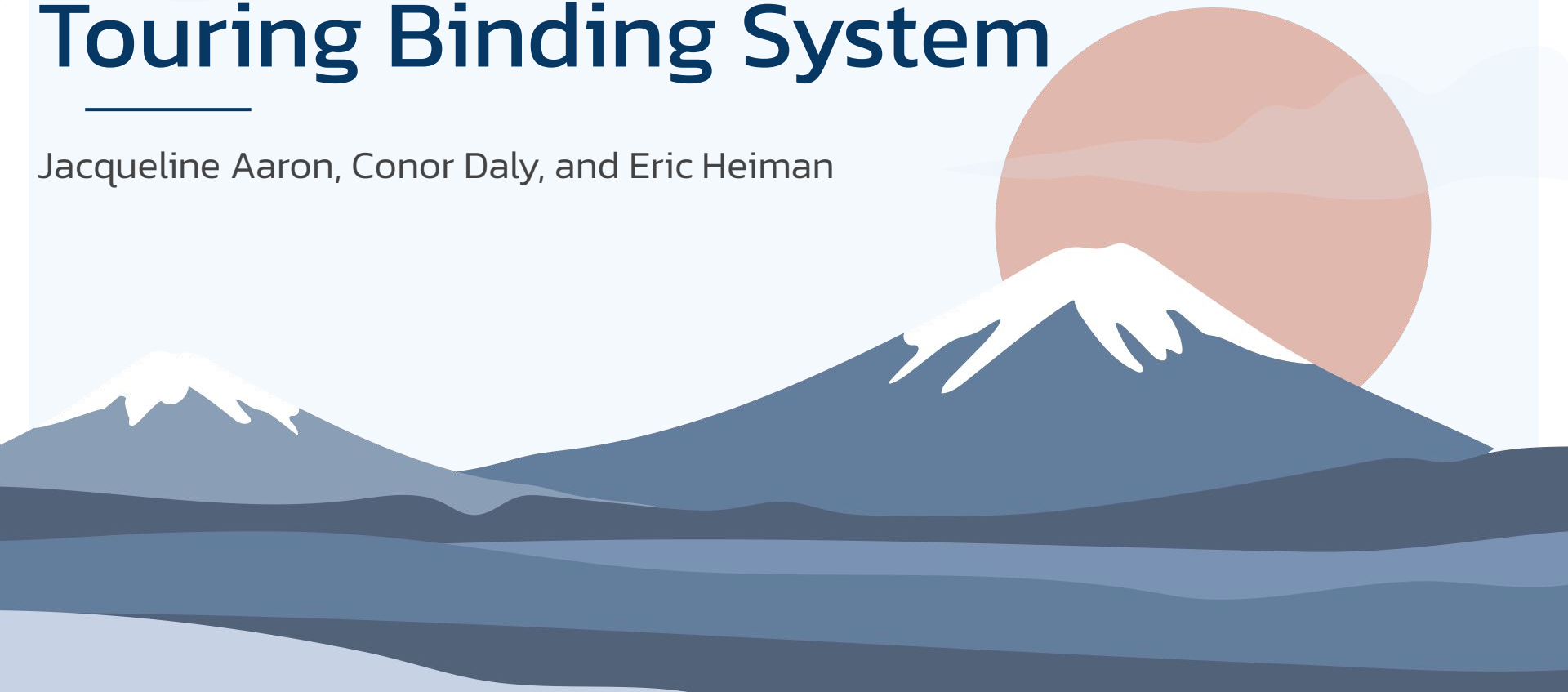
Design of a Hybrid Ski Touring Binding System

Jacqueline Aaron, Conor Daly, and Eric Heiman



Meet the Team

Jackie Aaron

Conor Daly

Eric Heiman

Introduction

- Our experience with equipment has led us to find deficiencies
- Many bindings good at one thing: long backcountry missions, short tours, resort laps
- No binding serves all purposes without compromises

Objective

- Create a system than interchanges between an alpine resort style and uphill touring style ski binding that satisfies two use cases:
  - Ascend and descend on a touring binding
  - Ascend on a touring binding and descend on an alpine binding

Disciplines of Skiing

Alpine Skiing

- Lift serviced terrain
- Defined safety standards
- Performance oriented
- Used for descent only

Backcountry Skiing

- Human-powered access
- Developing safety standards
- Lightweight oriented
- Used for ascent and descent

Mechanics of Ski Bindings: Alpine vs Touring

Alpine Bindings

- Always fixed at the heel and toe
- Held by forward and downward pressure from the heel piece
- Releasable at the heel and toe
- Provide suspension and power transfer

Tech Bindings

- Fixed at the toe while ascending
- Fixed at the toe and heel while descending
- Held by clamping force of the toe piece and ‘floating’ pins at the heel
- Limited suspension and power transfer

Toe Piece

Heel Piece

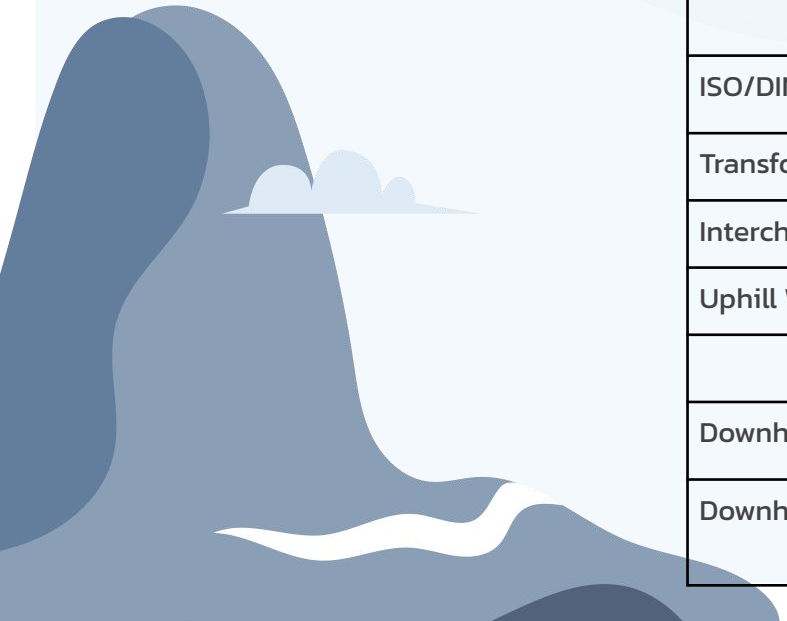
Current Market options

Fritschi Tecton

Salomon Shift

C.A.S.T. Freetour System

The State of the Art



	Hybrid Bindings		50/50 Bindings		
	Marker Kingpin 13	Fritschi Tecton 12	Salomon Shift 13	Marker Duke 16	C.A.S.T. Freetour
Features					
Tech Toe	X	X	X	X	X
Multiple Touring Risers	X	X			X
ISO/DIN Certified Toe		X	X	X	X
Transformable Toe			X	X	
Interchangeable Toe					X
Uphill Weight	775 g	680 g	886 g	1050 g	995 g
Use Cases					
Downhill Tech Toe Use	X	X			
Downhill Alpine Toe Use			X	X	X

Reasoning for product's development

Rational:

To support the need for a high performing setup that can be used in the resort and the backcountry

Ethos of Each Discipline

Alpine Skiing

- Unconcerned with weight savings as uphill use is not a part of alpine skiing
- Prioritize safety and performance features

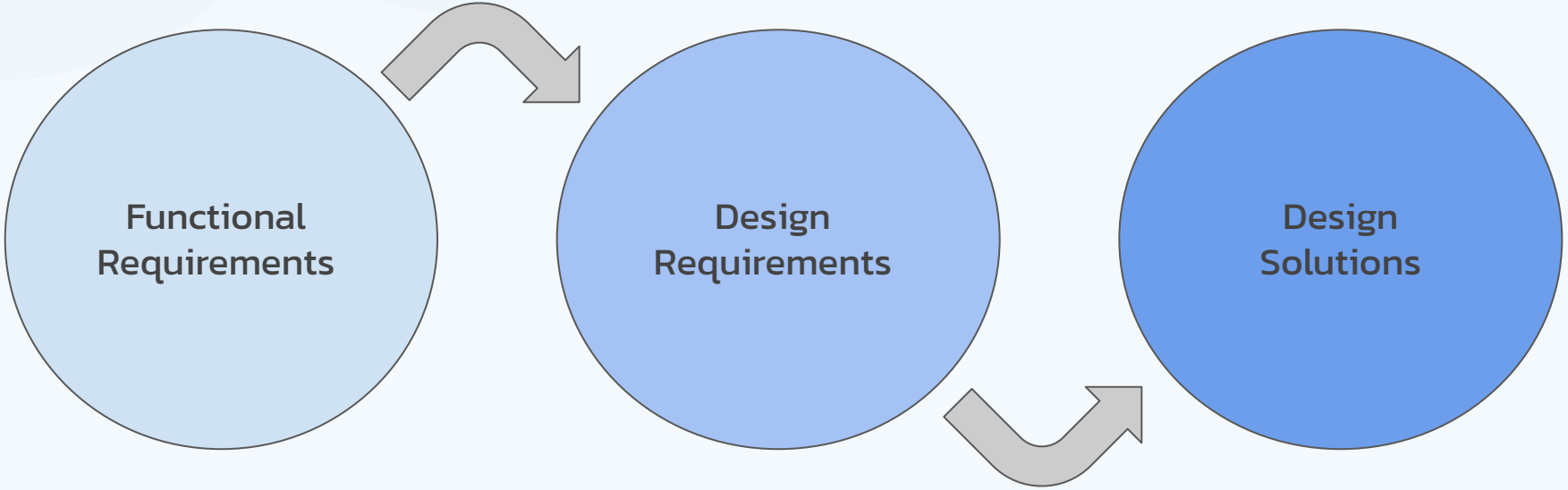
Both

- Expect gear to perform at a high level
- Desire for safety and performance features

Backcountry Skiing

- Prioritize lightweight gear over safety features and performance
- More cautious mentality of how a slope will be skied

Design Process



Design Process

Functional Requirements (FR)
FR1: Transmit skiing loads FR1.1: Transmit uphill skiing loads FR1.2: Transmit descending skiing loads

Design Process

Functional Requirements (FR)	Design Requirements (DR)
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Design Process

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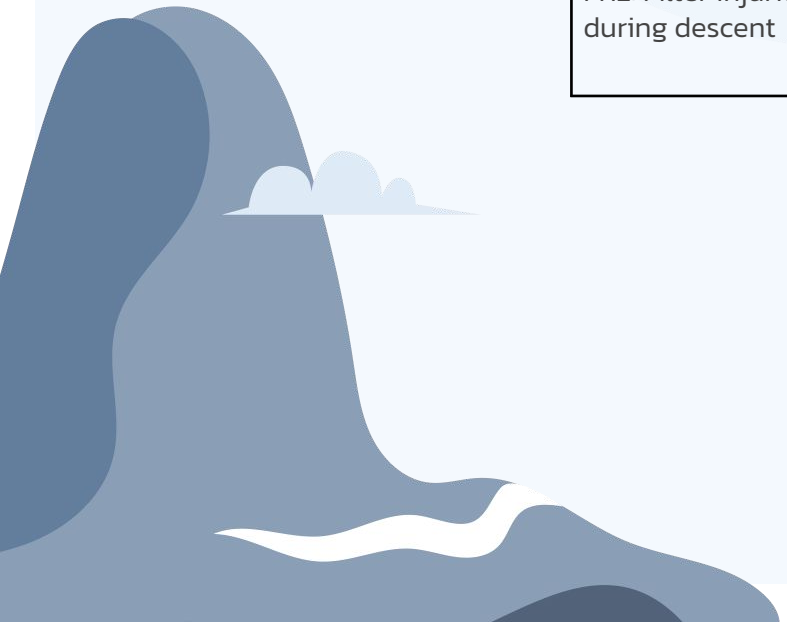
FR2: Filter injurious loads during descent	DR2: System that releases skier's boot during injurious loading	DS2: Alpine style components with ISO/DIN certification and elasticity at the toe and heel



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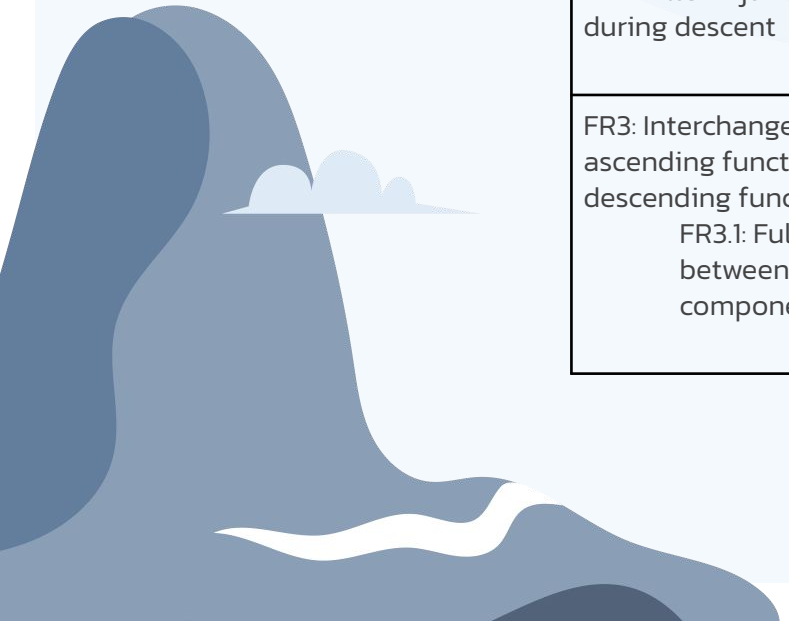
FR3: Interchange between ascending function and descending function FR3.1: Full interfacing between binding components	DR3: System that provides interchangeability for ascent and descent DR3.1: All components are compatible with each other	DS3: Alpine and tech toe compatible with demo binding track DS3.1: Both alpine and tech toes interface properly with heel piece for descent



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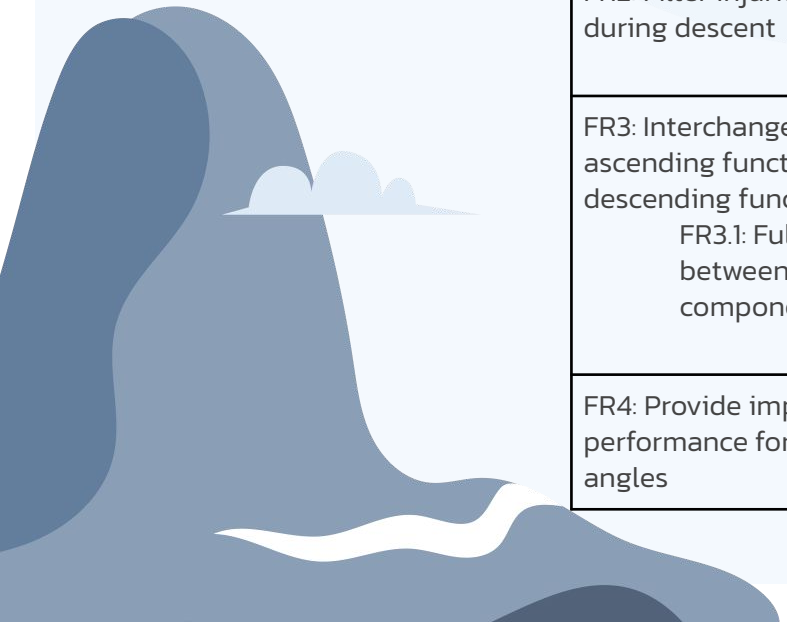
FR4: Provide improved climbing performance for various slope angles	DR4: System to improve climbing position on steep slope angles	DS4: Touring risers to elevate heel during ascent of steeper slopes



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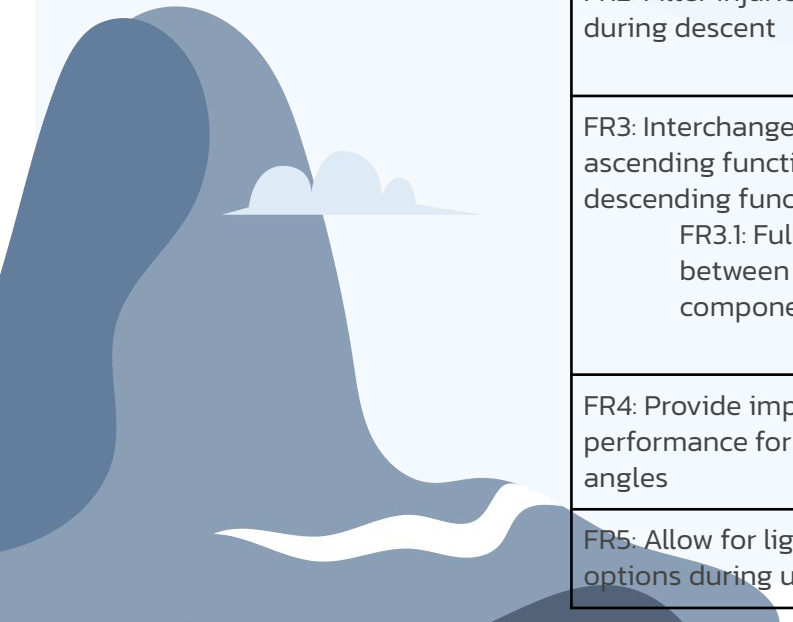

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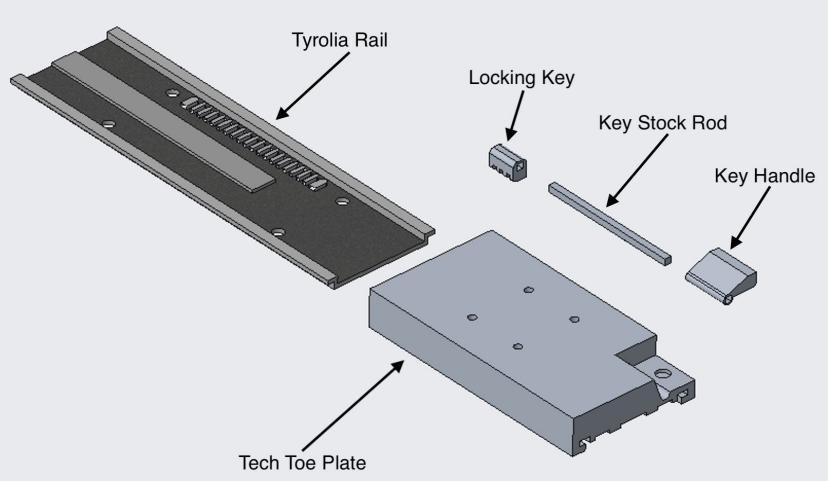
FR4: Provide improved climbing performance for various slope angles	DR4: System to improve climbing position on steep slope angles	DS4: Touring risers to elevate heel during ascent of steeper slopes
FR5: Allow for lightweight options during uphill use	DR5: Removable components during uphill use	DS5: Removable heel piece on demo track

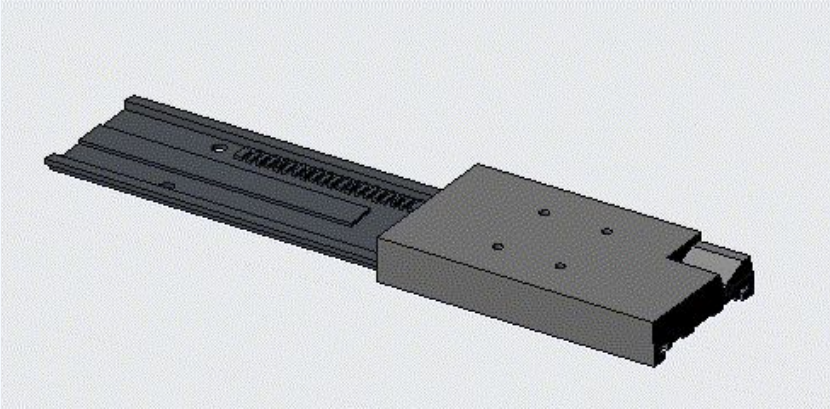
Tyrolia Attack2 13 Demo Binding and Voile Risers

Tyrolia Attack2 13 Demo Binding

Voile Climbing Risers

Our Design





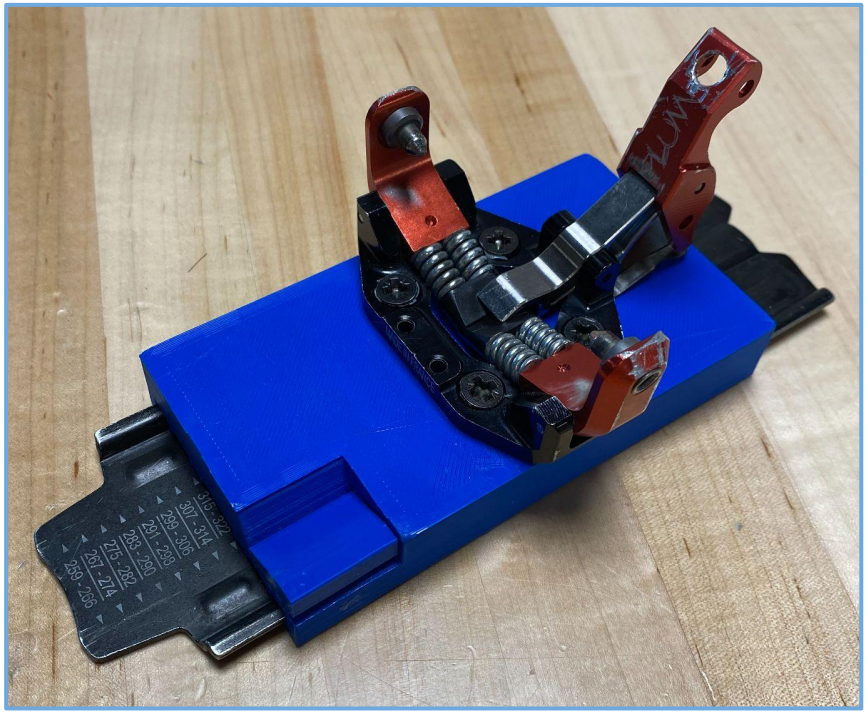
Material Choices: 3D Printed PLA vs. Aluminum 6061

- Strength characteristics
- Weight
- Availability at WPI

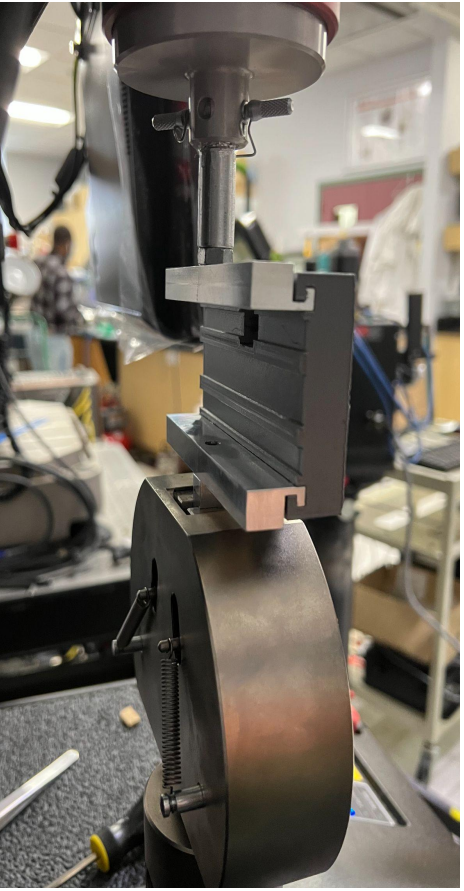
Design Changes

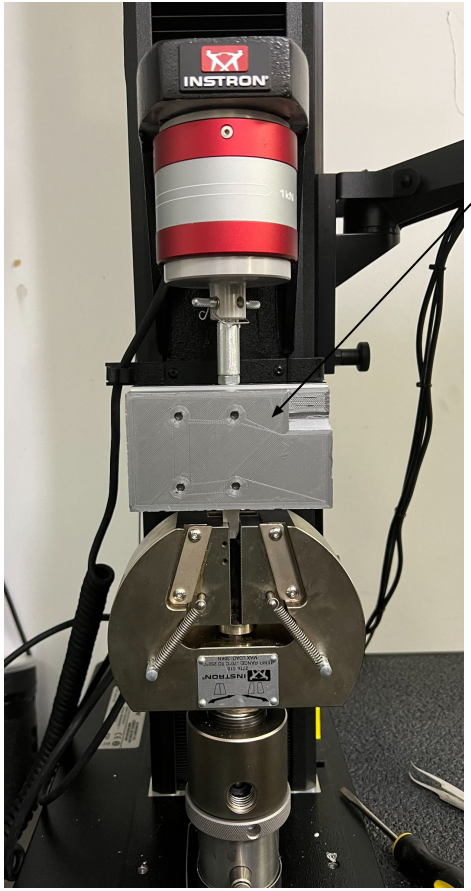
- Magnets instead of springs
- Use of more metal components

3D Printed Prototype

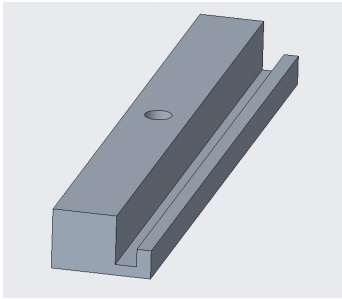


Instron Tensile Testing and Material Selection

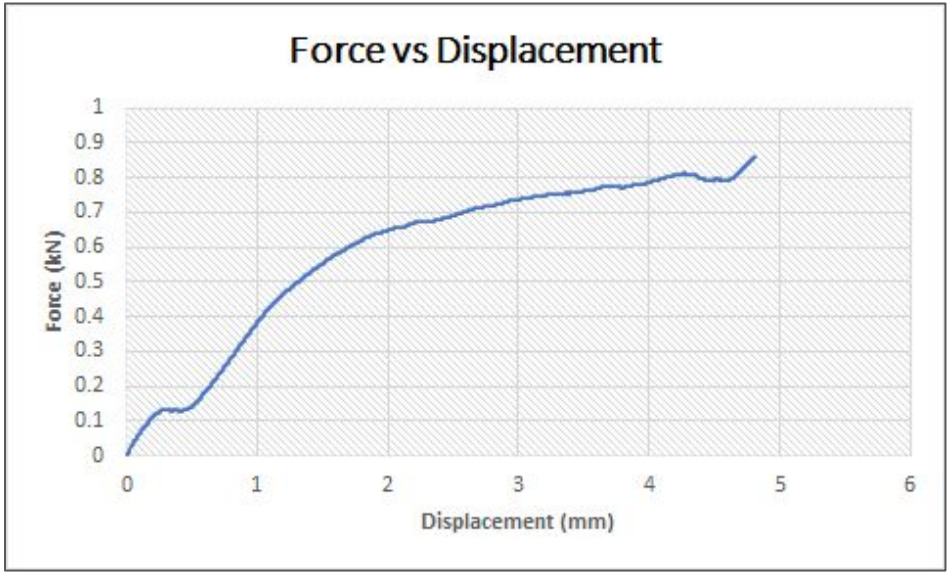




3D Printed Plate



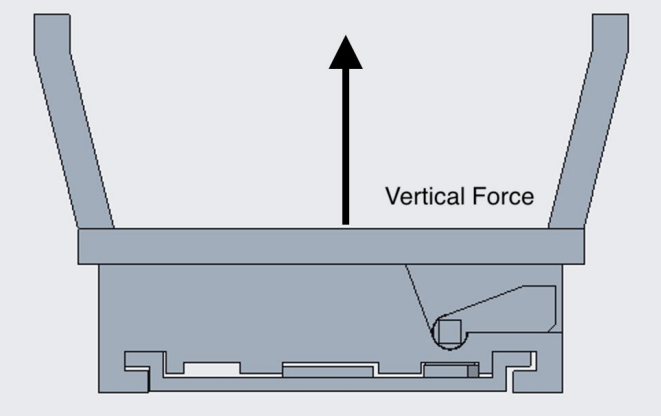
Testing Fixture

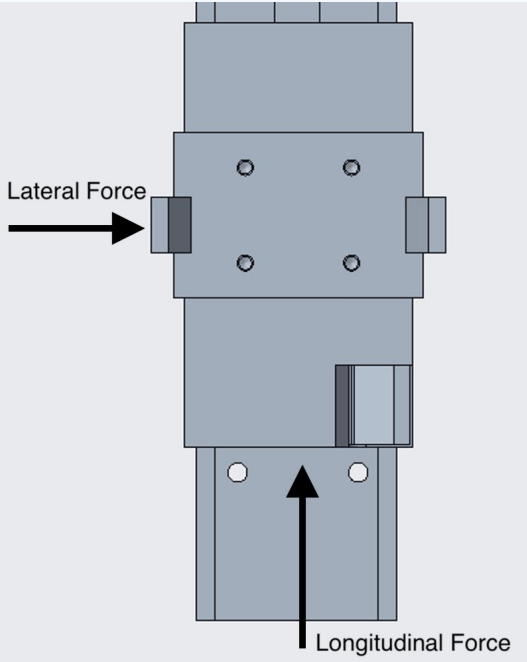


Simulations and Analysis

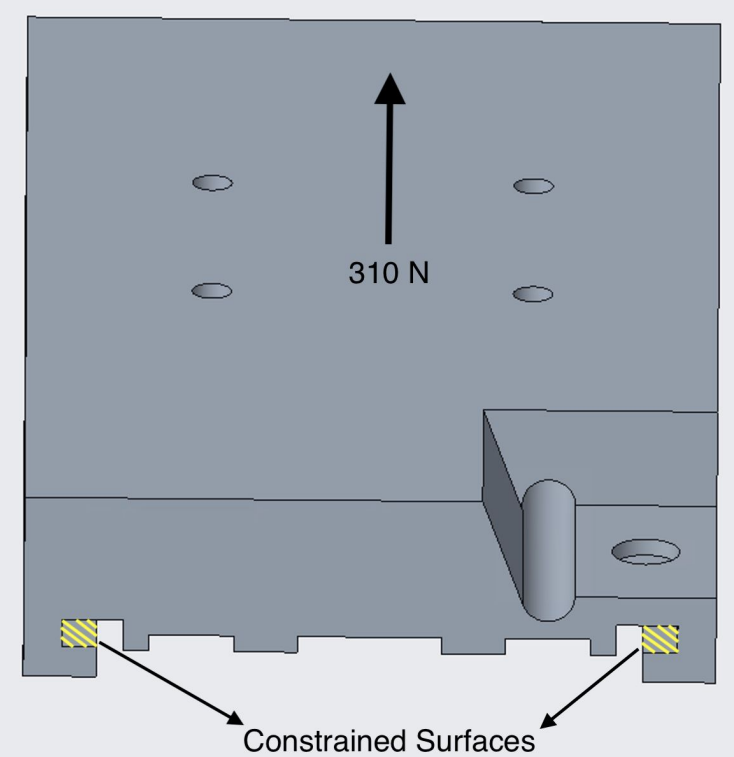
3 Analysis Cases

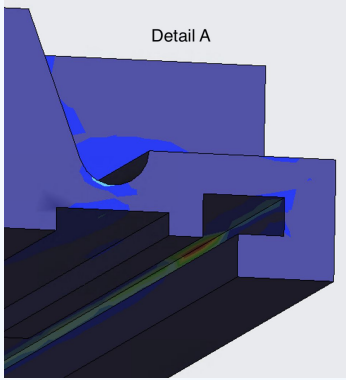
1. Vertical Load
2. Lateral Load
3. Longitudinal Load

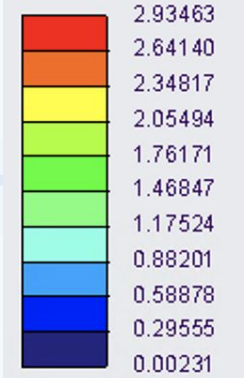


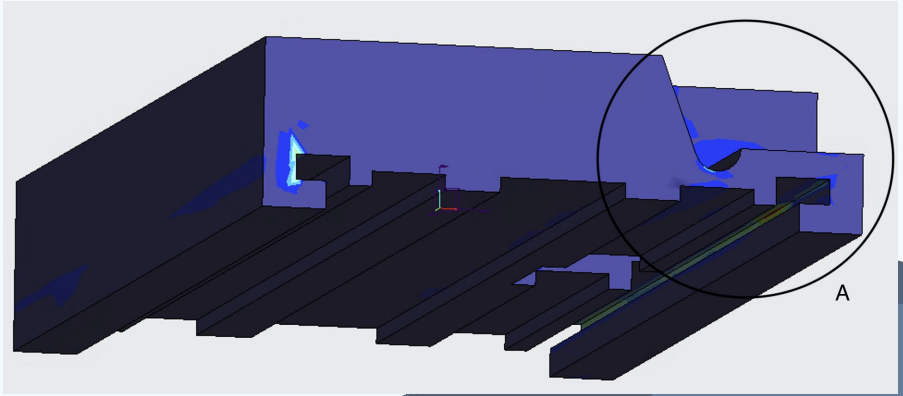


Case 1: Tech Toe Plate Under Vertical Load

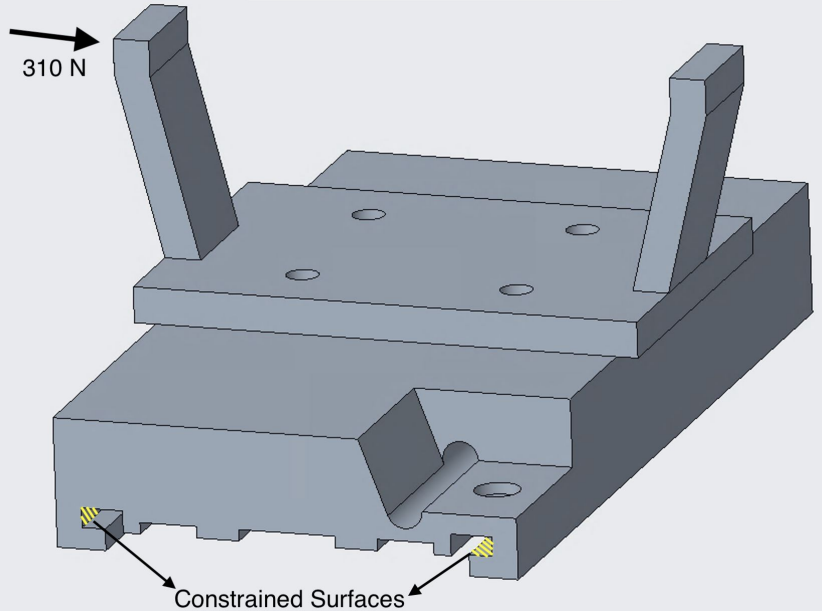


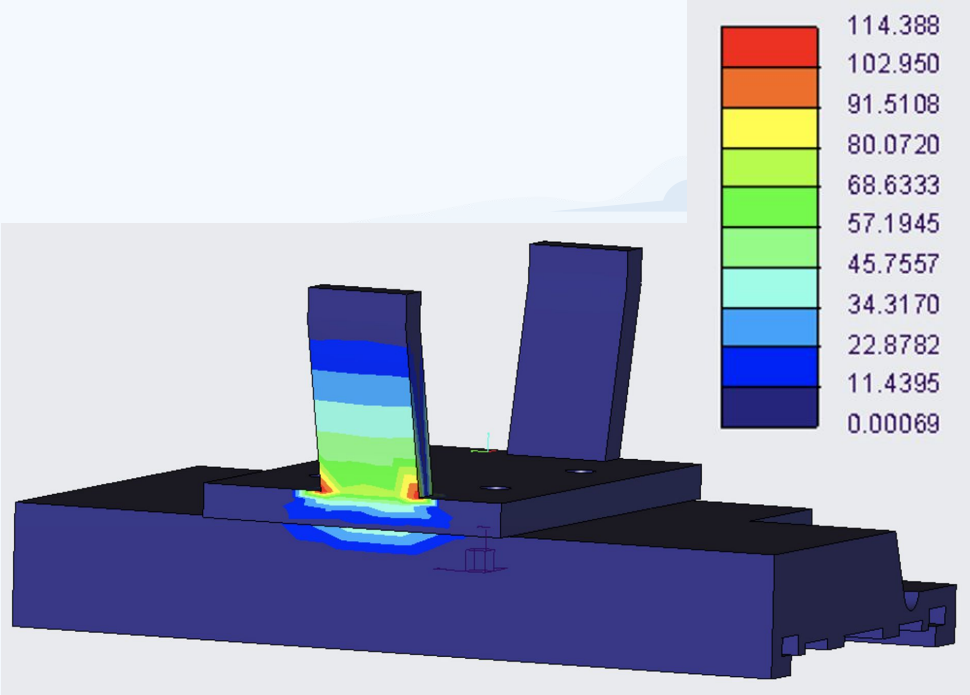




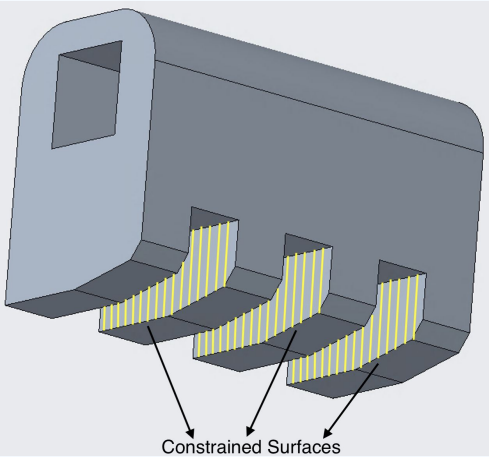


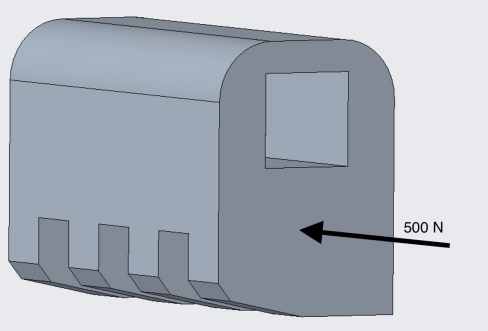
Case 2: Tech Toe Plate Under Lateral Load

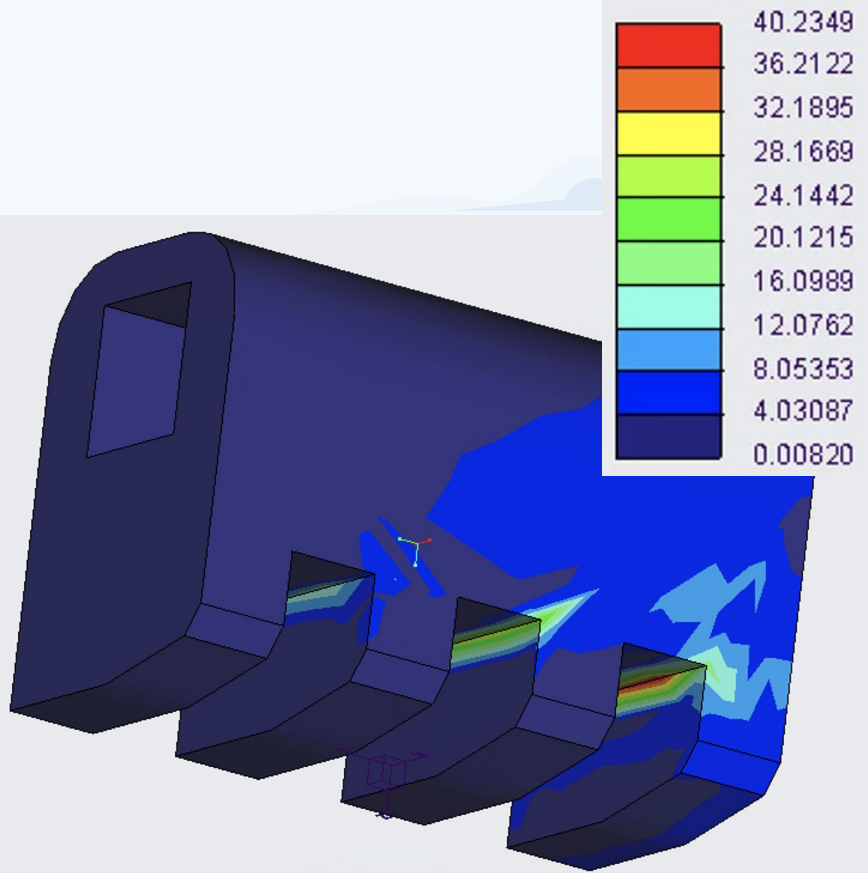




Case 3: Locking Key Under Longitudinal Load

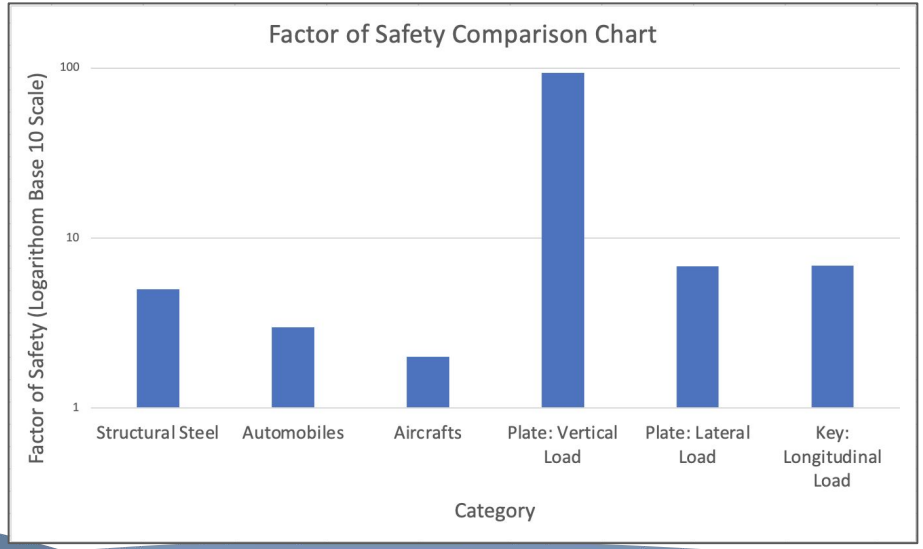






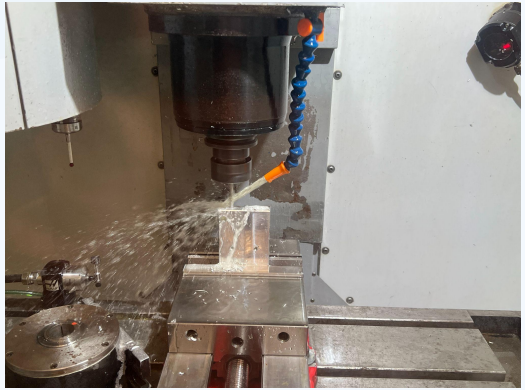
Simulations Summary

Analysis Case	Minimum Factor of Safety
Plate under Vertical Load	94.04
Plate under Lateral Load	6.85
Key under Longitudinal Load	6.86



Manufacturing Process

Haas Mini Mill

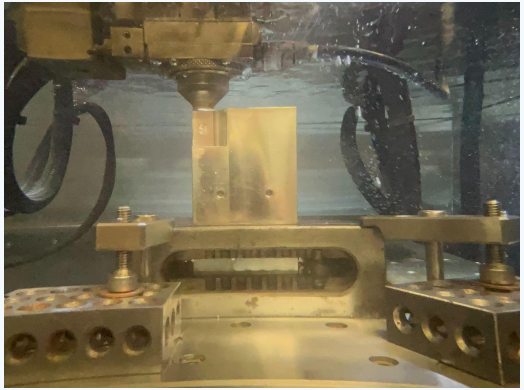


- Used for plate, initial cuts on stock for the handle and key

Haas Super Mini Mill

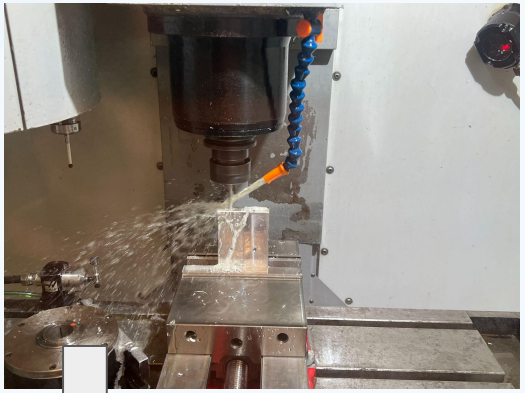
- Used for teeth on key, magnet pocket on handle

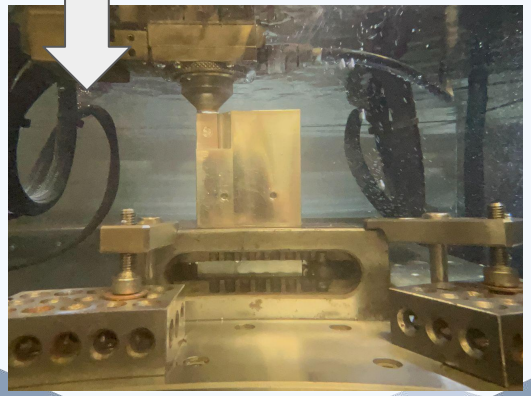
Accutex Wire EDM

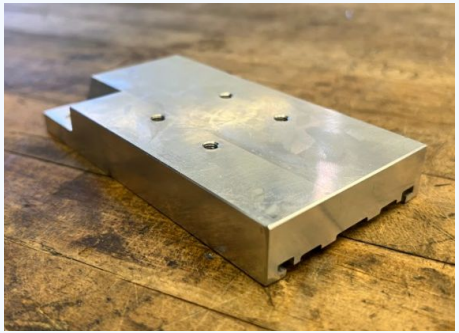


- Used for square hole on key and handle, outer profile of key and handle, rail cutouts on plate

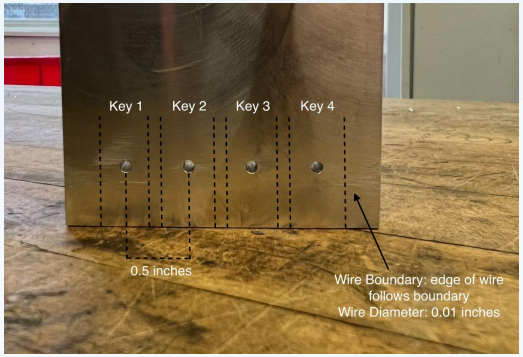
Manufacturing Process: Tech Toe Plate

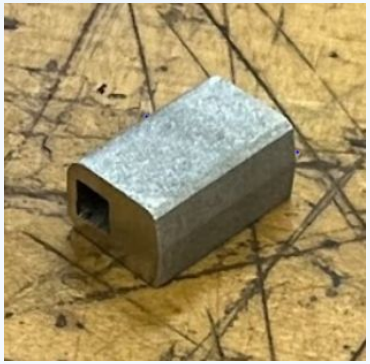


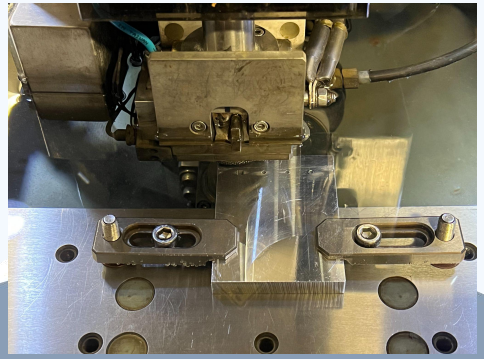




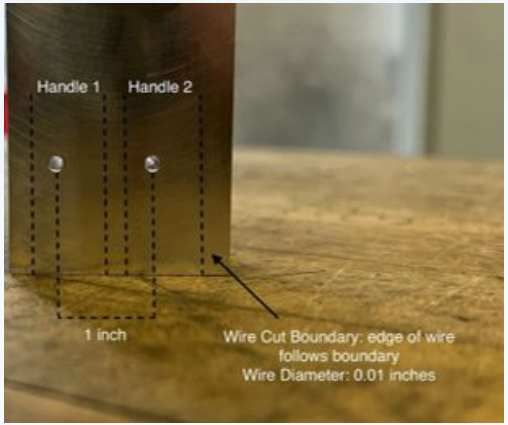
Manufacturing Process: Locking Key

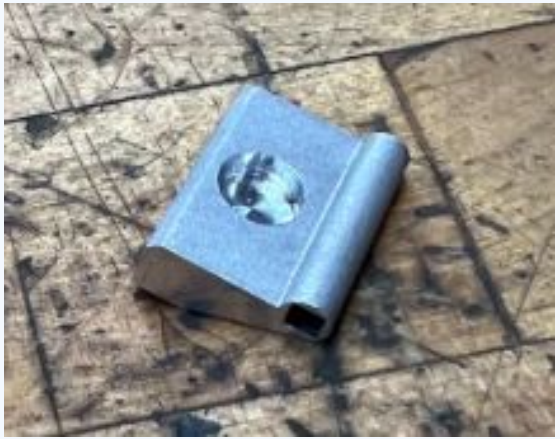




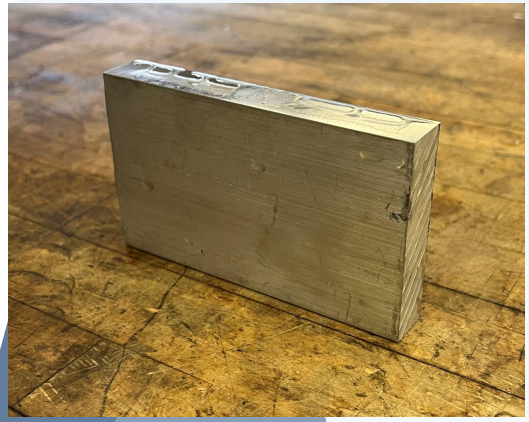


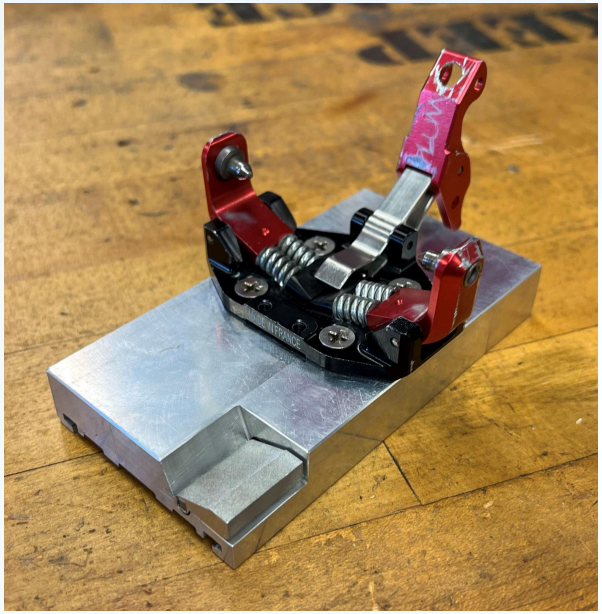
Manufacturing Process: Handle





Final Prototype





On Snow Testing

On Snow Testing

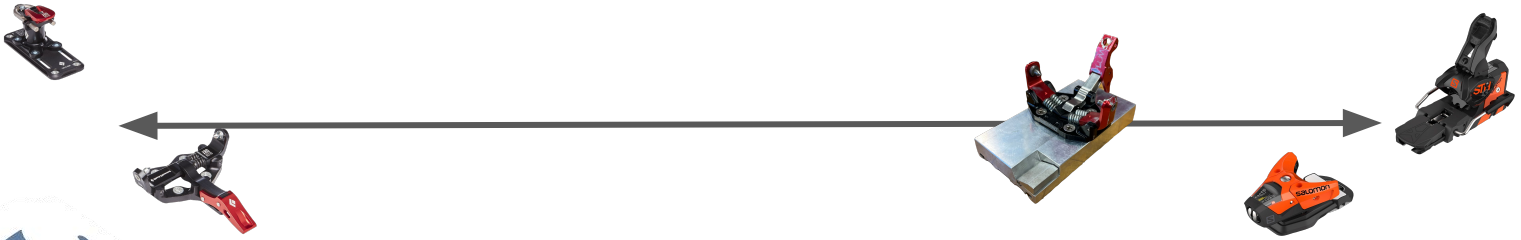
On Snow Testing: Results

Uphill Performance

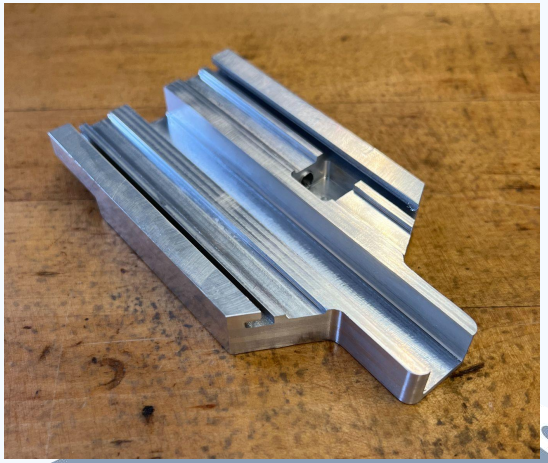
- Light, natural, and comparable to touring specific bindings
- Climbing risers were a cause of concern

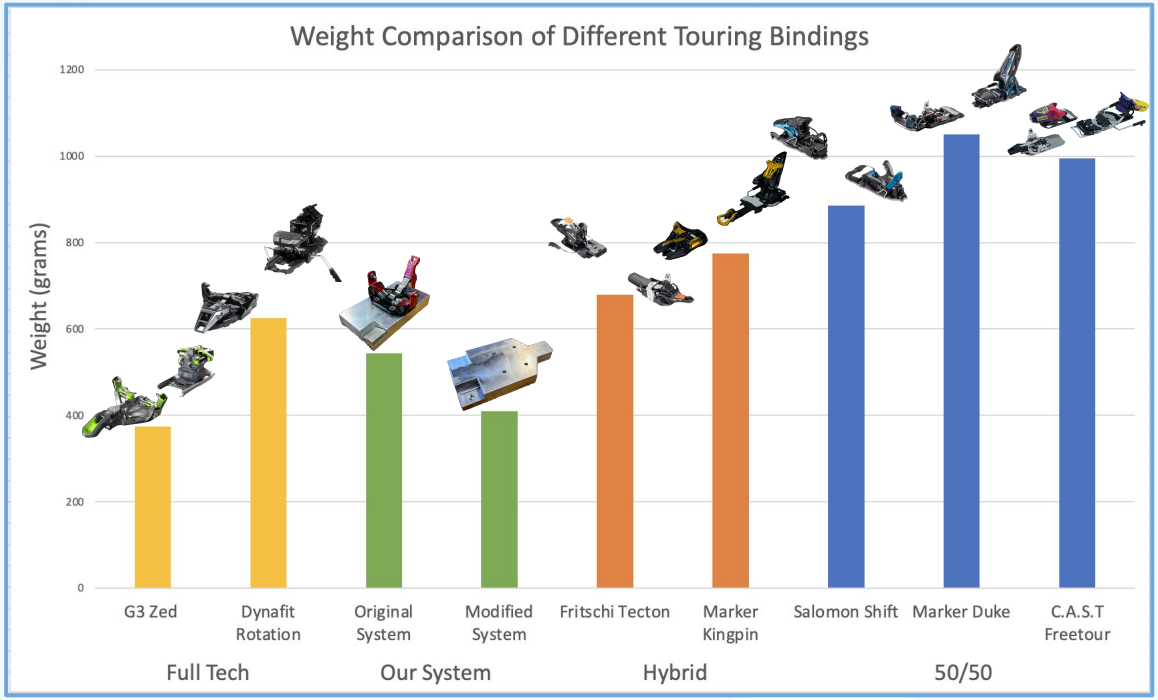
Durability

Downhill Performance



Modifications





Recommendations

- Consolidate components
- Integrate riser system into Kingpin/Tecton style heel piece
- Utilize rail attachment or Cast style toe piece interchanging system
- Injection molding

Fritschi Tecton Heel

Marker Kingpin Heel

Conclusion

Acknowledgements

Professor Ebadi

For guiding and advising our team throughout the semester

James Loiselle

For always being willing to lend us a hand in the machine shop

Ian Anderson

For aiding our team in the machine shop

Professor Oyewole (Kenny)

For aiding us in testing our prototype

Barbara Fuhrman

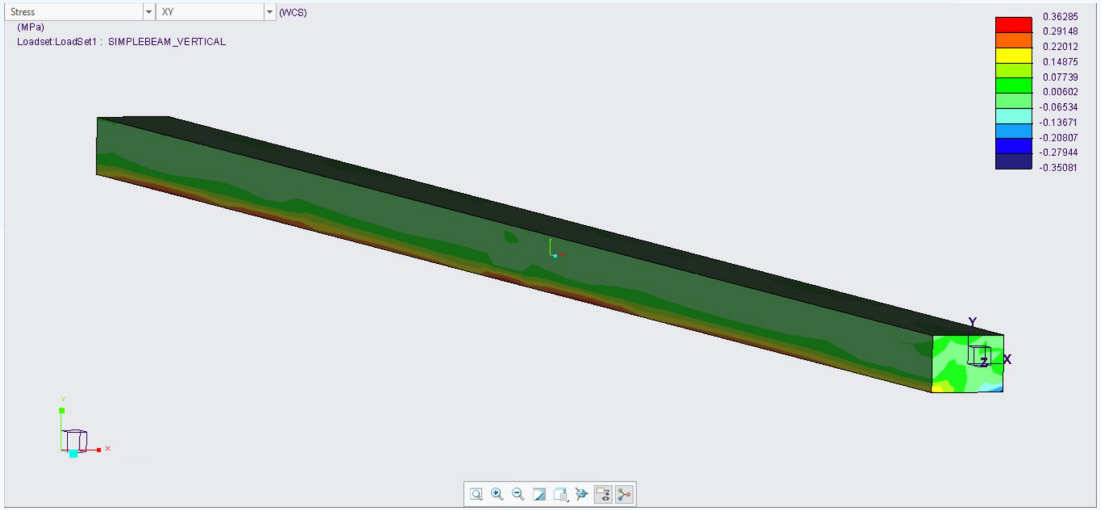
For helping us make the necessary purchases for our project

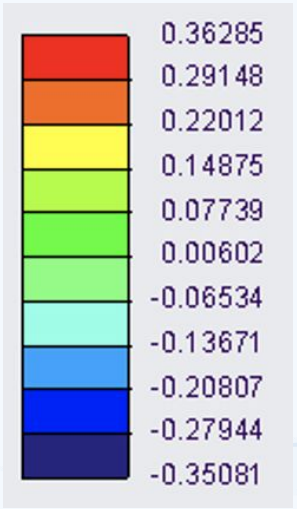
WPI

For providing the resources for us to complete this project

Questions?

Hand Calculations Case 1: Vertical



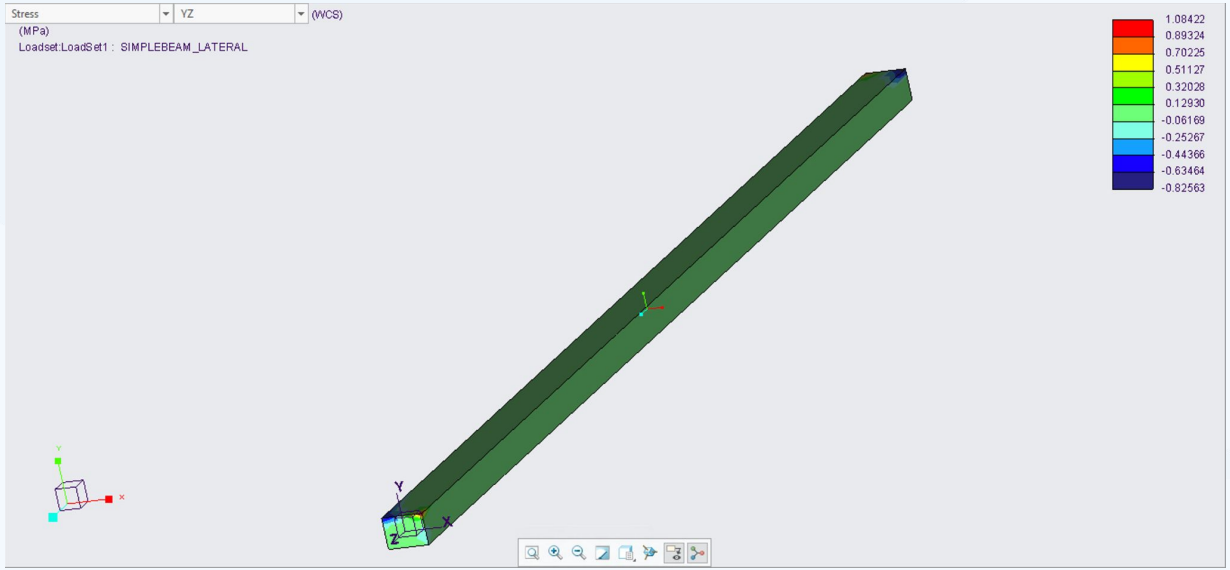


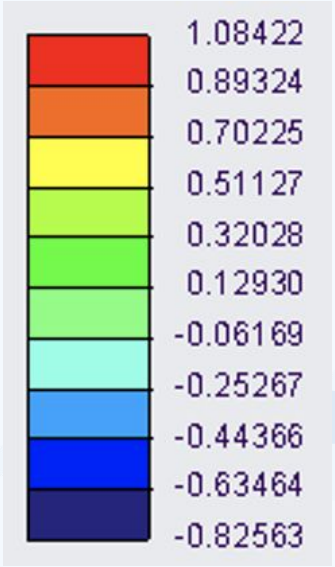
$$\sigma = \frac{P}{A_0}$$

$$\sigma = \frac{310\ N}{2(.120\ m \times .003575\ m)}$$

$$\sigma = 361,305.4\ Pa = 0.361\ MPa$$

Hand Calculations Case 2: Lateral

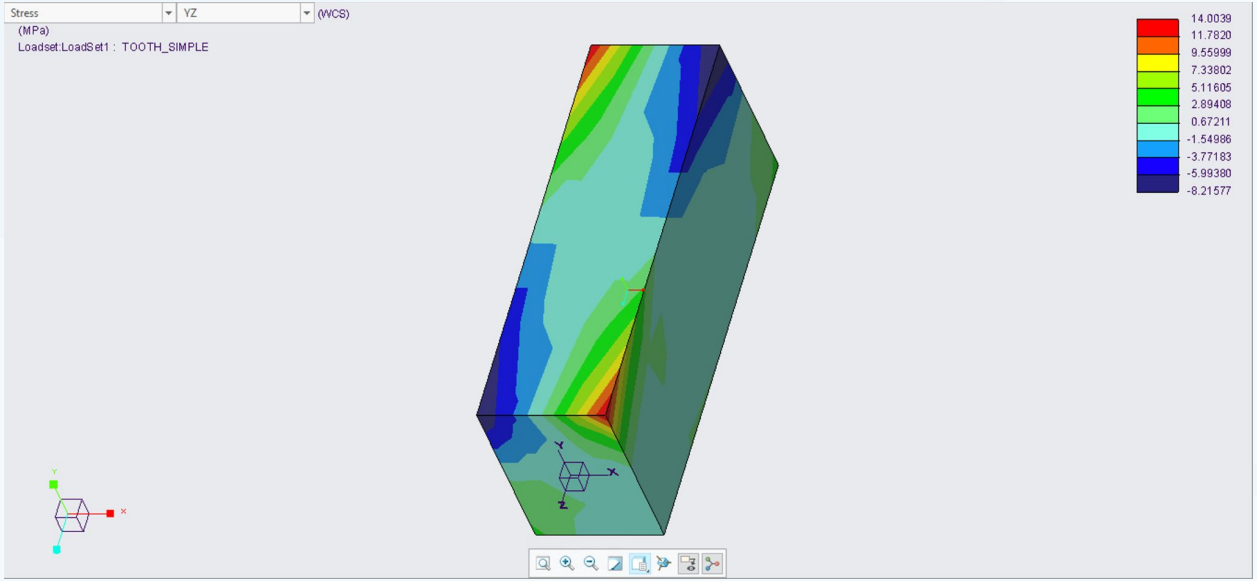




$$A = b \times l = 0.003575\ m \times 0.120\ m$$
$$A = 4.29 \times 10^{-4}\ m^2$$

$$\tau_{YZ} = \frac{3V}{2A} = \frac{3(310\ N)}{2(4.29\times10^{-4}\ m^2)}$$
$$\tau_{YZ} = 1,083,916.084\ \frac{N}{m^2} \times \left(\frac{1\ MPa}{10^6\ \frac{N}{m^2}}\right) = 1.0839\ MPa$$
$$\tau_{YZ} = 1.0839\ MPa$$

Hand Calculations Case 3: Longitudinally



$$A = b \times l = 0.002\ m \times 0.00675\ m$$

$$A = .0000135\ m^2$$

$$\tau_{YZ} = \frac{3V}{2A} = \frac{3(125\ N)}{2(.0000135\ m^2)}$$

$$\tau_{YZ} = 138,888,888.89\ \frac{N}{m^2} \times \left(\frac{1\ MPa}{10^6\ \frac{N}{m^2}}\right) = 13.89\ MPa$$

$$\tau_{YZ} = 13.89\ MPa$$