EML4551

Virtual Design Review 5

Flight Simulator Egress System

LOCKHEED MARTIN

Introduction

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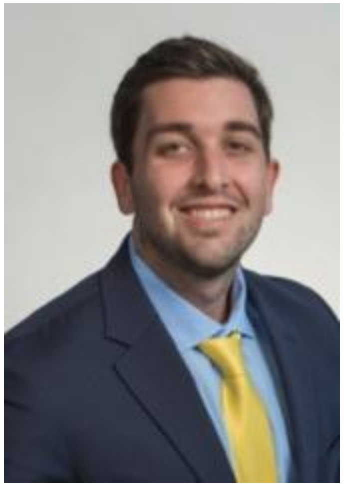

Financial Advisor
Daniel Swope

Historian
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Project Background

- Sponsor: Lockheed Martin
- The purpose of this project is to support pilot training through the design of a system to improve the way pilots get in and out of F-16 cockpit simulators.

Figure 1: A Lockheed Martin F-16 in flight. (Lockheed Martin, n.d)

Project Scope

- System must move users ranging from 5 foot to 6 foot 2 inches tall in and out of cockpit dome
- Must position user in exact orientation of current fixed cockpit seat
- Allows user to egress in case of emergency
- Produce functional prototype in under $2000

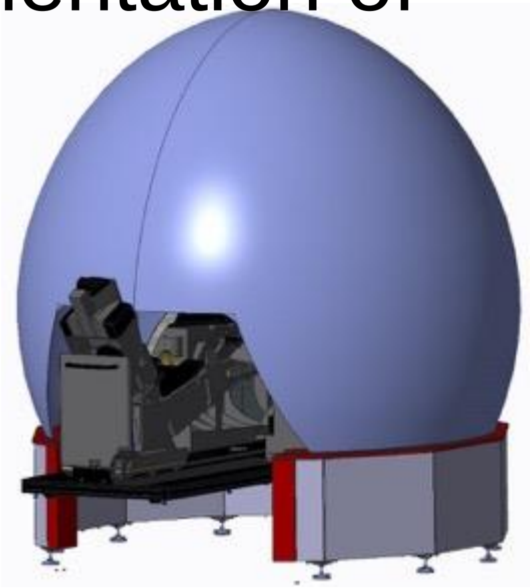


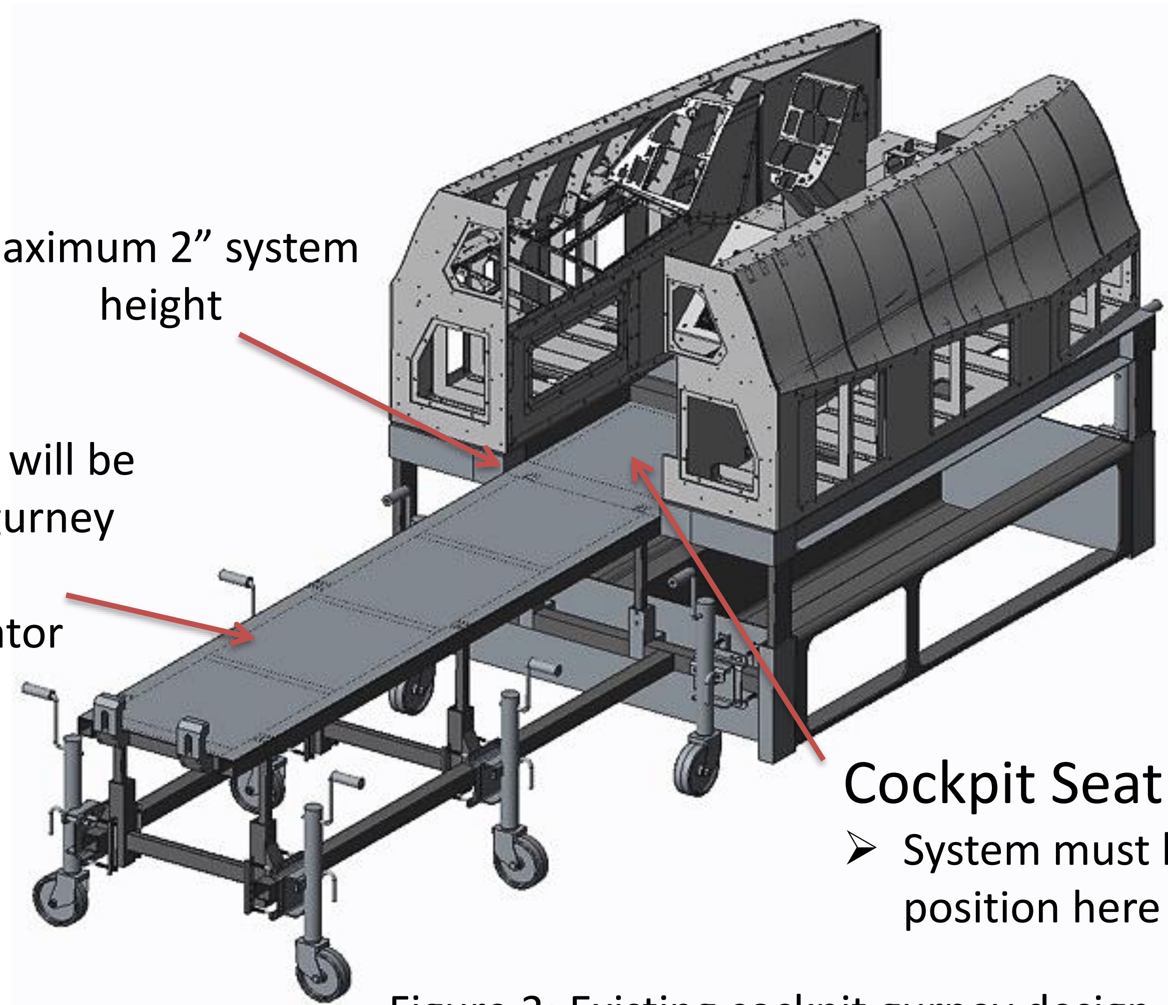
Figure 2: Existing cockpit dome design.

Design Constraints

Maximum 2" system height

Gurney

- Egress system will be mounted on gurney
- Locks into the cockpit simulator



Cockpit Seat Area

- System must lock seat position here

Figure 3: Existing cockpit gurney design.

First Semester Milestones

- Created functional decomposition
  - Provided basis for major design decisions
  - Used to extract major design goals of project

Safety → Allow quick exit → • 5 Seconds

Support → Support weight of seat and user → • 500 lbs.

Egress → Provide enough space to easily enter seat → • 26 Inches

First Semester Milestones Cont.

- Using Pugh matrix, selected a rail mounted, motor powered, belt driven system
- Created rough detailed design of selected concept

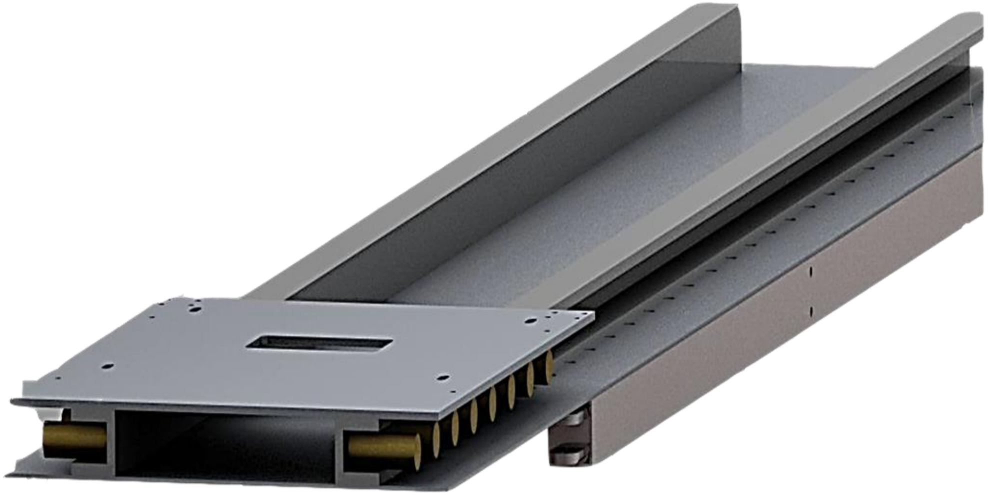


Figure 4: Fall Semester Concept.

Summary of Initial Design

- Custom steel rail and roller system
- 2 HP AC motor with belt drive
  - AC controller
  - AC power supply
- Mechanical locking system
  - “Break Away” would physically break the pin

Project Design

- Frank Cullen

Redefined Design

- After Winter Break and beginning of fall, realized our initial design was overbudget and out of scope
- Simplification was needed:
  - Electric powered system is not necessary
  - "In house machined" rails may save money, but increase complexity
  - Mechanical locking systems rely on ideal circumstance

Transition to a Manual System

- Factors that influenced this transition
  - Cost
  - Outside of our Project Scope
  - Convenience w/ Emergency Situations
- Main components of our human powered system:
  - Linear Rail System w/ Mounting Carriages
  - Locking System

Carrier Selection

- Selected CPC ball-type linear guide system
  - Friction Coefficient: 0.004
    - 2 lbs. of force to move seat
  - Price: $780
    - (39% of budget)
  - Lead Time: 1 Week

Figure 5: CPC linear ball carrier and rail.

Locking Mechanism Design

Challenges

- Limited space proved difficult to design under seat
- Emergency situation's require immediate response

Solutions

- AC electromagnet mounted to cockpit base outside of seat track
- Calibrate "break away" force without need to actually break the lock

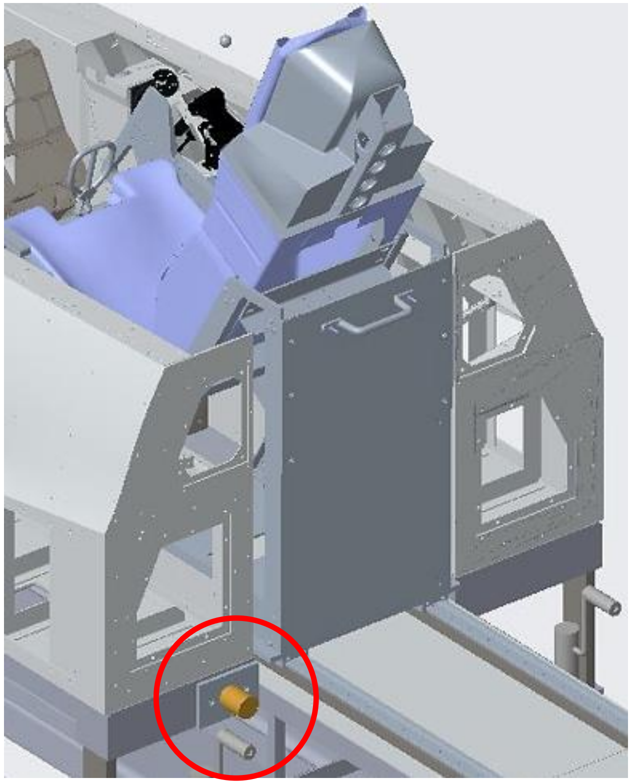


Figure 6: Electromagnet position with seat in fully extended position.

Electromagnet Lock Design

- Electromagnet will interface with ferritic steel plate
- Two variables control locking force
  - Distance from plate to magnet
  - Thickness of plate

Building and Testing of Prototype

- Andrew Filiault

Electromagnet Calibration

- Tested Electromagnet Specifications

Table 1: Electromagnet Specifications

Voltage	120 V AC
Wattage	14 W
Maximum Pull	180 lbs.
Maximum Temp	100°F

Figure 8: Electromagnet Used

- Found max pull for 5 different thicknesses of steel
  - 0.125”, 0.1875”, 0.25”, 0.375”, 0.50” [inch]
- Data analysis performed in MATLAB to acquire desired pull force

Electromagnet Testing

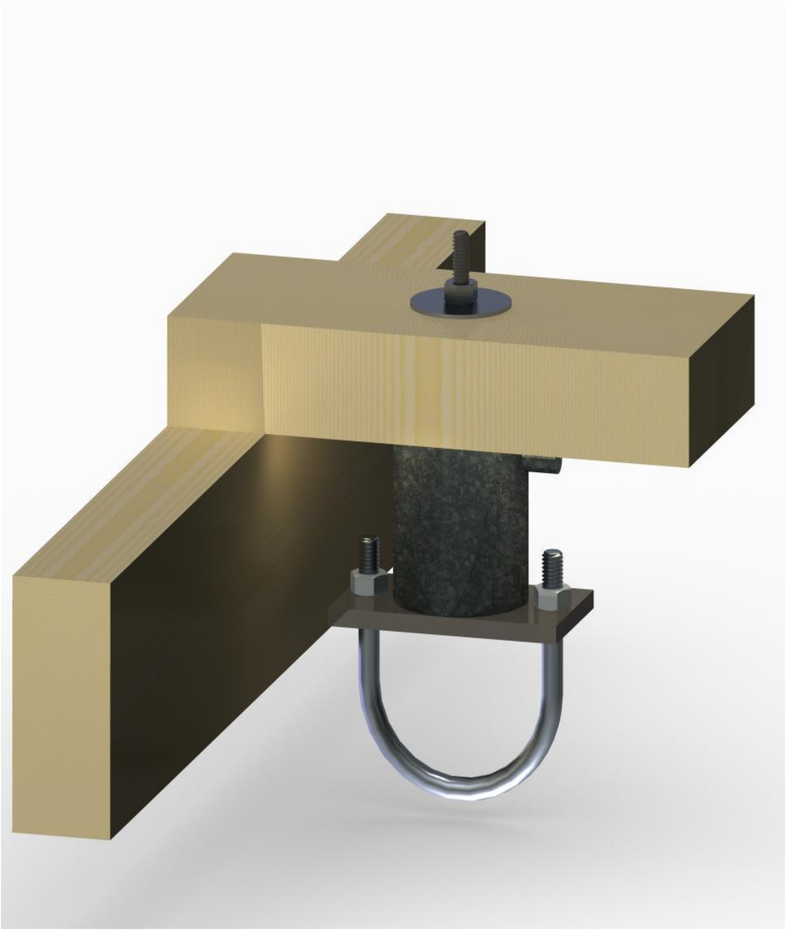


Figure 9: Electromagnet test rig concept (left) and model (right).

Electromagnet Results

- Function relating thickness to the max pull is a 4th degree polynomial

$$f(x) = ax^4 + bx^3 + cx^2 + dx + e$$

- Thickness needed to hit target max pull(110lbf) is approximately 0.16 inches

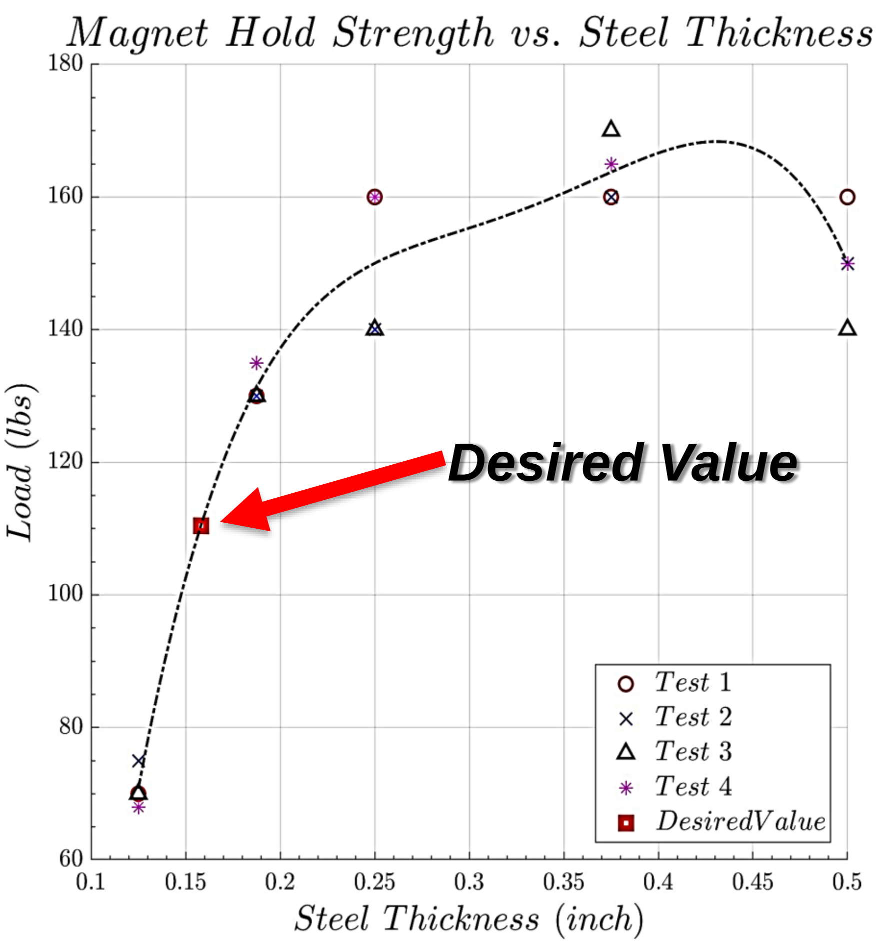


Figure 10: Electromagnet Test Results.

Final Deliverable

- Demonstrate proof of concept
  - Fully functional protoype with working guide and lock systems
  - Wooden mockup of F-16 simulator
  - Simulate pilot and chair with a 500lb payload

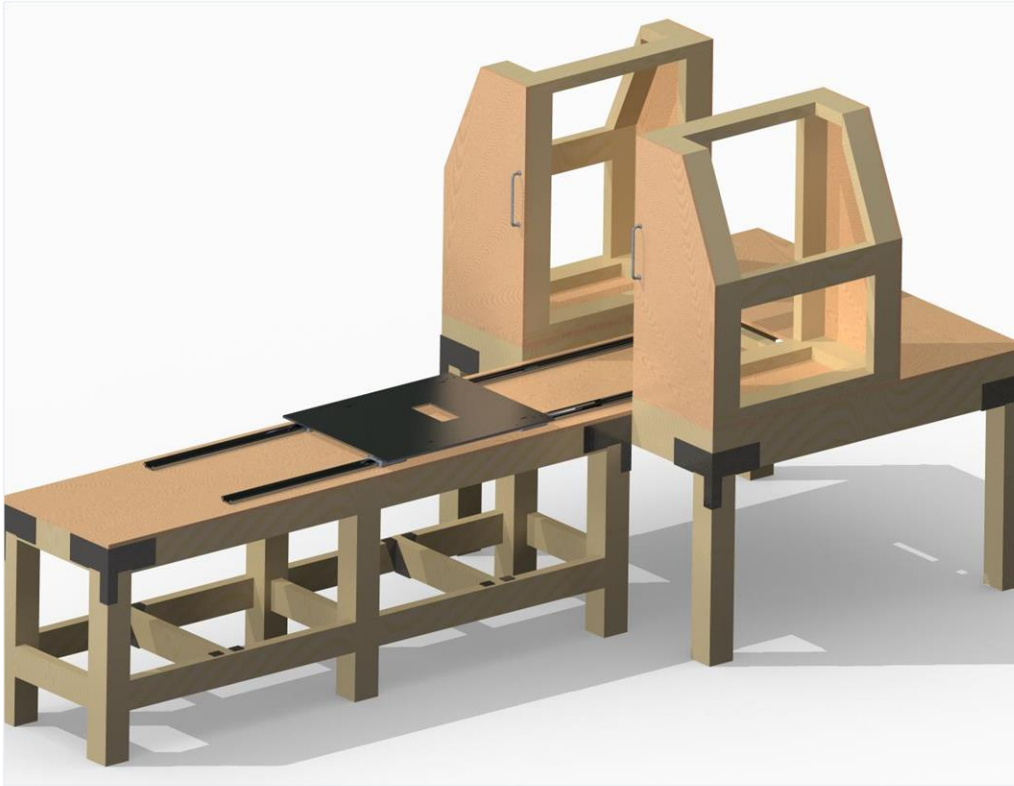


Figure 11: Wood mockup of the gurney and cockpit base.

Method of Rail Mounting

- The length of the rails are approx. 7 ft each
- Tolerancing for carriage system and to ensure minimal friction special care went into mounting them
- By mounting one rail first and attaching mounting plate the second rail will be mounted in the appropriate location

Mounting Steps

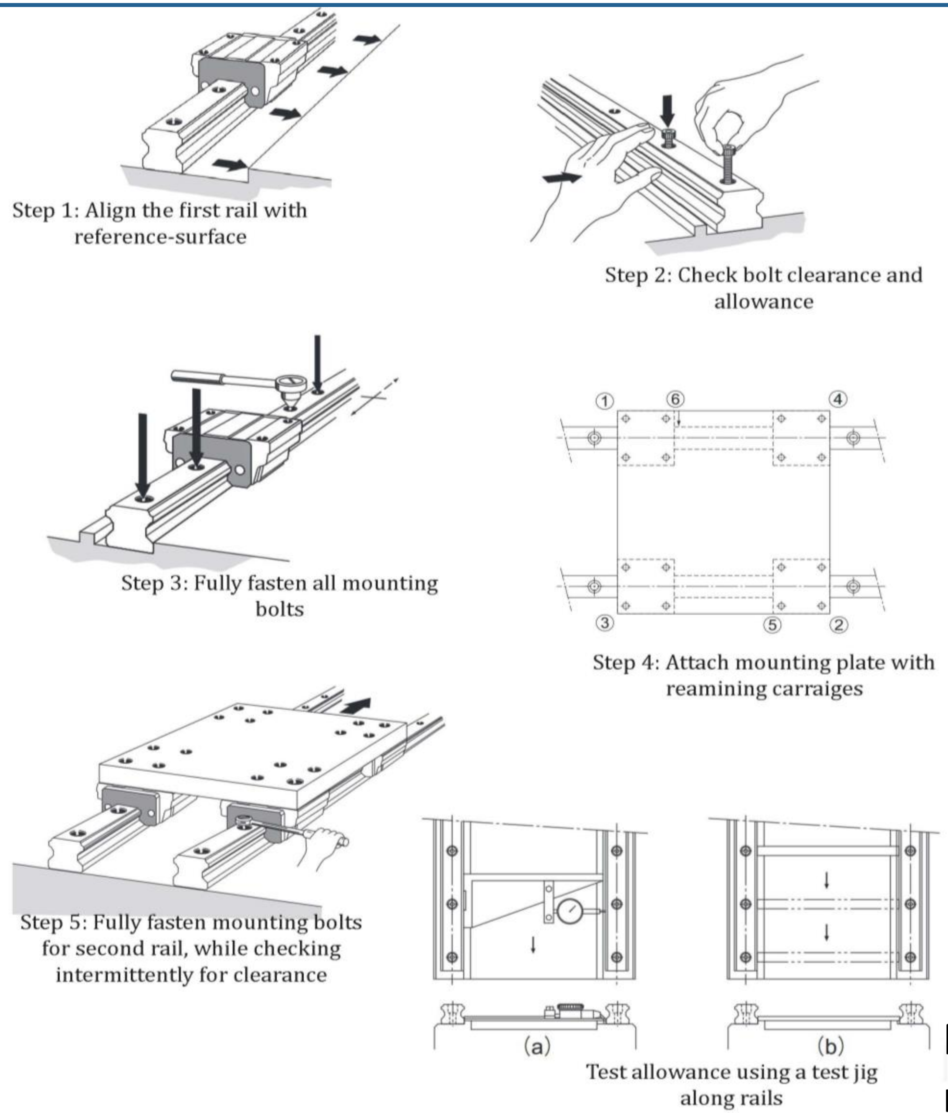


Figure 12: Rail mounting steps.

Additional Deliverables

- Additional belt-driven design for future implementation by Lockheed Martin that was out of scope of the project
- Complete CAD assembly for Lockheed Martin's system

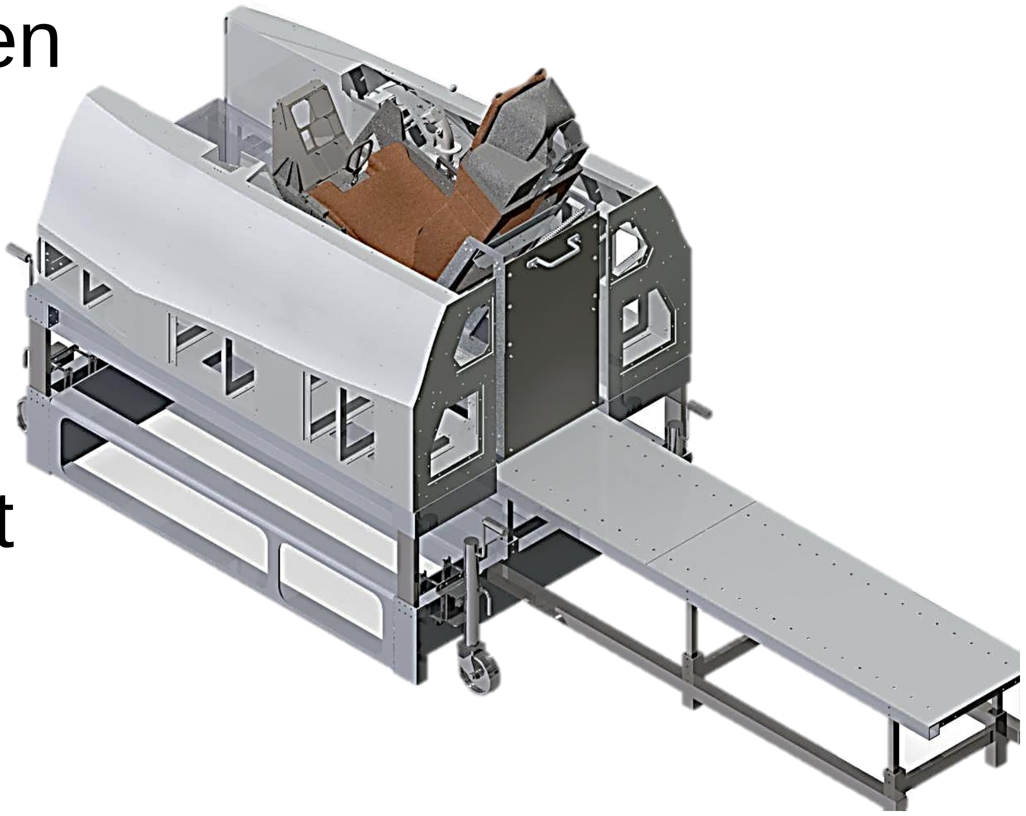


Figure 13: CAD model of the cockpit base and gurney.

Acknowledgments

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- Thank you to Dr. Hollis for his expertise on our project

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Questions?