Meteorite Imaging System Positioning Mechanism (MISPM)

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Background

Orbiting the Sun at an average distance of 272 million miles, in the asteroid belt between Mars and Jupiter, the metal-rich asteroid 16 Psyche may hold some answers about the interior of terrestrial planets like Earth. In collaboration with ASU and JPL, NASA will launch the Psyche spacecraft from Kennedy Space Center, Florida, in the summer of 2022. Fitted with a multispectral imager, magnetometer, and gamma-ray and neutron spectrometers, the spacecraft will orbit 16 Psyche for 21 months, studying its properties and relaying data back to Earth. To identify the composition of the asteroid, the received data will be compared to a database containing the material properties of previously analyzed meteorite samples.

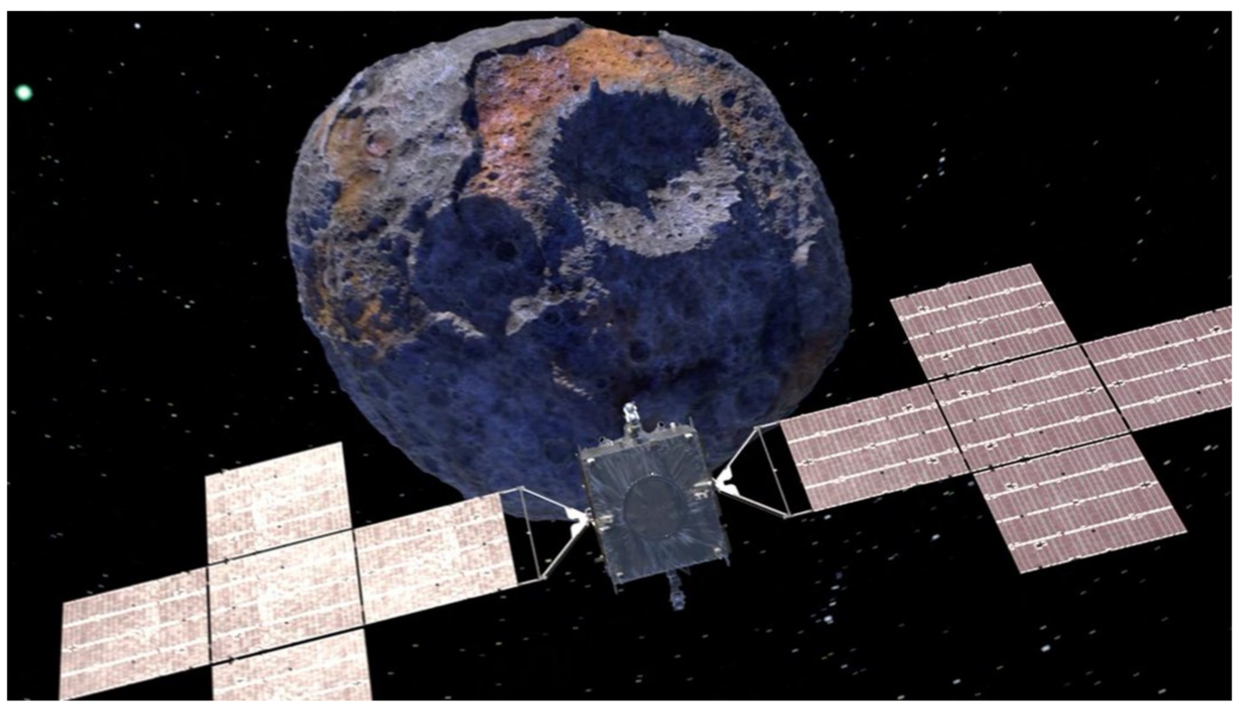


Figure 1. Artist's concept of Psyche spacecraft in orbit around 16 Psyche.

Objective

To assist in the collection of data from meteorites here on Earth, the MISPM team was tasked with providing a system prototype that will enable a technician to capture high quality images of meteorite samples of varying shapes and sizes by securely holding the sample while positioning vertically at a desired distance and then orienting the face of the sample normal to the imaging device.

Figure 2. Schematic of meteorite sample surface normal to imaging device.

System-Level Requirements

Table 1: Requirements

No.	Requirement Name	Requirement Objective
1	Secure Mounting	Sample must be held in place securely
2	Positioning	Lift sample to appropriate distance for imaging type
3	Orientation	Normal to imaging lens
4	Sample Size	Envelope dimensions: 10” diameter, 5” height
5	Sample Weight	95% Fe at envelope dimensions, 106 lbs
6	Automation	Position and orientation by command software
7	Portability	Disassembly, shipping, and reassembly by technician

Design Approach

Four subassemblies work in concert to accomplish the system requirements.

Fractal Vice

Figure 3. This 3D printed design has 14 points of articulation to conform to the edge shape of the meteorite sample. Bushings in the mounting holes add flexibility to contact points.

Sample Tray

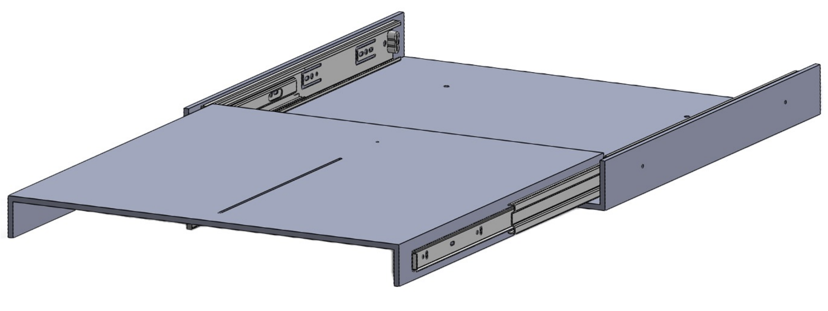


Figure 4. The fractal vice is mounted to the top of the inner tray, which is moved in and out of the outer tray and structure by a motor and rack and pinion for sample loading.

Dancing Table

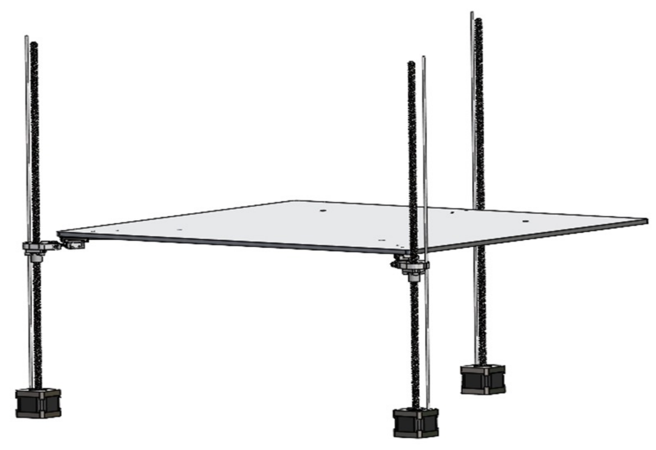


Figure 5. The outer sample tray is fixed to the dancing table whose movements about the x and y axes are controlled by motor-driven lead screws at the two front corners and center of the back edge.

Camera/Sensor Mount

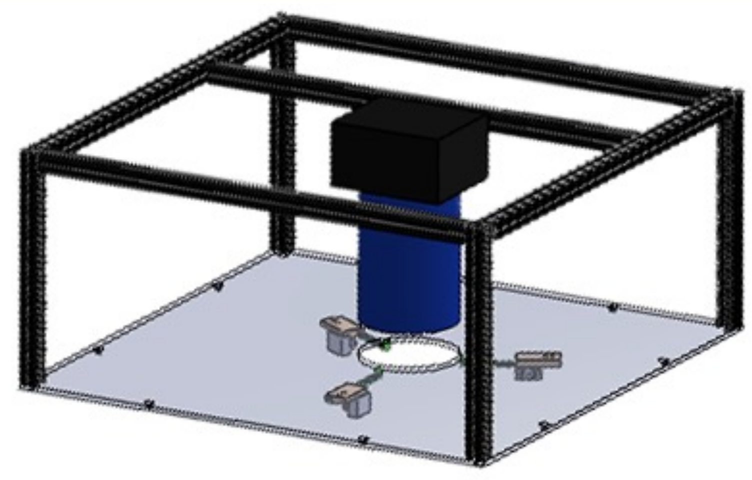


Figure 6. Three ultrasonic sensors are positioned over the sample to ensure normality, then retract for imaging. 8020 Aluminum was used for the frame to reduce weight and improve modularity.

Top-Level Assembly

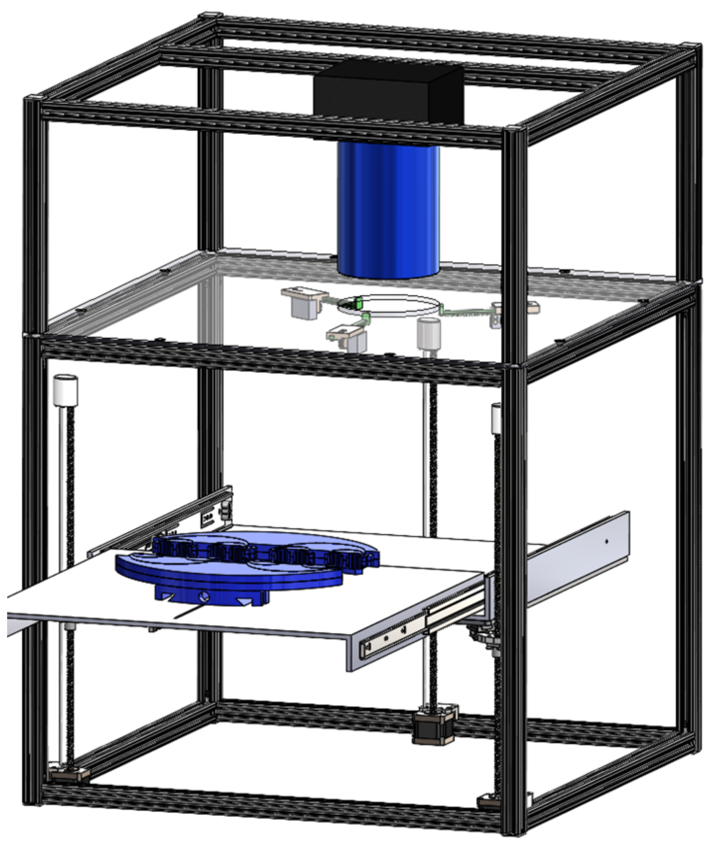


Figure 7. CAD model

Electronics/Command Script

A Raspberry Pi system receives data from the user or from ultrasonic sensors to turn the stepper motors by the amount required to reach proper position and orientation.

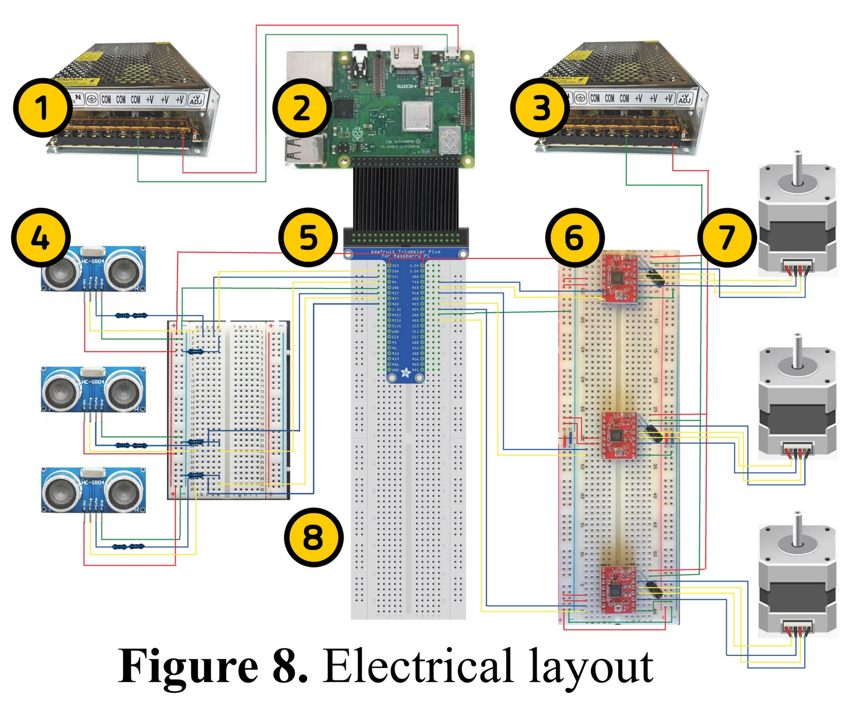


Figure 8. Electrical layout

Command script is written in Python and run via VNC remote desktop from a laptop connected with ethernet cable.

Table 2: Electronic Components

1	DC Power Supply 5V, 20A
2	Raspberry Pi 3 B+
3	DC Power Supply 12V, 20A
4	HC-SR04 Ultrasonic Sensor
5	Adafruit T-Cobbler Plus & Ribbon Cable
6	DRV8825 Stepper Motor Driver
7	NEMA17 Stepper Bi-Polar Motor
8	Prototyping Breadboard

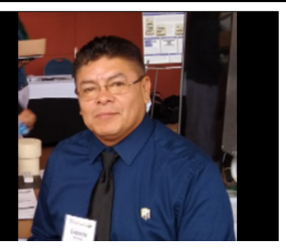
Assembled Prototype

Figure 9. Photograph of prototype

Conclusions

The MISPM team identified the system requirements requested by the client, ASU, in support of the NASA Psyche mission. The objective for this project was met as the team was able to design and manufacture a system prototype. The system allows for a technician to capture high quality images of meteorite samples of varying shapes and sizes. The design incorporates four main subassembly mechanisms to break up the requirements of the system and help simplify the design and manufacturing process. A control system was created around a Raspberry Pi platform to run a Python command script. The Raspberry Pi uses ultrasonic sensors as the main sensory device to evaluate and adjust the position of the sample. The positioner is adjusted by the three stepper motor-driven lead screws, which manipulate the positioning mechanism. The ultra sonic sensors are used to verify perpendicularity between the meteorite sample and the camera being used to capture images.

The Team & Acknowledgments



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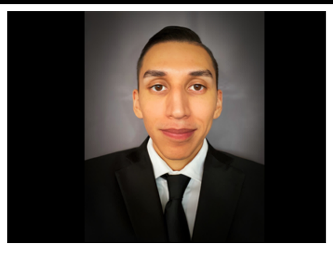

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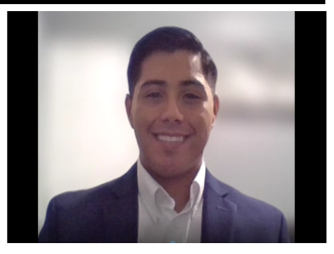

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