A Compact Tensegrity Lander and Rover Concept for Exploration of Martian Terrains

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Mars Pathfinder (MPF)

- MPF was a low-cost ($280 M) lander and rover.
- MPF used an aeroshell derived from the Viking Program and an inflatable airbag system.

MPF Lander (Left) and Rover (Right)

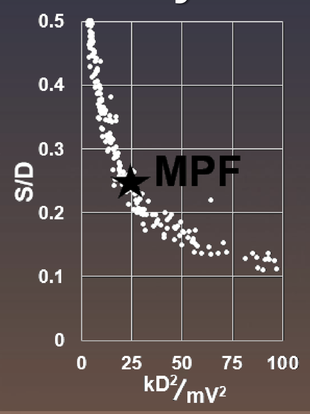
Tensegrity Rover

- The airbag and microrover are replaced with a tensegrity rover, which performs the entry, descent, and landing (EDL) plus locomotion (see EDL-L sequence on the right). The tensegrity system was scaled to match the ballistic coefficient of MPF to ensure a similar EDL profile.
- The Super Ball Bot demonstrated impact protection and locomotion of a tensegrity-based rover at the NASA Ames Roverscape. It sustains omni-directional impacts by distributing loads throughout its network of tension cables. Motors at the ends of the compression rods actuate the tension cables, enabling the system to morph its shape for stowage in the aeroshell and produce rolling locomotion.

NASA Super Ball Bot

Impact Survivability

- The adjacent plot shows the relationship between the normalized payload stroke on the y-axis and a dimensionless parameter which resembles a ratio between elastic energy and kinetic energy on the x-axis.
- The number of bars and stiffness of the cables were designed so that the central payload avoids collision with the ground and bars during impact.



Crashworthiness Studies

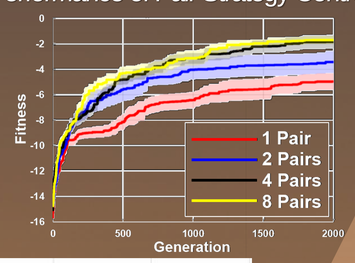
- TANDEM-class (see reference) impact prototypes for drop tower experiments are currently being developed at the ***CRASH*** Lab.
- Position and acceleration data of the central payload are captured using slow-motion video and an on-board accelerometer.
- Experimental data will be used to verify dynamics-based and finite-element-based modeling approaches.

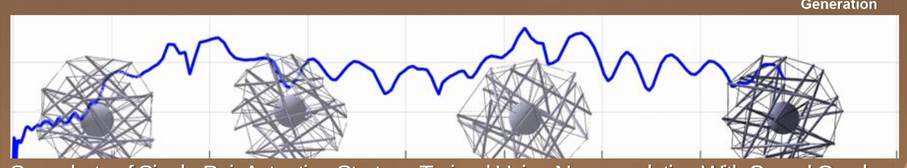
Impact Prototype

Locomotion Studies

- A cable-pair actuation strategy was developed to decrease the number of degrees of freedom for the control problem.
- The adjacent plot compares the performance of controllers trained with neuroevolution for different numbers of cable actuation pairs.

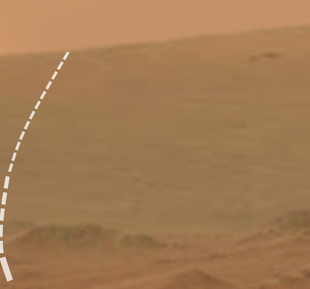
Performance of Pair Strategy Controllers

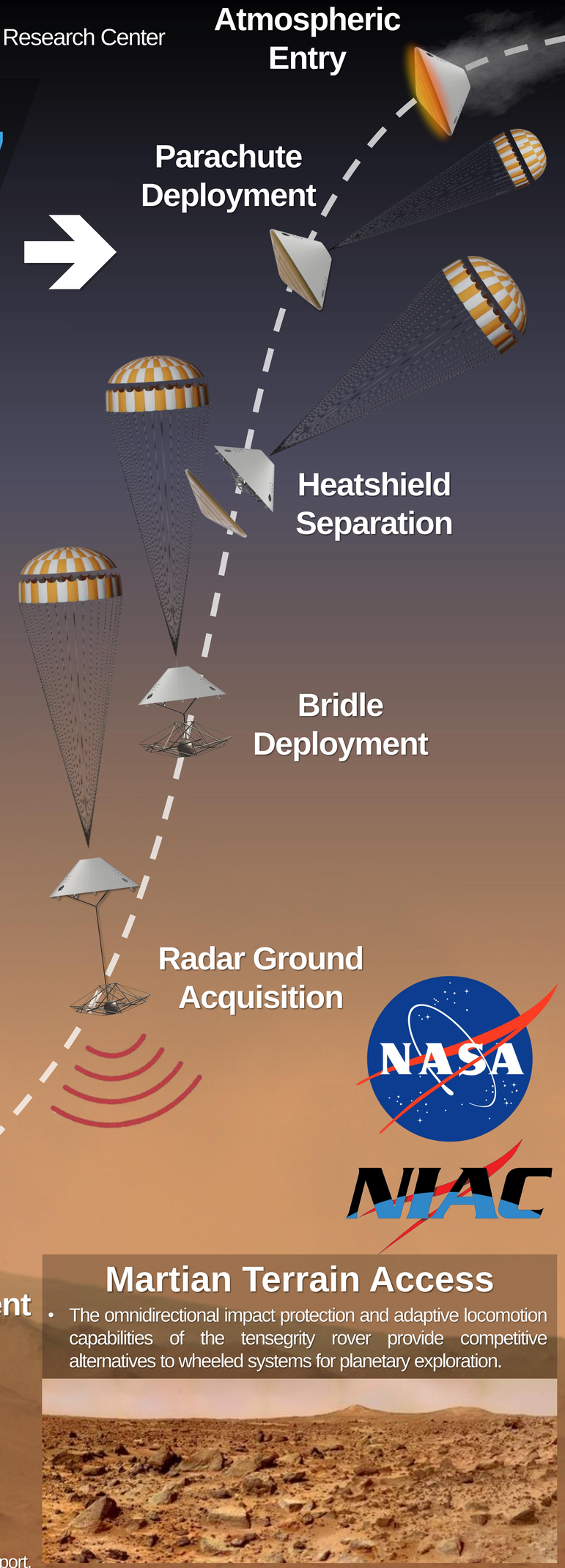




Snapshots of Single-Pair Actuation Strategy Trained Using Neuroevolution With Speed Overlay

Venus Tensegrity Rover





Martian Terrain Access

- The omnidirectional impact protection and adaptive locomotion capabilities of the tensegrity rover provide competitive alternatives to wheeled systems for planetary exploration.

Reference: Schroeder, K., Samareh, J., and Bayandor, J. "TANDEM: Tension Adjustable Network for Deploying Entry Membrane," JSR, Vol. 55, No. 6, Nov.-Dec. 2018.

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