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# Binding Innovation Technologies, Restoring Freedom to the World of Snowboard Bindings

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# BINDING INNOVATION TECHNOLOGIES, RESTORING FREEDOM TO THE WORLD OF SNOWBOARD BINDINGS

by

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**Capstone I Report**

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# Binding Innovation Technologies Final Design Report

From left to right

Back row: Ryan Willis, Colten Roberts, Tyler Lewis, Matthew Munsee

Front Row: Christopher Tryon, Longze Li, Michael Terry

## Abstract

Snowboarding technology has progressed by leaps and bounds since the sport's inception in the 1980's. However, there is one area that has gotten progressively worse. That area is flexibility and freedom of expression. In order to make the sport safer, the industry responded by making stiffer boots and bindings. Our goal is to bring back the high level of flexibility that built the sport while maintaining or exceeding current safety standards. We also need to reduce heelside shock so as to increase the comfort of the rider. Our design consists of three major systems that drastically increase flexibility, safety, and shock absorptivity. The base of our design lies in the baseplate. With flexible rubber hinges and dampening foam, the baseplate allows for much greater flexibility and greatly reduces the effects of uneven terrain. The composite material contained in the ankle strap will limit the ankle dorsiflexion to a safe range of 20 degrees while allowing for lateral flexibility and increased comfort. The stiff highback completes the design. Thanks to the highback the rider will have precise, immediate control over the board in any situation. With these three components we feel confident that our design meets the needs of any intermediate to experienced level rider looking for more flexibility and safety.

## I. Background

When snowboarding starting gaining popularity in the late 1980's most of the equipment that was made had little to no innovative technology. The riders themselves constructed a lot of the parts that were used out of common items that were not made for snowboarding, including using normal winter boots as a substitute for snowboard boots. While this allowed a lot of flexibility for the rider, it came at the price of compromising his/her safety.

### A. Problem Statement

One common injury is known as snowboarder ankle. Snowboarder's Ankle is the common term for a fracture of the lateral process of the Talus bone. This ankle injury is fifteen times more common in snowboarders than in the general population; therefore, this ankle injury is often referred to as Snowboarder's Ankle.

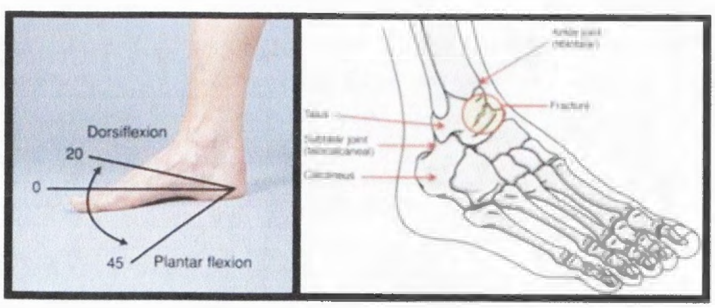



**Figure 1**

Over the past two decades the snowboarding industry has created better and safer equipment to reduce this injury, making boots and bindings that are stiffer and safer. This did come at a cost. Not only did this reduce the flexibility and movement of the ankle while riding, but it also took away the rider's ability to express themselves freely through movement and style.

This is the first problem encountered in designing a new and innovative binding. The ideal binding allows the desired flexibility and freedom to express oneself going down the mountain, while allowing a high level of safety and protection in the ankle region. The industry has approached this problem by creating stiffer and stiffer boots for the rider that allow little to no flexibility. This doesn't address the issue or solve anything for those who want to snowboard with softer, flexible boots. We need to keep this in mind when coming up with a design, in order to create something that will be universal for all riders, regardless of preference for softer or harder boot styles.

The second problem that we face deals with the way the snowboarder turns and stops as he goes down the mountain. The snowboard has two sides to it, a heel side and a toe side, as demonstrated in figure 2. In order to control your direction of motion as you go down the mountain you either lean on the toe or heel edge. This action causes the rider to turn in the direction of the lean.

**Figure 2**

One problem with snow is that it is full of inconsistencies, and any snowboarder will tell you that as you ride down the mountain, it isn't always a smooth and easy ride. While doing a toe-side turn, a moment is created on the rider's foot, with the origin of the moment at the ankle. From figure 3a, you can see the moment in purple, the force in red, origin in green, and the moment arm in blue. The foot, acting as the moment arm, is able to absorb and counteract most of the minor inconsistencies that are found in snow on a skiing hill.

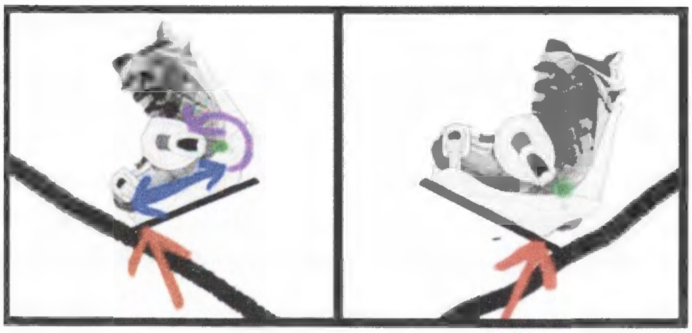


Figure 3a Figure 3b

The story is completely different when you look at the free body diagram of the heelside edge turn. In figure 3b you can see that the force due to inconsistencies in the snow goes directly through the snowboarder's ankle. In this configuration there is no moment arm to help absorb the change in terrain. This makes for a much rougher ride. It is our goal to dampen the inconsistencies found in the mountain as you do a heel side turn. In other words we wish to mimic a toe-side moment arm for the heel-side as you descend the mountain.

Our goal is to develop a snowboard binding that reduces heelside shock and allows for dynamic heel-side turns while limiting dorsiflexion motion to 20 Degrees. The binding design must be compatible with the standard mounting base plate and should have standard ankle/toe straps. The design must be safe, stylish, and rugged.

## B. Design Requirements

The Design Requirements are as follows:

**Flexibility**

The binding must limit the range of dorsiflexion (0-20 Degrees).
Ankle restriction must be gradual, and gently stop at the maximum angle.
The binding must allow for lateral flexibility (0-30 Degrees).

**Dampening**

The binding must reduce heelside chatter.
The binding must be responsive when riding.

**Weight**

The binding must not exceed 1.5x the weight of the current average.

**Material**

The materials must be durable and able to withstand adverse weather conditions.

### C. Current Market Designs

There are a few current designs on the market that attempt to address the problems of reducing the heel side shock and giving the rider the freedom for expression. However, these options still lack the desired range of motion. For example, none of them make any attempt to deal with the issue of limiting the dorsiflexion range to 20 degrees. The following figures show the current designs that try to limit the shock that riders feel while going down the mountain.

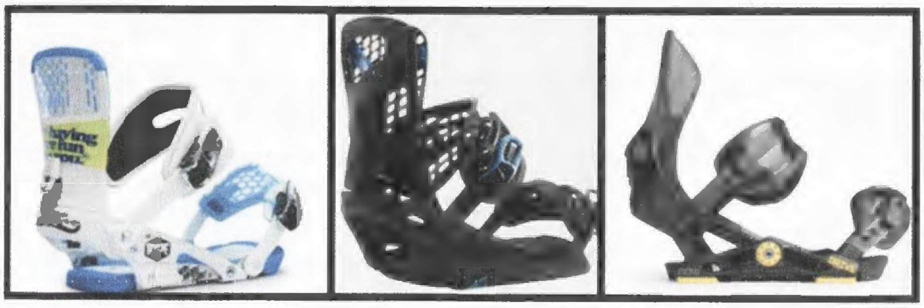


**Figure 4a** **Figure 4b** **Figure 4c**

The Ride Rodeo (Figure 4a) offers a responsive ride with the use of a flexible high back, gel mesh toe cup, and a "Wedgie" footpad which acts as a damper and absorbs chatter. The Burton Genesis (Figure 4b) offers a cushioned, two piece high back for improved response to heel side chatter. The high back design focuses on support and responsiveness. The Now Drive binding (Figure 4c) offers padded technology on all four corners of the base plate to allow for a dynamic, responsive ride while carving down the mountain. This binding has gotten bad reviews as it can make for an unstable ride. Each of these bindings aims to reduce the heel side shock, but none of them quite reach the goal. Our binding will reduce the heel side shock and limit the dorsiflexion range to less than 20 degrees.

## II. Final Design

After much deliberation and engineering analysis we feel confident that our selected design meets or exceeds all of the aforementioned design requirements. Shown below is an assembled 3D representation of the final design solution.

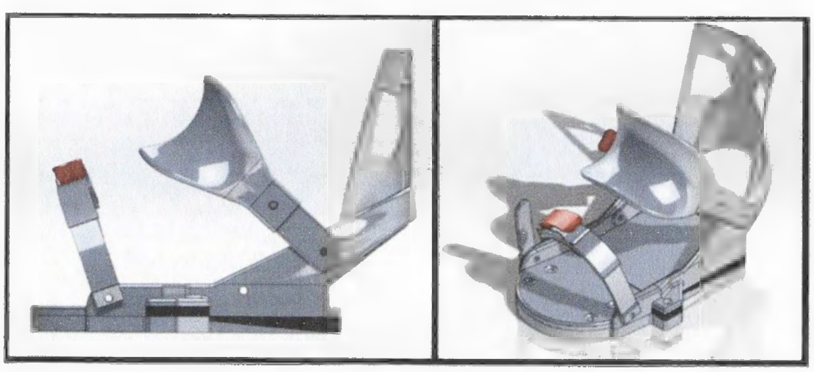


**Figure 5**

In order to fully understand our problem and solution, the design was broken up in to three major parts. These parts consist of the baseplate, the ankle strap, and the highback. Each portion of the design supports a specific function critical to meeting the design requirements. We will now take a closer look at each area of the design.

### A. Baseplate

The baseplate makes up the bulk of the design. As you can see in figure 6, there are 5 components that make up the base plate assembly, namely: the toe plate, heel plate, base ramp, heel foam, and rubber hinge. Each element is critical to the overall design and functionality of the binding.

The base ramp allows the binding to be mounted to any snowboard with a standard mounting disk. The base ramp also provides a half inch of clearance for the heel foam to be inserted below the heel plate. This feature is what gives the baseplate its dampening properties. Using this dense foam, the binding will be able to absorb and dissipate any jarring forces due to inconsistencies in the snow.

The heel plate rests on top of the heel foam and acts as a buffer between the rider's boot and the foam. The heel plate is attached to the rest of the assembly at the rubber hinge point. ¾ inch bolts will rise up from the base ramp, pass through the rubber hinge point, and through the protruding flanges on the heel plate. These bolts will be secured using adjustable nuts thereby connecting the base ramp, heal foam, rubber hinge and heel plate.

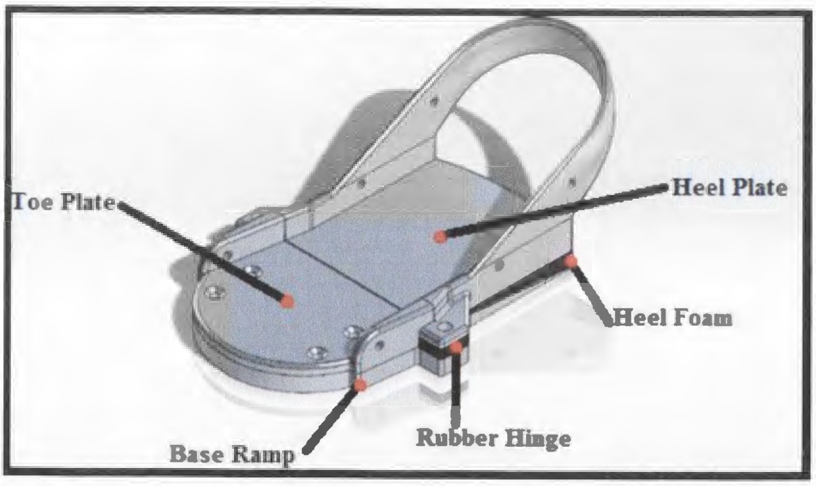



**Figure 6**

The rubber hinge is another critical piece to the puzzle. This feature allows the heel plate and the highback to move down with the compression of the heel foam. The hinge also provides a means for side to side movement as well. As a rider leans forward or backward on the board, the rubber hinge will compress on one side allowing for a higher range of motion in that direction.

Finally the toe plate acts as an upper limit to the forward motion of the heal plate. The wide lips on the vertical surfaces make contact with the heel plate as it travels above the horizontal, stopping the forward motion, while still allowing for the backward movement we desire. The toe plate is attached to the base ramp with four standard screws

**B. Ankle Strap**

The ankle strap is the most unique portion of the design and thus consists of the most unique solution. As you can see in the figure below, the strap will appear to be like any other strap on the outside. However, the integrated technology couldn't be further from the industry standard.

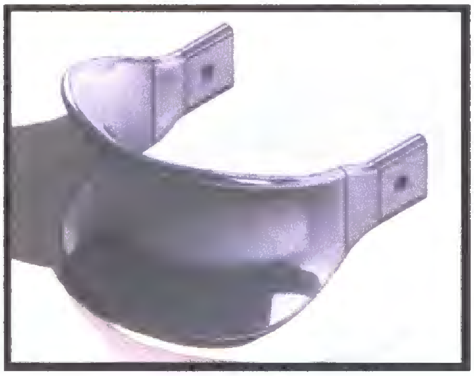


**Figure 7**

Our solution consists of a composite material made out of Kevlar and carbon fiber. The Kevlar is a relatively flexible material while carbon fiber is extremely stiff. Figure 8 depicts a schematic of our current layup schedule.

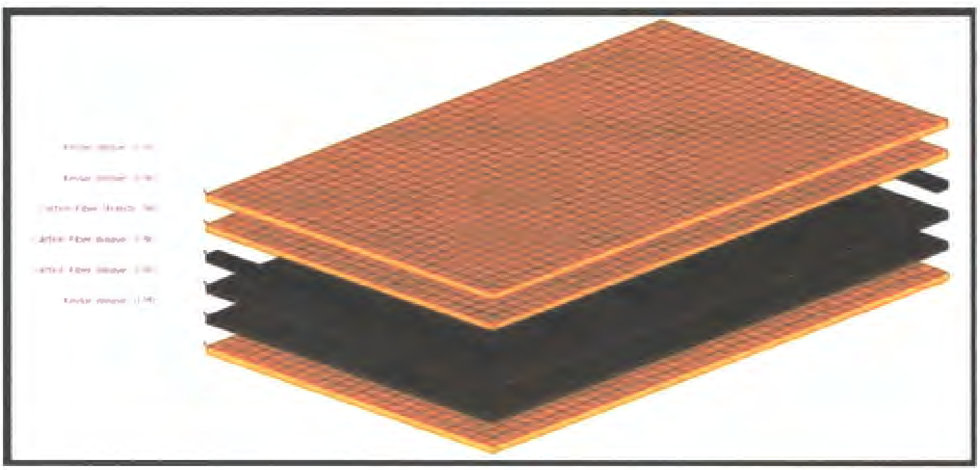


**Figure 8**

The Kevlar weave will provide the gentle response outlined in the design requirements while the carbon fiber strands will limit the dorsiflexion to 20 degrees. The carbon fiber weave sandwiched in the middle will prevent the strap from pinching tendons in the ankle as it rises in dorsiflexion. The entire strap assembly will then be wrapped in a weather resistant fabric and stitched closed with a small amount of padding. The padding will provide comfort for the rider and protection for the composite material. Ladder straps and ratchets will be bolted to plastic pieces that are bonded to the composite with adhesive.

### C. Highback

**Figure 9**

The highback will be machined out of the same material as the baseplate components. This will provide a responsive ride by allowing the rider to instantly apply pressure to the stiff highback. This will force the snowboard to react quickly regardless of the heel side damping. It is important to note that the movement of the heel plate will also allow the high back to move somewhat. This is by design and will add to the damping of heel side shock.

## III. Performance Specifications and Materials

Just as in almost every engineering problem, the answer lies in materials. A poor material will make the design perform poorly. This design is a perfect example. This design requires a light material, but one that is sufficiently strong. It must not become too brittle in cold temperatures, or become too soft and not recover during the summer when the product is in storage.

The high back and the base plate parts are the framework that supports the rest of the subassemblies and therefore must be the foundation of the binding. In the past, aluminum was used for the base plate. However, currently many companies use a variation of Short Glass Filled Nylon Composite. This composite material is popular because the amount of short glass material in the plastic can change the properties substantially. This composite can also be injection molded. This is an important part of our design. The material selected must be able to be machined; then, if the design proceeds to mass production, the material must also be able to be injection molded.

S.G Nylon has the needed properties for the design constraints. S.G Nylon behaves at cold temperatures in a way that is needed. The temperature range that this plastic behaves elastically is between -40 degrees Fahrenheit to 200 degrees Fahrenheit. In order to determine if the material would handle the stresses from the design, the places of highest stress will be evaluated and compared to the material properties. The place of highest stress for the high back and the base plate is at the interface between the two. The size of the bolts that hold the two together is .250". With a force of 431 lbf the stress on the material at this area is 8,800 PSI. The max stress for S.G Nylon is 13,000 PSI. The material has a safety factor of 1.5 against failure. The base plate has the highest stress at the same location. Meaning the base plate has the same safety factor. S.G Nylon meets the temperature requirements, manufacturing processes, and the needed strength.

The dampening foam in the baseplate must again handle cold conditions, ice and water, and be able to have a high life cycle. Extreme temperature silicone foam will handle these demands. This foam has a closed cell design meaning the water absorption is low. The temperature range is -65 degrees to 400 degrees Fahrenheit, satisfying the requirements. In addition, this foam has a high life cycle. Meaning this foam will be able to be compressed many times and not break down and become weak.

The rubber selected for the dampening under the heel is a 50 A durometer extreme temperature silicone rubber. This rubber can easily be switched to a harder or softer rubber if needed. This rubber also has the same temperature ratings as the silicone foam.

The materials used for the ankle strap will be Kevlar and carbon fiber. These materials will be inserted into a fabric material that will protect the carbon fiber and Kevlar from the elements and be more comfortable to the rider.

## IV. Design Justification

We've made every effort to ensure that our design will accomplish our specific goals. Through research, testing and engineering analysis we are confident that our design does just that. The table below outlines each major design parameter and explains how our design meets or exceeds each one.

| Design Requirements | Does Design Meet Requirement? | How Design Meets Requirement | Required Design Changes |
|---|---|---|---|
| **Flexibility** | | | |
| Limit Dorsiflexion | Yes | Composite Strap | None |
| Gradual Ankle Restriction | Yes | Composite Strap | None |
| Lateral Flexibility | Yes | Strap/Baseplate | None |
| **Damping** | | | |
| Heel Damping | Yes | Silicone Foam | None |
| Responsiveness | Yes | Stiff Highback | None |
| **Weight** | | | |
| Weight Limit (1.5X) | Likely | Lightweight Components | Minimize hardware |
| **Materials** | | | |
| Durable | Yes | Industry Standard | None |
| Temperature Range | Yes | -30 to 230 °F | None |

## V. Functional Models

This portion of our design did not require that we create functional models. However, we fully intend to explore this more in the future.

## VI. Bill of Materials

# Bill of Materials

| Item # | Name | Quantity | Description | Material | Process | Cost |
|---|---|---|---|---|---|---|
| 1 | Base Ramp | 1 | Board Attachment & Ramp | 30% S.G. Nylon | Machined | 2.00 per cu. in |
| 2 | Heel Foam | 1 | Dampening Foam | Extreme Temp. Silicone Foam | Purchased Cut | 0.79 per cu. In |
| 3 | Toe Plate | 1 | Base Attachment | 30% S.G. Nylon | Machined | 2.00 per cu. in |
| 4 | Heel Plate | 1 | Heel cup area | 30% S.G. Nylon | Machined | 2.00 per cu. in |
| 5 | Highback | 1 | Rigid for responsiveness | 30% S.G. Nylon | Machined | 2.00 per cu. in |
| 6 | Ankle Strap | 1 | Limit dorsiflexion | Kevlar/Carbon Fiber | Lay-up | 12.00 each |
| 7 | Rubber Hinge | 2 | Rubber material for movement | Extreme Temp. Silicone | Purchased Cut | 1.40 per cu.in |
| 8 | Canvas Cover | 1 | Sewn over composite ankle strap | Canvas | Purchased Sewn | 14.99 per yd. |
| 9 | Ankle Strap Extenders | 2 | Extend composite for assembly | Stiff Plastic | Purchased Cut | 3.33 each |
| 10 | Nutserts | 2 | Used for strap assembly | 316 SS | Purchased | 1.32 each |
| 11 | Ladders | 2 | lock down binding | Plastic | Purchased | 3.33 each |
| 12 | Screws | 14 | Throughout assembly | 316 SS | Purchased | 0.74 each |
| 13 | Nuts | 12 | Throughout Assembly | 316 SS | Purchase | 0.74 each |
| 14 | Toe Strap | 1 | Hold toe side down | Various | Purchased | 3.33 each |
| 15 | Ratchets | 2 | Ratchet ladders | Various | Purchase | 3.33 each |

**Appendix A: Project Schedule**

All of the major tasks on the team schedule are being completed on time. Our team decided to break our schedule up into four stages. Stage 1 included all proposal steps to finalize the design proposal based on customer requirements. Stage 2 walked through the initial concept design and all associated reviews with our concepts. Stage 3 was a period spent in preparation for the preliminary design review. Stage 4 was everything leading up to critical design review, and all end of semester submission requirements such as this report and the drawing package. All tasks have been completed on time without any major issues remaining. Our team is ready to move on to production. Table 1 shows the team schedule and important milestones.

| Binding Innovation Technologies 2014 Schedule | | |
|---|---|---|
| **Description** | **Due Date** | **Status** |
| Stage 1 | | |
| Rough Draft Design Proposal | September 9 2014 | Complete |
| Design Proposal | September 16 2014 | Complete |
| Stage 2 | | |
| Conceptual Design Review Presentation | September 23 2014 | Complete |
| Problem Definition | September 23 2014 | Complete |
| Conceptual Design | September 25 2014 | Complete |
| Stage 3 | | |
| Preliminary Design Review Presentation | October 28 2014 | Complete |
| Preliminary Design | October 30 2014 | Complete |
| Stage 4 | | |
| Critical Design Review Presentation | December 2 2014 | Complete |
| Design Report | December 9 2014 | Complete |
| Drawing Package | December 9 2014 | Complete |

**Table 1**

**Appendix B: Analysis and Calculations**

In order to fully understand our design solution, we used a failure modes and effects analysis (FMEA). The FMEA is a deep dive analysis into the design in order to recognize high risk failure potential. This tool allowed our team to allocate our limited resources to the most important areas in the design, and to improve our design so that we can assure the safety of the end user. There were a couple of areas within the design that the FMEA found to be concerns. The rubber hinge design has a number of potential failure modes, but due to high detectability the risk is not extremely high. Also, the straps pulling out could be a potential failure mode but it would be better if the binding failed here than in other locations because the parts could be easily replaced. For more details, please see the completed FMEA below.

| Item | Function | Failure Modes | Potential Cuases | LOC | Local Effect | End Effect | Risks | D | Severity | RPN | Improvement & Test Plan |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Front 4 Screws** | Connection to Base | Shear | Impact | 1 | Assembly will come apart | Fall and binding will not function | Falling could cause severe injury to the rider | 2 | 8 | 16 | No needed improvement at this point, The only potential improvement area would be design for manufacture and |
| | | Pull out of threading | Rotation | 1 | Assembly will come apart | Fall and binding will not function | Falling could cause severe injury to the rider | 2 | 8 | 16 | |
| **Heel Cup** | Heel Support and Rotation Prevention | Fracture Break | Tension, Rotation, Fatigue | 2 | The boot will no longer be secured in the binding | Rider could fall | Falling will cause injury | 1 | 8 | 16 | This failure is highly unlikely if materials are selected properly. It will be necessary to test the selected materials based on the potential failure modes. |
| | Connection to highback | Tear out of the bolt hole | Impact, Fatigue, Static Load | 2 | The Main strap will no longer be connceted to the base | Rider will be unstable | Instability will cause issues when riding that could lead to potential injury | 1 | 6 | 12 | |
| **Mounting Disk** | Mate binding to snowboard | Fracture, Crack | Impact, Fatigue | 1 | Attachment to the binding will be weakened | Binding could come off of snowboard if the break is | Rider could fall causing injury | 6 | 6 | 36 | The mounting disk is not seen so detectibility will be low. The likelyhood of the effects occuring |
| | | Smoothed or worn teeth | Fatigue | 1 | Will not attach to baseplate | need to replace mounting | Will not be able to ride | 2 | 3 | 6 | |
| **Interference stop between binding plastics** | Maintain the foam in compression and not allow vertical translation | Crack or fracture | Impact | 2 | Materials will be compromise | The binding will not function properly | The Binding will no longer function properly and could potentially cause falls | 1 | 5 | 10 | Interference stopping is not ideal we should test the materials to verify the accuracy of the calculations |
| | | Mushroom | Fatigue, Over loading | 2 | Materials will be compromise | The ride will not be smooth | No major risk to the user | 1 | 3 | 6 | |
| **Foam** | Provide Heel side dampening | Rip or Tear during replacement | Buttons could be difficult to get out | 4 | The foam will not function | The foam will need to be replaced | If the foam fell out a heel side turn would be difficult | 2 | 4 | 32 | This failure mode will likely occur when the rider is not riding it would likely occur due to neglegence while replacing the foam. It is also unlikely that the foam will permenantly deform. |
| | | Permenantly Deform | Large load over extended period of time | 2 | The dampening will not function properly | The foam will need to be replaced | The failure mode will not cause major risk to rider just an uncomfortable ride | 2 | 2 | 8 | |
| **Grommet Block** | Provide a responsive heel side turn | Bend or Shear Bolts | Cycling, Fatigue, and impact | 5 | The responsive ride will be compromised | The bolts will need to be replaced. | The only thing preventing over travel on the heel side is the foam this could be a risk. | 2 | 4 | 40 | the rider will need to have replacement bolts or graumett on the slopes in the event that this failure mode occurs. The binding will be virtually unrideable if there is any failure in this component until parts are replaced. In the event of fractured plastics above or below the graumett the binding will be |
| | | Break plastic above and below rubber | Dynamic Loading | 4 | The plastic will not hold the assembly in place | The responsive ride will not function | The risk would be in an unfamiliar ride. | 1 | 4 | 16 | |
| | | Tearing Rubber | Dynamic Loading | 3 | The assembly will not function properly | The responsiveness will be compromised. | The risk would be in an unfamiliar ride. The entire graumett will not entirely tear. | 1 | 3 | 9 | |
| **Strap Holes** | Hold the ankle and toe strap to the base of the binding | Bolt tear out | Dynamic loading | 1 | Binding strap will not attach | the binding will not be usable | Could cause injury to rider but the failure mode is highly unlikely | 1 | 6 | | This failure mode is highly unlikely the plastic on the strap will fail first. |
| **Highback Holes** | Hold the highback in place | Bolt tear out | Fatigue, Dynamic Loading | 2 | The highback will come off | The highback will not attach to the baseplate | Could cause injury if occurs during ride | 1 | 6 | | This failure mode is unlikely the bolt will shear before this failure |

**High Back**

| Item | Function | Failure Modes | Potential Cuases | LOC | Local Effect | End Effect | Risks | D | Severity | RPN | Improvement & Test Plan |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **High Back** | Holds the Riders Boot in place | Crack, overextend | Excessive Force, Twisting force | 2 | Rider will loose balance | Boot will become loose from binding | Rider could fall and obtain injury | 1 | 6 | 12 | Ensure that the high back has enough flexibility while still |
| **High Back Adjustable Bolt,** | Lets rider choose desired angle of High Back | Stripped threads, cracking | Excessive Tension force, excessive wear | 1 | High back will loose angled position | Could cause rider to loose balance | Rider could fall and obtain injury | 1 | 5 | 5 | This is an area of the binding that has a low likelyhood of failure. |

**Straps and Tounge**

| Item | Function | Failure Modes | Potential Cuases | LOC | Local Effect | End Effect | Risks | D | Severity | RPN | Improvement & Test Plan |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Toe and Ankle Ladder Straps** | Secures the riders boot to the board at toe | Shear, pull out | Tension force, twisting force | 2 | Boot will leave binding | Rider will fall and binding will no longer function | Could cause injury to rider | 1 | 7 | 14 | Could make the straps out of a stronger material, likelyhood of occurance is small |
| | Secures the riders boot to | Shear, pull out | tension force, twisting force | 2 | Boot will leave binding | Rider will fall and binding | Could cause injury to rider | 1 | 7 | 14 | |
| **Toe and Ankle Ratchet Buckle** | Tightens connection of boot with board at toe | cracking, excessive wear | Compressive force, over tightening | 3 | Strap will no longer be tight against boot at toe side | As long as both ratchets don't fail simultaneously, | Rider could loose balance and sustain an injury | 1 | 4 | 12 | Ensure that our ratchets are made of strong materials |
| | Tightens connection of boot with board at heel | cracking, excessive wear | Compressive force, over tightening | 3 | Strap will no longer be tight against boot at toe side | As long as both ratchets don't fail simultaneously, | Rider could loose balance and sustain an injury | 1 | 4 | 12 | |
| **Padded Toe and Ankle Strap** | Gives comfort to the rider | Tear padding, worn | Excessive wear, tear force | 6 | Rider will feel strap more | No Major affect | Uncomfortable strap | 1 | 1 | 6 | Have a padding that can last longer, and that has a long |
| | Gives comfort to the rider | Tear padding, worn | Excessive wear, tear force | 6 | Rider will feel strap more | No Major affect | Uncomfortable strap | 1 | 1 | 6 | |
| **Anke and Toe Strap Bolts** | Connect toe and heel | Shear, threads stripped | Excessive wear, shear force | 2 | Strap will become loose | der could loose balance and f | Could cause injury to rider | 1 | 5 | 10 | Ensure screws have enough strenght to withstand forces |

In order to find out the maximum stresses that the binding must withstand we looked at the conditions for which these might happen. The most likely cause of force in the binding is an impact load due to jumping or falling. We specifically ran the numbers for four different cases. In the first case a snowboarder simply jumps off of a ledge onto flat ground with no initial velocity as in figure 10a. The second case is similar to the first except the landing surface is now on an incline as shown in figure10b. The third case is most practical and consists of a rider jumping from a ledge with an initial velocity and landing on an incline (Figure10c). The final case is slightly different, in that, this case takes into account catching an edge while carving.

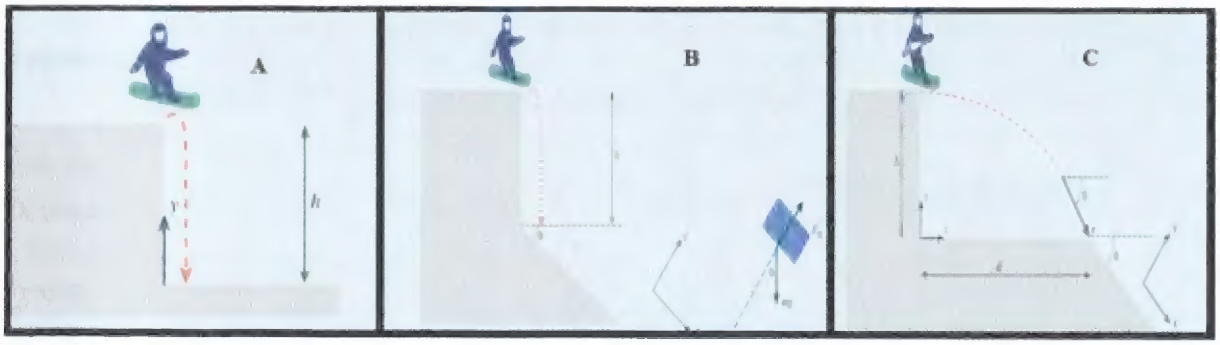



**Figure 10a** **Figure 10b** **Figure 10c**

**Case 1:** Jumping directly from a height H=3m on the flat surface.

The force applied on the base plate is Fn = M * g * (1+h/b) = 10300 N , where b is the distance from the bent knees. It is easy to see that the maximum force will be experienced when the landing platform is flat. For the following two cases, the landing has some measurable slope θ. Therefore the normal forces on the baseplate will be less than 10300 N.

**Case 2:** Jumping directly on a slope.

The normal force applied on the base plate is Fn = m * g * (1+h/b) * cosθ, where θ is the angle of the slope.

**Case 3:** Jumping with an initial velocity on a slope.

F = m*g*cosθ*[(d^2/2h+2h)*sin^(arctan(2h/d)- θ]/(2b*cos^2(θ))+1]

**Case 4:** Catching an edge.

This portion of the calculation is slightly more involved. The average speed of a snowboarder is 7.8 m/s. Assuming the rider catches the edge at this speed, and the time of catching the edge is around 0.5 sec (according to the principle of forces and momentum), and assuming that the total maximum mass of the snowboard bindings, boots and legs are 38kg, the average force applied on the binding is F = mv/t = (38kg*7.8 m/s)/0.5s = 592N. The force on one binding is 592 N / 2 = 296 N.

The distance from the strap holes to the interference contact surface is 0.06m, the moment applied on the contact surface is 296N * 0.06m = 17.8 N*m,

The contact surface area is 0.00027m^2, the height of the contact surface is 0.03m, the force applied on the surface is 17.8 N*m/0.03 m = 197Kpa.

The thickness of the shell is 0.01m, the contact surface of the hole is 0.0001m^2, the stress on the two holes are 296N/ (2*0.0001m^2)=1.98Mpa.

**Appendix C: Team Structure and Responsibilities**

Overall the team has been managed extremely well. Initially there were some struggles with completing tasks on time but some adjustments in communication and methods of task management have improved the struggles considerably. Our team has been lucky enough to have a very involved customer who has helped us with program management skills and tools. This section of the design report will detail scheduling, task assignment, budget, and preparations for spring 2015 semester.

Our team used a couple of tools to assure all of our tasks were formally assigned, and that they aligned with our overall goal detailed in the work break down structure. First and foremost our team used a great work break down structure to initially detail the work needed to be completed in order to deliver the final prototype. Branching from the work break down structure, our team prepared an overall high level Gantt chart to assure that we were reaching high level priorities and milestones. Last of all we used a system called a sprint and scum method to assign and complete all baseline tasks. The sprint and scrum method is connected to the work break down structure through our WBS code. The sprint and scrum method was a two week period when tasks were specifically assigned to team members in which they have two weeks to complete each task. The sprint and scrum method has been successful during fall semester and we will proceed with using this method during the spring. The first sprint schedule will be held on January 6, 2015. Please see the appendix of this report for a sample of the work break down structure, Gantt chart, and sprint and scrum method. Specific team roles and responsibilities can be found below.

**Tyler Lewis, Program Manager:**

Report Responsibilities

- Abstract
- Final Design
- Design Justification
- Team Structure and Responsibilities
- Labor Distribution

**Ryan Willis, Assistant to the Program Manager:**

Report Responsibilities

- Bill of Materials
- Project Schedule
- Analysis/Calculations
- Team Structure and Responsibilities

**Chris Tryon, Systems Engineer:**

Report Responsibilities

- Bill of Materials
- Performance specifications and materials

**Colten Roberts, Customer Relations:**

Report Responsibilities

- Background
- Problem Statement
- Design Requirements

**Matt Munsee, Purchasing Agent:**

Report Responsibilities

- Design Drawings
- Drawing Package
- Proof reading

**Michael Terry, Composite Expert:**

Report Responsibilities

- Final Design
- Bill of Materials

**Longze Li, Analysis Engineer:**

Report Responsibilities

- Analysis/Calculations
- Title Page

**Appendix D: Labor Distribution**

Throughout the semester our entire team worked extremely hard to ensure that we came up with the best design solution possible. Every team member pulled their weight and was always willing to help out other members. The table below shows a rough breakdown of approximately how many hours each member spent on the project per week.

| Team Member | Approximate Hours per Week |
|---|---|
| Tyler Lewis | 6-8 |
| Ryan Willis | 5-10 |
| Chris Tryon | 4-6 |
| Colten Roberts | 5-10 |
| Matt Munsee | 4-6 |
| Michael Terry | 4-6 |
| Longze Li | 4-6 |

**Binding Innovation Technologies**

**Matthew Munsee**

**Capstone II Report**

**Spring 2015**

**Document Title:** MS-10: Prototype Test Results and Evaluation

**Team:** Binding Innovation Technologies

**Date:** April 30, 2015

**Course:** MAE 4810

**Team Members:** Tyler Lewis, Ryan Willis, Chris Tryon, Colten Roberts, Matt Munsee, Mike Terry, and Longze Li.

## I. Test Objective

The objective for our binding design and overall concept has been the following since the beginning of this project: Develop a snowboard binding that reduces heel-side chatter and allows for dynamic heel-side turns while supporting dorsiflexion motion (0-20 Degree). The binding design must be compatible with the standard mounting base plate and should have standard ankle/toe straps, the design must be safe, stylish, and rugged.

Our design is aimed towards two main purposes, one with the ankle of the rider not breaking due to dorsiflexion and reducing the heel side chatter of the rider while heel-side turns are made. We have developed a system for solving both of these problems and will be testing both concepts to see if it has reached our needs and accomplished the goals of the customer.

### A. Heel Side Damping

One major feature of our design is supposed to reduce heel side chatter. This feature consists of a wedge of foam that is inserted under the heel of the rider. This foam will absorb the shock from any abnormalities that are found in the snow. We have two plans to test this concept. The first deals with the actual feel and feedback from riders, while the second will consist of visual conformation from a mounted camera.

### B. Ankle Dorsiflexion

Our design is also required to safely limit the amount of dorsiflexion that a rider and experience while making a toe side turn. Again the test will focus on feel and rider feedback as well as visual inspection from the test footage.

## II. Test Setup

## A. Heel Side Damping

### 1. Test 1:

We will go to beaver mountain ski resort April 9th with our prototype binding along with a survey (See attached) and a release form for security purposes. We will then ask experienced snowboarders to ride both our binding and control pair on an identical snowboard. The riders will then be asked to fill out a survey and give us honest feedback. The goal from this test is to see if the feel of the foam is noticeable to the rider and if it actually does comfort the heel-side turns while not compromising any other aspect or feel of the snowboard experience. The goal will be to have 10 different riders test our binding concept and compare it to the one they are currently using.

### 2. Test 2:

The second test will be to take a GoPro camera and mount it to the front of the snowboard. We will then make several runs with standard bindings and our prototype. This will be done on the same board with the same rider to reduce the amount of variables. The rider will do his best to go the same speed and make the same turns. We will then gather the footage from all the rides and compare them to the one with our prototype. The goal of this experiment is to see if there is a visual noticeability in the function of the heel foam to dampen the heel-side chatter.

Both of these tests will take place in on the mountain to get real time feedback and to see what modifications and adjustments need to be made. We anticipate the worst and hope for the best from the surveys that will be taken and understand the importance of getting a wide range of riders, young, old, male, and female to give us a better understanding as to what market this product will most likely should be aimed towards.

If we feel like the results of our test are too biased, we will conduct the surveys again but this time by placing black plastic bags over the riders boots and bindings to ensure that they don't know whether they are riding on our prototype or a normal binding.

## B. Dorsiflexion

For the testing of our composite ankle strap, we will be taking both a feel approach and also an experimental science approach to ensure that we meet our design criteria.

### 1. Test 1:

This test will be very similar to the above test 1 for the binding regarding heel-side chatter, and will be conducted at Beaver Mountain Ski Resort. We will have a variety of different riders use our binding in a run down the mountain and then have them take a survey to get their feedback. For this portion we will be focusing more on whether or not the strap limited their mobility of their ankle. We want the ankle strap to protect the rider and give them a safer ride, while not reducing the amount of flexibility that they currently are able to experience.

## III. Data Collected

The first visit to Beaver Mountain was successful. Two of our team members were able to ride the binding and take video of the binding in action, and we were able to find a couple of problems with our binding and make appropriate actions to fix them.

### A. Heel Side Dampening

One of the flaws with the baseplate portion of the binding that we noticed from our first test runs was the weight of the baseplate. This won't be an issue when the customer takes it to production, due to the fact that it will be made out of a much lighter plastic, but does make it a little difficult when trying to compare it directly to other bindings.

We took the baseplate ramps to a machine shop and were able to reduce the weight of each piece by 20%. The second go around on the mountain was a huge success. We had three different types of bindings: a similar burton model, an older aluminum model with no cushion, and our prototype. Colten rode the aluminum binding for most of the morning before trying out the prototype that we had created. The first thing he noticed was the amount of dampening that was in the heel side. He said beforehand he was skeptical and didn't think that it would be as noticeable, but after riding the binding was impressed with the design and how much more comfortable it made the ride.

We didn't make any changes other than reducing the weight of the baseplate because we were satisfied with the results we were seeing.

The GoPro that we attached to the binding got us some great video of it in action and you are able to really see how much the dampening plays into the actual ride that occurs. We would have gotten more video, but after the first run a skier lost control and broke the outer casing of the camera, making it impossible to mount to the board in any way.

### B. Dorsiflexion

The first issue with the composite strap became apparent early on. The geometry used to reduce the dorsiflexion motion was too weak. Both straps cracked in a "U" formation where the stresses were concentrated but, on a positive note, neither strap was a full failure. The straps used in testing can be found in the figure below. It is clear that we needed to increase the strength of the straps. This was accomplished by adding another layer of carbon fiber, along with a few thicker layers of Kevlar to each piece.


**Figure 1:** Original composite straps after testing.

Once we added more layers to the strap we again ventured to the slopes for testing. Our customer Sean was able to accompany us on this trip so we could get his feedback on the progress that we had made. These straps were much stronger and didn't break from hard riding all day. Actually they were too stiff. Sean wanted them to have a little bit more give, while still providing a high level of safety to the ankle. He was however, able to ride the bindings with his boots extremely loose. This was a very positive aspect of the ride because it was one of our design goals from the beginning.

Our next move to get the strap how we want it was to remove one of the layers of carbon fiber, and a couple layers of the Kevlar. This still allows for more strength than our first strap (which cracked), while giving more flexibility and comfort to the riding experience. We anticipate that more give will be allowed once fabric and cushion are added to the outside.

## IV. Data Analysis

### A. Rider Surveys:

The original plan was to have several different riders use the bindings and then take a survey to be able to quantify results such as feel and style. Unfortunately, we ran out of time and snow. We did get some surveys, but they were our own team members. We did have one survey though that is more valuable than all the others combined, and that is of our customer Sean. He loved the feel and overall design of what we had created. Sean offered some input regarding some minor design changes but as far as the overall operation, he loved it. The following is what our team members who rode the binding had to say about it.

**Colten Roberts:**

"After riding my old aluminum bindings with no give in the heel side, I was blown away by the amount of dampening I had on the heel side! Sometimes after a long day of riding my shins can hurt because of the strain I feel through my heel. I have a strong feeling that if I were to use this binding all day I wouldn't be as sore as previously with older models."

"This binding is also not for everyone. If you are one who wants to hit the terrain park up all day, I wouldn't recommend it. If you like carving and staying on the more packed snow, it is definitely for you."

**Tyler Lewis:**

The first test run of the prototype bindings went extremely well. The testability of some of the designed functions were limited due to the snow conditions, however, valuable information was still gained from the experience. It was shown that each of the design concepts worked as expected and only required minor modification in order to optimize the operation.

**Heel Side Damping**

**Test 1:** As mentioned earlier, the base plate was limited in its function due to the fresh snow. It was still possible to feel the dampening offered by the heel foam and rubber joint however it was unclear how much was actually due to the binding and how much was due to snow compression. In my opinion the baseplate had a great mixture of flexibility and responsiveness. The rubber joint allowed the foot to absorb a lot of the inconsistencies in the terrain while still offering the stiffness required to make quick, sharp turns in the snow.

**Test 2:** During this test the differences between bindings became remarkably obvious. For example after riding the flexible Burton bindings the prototype felt much more secure and safe without over constraining any lateral movement. An even bigger difference could be seen after riding the rigid pair of bindings. While on the rigid bindings every bump and crevice was jarring to the legs and the straps felt uncomfortable on the feet; but with the prototype these jarring motions were greatly reduced and the damping was exceedingly easy to detect.

**Composite Strap/Dorsiflexion**

**Test 1:** The functionality of the ankle strap was the biggest unknown prior to testing. The strap was designed to be as light as possible in order to show areas of high stress or critical failure. As expected the strap failed, however, this did not render the strap useless. Even though the straps cracked, they continued to operate in an acceptable fashion. As for the feel of the straps, they were phenomenal. The straps offered a high level of support without restricting the rider's movement. While riding, it was actually possible to feel the straps flex with the boots until the maximum angle was achieved at which point they became rigid.

**Test 2:** For this round of testing the ankle strap was built up with multiple layers of thicker Kevlar. This caused the strap to lose most of it flexibility to the point that it was virtually immobile compared to the first set of straps. This stiffness still contributed to keeping the ankle from overextending but it offered another, unforeseen, benefit. The rider could now count on the straps to support the weight of body rather than depending on the leg muscles for extended periods of time. This new feature could become a life saver towards the end of the day when the leg muscles are near exhaustion. The ideal solution would be somewhere between the first and second set of straps. This option would offer the flexibility and protection required of the design without the risk of breaking or failing and the added benefit of leg support.

**Ryan Willis:**

**Feel**

The binding had a unique feel that initially I wasn't used to. It took me a little while to adjust to the amount of heel side translation the binding provided. The binding felt really good while riding. It was a touch heavy while going up the lift that would tire a rider if ridden all day long. The binding did provide more freedom for a unique type of ride.

**Durability**

The main portion of the binding was extremely durable. Being made of aluminum the binding could be ridden without worrying about a failure in the main portion of the binding. During my ride the composite strap did break and was addressed on a redesign.

**Requirements**

The snowboard binding met most of the design requirements on my day on the slopes. The heel side dampening was apparent and worked exceptionally well. The only thing that needed to be addressed during my day on the slope was the broken strap. The strap has since been updated and works as planned.

**Overall Opinion**

Personally my riding style is different than what this binding provides. I like a more rigid binding for jumps, and rails. But using the more rigid binding I did feel that my legs tired faster than they did while riding the new design. The strap helps transfer load from your legs, and the heel side dampening helps take load from the riders legs. Overall I think the binding performed well.

**Sean Waddel:**

The binding test day at Beaver Mtn was extremely valuable. This was my opportunity to evaluate the prototype under real usage conditions. Here is my feedback listed in no particular order:

**Snow Conditions**

This late in the season, the snow was fairly slushy making it a little more difficult to assess the binding effectiveness. However, I do not consider this a significant detractor because the 'feel' for the binding was still evident in these conditions.

**Identical Snowboards**

Using two identical snowboards, one with the Burton Genesis and one with our prototype was critical to the results. The snowboards being identical allowed us to concentrate on the feel of the binding as the biggest variable. I had not thought about this previously but noticed this was an important factor in the test effectiveness.

**Heel Side Damping**

I did not have a sense of how dramatic or minimal the ramp would feel in actual riding conditions. I was surprised at how much I could feel the dampening even in soft snow conditions. To emphasize it even more, my right heel has had plantar fasciitis. Though this isn't the intent of the design, it had the effect of padding my heel enough to avoid discomfort even in the arc of turns where the most pressure is exerted. Knowing how this will reduce heel side chatter is inconclusive due to the snow conditions preventing a hard packed heel side turn. However, the indications are very positive. I believe another benefit will be reduced rider fatigue. When I switched to the Burton Genesis binding, my heel pain was significantly more noticeable. Neither the dampening in the binding baseplate nor the high back sling provided noticeable value. It surprised me because this is a high-end binding produced by the top equipment manufacturer in the sport.

**Composite Strap/Dorsiflexion**

I used the much stiffer version of the tongue in this test. This tongue definitely provided the support required to allow me to hold hard toe side turns with no concern about my ankles over dorsi-flexing. Another benefit that was similar to the heel ramp was the reduced fatigue. Riders often sustain calf fatigue when traversing longer distances on their toe side edge. This tongue provided a very similar experience to riding in a hard boot without requiring a hard boot. The tongue was, in fact, too stiff. It prevented me from bending my ankles into an aggressive riding position and felt too much like hard boots. I hope that the ideal epoxy layering and some refinement of the angle will address this. Ideally, the tongue will also have a slight cushioning effect when progressive pressure is applied. When I switched to the Burton Genesis, I experienced the typical free range of ankle dorsiflexion (good) as well as the weak ankle support (bad) and calf fatigue (bad)

All-in-all, I was very pleased with the results and the promise they hold. And, I hope to continue refining the binding mechanics.

## B. Computer Analysis:

We wanted to test the overall strength of the strap, but decided that using composite material properties along with a computer program, we would be able to better understand the stresses and strains the binding experiences, due to its unique shape. With the help of Dr. Fronk we were able to run the program and determine the following failure information.

| Lamina | Location | Failure_1 | Failure_2 | Failure_12 | Tsai_Wu |
|---|---|---|---|---|---|
| 1 | 'Top' | -17.177 | -18.633 | 23.397 | 269.63 |
| 1 | 'Bottom' | -13.391 | -15.031 | 24.367 | 175.11 |
| 2 | 'Top' | -23.363 | -11.494 | -24.367 | 279.13 |
| 2 | 'Bottom' | -17.933 | -6.5223 | -20.337 | 166.63 |
| 3 | 'Top' | -9.7143 | -11.459 | 20.337 | 111.78 |
| 3 | 'Bottom' | -2.9133 | -4.8734 | 13.413 | 17.484 |
| 4 | 'Top' | -6.1729 | -3.0493 | -13.413 | 35.134 |
| 4 | 'Bottom' | 1.68913 | 1.96967 | -5.989 | 1.1138 |
| 5 | 'Top' | -10.757 | 2.7565 | 1.44877 | 64.979 |
| 5 | 'Bottom' | 5.4264 | 2.7723 | -1.2373 | 54.54 |
| 6 | 'Top' | 2.9798 | 3.6384 | 1.2373 | 47.36 |
| 6 | 'Bottom' | -0.55 | 6.5134 | 1.92337 | 165.5 |
| 7 | 'Top' | 14.557 | 2.7591 | -1.92337 | 551.43 |
| 7 | 'Bottom' | 20.022 | 2.795 | -1.2959 | 1151.1 |
| 8 | 'Top' | -5.2135 | 11.112 | 1.2959 | 315.45 |
| 8 | 'Bottom' | -9.8371 | 13.71 | 1.6652 | 492.47 |

**Table 1:** Tsai Wu Failure Criteria

According to the criteria presented in the program, a value of 1 or more indicates that a failure will occur while a value less than one shows that no failure is expected. According to the results shown above we should have seen multiple points of failure in the strap we tested, however, the strap remained rigid and unbroken. This is due to the simplifying assumptions made for the sake of analysis. In reality the geometry of our strap is far beyond the capabilities of anything that we have encountered as undergraduates. The results in the table above are simply a reference for where we might expect possible failures.

# V. Conclusions and Results

The testing that we were able to perform was sufficient to prove that we produced a valid solution for the design problem. It would have been nice to get a larger selection of riders opinions and feelings on the design to better gauge the public opinion. We also could have ridden the biding more but had a lot of unforeseeable hiccups that put us behind schedule. That being said, I have faith that our testing does prove our results and the design of the product. Our team members and customer were absolutely thrilled with the final product, both in operation and appearance.

**Document Title:** MS-12 As Built Drawing Package

**Team:** Binding Innovation Technologies

**Date:** April 30, 2015

**Course:** MAE 4810

**Team Members:** Tyler Lewis, Ryan Willis Chris Tryon, Colton Roberts, Matt Munsee, Mike Terry, and Longze Li

# I. Letter of Transmittal

Dear Sean Waddel,

On behalf of Binding Innovation Technologies (BIT) I present to you the final drawing package and documentation for the design of your prototype binding assembly. This document contains detailed technical drawings of all components associated with the design as well as a bill of materials and user instructions on the use and operation of the product.

Sincerely,

Tyler Lewis

Program Manager

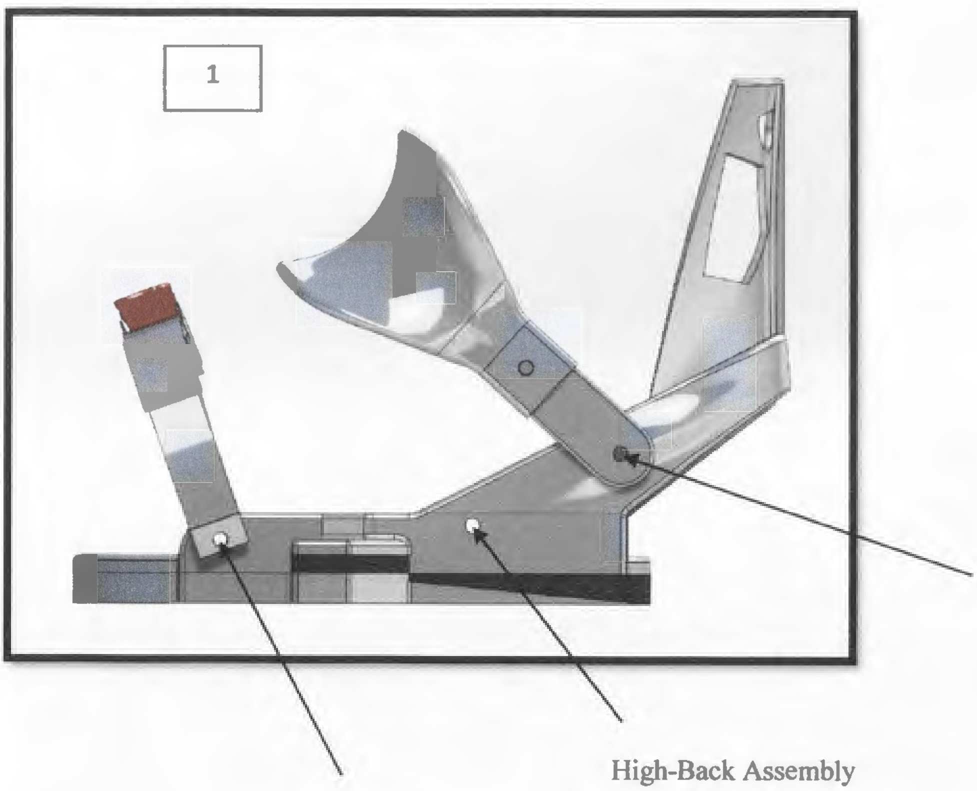
Binding Innovation Technologies

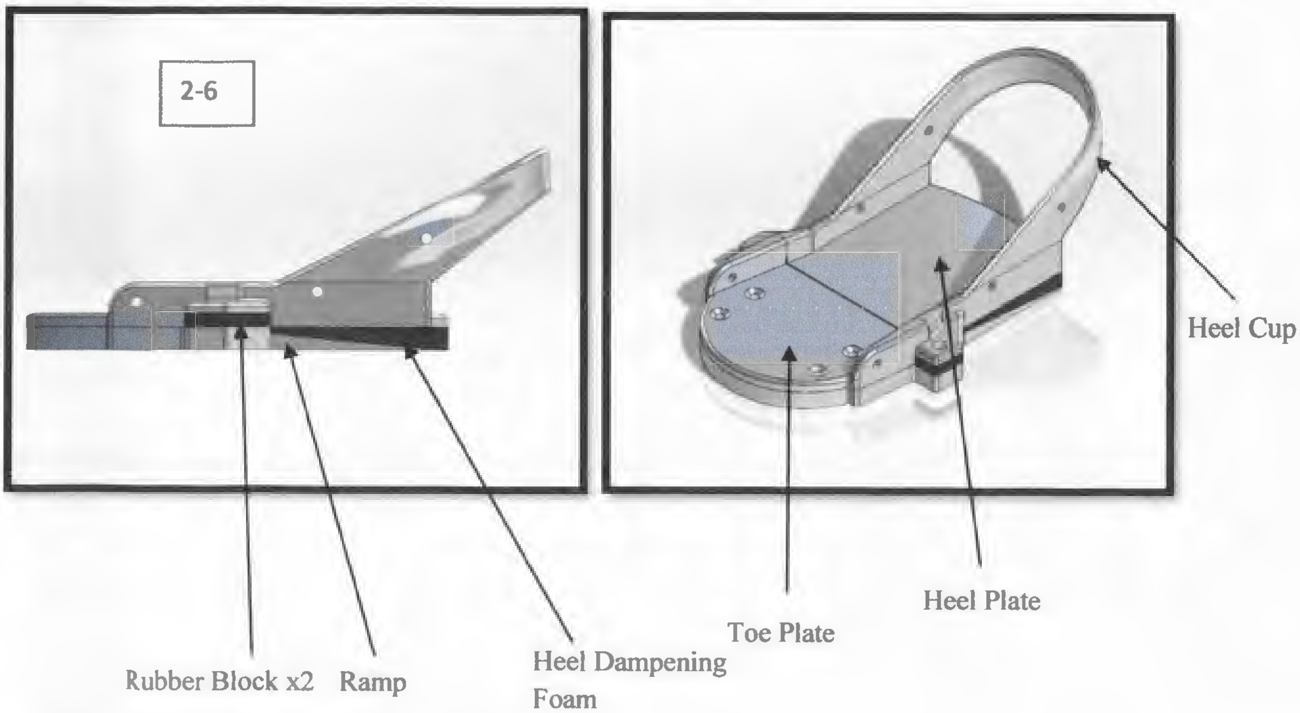
## II. User instructions

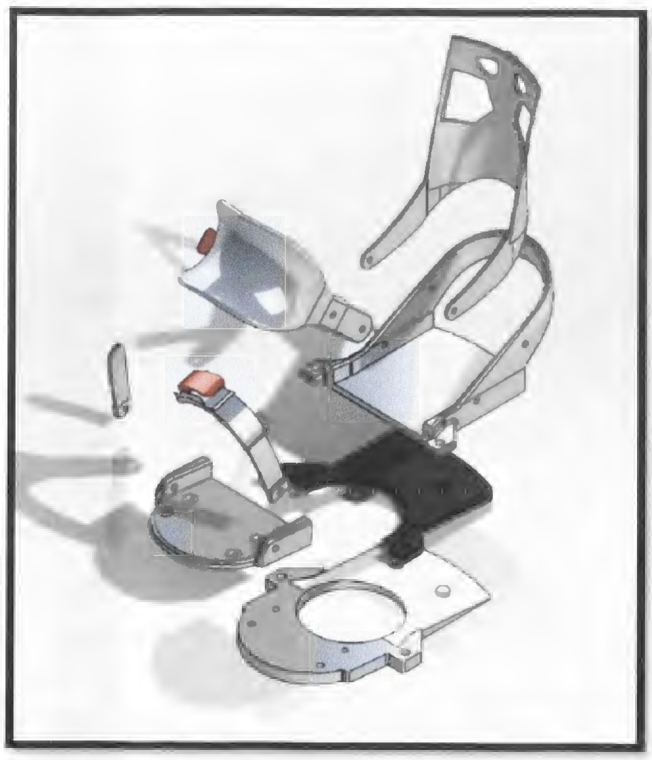
**Assembly**

The binding should typically come to the end user fully assembled, but in the situation where the binding must be disassembled to fix or otherwise follow the following assembly steps. All steps have corresponding figures.

1. Assure that the high-back and straps are attached to the heel cup and toe plate. According to the following diagram.
2. Place heel dampening foam on ramp.
3. Assemble to toe plate to the front portion of the ramp base.
4. Place stainless steel bolts through the countersunk holes on the ramp base, slide rubber blocks over stainless steel bolts.
5. Place heel plate over heel dampening foam with the corresponding holes over the stainless steel bolts.
6. Connect locking nuts to stainless steel bolts.





Exploded View

### Board Attachment

The board will be attached using a standard snowboard attachment plate that will be inserted in the ramped base plate. All hardware is provided for attachment.

### User Instructions

Once the binding is assembled and installed using the snowboard binding is simply a matter of placing the heel of your boot in the heel cup resting against the high-back, and ratcheting the traps to the ladders. See above image for strap and ladder location. To ratchet insert the ladder into the buckle. Grab the buckle flange and ratchet until tight.

## III. Production Recommendations

For mass production of this design, injection molding seems to be the best possible solution. Even though injection molding can be costly initially, the longevity of the molds, and the cost reduction per pert allows for high production quantities and reasonable payback period.

Injection molding is much more than simply melting plastic and pouring the melted plastic into a mold. The process entails a complex system of temperature pressure and liquid flow design. There are various design considerations that need to be accounted for in practical part design. The reason the team did not take these considerations into account for the prototype was mostly to reduce cost, machining time and for fabrication methods that the team was limited to for the prototype build. In addition, because of the complexity of making specific changes to the part, and the teams inexperience in regards to the specifics of the molding process the team can not make the exact changes to the parts, only mention that these things need to be considered and why.

One major injection molding design change is called draft. A properly designed part for injection molding has draft, which is defined as taper applied to faces on the part to ensure ease of ejection from the mold and to prevent damage as the part releases from the mold. Because the team used an already built binding, no draft analysis was performed.

Secondly, where there is excess material in specific regions of an injection molded part, the material can start to cool at different rates which causes what is called sink. Sink can manifest in inconsistencies in the surface appearance of the part. Also, there can be small voids in the parts as well creating weak points and potential points of failures.

Complex parts require what is called as a slide action additions to the molds. These slide actions are built into the mold that slide into place when the mold closes to make complex geometry on the sides or other regions on the part. And when the mold opens, these features slide out of the way of the ejecting part. These slides greatly increase the cost of the mold.

So for each of the parts that will be injection molded a draft analysis will need to be performed to allow for proper ejection and part release. The ramp will most likely not need any slide action features added to mold. However, the ramp will be the most problematic for sink. So the ramp will need to have large amounts of material removed to ensure minimal sink will occur. To maintain the proper mechanical characteristics of the ramp, stiffening ribs will need to be added to the cavities in which the bulk of the material was removed. The baseplate will need to also be analyzed to minimize sink as well. But in addition the baseplate poses the most complex features and geometry of the design and therefore will definitely need different slides to create all the needed geometry. The high back may not have significant sink issues, but an analysis will need to be performed to ensure this. And the geometry may be simple enough that slides may not be required. Again, an analysis by an experienced molding engineer will provide the specifications needed for the part.

In conclusion, the prototype was built with the current fabrication process that were at our disposal and budget. And the parts are the absolute best that the team could produce. For mass production, the above stated modifications will further the development of this design. The prototype currently satisfies all the constraints for the project, these considerations will bring the standard for the design far above the minimum requirement creating a higher quality product.

## IV. Individual Level of Effort

| Team Member | Approximate Hours per Week |
|---|---|
| Tyler Lewis | 5-7 |
| Ryan Willis | 5-7 |
| Chris Tryon | 4-6 |
| Colton Roberts | 4-6 |
| Matt Munsee | 4-6 |
| Michael Terry | 5-7 |
| Longze Li | 3-4 |

## V. Unique Lessons Learned

**Matt Munsee**

Get testing done as soon as possible; don't think you'll have time later on in the semester. Make sure the input from the entire group is used and appreciated so as to have the best possible final product. On drawings, make sure they are fully dimensioned to be able to quickly review and adjust later on. Communication between the whole group is the key to reaching common goals as a team. Find some effective way for everyone to communicate their progress to each other. Assigning individual tasks over specific time intervals was very effective to ensure completion. Also, be honest with the customer and reviewers when something is beyond your capabilities. Most often they will be understanding and you will have represented your progress more accurately.

**Chris Tryon**

As the project progressed it was clear to see each of the strengths that each team member had. The lesson that really will stick with me is that no matter the team, there is always specific talent in each team member that will allow for the project to be accomplished. It was fun to see how each team member excelled in their respective element. In addition, each team member really had the drive and motivation to complete their tasks and do the best they can.

**Mike Terry**

This last year of design and construction of our customers snowboard binding has been a valuable lesson in the effect of small changes. The Kevlar ankle strap has been iterated using small changes to layup schedule and orientation to produce a strong but flexible piece. A little bit of foam under the heel has provided a softer more comfortable feeling. Finally two small pieces of rubber have given the necessary support to make the board feel responsive and enjoyable.

**Tyler Lewis**

This semester was full of lessons to be learned, especially for someone like me who had no prior experience with project management. I learned very quickly that if tasks were not clear and direct, more often than not, they would not be completed. This is something I struggled with early on due to the fact that I was uncomfortable in assigning tasks to my team mates. As soon as the awkward power dynamic worked itself out things went much smoother and the team members stepped up to hold themselves accountable for their responsibilities.

**Longze Li**

After we finished the project, I learned how to finish a project with other students as a team. For example, we used the weekly meeting agenda to plan our design and trace our progress, with this meeting agenda, we meet together every week and discuss what we have done and what we should do. It is efficient because it divides the task specifically to every student in the team. The second thing I learned from this class is how to lay up composite materials in real life, my teammate Michael works in a composite material company, he teaches me how to lay up the Kevlar-carbon fiber with specific glue and use the vacuum bag to get the air out of the lay-up materials to make the strap durable. For the base plate, our team member Chris introduced the injection molding method, which let me know an industrial method to massively produce a plastic part. From all the parts we bought for this binding, I learned many industrial standards in manufacturing process. This project also let me know more about this sport, I have always been skiing, I never knew that a binding can be very flexible instead of very stiff.

**Ryan Willis**

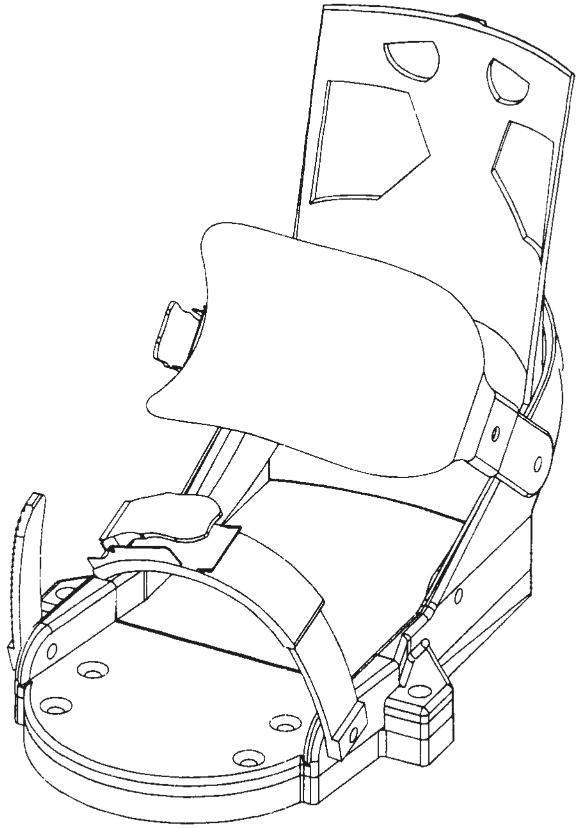
Senior design provided ample opportunities to learn about the engineering design process. I learned a lot about manufacturability of designed products, how to work in a team environment, and how to understand and design to customer specifications. As part of my role with the team I also had the unique opportunity to learn how to use Microsoft project to effectively generate Gantt charts and schedule the teams work. It was important to be able to capture potential roadblocks to the schedule before said roadblocks would actually occur.

**Colton Roberts**

Over the course of the past eight months I've learned many lessons that will be valuable to me in the coming years as I begin my career. I learned that there are multiple solutions to every answer, but what is important is that you choose the best solution, not the first one.

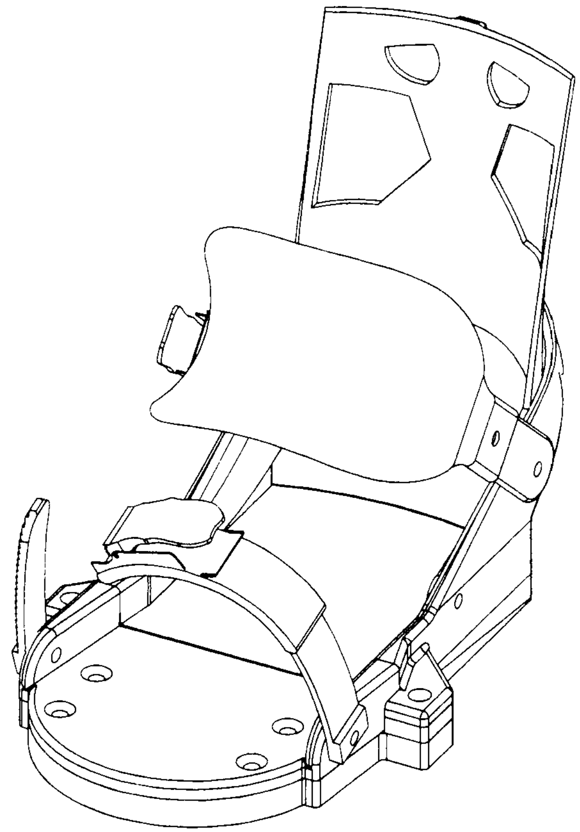
I learned that when you are debating ideas that emotions need to be taken out of the equation. Most times people really have the strong need to fight for their solution due to the fact that its what they came up with, while in reality it may not be the best solution. When comparing ideas, facts are what needs to be debated, not emotions! This can be valuable when finding the best solution for the question at hand.

| ITEM NO. | PART NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 1 | Ramp | 6061 Aluminum 6"x6"/5/8 | 1 |
| 2 | High Back | Used Existing Highback | 1 |
| 3 | Baseplate Bolts | 3/8-16 x2 Stainless Steel | 2 |
| 4 | Baseplate | Used Existing Baseplate | 1 |
| 5 | Rubber Grommet | Part No. 7665K45 | 2 |
| 6 | Foam | Part No. 1059N363 | 1 |
| 7 | Nuts | 3/8-16 Nylock Stainless | 2 |
| 8 | Washers | 3/8 Stainless Washer | 2 |
| 9 | Strap and Ratchet | Used Existing Strap | 1 |
| 10 | Buckle and Ratchet | Used Existing Ratchet | 1 |
| 11 | Composite | Kevlar/Carbon Fiber | 1 |



Final Binding Assembly
Bill of Materials

A3



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBUR AND
BREAK SHARP
EDGES

DO NOT SCALE DRAWING

REVISION

| | NAME | SIGNATURE | DATE |
|---|---|---|---|
| DRAWN | | | |
| CHK'D | | | |
| APPV'D | | | |
| MFG | | | |
| Q.A | | | |

TITLE:

MATERIAL:

DWG NO.

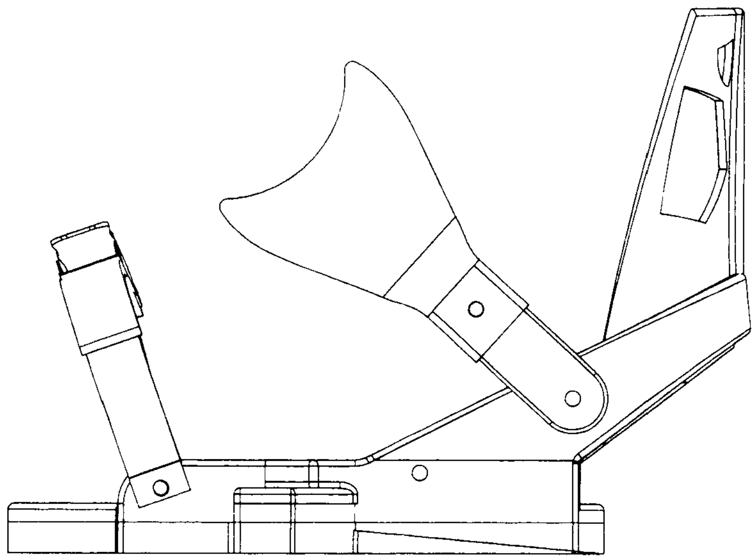
# Assembly Trimetric

A3

WEIGHT:

SCALE:1:5

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
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SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH

DEBUR AND
BREAK SHARP
EDGES

DO NOT SCALE DRAWING

REVISION

| | NAME | SIGNATURE | DATE |
|---|---|---|---|
| DRAWN | | | |
| CHK'D | | | |
| APPV'D | | | |
| MFG | | | |
| Q.A | | | |

TITLE:

MATERIAL:

DWG NO.

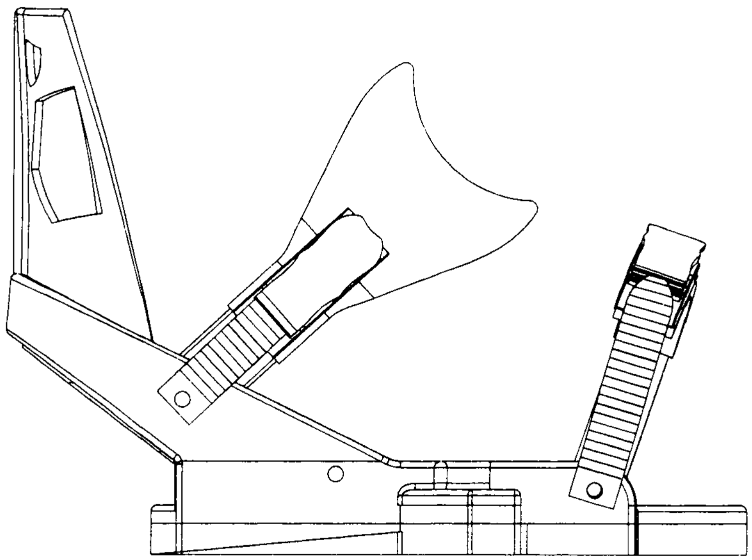
# Assembly Right

A3

WEIGHT:

SCALE:1:5

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH
TOLERANCES

FINISH

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

| | NAME | SIGNATURE | DATE |
|---|---|---|---|
| DRAWN | | | |
| APPV'D | | | |
| MFG | | | |

TITLE

MATERIAL

DWG NO.

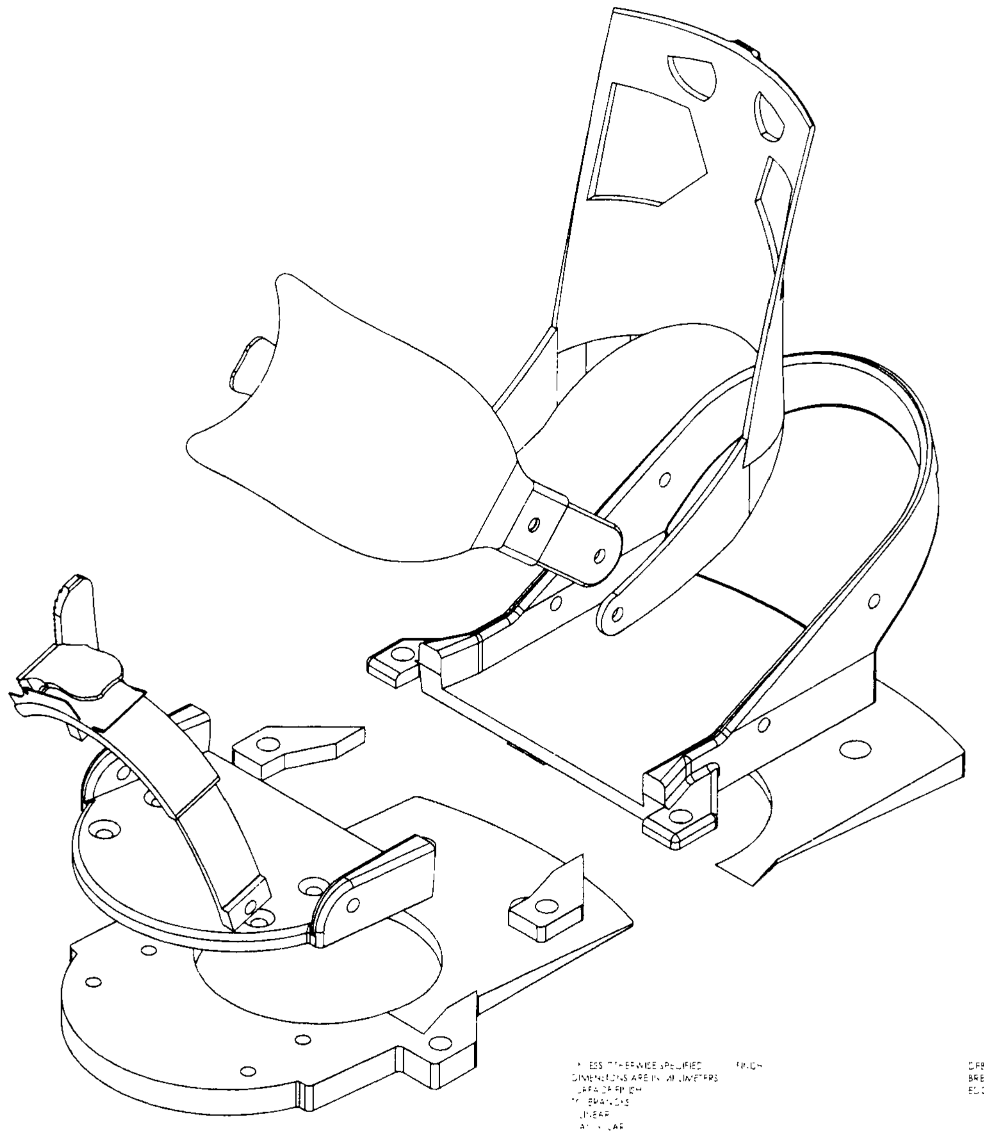
# Assembly Left

A3

WEIGHT

SCALE 1:5

SHEET 1 OF



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DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

| | NAME | SIGNATURE | DATE |
|---|---|---|---|
| DRAWN | | | |
| CHK'D | | | |
| APPV'D | | | |
| MFG | | | |
| Q.A | | | |

TITLE:

MATERIAL:

DWG NO.

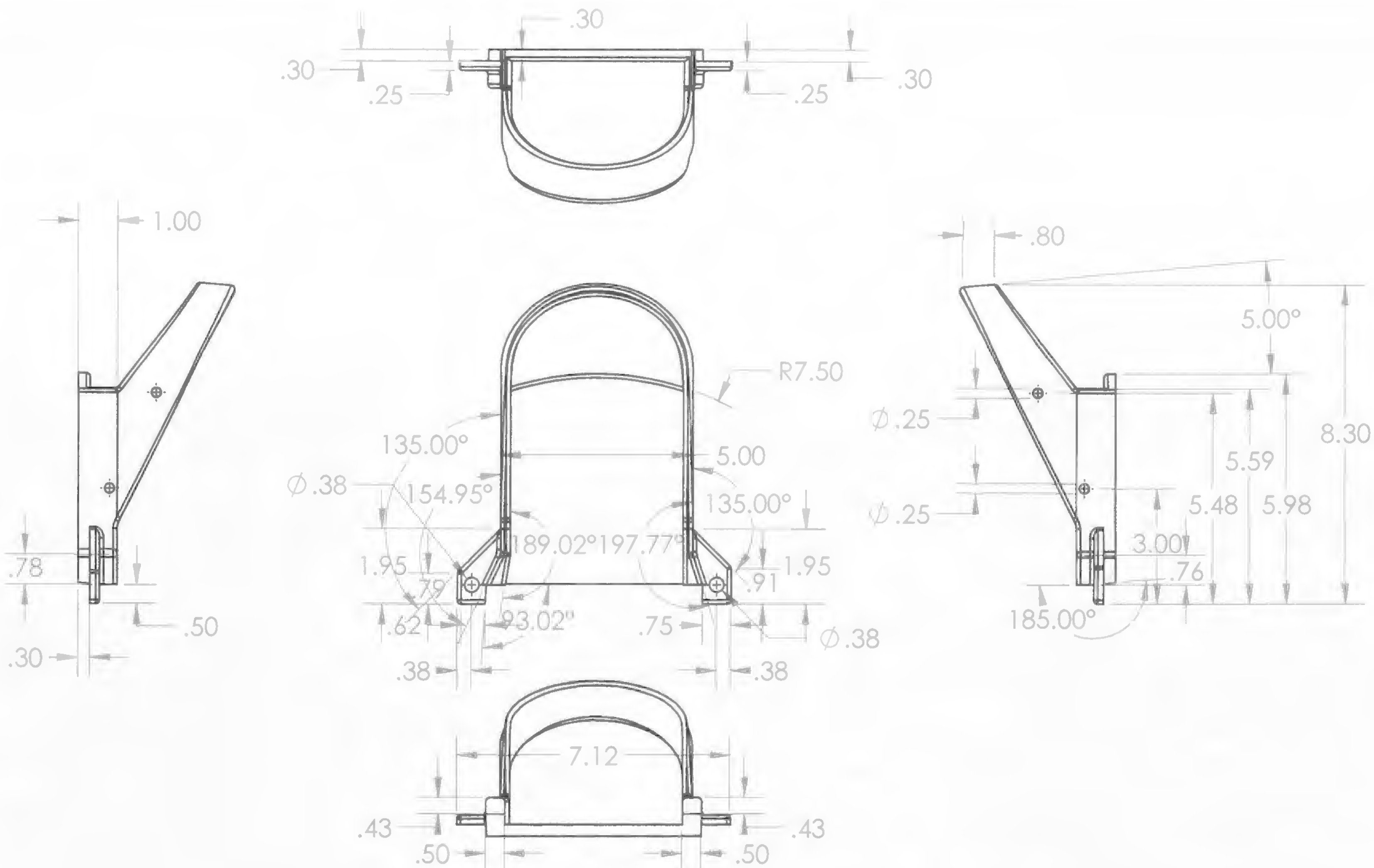
# Assembly Exploded

A3

WEIGHT:

SCALE:1:5

SHEET 1 OF 1




UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:

All fillets .1 in radius unless otherwise stated

TITLE:

Grommet Rear Base Plate

SIZE DWG. NO. REV

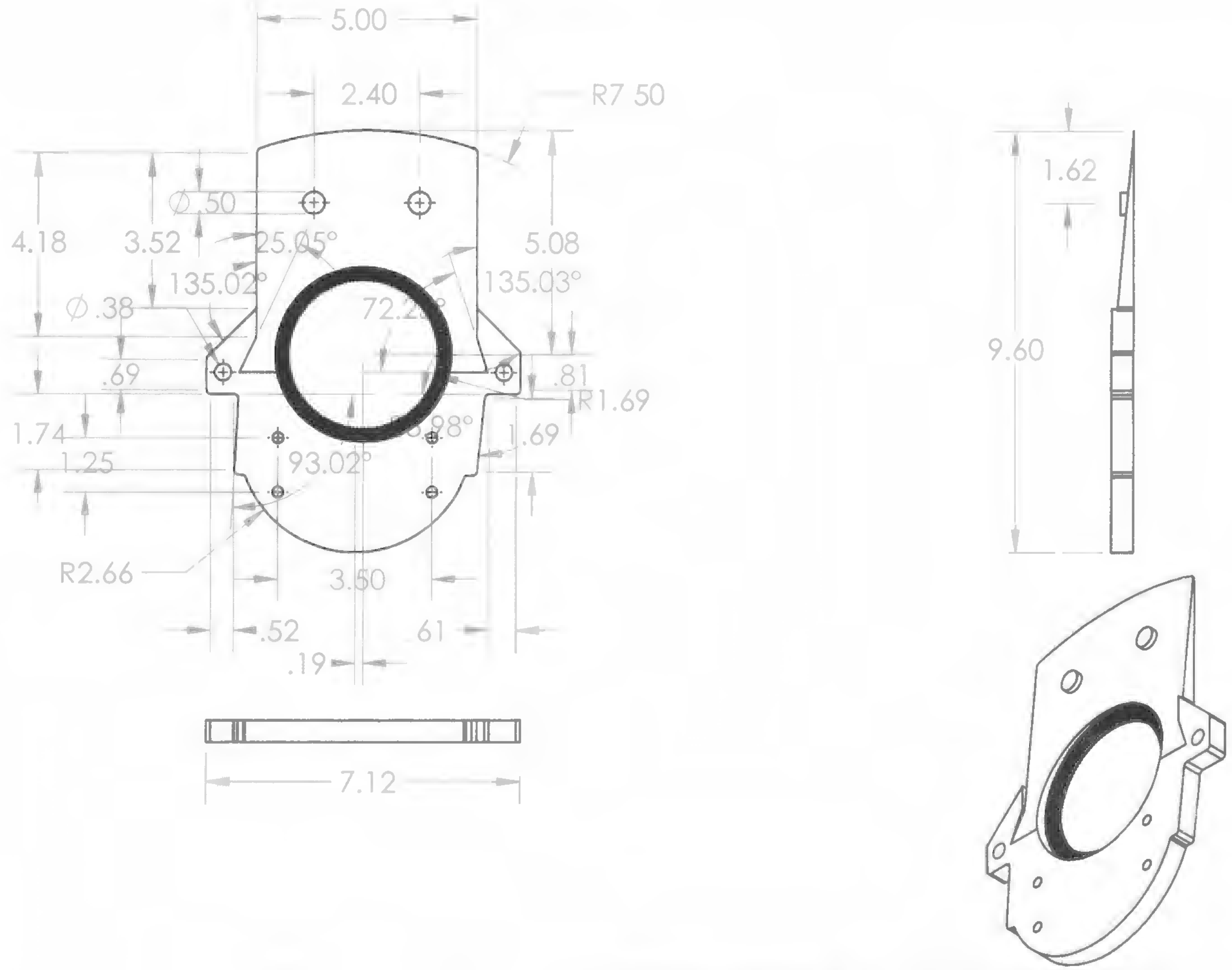
A

SCALE: 1:4 WEIGHT: SHEET 1 OF 1

| NEXT ASSY | USED ON |
|---|---|
| APPLICATION | |



5 4 3 2 1

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:

All fillets .1 in radius unless otherwise stated

TITLE:

Grommet Base Plate Ramp

SIZE A DWG. NO. REV

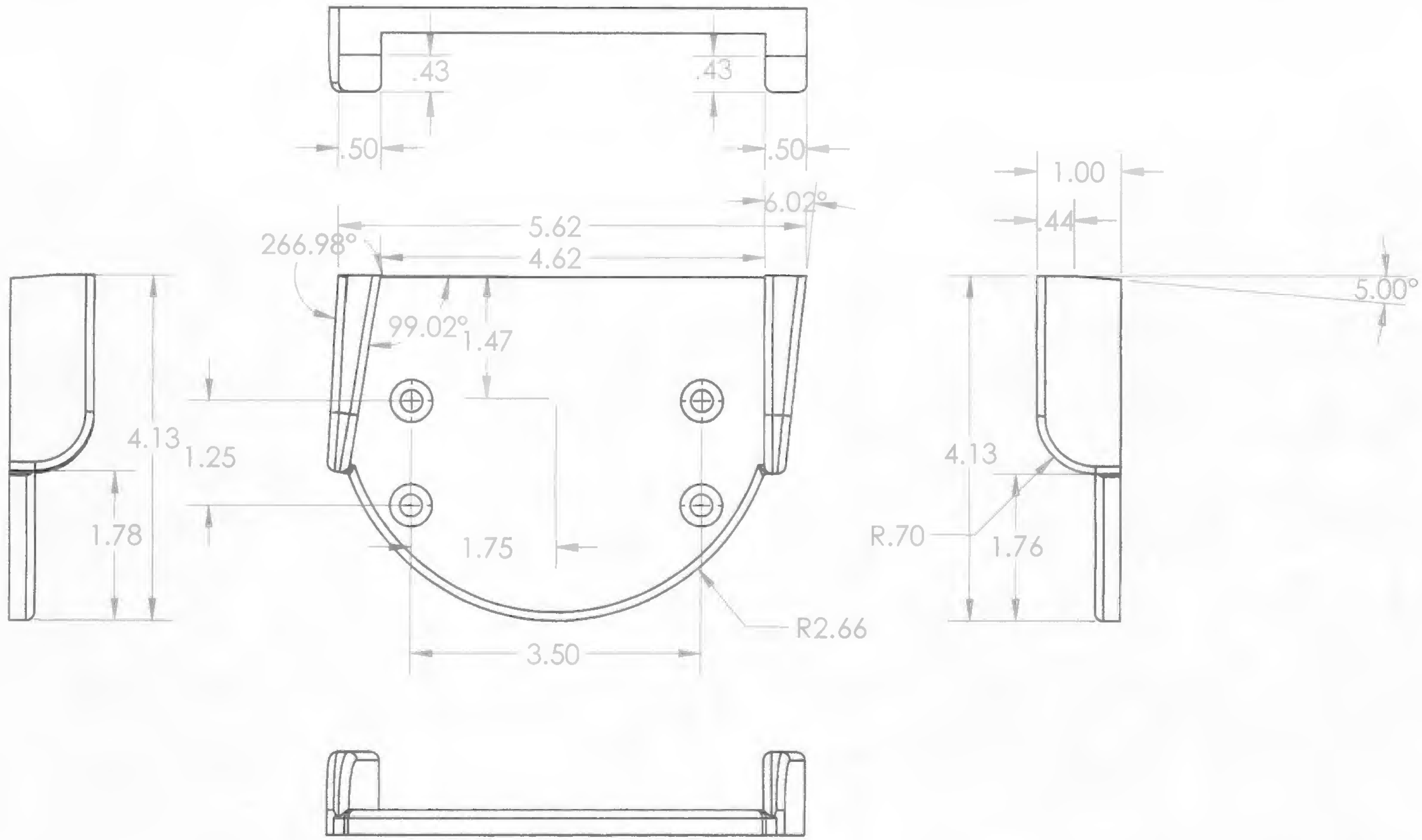
SCALE: 1:4 WEIGHT: SHEET 1 OF 1

NEXT ASSY USED ON

APPLICATION



5 4 3 2 1

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ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:

All fillets .1 in radius unless otherwise stated

TITLE:

Grommet Front Base Plate

SIZE A DWG. NO. REV

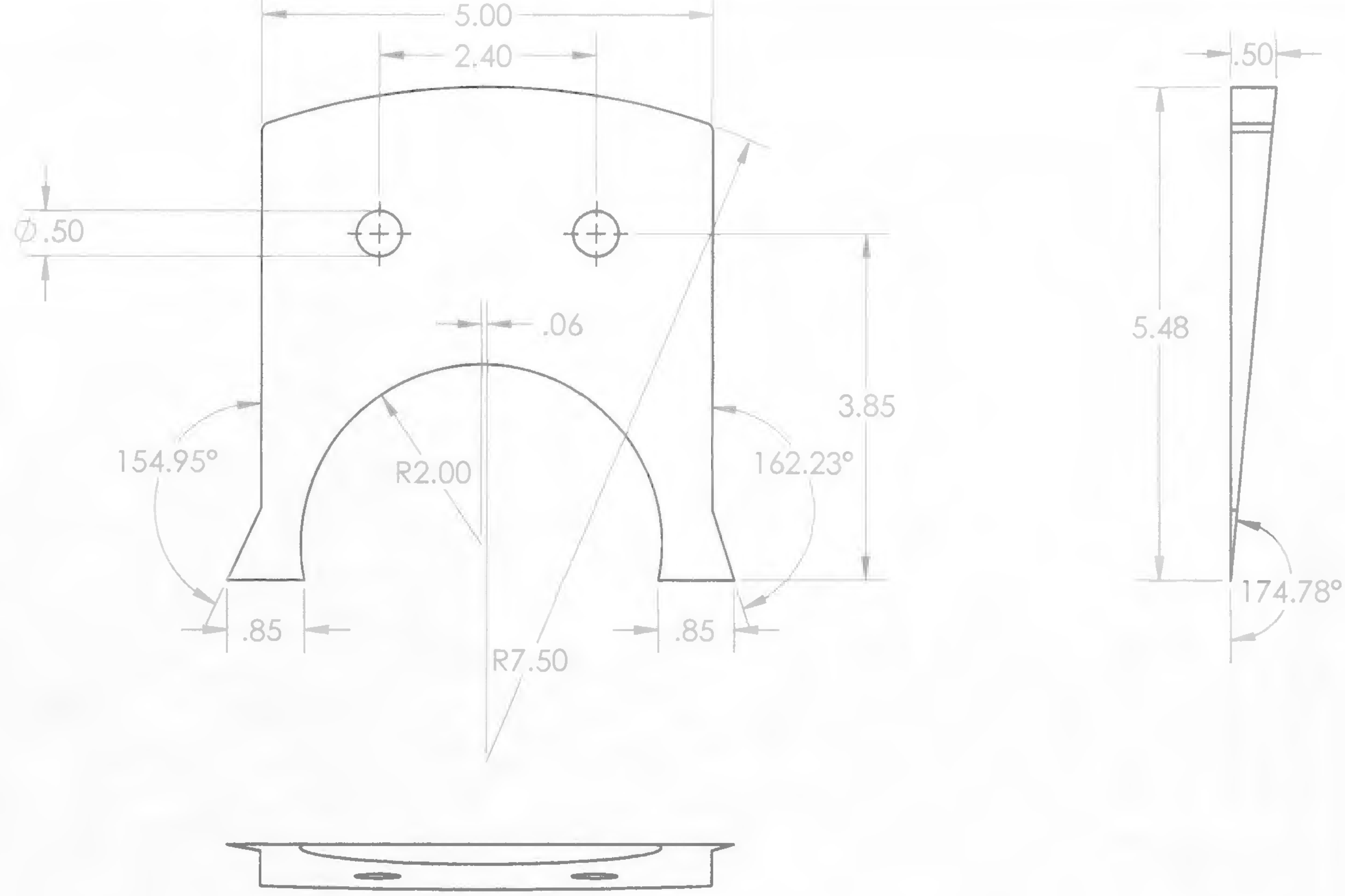
SCALE: 1:2 WEIGHT: SHEET 1 OF 1



NEXT ASSY USED ON

APPLICATION

5 4 3 2 1

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NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:
All fillets .1 in dia unless otherwise noted

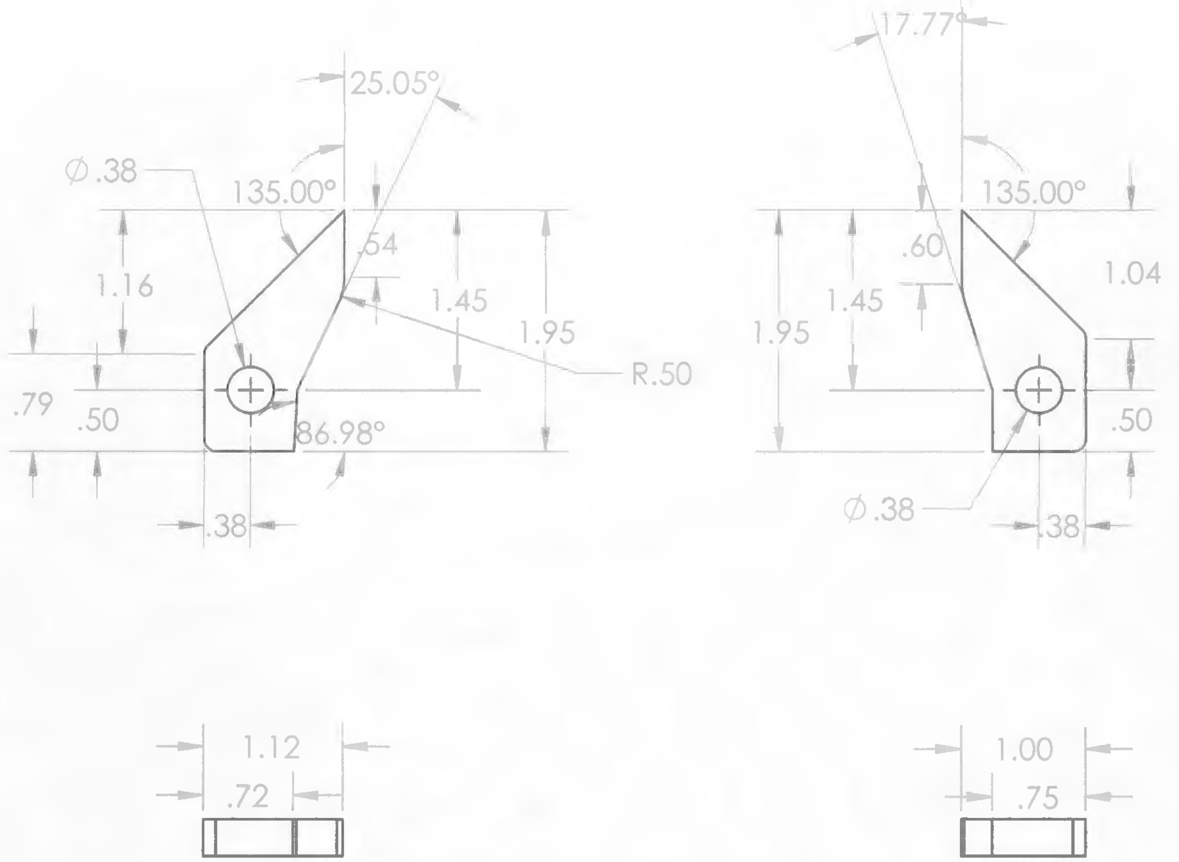
TITLE:

Grommet Base Plate Rubber

SIZE A | DWG. NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1




| UNLESS OTHERWISE SPECIFIED: | | NAME | DATE |
|---|---|---|---|
| DIMENSIONS ARE IN INCHES<br>TOLERANCES:<br>FRACTIONAL ±<br>ANGULAR: MACH ± BEND ±<br>TWO PLACE DECIMAL ±<br>THREE PLACE DECIMAL ± | DRAWN | | |
| | CHECKED | | |
| | ENG APPR. | | |
| | MFG APPR. | | |
| INTERPRET GEOMETRIC TOLERANCING PER: | Q.A. | | |
| MATERIAL | COMMENTS:<br>All fillets .1 in radius unless otherwise stated | | |
| FINISH | | | |
| DO NOT SCALE DRAWING | | | |

| NEXT ASSY | USED ON |
|---|---|
| APPLICATION | |

TITLE:

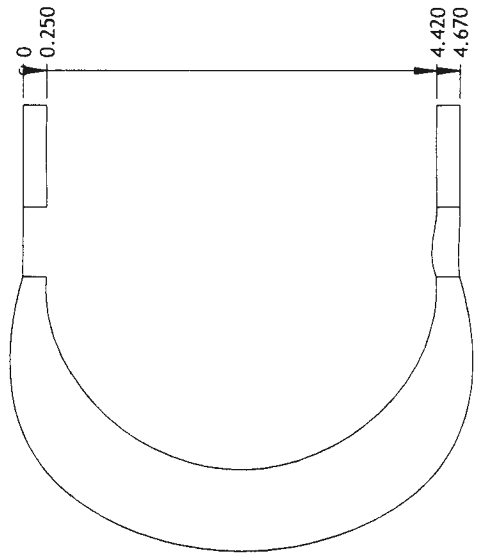
Grommet Rubber
Base Plate B

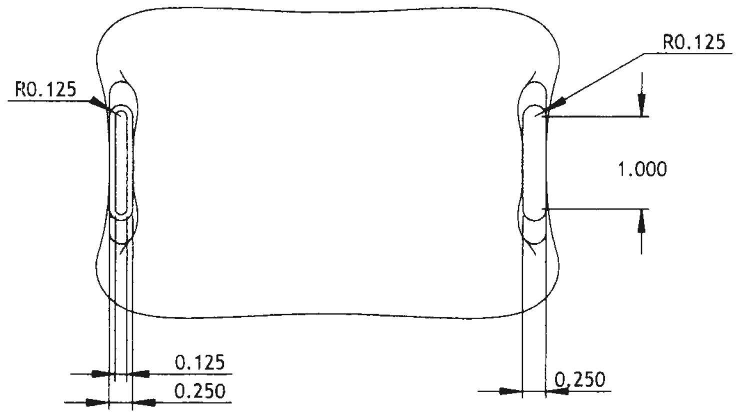
| SIZE | DWG. NO. | REV |
|---|---|---|
| A | | |

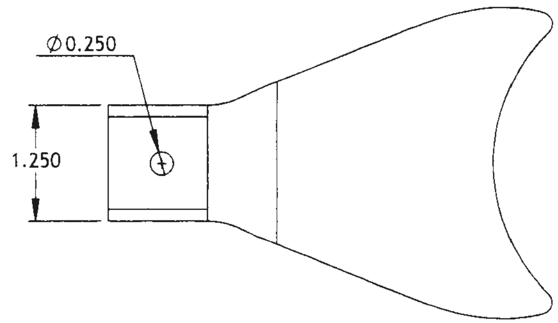
SCALE: 1:2 WEIGHT: SHEET 1 OF 1

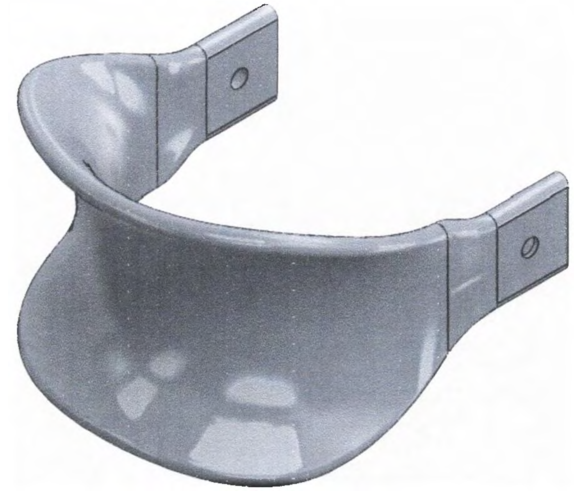


5 4 3 2 1



Kevlar 440 MPa
Carbon Fiber 600 MPa

Layup from top down is as follows:

Kevlar 3K 45 degrees
Kevlar 7K 45 degrees
4-2inx2in Kevlar 7K reinforcements around mount points
Kevlar 7K 0 degrees
1in wide strip of Carbon Fiber 7K 0 degrees
4 Carbon Fiber tow 13K
Kevlar 3K 0 degrees

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TOLERANCES:
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ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |
| COMMENTS: | | |

TITLE:

SIZE DWG. NO. REV

**A New Strap**

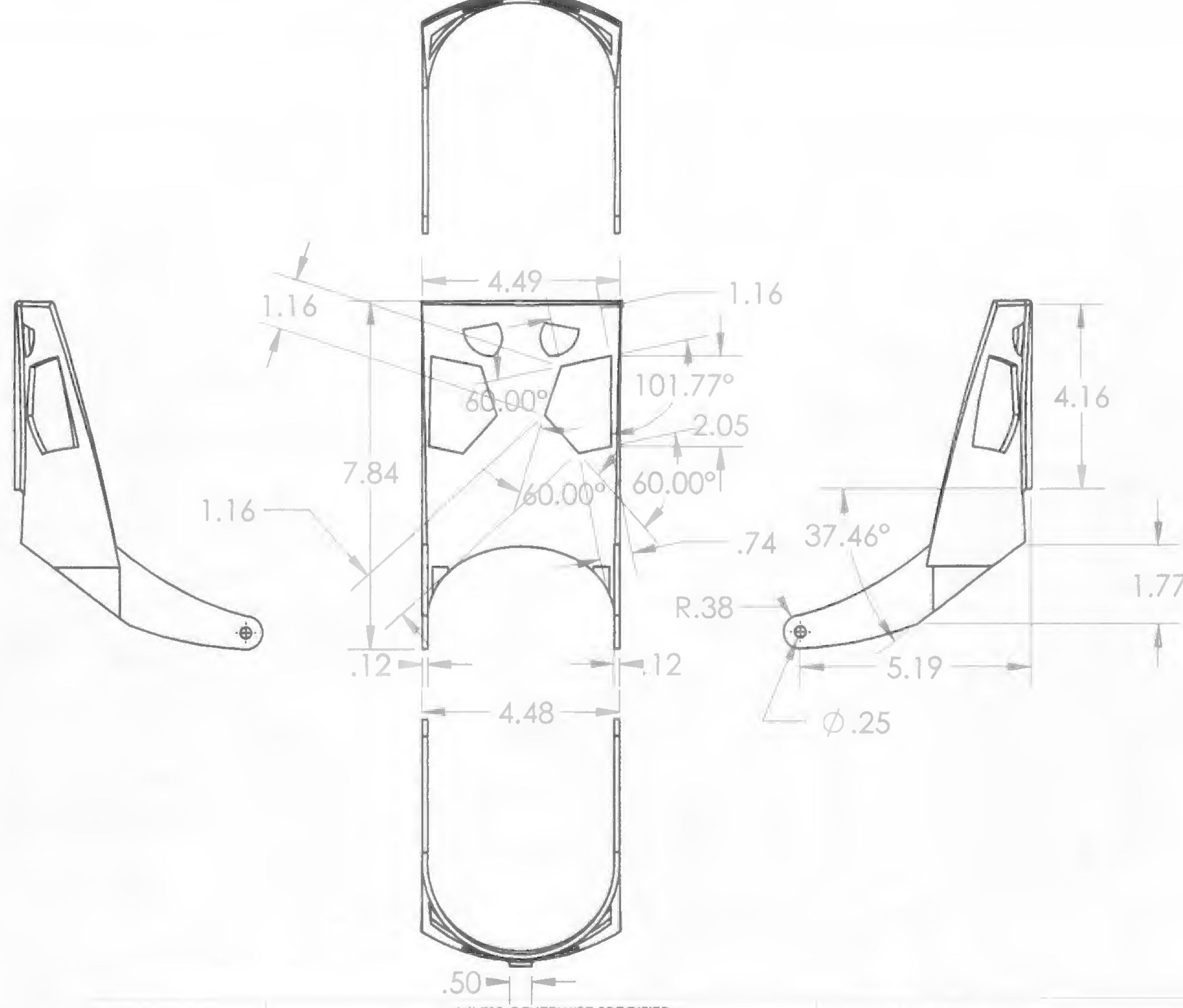
SCALE: 1:2 WEIGHT: SHEET 1 OF 1



NEXT ASSY USED ON

APPLICATION

5 4 3 2 1

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ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

| | NAME | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | | |
| ENG APPR. | | |
| MFG APPR. | | |
| Q.A. | | |

COMMENTS:

TITLE:

SIZE A DWG. NO. try 1000000 REV

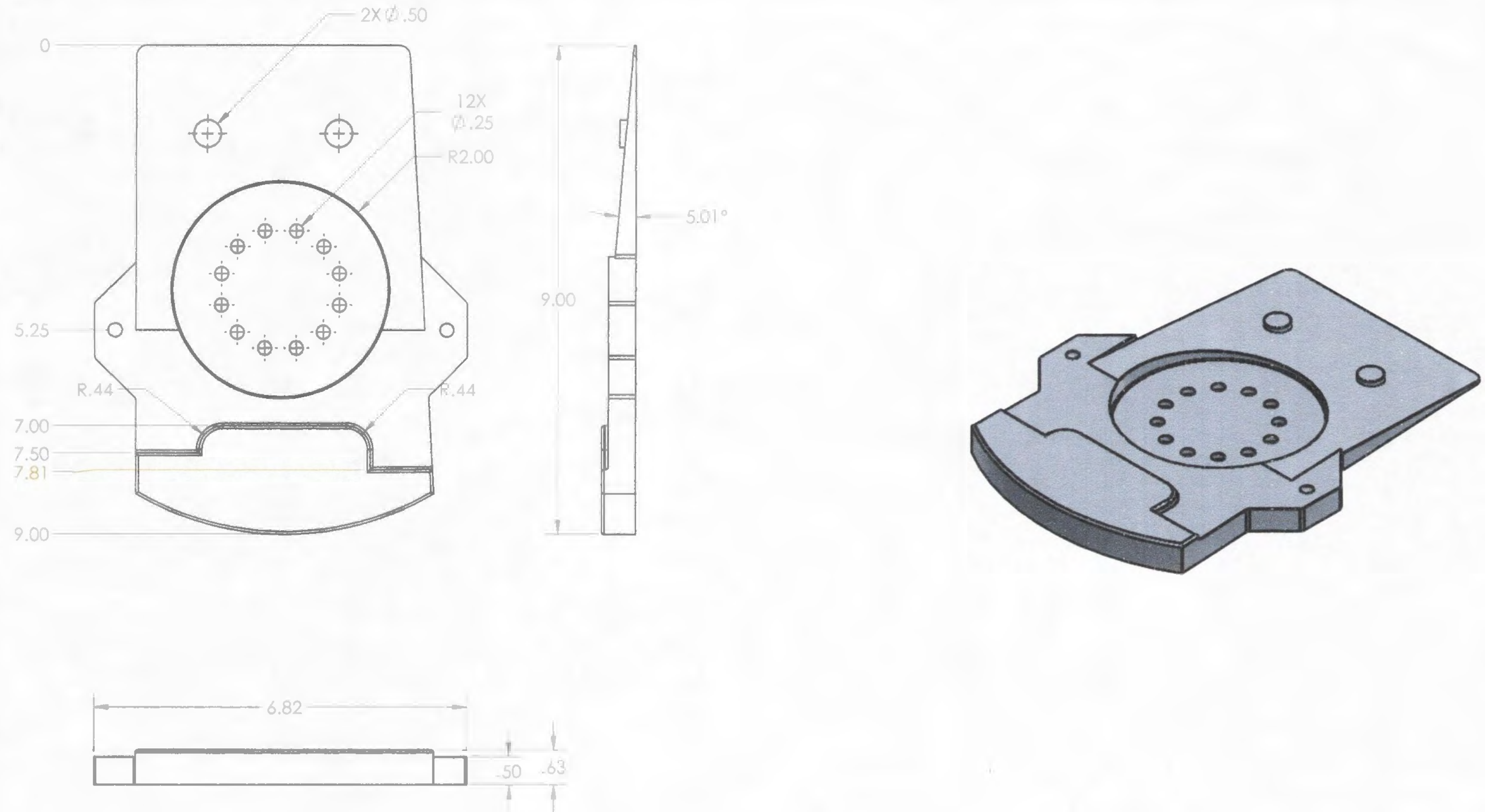
SCALE: 1:4 WEIGHT: SHEET 1 OF 1

NEXT ASSY | USED ON

APPLICATION



5 4 3 2 1

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|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED: | | NAME | DATE |
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| | | | CHECKED | | |
| | | | ENG APPR. | | |
| | | | MFG APPR. | | |
| | | INTERPRET GEOMETRIC TOLERANCING PER: | Q.A. | | |
| | | MATERIAL | COMMENTS: | | |
| NEXT ASSY | USED ON | FINISH | | | |
| APPLICATION | | DO NOT SCALE DRAWING | | | |

TITLE:

SIZE DWG. NO. REV

Tyler Lewis Binding Ramp

SCALE: 1:2 WEIGHT: SHEET 1 OF 1