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Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

Reducing Whole Body Vibration in Neonatal Transport

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Advisor:
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The Team

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Joey Byrne: BPAG

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Figure 1: Team Picture

The Clients

- Dr. Ryan McAdams, MD
  - Neonatology Division Chief
  - UW faculty member for the UW School of Medicine and Public Health
  - 24 years of experience in neonatal transport medicine
  - 10 years of experience with aeromedical transports in the Air Force

- Dr. Joshua Gollub, MD
  - Fellow at the University of Wisconsin School of Medicine and Public Health
  - Specializes in neonatal medicine

Figure 2: Team Members, Clients, and Med Flight team at the UW Hospital Helicopter Pad

Overview

- Problem Statement
- Background Research
- Competing Designs
- Product Design Specifications
- Competing Designs
- Preliminary Designs
- Design Matrix
- Conclusion and Future Work
- Acknowledgements
- References

Problem Statement

- The need to transport critically ill neonates is very common
- Transport vehicles induce vibrations, translational and rotational motion, and excessive sound [1]
  - Whole Body Vibrations (WBV)
  - Causes intraventricular hemorrhage (IVH), neurodevelopmental impairment, or death [2].
- No established vibration-reducing device.

Figure 3: Neonatal Transport via Med Flight [3]

Figure 4: Transport Via Ambulance [4]

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Background

- Critically ill neonates
  - birth defects
  - pre-term (<37 weeks of gestation) [5]
  - VERY fragile
- Current transport setup consists of:
  - Incubator
  - Incubator control box
  - Support systems
  - Platform
  - Mattress
- Incubator Functions/ Compatibility:
  - Ventilators
  - Temperature control
  - Monitoring Equipment

Figure 5: Neonate in NICU [6]

Figure 6: Incubator Assembly [3]

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Competing Designs

- Quasi-zero-stiffness (QZS) isolator [7]
  - Uses a pair of repelling permanent magnets
  - Magnets are in parallel connection to a coil spring
  - Targets low-frequency components of vibration
- Isolation device for shock reduction [8]
  - Pair of plates- one on stretcher and one on incubator
  - Springs/ gas springs in the gap between the plates

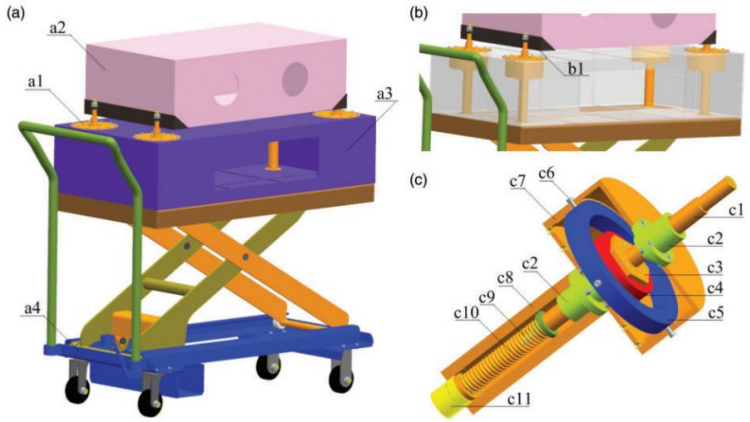

Figure 7: Quasi-zero-stiffness isolator design [9]

Product Design Specifications

Decrease vibrations to be below 0.87 m/s^2 [11]

- Allow for continuous treatment with no interference
- White or gray to be easily cleaned [10]

Should follow all medical safety standards

Reduce the volume of excessive sound levels to be below 45 decibels [12]

Allow the infant to maintain proper vital signs [13]

Functional for neonates ranging from 300g to 5500g (0.66-12lbs) [14]

Magnet-Induced Levitation

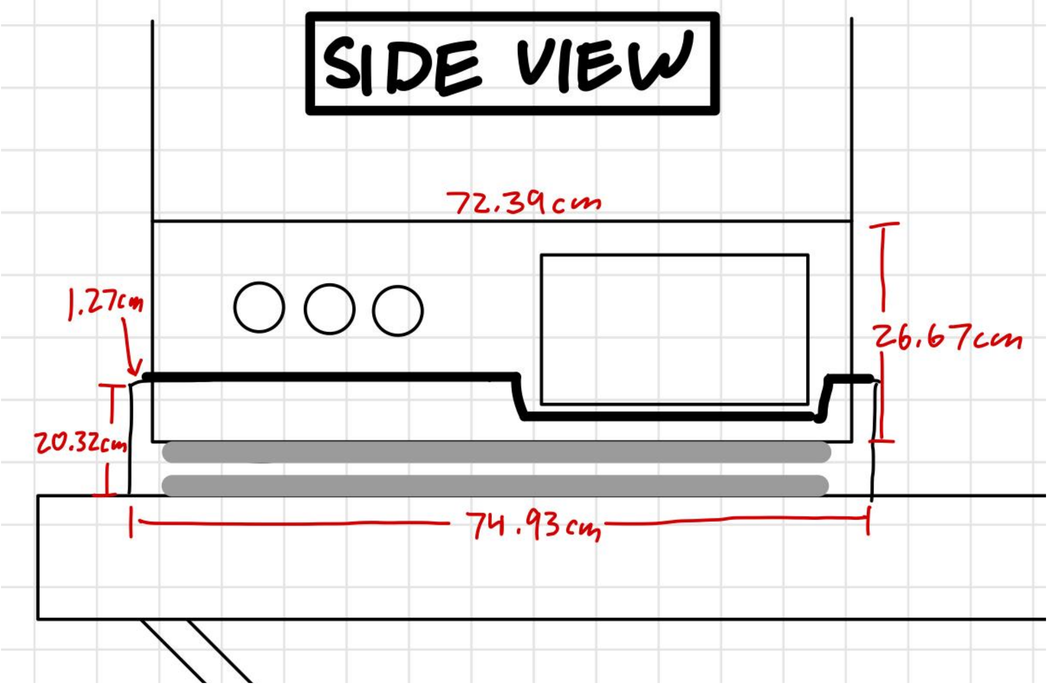

Figure 8: A side view of the magnet-induced levitation concept.

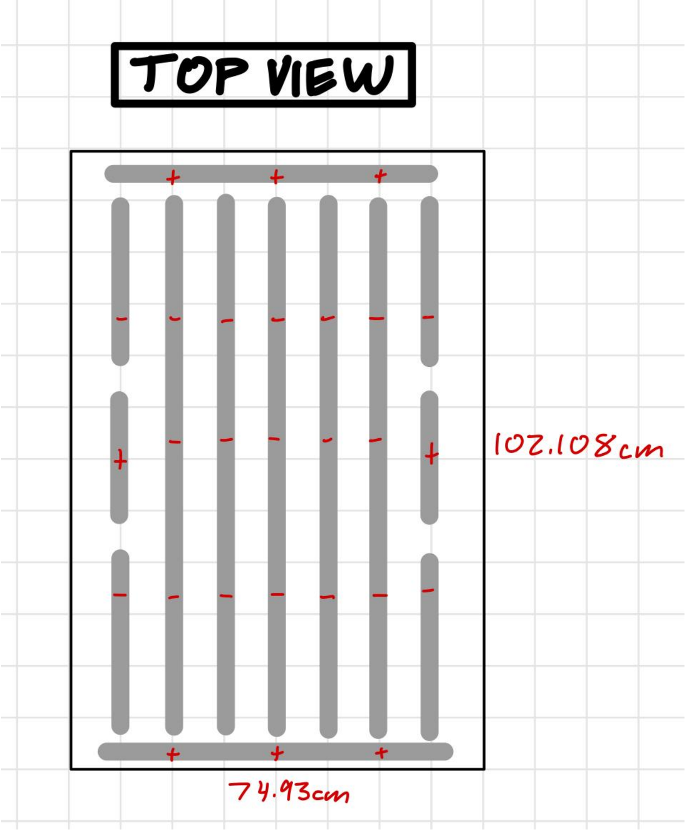

Figure 9: A cross-sectional top view of the magnet configuration.

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Metal/Gel Composite Damping

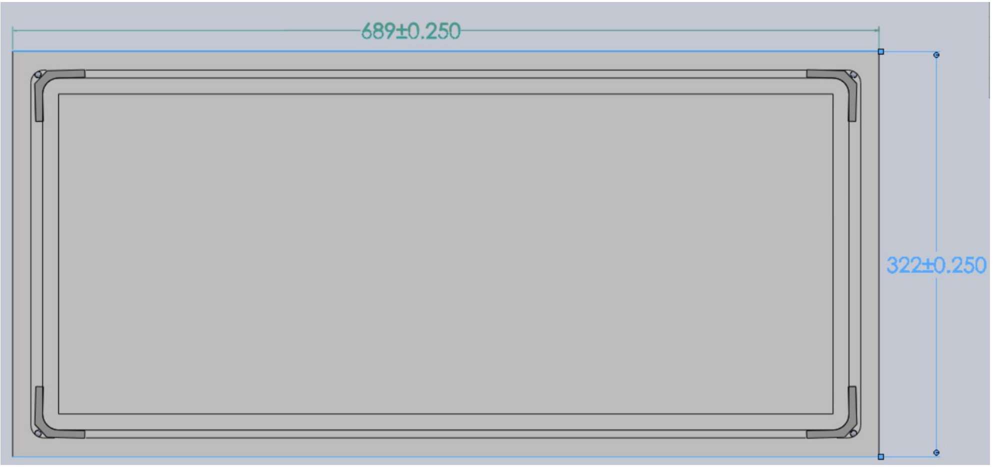


Figure 10: Top view of incubator trays with corner dampers

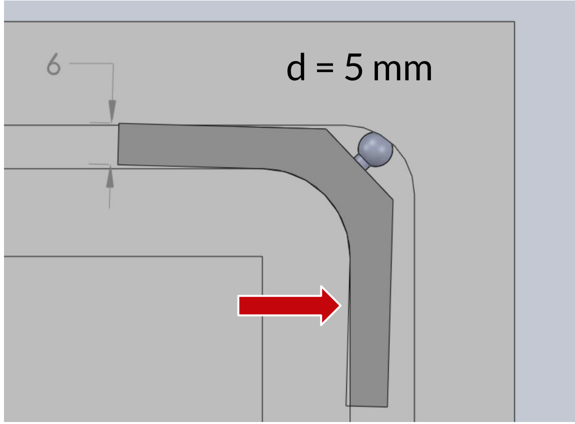


Figure 11: Close-up corner view of damper

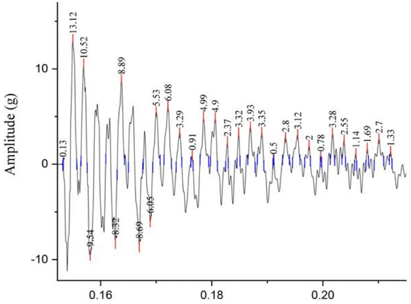


Figure 12a: Damping curve of solid steel [15]

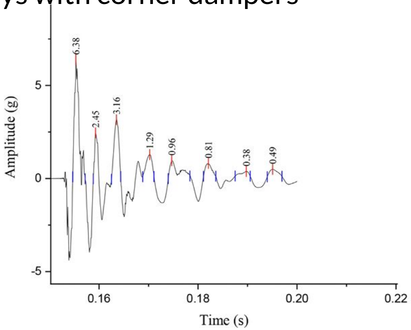


Figure 12b: Damping curve of layered damper [15]

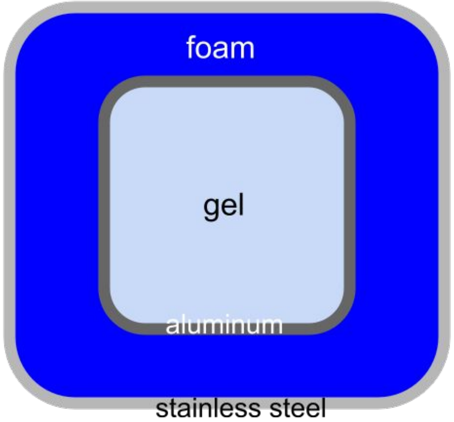


Figure 13: Cross section of damper material

Shock-Absorbing Mat

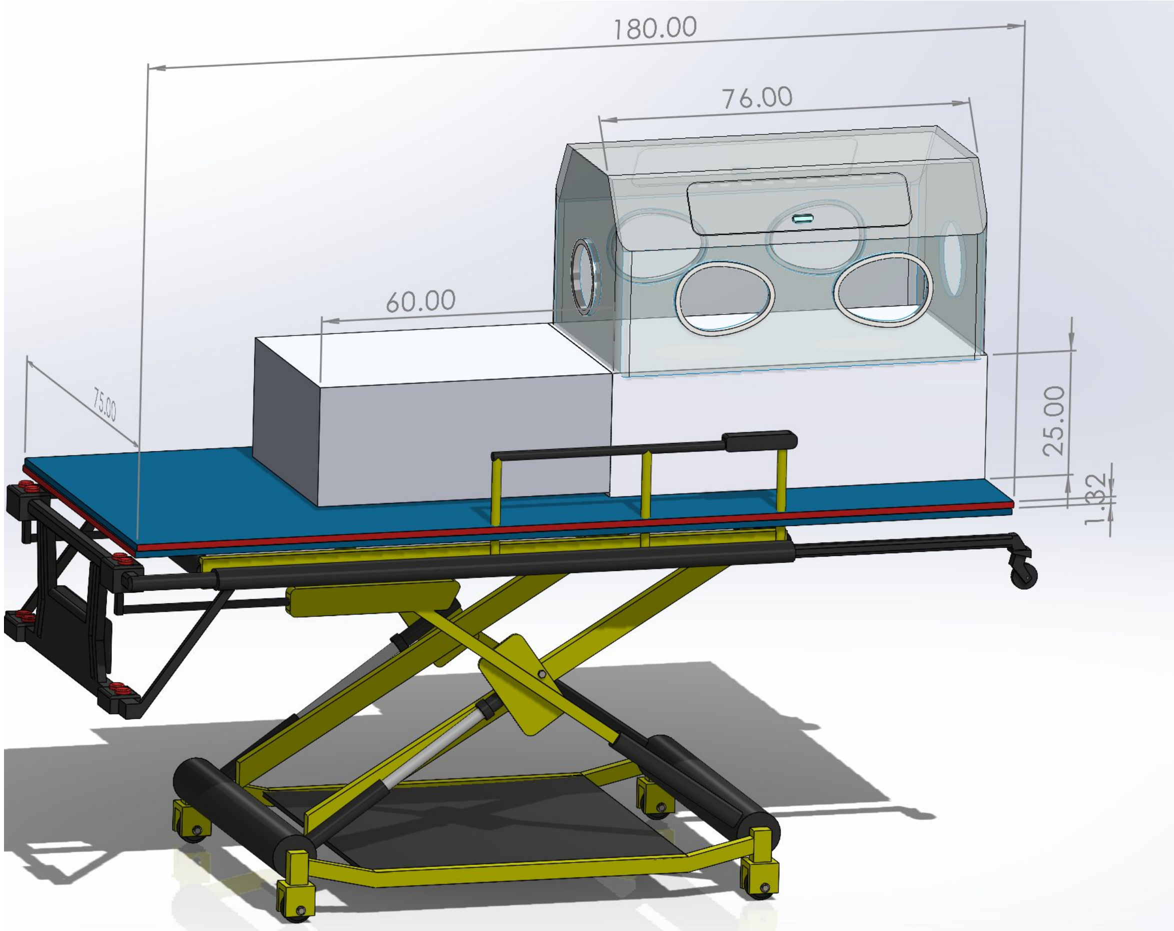
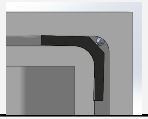
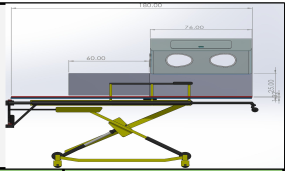


Figure 14: 3D Model of the Implementation of a 1.32 cm foam mat between the stretcher and transport monitoring systems.

Design Matrix

Table 1: Design matrix for the evaluation of 3 proposed designs.

Design Categories (Weight)	**Magnet-Induced Levitation**		**Metal/Gel Composite Damper**  		**Shock-Absorbing Mat(s)** 	
Safety (25)	3/5	15	4/5	20	5/5	25
Projected Performance (25)	3/5	15	5/5	25	2/5	10
Compatibility (20)	2/5	8	3/5	12	4/5	16
Ease of Fabrication (15)	1/5	3	2/5	6	5/5	15
Longevity (10)	3/5	6	3/5	6	4/5	8
Cost (5)	4/5	4	3/5	3	3/5	3
Total Points:	51		72		67	

Future Work

- Combining designs
  - Metal/Gel Damper
  - Head restraint [16]
  - Shock-Absorbing Mat
- Build prototype
  - Challenges: size of design, attachment to existing system
- System for measuring vibration → testing

Figure 15: Head restraint system [16]

Acknowledgements

- Dr. Ryan McAdams, MD
- Dr. Joshua Gollub, MD
- Dr. Justin Williams
- Dr. Heidi Kamrath, MD
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- BME Department

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Questions?