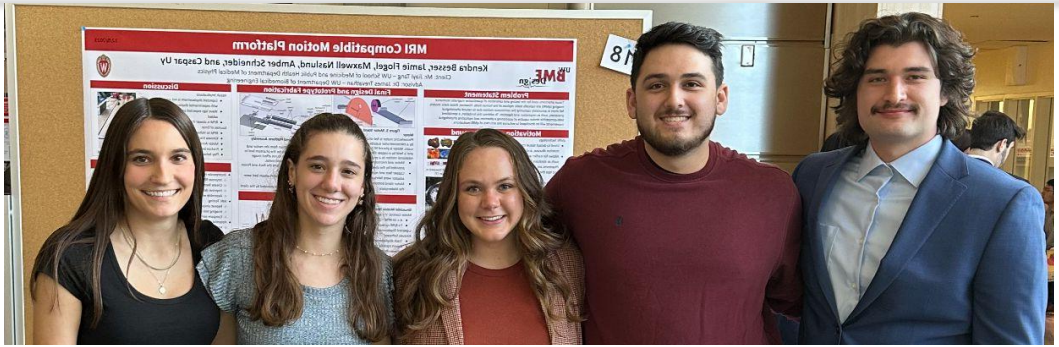


BME Design

MRI - Compatible Motion Platform

Team Members: Amber Schneider, Jamie Flogel, Kendra Besser, Caspar Uy, Maxwell Naslund

Client: Mr. Jiayi Tang - UW School of Medicine and Public Health Department of Medical Physics

Advisor: Dr. James Trevathan

Date: February 9th, 2024

Overview of Presentation

- Problem Statement
- Motivation & Background
- Competing Designs
- Key Specifications
- Fall Final Design
- Prior Testing Results
- Timeline
- Future Fabrication
- Future Testing
- Summary
- Budget
- Acknowledgements
- Questions
- References

Problem Statement

- Quantitative MRI (qMRI) measures physiological characteristics of tissues
- Calibration and quality of qMRI techniques are tested with controlled phantoms [1]
- Static phantoms do not represent physiological motion that alter imaging
- Design a MR-compatible device that will hold a phantom and simulate physiological movements
  - Respiratory motion
  - Liver phantoms
- Can lead to earlier detection of steatosis (affects 25% of population)

Motivation & Background

qMRI Technology

- Used to detect tissue composition, diagnose and monitor disease, and determine drug efficiency [2][3]
- Allows for earlier and noninvasive detection of diseases, such as steatosis [4]
- Phantoms are required to calibrate encoded techniques and test the accuracy and precision of imaging methods [5]

Current Solution – Breath Holds

- Required because respiratory motion produces image artifacts [6]
- Implications:
  - Short data acquisition time, typically 10 to 30s [6]
  - Children, severely ill, or sedated patients are unable to perform [7]

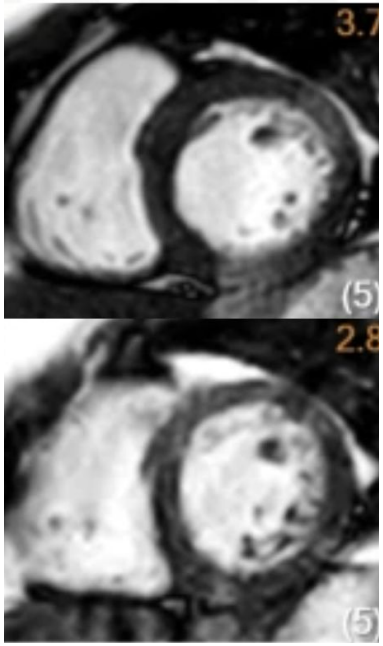


Figure 1. Motion Artifact [7]

Competing Designs

Design 1

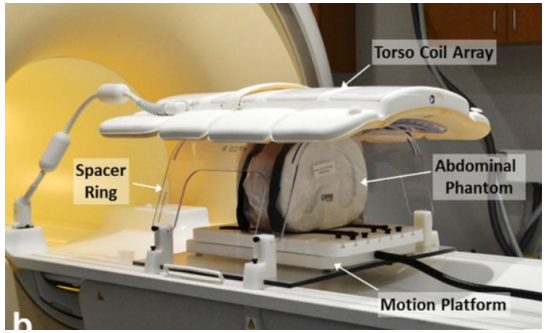


Figure 2. University of Texas Linear Motion Phantom [8]

Design 2

Figure 3. Vital Biomedical Technologies MRI Compatible Motion Stage [9]

Design 3

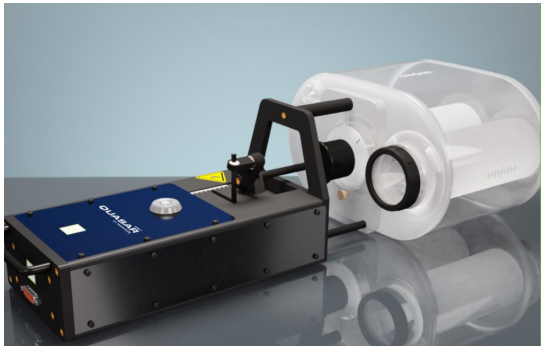


Figure 4. Quasar MRI Motion Phantom [10]

Key Specifications

- MR Compatible
- Create a prototype with a budget of $1000
- Utilize commercially available parts/easy fabrication
- Must support 4 kg and be larger than 25cm x 35cm [11]
- Supports physiologically realistic breathing frequency (eg. 8 cycles/min) [12]
- Supports a realistic amplitude (eg. 3cm) [8]
- Consistent for 10-15 minutes to 5% deviation [12]

Fall 2023 Final Design-Motor

Piezoelectric motor is fed sinusoidal waves by a microcontroller outside of the MRI room. Motor is placed 5ft from MRI bore and is held by a copper sheet. It transfers rotational motion to a pvc pipe driveshaft.

- Motor and microcontroller were provided by the client
- Copper face and motor to drive shaft adaptor were fabricated in the TEAM Lab
- Motor stand bottom was 3D printed in the Makerspace

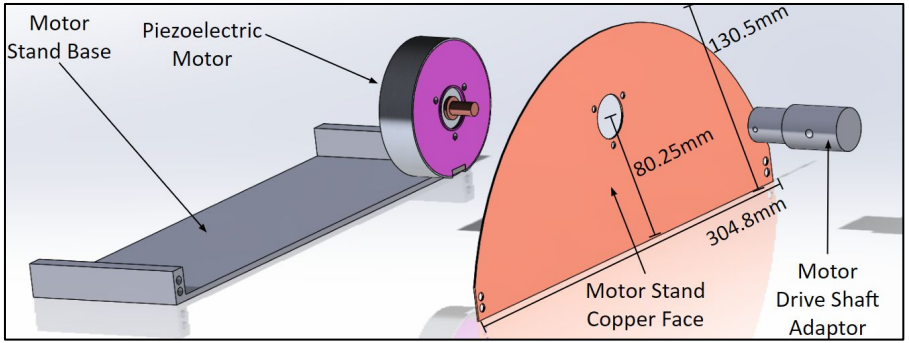


Figure 5. CAD Model of Motor Stand and Driveshaft Adapter

Fall 2023 Final Design - Gearbox

Rack and pinion takes rotational motion from the motor and converts it to linear motion efficiently for the phantom bed to oscillate to. To be MR compatible and to not affect image quality, the gearbox assembly contains no metal.

- Gearbox, Extensions, Bevel Gears, and the Rack and Pinion were 3D printed in the Makerspace
- Driveshaft Adaptor, Crosspin, and the Phantom bed were fabricated in the TEAM lab
- Linear Rail, Slides, and bearings were provided by the client

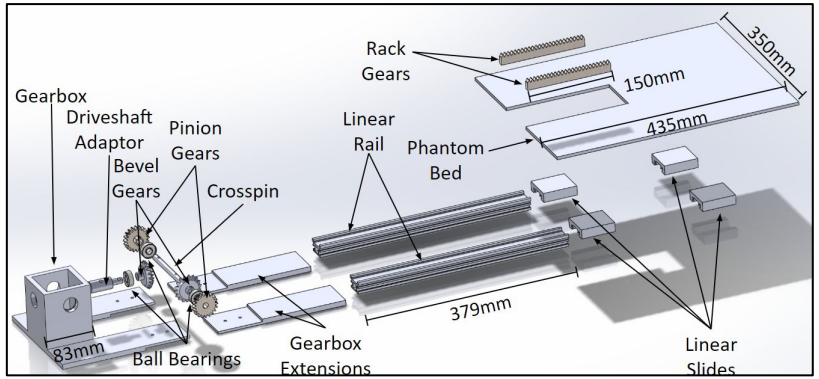


Figure 6. Fall 2023 Final Gearbox Prototype

Evaluation/Testing Results

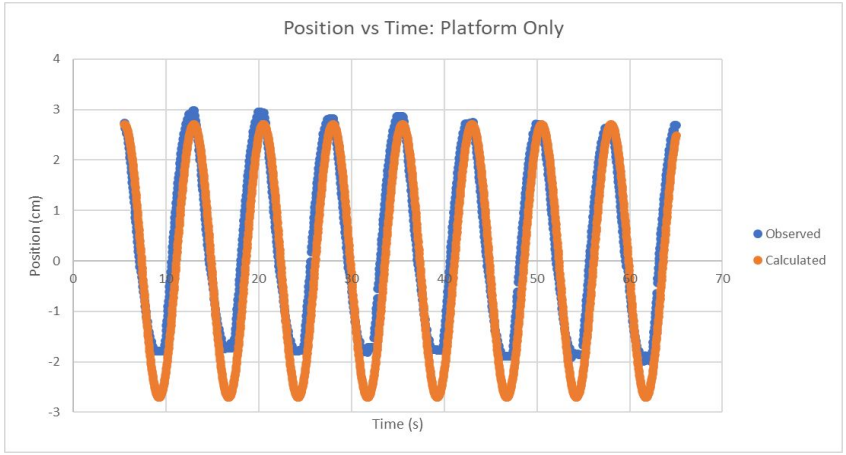


Figure 7. Platform movement during sinusoidal motion

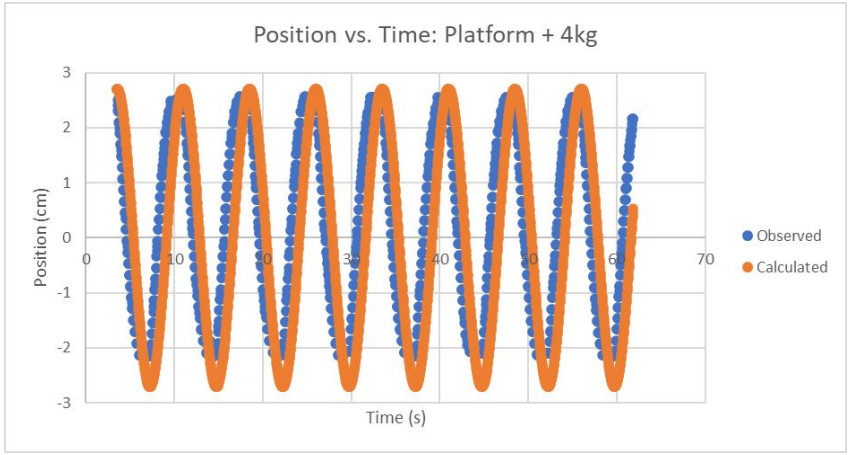
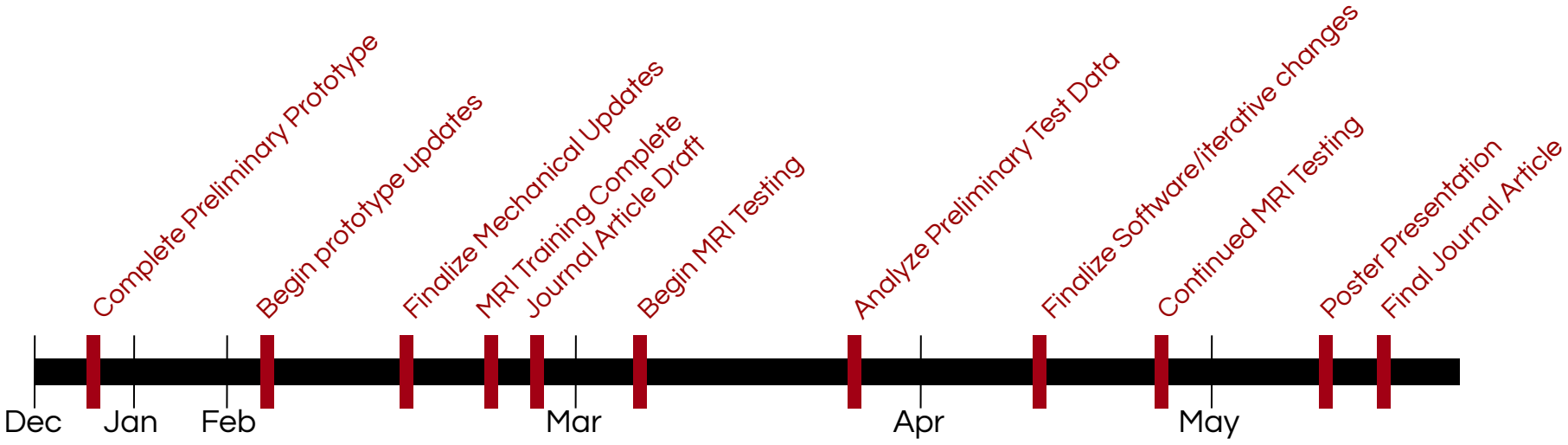


Figure 8. Platform movement with additional 4kg weight

Overview: Spring 2024 Timeline



Summary

- Packaging
  - 3 Main Parts
- Documentation
  - User Manuals
  - Assembly Manual
  - Certifications
  - Cautionaries
- MR Safe Environment
  - Set-up
  - Sinusoidal Motion on one axis

Figure 11. MRI Hazards

Future Fabrication

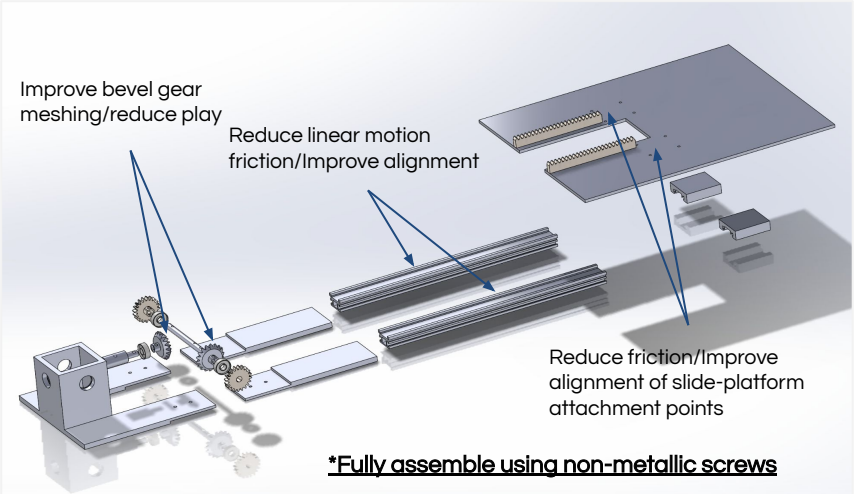
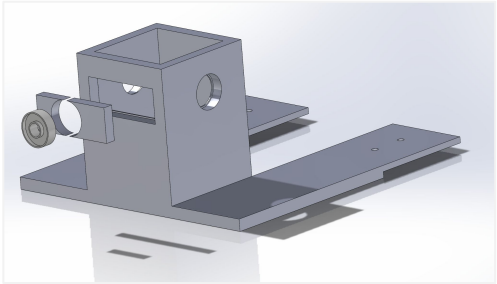
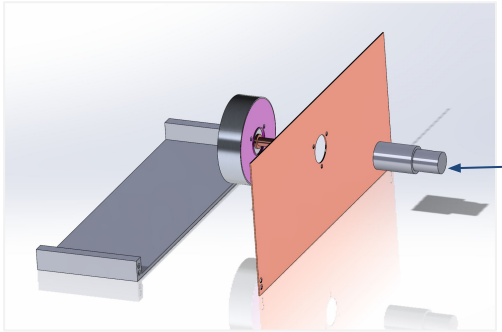


Figure 8. Gearbox Assembly



Implement Interchangeable Gears
- Allow for higher gear ratios
- Improve torque output
- Improve linear motion output

Figure 9. Proposed Gearbox design



3D print out of flexible polymer OR order flexible coupler
- Reduce torsional strain on motor

Figure 10. Motor Assembly

Future Testing

Test	Outcome
Motor RPM	Compare to past data Verify motor is running as directed
PID Control	Validate PID algorithm Use to fine tune gains
Sinusoidal Motion	Compare to past data Detect if design improvements impacted results
MRI Artifact	Simulate real use case scenario Identify issues with MRI/phantom use

Budget

Fall 2023:

- PLA 3D printing
- Linear Rails and Sliders
- Driveshaft
- Platform
- Glass Ball Bearings
- Total Spent: $574.03

Spring 2024:

- Continued PLA for 3D printing
  - Gears
  - Gearbox
- Flexible coupling
- Plastic Screws
- Projected $200 or less

Total spent: $574.03

Estimated total cost: $774.03

Starting budget given: $1000

Acknowledgements

We would like to thank Dr. James Trevathan and Mr. Jiayi Tang for their help and guidance.

Questions?

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