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Psyche Asteroid Sample Acquisition
Team 501

Michael G., Conner H., Claudia I., Jake M., Janna R., Jerry R.

02/19/2026

Team 501: Introductions

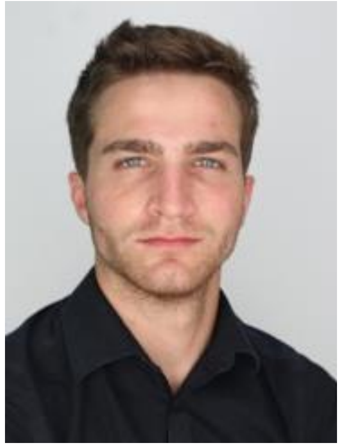
Michael Gregory
Mechanical Engineer

Jake Marcus
Design Engineer
Presenter

Claudia Irausquin
Structural Engineer
Presenter

Janna Rhodes
Test Engineer

Conner Holmes
Robotics Engineer



Jerry Richardson
Systems Engineer
Presenter

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Sponsor and Advisor

Dr. Cassie Bowman
Project Sponsor

PSYCHE NASA Arizona State University

Dr. Shreyas Balachandran
Faculty Advisor

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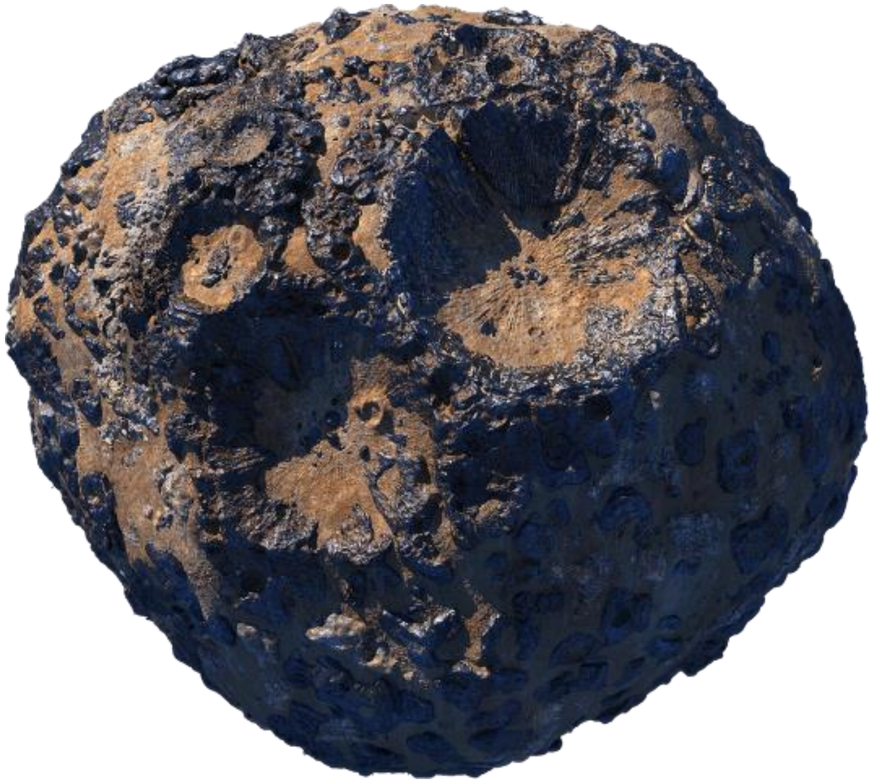
NASA Rendering of Asteroid (16) Psyche

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.

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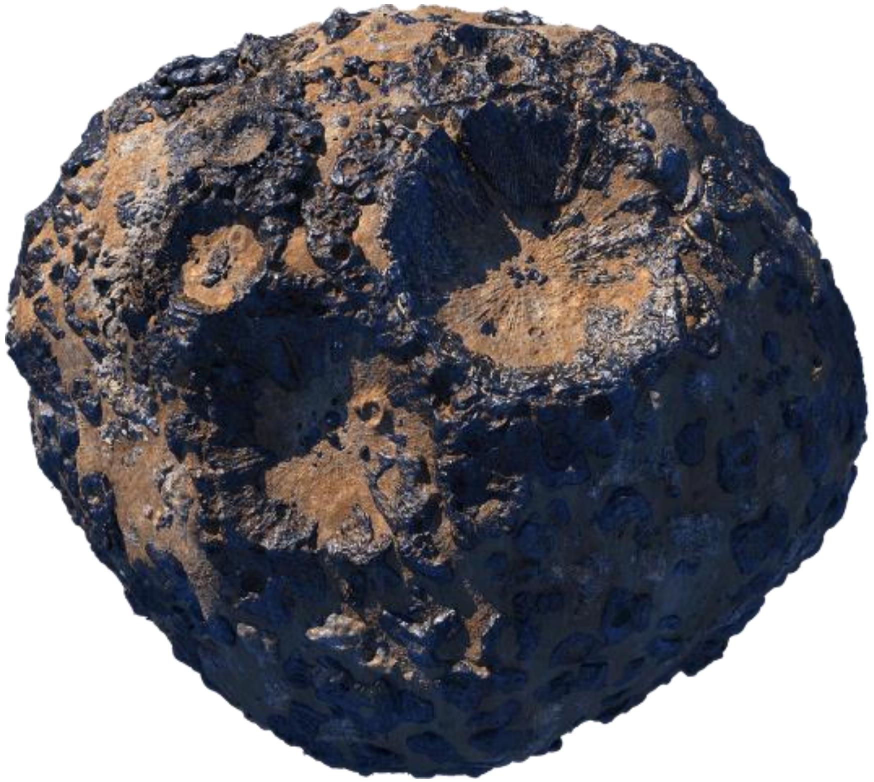
Background

- 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

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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

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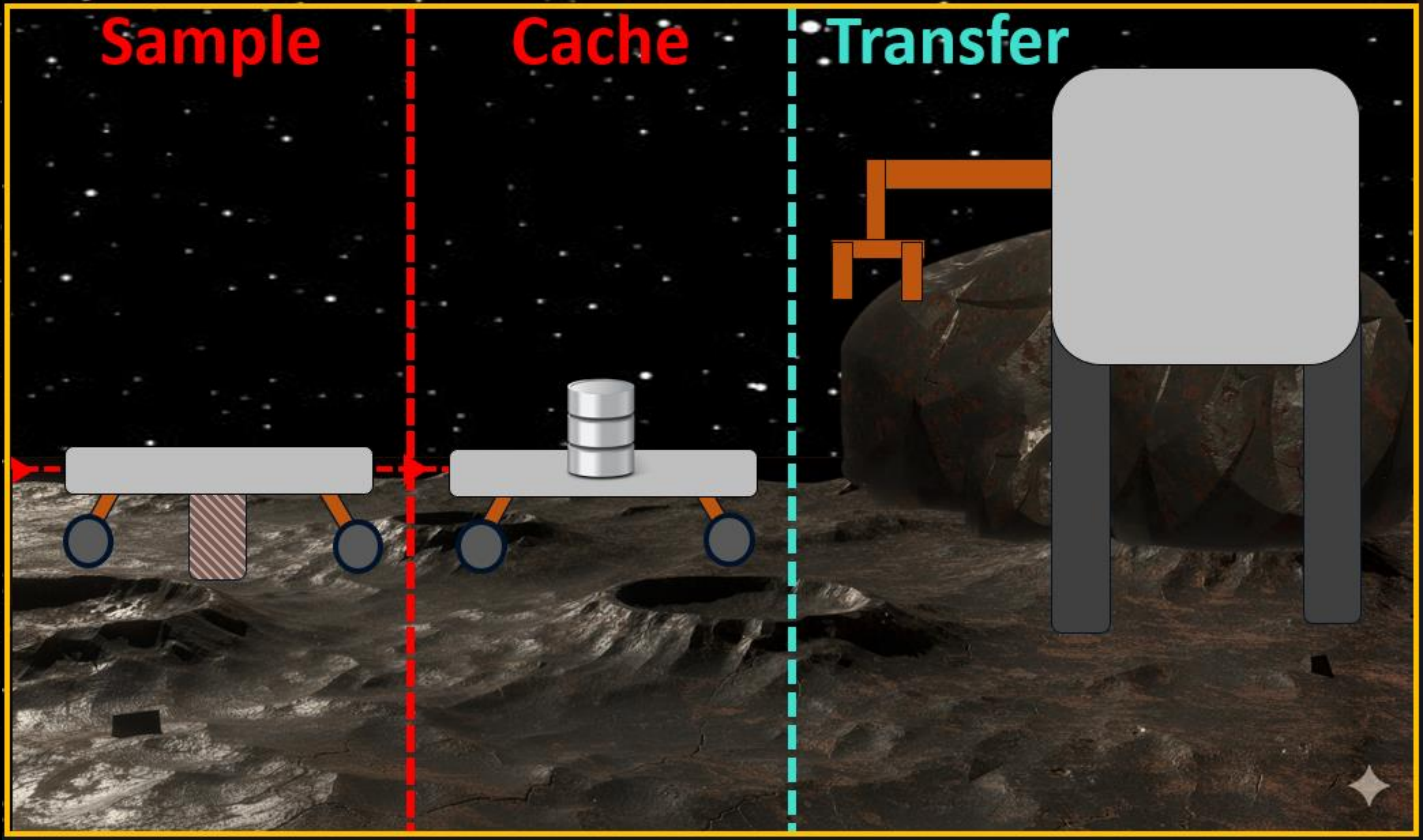
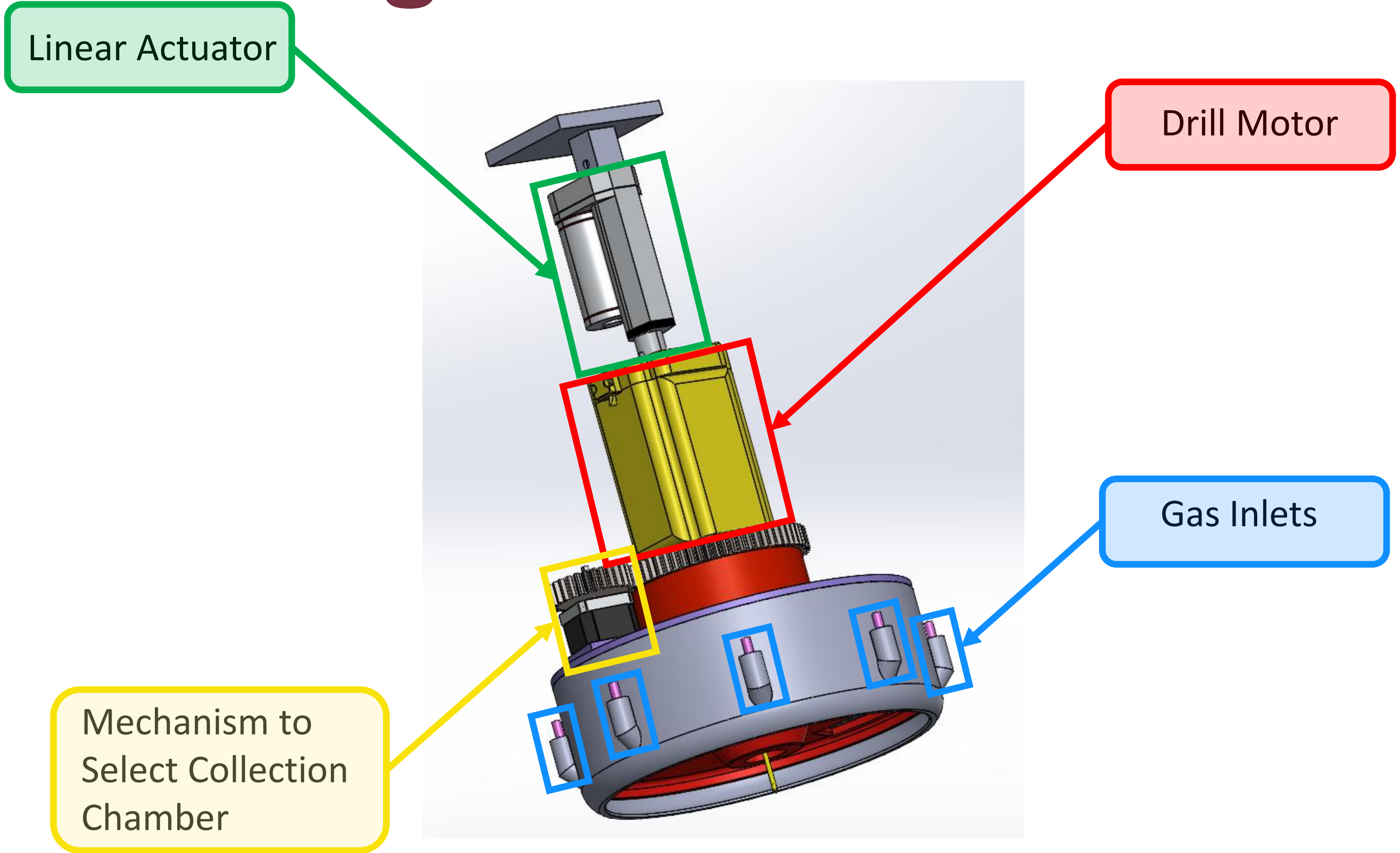
Critical Functions:



Jake Marcus

VDR4 Design



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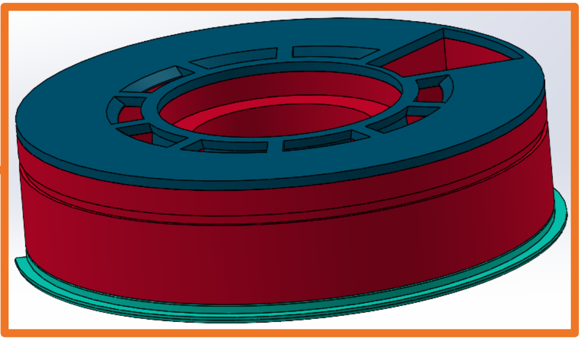
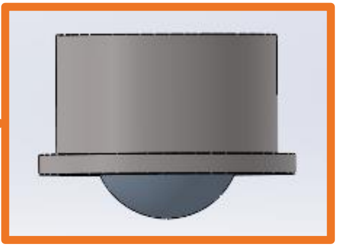
Changes Needed

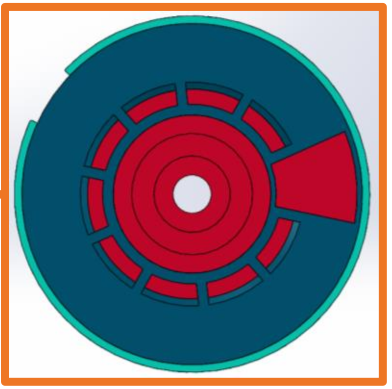
Attachment and detachment mechanism



Introduce bearings to eliminate rotational friction



Increase number of sampling chambers



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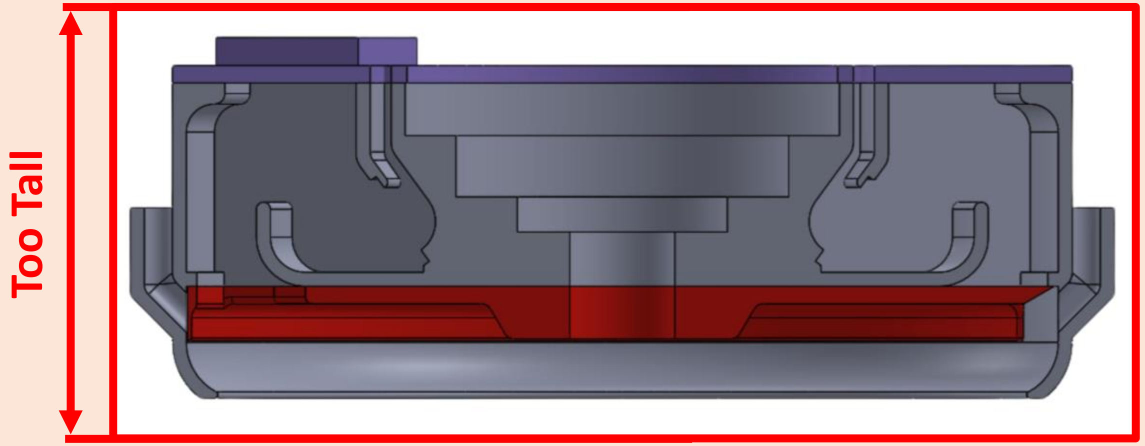
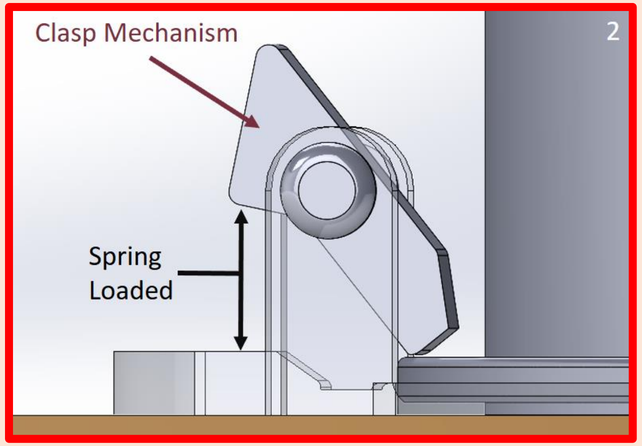
Changes Needed

Meet team 502's specifications

- Cache max height=78mm
- Compatible with end defector and locking into the SRC



Old Cross Section



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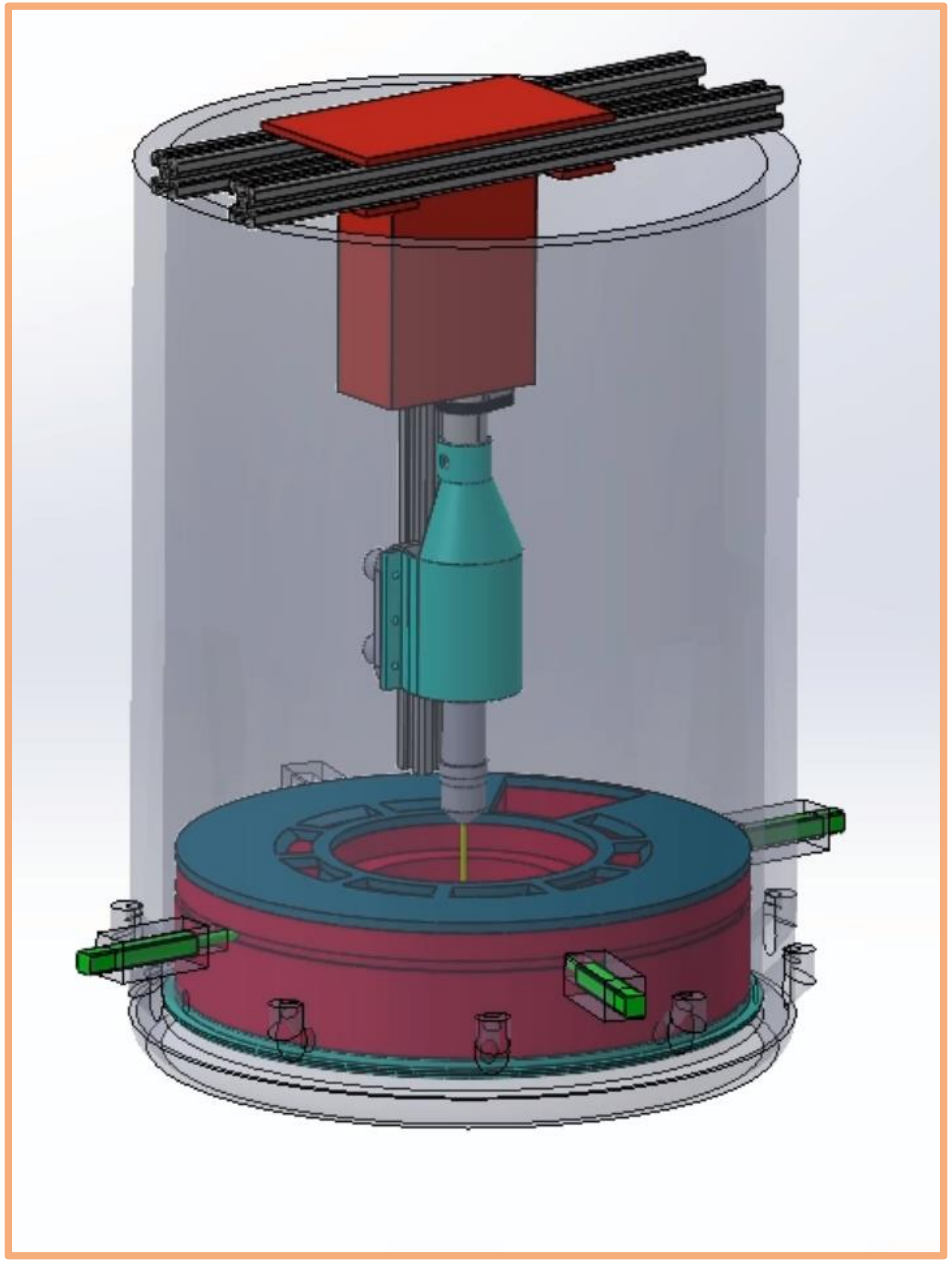
Current Design



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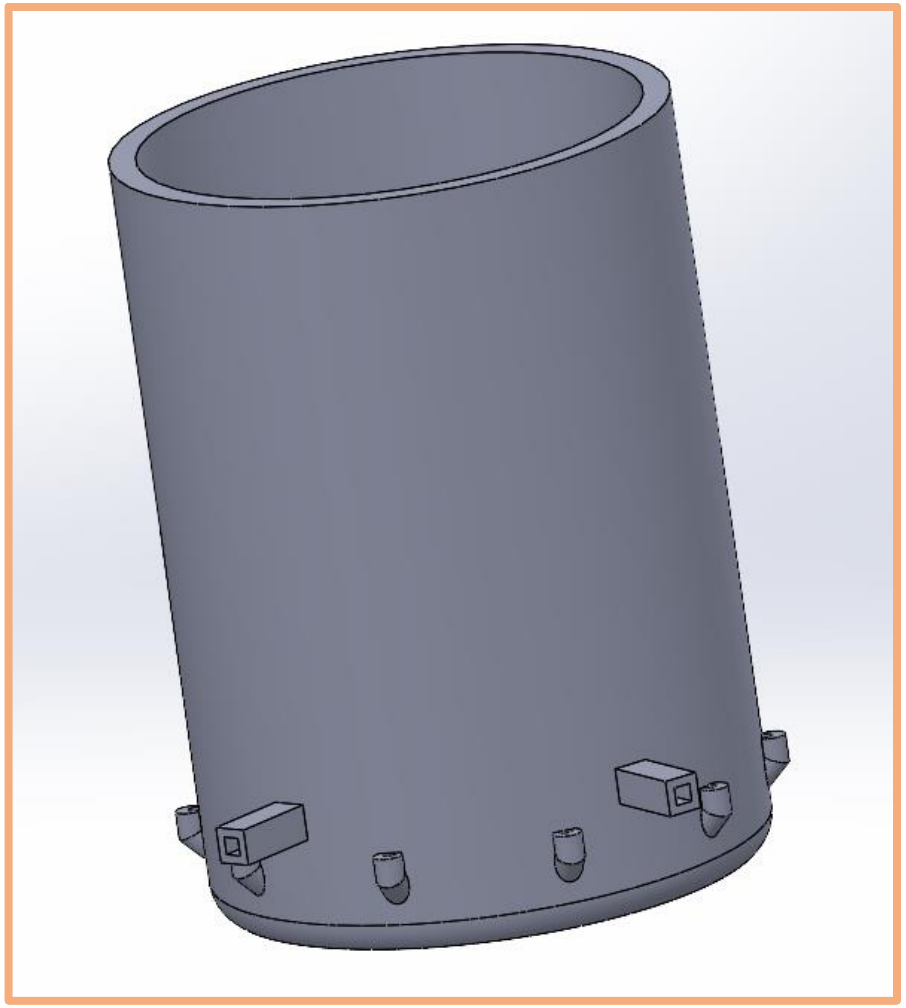
Housing Capsule



Housing
- Cache
- Detachment mechanism
- Gas blast system
- Motor assembly

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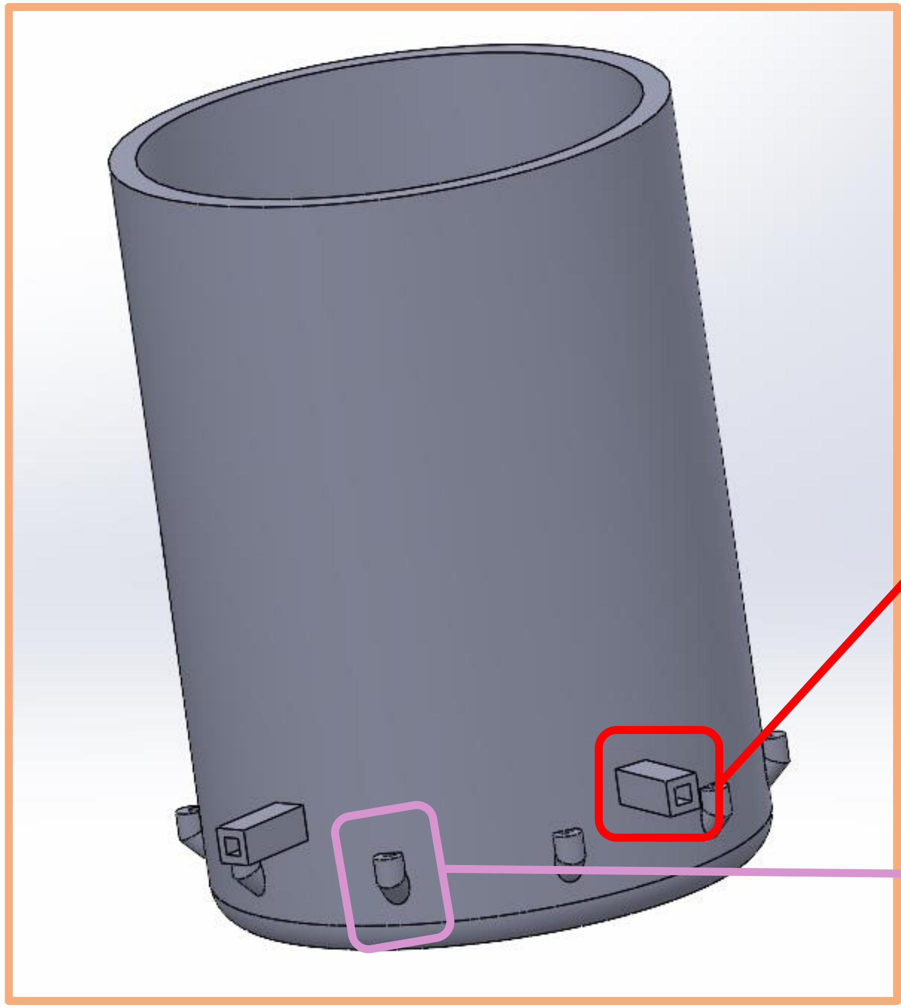
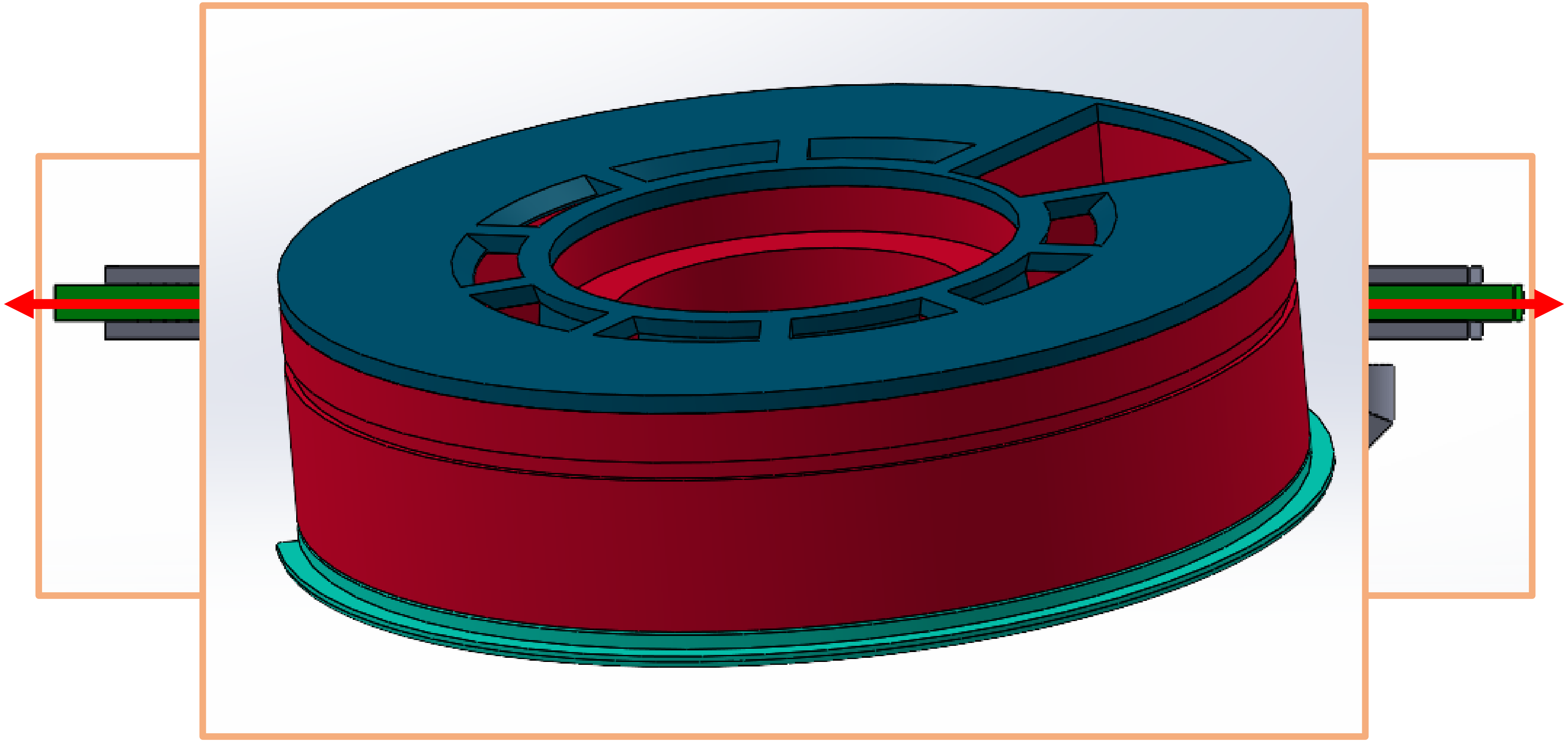
Housing Capsule



Electro Magnetic Actuator Housing

Gas Inlets

Detachment Mechanism



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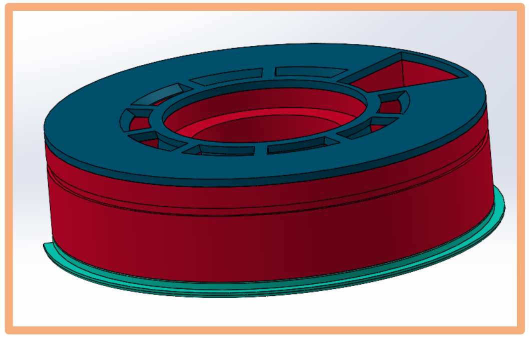
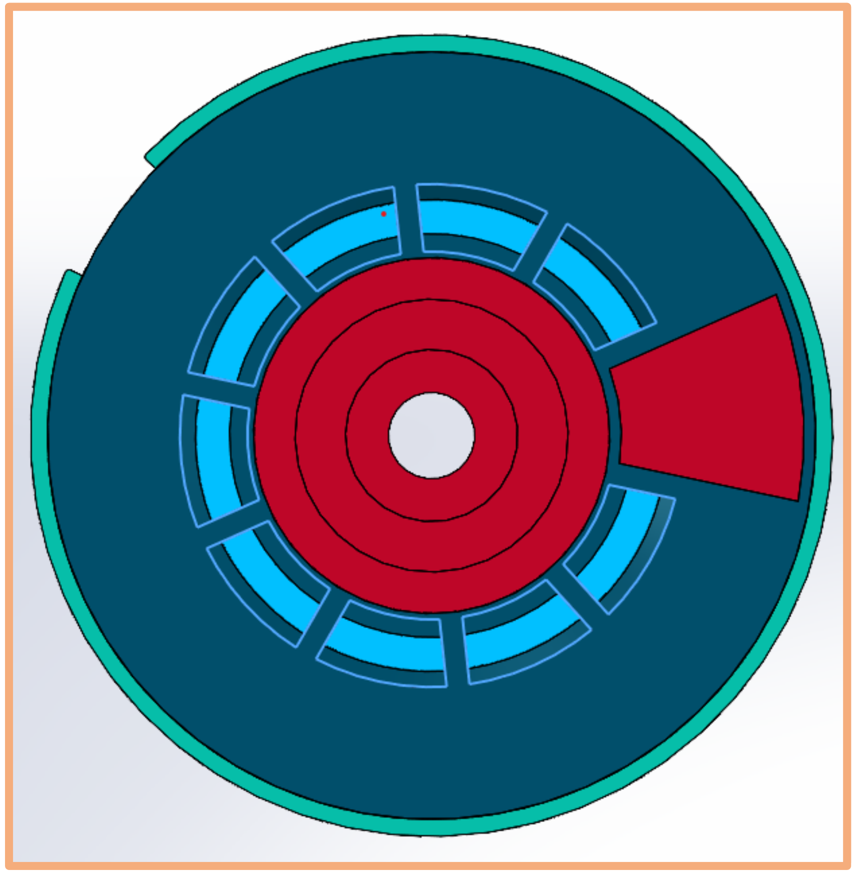
Changes made to cache



TOP VIEW



9 sample chambers

- 8 for collection 1 for clean out

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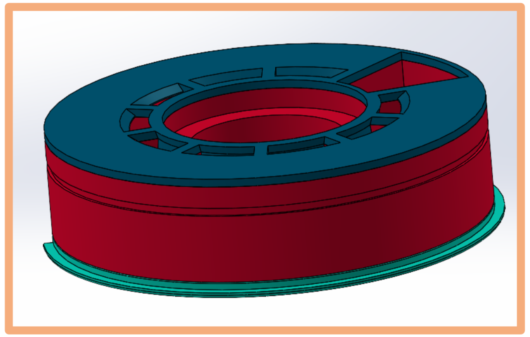
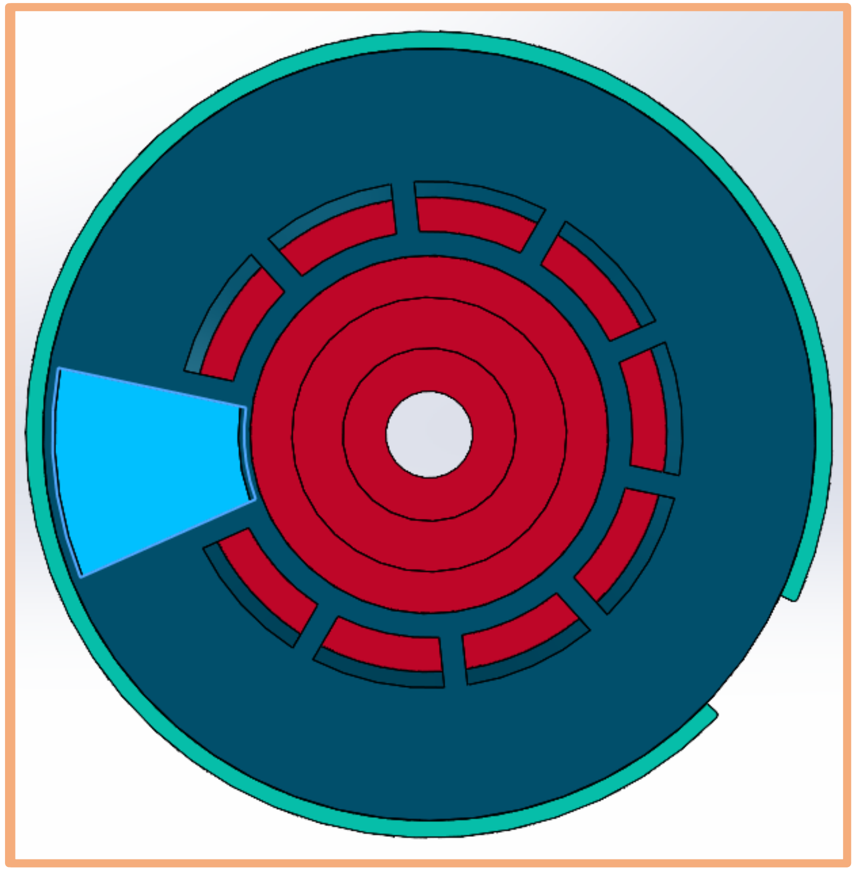
Changes made to cache

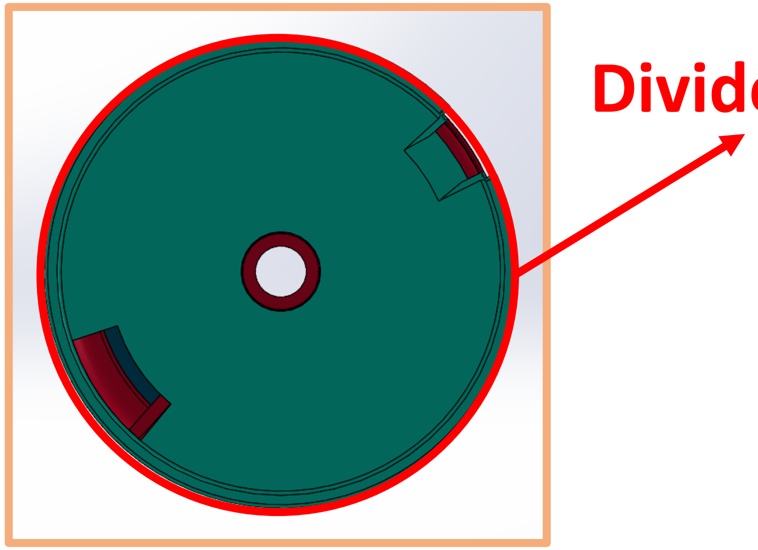


TOP VIEW



Chamber responsible for housing the **divider flap** rotating mechanism

Divider flap



BOTTOM VIEW

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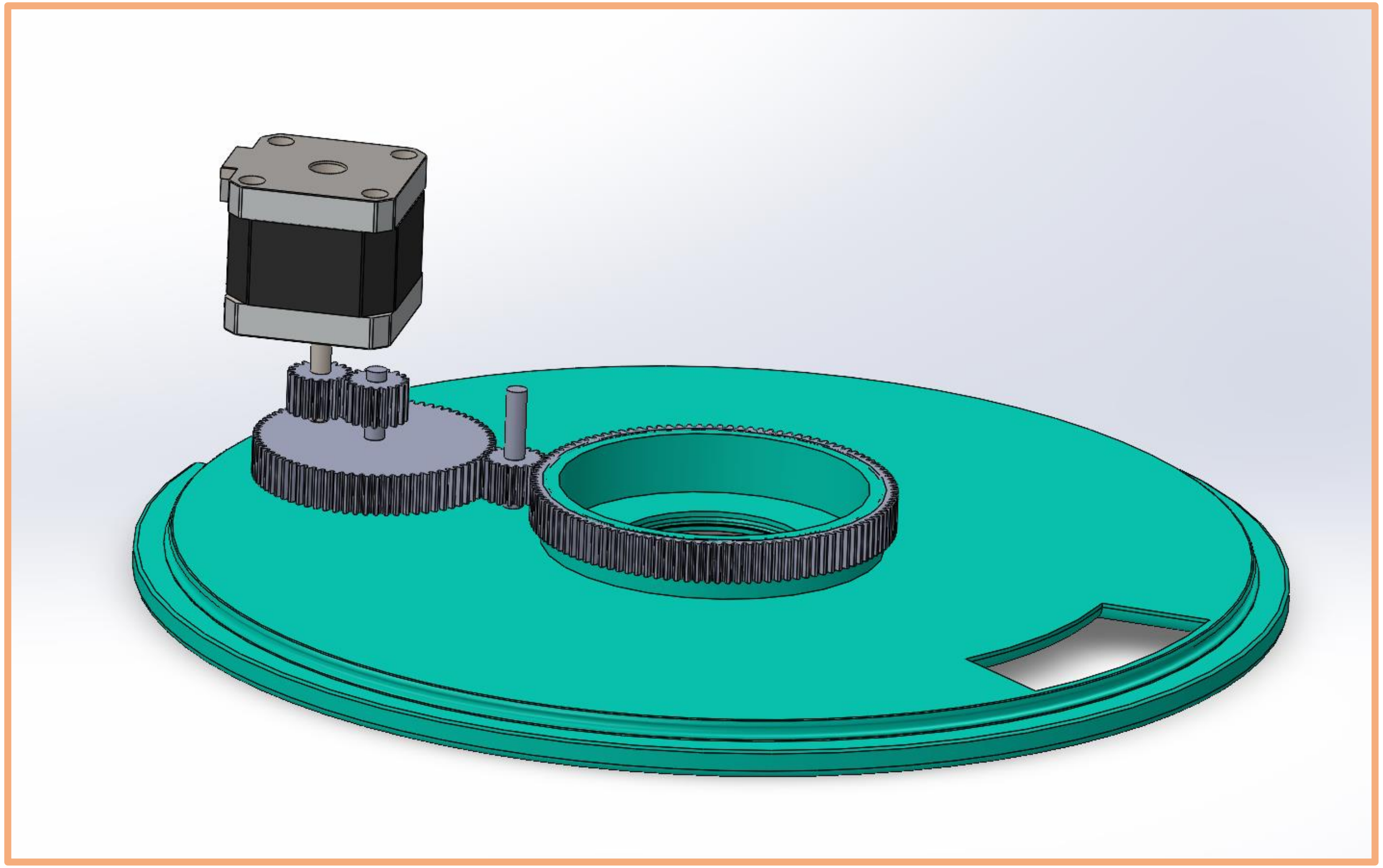
Divider flap rotating mechanism



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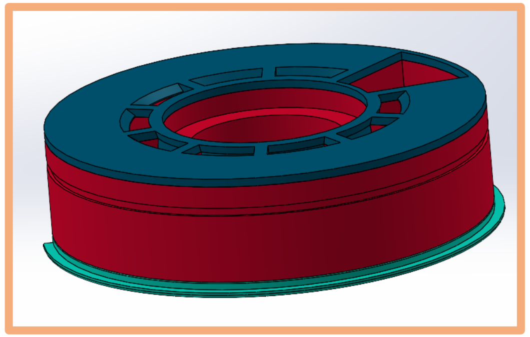
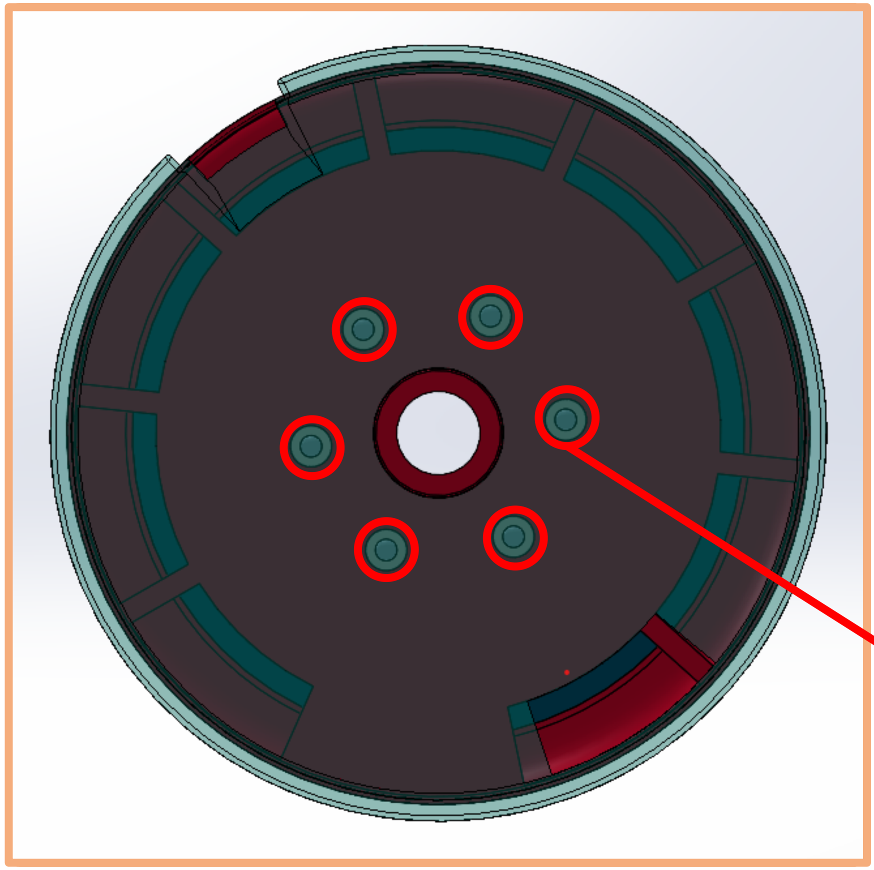
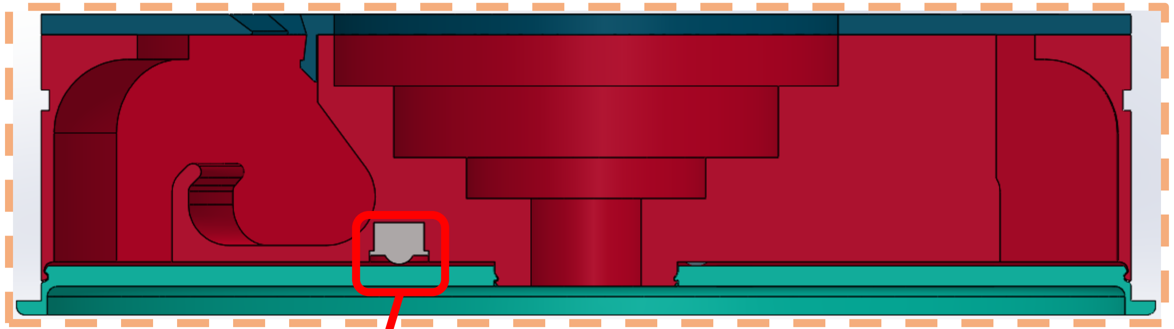
Changes made to cache

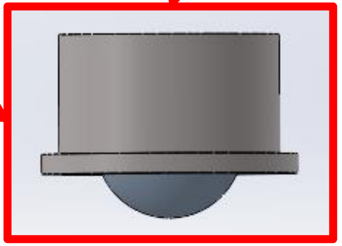


BOTTOM VIEW



Cross Section View





Roller Bearing

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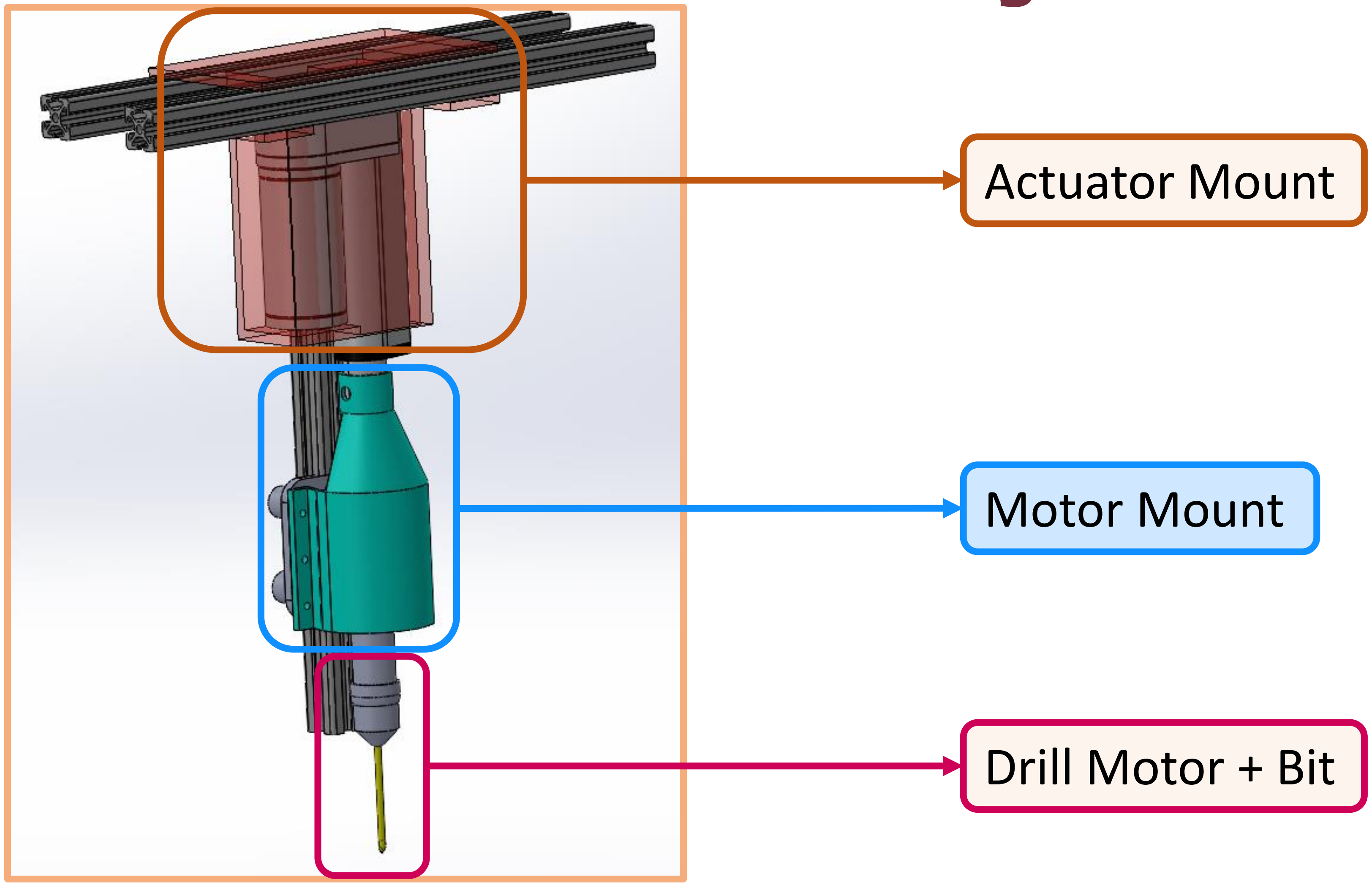
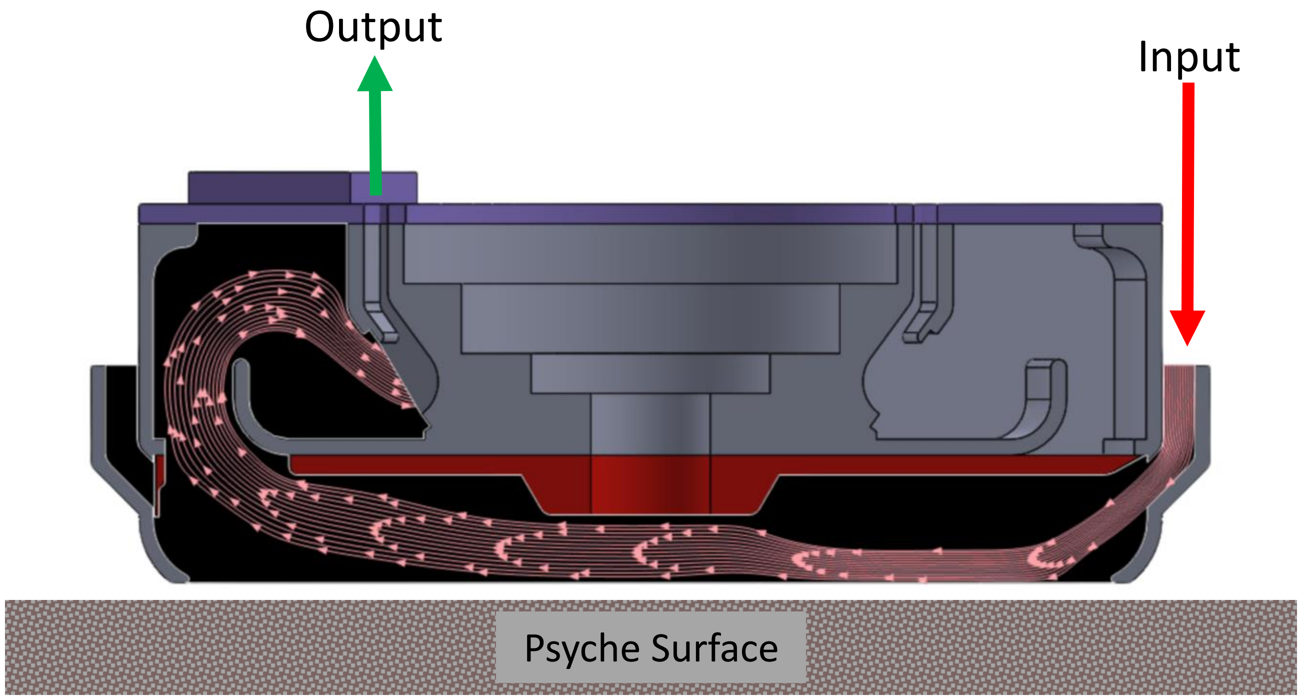
Drill Mount Assembly



Flow Design Updates

- Optimized vent placement to improve internal circulation
- Adding transitions to reduce flow separation and increase mass flow
- Enlarged rotating disk and flap geometry to enhance particle mobilization



VDR5 Iteration: Velocity Field Streamline Simulation

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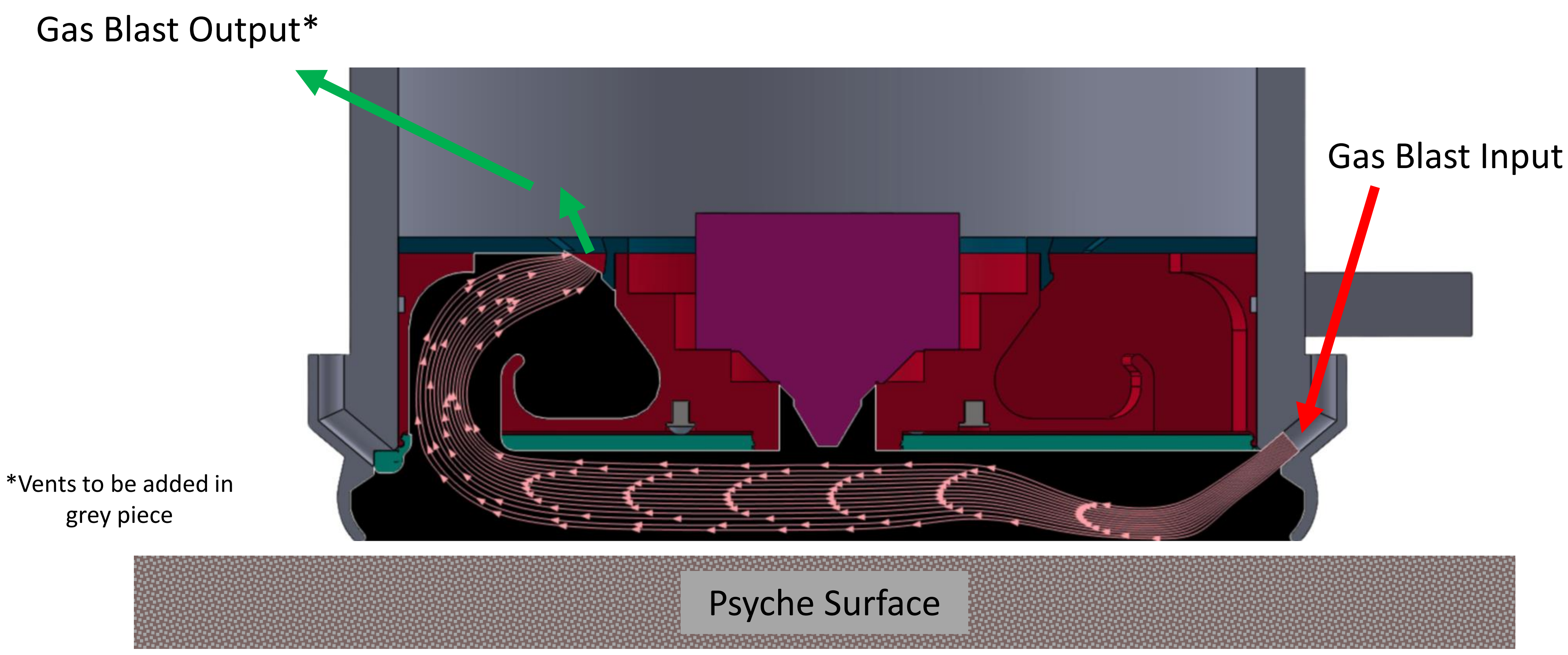
Current Gas Blast Flow Model



Velocity Field Streamline Simulation using V = 50 m/s

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Jerry
Richardson

Blast Nozzle Considerations

Goal:
Mobilize Surface Particles

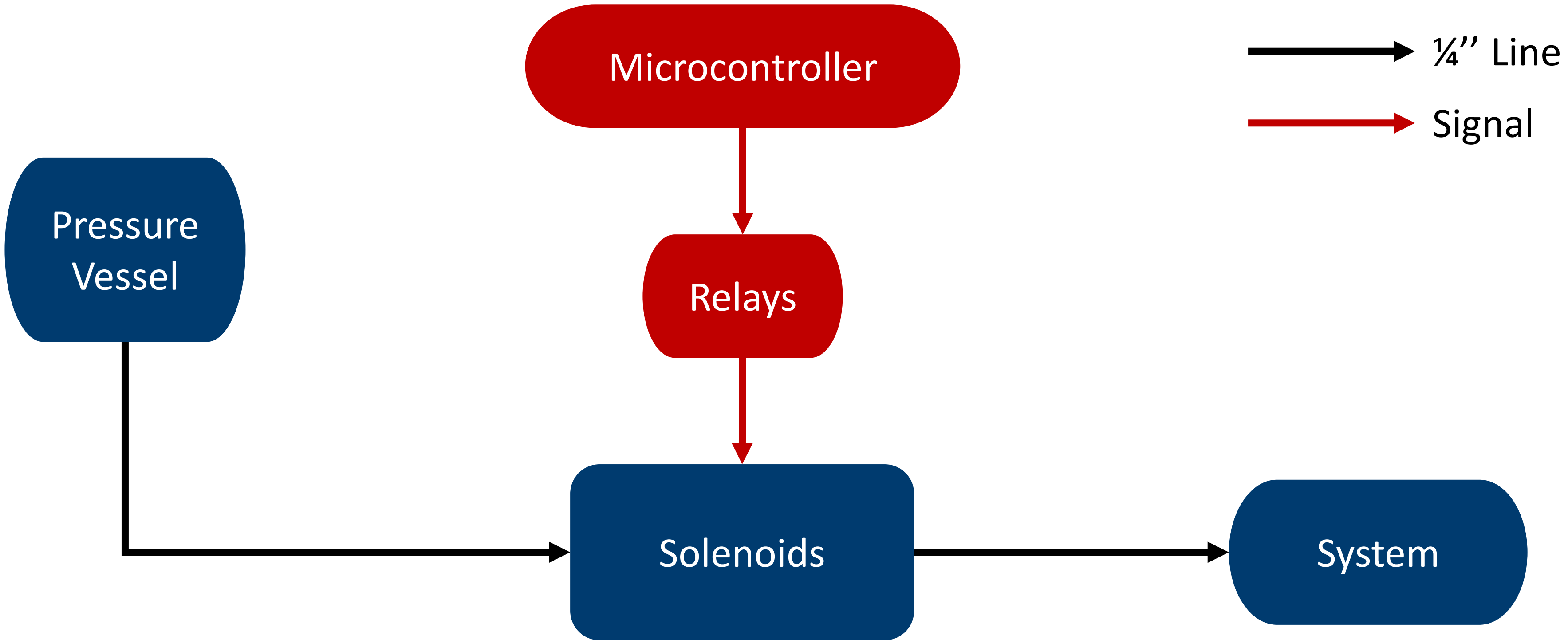
Constraint:
Minimize net thrust on rover

Given:
Pressurized tank discharge in vacuum environment

Optimal Configuration: Converging Outlet
- Choked, limited velocity
- Reduced thrust magnitude
- Simpler and lighter

Jerry
Richardson

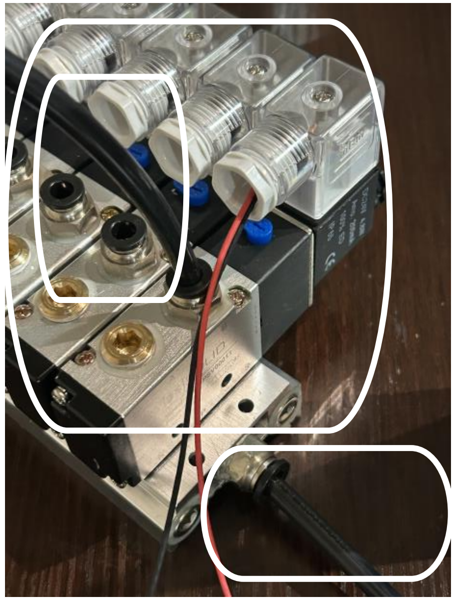
Blast Architecture



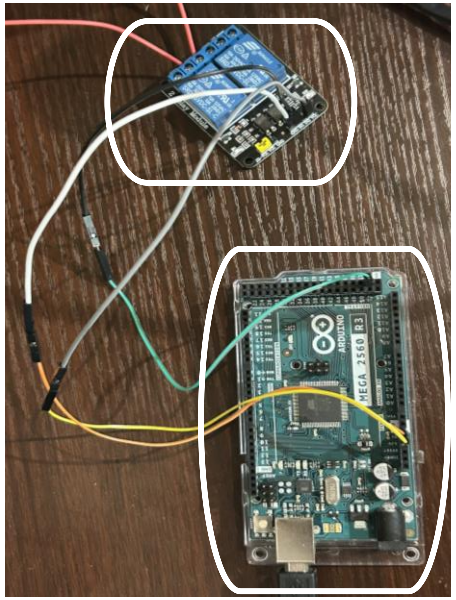
Jerry Richardson

Blast Assembly & Testing

- Pressure Vessel
- Secondary Regulator
- Supply Line



- Supply Line
- Solenoid Bank
- Feed Line



- Microcontroller
- Relay

Blast Design Validation

Electrical Verification

- MC successfully actuates relays
- Solenoids open/close under load

Flow Validation

- Velocity field confirms internal circulation
- Optimized vent placement reduces separation
- Converging outlet selected to reduce thrust

Mechanical Readiness

- Blast architecture assembled and bench tested
- Nozzle geometry finalized

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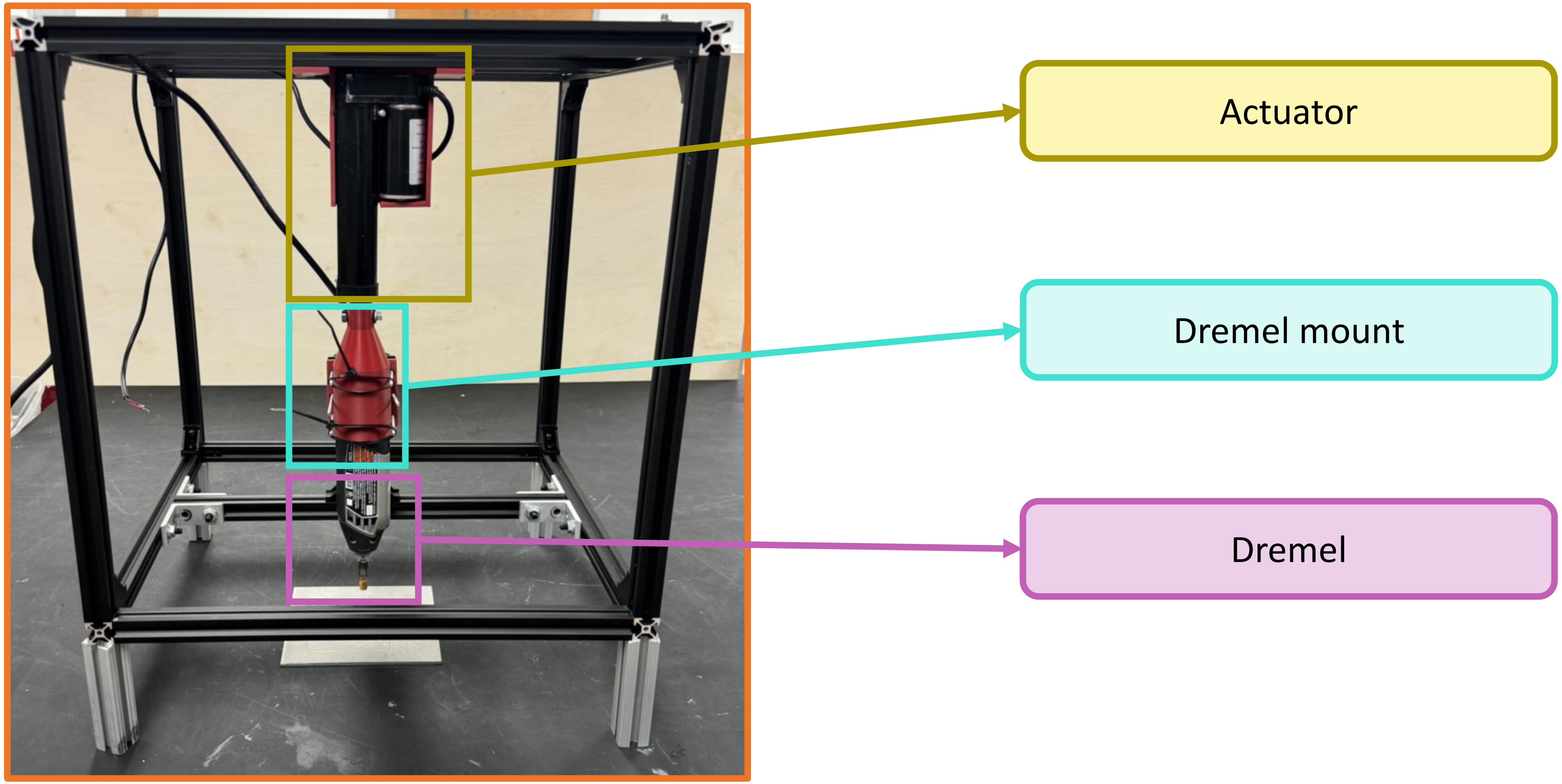
Drill Test Updates



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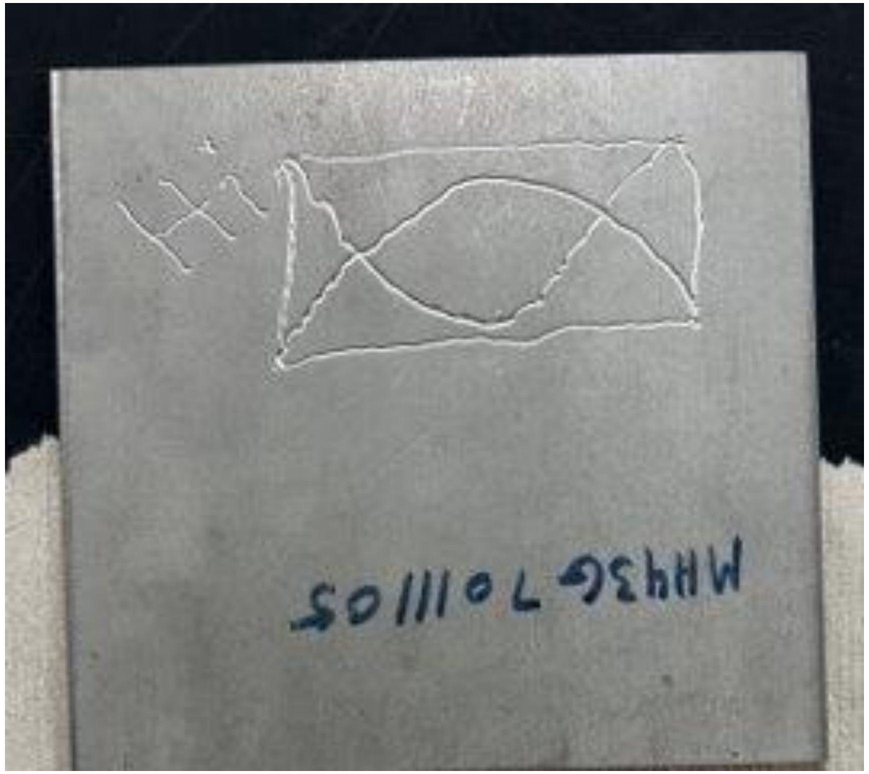
Motor Testing Problems

- Drill was not 100% secure in test-rig
- Stalling issues
  - Indicated lowering speed was too quick
- Chips not generating
  - Suggested drill shape was not optimal
- Test-rig needed to be secure & properly to have repeatable results
  - Ideally before trying new drill shapes



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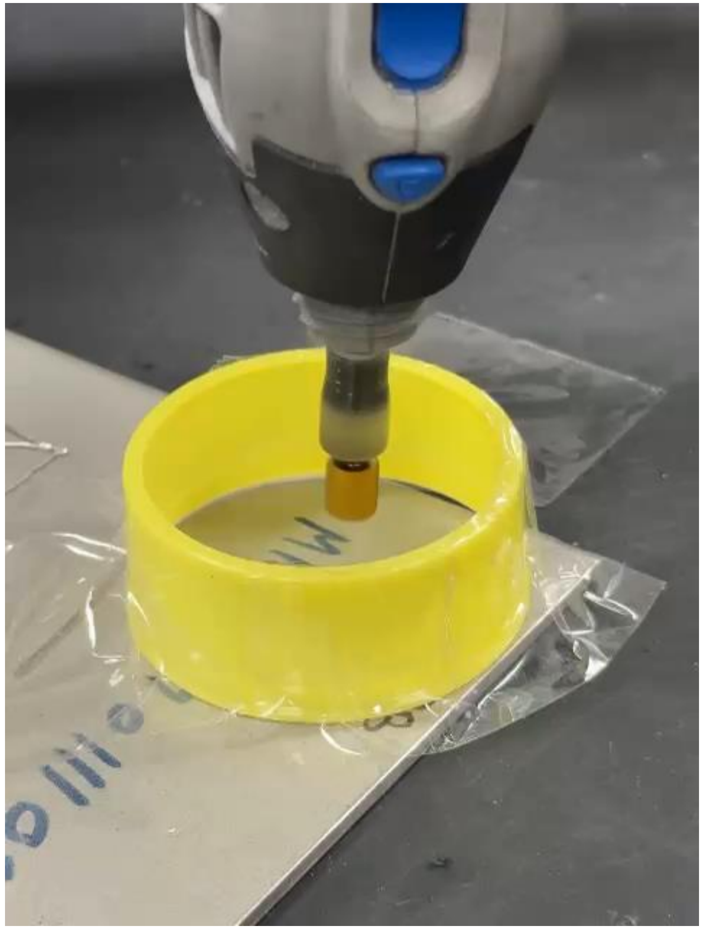
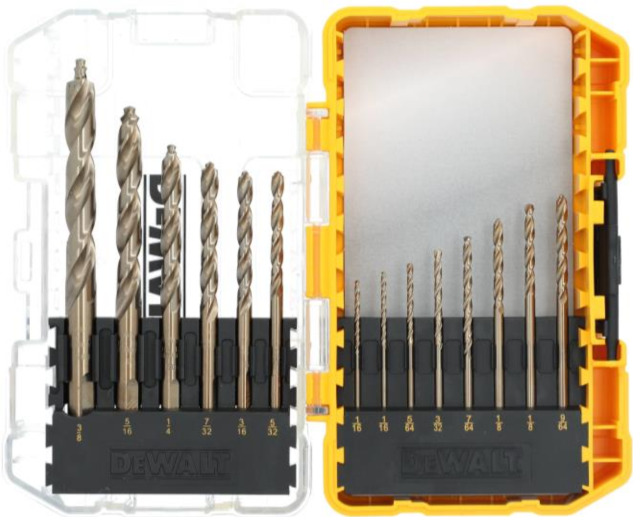
Old Motor Testing



Drill Updates

- Old shapes were barely scratching & not as accurate
  - Tungsten Carbide
  - Engraving & boring type
- Further research into different drill heads
- Pilot head
  - Prevents slipping
- Cobalt Alloy Steel material
  - Can also work for Cryogenic applications



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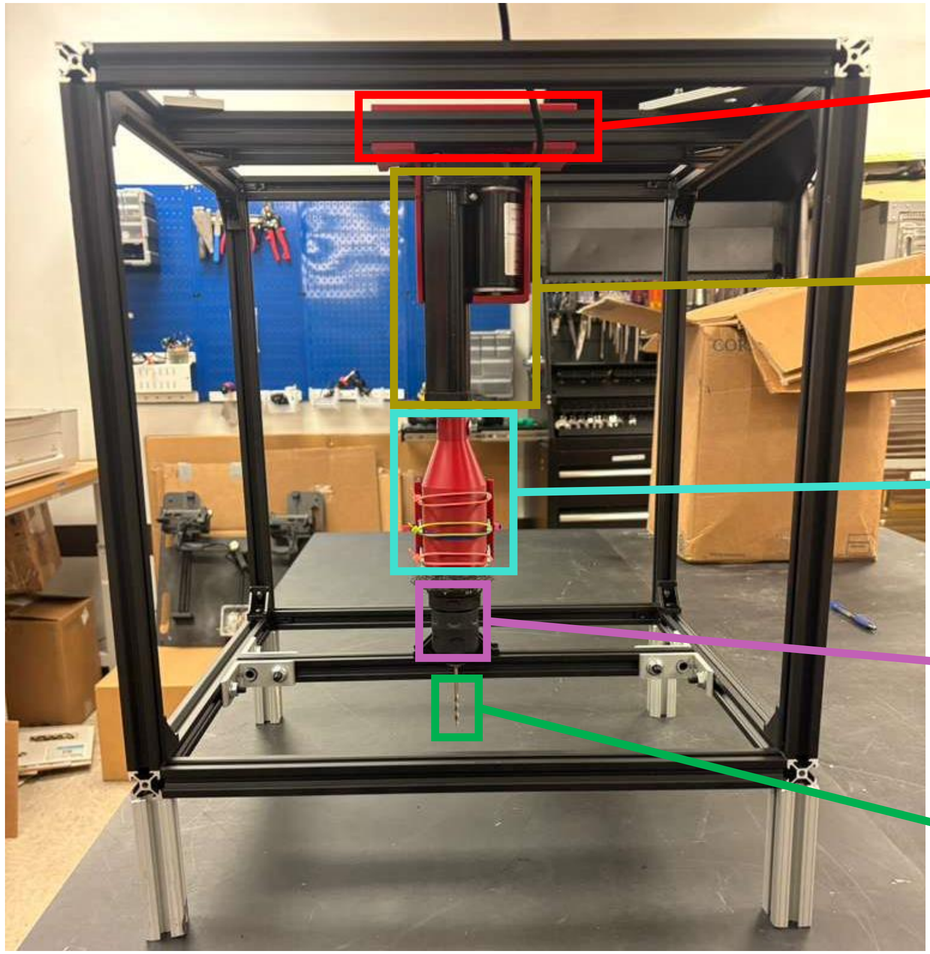
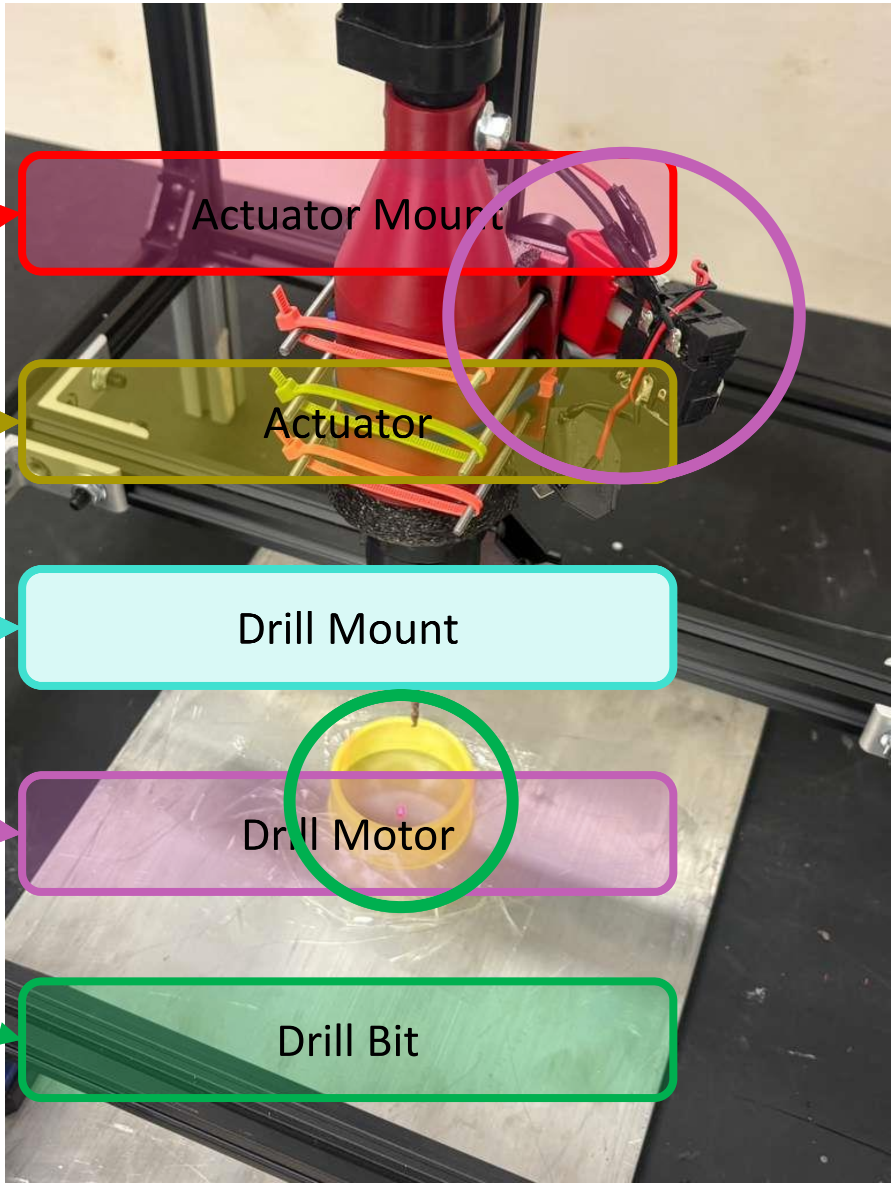
Updated Test Setup





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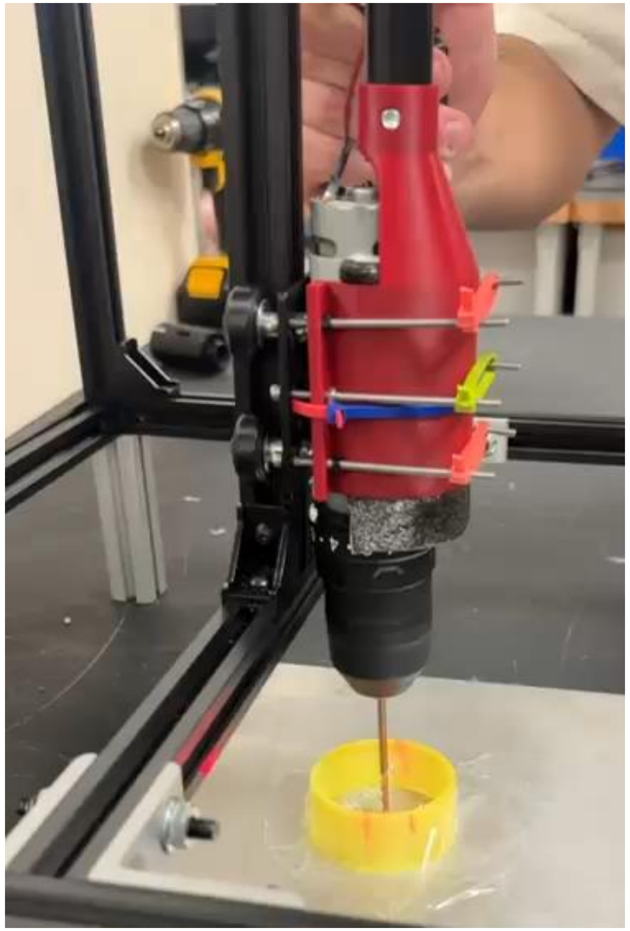
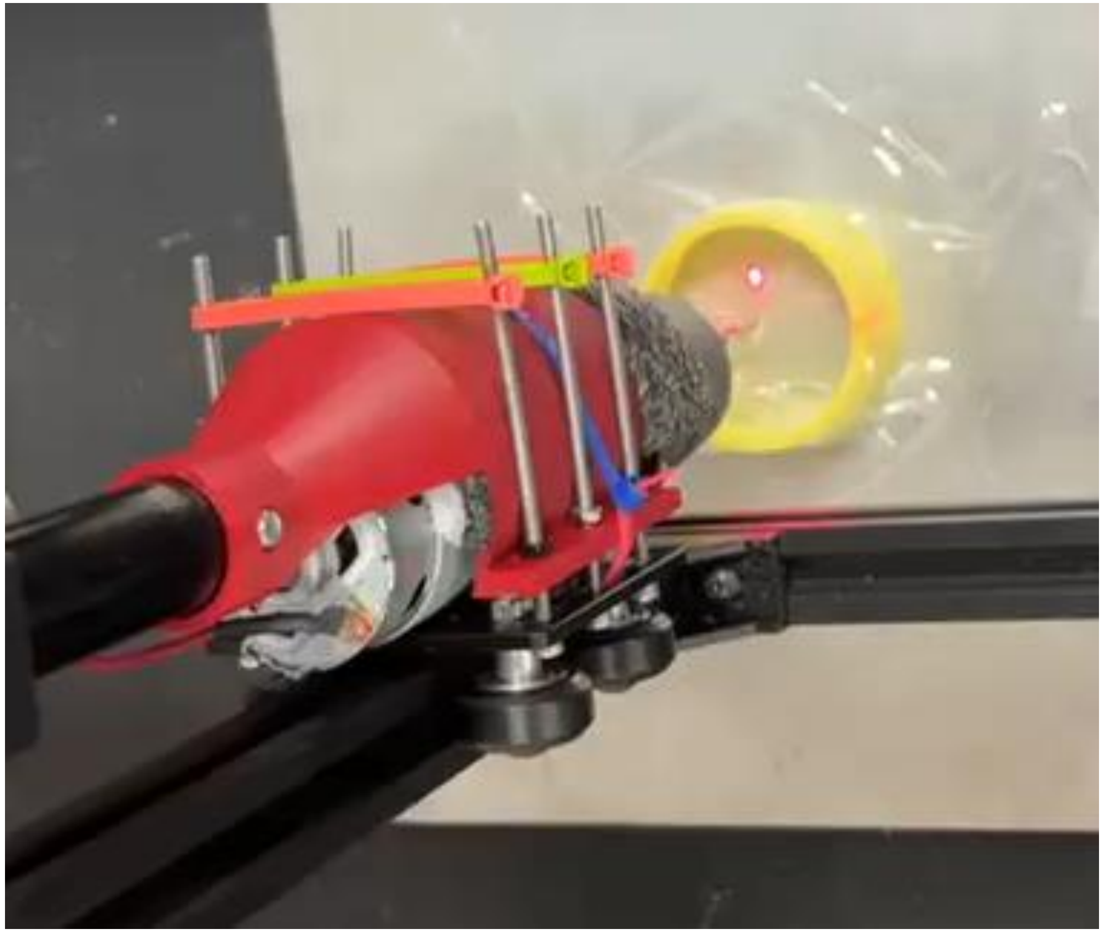
New Motor Testing





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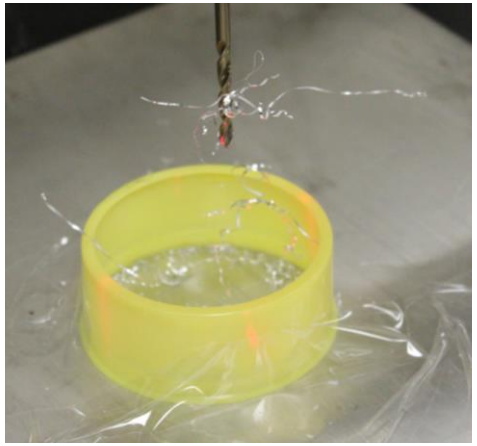
Future Adjustments to Motor

- Redesign of drill containment system
  - Improve Securing
- Begin code implementation
  - Pulsed drilling for testing
- Add any necessary sensors
  - Force
  - Current



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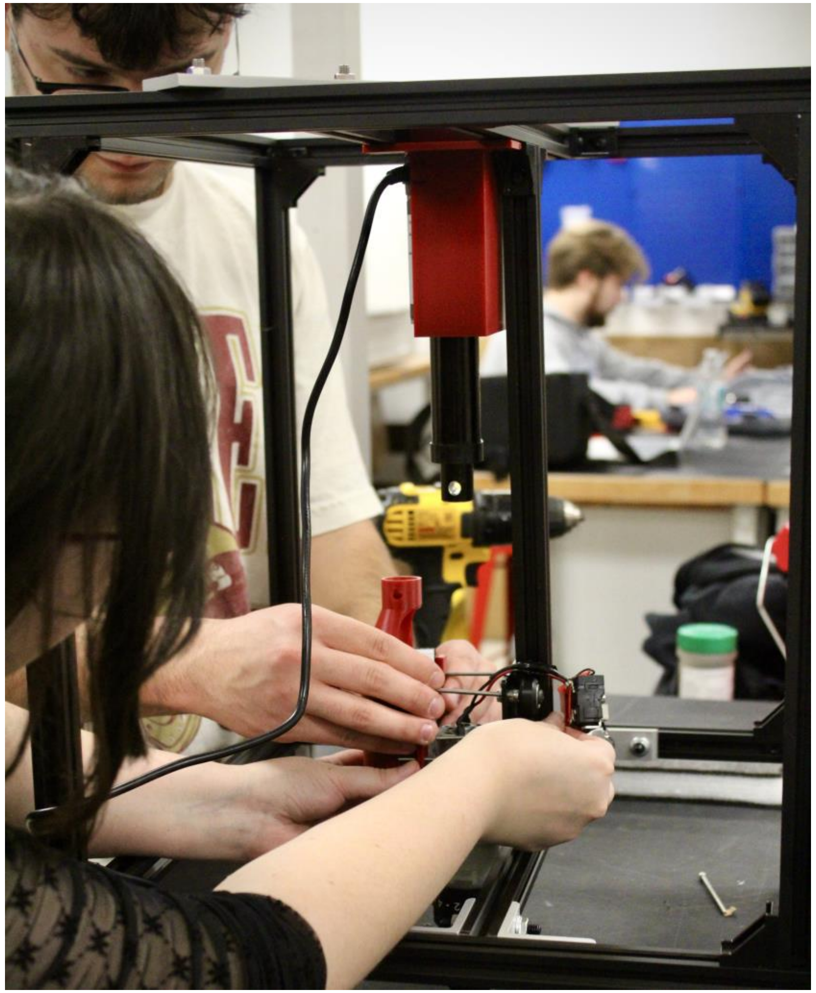
Present Challenges

- Implementation of flap rotation system
- Gas blast system accuracy
- Precise solenoid actuation
- Introducing force sensor controller



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Next Steps

- Integration of gas blast with capsule housing
- Unified control code implementation
- Fabricate full-Scale prototype for testing
- Finalize models and run validation simulations

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Questions?

Back Up Slides

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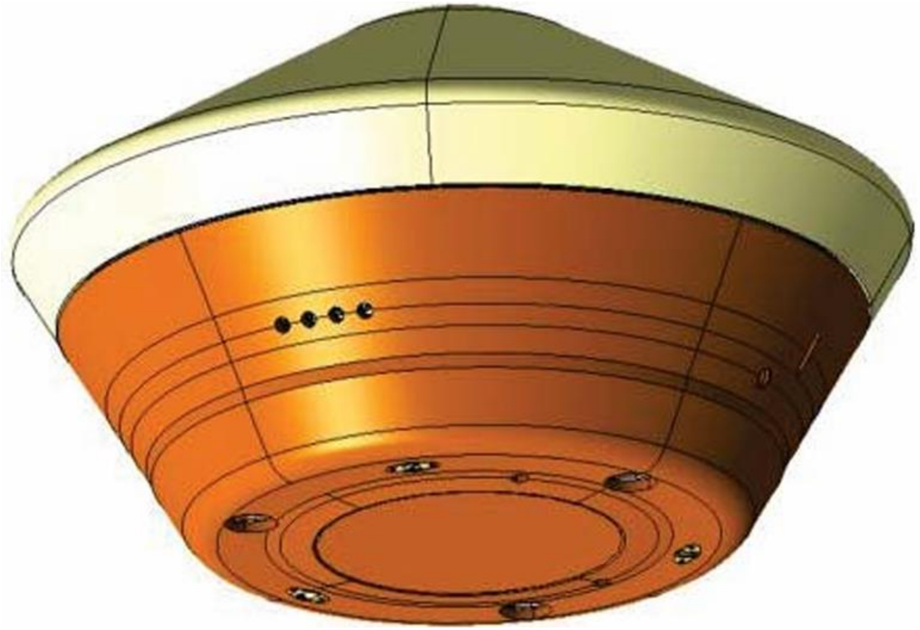
Integrating With T502



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

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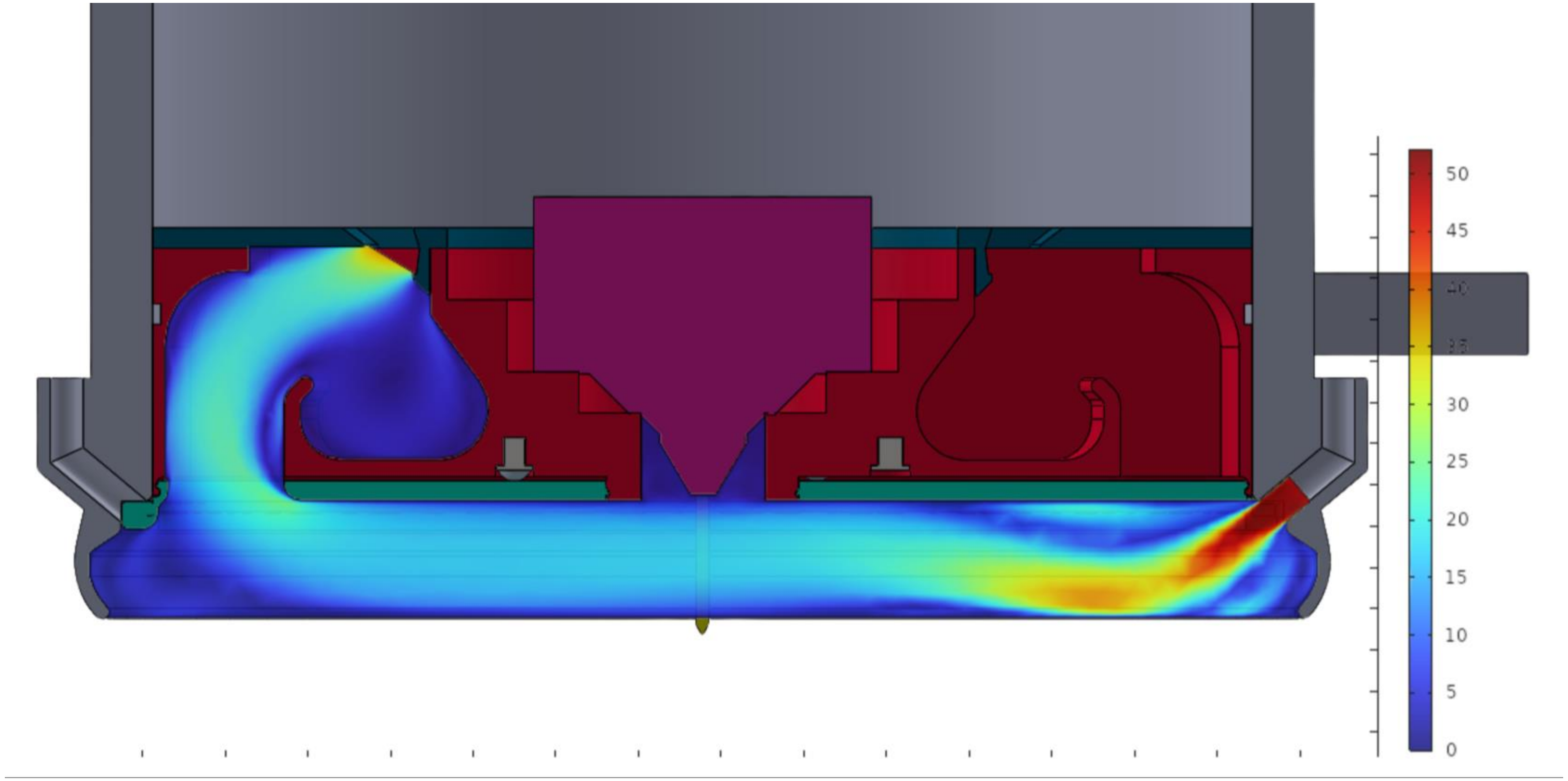
Current COMSOL Velocity Model



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Reduced Friction Between Flap and Collection Chambers

- Roller bearings between parts
- 2mm Silicone tubing around chamber opening bases to decrease particle contamination in open gap between parts
- Insert pic or solidworks animation of the sorts to show??

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Changes still need to be made

Better contain the motors and mechanics from Psyche particles

- Adjustments in flap size and redesign of outside container for T502’s change in securing mechanism

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Rotating Flap

- Gear system plan
- Reason for rotating flap from top and not bottom (simplify separation)
- Locking mechanism when separating
- Drawing or something
- Why the flap has to have such a fat rim and why it messes up are flow but theres NOTHING we can do about it ☺

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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 a 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

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

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

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

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Temperature Rate Calculation

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

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

So that,

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

$$\dot{Q} = mc\frac{dT}{dt} \quad \Longrightarrow$$

$$\dot{Q} = mc\dot{T} \quad \Longrightarrow$$

$$\dot{T} = \frac{\dot{Q}}{mc} \quad \Longrightarrow$$

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

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

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