Lockheed Martin Deployable Trainer

Team 515: DR #6

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Team Introductions

Kemuel Nelson

- Design & Test Engineer

Jarrod Darrow

- Quality & Test Engineer

Ryan Irwin

- Structural Engineer & Web Developer

Christian Gonzalez

- Project Manager & Performance Engineer

Sponsor and Advisor

Sponsor

Jeffrey Payne, PE
Staff Mechanical Engineer
Mission Systems & Training

Engineering Advisor

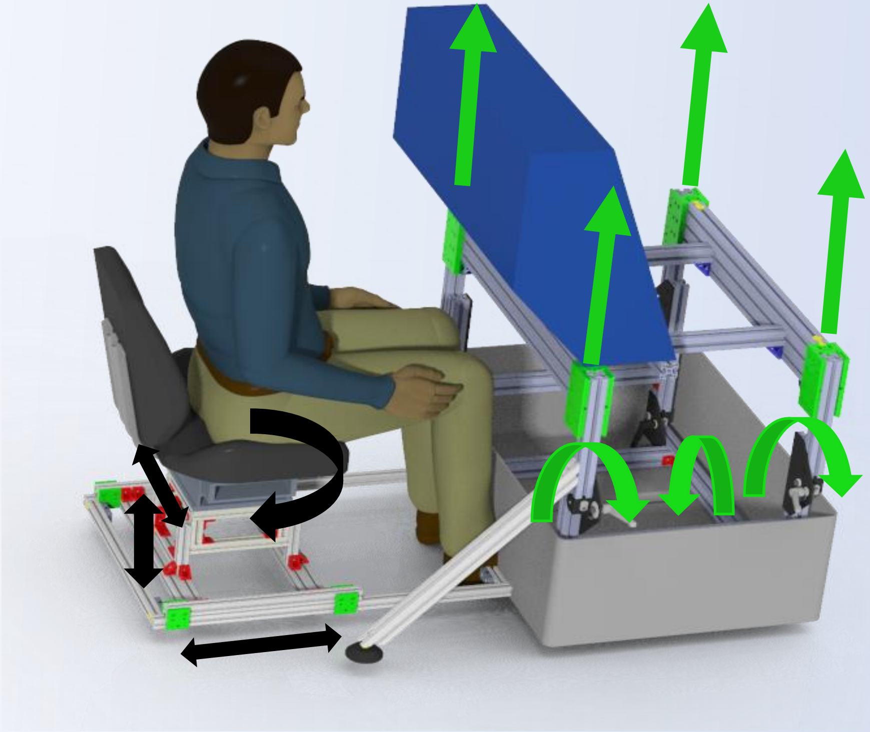
Patrick Hollis, PhD
Mechanical Engineering Professor

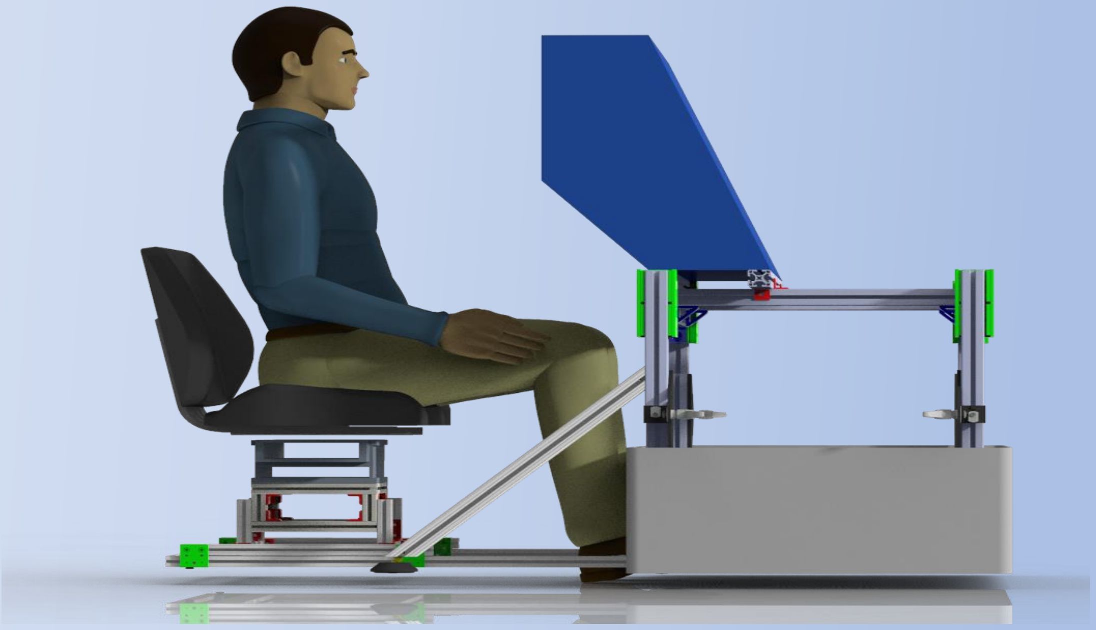
1. Meet the required weight specification
2. Require two people or less to carry
3. Assemble/Disassemble in a timely manner
4. Require a maximum of three cases for storage
5. Adjustable dimensions between seat and mounted simulator
6. Eliminate the need to source a chair/table

Objective

To design a portable, configurable module that is readily available for operation and eliminates the need for the user to source a chair/table.

Final Design





Final Design

The assembled design, ready for use

The design stows away neatly into the transport cases

Simulator Mount Features

Pros

- Assembly, disassembly, and usage is simple and intuitive
- No loose mechanical components
- User safety is maximized with redundant design features
- Utilization of the 8020 extrusions allows for convenient modifications/additions in the future
- User has options for simple and effective height adjustment

Cons

- Slightly tedious to install the tabletop during assembly due tolerances

Case Weight

Simulator Case Weight	Target Weight	Seat Case Weight
91.72 lbs.	88.00 lbs.	64.89 lbs.

- Components in respective cases

Simulator Case Weight	Target Weight	Seat Case Weight
83.48 lbs.	88.00 lbs.	72.17 lbs.

- Tabletop mount is inside seat case and seat is inside simulator case
- Not ideal & will require custom foam or support inserts

Seat Design

The assembled seat, ready for use

Even with the seat at 1 notch before its forwardmost position, the user retains legroom within the area of the seat design.
*Note: User is 5’ 10” in this photo

Seat Features

Pros

- Assembly, disassembly, and usage are simple and user friendly
- Highly adjustable. Adjusts vertically, horizontally, laterally, and rotates
- Seat is comfortable and sturdy for continuous, repeated use

Cons

- Height adjustment of the seat is tedious, but results in a sturdy base
- Assembly of the swivel base usually results in some grease on the user's hands

Budget

	Simulator Mount Frame	Seat Frame	Total For Project	Total Remain From Budget
Percentage Of Parts Ordered	% 100.00	% 100	% 100	% 0
Percentage Of Parts Delivered	% 100.00	% 100	% 100	% 0
Percentage Of Parts Installed	% 100.00	% 100	% 100	% 0
Total Spent without Discount	$ 1,490.62	$ 1,133.93	$ 2,624.55	$ -624.55
Total Spent with Discount/ Free Parts	$ 1,359.21	$ 848.54	$ 2,207.75	$ -207.75

Budget

- Received a 15% discount from Pelican Cases and saved $154.69
- Found all the 8020 and fasteners needed for the seat frame, as well as 22 of the gussets in the senior design lab, saved $266.50
- Found several pieces of 8020 for the simulator mount in the senior design lab, saved $118.12
- All purchases were tax exempt
- Free Machining from COE machine shop

Target and Metrics

Metric:	Target:	Achieve
Distance from Seat to Simulator	22.0 – 28.0 in.	Yes
Height of Seat relative to Ground	13.0 – 19.0 in.	Yes
Simulator Frame Height Relative to Ground	25.0 – 29.0 in.	Yes
Maximum Frame Deflection from Joystick	0.12 in.	Yes
Case and Mechanism	≤ 88 lbs.	No
Support Mounted Simulator	60 lbs.	Yes
Support User	214 lbs.	Yes

Physical Testing

- With the design assembled, the configurability of the seat and simulator mount were tested by adjusting the various dimensions

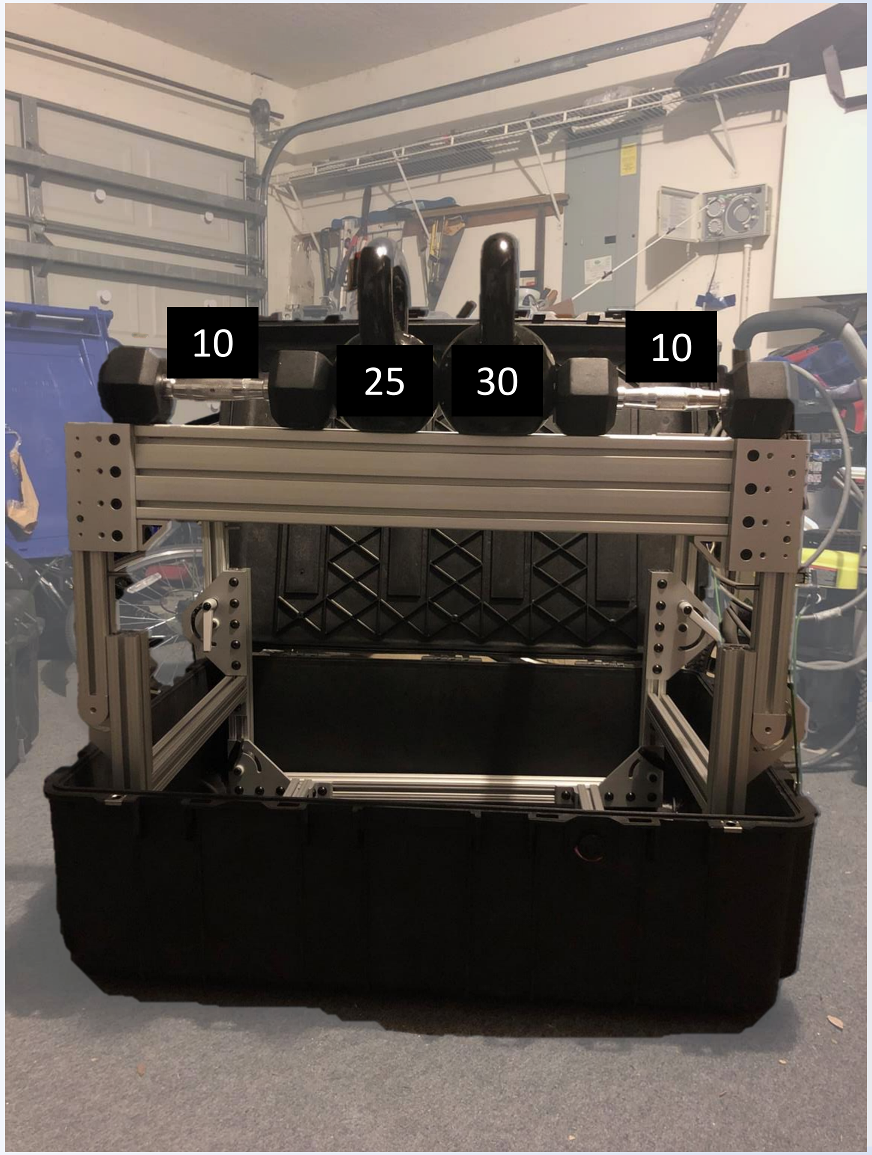
Test Requirement	Adjust seat horizontally between 22 and 28 inches	Adjust seat vertically between 13 and 19 inches from ground	Adjust tabletop vertically 25 – 29 inches from ground	Adjust seat laterally 3 inches on either side
Achieved (✓/✗)	✓	✓	✓	✓

Ryan Irwin

Physical Testing

- With the design assembled, the loading requirements of the seat and simulator mount were tested by adjusting components and loading them accordingly

Test Requirement	Rotate the seat 25º in either direction	Support 214 pounds on the seat	Support 60 pounds on the simulator mount	Deflect no more the 1/8 (0.125) inches with an input force of 2.5 pounds
Achieved (✓/✗)	✓	✓	✓	✓

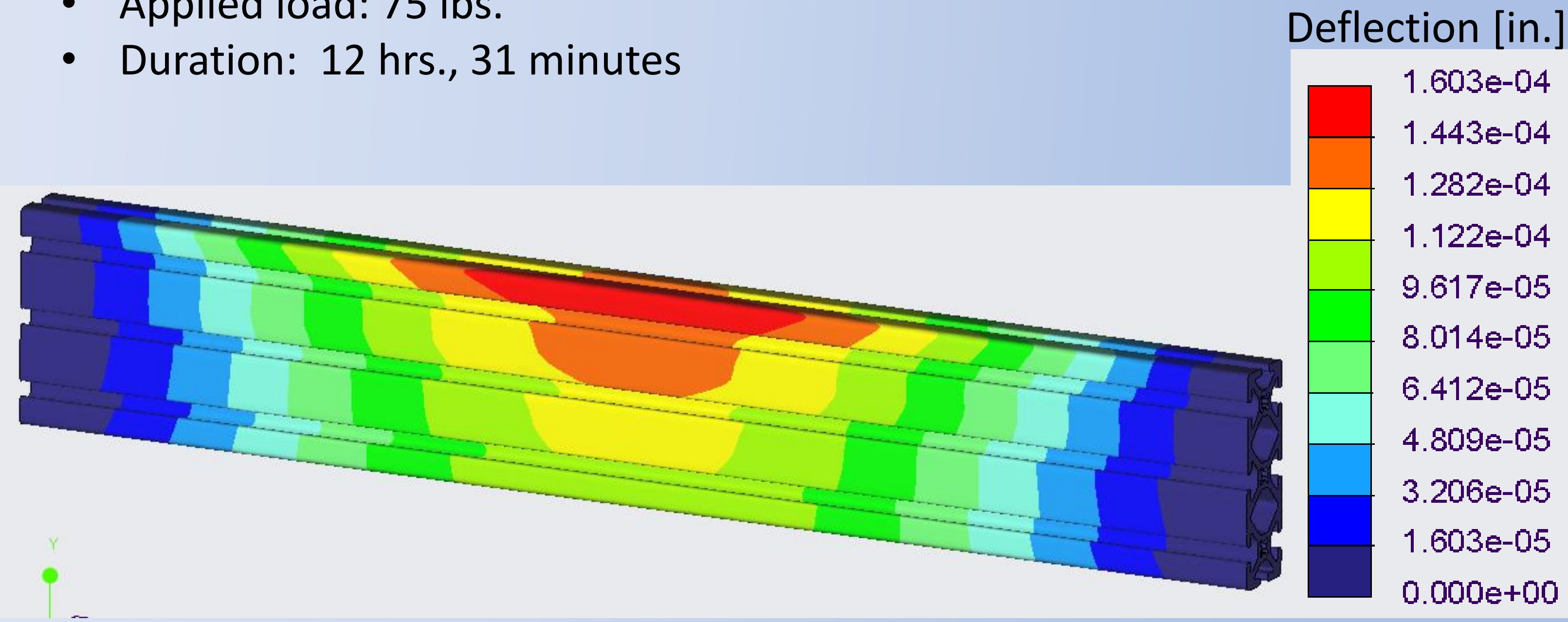


Verification

- Simulator mount can support maximum load of 60 lbs. during use
- Simulator mount will deflect less than 1/8 in. with 2.5 lbf applied
- Can adjust to different heights
  - Physical testing
  - Computer simulations

Simulator Load Testing

- Applied load: 75 lbs.
- Duration: 12 hrs., 31 minutes



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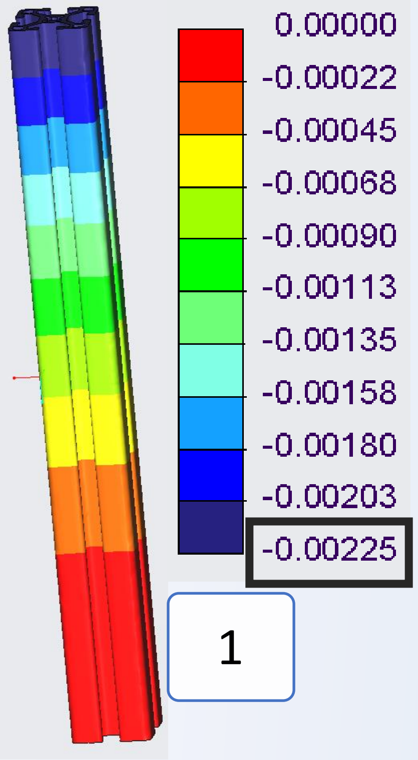
Deflection [in.]



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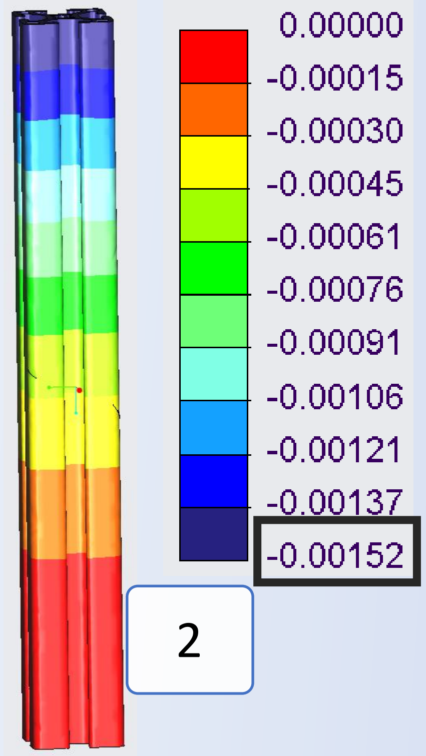

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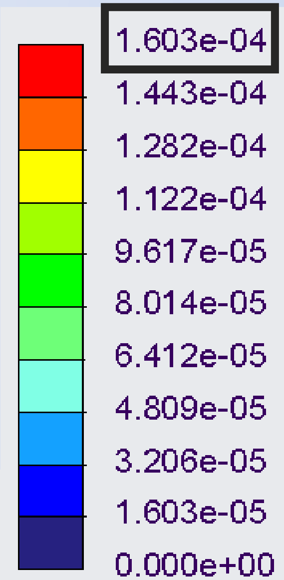

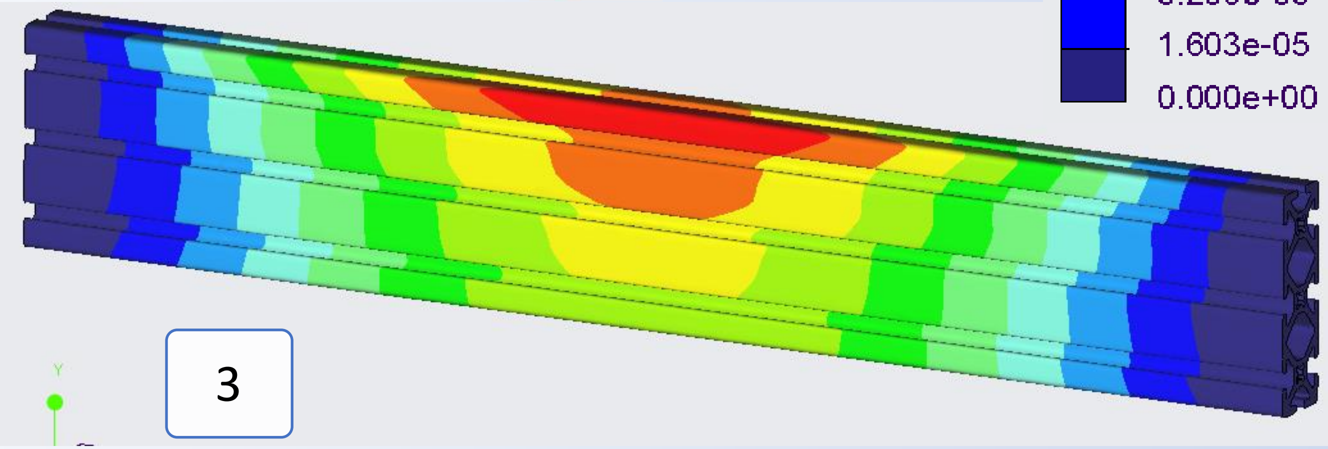

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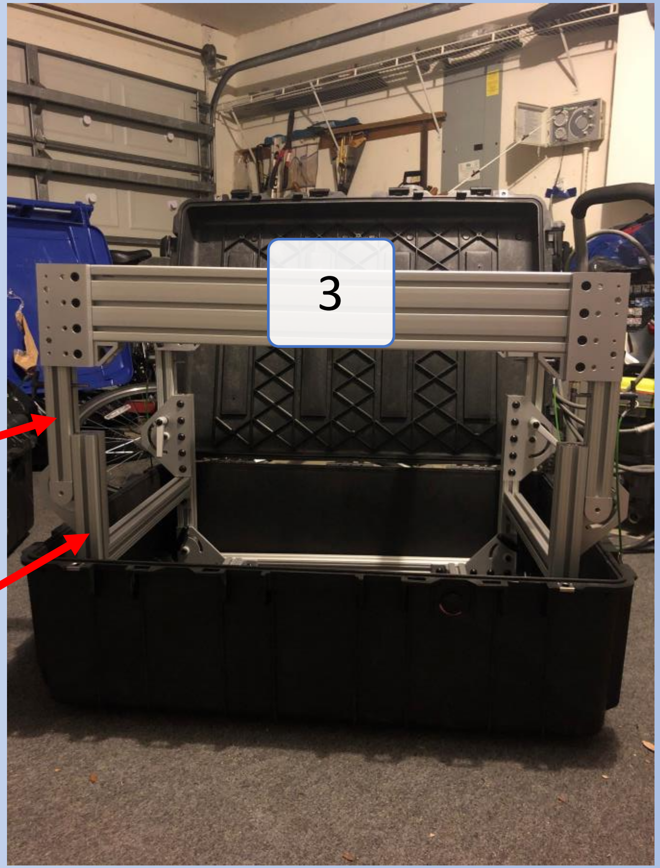


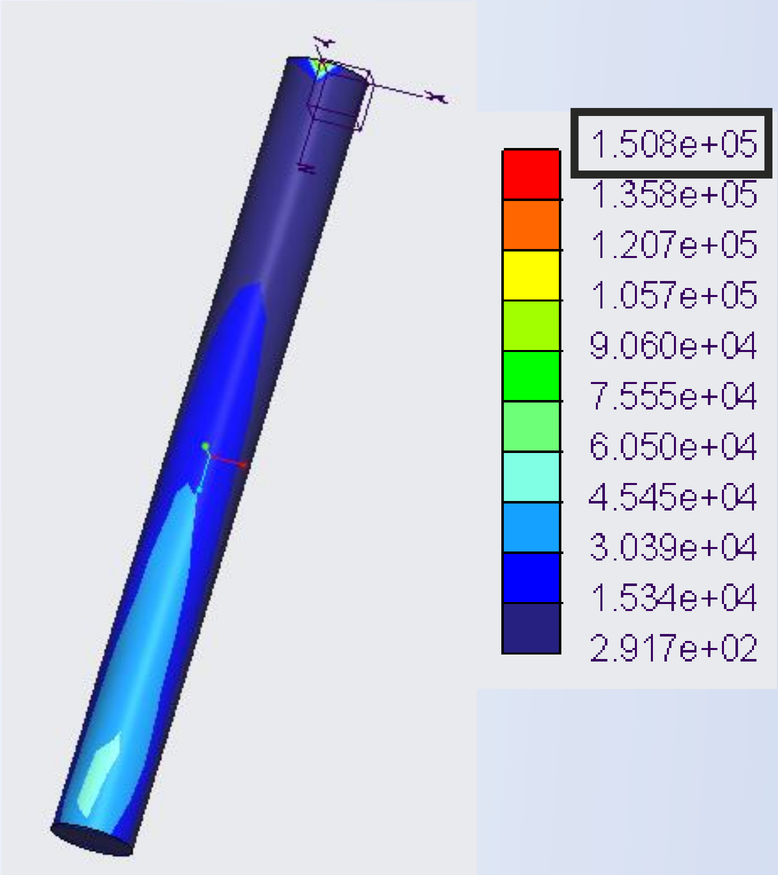
Total Deflection: 0.00393 in. < 1/8 in.

Verification

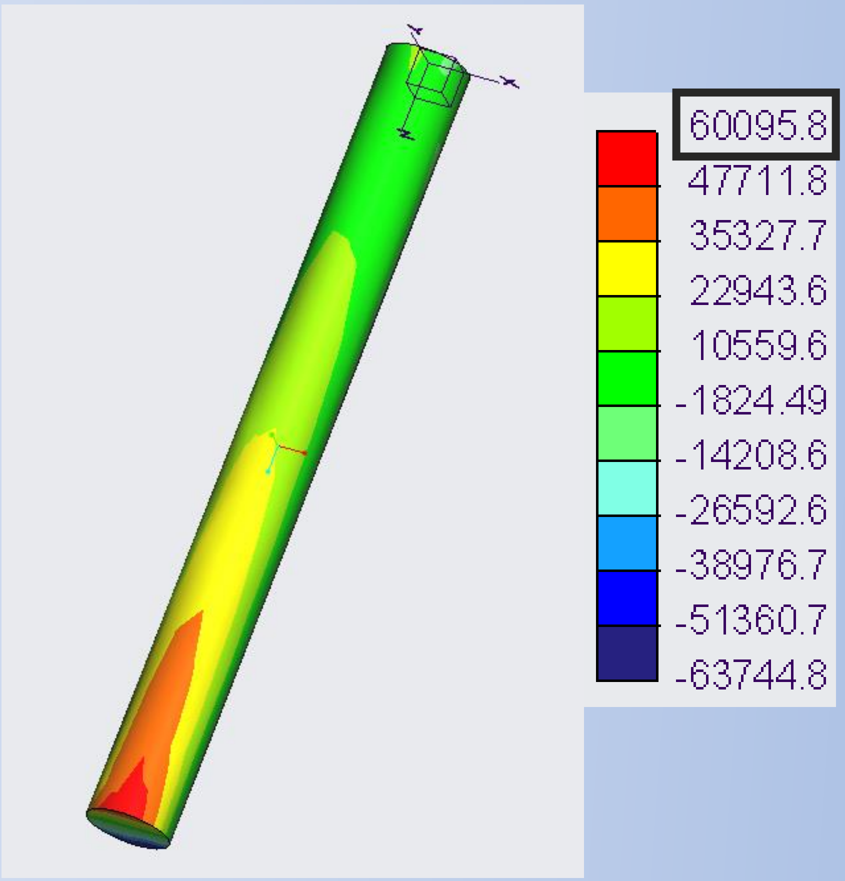
- Seat can support maximum load of 214 lbs. for duration of use
- Seat can adjust with 4 degrees of freedom: vertical, horizontal, lateral, rotational
  - Physical Testing
  - Computer Simulations

Simulator Load Testing

- Applied load: 220 lbs.
- Duration: 1 hr., 42 minutes



Von Mises Stress [psi]



Normal Stress [psi]

Tape Calculations

- The VHB Tape has 3 main modes of failure:
  - Normal Tensile Shear
  - Dynamic Overlap Shear
  - 90° Peel
- The force required to achieve each type of failure is based on information from the 3M website for this specific VHB tape
- The VHB tape was tested under ASTM D-897, ASTM D-1002, and ASTM D3330 standards, respectively

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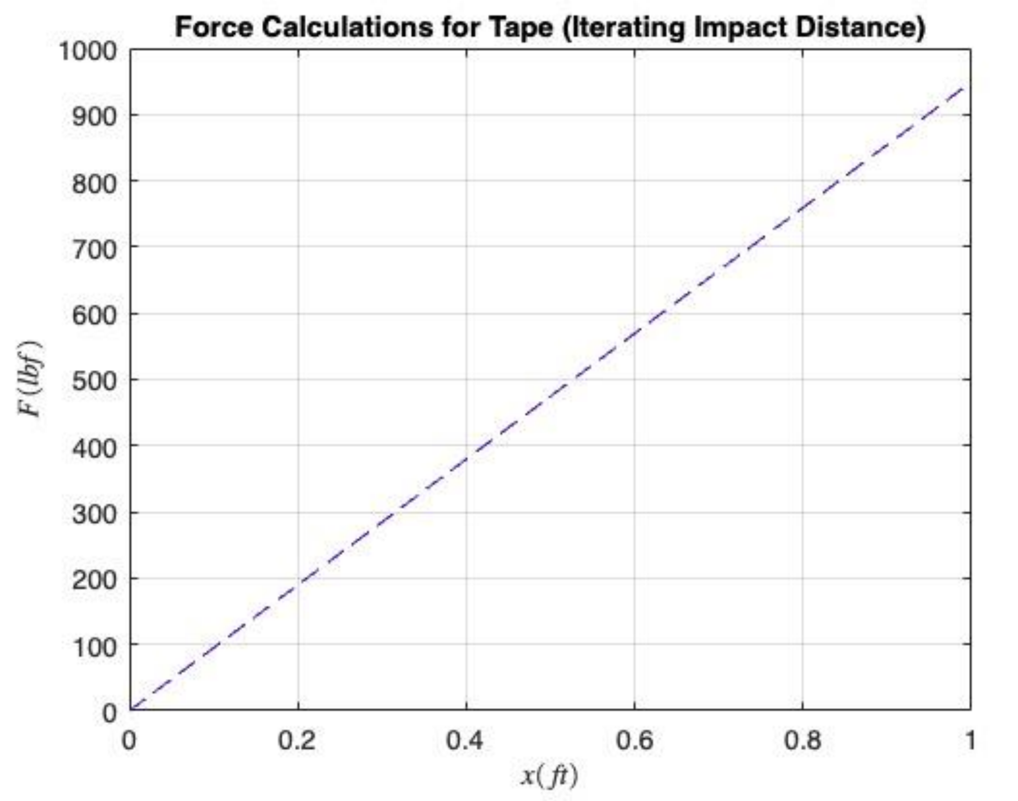
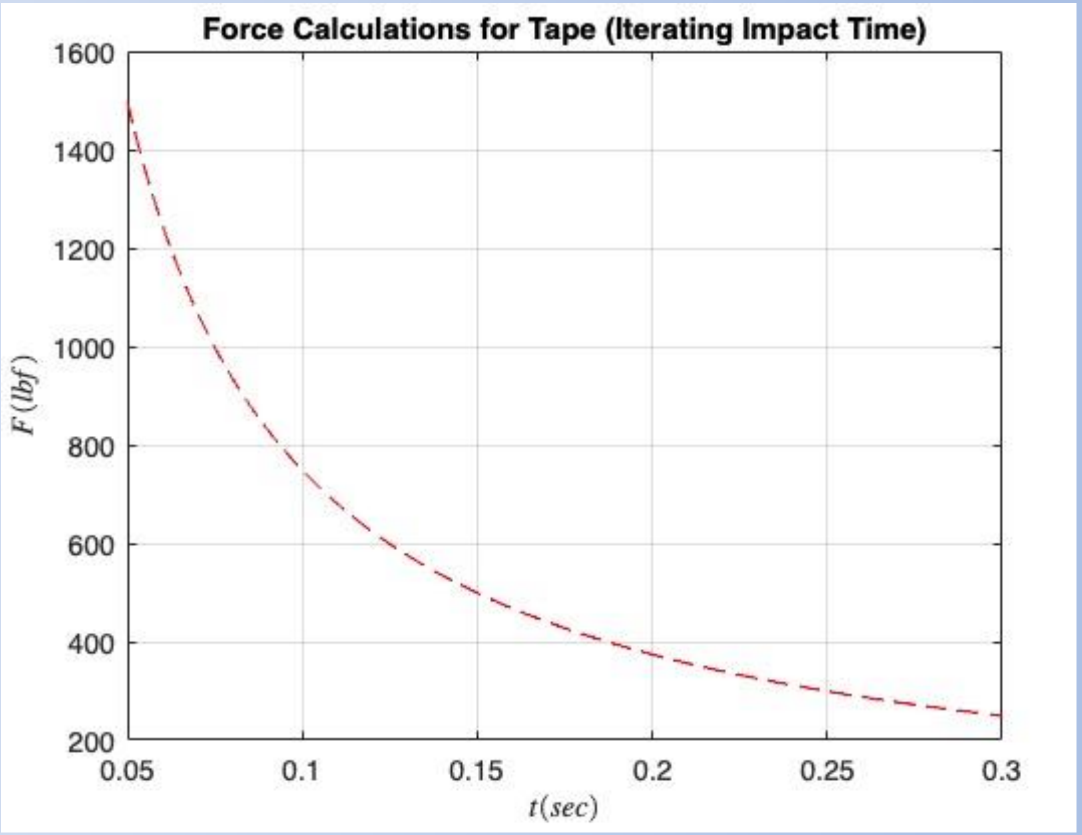
Tape Calculation Graphs



This figure shows the impact force as function of the distance the CG moves during impact



This figure shows the impact force varies as a function of the time it is impacting

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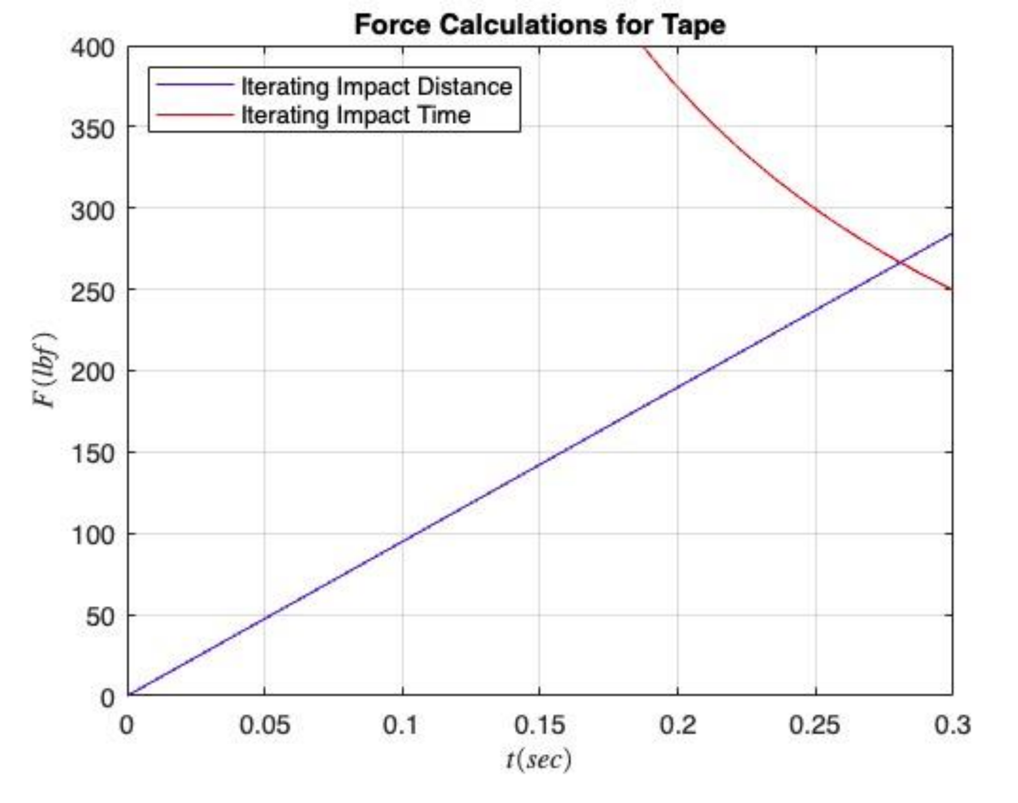
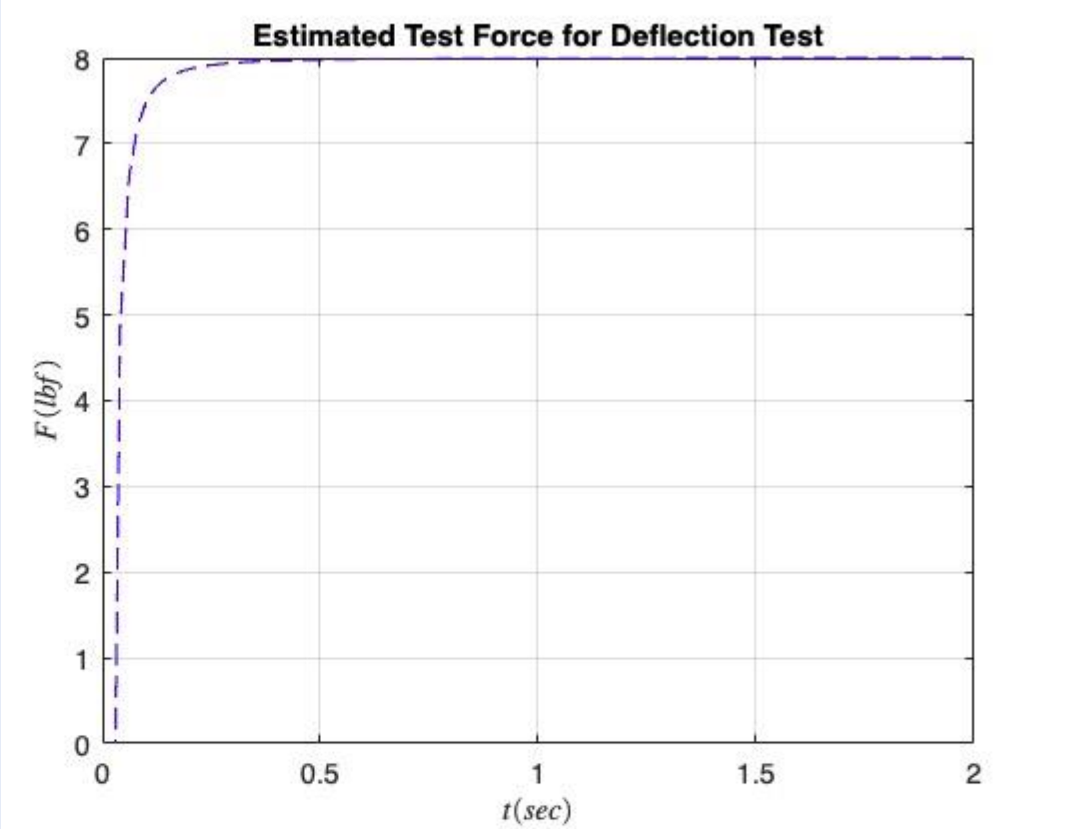
Tape Calculation Graphs Continued



This figure shows the intersection of the previous graphs, yielding the 266 lbf impact force and 0.2809 second impact time



This figure shows the force applied during the slow-motion deflection test in prior slides as a function of the time of the applied force

Tape Calculations Continued

- For a test height of 10 feet, it was calculated that the 95-pound simulator case would impact with a force of 266 pounds.
- The table below shows the VHB tapes calculated strength in each of the 3 possible failure methods.

Failure Method:	Normal Tensile Shear (lbf)	Dynamic Overlapping Shear (lbf)	90° Peel (lbf)
Force Needed to Achieve Failure Method	7000	8500	5000

*All values are based off dynamic tests. Static test values require larger forces to achieve failure

Future Tests

- Conduct survey with students to determine the average assembly and disassembly time with and without the product manual to determine “ease of use” criteria.
- Product fragility testing to ensure components can endure handling misuse and meet the requirements of MILSPEC and ASTM standards
- Life cycle performance to determine if the product will perform for the stated 5-year life cycle
- Environmental testing to ensure that product can withstand extreme weather conditions

Improvement for Future Design

- Constructing the simulator mount out of the Lightweight 15-Series from 8020.
- Similar to the simulator mount, handles can be used to tighten and lock the seat in place, along with pins, as it moves towards and away from the simulator.
- Integration of precut, sturdier foam to keep the even more secure during rough transport.

Lessons Learned

- Sometimes designs change, even if that change happens after an entire semester of work. If the change makes sense after thorough analysis, follow through with full force.
- Ask questions, even if you're questioning a basic element of the design, you never know what your answer may reveal.
- Communication and meeting as a group regularly is key to staying organized and meeting deadlines.
- Take the time necessary to assemble everything correctly the first time. Tolerances can be tricky and cause issues, but they are not impossible.

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"The Pessimist Sees Difficulty In Every Opportunity. The Optimist Sees Opportunity In Every Difficulty." – Winston Churchill