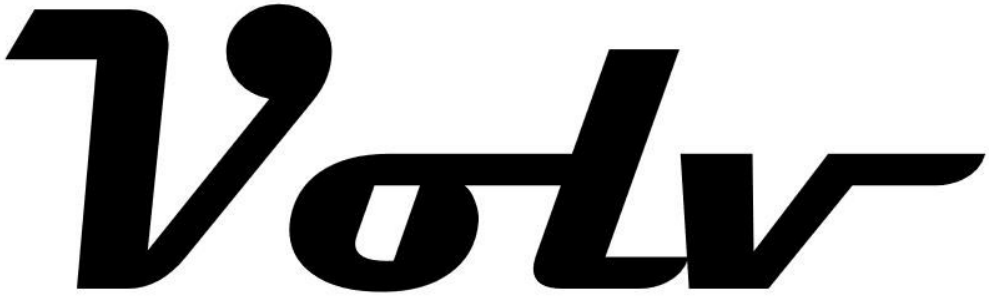
INDUSTRIAL & SYSTEMS ENGINEERING
TEXAS A&M UNIVERSITY

Final Report:



"The Revolving Refrigerator"

ISEN 489.503
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Team 5:

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I. Introduction

The “Revolving Refrigerator” is a design made to serve the many men and women who are unable to access all of the storage locations within common refrigerators today. Specifically, individuals who use wheelchairs, children, and older people will now able to utilize all of their refrigerator space. The Volv is a refrigerator made to bring shelves up or down to the user. This design allows the customer to achieve accessibility without the cost of unused shelf space.

The market has yet to witness a refrigerator product that allows for complete accessibility by all users without limiting the storage space of the product. Our product is the only design that can accommodate any user while maintaining all of the specifications of refrigerators today.

II. Background

About 10% of the global population requires the use of a wheelchair. In the U.S. alone 6.3 million citizens are confined to a wheelchair and as the “Baby Boomer” population grows older, that number is expected to quickly grow in the next couple of years. In order to allow handicapped people to live and work alone comfortably, the American Disability Act was put in place in 1990. While much of the industry has adjusted their products to meet these standards, very few products are designed for the disabled with accessibility to the general public. Team 5 has traveled the path less traveled by and followed the latter strategy. “Volv”, the revolving refrigerator, was designed specifically for those in wheelchairs, but usable by all.

III. Objectives

A. Requirements

The requirements for this project were derived from current ADA standards for refrigerators, industry-defined kitchen size constraints, and competitor standards. The following are the requirements used for the design of Volv:

1. Will move items on shelves to be within the user reach defined by the ADA Refrigerator standards as below 54” from the ground.

2. Will move items on shelves to be within comfortable reach of a wheelchair user at above 12" from the ground.
3. Will hold items securely.
4. Should have a modern and appealing outer design.
5. Shall operate at the push of a button.
6. Will be operable with one hand.
7. Will not require grasping, pinching or twisting of the wrist to move.
8. Should fit in the industry-standard kitchen width (40"), depth (30" with doors closed/ 43" with doors open), and height (72").
9. Will require a force of less than 5 lbs to activate.

B. Project Goals

1. Develop a product that consumers saw as life-changing for both the handicapped and the able-bodied.
2. Create a working CAD model to demonstrate the industrial design and motion of the developed product.
3. Present a holistic view of Team 5's use of the engineering design process to create a product that solves a user's problems.

IV. Project Tasks

Team Member	Responsibility
Erin Sylve	1. Apply Industrial Design to CAD Modeling to make the overall appearance of the refrigerator shell appealing. 2. Organize and Design the Powerpoint used for the final presentation from the information outlined in the Design Notebook. 3. Finalize design requirements and recommended materials for the final product. 4. Organize the Final Report to be submitted with the CAD model of the final design.
Anthony Arambula	1. Implement the mates for shelve rotation. 2. Create the final Volv animation for the presentation. 3. Generate an FEA report on the shelves for the freezer and

	refrigerator. 4. Create the AR image using eDrawings.
Aaron Kim	1. Apply CAD Modeling to make the side-by-side refrigerator appearance. 2. Manage the project by delegating and contributing tasks 3. Finalize the dimensions of the refrigerator and its materials 4. Contribute to the final design and the final report to be submitted.

V. Procedures

To create the design of "Volv," the team first created concept art for what the product would look like and how it would work. This concept art and additional information on the concept were submitted as a proposal. Once approved, the team began work on the next steps of the Engineering Design Process.

Using continuous research, design requirements were defined and refined throughout the design process. These requirements were mostly defined through research on competitor's requirements and ADA standards. To measure how well the system design fits within the requirements, the design dimensions were documented in a table available in Appendix A. This allowed the team to continually check the CAD design against the planned limits.

Once the concept was fully formulated, the design was presented for a first design review. From this review, the team was able to refine the requirements and intended end-users.

For the design, the system was divided into three subsystems, and each team member specially focused on one. The refrigerator unit was divided into the shell/doors, shelf rotation mechanism, and shelves. After each subsystem was finished, the refrigerator was assembled and underwent a second design review.

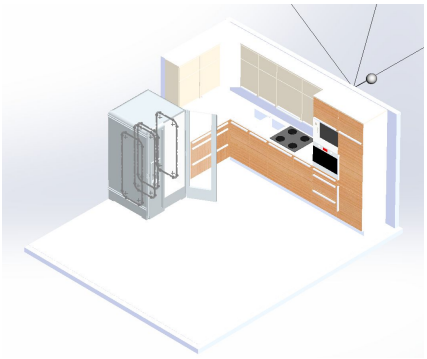
After the second design review, the team decided to improve the industrial design of the product and optimize the CAD assembly file. Optimizing the file would allow the shelf movement to be shown more smoothly.

Finally, the team conducted load testing and user testing. The product was made viewable from the inside CAD model of a kitchen and augmented reality. This report accompanies the final design review submission of the product.

VI. Results

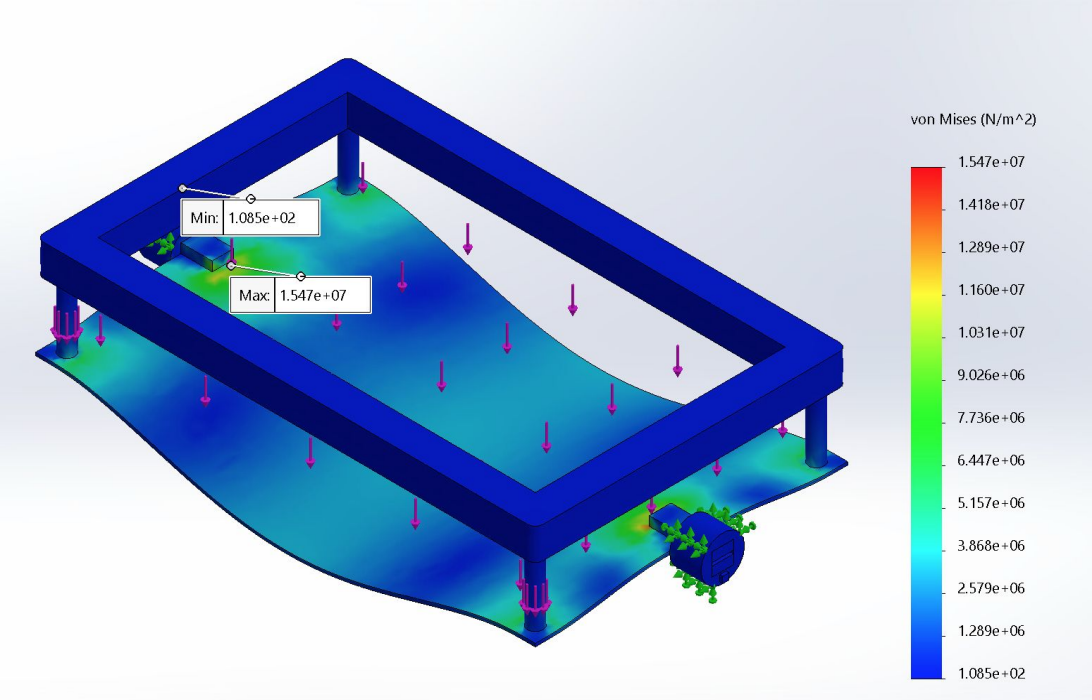
Pictured above is "Volv." The finished assembly features 203 components, including its rotational system and shelves.

The goal of "Volv" was to create a refrigerator, in which each shelf within the refrigerator was easily accessible. In addition to this, the refrigerator shall function normally and not sacrifice any storage volume. The complexity behind the moving shelves derived from designing a shelf that secured produce while in motion and was strong enough to support the weight of produce.

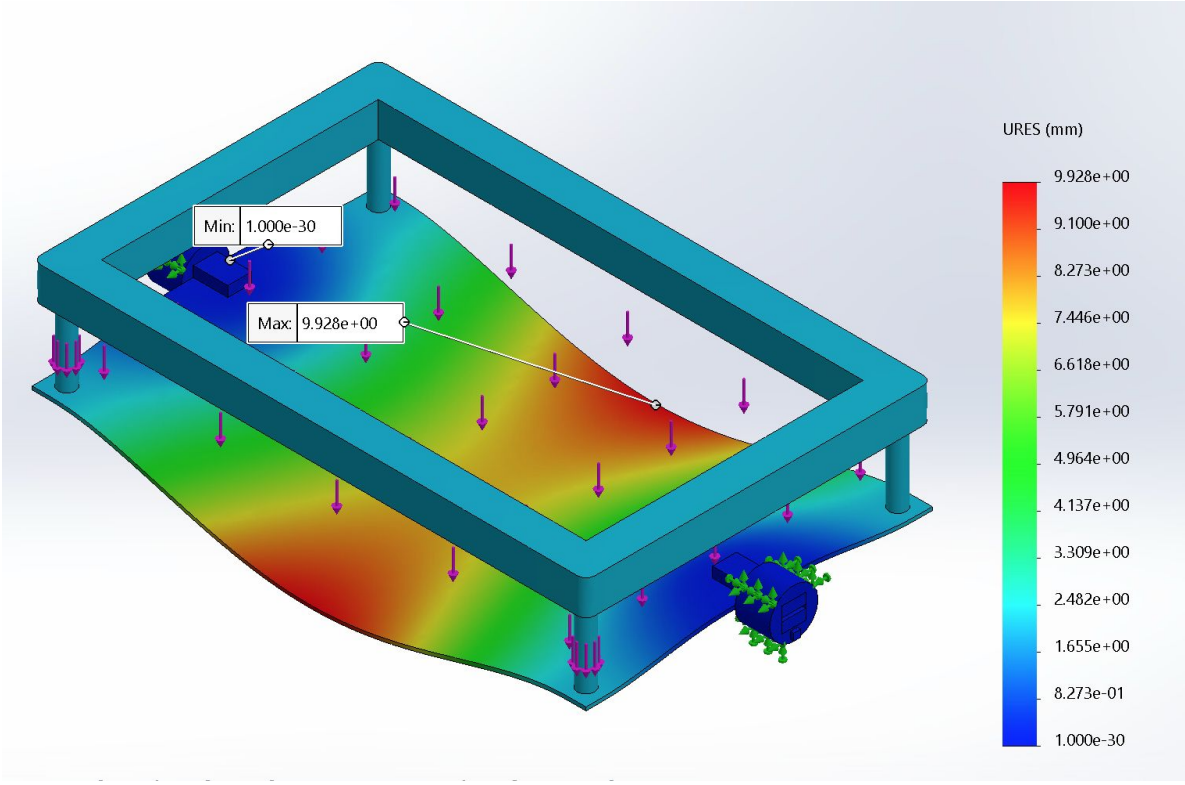


The FEA results indicate that the shelves are strong enough to support a common refrigerator shelf load. The force applied on the freezer shelf was 5 lbf, while the refrigerator side was tested at 15 lbf. The displacement test indicated a maximum displacement of 1.5 mm on the freezer shelf and 9.9 mm on the fridge shelf. The results are listed in the following pages.

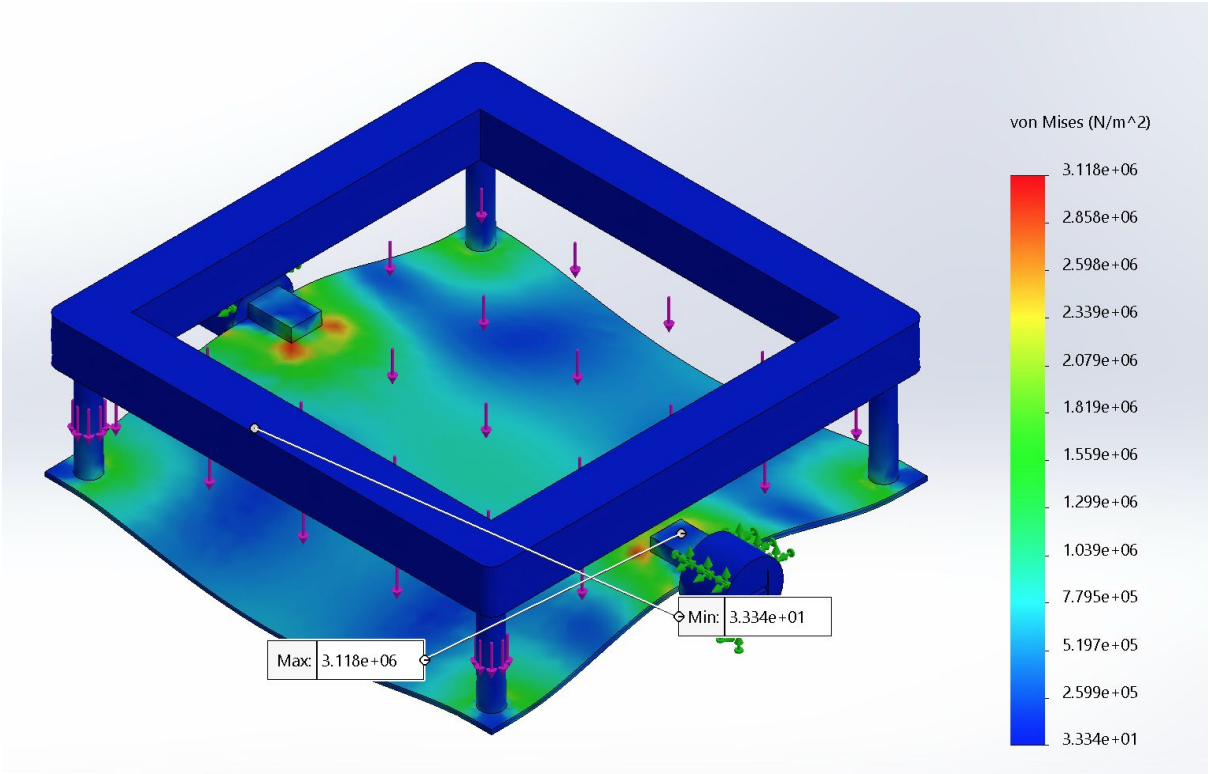
Fridge Shelf: Stress Test



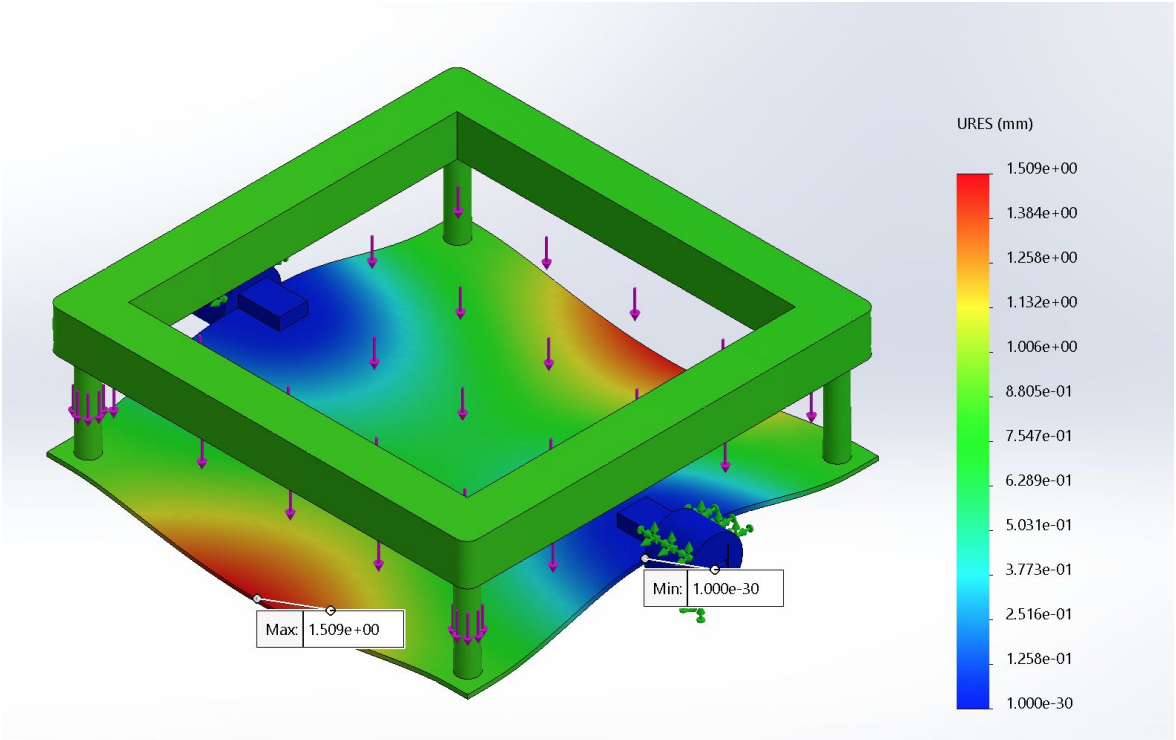
Fridge Shelf: Displacement Test



Freezer Shelf: Stress Test



Freezer Shelf: Displacement Test



VII. Conclusion

The conveyor system refrigerator or what we call the revolving refrigerator “Volv”, eliminates the reach constraints of all anticipated users by abandoning the concept of fixed shelving. As the shelves are now free to accommodate the needs of the user by rotating vertically, the accessibility within a refrigerator increases. Overall, our final design successfully incorporates crucial functions of rotating shelves along with the built railing system. Conclusively, the final design of the revolving refrigerator met the predefined goals and the statement of need by making the fridge more accessible for everyone.

VIII. Appendix

Appendix A

All units in IPS	Side by side fridge				
Part	Dimension	Magnitude	Unit	Material	Designer
Refrigerator Base	Height	72.75	in	Stainless Steel Sheets injected with foam	Aaron
	Width	38	in		
	Depth	37.5	in		
Inside Space (Fridge)	Height	61.5	in	High Impact Polystyrene	Aaron
	Width	20	in		
	Depth	33.5	in		
Inside Space (Freeze)	Height	69	in	High Impact Polystyrene	Aaron
	Width	14	in		
	Depth	33.5	in		
Door	Height	63.8	in	Stainless Steel Bar	Erin
(handle)	Arc Length	2.25	in		
	Thickness	0.5	in		
Buttons	Radius	1	in	High Impact Polystyrene	Erin
Leveling Feet	Height	0.75	in	Stainless Steel Bar	Aaron
Fridge Rails	Height	50	in	High Impact Polystyrene	Erin
	Width	22	in		
	Depth	2.06	in		
	Radius	2	in		
Freeze Rails	Height	60	in	High Impact Polystyrene	Erin
	Width	22	in		
	Depth	2.06	in		
	Radius	2	degrees		
Fridge Rings	Outer Radius	1.4	in	High Impact Polystyrene	Erin
	Inner Square Side	0.7	in		
	Height	1	in		
Fridge Clips	Width	0.69	in	High Impact Polystyrene	Erin
	Length	2	in		
	Height	0.3	in		
	Inner Hole Diameter	0.25	in		
Fridge Pins	Diameter	0.25	in	High Impact Polystyrene	Erin
	Height	0.3	in		
Smart Display	Height	9.5	in		Erin
	Width	7	in	Capacitive Screen Glass/Plastic	
Fridge Shelves	Height	3.25	in	Capacitive Screen Glass/Plastic	Anthony
	Width	10	in	High Impact Polystyrene	
	Length	16	in		
Freezer Shelves	Height	3.25	in	Capacitive Screen Glass/Plastic	Anthony
	Width	10	in	High Impact Polystyrene	
	Length	10.25	in		

The side-by-side revolving refrigerator measures 72.75 inches in height and 37.5 inches in depth. The total volume is about 60 cubic feet, which can have more fresh food inside the fridge and freezer. The dimensions of the shelves can be customized, but its dimensions are usually 3 * 10 * 12.5 inches. Materials used in this refrigerator include stainless steel sheets injected with the foam, high impact polystyrene, and capacitive screen glass, etc. More details are included in the attached picture above.