

Two-Axis Circular Treadmill for Human Perception and Behaviour Research in Virtual Environments

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Overview

Introduction
Structure
Drive Train
Control
Implementation and Testing

Introduction

Project Need

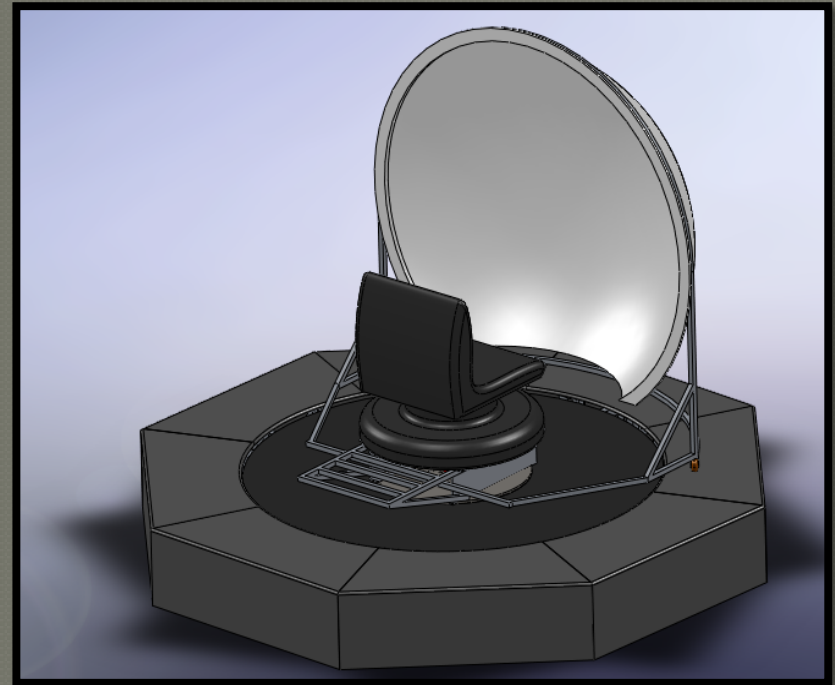
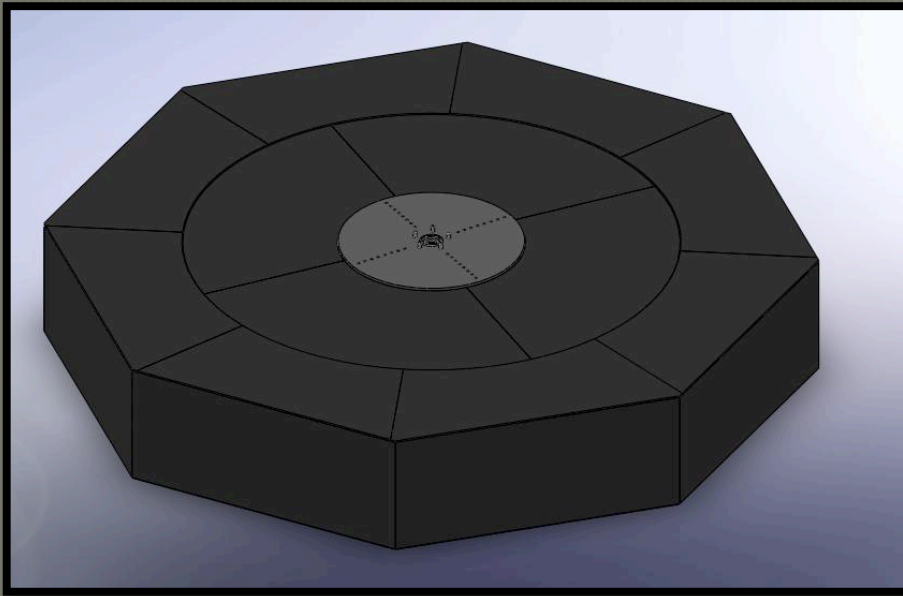
- Dr. Bernhard Riecke: SIAT, SFU
 - iSpace Lab
- Research platform to study human behaviour and perception of spatial orientation in virtual environments
- Specifically examining subjects responses to rotational cues
- Engineering Supervisors:
 - Dr. Gary Wang
 - Dr. Siamak Arzanpour

Project Goal

- Two-axis circular treadmill platform
 - Independently controlled axis
 - Capable of moving human participant and equipment
- Smooth and precise operation

Project Goal

- Base Platform
- Primary configuration



Structure

Main Frame

Objectives:

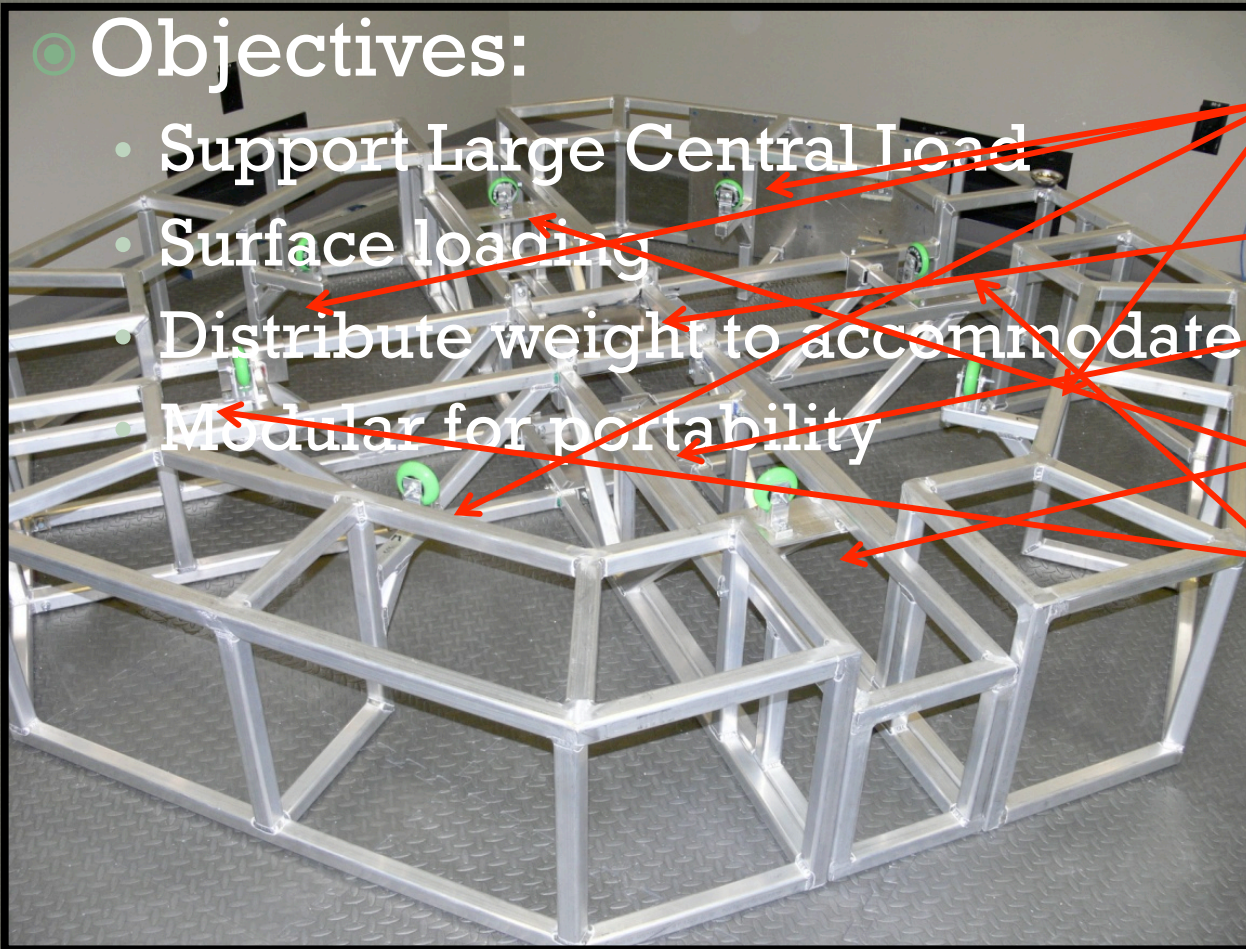
- Support Large Central Load
- Surface loading
- Distribute weight to accommodate floor limitations
- Modular for portability

Quarter Sections

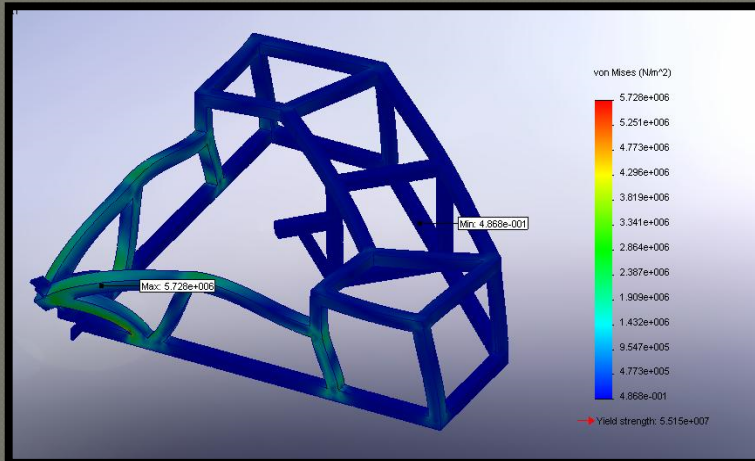
Upper center hub

Motor housings

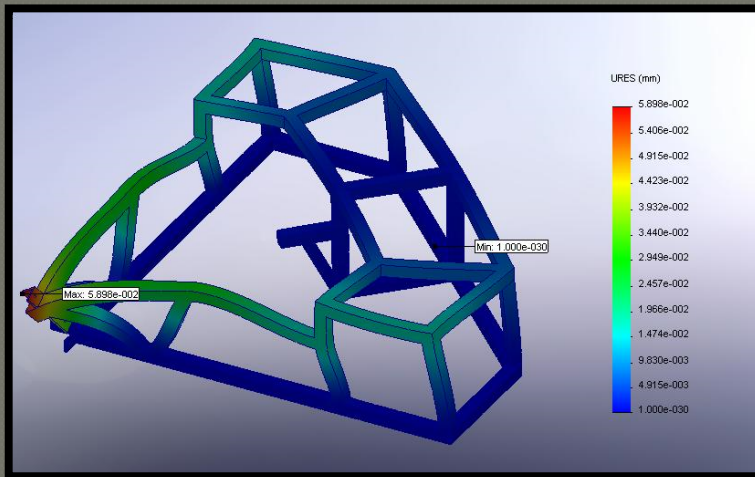
Support spacers



Main Frame Quarter Sections

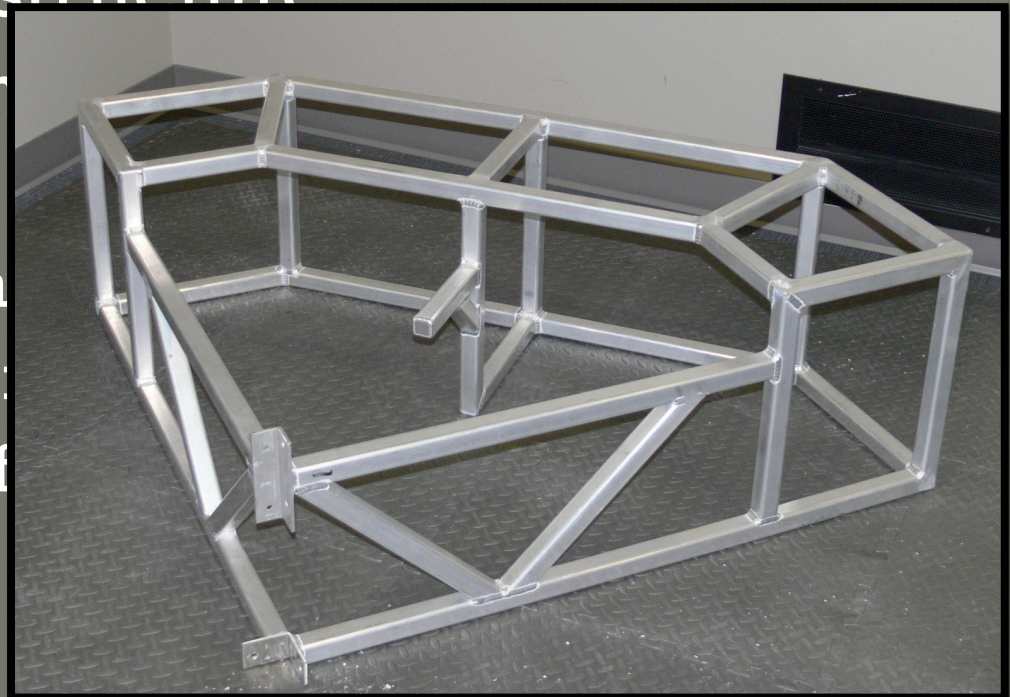


Stress analysis



Displacement analysis

structure

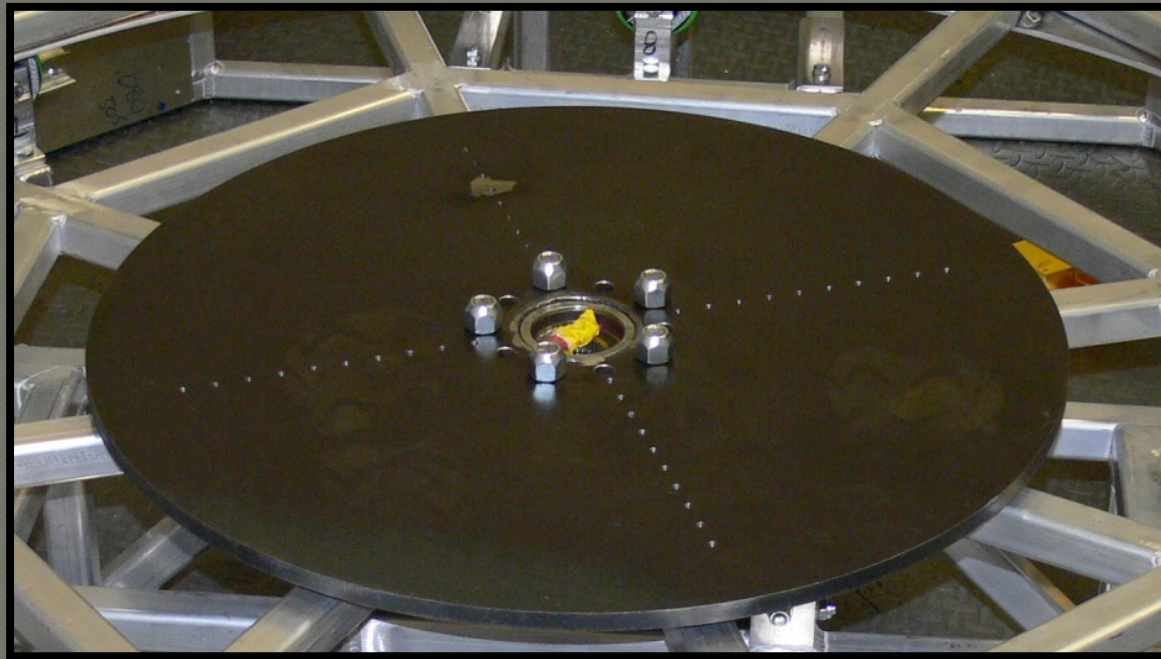


Rotating Outer Ring



- Supports dynamic surface loading
- 1.8m Diameter
- Connected to main frame at its center
- Supported by roller wheels around its circumference

Rotating Inner Disk



- Provides secure mounting base for test equipment

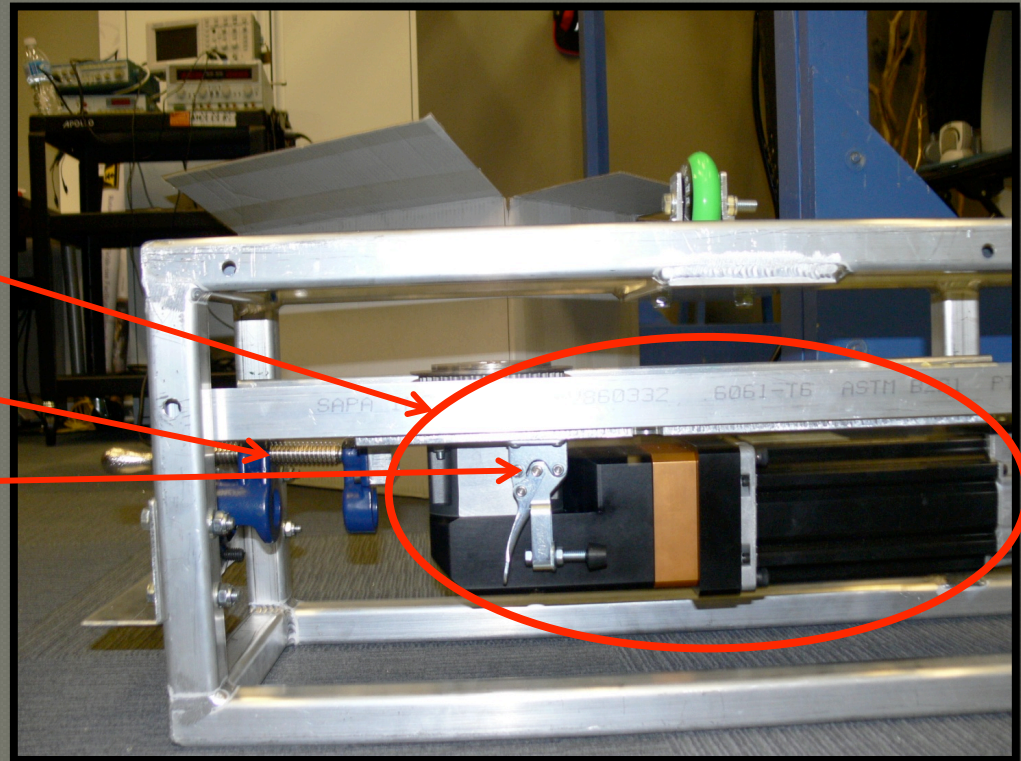
Drive Assembly Tension/ Mounting Mechanism

- Tensions synchronous belt for bi-directional motion

Linear slide

Lead screw

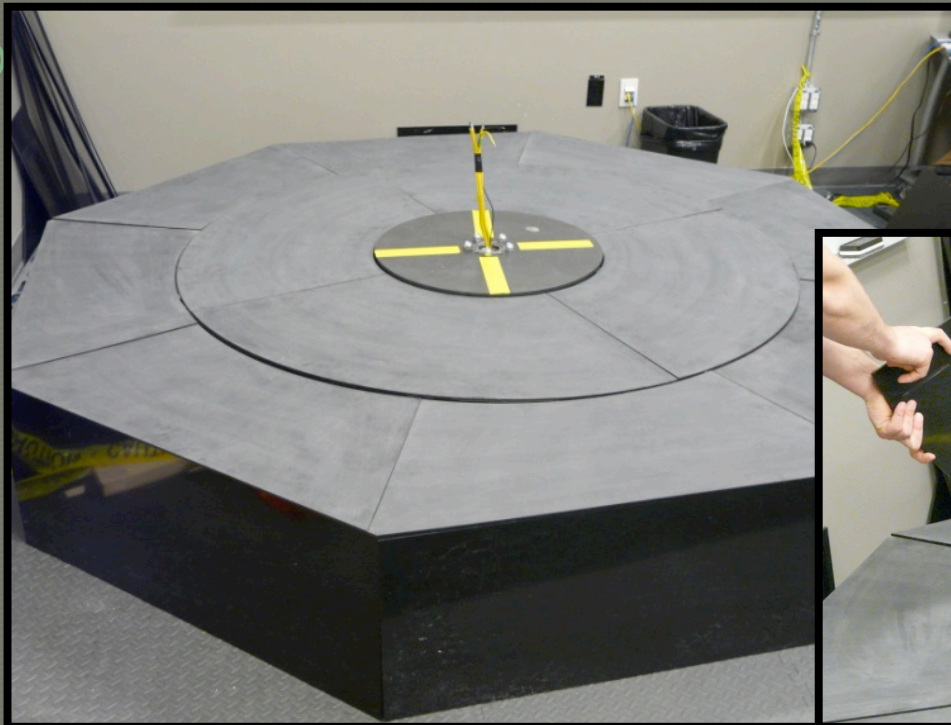
Toggle clamps



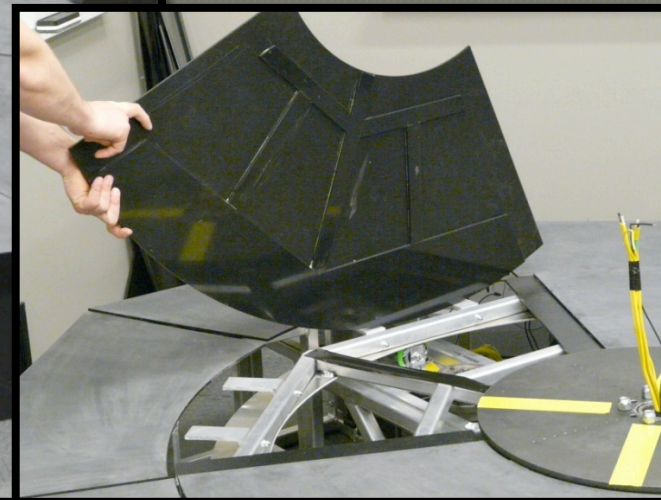
Floor Cover Panels

- Platform surface

- Supports weight of participants
- Matte finish



- Reinforced support points



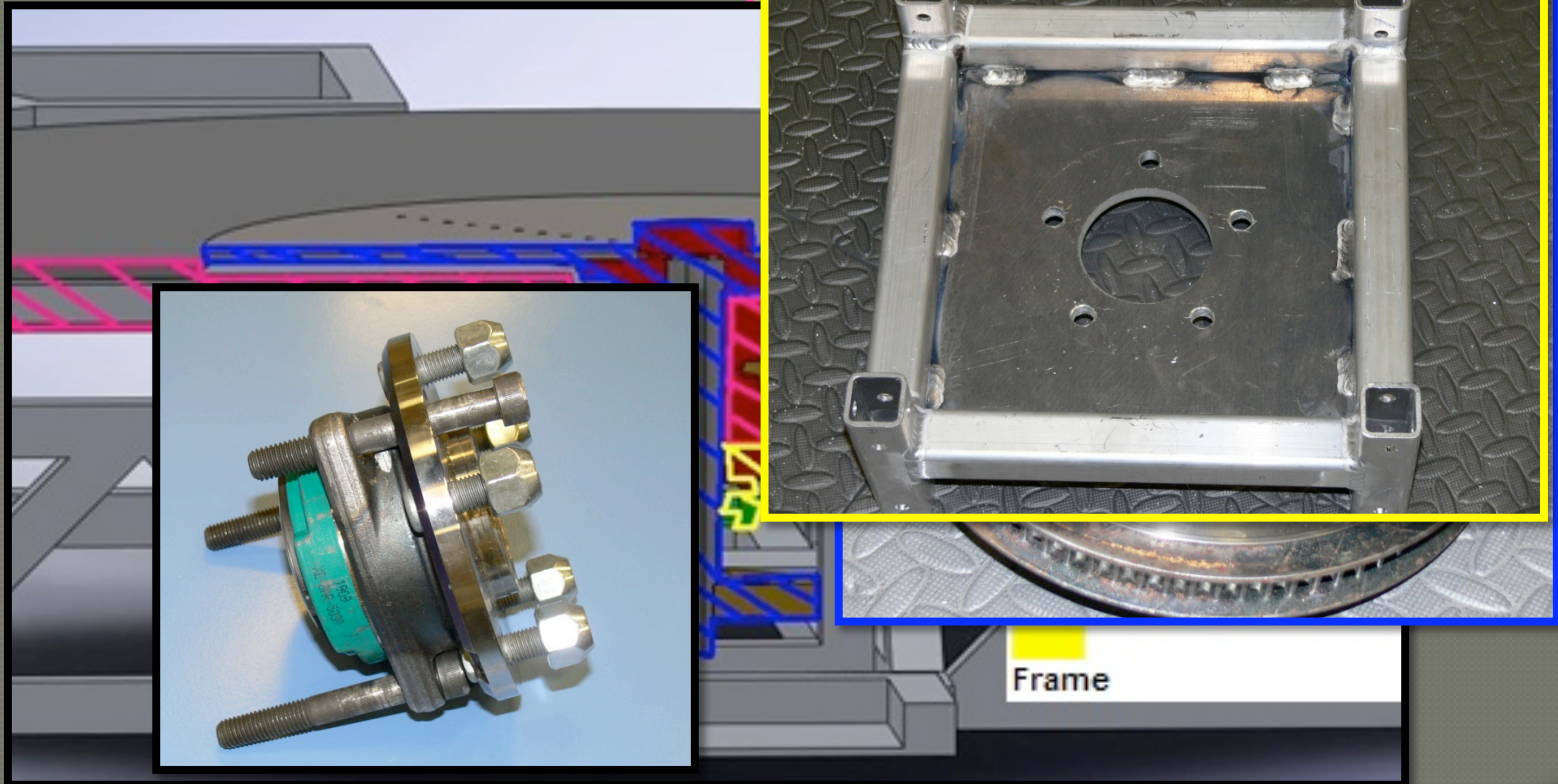
Drive Train

Drive Train

- ◎ Synchronous belts
 - 2:1 speed reduction
- ◎ Gearheads
 - 50:1 speed reduction
- ◎ Motors
 - DC brushless servo motors

Central Drive Assembly

- Two independently rotating wheels
- Innovative concentric



Power Requirements

● Operational dynamics

- $\omega = 180^\circ/\text{s}$
- $\alpha = 40^\circ/\text{s}^2$

● Inertia

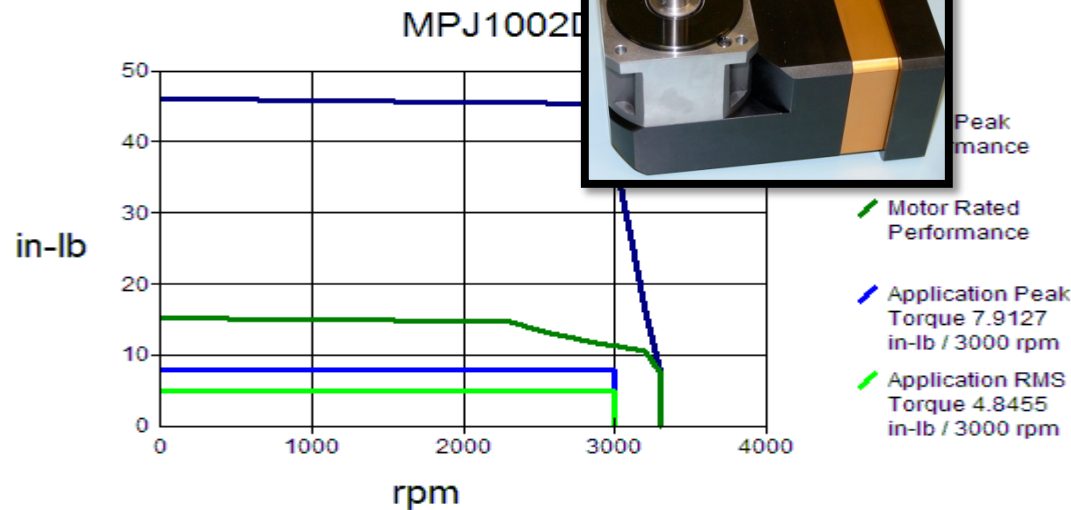
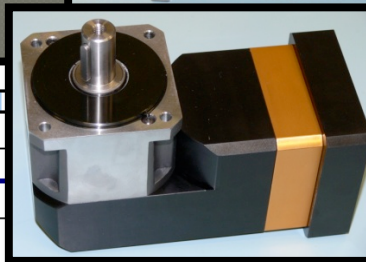
- $I \text{ (inner disk)} = 67 \text{ kg/m}^2$
- $I \text{ (outer ring)} = 10 \text{ kg/m}^2$

● Applied Torque

- $\tau_{\text{(friction)}} = 50 \text{ N}\cdot\text{m}$

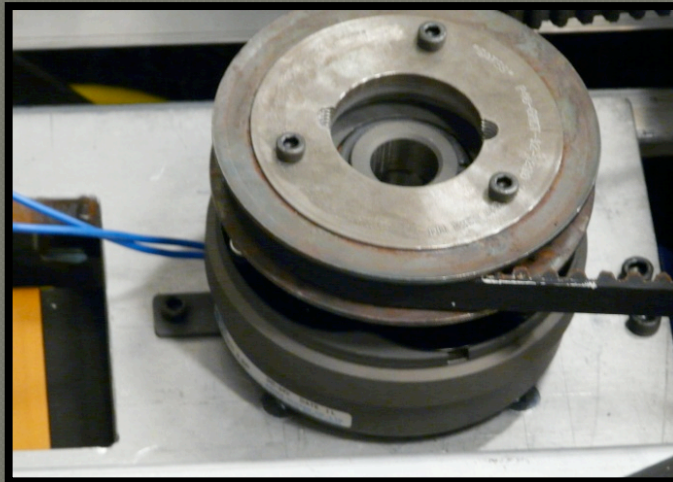
Motors & Gearheads

- Sized to minimize costs and maximize performance
- 100:1 ratio between load and motor allowed for smaller, less expensive motors



Clutch and Static Brake

- Clutch allows for the foot ring to be used as an input



- Static Brake provides safety by holding the ring stationary when the clutch is not engaged

Control

Control Features

- Emergency off switches for operator and participant
- Small scale I/O electronics
 - Motion Enable
 - Clutch and brake controller

Servo Motor Control

- Two axis motor controller
(Parker ACR9000)
 - USB, Ethernet, COM communication
 - Stored motion profiles
- Servo drives controlled by ACR
(Parker Aries AR-04)

Implementation and Testing

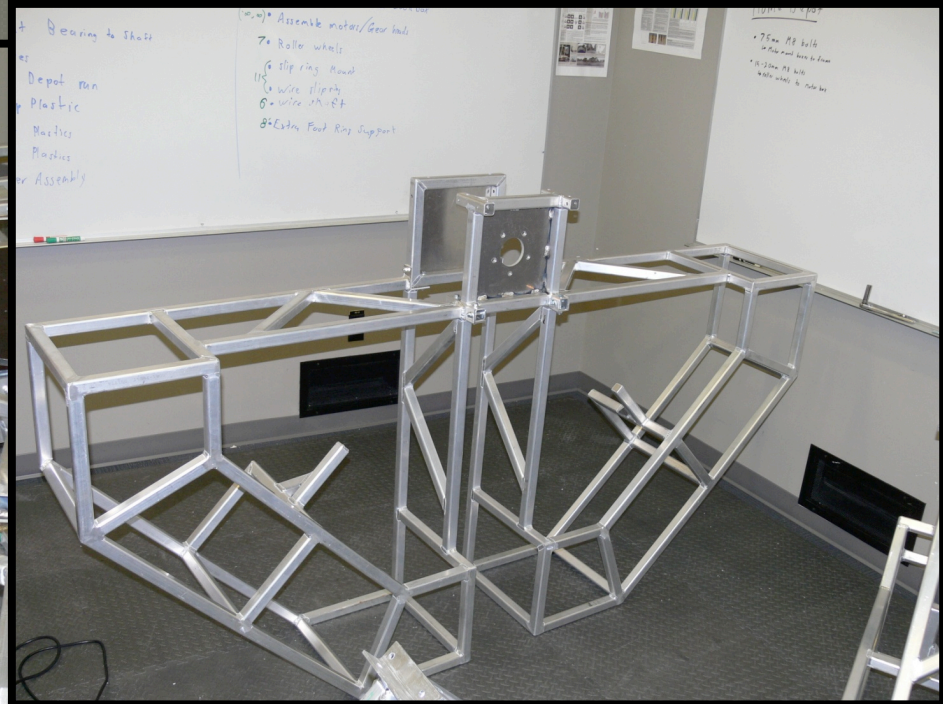
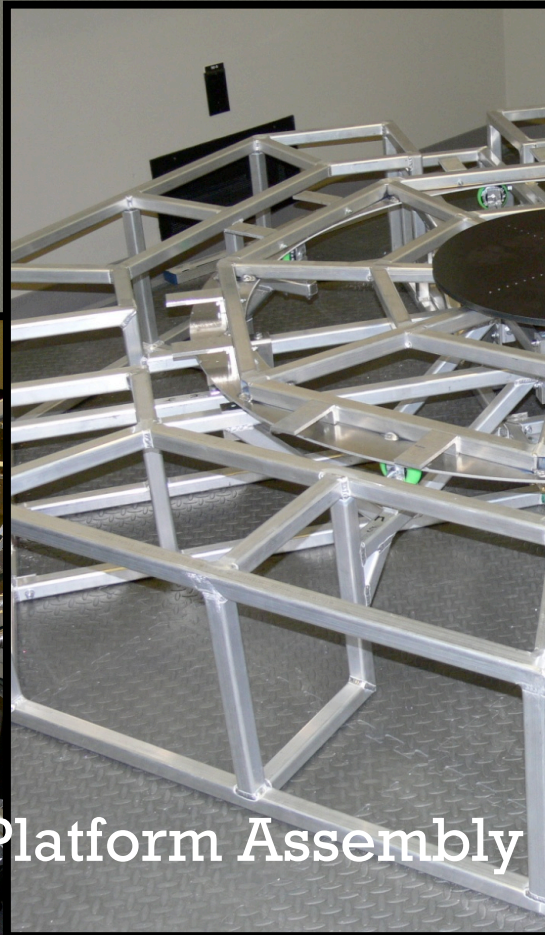
Fabrication

- ◉ Acquired components and materials
- ◉ Custom parts
 - Machined aluminum, fabricated ABS
 - Repurposed existing hardware
- ◉ Outsourced labour
 - Welding of structure
 - CNC cutting of covers

Assembly

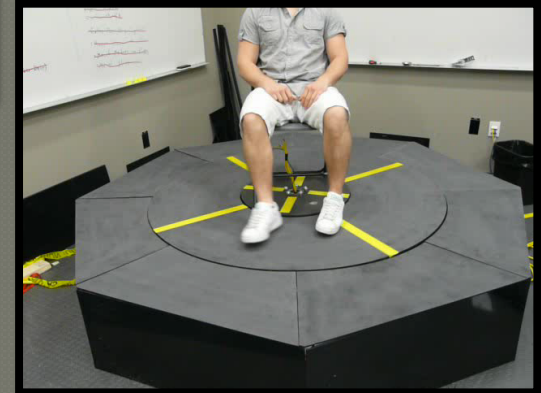


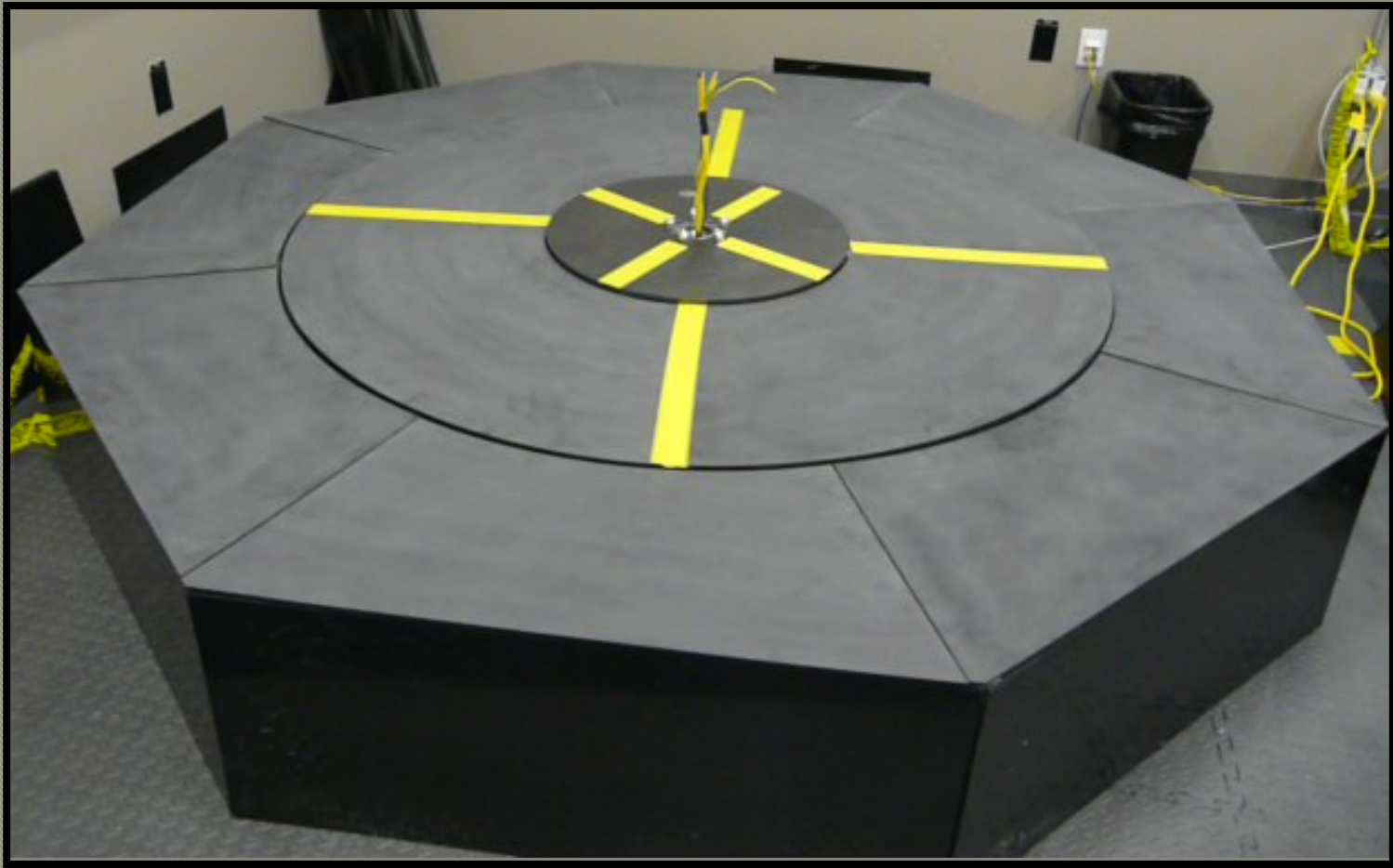
Actual Platform Assembly



Assembling of main frame
SolidWorks Model of Platform

Testing





Questions