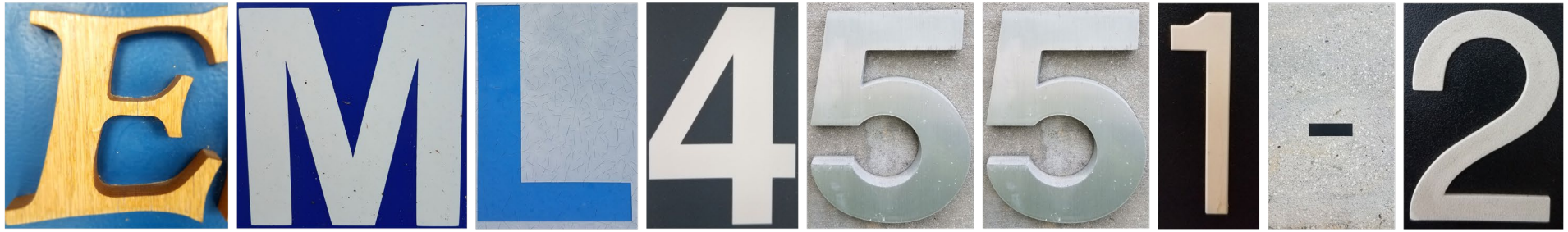


Virtual Design Review

Nick Ajhar, Bryce Lankford, Marissa Jackson
Team 506: Mobile Anechoic Chamber

24-Jan-19

Danfoss

TURBOCOR

FAMU-FSU
COLLEGE OF
ENGINEERING

Team Introductions

Team 506: Mobile Anechoic Chamber

Marissa Jackson
Project Manager

Bryce Lankford
Systems Engineer

Nick Ajhar
Mechanical Engineer

Objective

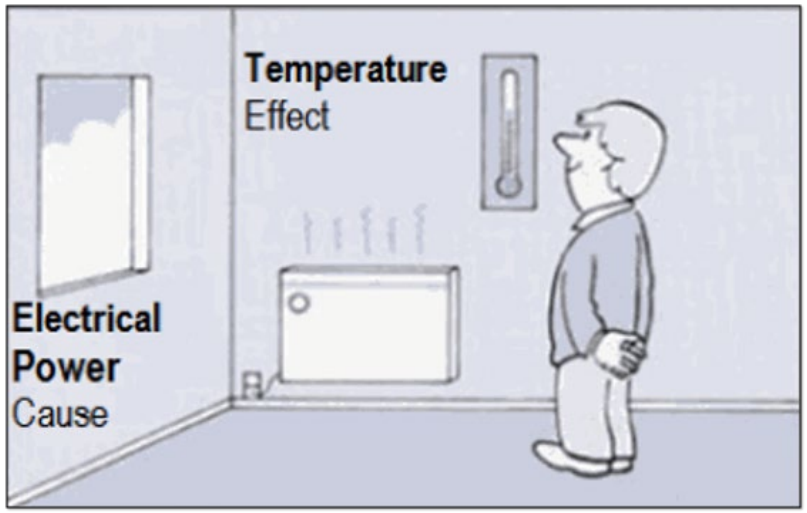
Design a way to efficiently and consistently record sound power for centrifugal compressors while managing surrounding noise

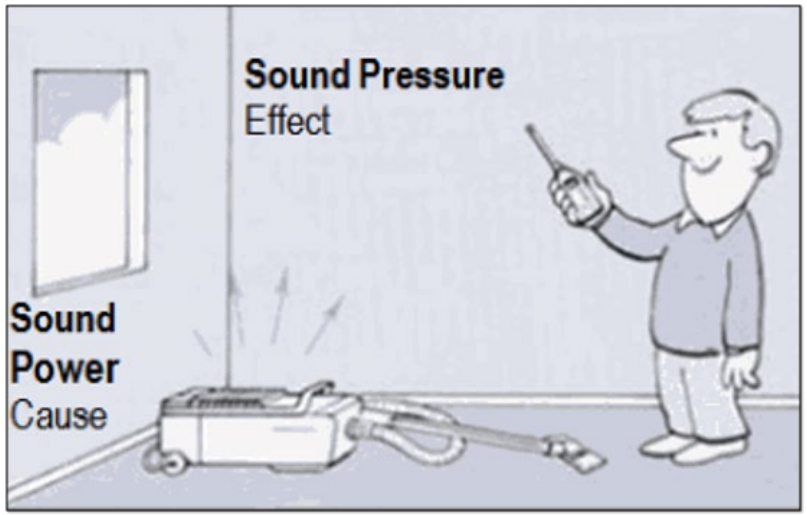
Project Summary

- Measure the sound power of the TT series compressors
- Sound power is the energy emitted by the source and is measured in Watts
- Reduce the surrounding sound to get a consistent reading from the compressors
- Must be able to be easily assembled and portable

Project Background

- Centrifugal Compressors
  - TT Series
    - 4 Different Models: 300, 350, 400, 500
  - R134a refrigerant
  - Quiet Operation (92 dB)
  - Background noise (78 dB)
- Sound Power
  - Rate at which sound is emitted
  - Measured in Watts (W)
  - Deviated from sound pressure (dB)
  - Indicator for how intense the sound of a machine will be



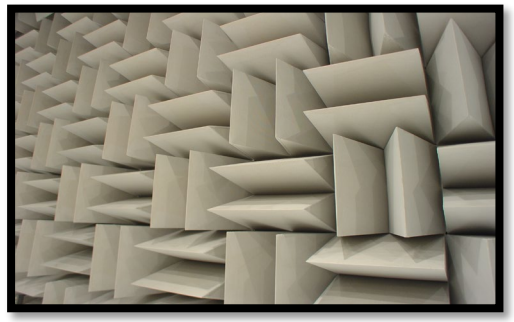


Marissa Jackson

Project Scope

- Consistently measure the sound power across TT series compressors

Sound Pressure

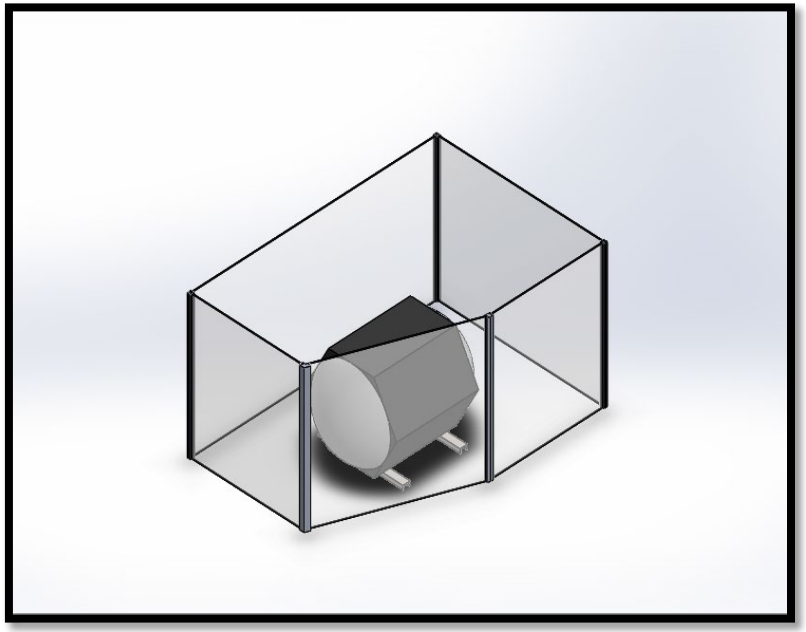


Sound Power

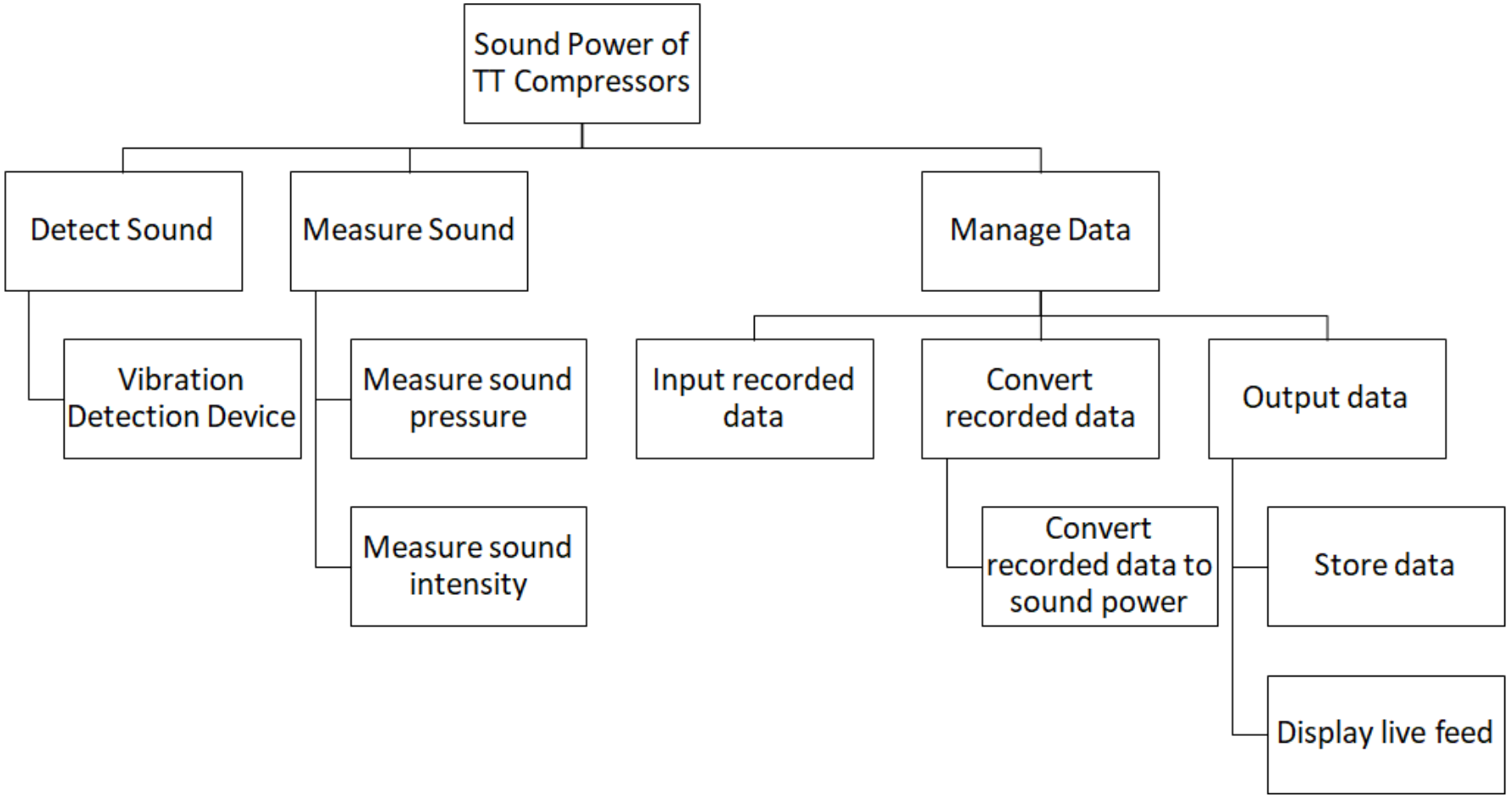
Marissa Jackson

Customer Needs

- Measure sound across compressors
  - Be able to convert to sound power
  - Consistent reading
- Reduce ambient sound to get most accurate recording
- Store and display the results
- Easy setup and breakdown of system within current test stand



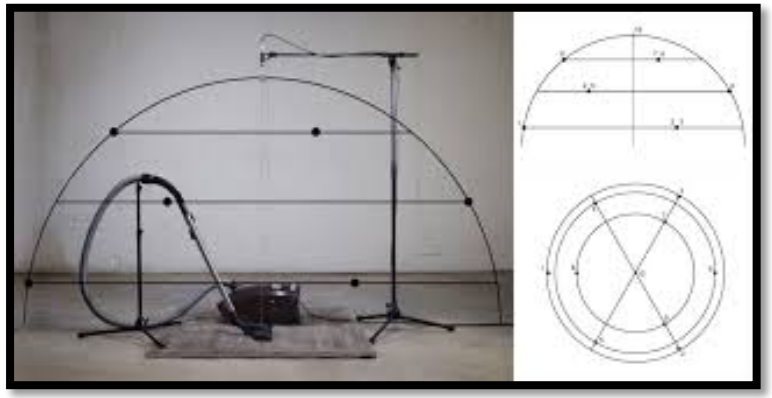
Functional Decomposition



Marissa Jackson

Subsystems

Reduce Ambient Sound



Record Sound

Convert to Sound Power

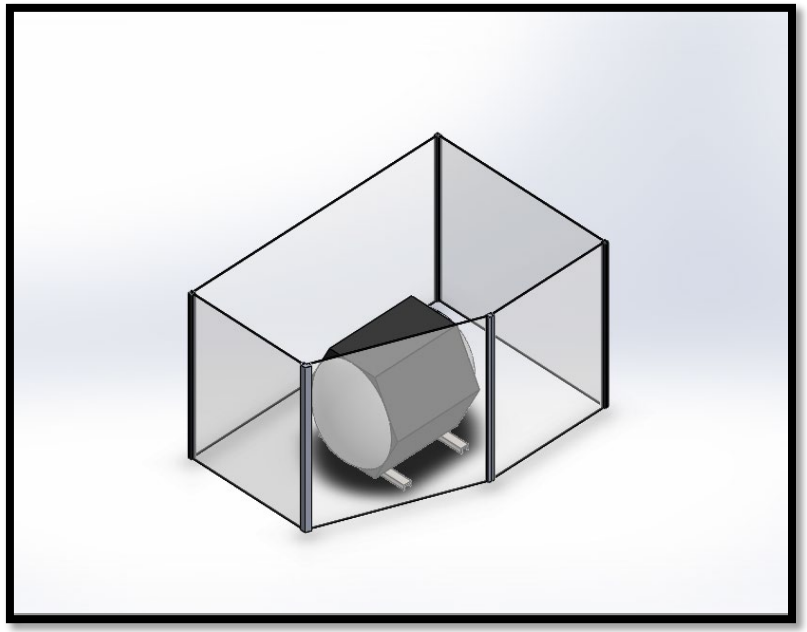
Bryce Lankford

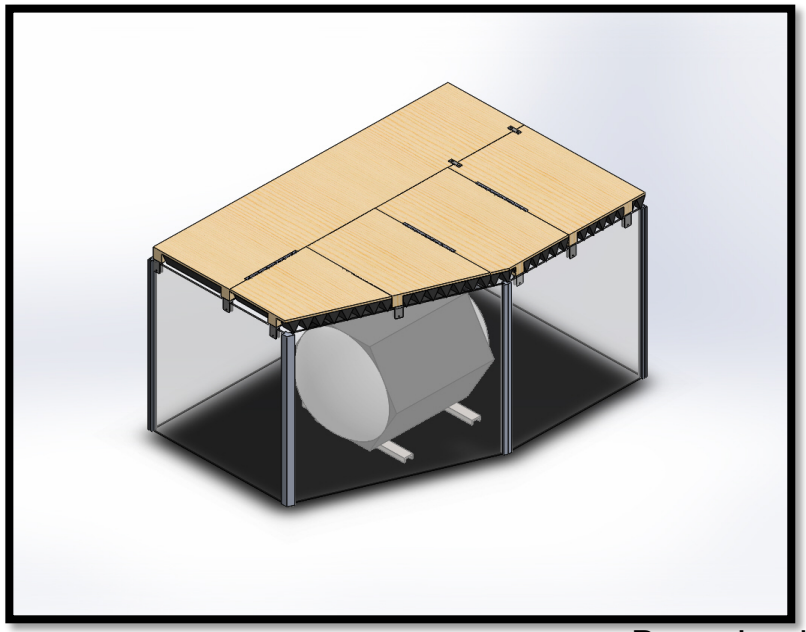
Reduce Ambient Sound

Concept Generation

Full Coverage of Compressor

- Completely surrounds compressor in Anechoic Box structure
- Would dampen sound more fully by isolating the compressor stand from the production floor





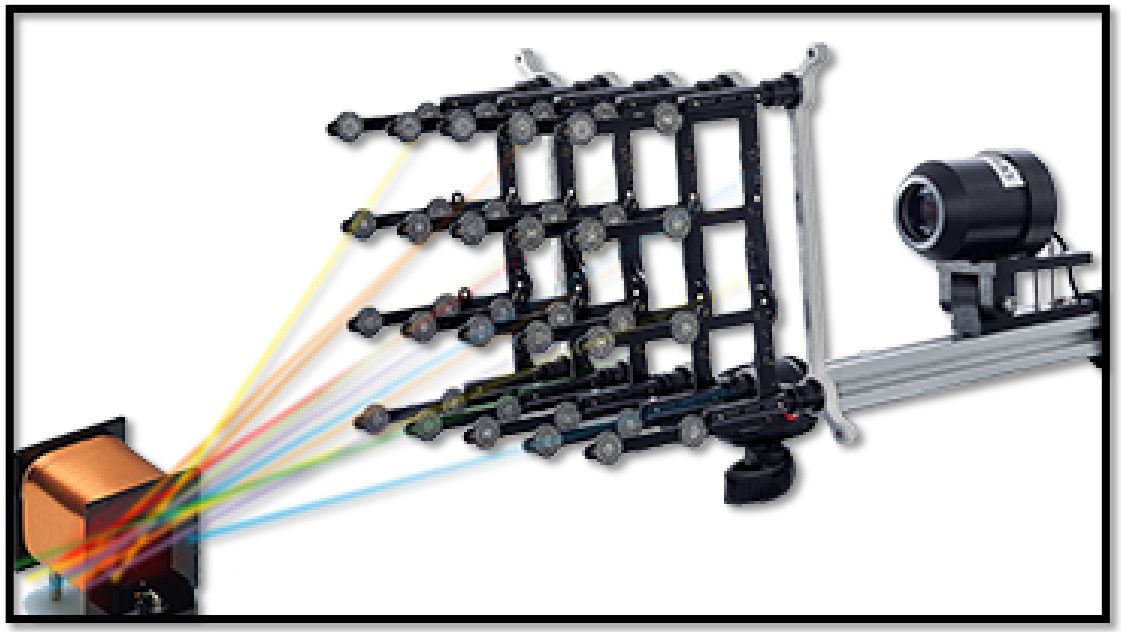
Bryce Lankford

Measure Sound Pressure

Concept Generation

Array of Microphones

- Can record sound power over a predetermined area
- Array consists of many preset microphones which all record the same sound source simultaneously
- Has the potential to map sound intensity at specific points on the compressor



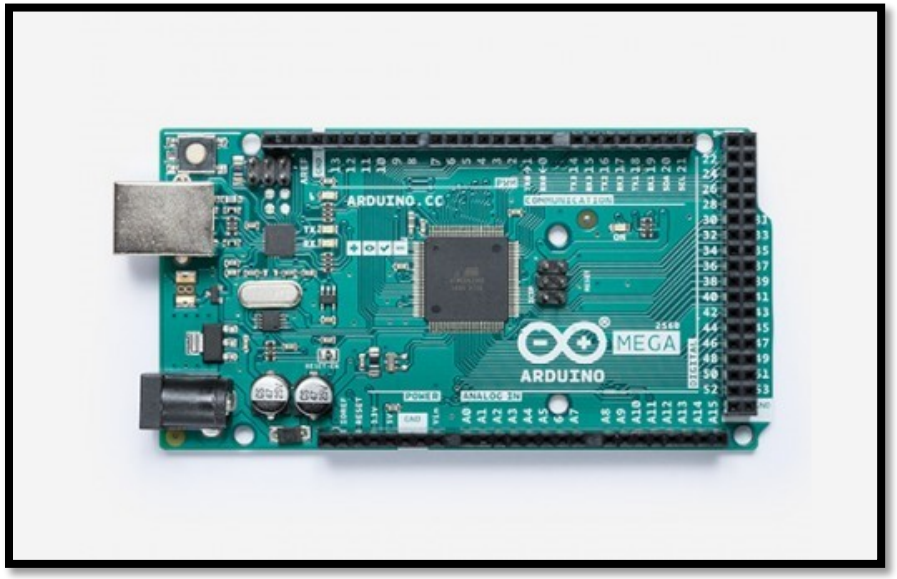
Bryce Lankford

Convert to Sound Power

Concept Generation

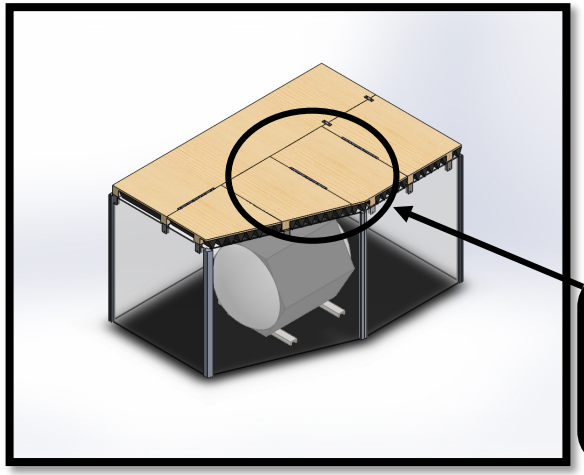
Direct Connection

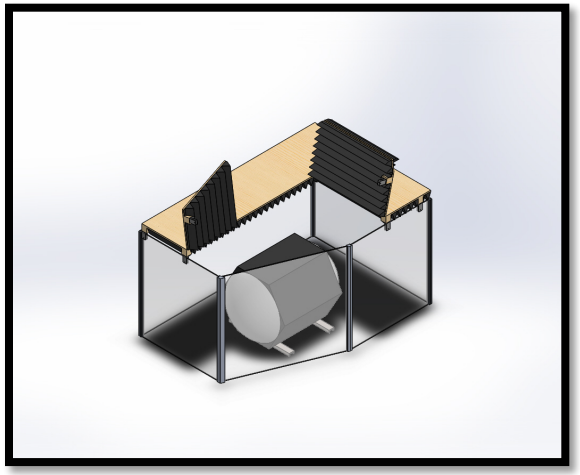
- Setup of a microcontroller that will perform the needed conversions
- Computer program will simultaneously convert data during recording

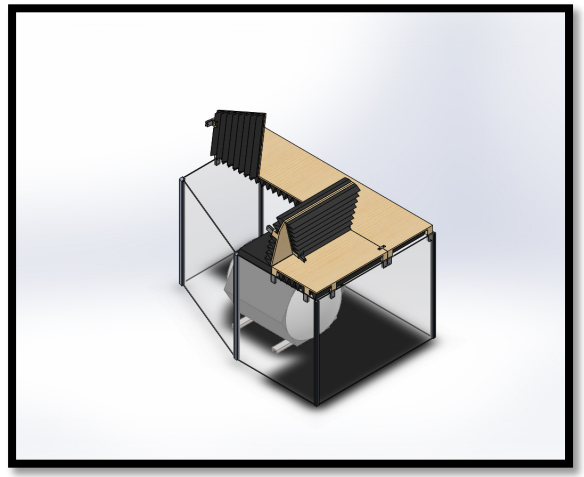


Detailed Design Overview

- Top cover is 2 pieces
  - Left support with hinge
  - Right support with tonneau hinge
- Hinge is to allow compressor mobility
- Microphones are inserted into the two middle folding panels



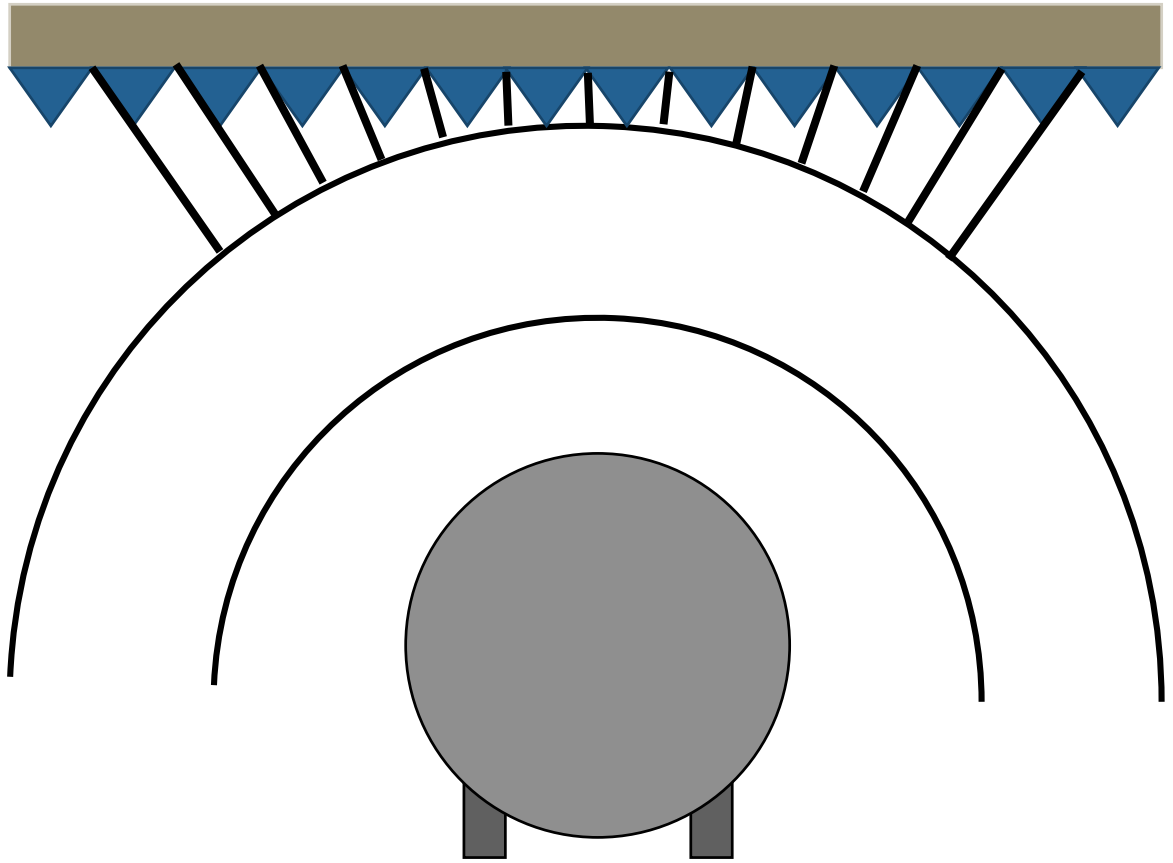




Bryce Lankford

Detailed Design Overview

- Microphones spread throughout middle folding pieces
- Angled at 10º increments



Bryce Lankford

Future Work

- Determine best microphone setup
- Finalize frame design with Danfoss
- Order materials to start construction
- Program microphones to record sound pressure
- Determine calculations to be used to convert to sound power

Bryce Lankford

References

- Danfoss Turbocor - TT. (n.d.). Retrieved from https://www.danfoss.com/en/products/compressors/dcs/turboc or/turbocor-tt/#tab-overview
- Brüel & Kjær. (1993). Sound Intensity. Retrieved from
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Questions?

Preliminary Data

From a test Danfoss previously conducted, the level of sound from the compressors was measured and averaged.

- Ambient Sound Level – 78 dB(A)
- Compressor Sound Level – 92 dB(A)

Next Steps

- Targets and Metrics
  - Consistency of sound power range
  - Display the data collected
- Concept Generation and Selection
  - Design of various systems
  - Selection of design using house of quality

Targets

Function	Target
Vibration Detection Device	20-20000 Hz
Measure Sound Pressure	92 dB
Reduce Ambient Sound	± 5 dBA
Weight	50 lbs.
Input Recorded Data	16 Bits
Convert Recorded Sound to Sound Power	± 5W
Output Data	64 GB
Store Data	250 GB
Display Live Feed	1 ms
Compatible with Testing Stand	30 min

Bryce Lankford

Pairwise Selection

Pairwise Selection										
	1	2	3	4	5	6	7	8	9	Sum
1. Measure Sound	-	1	1	1	0	0	1	1	1	6
2. Compatible with Testing Station	0	-	1	1	0	0	1	1	1	5
3. Store Data	0	0	-	1	0	0	1	0	1	3
4. Display Data	0	0	0	-	0	1	1	0	0	2
5. Consistent Recording	1	1	1	1	-	0	1	1	1	7
6. Convert to Sound Power	1	1	1	1	1	-	1	1	1	8
7. Ease of Conversion	0	0	0	0	0	0	-	1	0	1
8. Reduce ambient sound	0	0	1	1	0	0	0	-	0	2
9. Mobility of system	0	0	0	1	0	0	1	1	-	3
Sum	2	3	5	7	1	1	7	6	5	n-1=7

Pugh Matrix

Secondary Pugh Matrix for Subsystem 1			
Selection Criteria		Concepts	
	Concept 4	1	3
Measure Sound Pressure		+	+
Wavelength frequency detected		S	S
Recorded ambient sound		+	+
Time to set up and break down system		-	-
Weight of system		-	-
Cost		-	+
Ease of Conversion		+	+
Sum of Positive		3	4
Sum of Negative		3	2

Criteria Comparison Matrix

Criteria Comparison Matrix for Subsystem 1						
	Measure Sound Pressure	Wavelength Frequency Detected	Recorded Ambient Sound	Time to set up and break down	Weight of system	Sound power conversion
Measure Sound Pressure	1.00	3.00	0.14	0.20	0.20	3.00
Wavelength frequency detected	0.33	1.00	0.14	0.20	0.14	3.00
Recorded ambient sound	7.00	7.00	1.00	7.00	7.00	7.00
Time to set up and break down system	5.00	5.00	0.14	1.00	0.33	5.00
Weight of system	5.00	5.00	0.14	3.00	1.00	1.00
Sound power conversion	0.33	0.33	0.14	0.20	1.00	1.00
Sum	18.67	21.33	1.71	11.60	9.68	20.00

Normalized Criteria Comparison Matrix for Subsystem 1							
	Measure Sound Pressure	Wavelength Frequency detected	Record ambient sound	Time to set up and break down system	Weight of system	Sound power conversion	Weight
Measure Sound Pressure	0.05	0.14	0.08	0.02	0.02	0.15	7.76%
Wavelength frequency detected	0.02	0.05	0.08	0.02	0.01	0.15	5.50%
Recorded ambient sound	0.38	0.33	0.58	0.60	0.72	0.35	49.39%
Time to set up and break down system	0.27	0.23	0.08	0.09	0.03	0.25	15.94%
Weight of system	0.27	0.23	0.08	0.26	0.10	0.05	16.63%
Sound power conversion	0.02	0.02	0.08	0.02	0.10	0.05	4.79%
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00