

Cool Charge

Beau Nuxoll

Chase Dinning

Chris Standley

Trevin Kretz



University of Idaho

Background Recap

- Developing an all electric fork truck
- Replacing an internal combustion engine with an electric vehicle drivetrain
- Battery pack must perform optimally in all operating conditions





Objective

- Design a heavy-duty cooling system for the battery pack
- Maintain internal battery temperatures below 55°C



Project Value

Developing a battery cooling system which will aid in advancing electric vehicle technology for industrial forklifts

Applying electric vehicle technology to more industries will lead to a lower fossil fuel dependency



University
of Idaho

Constraints

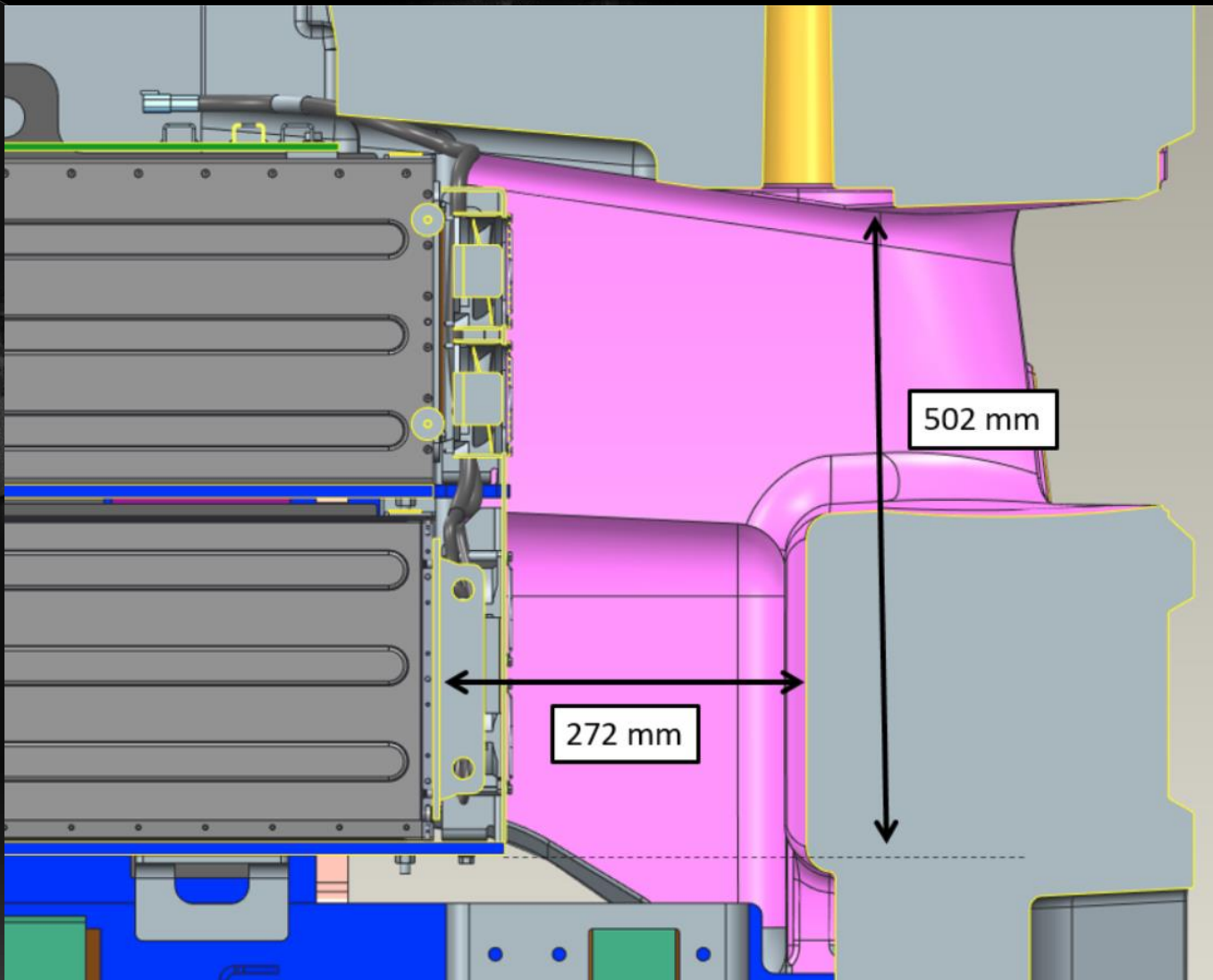
Maintain battery temperatures below 55 °C, in ambient temperatures up to 40 °C (104 °F)

System must fit in cavity between battery pack and counterweight

Height: 502 mm

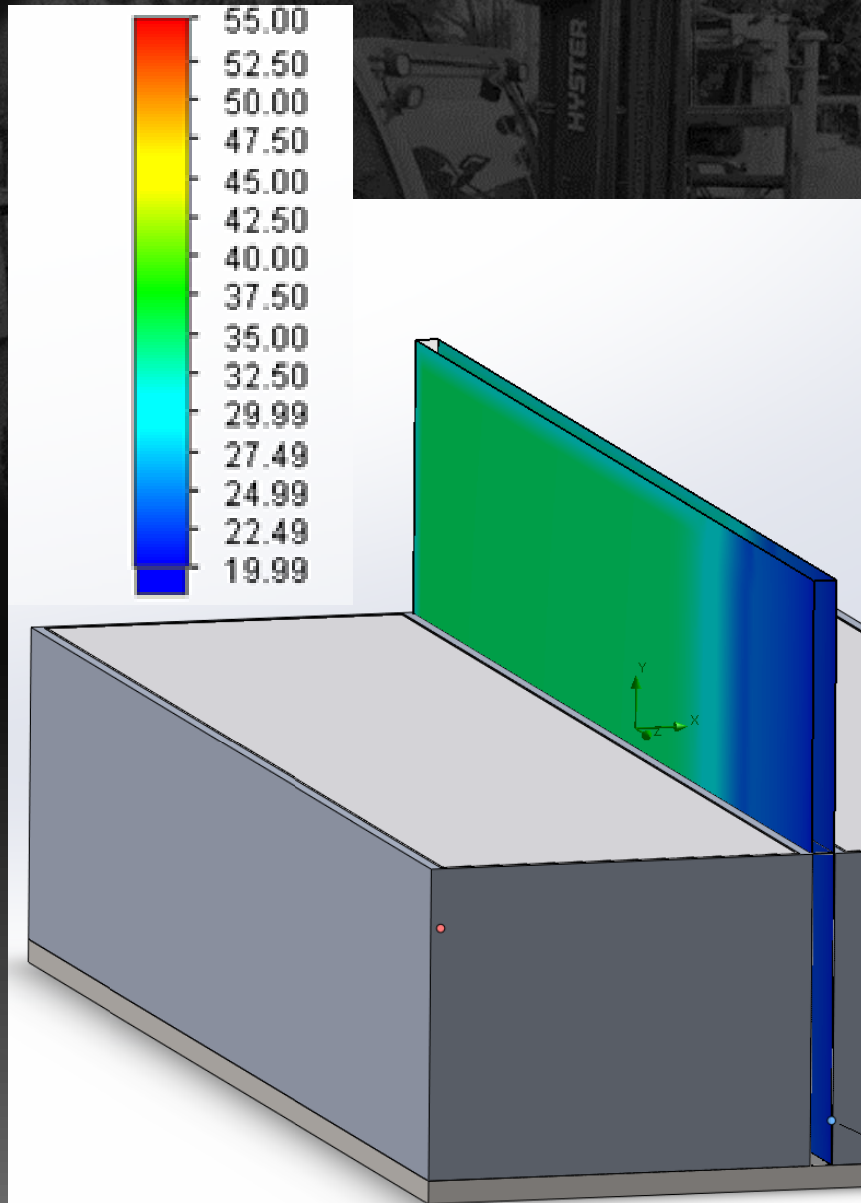
Depth: 272 mm

Width: 651 mm



University
of Idaho

Data Collection



Uniform heat generation

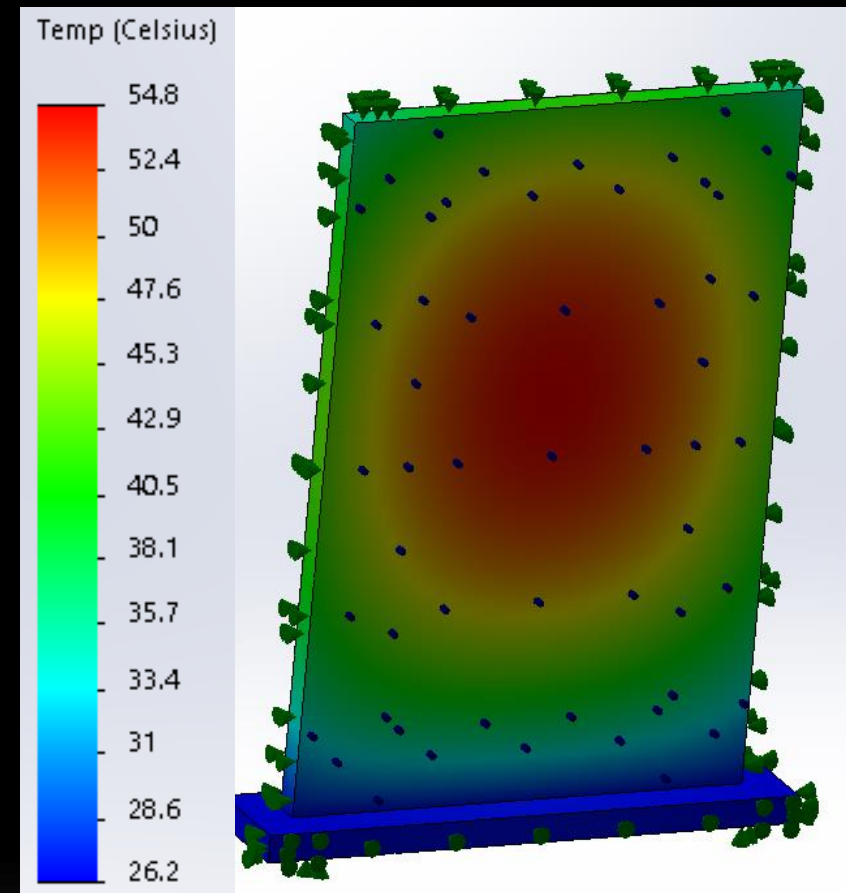
Internal temp at 50 °C

Surface temp must remain below 40 °C

Wall temp is 40 °C

Air enters @ 20 °C

Air exits near 40 °C



University
of Idaho

Project learning



Conclusion:

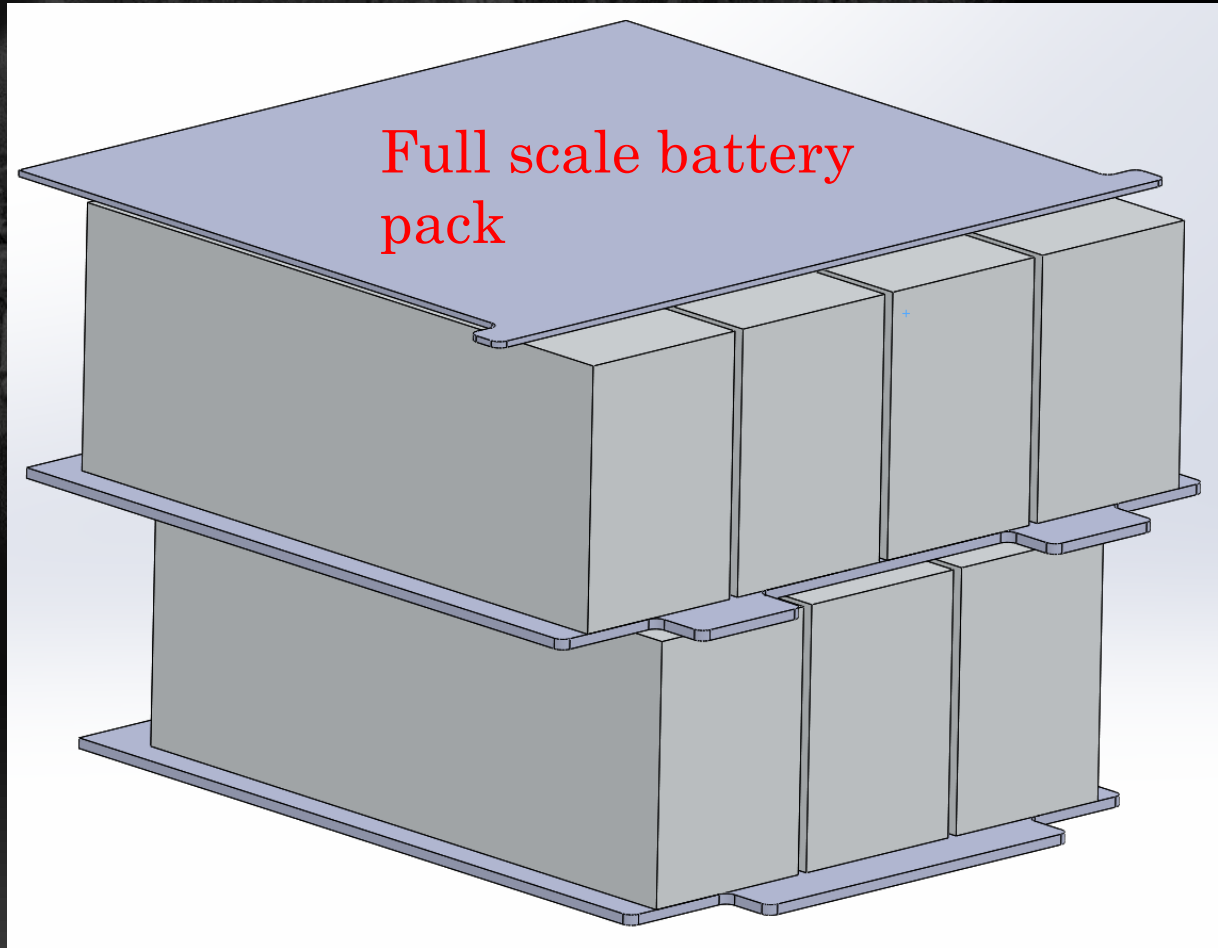
Forced air convection alone, will not work at high ambient temperatures

Pre-cooling air to around 20 °C will maintain desired internal temperatures

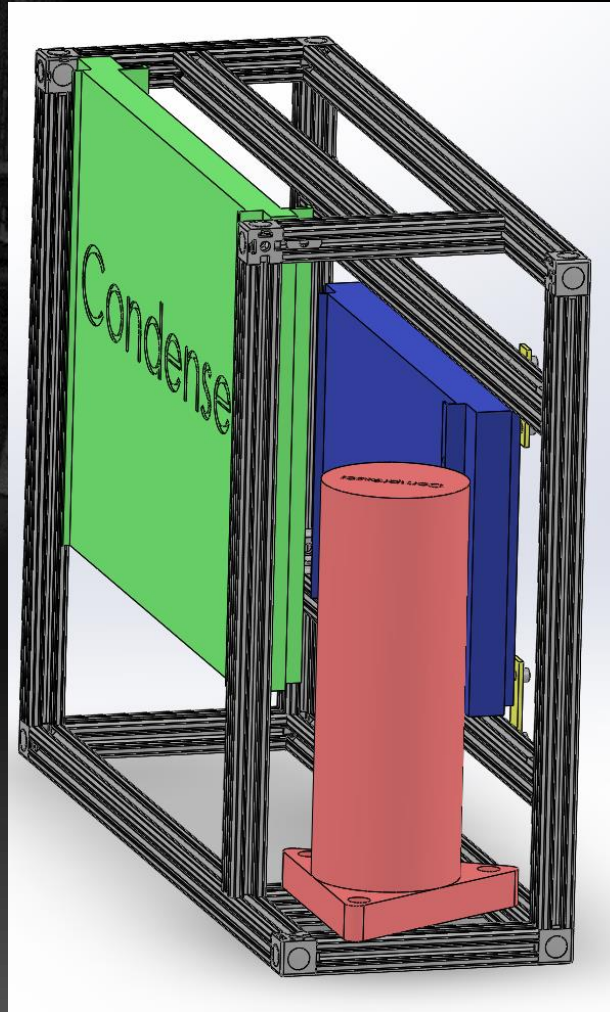
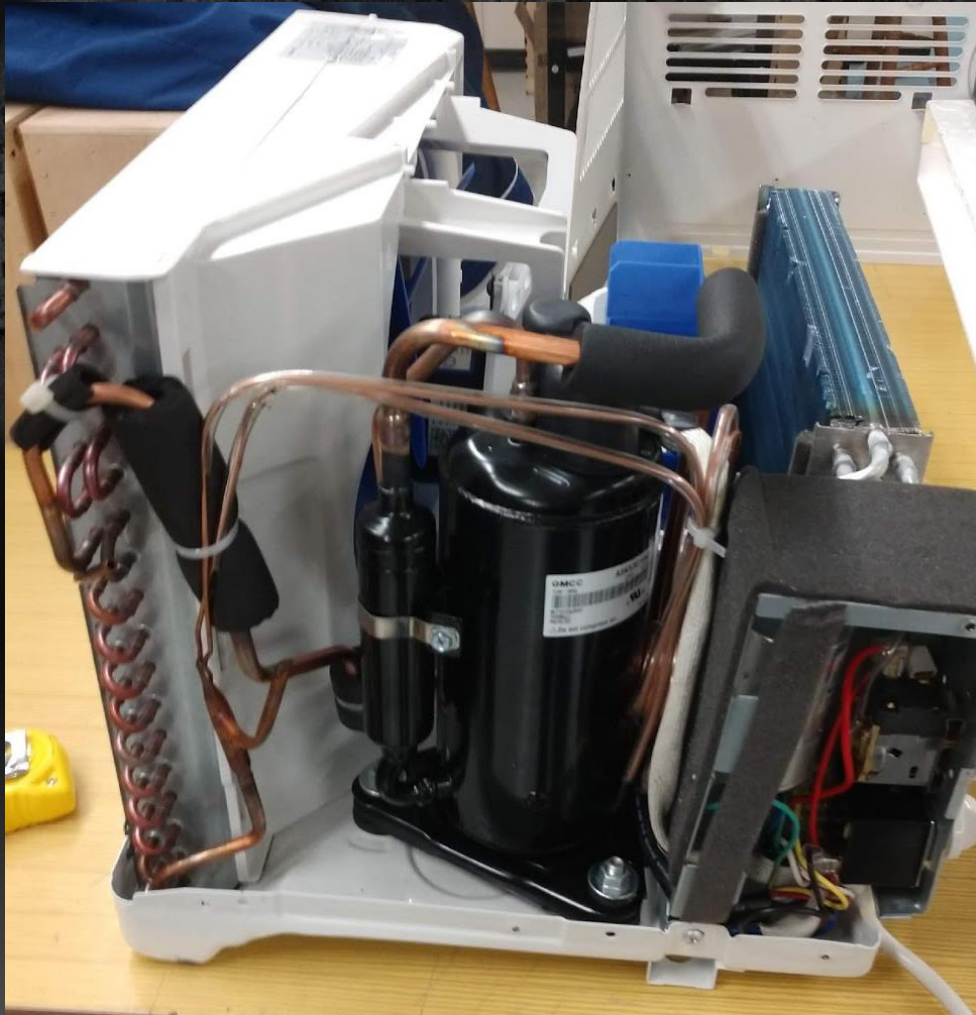
From total heat generation, we sized the HVAC system to roughly 5000 Btu

Components purchased in the form of a working refrigeration system

HVAC System Models



Component Orientation



Compressor out to the side away from air flow

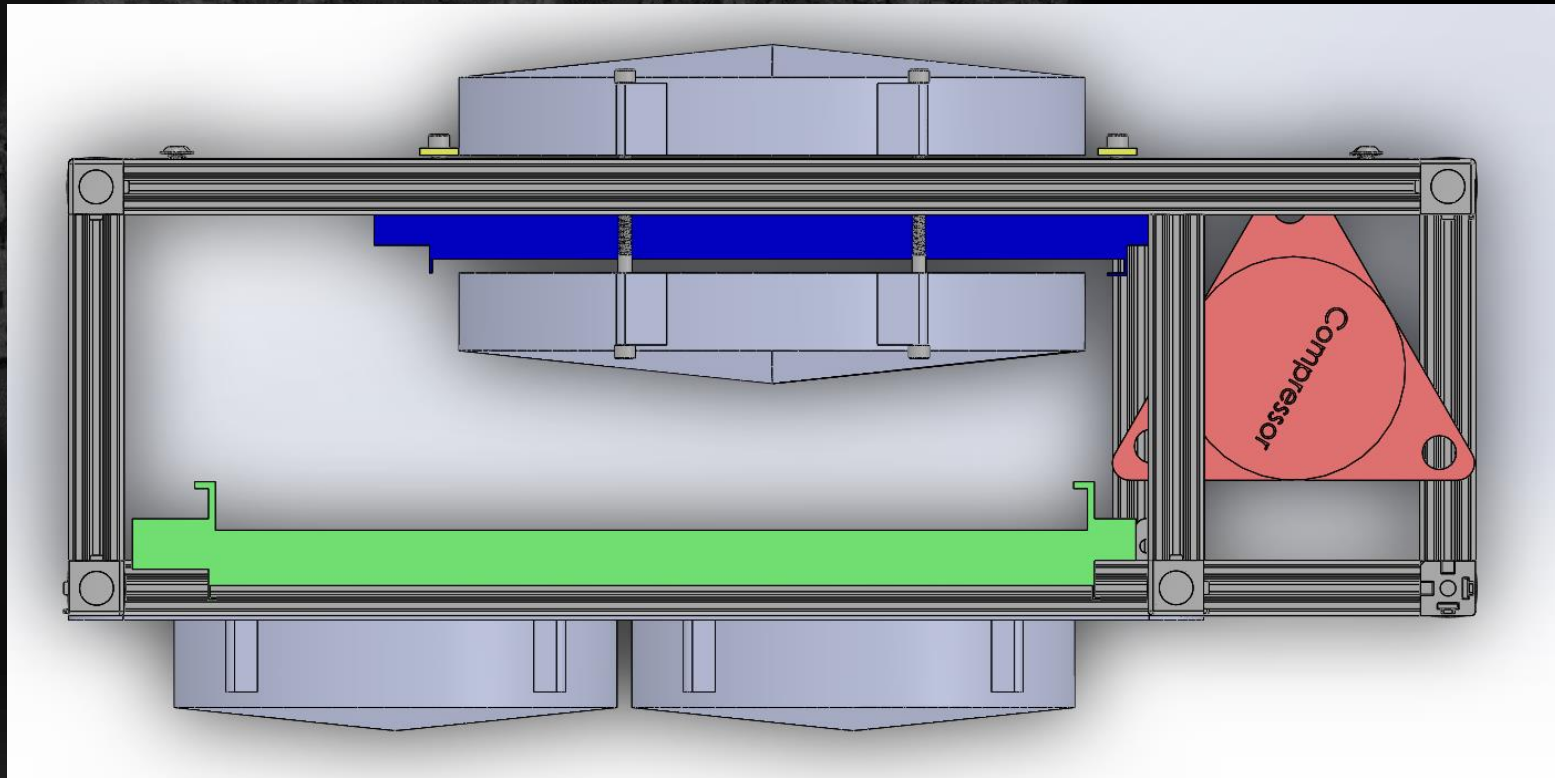
Condenser positioned high to move warm air out

Evaporator positioned centrally to supply cooled air to the battery pack



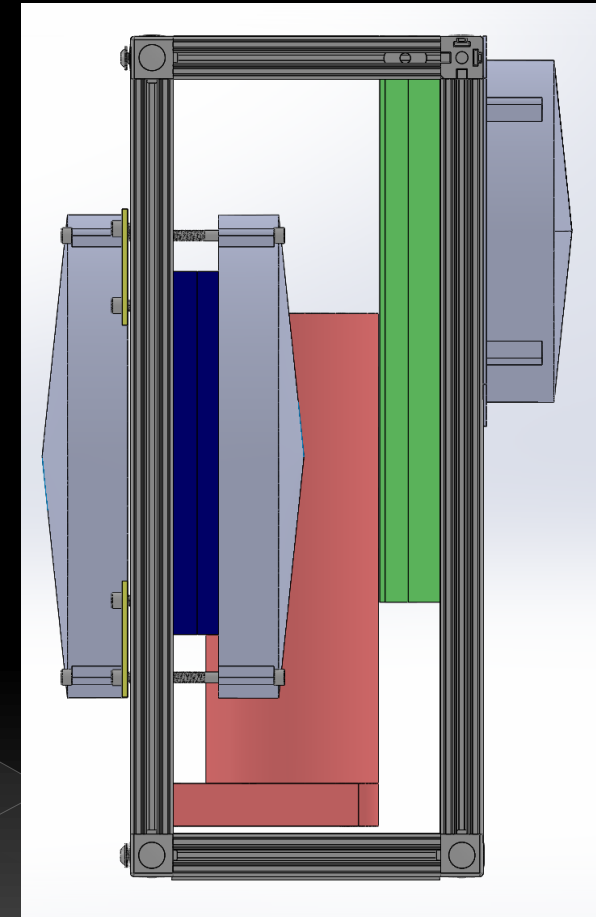
University
of Idaho

Air Movement

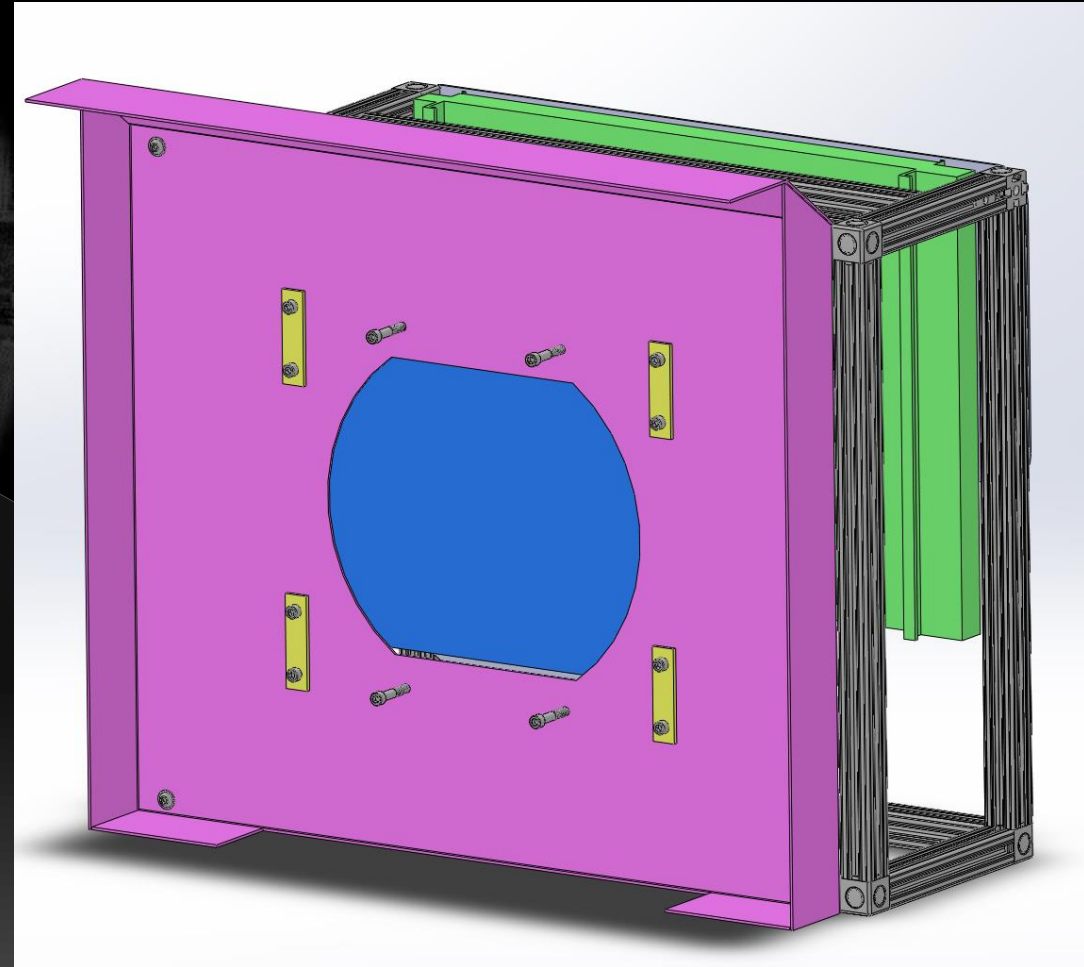
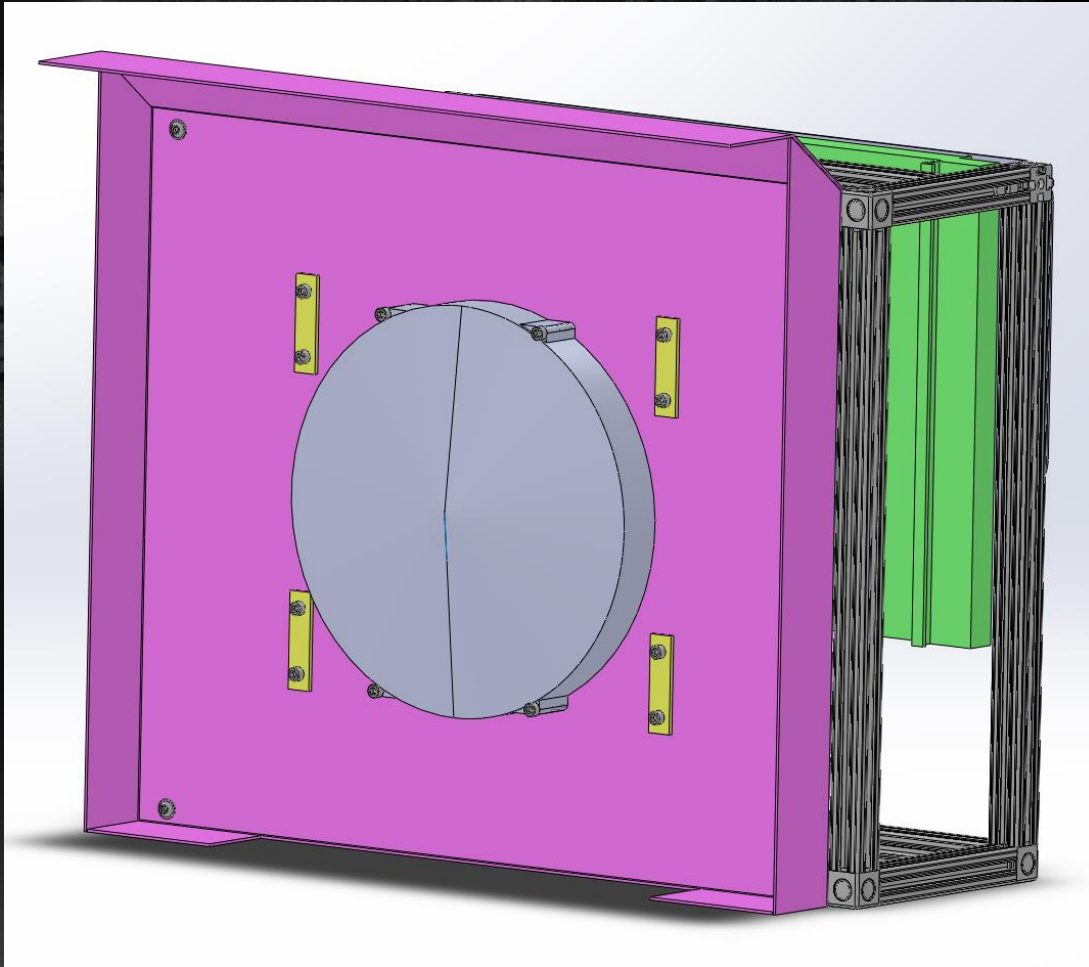


Two 8" axial fans to move air through condenser

Two 10" inline axial fans to move air through evaporator and past the battery modules



Fan Shrouding

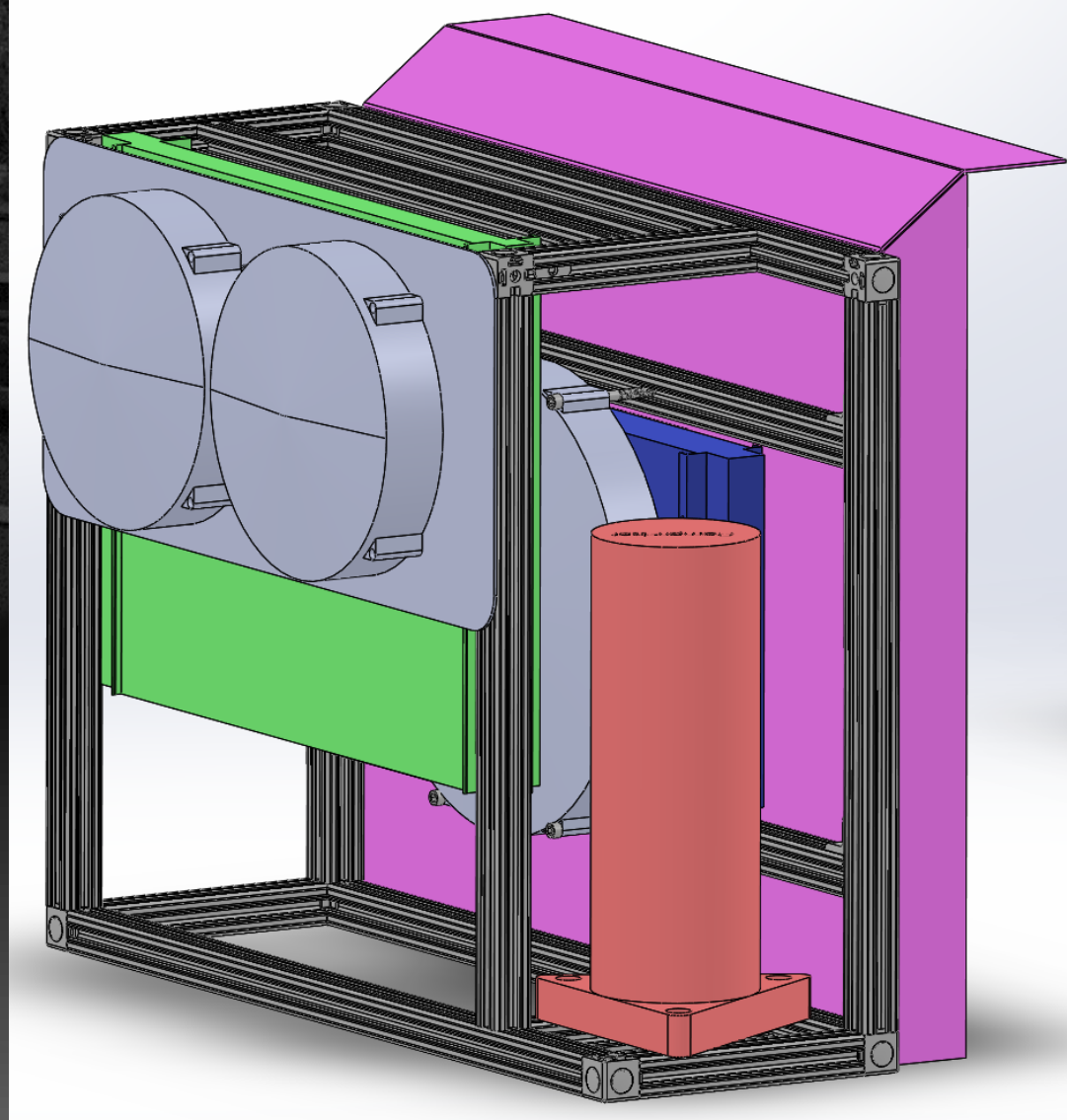
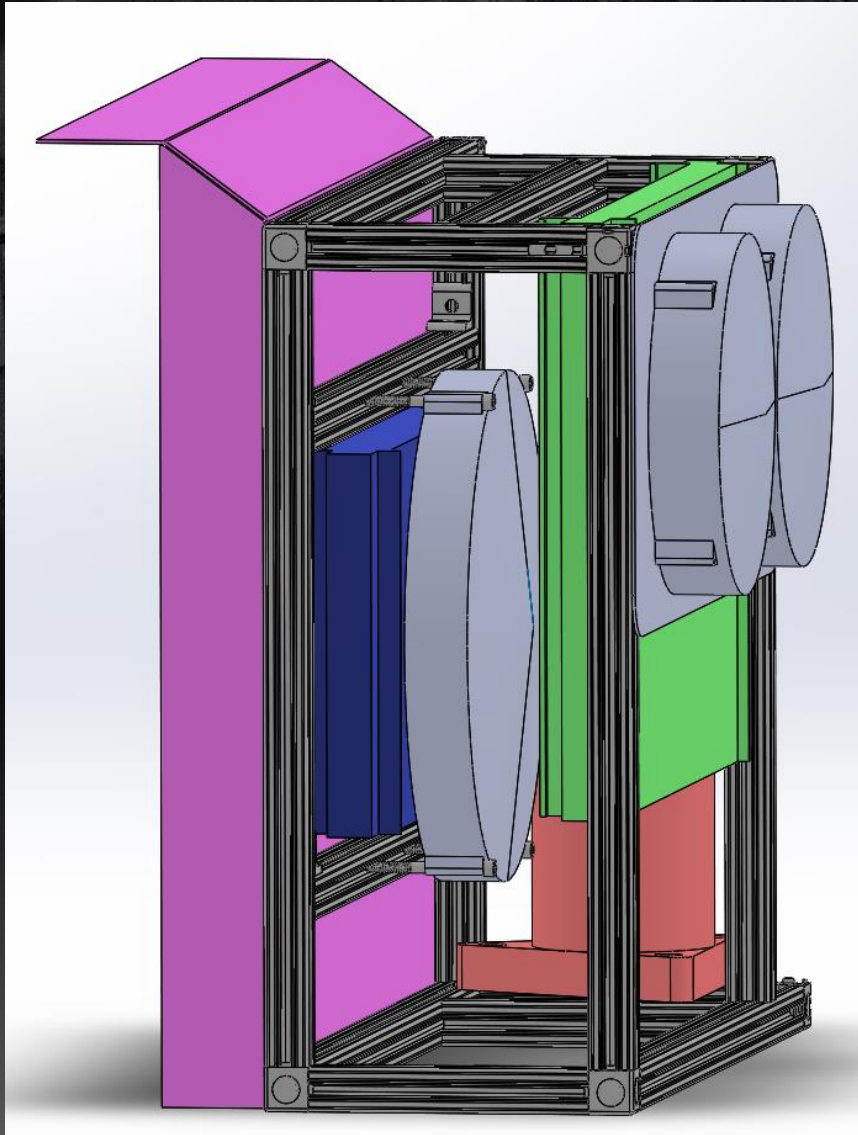


Air directed through evaporator and blocked from escaping by a sheet metal shroud

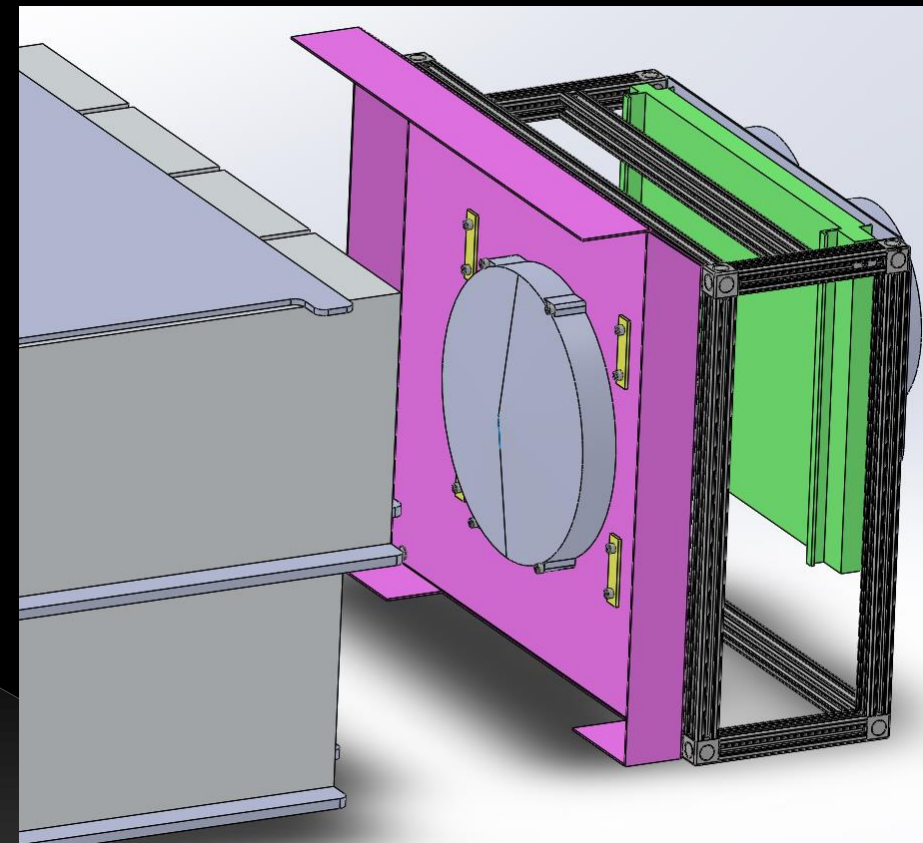
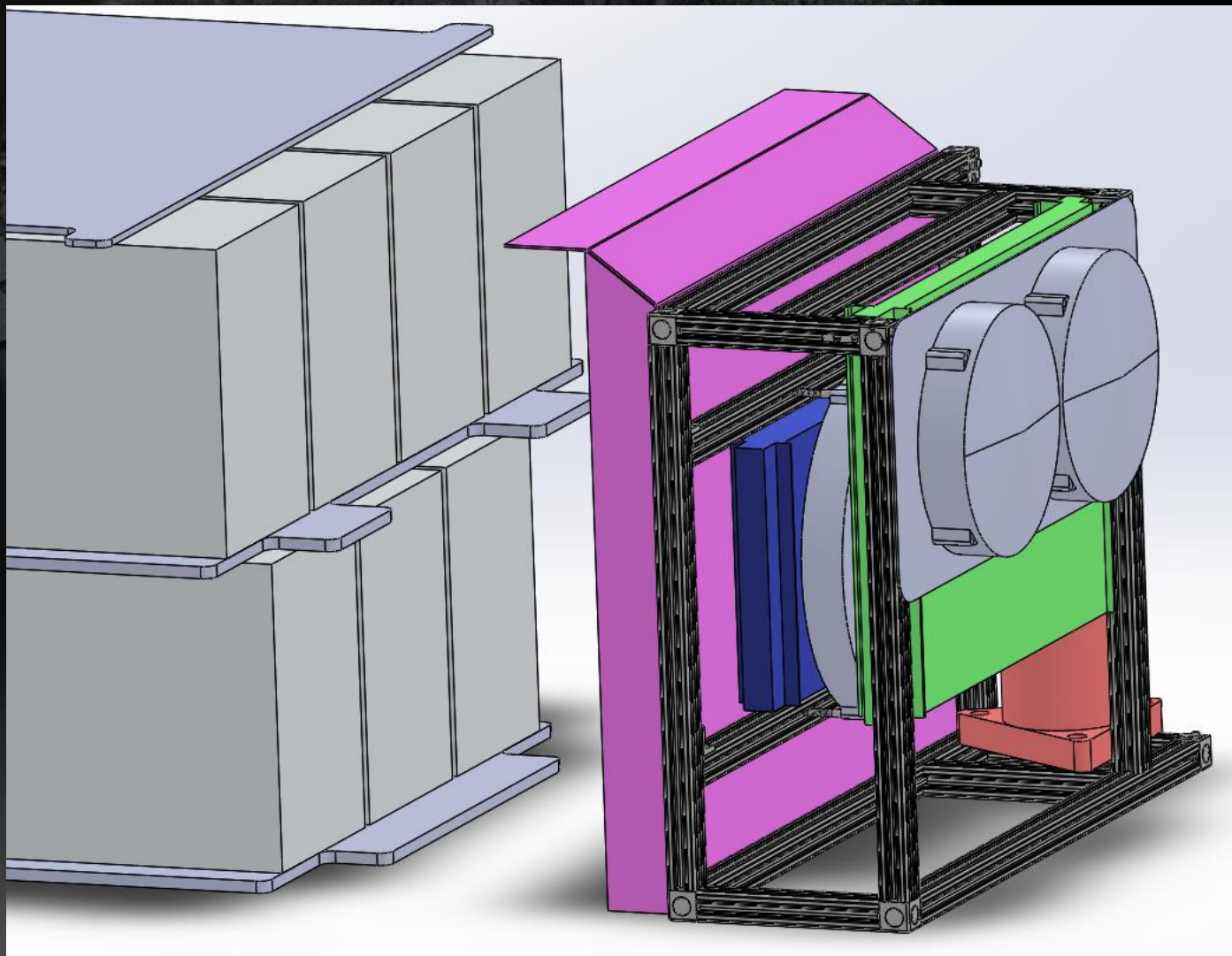


University
of Idaho

Finished System

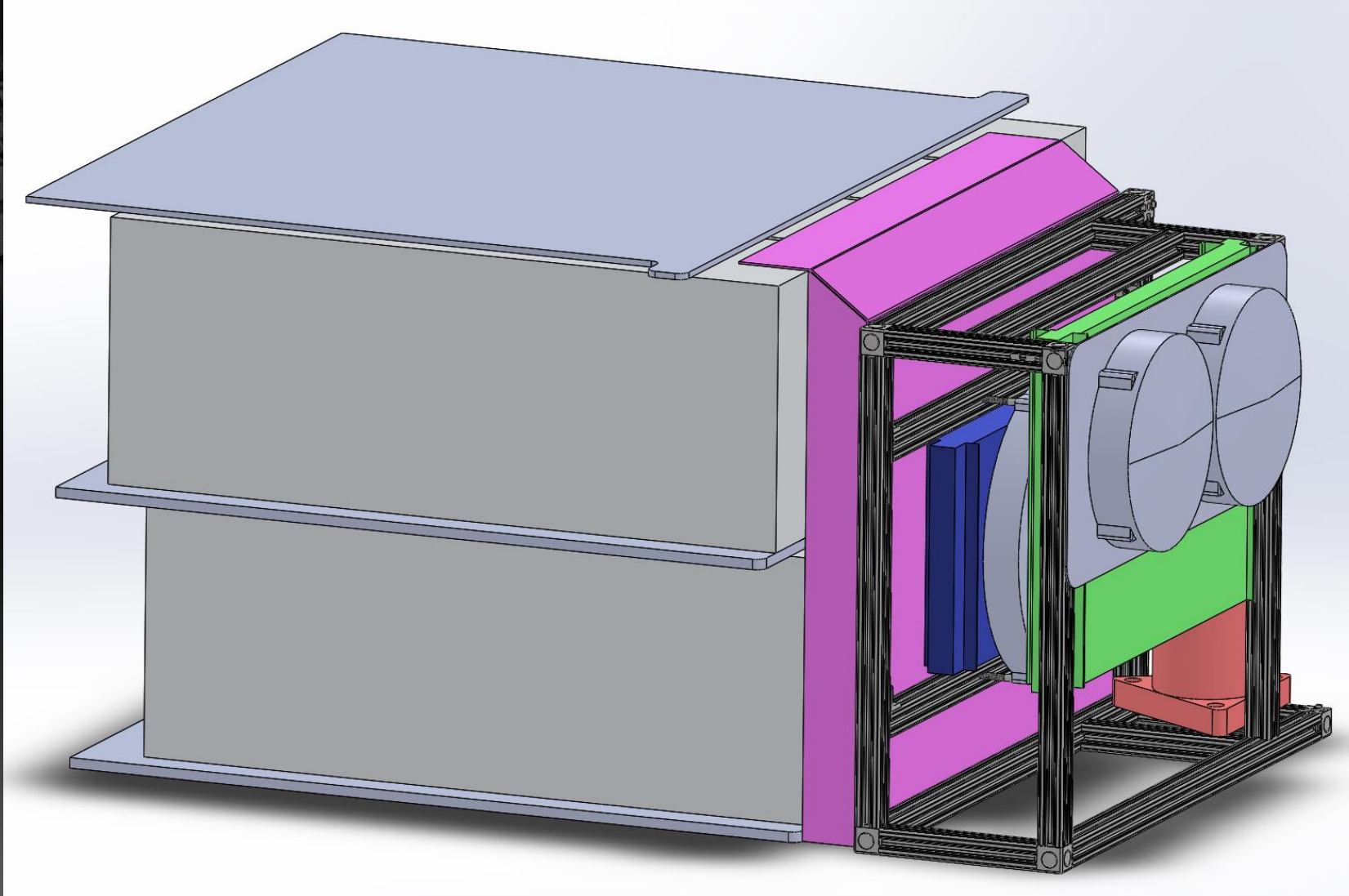


System Fitment



Frame and Shroud
lined up with battery
pack

System Installed on Battery

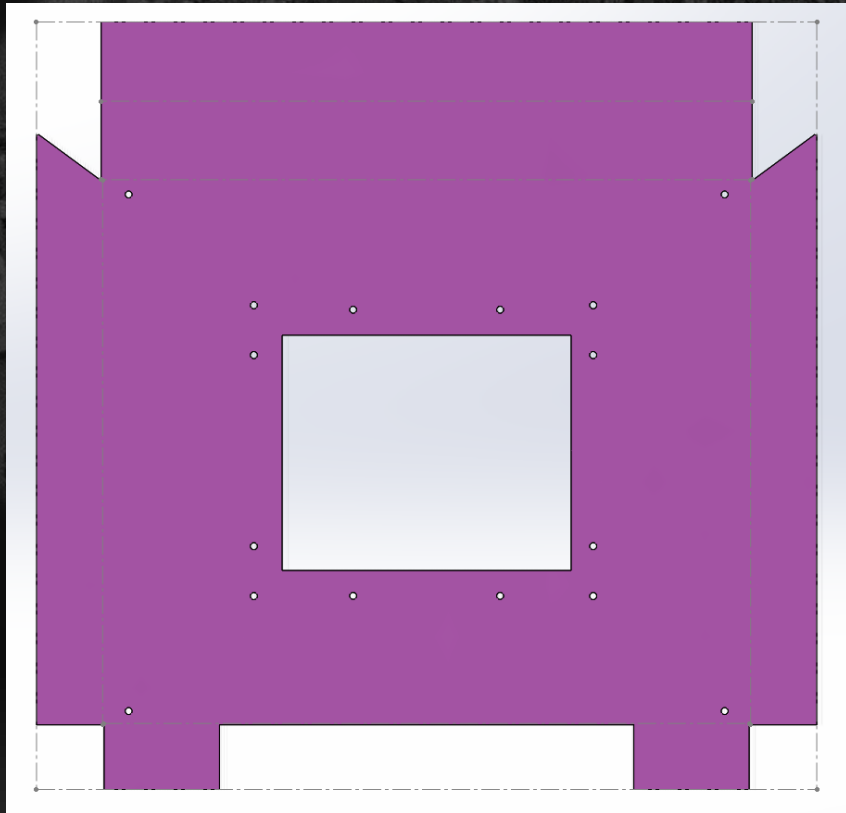


HVAC system
installed on the
full scale
battery pack

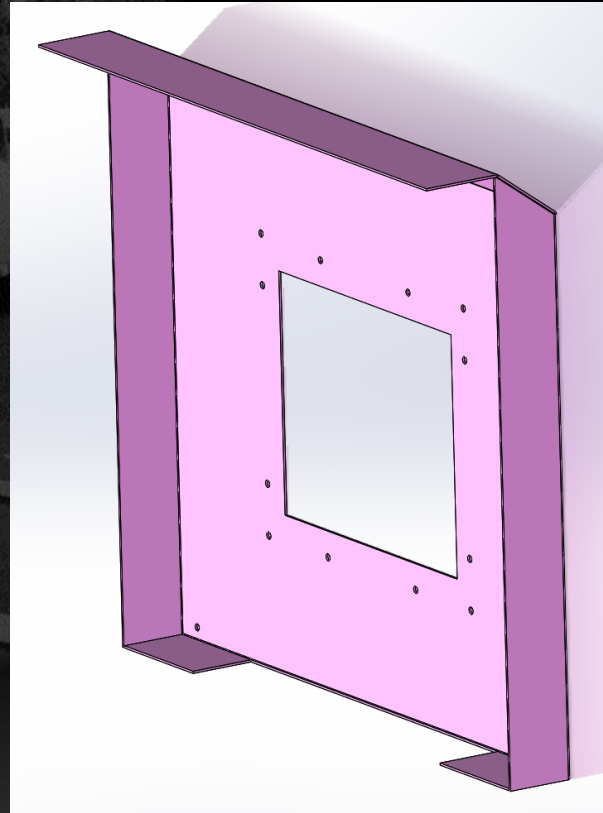


University
of Idaho

Manufacturing



Shroud cut from single piece of sheet metal and folded into shape



Frame made from 80/20 Aluminum

Components assembled using 80/20 T-slot hardware



University
of Idaho

Bill of Materials

80/20 aluminum

80/20 hardware

HVAC components

	B	C	D	E	F	G	H
	Part Number	Quantity	Unit Price	Total	Vendor	Link	Build/Buy
1	47065T244	4	6.83	27.32	McMaster-Carr	https://www.mcmaster.com/80/20-compatible-t-slotted-framing	Buy
2	47065T242	4	9.86	39.44	McMaster-Carr	https://www.mcmaster.com/80/20-compatible-t-slotted-framing	Buy
3	47065T139	4	1.85	7.4	McMaster-Carr	https://www.mcmaster.com/80/20-compatible-t-slotted-framing	Buy
4	91525A324	1	11.96	11.96	McMaster-Carr	https://www.mcmaster.com/standard-washers	Buy
5	PRM-19128	2	74.99	149.98	Summit Racing	https://www.summitracing.com/parts/prm-19120/overview/	Buy
6	PRM-19120	2	75.98	151.96	Summit Racing	https://www.summitracing.com/parts/prm-19120/overview/	Buy
7	N/A	1	189.99	189.99	Amazon	https://www.amazon.com/gp/product/B00T8VQ98O/ref=ox_sc_act_title_2?smid=ATVPDKIKX0DER&psc=1	Buy
8	N/A	1	N/A	0	Amazon	https://www.amazon.com/gp/product/B00T8VQ98O/ref=ox_sc_act_title_2?smid=ATVPDKIKX0DER&psc=2	Buy
9	N/A	1	N/A	0	Amazon	https://www.amazon.com/gp/product/B00T8VQ98O/ref=ox_sc_act_title_2?smid=ATVPDKIKX0DER&psc=3	Buy
10	#1	4	N/A	0	Uldaho		Build
11	#2	3	N/A	0	Uldaho		Build
12	#3	5	N/A	0	Uldaho		Build
13	#4	1	N/A	0	Uldaho		Build
14	N/A	3	15	45	AutoZone		Buy
15	91251A550	1	6.89	6.89	McMaster-Carr	https://www.mcmaster.com/standard-socket-head-screws	Buy
16	92825A138	2	7.57	15.14	McMaster-Carr	https://www.mcmaster.com/unthreaded-spacers	Buy
17	N/A	1	100	100	Pacific Steel		Buy
18	#5	4	0	0	Uldaho		Build
19	#6	1	25	25	McMaster-Carr		Build
20	47065T236	8	5.6	44.8	McMaster-Carr	https://www.mcmaster.com/80/20-compatible-t-slotted-framing	Buy



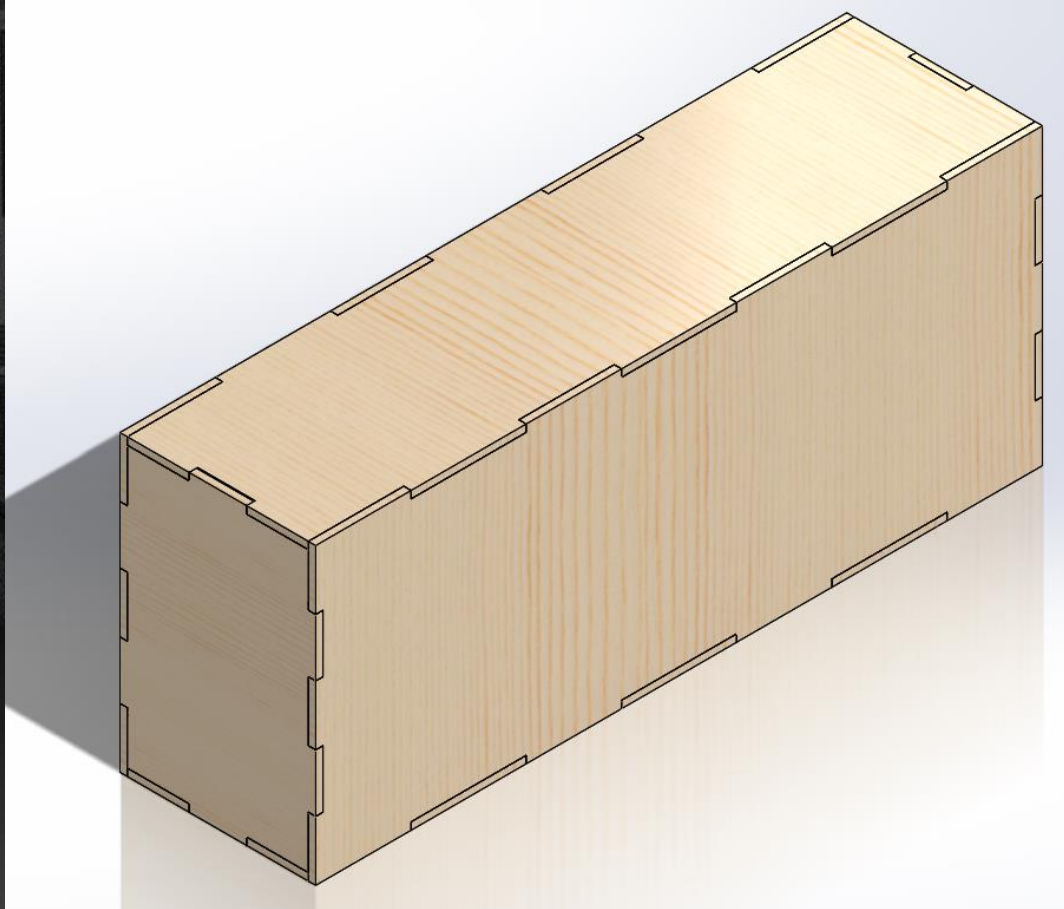
University
of Idaho

Budget

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Capstone Project Budget Template - Summer/Fall												
2		Project: HYG												
3		Last Updated 2/19/2019												
4														
5			Year									Item		
6		Expense Items	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr		Total		
8		Equipment/Tools:												
9												\$ -		
10												\$ -		
11		Travel:												
12		Trip To HYG							\$ 750			\$ 750	\$ 1,983	
13												\$ -		
14		Supplies / Parts / Services:												
15		Axial Fans					\$ 31					\$ 31		
16		Faciliates					\$ 90					\$ 90		
17		Faciliates/Recharge							\$ 90			\$ 90		
18		Wood				\$ 40						\$ 40		
19		Air Conditioner Unit					\$ 190					\$ 197		
20		3D Printer Filiment					\$ 20	\$ 160				\$ 80		
21		Power supply					\$ 100					\$ 100		
22		Three-Way Outside Corner						\$ 39				\$ 79		
23		2 Way-Outside Corner						\$ 27				\$ 27		
24		Compact Head/Black Zinc-Plated Steel 1/4"-20						\$ 22				\$ 22		
25		Perma Cool 8" Fans						\$ 75				\$ 75		
26		Perma Cool 10" Fans						\$ 76				\$ 75		
27		Automotive Tubing							\$ 45			\$ 45		
28		Sheet Metal Pacific Steel						\$ 100				\$ 100		
29		Compressor Plate							\$ 25			\$ 25		
30		Partially Thaded 1/4 -20						\$ 15				\$ 15		
31		L-Brackets							\$ 45			\$ 45		
32		LDPE Unthreaded Spacers							\$ 15			\$ 15		
33		Washers/Finders										\$ 12		
34		Display/Presentation							\$ 70			\$ 70		
35		Shop Usage (est. Hrs):										Hours		
36		Shop/Construction						10	10	10		30		
37												0		
39												Graduate Student Support	\$ 779	including fringe
40												Shop Overhead	\$ 600	
41												University Overhead	\$ 99	5% of all expenses
43												Totals	\$ 3,461	\$ 4,000 \$ 539
44													Budget	Excess



Validation and Deliverables



Build full size mock battery

Install assembled HVAC system on mock battery to test for cooled airflow



- Deliver completed system for Hyster-Yale to bench test
- Deliver all gathered information and test data
- Deliver CAD models for components and system

Schedule

	January	February
Purchase Wood Building Materials	Chris/Beau - Done	
Build Mock Battery	Beau - Done	
Order Small Air Conditioner	Chris - Done	
3D print most efficient nozzles	Trevin - Done	
Mount Fans with nozzles	Chase - Done	
Test fans with proposed ducting	Team - Done	
Dissassemble A/C unit and inspect parts	Team - Done	
SolidWorks Model of Compartment		Trevin - Done
Model Components and Assembly		Team - Done
Order Shrouding from Pacific Steel		Trevin - 27th
Order 80/20 parts for framework		Chris - 27th
	March	April
Buy wood	Chris - 1st	
Buy Fans	Trevin - 1st	
Laser Cut wood	Chase - 4th	
Build mock batteries	Team - 5th	
Assemble components in the frame	Team - 7th - 12th	
Test airflow design	Team - 13th - 19th	
Have AC lines crimped	Beau - 19th	
Recharge AC system	Beau - 20th - 24th	
Test Onboard Precooling Components	Team - 25th - 28th	
Finishing touches on assembly	Team - 29th - 14th	
Prepare for Design Expo		Team - 15th - 25th
Present at Design Expo		Team - 26th
Visit Client		Team - 30th
Deliver Prototype / Computer Models to Client		End of Semester



Risks and Recommendations

Main concerns:

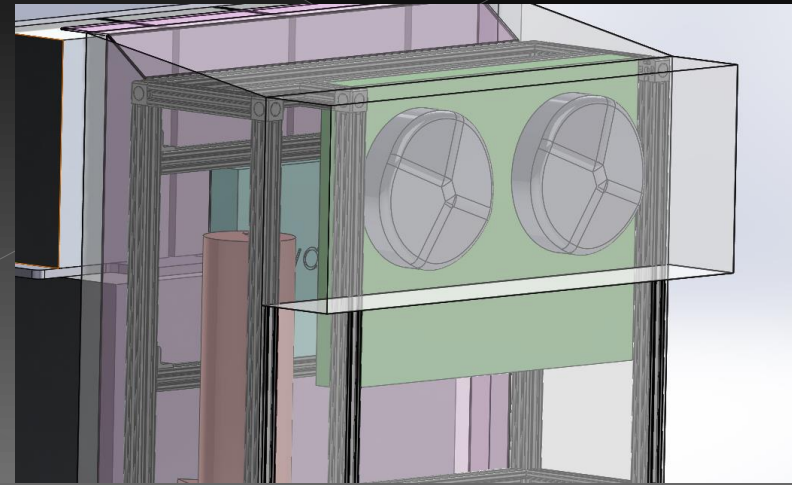
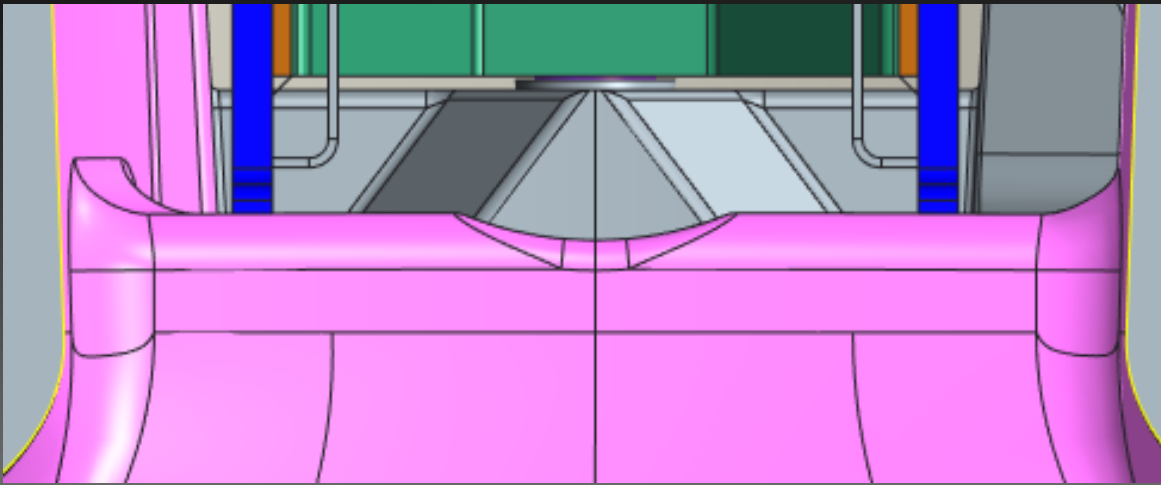
Fitment of Condenser fans in the opening of the counterweight

Maintaining air velocity past battery modules after restrictions from evaporator fins

Possible Solutions:

Smaller diameter axial fans or installing on the other side of the condenser

Replacing axial fans with blower style fans or installing secondary fans for battery slots



University
of Idaho



Questions?



University
of Idaho



Thank You!



University
of Idaho