UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Faster Than Darwin Micro-Bioreactor

Group 18
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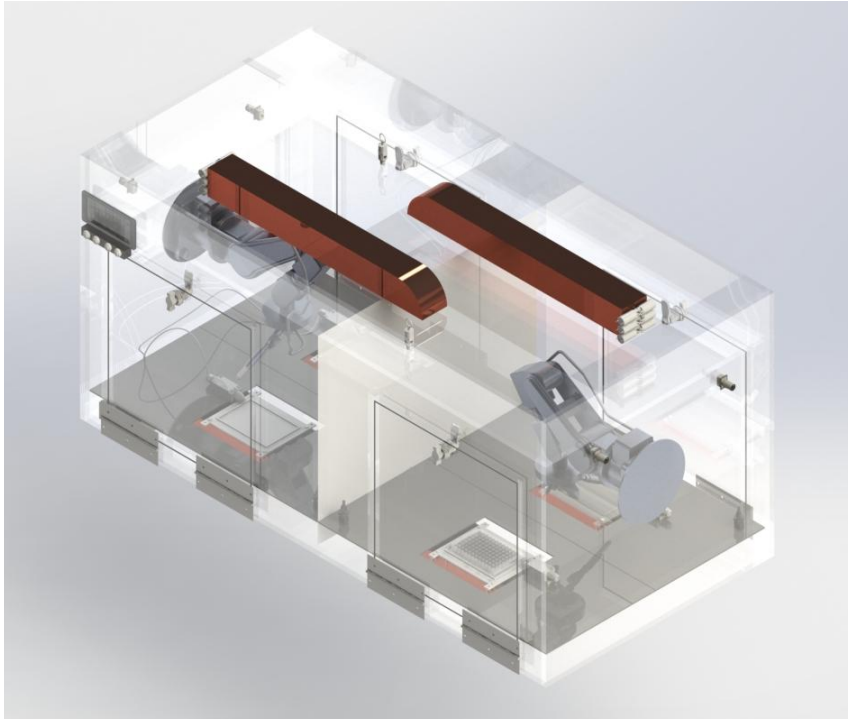
POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

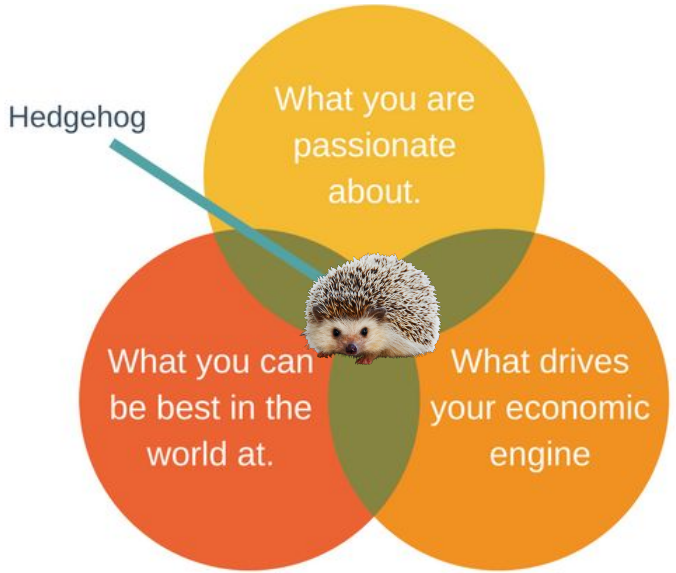
Outline

- Current Products/Market Overview
- Hedgehog Concept Overview
- Product Overview
- Subsystem Overview
- Subsystem Analysis Results
- Highlights of Design
- Cost Analysis



Hedgehog Concept Overview

Product Function: The overall goal of the micro-bioreactor device is to allow for the optimization of biological processes and cultivations to speed up the production of various biological products. The device is capable of monitoring microbial physiology under various processing conditions in order to obtain a desired output.



Hedgehog Concept:

The Faster Than Darwin Micro-Bioreactor captures the groups passion for product efficiency with respect to simplicity, time, and cost.

Market Overview

- Current bioreactors on the market are used in large scale operations for culturing of yeast, animal cells, or bacteria
  - Limited variations in size of current products on the market
- Current microbioreactors lack variability in the conditioning capabilities and are not always fully autonomous
- This leaves an opportunity in the market for a product like the “Faster Than Darwin Micro-Bioreactor”

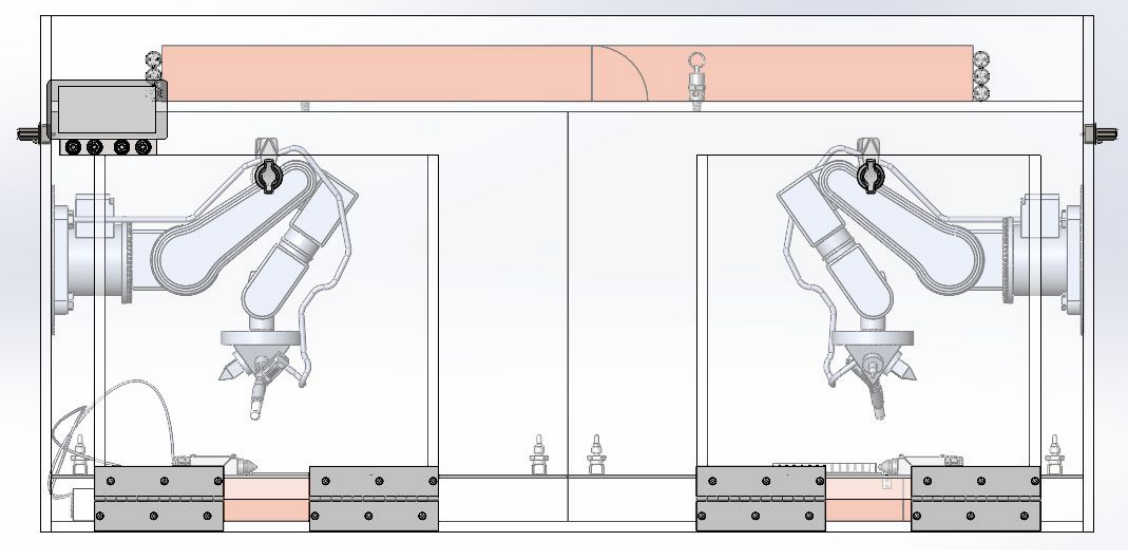
Product Overview

The product developed was a direct result of the needs provided by the customer

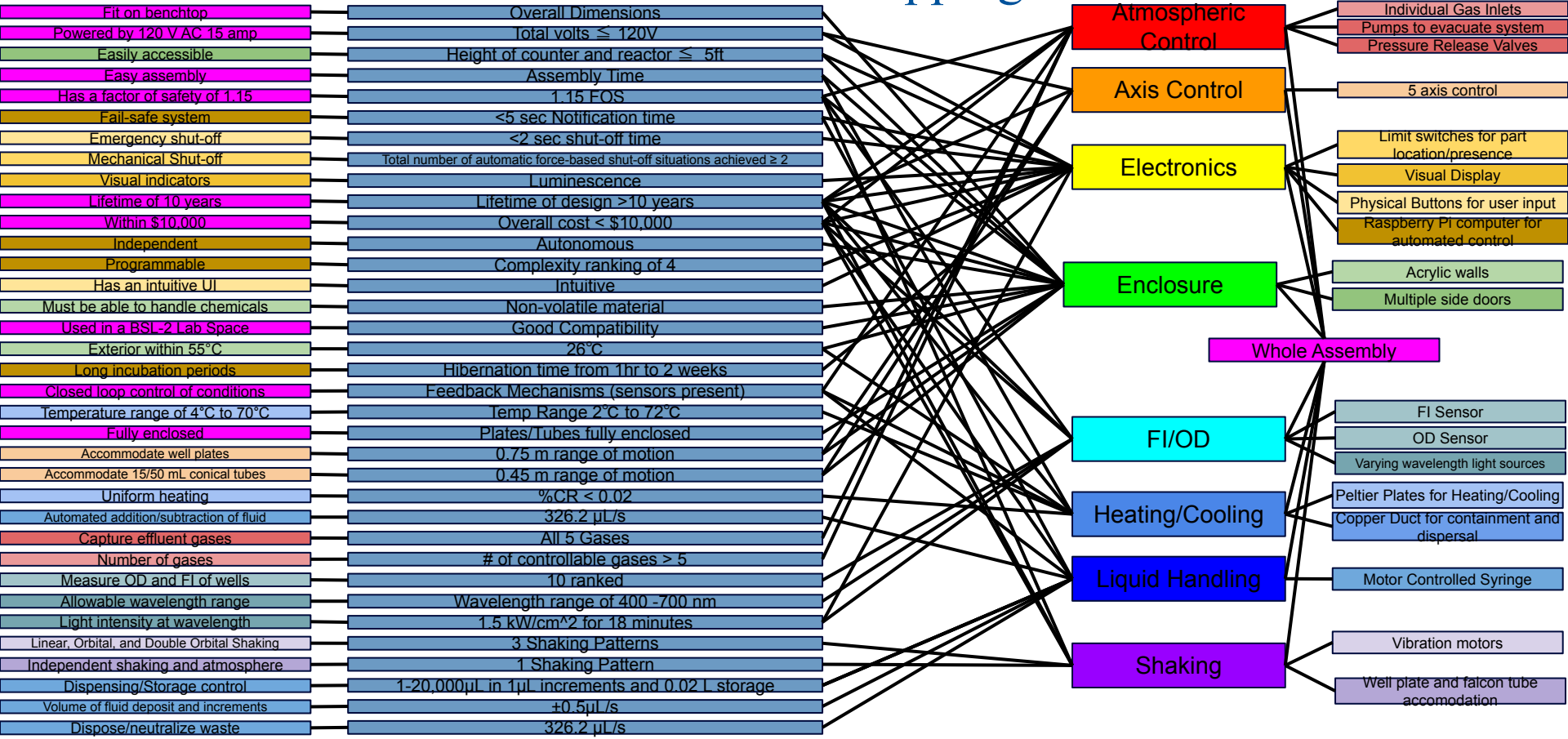
The device measures 4ft. X 2ft. X 2ft. to meet the customer need

The product is comprised of eight subsystems to meet the customer's needs

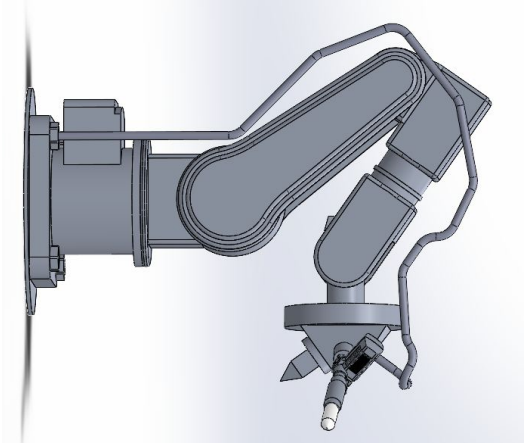
1. Liquid Handling System
2. Axis Control System
3. Shaking System
4. Heating/Cooling System
5. Enclosure System
6. FI/OD System
7. Electronics System
8. Atmospheric System



Customer Needs Mapping



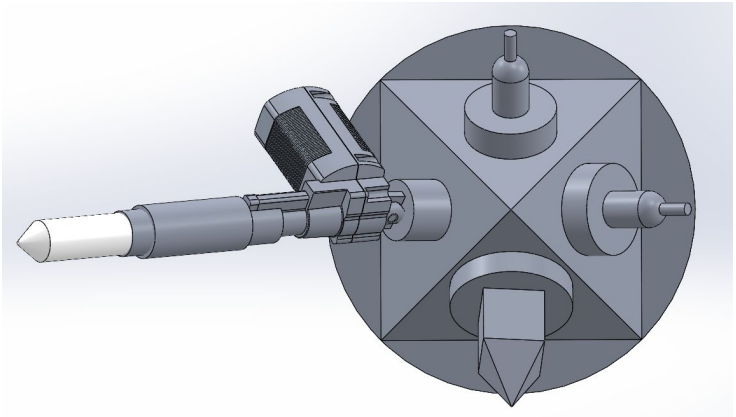
Biological Delivery Systems



Axis Control: The system is controlled with a 5 Axis robot arm to position a tool changer over the cultures

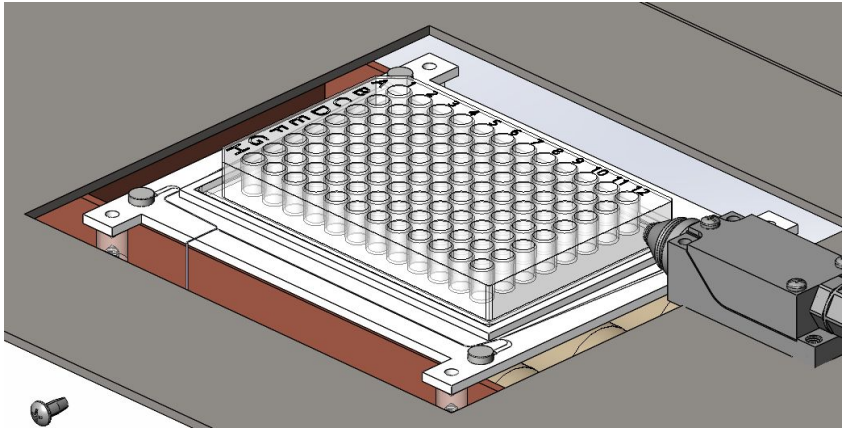
Liquid Dispensing

- Custom Syringe
- Linear Actuator Pushes on syringe (clamp also retracts syringe top)
- Syringe is fed culture with a tube that goes to storage tank

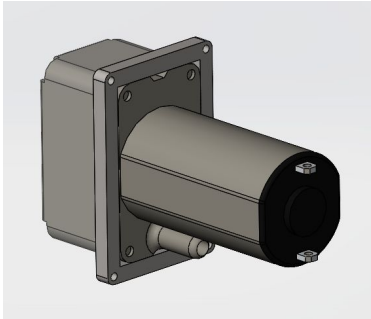


Shaking

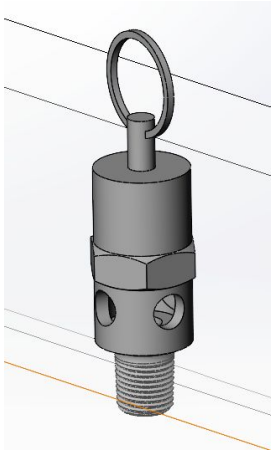
- Each well plate/tube is mounted on a holder plate mounted on rubber vibration dampeners to allow them to vibrate.
- The vibrational mechanism is controlled with coin cell vibrator motors
- The vibrators can be independently controlled to induce the proper agitation of the culture

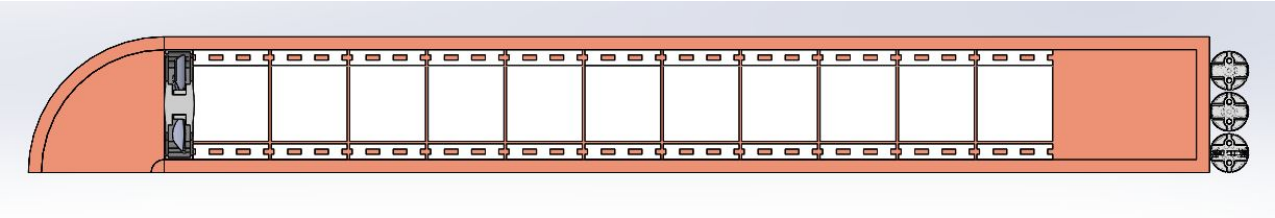


Conditional Alteration Systems



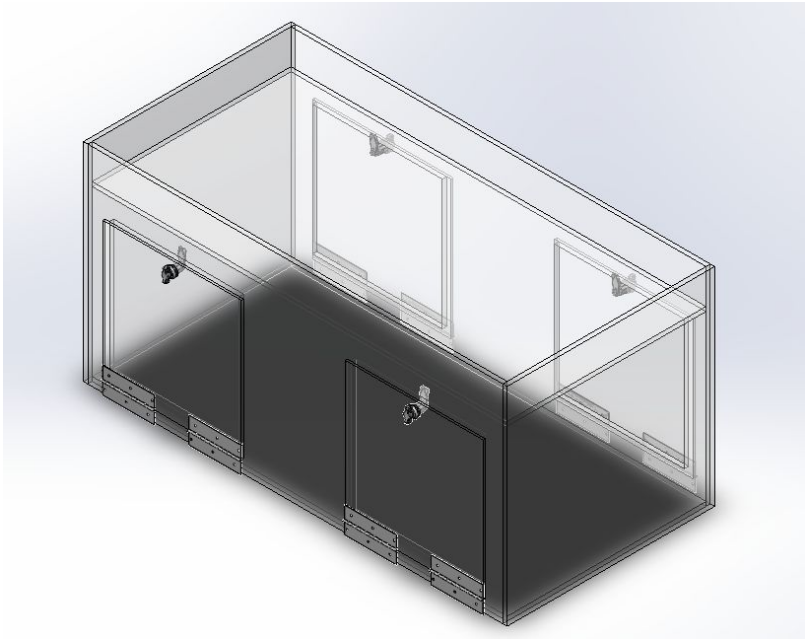
- The system uses a square duct with internal flow over thermoelectric plates to heat or cool the gases let into the system
- The roughing pump is used to partially evacuate the system to reduce the time it takes to reach desired steady state conditions
- The pressure release valve is ensure the system does not exceed 1.5atm





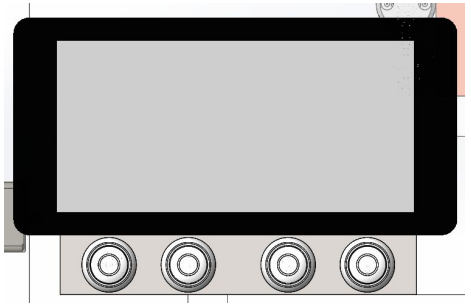
Structure

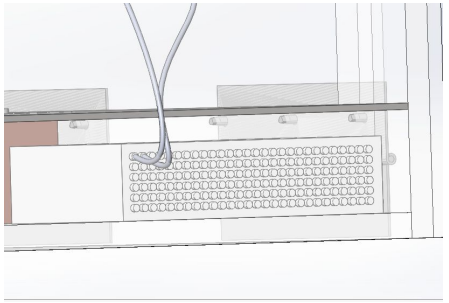
- The enclosure is made of an opaque acrylic material due to its cost effectiveness and thermal/mechanical material properties
- The internal components are accessible via two doors on the front and two doors on the back of the device

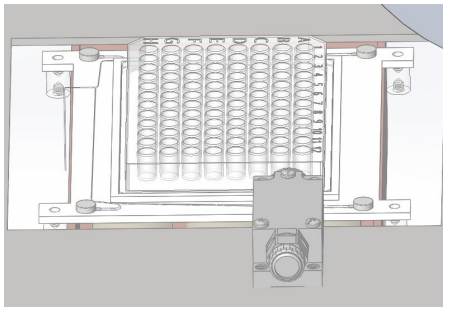


Electronics System

- Computer controlled with a Raspberry Pi.
- Interactive UI
  - 5” LCD display to provide current state of system and any notification for the user.
  - Push buttons to allow user input (i.e. emergency shut-off or run time duration).
- Limit Switches to inhibit operation if well plates/falcon tubes are misaligned.



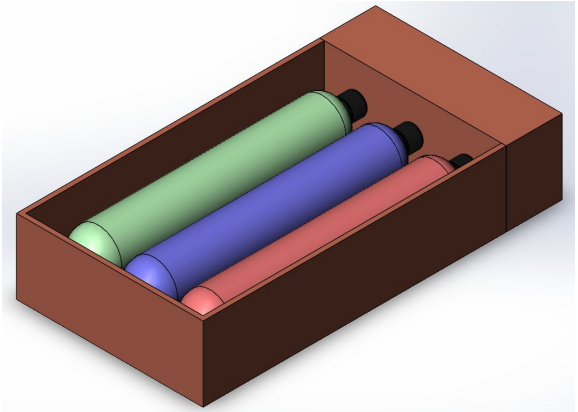


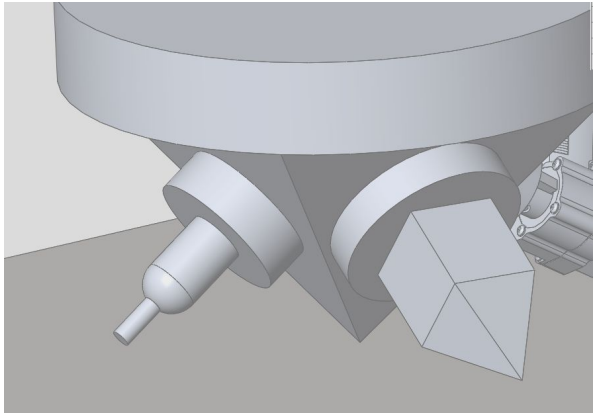


FI/OD System

Can generate variable wavelengths at various intensities.

- Faster mutation
- Boost cell reproduction
- Faster results compared to other bioreactors





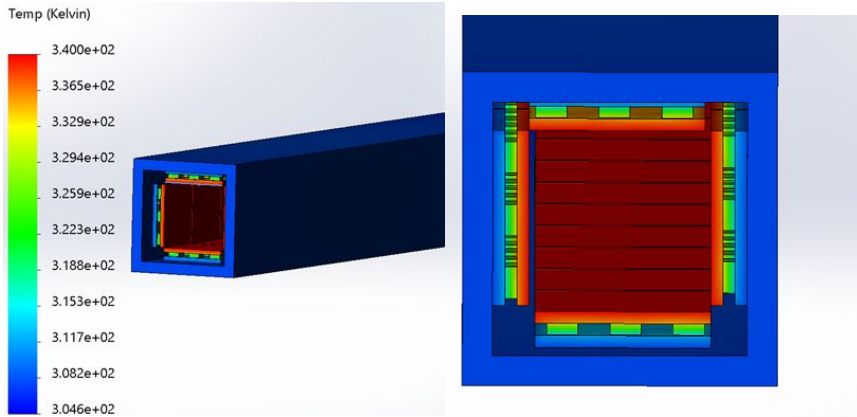
Design Highlights vs Competition

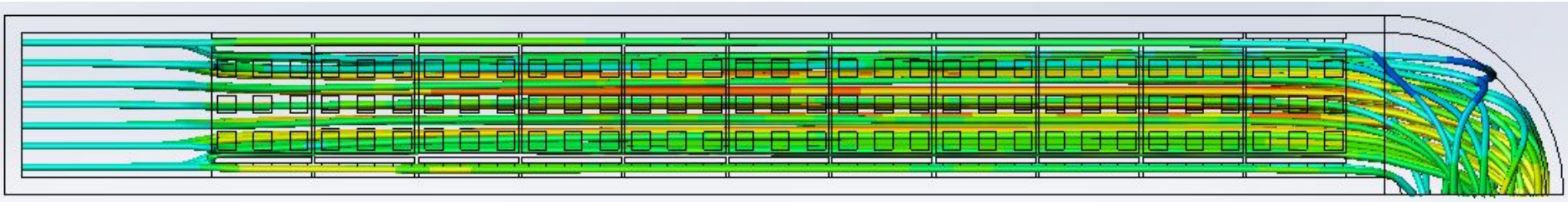
- Multiple wavelengths to provide faster throughput
- Modularity and Ease of Use
- Split system able to run two experiments simultaneously
  - Each experiment can have two well plates, two conical tubes, or a combination of both

Conditional Alteration System Analysis

Heat transfer and flow analysis were performed on heating/cooling duct to ensure the proper design.

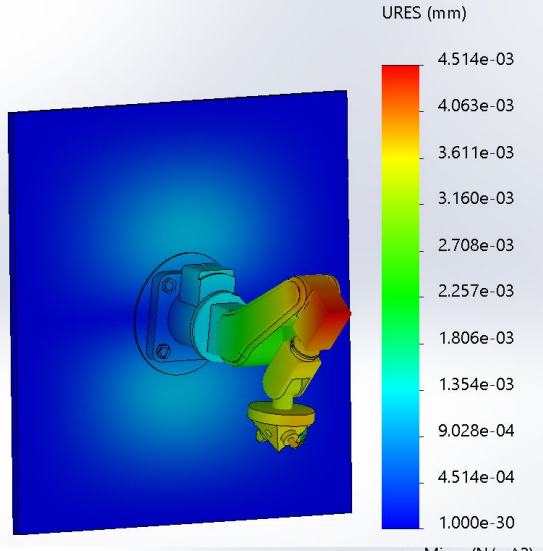
- Performed analysis to ensure peltier plates could reach desired temperature.
  - Determined outer material is suitable for regulating surface temperature of duct
  - Determined outlet temperature is sufficient for heating and cooling of cultures
  - Ensured duct size was sufficient for pumping gas quickly enough given pressure of the source tank

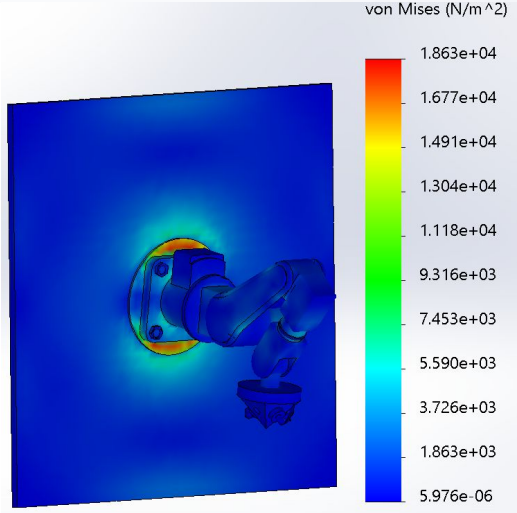




Subsystem Analysis

- An analysis was performed to look at the effects of the weight of the robot arm and the bolted joint connection
- The results provide information on the stresses induced in the acrylic walls and in the flange of the robot base.
- The wall was optimized for the thickness to reduce cost and weight of the enclosure

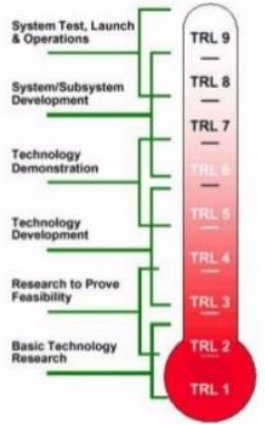




Evaluation of Technology Readiness

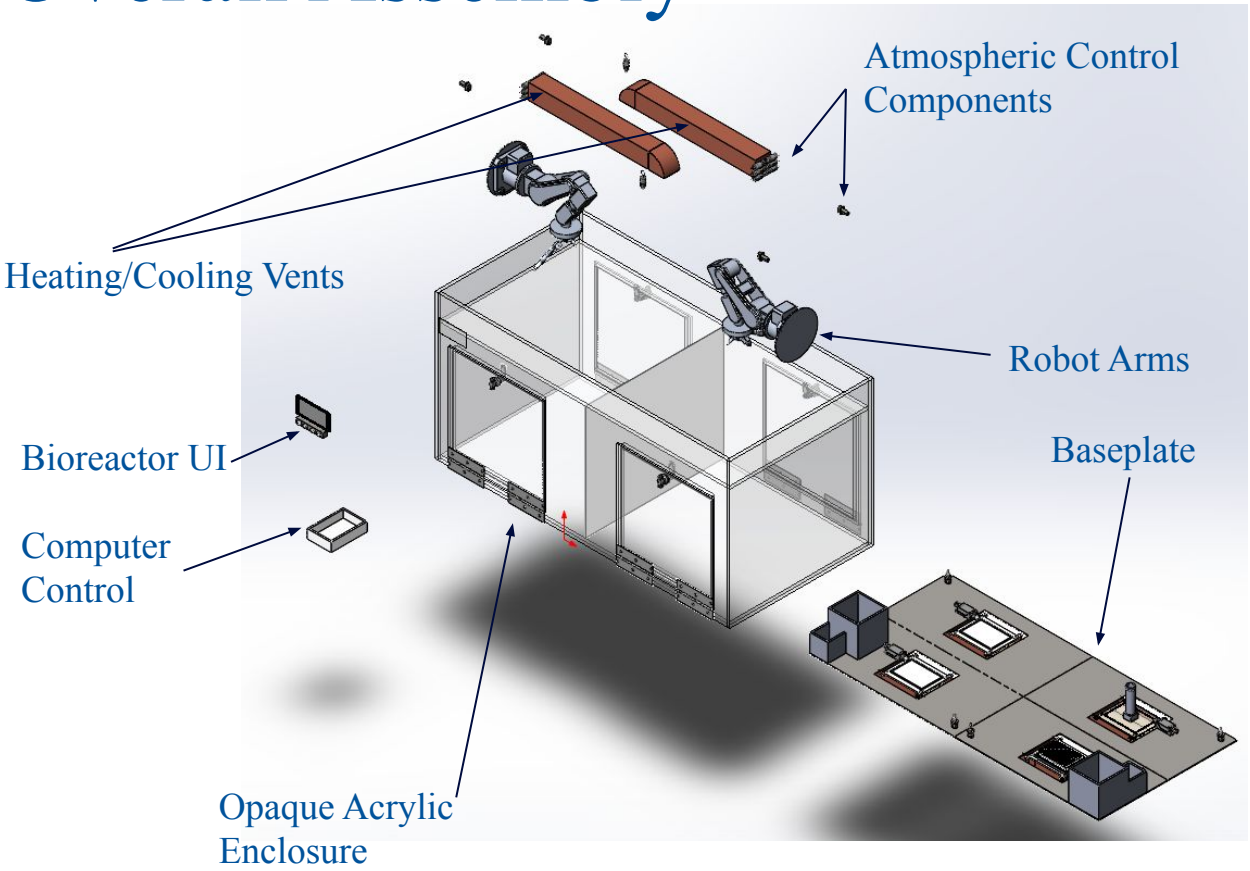
The table below displays the Technology Readiness Levels (TRLs) for each subsystem.

Level 1 : Basic principles observed and reported
Level 2 : Concept and/or application formulated
Level 3 : Concept demonstrated analytically or experimentally
Level 4 : Key elements demonstrated in laboratory environments
Level 5 : Key elements demonstrated in relevant environments
Level 6 : Representative of the deliverable demonstrated in relevant environments
Level 7 : Final development version of the deliverable demonstrated in operational
Level 8 : Actual deliverable qualified through test and demonstration
Level 9 : Operational use of deliverable



TRL	Enclosure	Axis Control	Liquid Handling	Shaking	Heating/Cooling	Atmospheric Control	Electronics	FI/OD
Score	3	3	2	1	3	4	4	2

Overall Assembly



Manufacturing and Assembly Times	
Assembly Time	2.37 Hours
Manufacturing Time	6.28 Hours

Cost Analysis

The bulk of the system cost consists of OTS parts and materials for custom parts. The majority of the machining processes for manufacturing are simplistic and cheap. The resultant cost is slightly above half the permissible budget.

Section	Cost
OTS Parts	$4,764.54
Raw Material	$863.83
Manufacturing and Assembly	$80.47
Total	$5,708.84

Why Should This Design Be Chosen?

- The design is low cost at only about half of the budget.
- The use of an additional wavelength increases the number of generations.
- Two isolated chambers allow two separate experiments to be run each with two well plates.
- The design utilizes mostly OTS with only simple custom parts.

Conclusion

- In summary the design concept presented is available for prototyping in EML4502
- The design is capable of meeting all the needs presented by the customer

Thank you to our sponsors Northrop Grumman and Cummins.

Any Questions?