



FAMU-FSU
College of
Engineering

Psyche Asteroid Sample Acquisition Team 501

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Jerry R.

01/20/2026

Team 501: Introductions



Michael Gregory
Mechanical Engineer
Presenter



Jake Marcus
Design Engineer



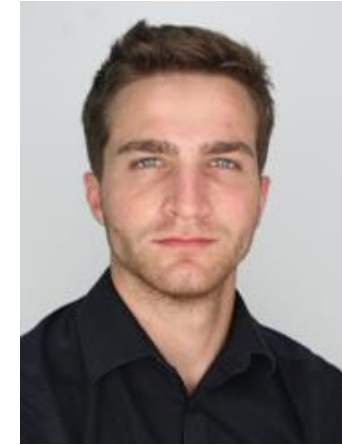
Claudia Irausquin
Structural Engineer



Janna Rhodes
Test Engineer
Presenter



Conner Holmes
Robotics Engineer
Presenter



Jerry Richardson
Systems Engineer

Sponsor and Advisor

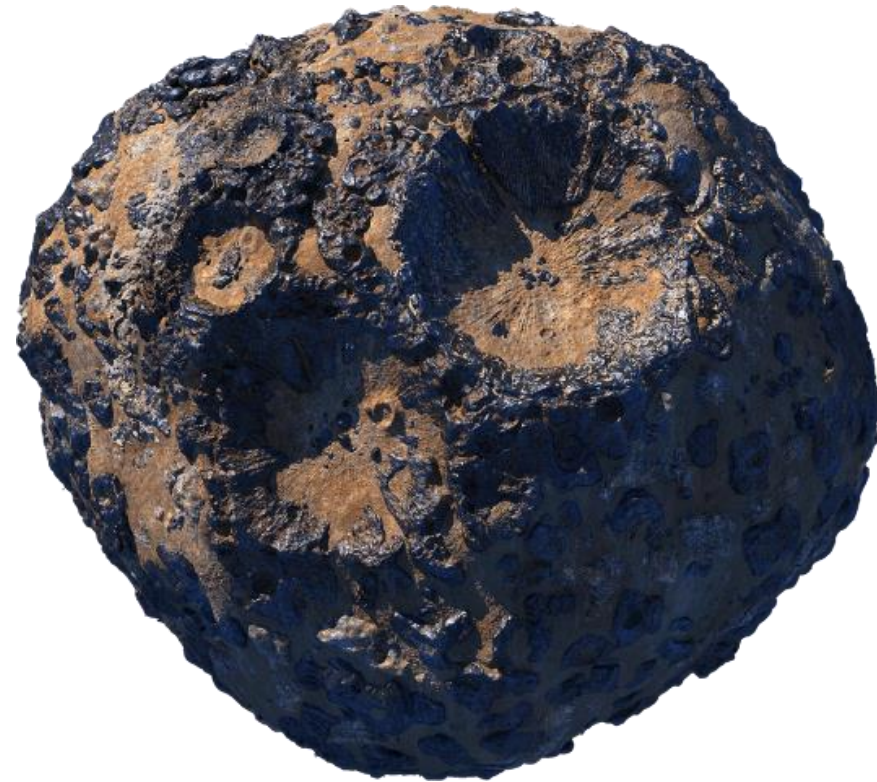


Dr. Cassie Bowman
Project Sponsor



Dr. Shreyas Balachandran
Faculty Advisor





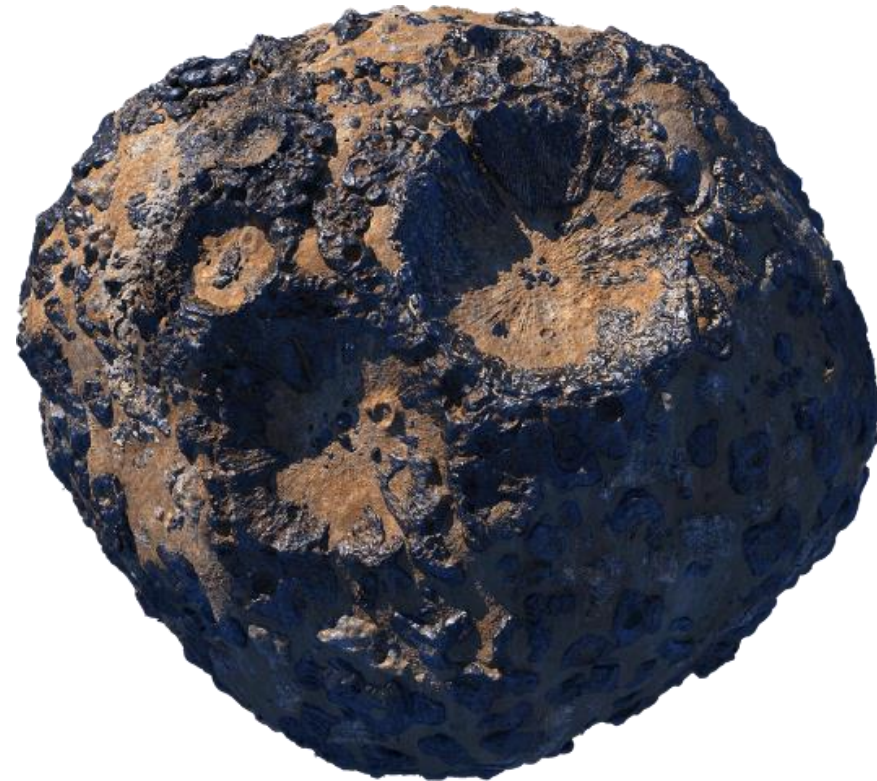
NASA Rendering of Asteroid (16) Psyche

Objective

The objective of this project is to acquire and cache samples across multiple surface types on asteroid (16) Psyche. This effort is coordinated with Team 502, who is focused on sample retrieval.

Background

- Located in the Main Asteroid Belt.
- Psyche is believed to be an exposed core of an early planetesimal.
- Rocky outer layer from collisions occurring billions of years ago.
- Hypothesized metal composition of iron-nickel and silicates.
- Spacecraft sent by NASA in 2023 will arrive in 2029 to observe and map Psyche's surface.



NASA Rendering of Asteroid (16) Psyche

Customer Needs and Assumptions

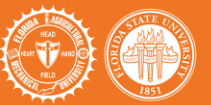
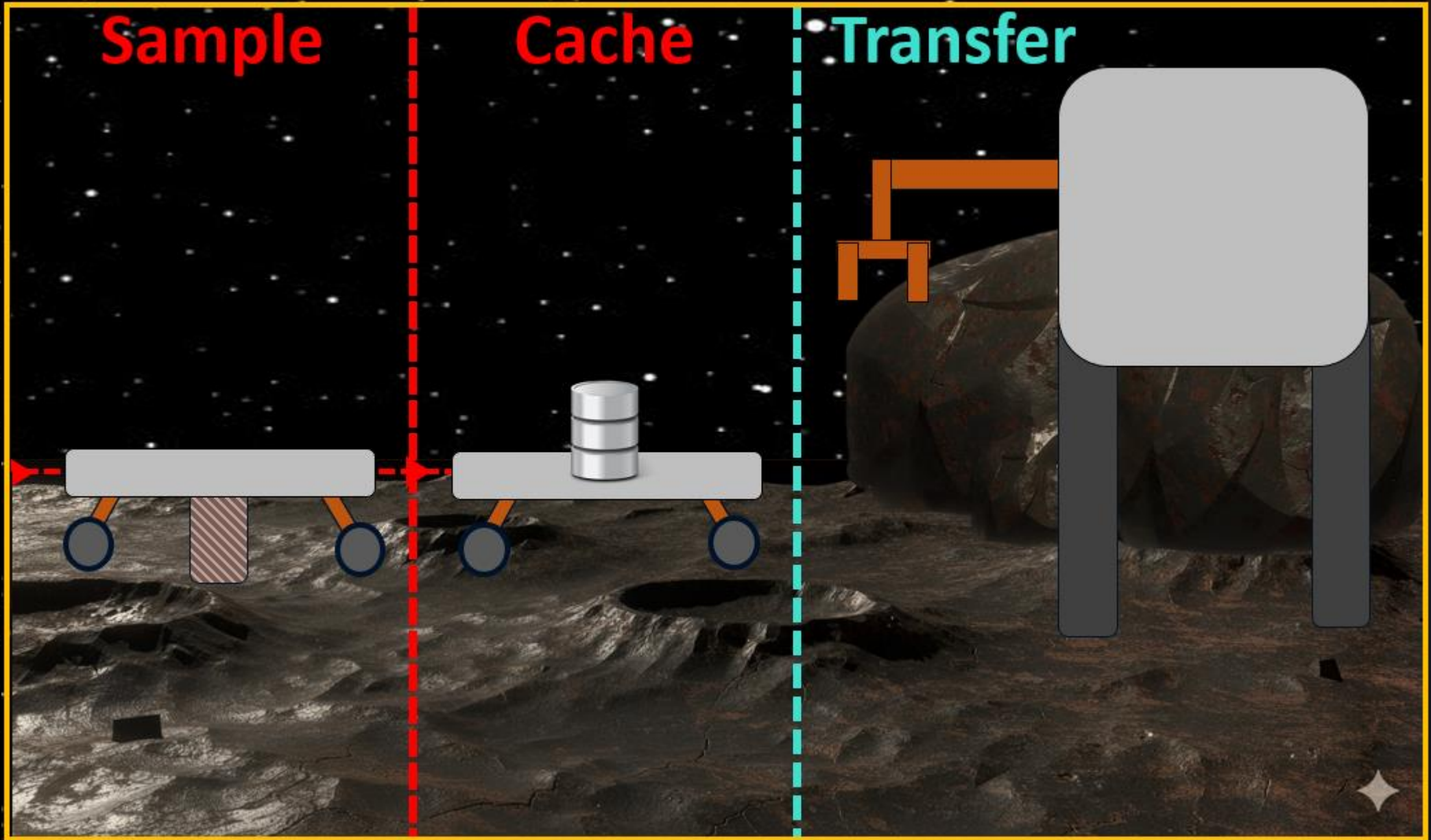
Customer Needs

- Take multiple samples
- Keep integrity of samples
- Remain compatible with Team 502

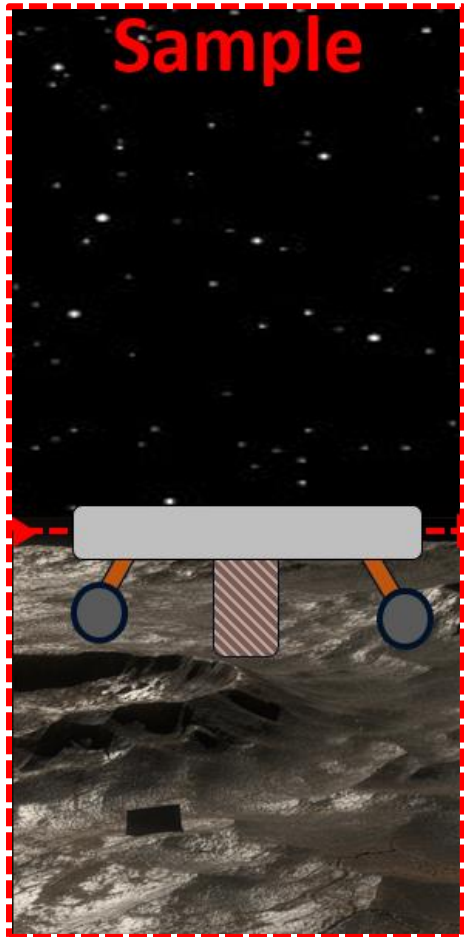
Assumptions

- Sampling system is on host of our choice
- Host begins on Psyche asteroid
- Host provides power to sampling system
- Host safely traverses to extraction points

Critical Functions:



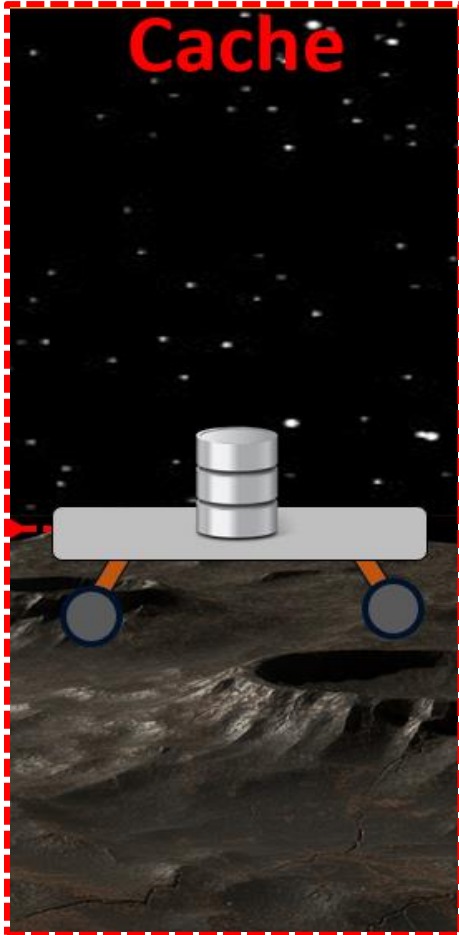
Sampling Function



- Two main sample types
 - Regolith
 - Subsurface materials

- Host will move to an optimal location for sample extraction

Caching Function



- Caching system seals samples between sample extraction and movement
- Stores 10 samples total
 - 1 Witness Sample
 - 1 Redundant Sample
 - 4 Regolith Samples
 - 4 Subsurface Samples

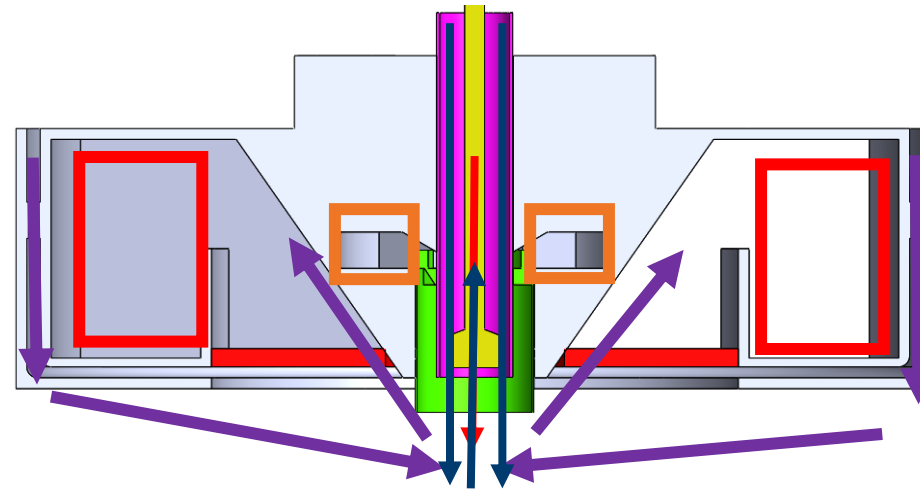
Transfer Function



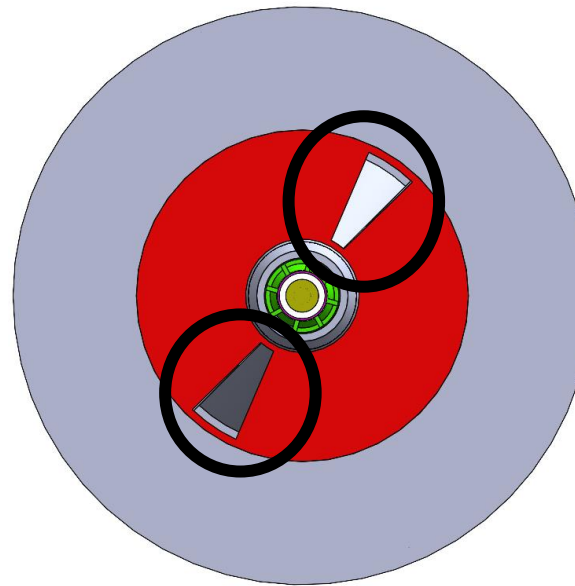
- Host moves to handoff site
- Sampling system prepared for handoff
- Team 502 will take over

Former Design

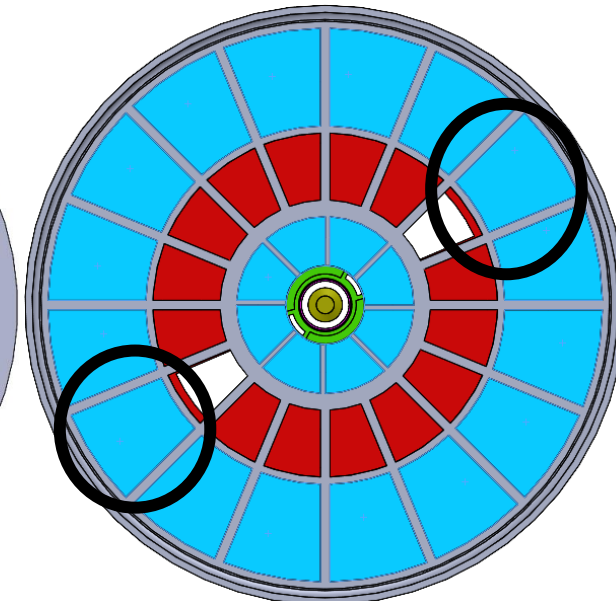
- Regolith collected with outer gas blast
- Grinding bit generates subsurface samples
- Center gas blast pushes subsurface samples into inner chambers
- 8 regolith samples and 4 subsurface samples



Vertical Cross-Section of Former Design



Bottom View of Former Design

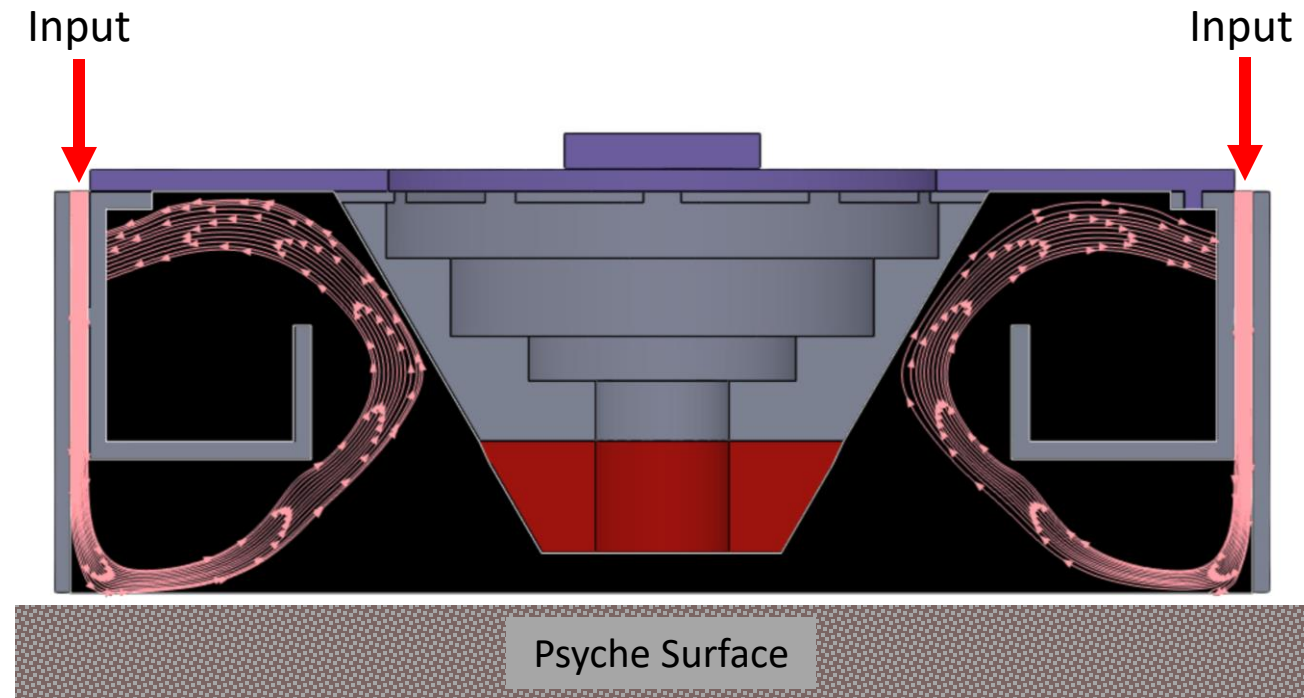


Horizontal Cross-Section Former Design

Gas Blast Simulation Iterations

Original simulation problem areas:

- Unable to perform a regolith sweep from drilling center
- Lack of curves for flow
- Filling two containment chambers each blast

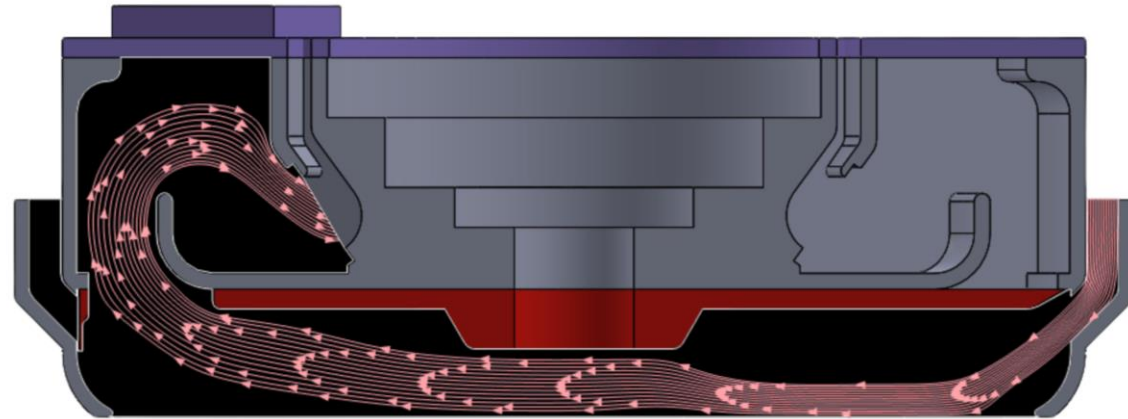


Iteration 1: Velocity Field Streamline Simulation

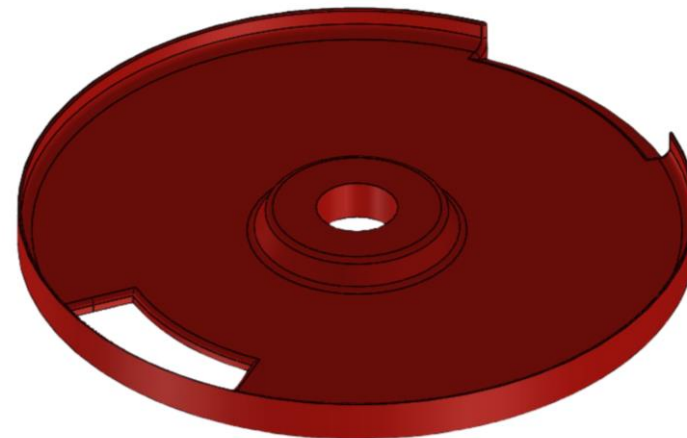
Gas Blast Simulation Iterations

Adjustments for current prototype:

- 1 input flow instead of 2
- Moved collection chamber entrances and vents
- Added curves to design
- Expanded rotating disk and flap size

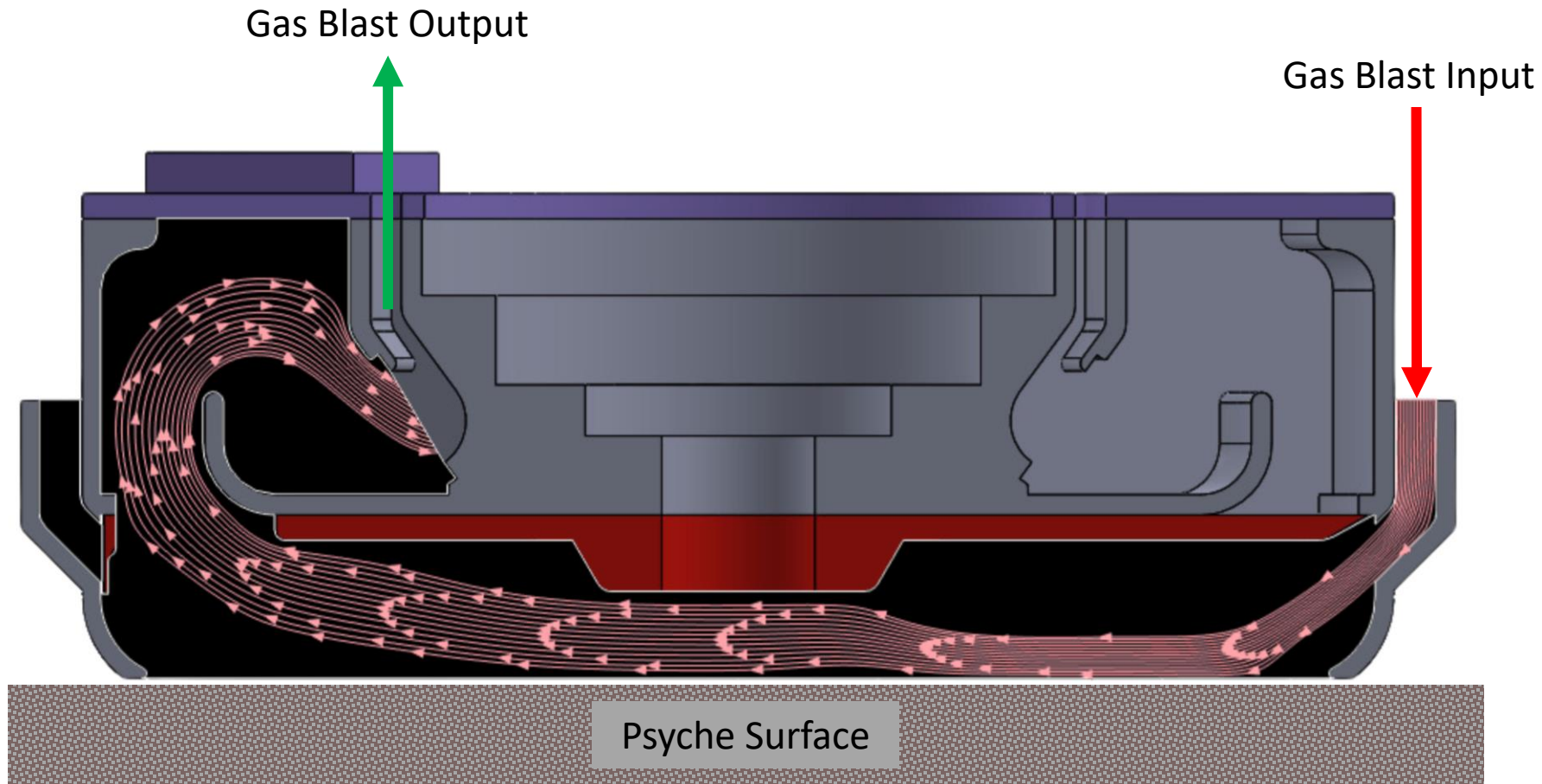


Current Iteration: Velocity Field Streamline Simulation



Bottom View of Rotating Disk

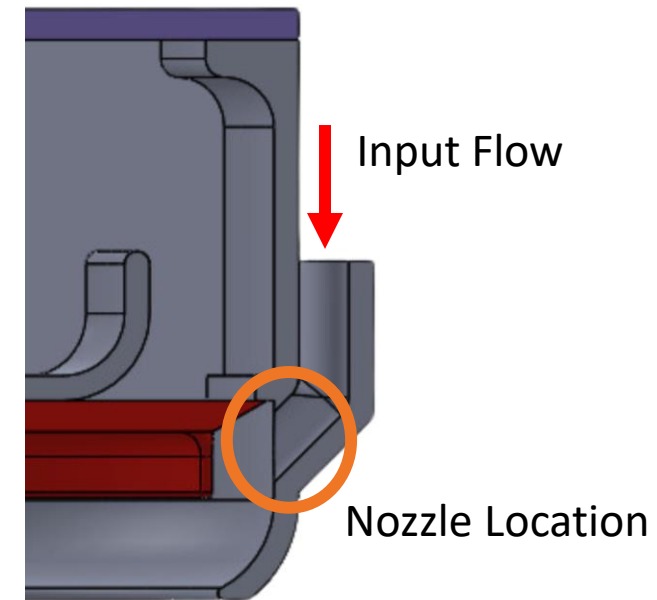
Current Gas Blast Flow Model



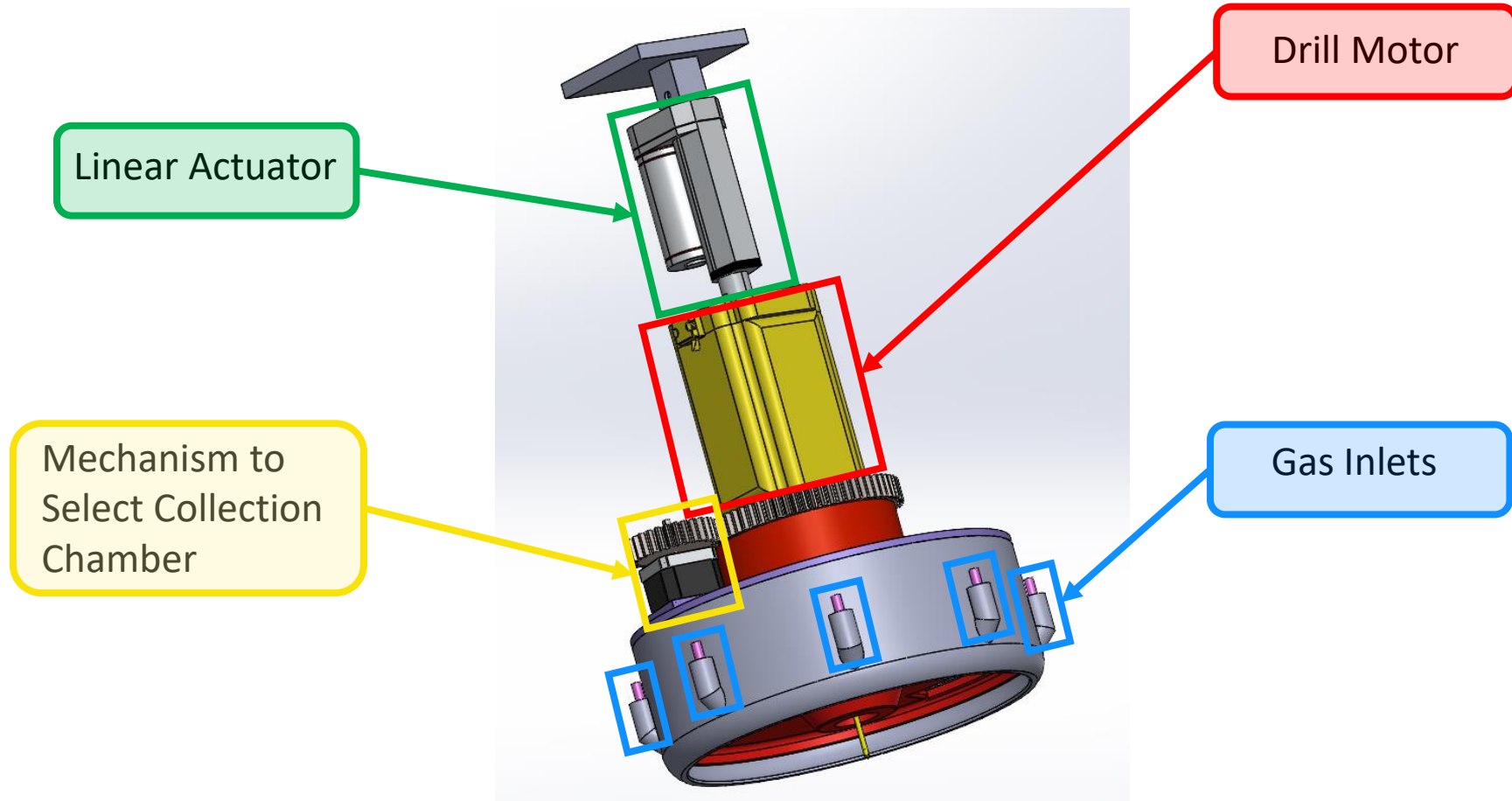
Velocity Field Streamline Simulation using $V = 50 \text{ m/s}$

Nozzle Geometry Selection for Regolith Mobilization

- Two nozzle concepts were evaluated to control the direction and magnitude of the gas blast:
 - a) Slot / Flat Jet Nozzle
 - Generates planar sheet of air
 - High near-surface shear over a wide area
 - Improves surface sweeping flow towards collector
 - b) Round Converging Nozzle
 - Generates axisymmetric jet
 - Higher centerline velocity
 - More localized particle agitation

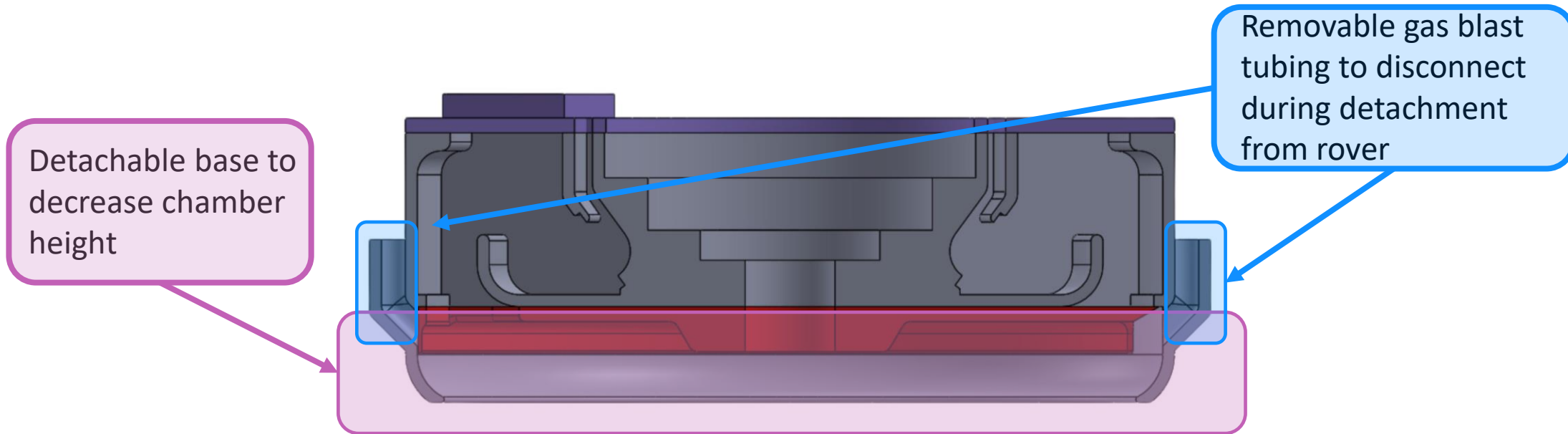


Current Design



Next Adjustments – Gas Blast

Goal: Decrease size to better integrate with T502's size constraints



Gas Blast Testing

Regolith Gravity Scaling

- Psyche bulk density: $4000 \frac{\text{kg}}{\text{m}^3}$
- Psyche gravity: $0.1 \frac{\text{m}}{\text{s}^2}$
- 2mm foam ball \approx 1.8 mm regolith



Drill Equations

- Step by step to determine drilling operation
- Heat generation from drill due to spinning
 - General Friction equation $Q_{friction} = F_f d$
 - Derived to $\Rightarrow \dot{Q}_{friction, drill\ bit} = F_N \mu \alpha 2\pi r N$
- Temperature increase over time
 - General Heat Transfer $Q = mc\Delta T$
 - Derived to $\Rightarrow \dot{T}_{friction, drill\ bit} = \frac{\dot{Q}_{friction, drill\ bit}}{mc}$
- Drilling determined to be “Touch & Go” method
 - Operation time of about 3 seconds



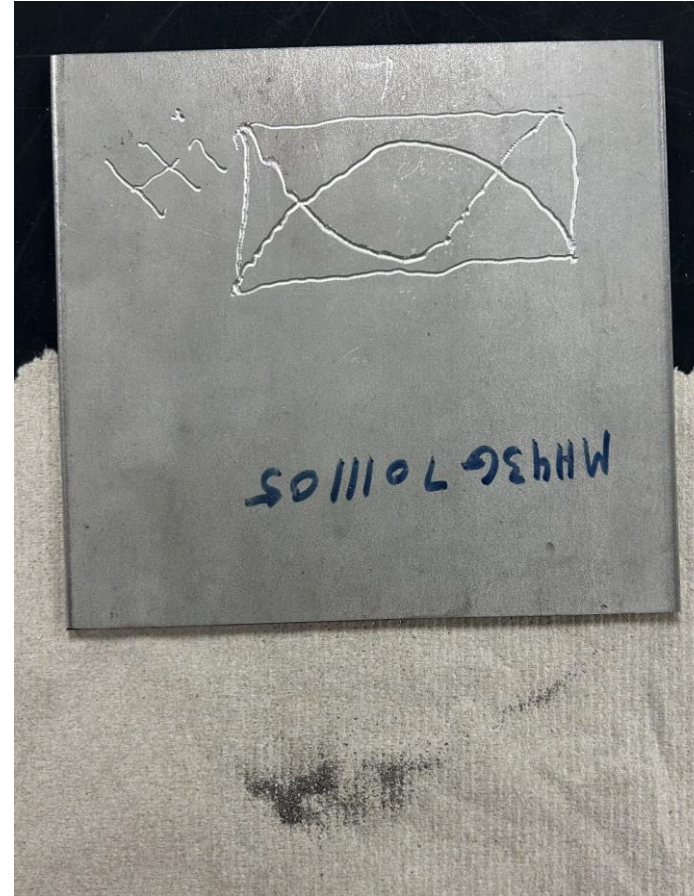
Metal Alloys for Drill Bits

- Best found material = PVD-Coated solid carbide drill bit
 - Possible coatings:
 - TiAlN – Titanium Aluminum Nitride
 - AlTiN – Aluminum Titanium Nitride
 - TiCN - Titanium Carbonitride
- Carbide keeps hardness and edge strength, resists abrasion, and greatly extends life when machining tough Ni-Fe Alloys

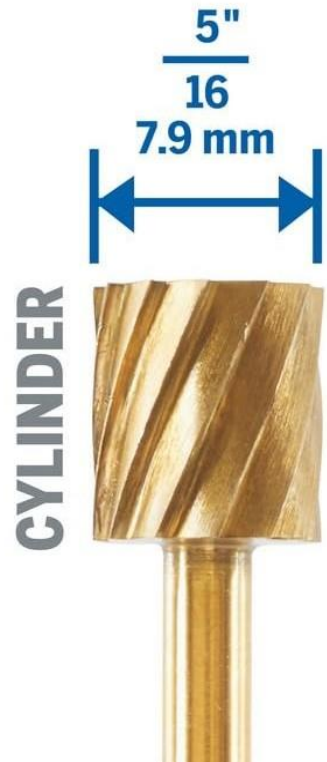


Initial Drill Bit Testing

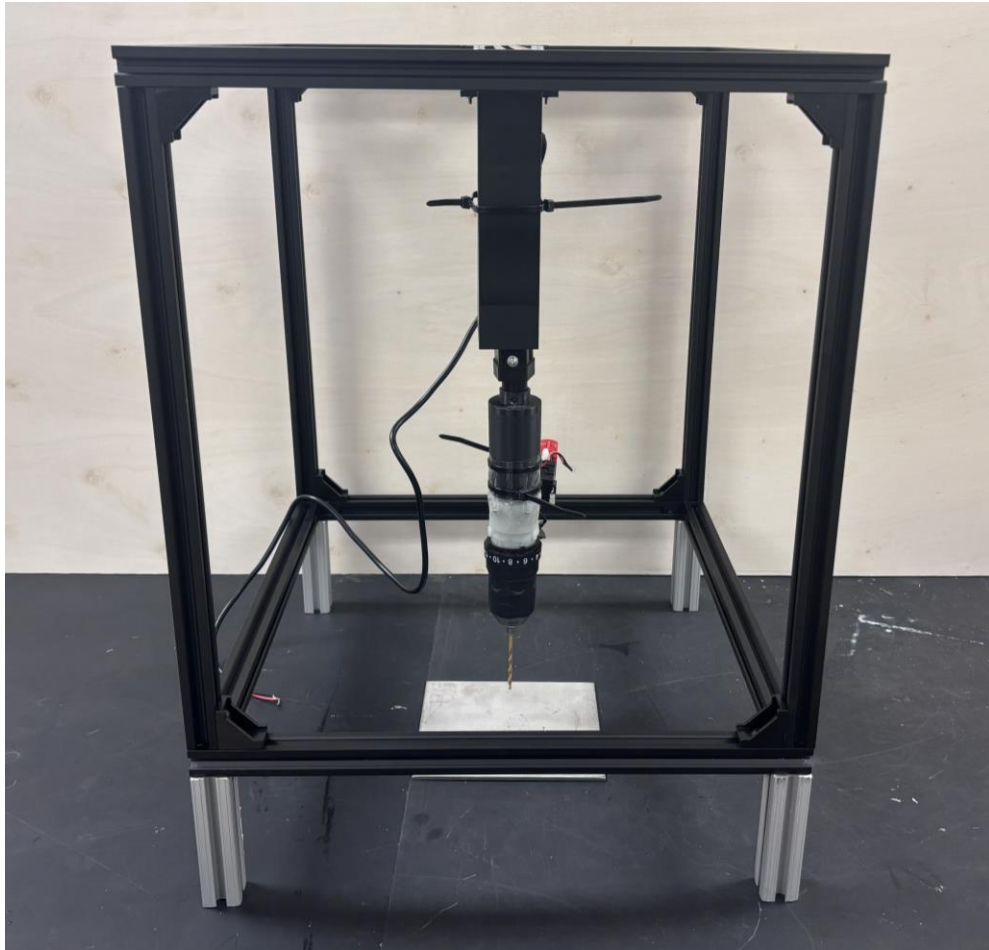
$\frac{1}{8}$
3.2 mm



Future Drill Bit Testing



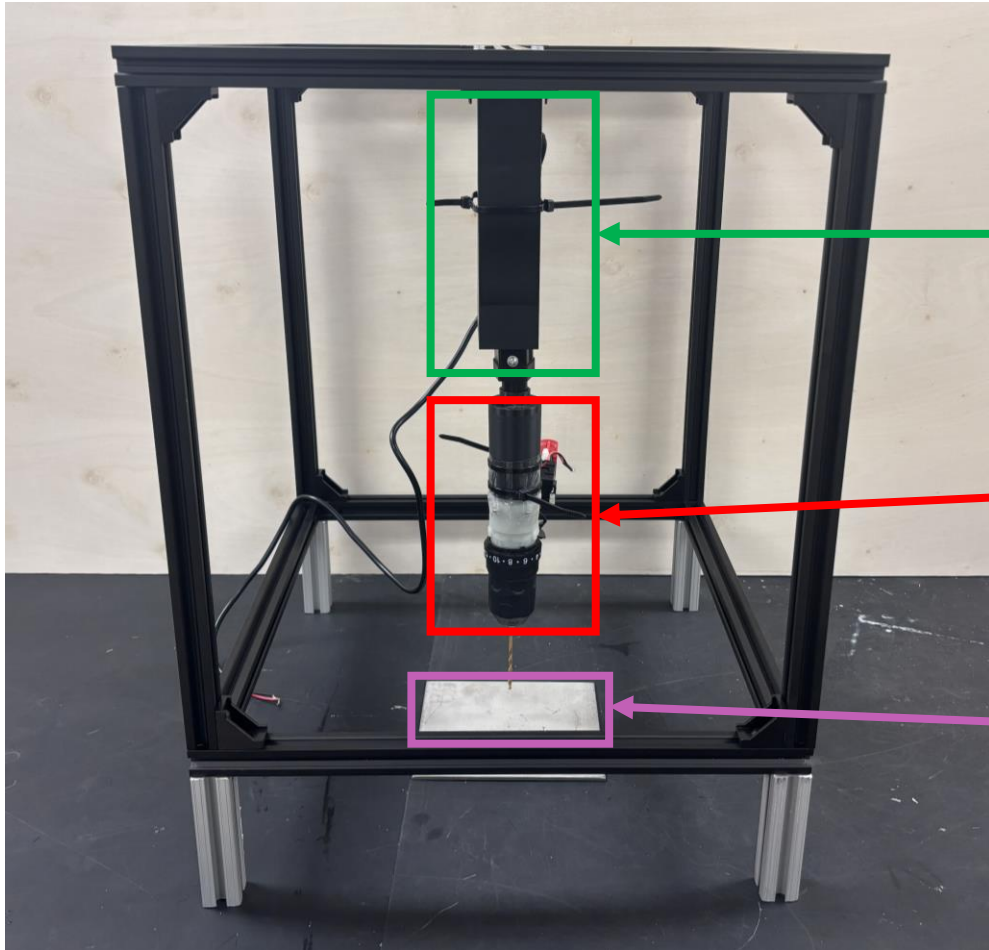
Motor Test-Rig Development



Test Purpose

- Chip generation rate
- Required downward force
- Drill bit temperature vs time
- Drilling duration to reach desired chip accumulation
- Overall system behavior

Motor Test-Rig Development

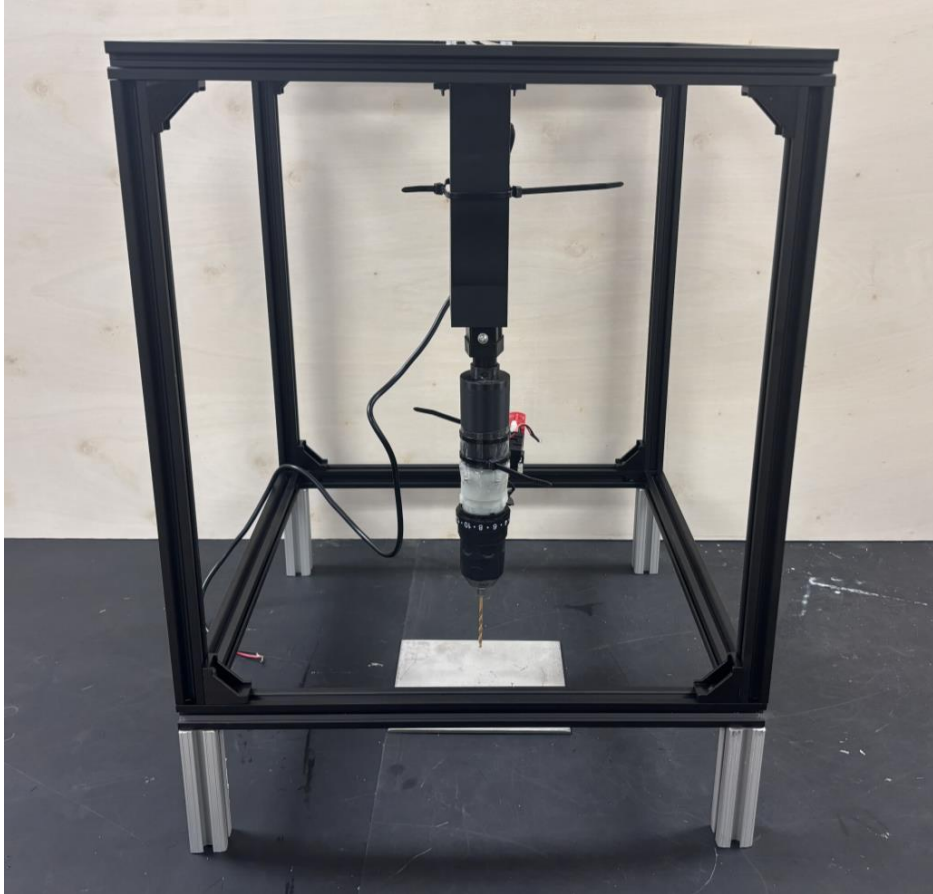


Linear Actuator

12V Drill Motor + Bit

Stainless Steel Plate

Motor Test-Rig Development



Required Equipment and Instrumentation

- Inline load cell(force measurements)
- IR Thermometer
- Mounts
- Chip Collection Tray
- Stopwatch
- Power Supply

Independent Variables

- Thrust force
- Motor feed rate
- Bit type
- Material type

Challenges and Risks

Reactive forces pushing away from Psyche

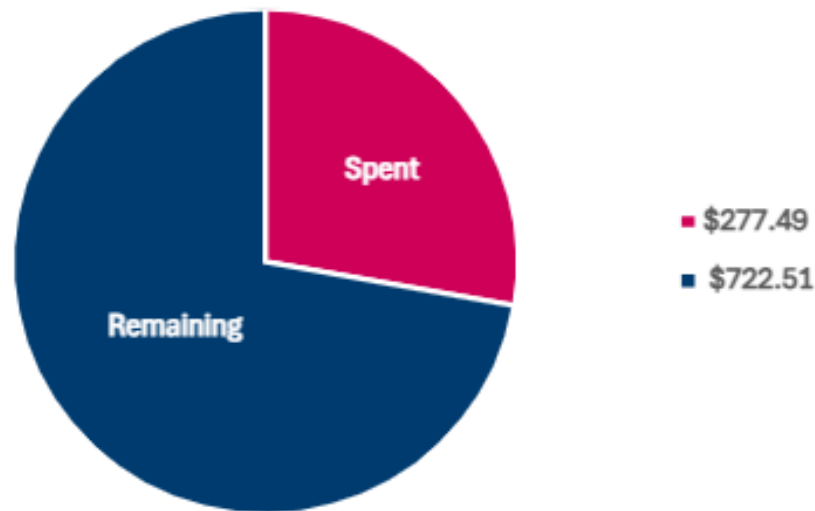
Meeting T502 Design Constraints

Contamination between samples

Drill overheating

Budget & Manufacturing Considerations

SD T501 Budget



- Exhausted about 27% of the budget thus far
 - Completes most of the gas blast system

Progress Timeline



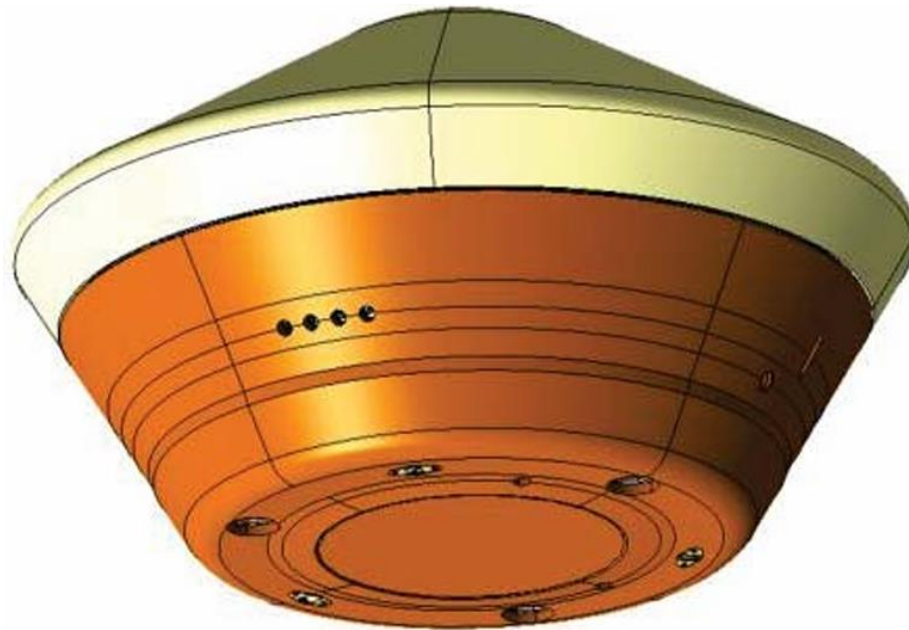
Questions?



Back Up Slides

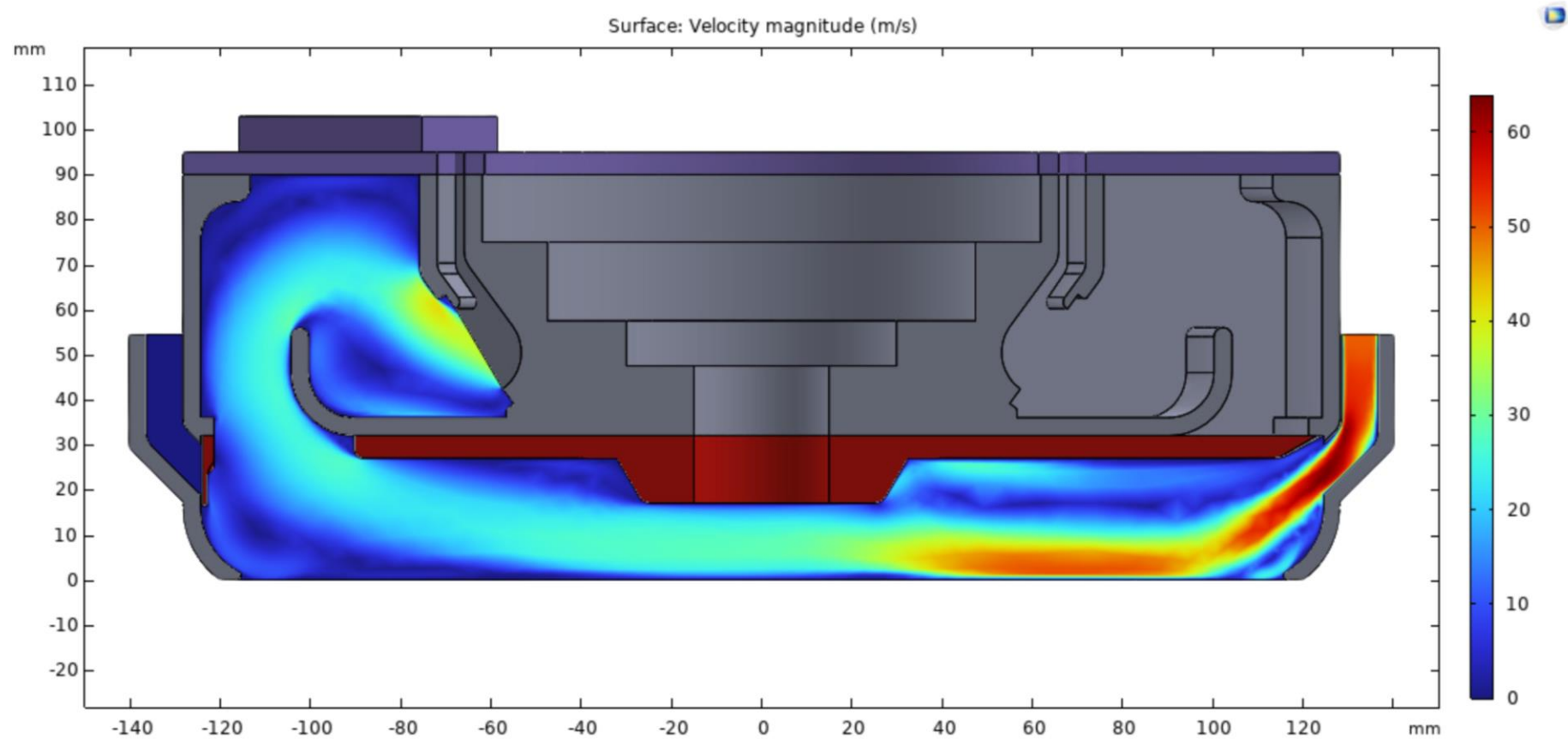


Integrating With T502



OSIRIS-REx: Returning the asteroid sample [PDF]. NASA/Lockheed Martin.

Current COMSOL Velocity Model



Friction Heat Rate Calculation

The given heat transfer rate resulting from a friction is governed by the equation

$$Q_{friction} = F_f d$$

Where F_f is the friction force, t is time, and d is the distance over which the friction acts upon. Given that the frictional force is unknown, we change the equation to a rate of heat equation

$$\dot{Q}_{friction} = F_N \mu v$$

Where F_N is the normal force, μ is the friction coefficient, and v is the sliding speed, which occurs at the interface. The sliding speed is also a variable, shown in the equation below

$$v = 2\pi r N$$

N is the number of revolutions per minute, and r is the radius of the drill bit. So, the expanded equation for the friction heat transfer is

$$\dot{Q}_{friction, drill\ bit} = F_N \mu 2\pi r N$$

It's important to know that specifically for a drill bit, the friction heat transfer does NOT equal the heat transfer on the bit. Instead, a drill bit gets a fraction of this heat transfer, which is determined by the drill bit's heat partition coefficient. For this analysis, we will denote this as α . Thus, the full equation for the friction heat transfer to the drill is denoted by

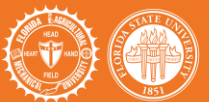
$$\dot{Q}_{friction, drill\ bit} = F_N \mu \alpha 2\pi r N$$

Regarding the coefficients, friction coefficient and heat partition coefficient cannot be calculated directly, thus they must be estimated. The friction coefficient is estimated to be 0.8 from a source that gives the coefficient value for Tungsten Carbide and Iron. A separate study suggests that coating has no large effect on friction coefficient, so we do not need to address the Titanium Nitride coating of the drill. As for the heat partition coefficient, this value has a range of 0.5-0.8 for an uncoated Tungsten Carbide Drill. We will estimate it to 0.65. With the assumed coefficients we get the equation

$$\dot{Q}_{friction, drill\ bit} = F_N (0.65)(0.8) 2\pi r N \Rightarrow$$

$$\dot{Q}_{friction, drill\ bit} = 1.04\pi F_N r N$$

$$\dot{Q}_{friction, drill\ bit} = 324.2\ J/s$$



Temperature Rate Calculation

We know that $\dot{Q} = 324.2 \text{ J/s}$. The mass of the drill is 0.00478 kg , with a heat capacity of $280 \left(\frac{\text{J}}{\text{kg}\cdot\text{K}}\right)$. The thermal energy of an object is given by:

$$\dot{Q} = mc\Delta T$$

So that,

$$\frac{dQ}{dt} = \frac{d(mcT)}{dt} \Rightarrow$$

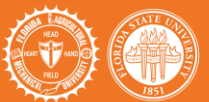
$$\dot{Q} = mc \frac{dT}{dt} \Rightarrow$$

$$\dot{Q} = mc\dot{T} \Rightarrow$$

$$\dot{T} = \frac{\dot{Q}}{mc} \Rightarrow$$

$$\dot{T}_{\text{friction, drill bit}} = \frac{\dot{Q}_{\text{friction, drill bit}}}{mc}$$

Hence, we know that the drill will increase by about 242 K per second.





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