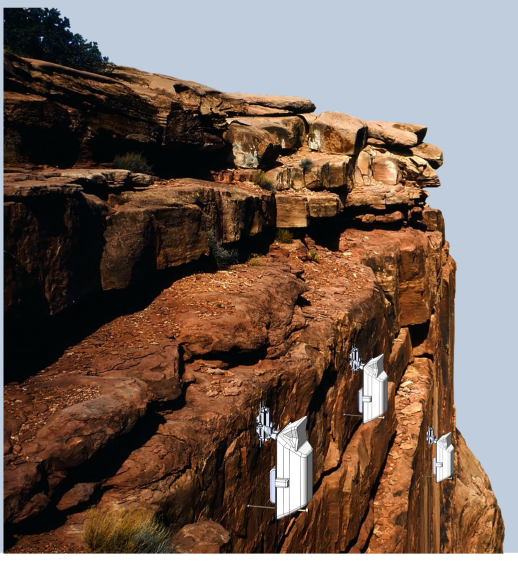

Deployable Anchoring Instrument Platform for the Exploration of Extreme Terrains on Mars

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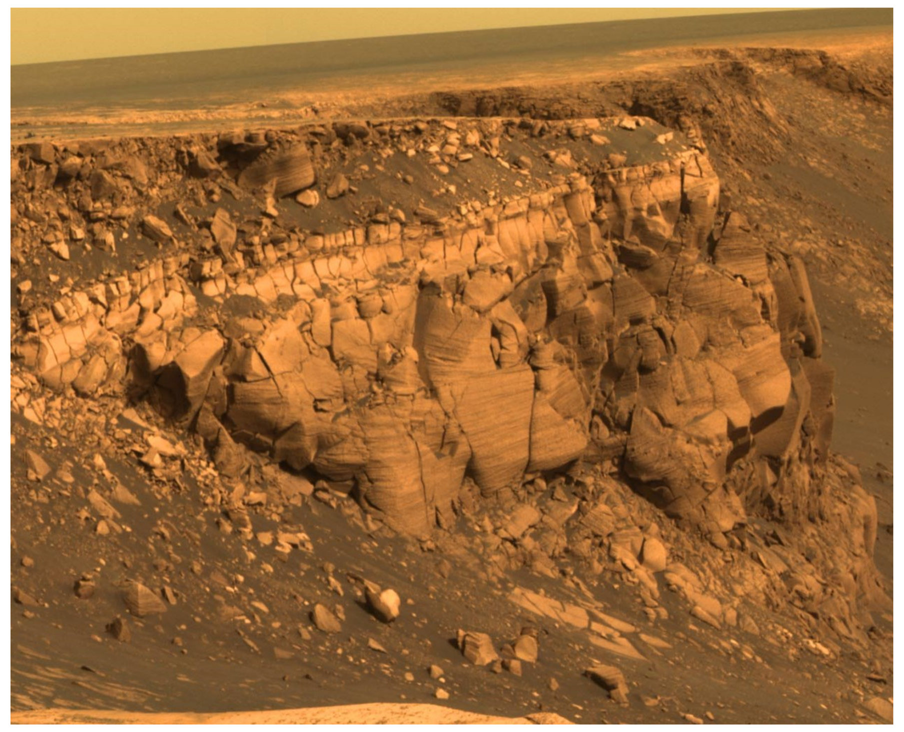
Background

Robotic exploration of planetary surfaces enables science investigations of high value targets. Exploration by conventional wheeled rovers may be restricted to measurements of targets on relatively flat surfaces. Deployment of science payloads by a UAV in extreme terrain, including steep cliff faces (e.g. Victoria Crater, shown), overhangs, or caves expands the potential science investigations for a mission. This mission architecture enables measurements over tens of kilometers by multiple, replaceable instruments, including long-term monitoring and short-duration high resolution spectral scans.



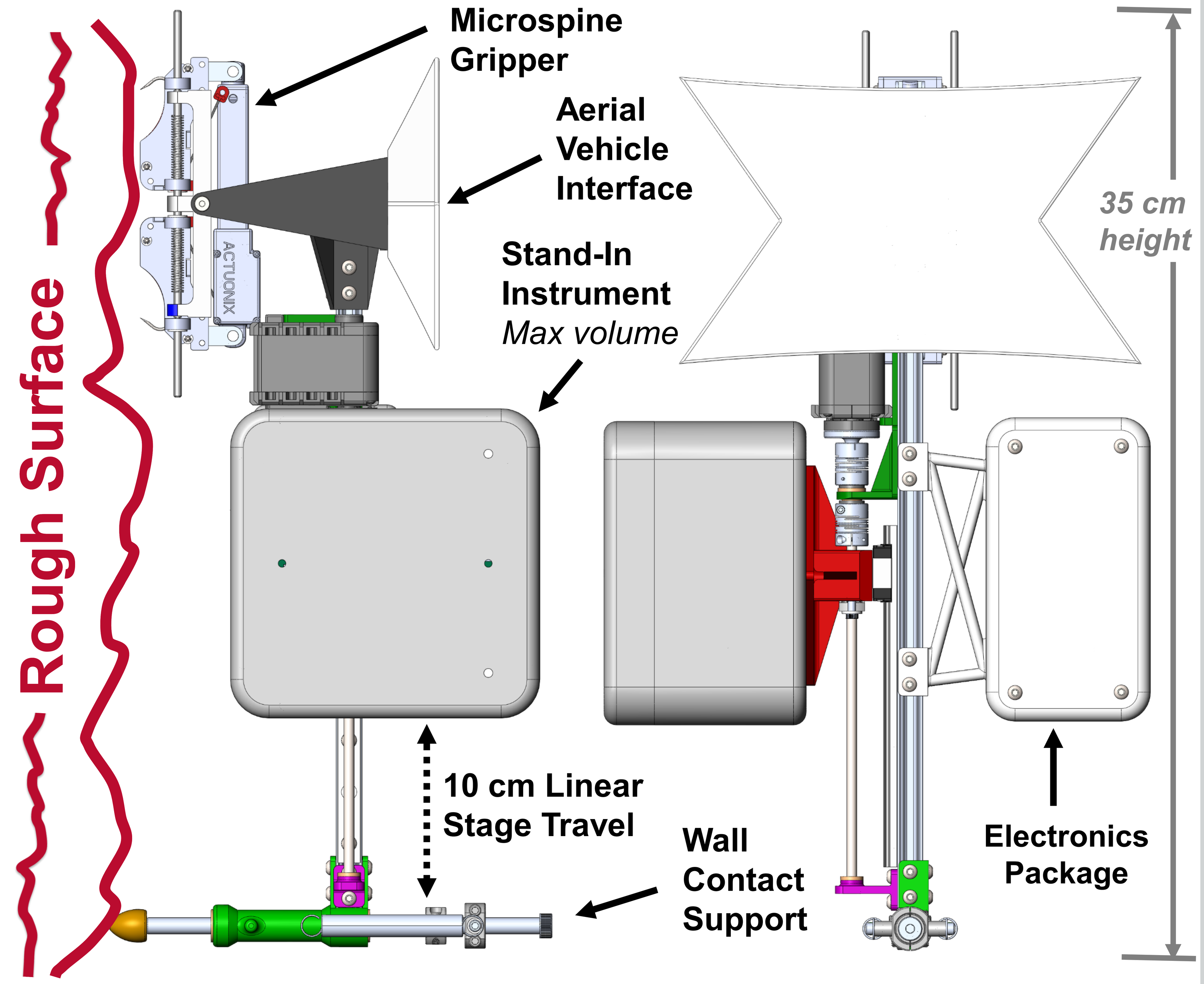
Cape St. Vincent, a geologically interesting outcrop imaged by Opportunity, was unreachable for sampling due to its 8m height. *[Squyres, Steven W., et al. Science 324.5930 (2009): 1058-1061]*

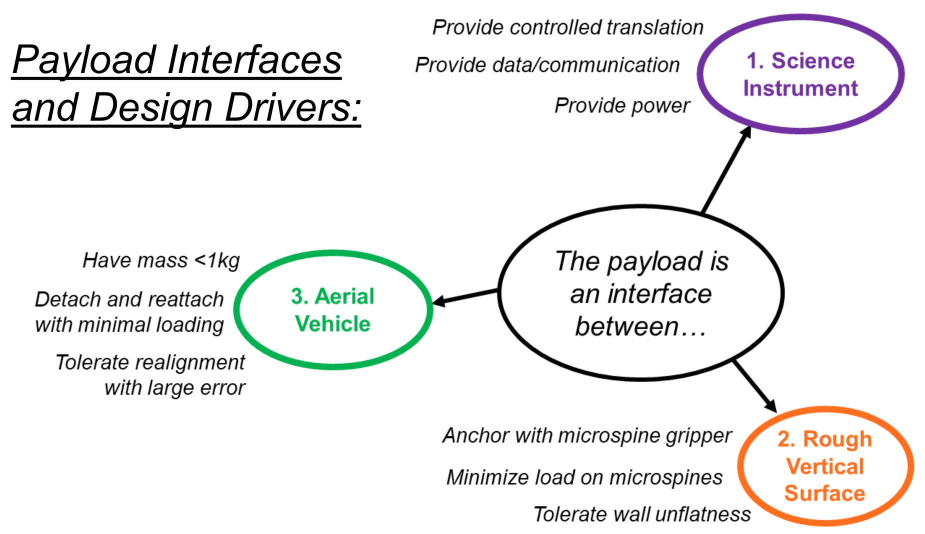
Potential Investigations Enabled

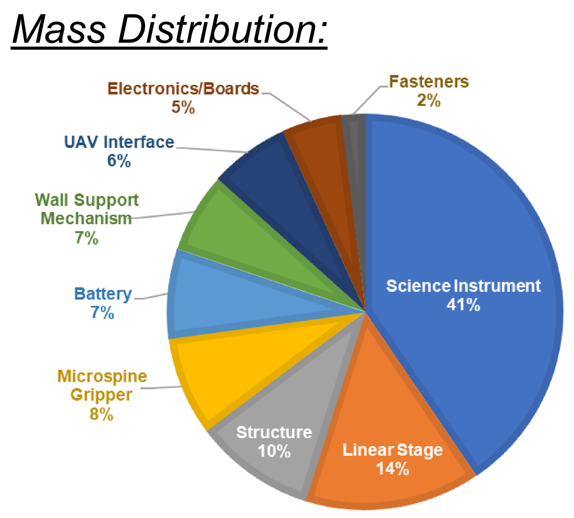
- Biosignature detection on cliff faces and outcrops
- Geologic characterization of exposed strata
- Atmospheric monitoring from strategic deployments
- Network of air flow and atmospheric compositional monitoring in lava tube caves

Current Package Design Overview

An anchoring instrument "package" targeting Earth-analog field tests

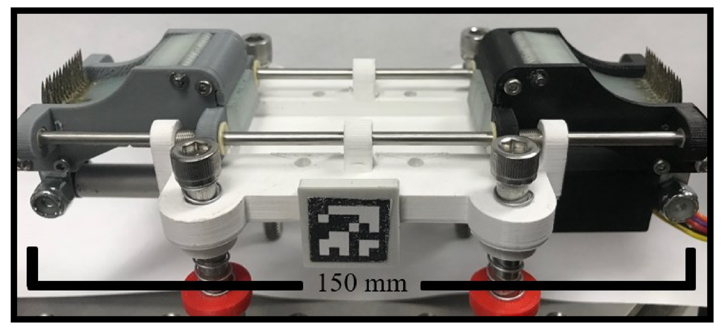




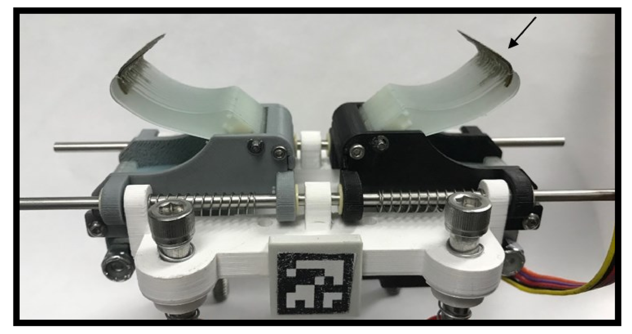


Microspine Gripper (Anchor)

The package adheres to the wall using a gripper consisting of two rows of pointed steel hooks (microspines) cast in flexible resin. Once preloaded to a rough surface, an actuator pulls the two rows of spines together. As they are dragged across the surface, each individual spine is able to grab hold of tiny surface irregularities. This lightweight (100 g) gripper can withstand loads up to 10 N and 5 N in the shear and normal directions.



Gripper Open



Gripper Closed (Anchoring)

Prototype Design Specifications

Supported Instrument

Mass: 500g
Volume: 12cm x 12cm x 8cm
Continuous Power: 5 W / 1 hour
Linear Stage Travel: 10 cm

Entire Package

Total Mass: 1.2 kg
Stowed Volume: 35cm x 24cm x 17cm
Operation Time: 3 hours on a single charge, with 1 hour total of instrument use
Surface Roughness Tolerated: +/- 2 cm

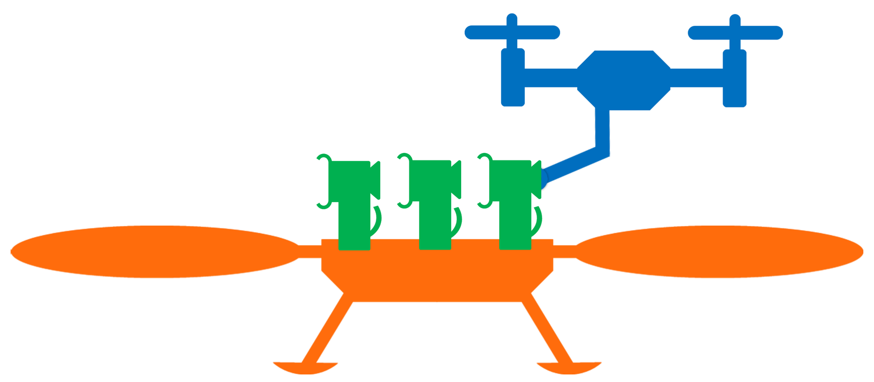
Instrument Candidates

- UV Imager
- LIBS
- APXS
- Atmospheric Sensor
- Green Raman Spectrometer
- Dosimeter
- Multispectral Imager
- Microscopic Imager

Example Investigation ConOps

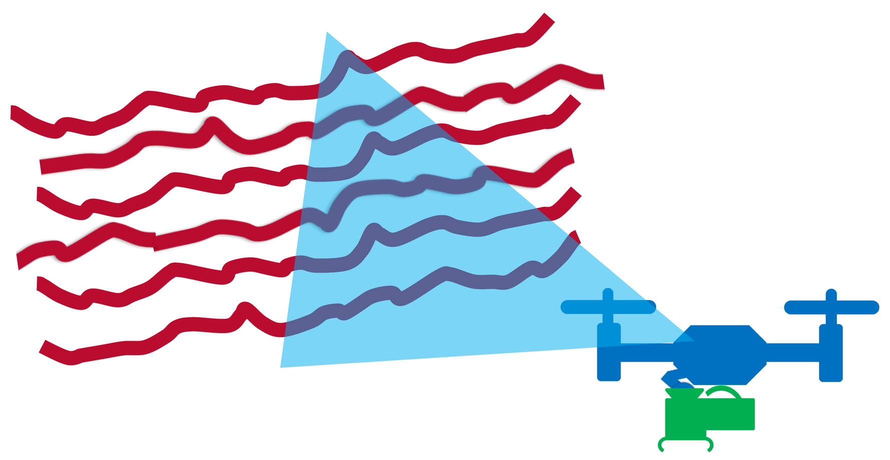
Repeat process with multiple packages and multiple deployments

1. Aerial vehicle acquires an instrument package from the lander



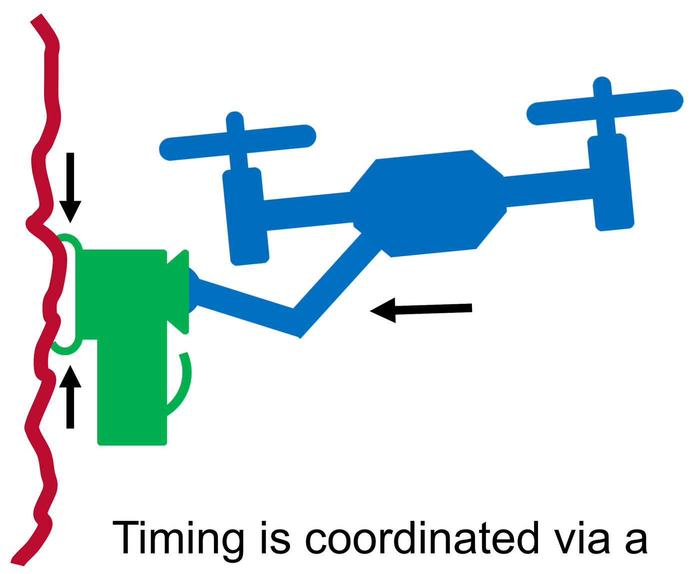
Each package supports a 500 gram instrument or suite of instruments.

2. Aerial vehicle surveys a surface for potential targets



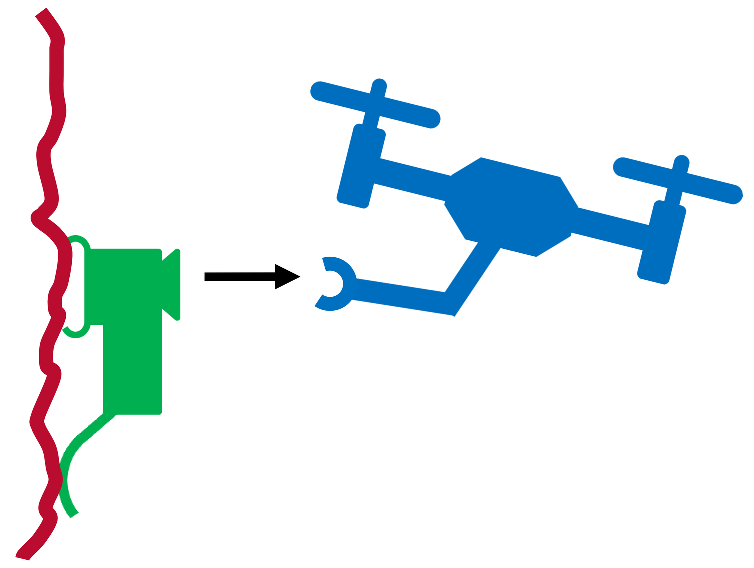
Potential placement locations are evaluated for scientific value and favorability for robust anchoring.

3. Aerial vehicle preloads package to the surface, and anchoring activates



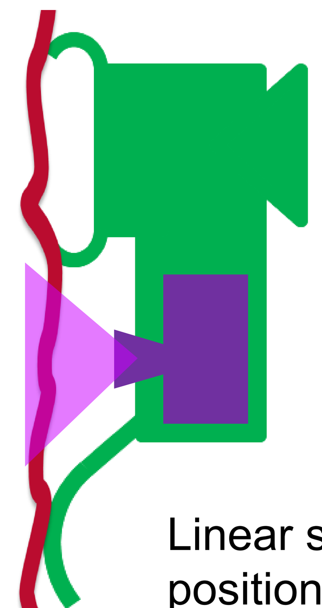
Timing is coordinated via a wireless communication link.

4. Anchoring is verified, and the aerial vehicle detaches



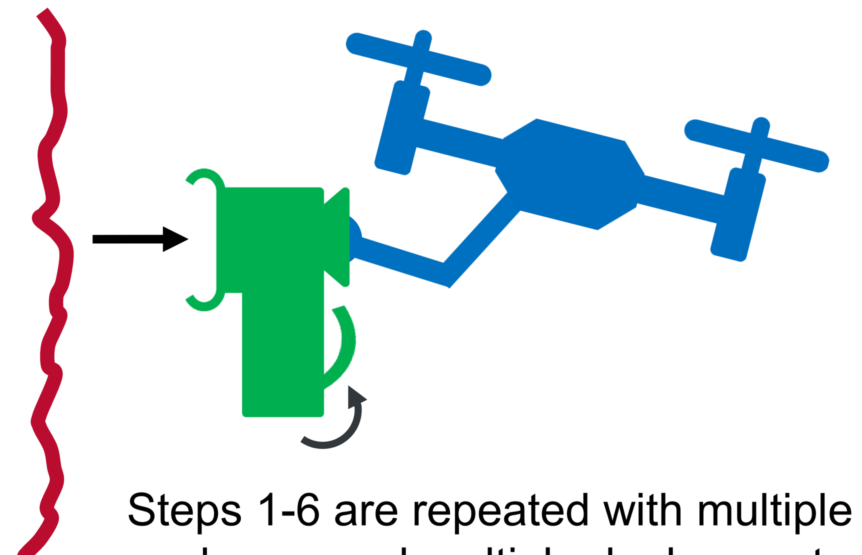
Anchoring verification is accomplished with a pull test prior to detachment.

5. Science instrument acquires measurements



Linear stage enables fine positioning of instrument within 10 cm.

6. Package is retrieved and redeployed, or returned to lander.



Steps 1-6 are repeated with multiple packages and multiple deployments.