EML4551-2

Virtual Design Review 2

Team 502
Retractable Storage Rack for Inert Atmosphere Glove Box

Jacqueline Matthews
Micheal Rodino
Evan Ryan

Team Introductions

Jacqueline Matthews
Project Manager/ Mechanical Engineer

Micheal Rodino
Manufacturing Engineer

Evan Ryan
Design Engineer

Sponsor and Advisor

Sponsor: Bill Starch-Applied Super Conductivity Center (ASC)

Advisor: Dr. Eric Hellstrom

Jacqueline Matthews

Objective

The objective of this project is to create fully functional retractable racks that will be implemented into an inert atmosphere glove box. The retractable racks will be used to store materials, tools, scales, etc., inside the glove box, creating an organized, uncluttered working area for the user.

Jacqueline Matthews

Inert Atmosphere Glove Box

- Controlled atmosphere apparatus which uses inert gas to provide a stable and sterile work environment.
- User reaches into box through gloves and conducts experiment/ test.
- Can manipulate air properties and allow for more accurate testing.

Jacqueline Matthews

Past Work

- Project Scope
  - Key goals
    - Retractable storage racks
    - Optimize storage space
    - Unrestricted work area
    - Able to be used by one user
    - Easily removable
  - Markets/Stakeholders
    - Applied Superconductivity Center (ASC) and its graduate students
    - FAMU and FSU chemistry departments
    - Glove box manufacturers
- Customer Needs
- Functional Decomposition
  - Provides extra storage
  - Creates an open work space
  - Retracts back to original location

Jacqueline Matthews

Work Completed after VDR1

- Targets and Metrics
- Concept Generation
- Concept Selection
- Bill of Materials

Jacqueline Matthews

Targets and Metrics

Category	Targets	Metrics
Quantitative	Cost	Budget of $2,000 USD
	Dimension	7in x 10in x14in
	Weight	~10 lbs
	Carrying Capacity	~40 lbs
	Longevity	The life of the glovebox (~40-50 years)
Qualitative	**Functionality**	Surface area gained by storage solution (1ft^2)
	Wall Support	Screw fasteners or magnets
	Usability	Storage solution within the back of the glovebox wall for easy reach (1.5ft)
	Material	Stainless Steel and/or Aluminum

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Concept Generation

- Brainstorming, crap shoot, anti-problem, and a morphological chart to create 100 different design ideas.
- 3 High Fidelity Concepts and 5 Medium Fidelity Concepts were selected based on the satisfaction of the customer needs and key goals of the project.

Feature	Option 1	Option 2	Option 3	Option 4
Support	Free Standing	Hanging	Screwed	Tracks
Movement	Spin	Pull	Swing	Stationary
Location	Wall	Ceiling	Back	Floor

Jacqueline Matthews

High Fidelity Concepts

Concept 1	The rotating shelves (Lazy Susan) will be attached to the box using rails and will be able to swing out of its position in the corner and forward to the user, where it can be rotated 360 degrees.
Concept 2	The Accordion style rack will sit against the back of the box and can be pulled forward towards the user on an extending wall support. A box or platform will be used to store the experiment materials and this area can be pushed back out of the way after use.
Concept 3	A four-bar linkage could be used to create a swinging platform that pulls outwards and towards the user from the corners which are out of reach. When the rack is fully extended it will lock into a forward storage area that holds it securely to the wall.

Micheal Rodino

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Medium Fidelity Concepts

Concept 4	The fold out wall design consists of a plate pressed up against the wall that can be folded out and provide an extra platform for lab materials
Concept 5	The telescope style extending rack uses increasingly small cylinders to pull the shelf out towards the user where materials can be stored and then pushed back against the wall.
Concept 6	The pegboard shelf concept takes a typical pegboard found in many workshops to hold tools and materials, and adapts it to create a pegboard that can be utilized in the inert atmosphere glovebox.
Concept 7	A hide-able rack that is able to be opened by pressing a button is a concept that was created for users with high ceiling spaces inside their gloveboxes.
Concept 8	A window shutter design could be implemented using several elevated shelves that can be slid out of the wall and into a lab platform position from a shutter mechanism.

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Concept Selection

- House of Quality
- Pugh Chart
- Criteria Comparison Matrix
- Normalized Criteria Comparison Matrix
- Consistency Check
- Consistency Index and Consistency Ratio Summa

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House of Quality

- Takes engineering characteristics and relates them to customer requirements by ranking them based on importance

		Engineering Characteristics								
Improvement Direction		↑	↑	↑	↑	↑	↑	↑	↓	↓
Units		lb.	psi.	n/a	n/a	in^3.	in^2.	n/a	min.	lb./lb-ft.
Customer Requirements	Importance Weight Factor	Weight Held	Material Rigidity	Corrosion Resistant	Mechanism Simplicity	Storage Volume Increase	Surface Area Increase	Ease of Use	Time to Install	Force or Torque Required to Use
Glovebox Lifetime	1	1	9	9	3					1
Retractable	4	3			9					1
More usable storage space	3					9	9	3		
Glovebox active installation	4		3		1				9	
Non-Obtrusive	3					3	3	3	6	3
Usable with gloves on	5							9	6	9
Compatability with multiple glovebox designs	5	1	1	1	3	3	3		1	1
Raw Score (434)		18	26	14	58	51	51	63	89	64
Relative Weight %		4.14746544	5.99078	3.22581	13.3641	11.7512	11.7512	14.5161	20.5069	14.7465
Rank Order		9	7	8	4	5	5	3	1	2

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PureLab HE2GB

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Pugh Chart with PureLab HE2GB as Datum

Engineering Characteristics	Storage Solution in PureLab HE2GB	Concepts 1	2	3	4	5	6	7	8
Weight Held	DATUM	+	S	-	+	-	+	-	S
Material Rigidity		S	S	S	S	S	S	S	S
Corrosion Resistant		S	S	S	S	S	S	S	S
Mechanism Simplicity		-	-	-	-	-	+	-	-
Storage Volume Increase		+	+	-	-	+	-	+	-
Surface Area Increase		+	+	-	+	+	-	-	+
Ease of Use		-	-	-	S	-	S	-	-
Time to Install		-	-	-	-	-	S	-	-
Force or Torque Required to Use		-	-	-	-	-	+	-	-
Positive		3	2	0	2	2	3	1	1
Negative		4	4	7	4	5	2	6	5
Satisfactory		2	3	2	3	2	4	2	3

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Pugh Chart with Concept 1 as Datum

		Concepts			
Engineering Characteristics	Concept 1: Lazy Susan	2	4	5	6
Weight Held	DATUM	-	-	-	+
Material Rigidity		S	S	S	S
Corrosion Resistant		S	S	S	S
Mechanism Simplicity		-	+	-	+
Storage Volume Increase		+	-	+	-
Surface Area Increase		-	-	-	-
Ease of Use		-	S	-	+
Time to Install		S	+	S	+
Force or Torque Required to Use		S	-	S	S
Positive		1	2	1	4
Negative		4	4	4	2
Satisfactory		4	3	4	3

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Criteria Comparison Matrix

- Takes selection criteria and weights each one accordingly.

Selection Criteria	Time to Install	Force or Torque Required to Use	Ease of Use	Mechanism Simplicity	Storage Volume Increase	Surface Area Increase	Material Rigidity	Corrosion Resistance	Weight Held
Time to Install	1	7	7	3	7	7	3	5	7
Force or Torque Required to Use	0.14	1	3	0.33	5	5	1	1	7
Ease of Use	0.14	0.33	1	0.2	1	1	0.33	0.33	5
Mechanism Simplicity	0.33	3	5	1	5	5	3	1	7
Storage Volume Increase	0.14	0.2	1	0.2	1	1	0.2	0.2	3
Surface Area Increase	0.14	0.2	1	0.2	1	1	0.2	0.2	5
Material Rigidity	0.33	1	3	0.33	5	5	1	1	5
Corrosion Resistance	0.2	1	3	1	5	5	1	1	5
Weight Held	0.14	0.14	0.2	0.14	0.33	0.2	0.2	0.2	1
Sum	2.56	13.87	24.2	6.4	30.33	30.2	9.93	9.93	45

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Normalized Criteria Comparison Matrix

- Normalized criteria comparison matrix by dividing the sum of the previous criteria.

Selection Criteria	Time to Install	Force or Torque Required to Use	Ease of Use	Mechanism Simplicity	Storage Volume Increase	Surface Are Increase	Material Rigidity	Corrosion Resistance	Weight Held	Criteria Weights
Time to Install	0.39063	0.50468637	0.28926	0.46875	0.23079	0.23179	0.30211	0.50352	0.15556	0.3419
Force or Torque Required to Use	0.05469	0.07209805	0.12397	0.05156	0.16485	0.16556	0.1007	0.1007	0.15556	0.10997
Ease of Use	0.05469	0.02379236	0.04132	0.03125	0.03297	0.03311	0.03323	0.03323	0.11111	0.04386
Mechanism Simplicity	0.12891	0.21629416	0.20661	0.15625	0.16485	0.16556	0.30211	0.1007	0.15556	0.17743
Storage Volume Increase	0.05469	0.01441961	0.04132	0.03125	0.03297	0.03311	0.02014	0.02014	0.06667	0.03497
Surface Area Increase	0.05469	0.01441961	0.04132	0.03125	0.03297	0.03311	0.02014	0.02014	0.11111	0.03991
Material Rigidity	0.12891	0.07209805	0.12397	0.05156	0.16485	0.16556	0.1007	0.1007	0.11111	0.11327
Corrosion Resistance	0.07813	0.07209805	0.12397	0.15625	0.16485	0.16556	0.1007	0.1007	0.11111	0.11926
Weight Held	0.05469	0.01009373	0.00826	0.02188	0.01088	0.00662	0.02014	0.02014	0.02222	0.01944
Sum	1	1	1	1	1	1	1	1	1	1

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Consistency Check

- Criteria weights found from the normalized criteria comparison matrix table.
- The weighted sum vector uses matrix multiplication between the normalized table [C] and criteria weights{W}.

Weighted Sum Vector{Ws} = [C]{W}	Criteria Weights {W}	{Cons} = {Ws}./{W}
3.547259	0.341899	10.375166
1.0909151	0.109966	9.920476
0.41228911	0.043857	9.40076
1.80894867	0.177428	10.195396
0.32889146	0.034968	9.405498
0.36776346	0.039906	9.215743
1.11700391	0.113275	9.860992
1.1914338	0.119264	9.989886
0.18233686	0.019436	9.381398

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Consistency Index and Consistency Ratio Summary

- Consistency values show that the values were accurate because the Consistency Ratio was below the threshold of 0.1.

- λ comes from the average of the cons column from the consistency check.

Random Index Value	1.45
λ	9.74948
Number of Engineering Criteria	9
Consistency Index	0.093684954
Consistency Ratio	0.064610313

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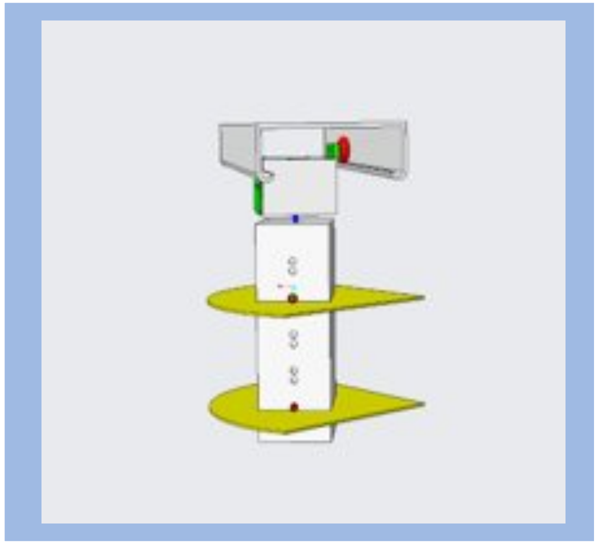
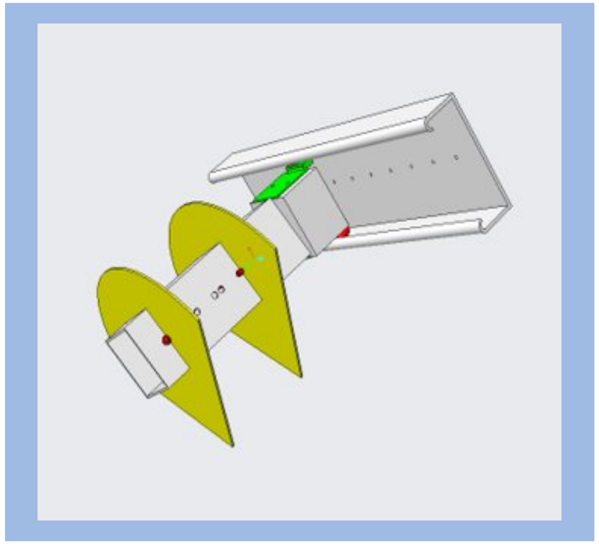
Final Concept

Concept 1: The Lazy Susan

- Final selected design concept:
  - Provides the most useable space without compromising experimental space
  - Combines rotational and linear movements to have a retractable and rotating shelving system
  - Shelves are held up by pins to allow them to change the position or add more shelves
  - Added concept: Having one shelf act as a pegboard to put tools into
  - Hangs from the ceiling to reduce wasted floor space





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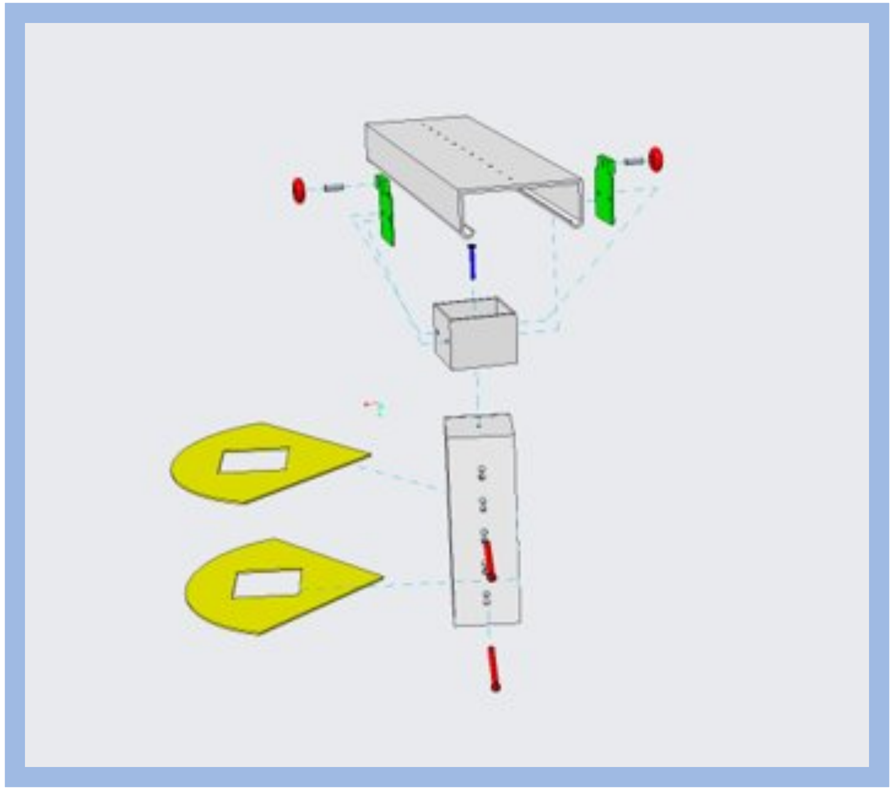
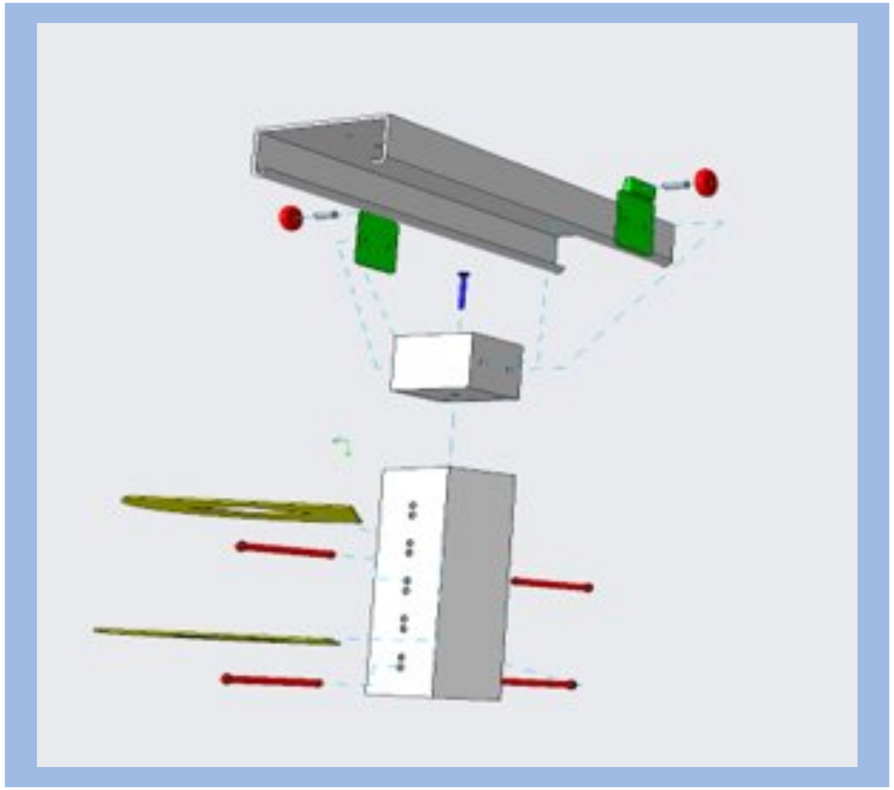
Final Concept Exploded View





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Future Work

- Risk Assessment
- Spring Project Plan
- Prototype

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Acknowledgments

- Bill Starch, Chongin Pak, and Arland Ohrt for demonstrating the use of the glovebox and giving us a decommissioned box for prototyping.
- Dr. Hellstrom for his helpful expertise on the project.
- ASC for sponsoring the project and allowing us to work on it.

Micheal Rodino

References

Cleartech. “Inert atmospheres glove box.” *Cleatech.com*, 2018, 30 September 2019. https://www.cleatech.com/inert-atmosphere-glove-box/

Inerttechnology, “Gloveboxes.” *Inerttechnology.com* , 30 September 2019 https://www.inerttechnology.com/gloveboxes/

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Questions

Embodiment

Upcoming Presenter’s Name

Manufacturing

Upcoming Presenter’s Name

Testing

Upcoming Presenter’s Name

Project Management

Most Important Points

1. The quick brown fox jumps over the lazy dog.
2. The quick brown fox jumps over the lazy dog.
3. The quick brown fox jumps over the lazy dog.
4. The quick brown fox jumps over the lazy dog.
5. The quick brown fox jumps over the lazy dog.
6. The quick brown fox jumps over the lazy dog.

Lessons Learned

Reference

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Questions (be sure to design your own)

Backup Slides

Functional Decomp Backup

Concept Selection Backup

Detailed Math Backup

Standard Shapes

Summary Box

Text box 1

Outlined Text Box

Approved Logos

FAMU-FSU
College of
Engineering

FAMU-FSU
Engineering

FAMU-FSU
Engineering

FAMU-FSU
College of Engineering

Color Palette

PANTONE®
2299 C

2299 C
Color values:
RGB 164 210 51
HEX/HTML #A4D233
CMYK 41 0 84 0

PANTONE®
1788 C

1788 C
Color values:
RGB 238 39 55
HEX/HTML #EE2737
CMYK 0 88 82 0

COE Dk Gray

75% Black
Color values:
RGB 64 64 64
HEX/HTML
#404040
CYMK: 0 0 0 75

PANTONE®
2239 C

2239 C
Color values:
RGB 0 207 180
HEX/HTML #00CFB4
CMYK 59 0 39 0

PANTONE®
647 C

647 C
Color values:
RGB 35 97 146
HEX/HTML #236192
CMYK 96 54 5 27

COE Md Gray

50% Black
Color values:
RGB 128 128 128
HEX/HTML
#808080
CYMK: 0 0 0 50

PANTONE®
2199 C

2199 C
Color values:
RGB 0 187 220
HEX/HTML #00BBDC
CMYK 77 0 16 0

PANTONE®
7535 C

7535 C
Color values:
RGB 183 176 156
HEX/HTML #B7B09C
CMYK 10 11 23 19

COE Lt Gray

25% Black
Color values:
RGB 191 191 191
HEX/HTML #bfbfbf
CYMK: 0 0 0 25

APA Tables

Category 1	Category 2	Category 3	Category 4	Category 5
Item 1				
Item 2				
Item 3				
Item 4				

	Category 2		Category 3	
Category 1	subcategory 1	subcategory 2	subcategory 1	subcategory 2
Item 1				
Item 2				
Item 3				
Item 4				