Modification of Heritage Scientific Instrumentation for Exploration of Hypothesized Surfaces

Fall 2024 ME 481 Capstone Design Project | Design Group 9

Sponsor: NASA/ASU Psyche Mission

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Background

The NASA Psyche mission was selected in 2017 with the goal of studying 16 Psyche, an M-type asteroid located in the main belt between Mars and Jupiter. Future proposed missions to 16 Psyche will likely incorporate a lander for surface exploration. The capstone team identified prior roving missions with instrument suites that were most compelling for scientific surface exploration of 16 Psyche to be used on possible future missions.

Objectives:

- Select instruments used on previous roving missions
- Assume that 16 Psyche is a metal-rich planetary core
- Optimize weight, cost, and power usage by focusing on complementary instruments/structures

Figure 1: Illustration of 16 Psyche

Figure 2: Illustration of Psyche Spacecraft

Research

- Several professionals were consulted for input on concepts of interest
- 16 Psyche is hypothesized to be either a rocky chondrite or a metallic planetary core remnant
  - The capstone team decided to prioritize designing an instrument suite for a metallic planetary core
- Selected instrument candidates from previous NASA missions including imagers, spectrometers, seismometers, sampling mechanisms, and magnetometers
- Due to weight and power constraints, a maximum of four smaller instruments would be feasible for the first mission
- Overall, an imager, spectrometer, magnetometer, and a sampling mechanism can be supported for the first mission to 16 Psyche

Final Concept

Imager

- Use of a stereoscopic, multispectral imager akin to Perseverance's Mastcam-Z
- Allows for high-resolution 3D imaging of the surface
- Design adjustments for power minimization will likely need to be employed

Figure 3: Multispectral Imager

Spectrometer

- PIXL device used on the Perseverance rover is best option
- Harbors an X-ray spectrometer for composition analysis
- Arm-mounted, can identify elements as small as a grain of salt

Figure 4: Illustration of PIXL

Magnetometer

- MASMag is the magnetometer selected for this mission
- Used on the MASCOT CubeSat on the Hayabusa2 mission
- Offers low mass and power requirements

Figure 5: MASMag Magnetometer

Sampling

- TAGSAM collection mechanism from OSIRIS-REx
- Uses nitrogen gas to collect debris from the surface and stores samples in test tubes

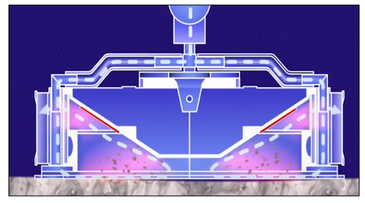

Figure 6: Illustration of TAGSAM Collection

Sample Return

- Inspiration from Mars Sample Return (NASA & ESA)
- TAGSAM robot arm places samples in launch capsule via sample delivery window
- Capsule to be launched from the surface and meet an orbiter for voyage to Earth

Conclusion

If the Psyche spacecraft's initial analysis of 16 Psyche describes its composition as a metal-rich planetary core, the above suite of instruments could support the first rover mission. Future researchers could use these results to study planetary formation, including the past formation of our own Earth.

References

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