Science Mission

The University Rover Competition is held annually near Hanksville, UT at the Mars Desert Research Station. Each team must design and build a rover to compete in four different tasks:

1. **Science Mission.** The rover is required to conduct an in-situ analysis to determine the presence of extinct or extant life at designated sites.

2. **Extreme Retrieval and Delivery.** The rover is required to pick up and deliver objects in the field while traversing a wide variety of terrain no further than 1 km from the base station.

3. **Equipment Servicing.** The rover is required to perform operations on an equipment system after traveling up to 0.25 km.

4. **Autonomous Traversal Mission.** The rover is required to autonomously traverse between markers across moderately difficult terrain up to a total distance of 2 km.

The science mission is worth 20% of a team’s overall score. All analyses must be performed by the rover on site, and any liquids used for the analysis must strictly follow a no-spill policy.

Completion of the science task requires knowledge of astrobiology and modern methods used to determine the existence of life. Once the rover has completed an analysis of each site, the team is required to prepare a 10 minute presentation describing the results of each test.

Methods

Raman spectroscopy is a vibrational spectroscopy method that measures photons that have undergone Raman scattering, which changes the photons’ energy. The energy change results in a shift in wavelength of the scattered photons, which varies based on the chemical composition of the sample. Because Raman scattering only affects approximately one photon per million, excess light is filtered out while meaningful light is projected onto a Charge Couple Device (CCD) photodetector for analysis.

The data output from the CCD can be displayed as the Raman shift intensity graphed against the wavelength of the shifted light. These graphs are compared to existing databases created from analyzing known materials. The team will compare data output to detect the presence of biomarkers including carotenoids, DNA, RNA, L-amino acids, and lipids. The team will also analyze samples for geobiological materials. The team will compare data output to detect the presence of biomarkers including carotenoids, DNA, RNA, L-amino acids, and lipids. The team will also analyze samples for geobiological materials.

The custom-built Raman spectrometer uses a 532.3 nm green laser. Using a monochromatic excitation signal prior to entering an optical fiber, the laser beam passes through an optical fiber bandpass filter to ensure a single frequency excitation signal prior to entering an optical fiber.

The signal runs through an excitation fiber to the probe head. The probe uses a 6-around-1 fiber configuration where the light source travels through the central excitation fiber. The six exterior fibers collect the light scattered by the sample surface and direct the retrieved light through a series of optical filters and lenses onto the photodetector. A shutter on the probe head allows the fiber optic cable to maintain a small required stand-off distance from the sample surface and prevents external light from entering the probe.

Conclusion

The competition rules required that the science sub-team become familiar with the field of astrobiology and the search for extraterrestrial life. Undertaking this project also familiarized members of the science sub-team with the work currently being done by NASA and ESA to develop a similar Raman spectrometer for use on a future rover mission to Mars.

In order to develop this instrument, members of the science sub-team researched life-detection methodologies, optical engineering, and rapid-prototyping and manufacturing processes. The project also required working with larger interdisciplinary teams for the purposes of integrating the spectrometer with the rover’s power and communications systems.