tensegrity frame distributes loads across its tension network, providing omnidirectional payload protection during impact.

7 **Surface Exploration:** Once landed TANDEM travels through the tesserae environment to areas which are optimal for data acquisition. [1][2]

Science Objectives

TANDEM's design offers inherent omnidirectional protection of an insulated payload containing science instrumentation, enabling a range of data to be gathered.

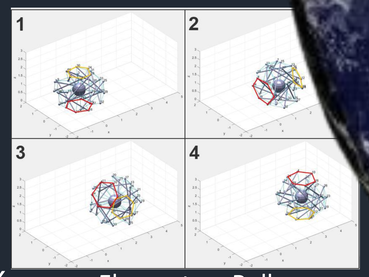

TANDEM on Venus Surface

The main science objectives of this mission are to:

- Determine the chemical composition of the atmosphere at key altitudes
- Characterize topology, chemistry, and mineralogy of the surface
- Constrain the size and timeline of potential oceans in Venus' past [3]

Locomotion Studies

Initial hand-tuned locomotive gaits demonstrate the feasibility of using cable actuations within the tensegrity frame to navigate across a surface. For more complex gaits Central Pattern Generators (CPGs) are under development. Selection of gain values is made initially through the use of Monte Carlo sampling and further refined using genetic algorithms.



Elementary Roll

Acknowledgement

NASA Innovative Advance Concepts (NIAC) Program

References

[1] J. Bayandor, K. Schroeder, and J. A. Samareh, "Lightweight Multifunctional Planetary Probe for Extreme Environment Exploration and Locomotion," NIAC Phase I, 2016. https://ntrs.nasa.gov/citations/20170003125
[2] K. Schroeder, J. Samareh, and J. Bayandor, "TANDEM: Tension adjustable network for deploying entry membrane," Journal of Spacecraft and Rockets, vol. 55, no. 6, pp. 1379–1392, 2018.
[3] National Research Council, Vision and Voyages for Planetary Science in the Decade 2013-2022. Washington DC: The National Academies Press, 2011.