User Manual

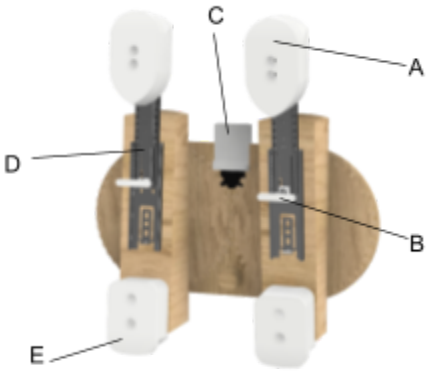

Figure 1: Front Establishing View of Product

Parts:

A - Part A is the fake boot mechanism that works together with part E to lock your skis
B - Slider locking mechanism to lock the skis in place for your ski size
C - Gear Locking mechanism with elastic (rubber band) locking
D - Slider for ski size adjustment
E - Fake boot mechanism working together with part A
F - Ratchet Strap to attach to backpack

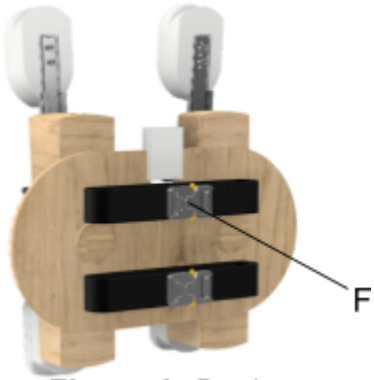

Figure 2: Back establishing shot

Setup:

Minimal setup is needed for this product, as it comes fully assembled. In order to set up this product, ensure the slider fits your ski size by placing the back of your ski on part E, then lining up part A with the front of your ski. Once part A is in the correct position, tighten part B until the slider (part D) is locked. The only setup needed for this product is to adjust the ski size. You should not have to change the slider position after the first use. Additionally, you can test the ratchet straps (part F) on your backpack and tighten as needed.

Attachment of Skis:

Parts A and E act exactly like your ordinary ski boot, and the act of attaching your skis to this product is very similar to how you lock your skis into your boots. First, place the front of the ski on part E, then press the ski down onto part A until it locks with a click. The ski should be locked into place on parts A and E. Ensure part B is fully tightened (on both ends) before strapping the entire product onto your backpack.

General Use:

After the skis are attached, strap the entire product onto your backpack, tightening the ratchet straps as needed. When the product is on your back, you can rotate your skis as needed by simply reaching behind you and lifting up part C, then manually moving your skis as needed. Once they are in the desired position, let go of part C to lock the skis in place.

Design for Assembly Reflection:

The user does not have an assembly process for this product, but the manufacturer does. Therefore, there are many good modifications that can be made to standardize the assembly process, ensuring the resulting product is consistent, easy to assemble, and cheap. First, I want to outline the parts of our product that already work well for assembly. The modular nature of the product allows for subsections of the product (like each individual attachment to the gears) to be made independently by different people, which speeds up the assembly. It also allows for easy storage and organization of the assembly process so no faulty products are released to the public, as individual parts can be color coded or organized in strategic ways to ensure no mistakes are made during assembly.

The three modifications to the CAD that have been made in order to improve the assembly process all have to do with ensuring the assembly process is standardized enough to ensure the product looks and works the same exact way every single time it is assembled. Although the modular nature of our product allows for faster assembly and better organization, it introduces more opportunities for mistakes to be made while connecting parts. Small offsets in gear positioning can mean a lot and really impact the operation of our product, so it is important to ensure that the product maintains its structure and operation for every individual unit assembled.

To achieve this, I have developed guides within the individual components to force the assembly to remain consistent. The first modification is a 0.05” groove cut into the gears to ensure that the slanted wooden mounts are placed in the correct position every time the model is assembled. These grooves are in the same shape as the base, so that the groove is forced into its correct position during assembly. The second modification made is a 0.05” guide cut into the slanted wooden mount to ensure that the sliders are positioned correctly. These guides are in the exact shape of the slider, so the assembler can simply place the slider in the groove to ensure that it is placed in the correct position. Small variations in the positioning of the mounts or sliders on the mounts can introduce asymmetries to the product, making it difficult, annoying, and not convenient to use. Finally, the third modification to design for assembly is 0.05” mounting slots made for the ratchet straps on the backboard. These grooves are made to ensure the ratchet straps are attached symmetrically to the backboard. If the ratchet straps are not perfectly attached, the product can easily fall off of the backpack under the load of the skis, or can make carrying the product awkward for the user.

Manufacturing Reflection:

When thinking about these manufacturing methods, we also take into consideration our sustainable mission, reducing the amount of wasted material that comes with each part.

We created a table of manufacturing types with some features we thought were necessary.

1 = The Best
2 = Okay
3 = The Worst

Features/Types	CNC Router	Jig	Injection Mold
Maintenance	2	1	3
Supervision(Quality Control)	2	3	1
Cost	2	1	3 (upfront cost but we will be neglecting for high quantity production)
Wasted Material	2 (some chips)	3 (depends on the cut)	1
Production Speed	3	2	1

From this table, most of our answers below will come from injection molds or the usage of jigs, however, these answers are based off of the material for our product. Metal products could require casting manufacturing/injection molding.

Necessary parts for our prototype:

- Wooden Gears
  - Although laser cutting our wooden gears required an extensive amount of time in the rapid prototyping lab, we believe that industrial-grade laser cutters are much stronger, allowing it to cut through the thick plywood in one go rather than having to lap the path multiple paths.
- Wooden Board
  - We also believe that the best manufacturing process to reduce cost as well as putting into consideration the material and the design is an industrial grade laser cutter. It is a very simple design and can be cut out from a piece of plywood.
- Ski Boot Attachment (Parts A, E, C)
  - 3D printing is normally expensive as well as requires constant quality control, we believe that the best way to manufacture these ski boot attachments is to use an injection molding machine that pumps in glass-filled nylon, the same material as ski bindings to ensure strength in the cold. PLA is not strong with the cold and 3d

printing is also a time-extensive process even in today's standards.
    - From my own experience using a 3D printer, it messes up a lot, and this could result in a weak automation cycle (the need for quality control which will increase the cost per prototype and increase the amount of wasted material accrued during production). With injection-molding, we completely remove the worry for wasted materials, in addition to achieving the same product in a fraction of the time compared to a 3D printer.
- Wooden Block
    - The slanted wooden block only needs a few major cuts to get it to the size: getting it down to the rectangular size, and then a cut that cuts the appropriate ramp angle for the block.
    - The best approach to wooden blocks with cost and repeatability in mind is a saw and a slanted jig. The only maintenance for this is to replace the saw blade, but that comes after thousands, if not tens of thousands of cuts

2 DFMs:

1. From our table, injection molding has the highest wear out of the three manufacturing types, we are also using injection molding for our ski boot attachments. One possible design change is to make rounded edges to reduce the amount of wear on the mold itself. The design is already pretty smooth itself, but there are some sharp edges that could help mitigate this issue like the pointy tip of part A.
2. For the cylindrical rods, we can also adjust them for industry-standard sizes so we do not have to make our own custom diameter parts for production

Sustainability Reflection

Our current prototype is a backpack mount that allows the carriage of boots and skis via the employment of wooden spacers, epoxy resins, metallic fasteners, nylon straps, and 3D-printed components. While this arrangement was adequate for testing, it has several sustainability problems. PLA plastic, as it is biodegradable under regulated environments, is not appropriate for winter employment and deteriorates when subjected to stress. Epoxy was one of the vulnerabilities of our weight test, and it's not recyclable, so repairing or replacing parts can be difficult. Additionally, glueing and mixing materials decreases end-of-life recyclability.

To have a better environmental impact, we revisited our materials using the 2030 Calculator and found that the biggest carbon emitters for our product were the PLA 3D-printed components and

epoxy resin. Both consume a lot of energy and don't offer good long-term stability. When in use, though, the present design would only end up in a landfill because users would not be able to disassemble, or repair any broken part for that matter, with ease. A single such broken piece can make the whole assembly useless.

In order to improve sustainability, we suggest three basic changes: replacing PLA with recycled ABS or PETG for greater longevity and recyclability, employing mechanical fasteners or snap-fit joints in place of epoxy, and making parts in 3 modular parts. The 3 parts would be the backboard with the gears and then the left and right boot mounts. These changes would make the product easier to fix, extend its lifespan, and reduce waste, but not sacrifice the design being functional and easy to use.

Servicing Reflection

Our product features a modular ski and boot carry backpack attachment system. Over time, aspects such as the replica boot mounts, straps, and connectors will certainly be exposed to wear from repeated loading, cold temperatures, human movement, and moisture. We expect users to need occasional maintenance of the boot interface, the ratchet strap, and potentially the backboard if it takes impacts. This is an outdoor product, so we expect servicing would be done by the user themselves, using simple hand tools or by purchasing replacement parts directly from us, rather than through retail outlets like Lowe's.

Now some of the servicing problems are that epoxy is employed, which binds pieces together irreversibly, and that the design does not readily disassemble into sections that can be replaced. If something is worn out or broken, users would need to replace the whole unit or perform complex repairs. To address this, we redesigned the mock boot attachment to bolt on instead of glue on, so users can remove it and reinstall it without damaging the rest of the system. We also made sure that stress-bearing parts like the strap anchors can be removed and replaced without having to take apart the entire product.

One of the CAD modifications we made for repair was the addition of bolt holes with functional heads in the point of attachment of the fake boot. This makes it easy to remove from the backboard and replace if it cracks or breaks. This will extend the product life, enable lower-cost part replacement, and render maintenance more accessible to customers without technical skills.

Final Recommendations:

After a full analysis of our final prototype, keeping in mind our target market, design functionality, and competitors, we see real potential with this product, but **recommend an extension of the development cycle** for our product. First, I want to outline the positives of this product. We developed a feasible solution to a real problem that all skiers are conflicted with: how to transport skis conveniently and efficiently. We also made the product convenient and easy to use–just strap in the skis and attach it onto the backpack–as well as universal–it can be attached to any backpack and can fit any ski size. Additionally, our product is significantly cheaper than ski backpacks currently on the market, providing a cheaper alternative to carrying skis. Ultimately, the product provides a more convenient and cost-efficient method of carrying skis to and from the mountain than carrying them.

Although our product solved a lot of important problems and we have confidence that there is a place for our ski backpack attachment on the market, there is still progress to be made before releasing the product to the public. There are some fundamental flaws that would need to be addressed in order to increase customer satisfaction in our product. The first would be better fastening methods, especially with the ratchet strap to the backboard. When attaching the product to a backpack and adding skis, we saw failure in the staples that were used to fasten the ratchet strap to the backboard. The weight of the skis and the backboard caused failure in the staples. To me, one of the most important factors in my purchasing decisions arises in durability. I want a durable product that will last me as long as I want to use the product for. I'm sure further market research and interviews will provide further support of this idea. Extension of our development cycle should include a rigorous testing process of new fasteners to ensure that failure will not occur under any circumstances during normal use of the product.

Another focus during the extension process should be material selection. The backboard is made out of wood, which will not hold well or be durable during harsh winter weather. We would need a weather resistant material that is durable enough to withstand winter weather, while also accommodating for the fasteners that are required for securing the ratchet straps to the product as well as securing the gears. This material selection process should reflect our strong desire to provide a functional, cost-efficient, and durable product to skiers by ensuring testing is rigorous, accurate, and maintains the low-cost appeal of our product. Regarding a timeline, given a normal 9-5 work-week, working 5 days a week, the material selection process should happen before the fastener optimization process. I would give one week for material research and ordering (assuming the four of us are working together on these hours), then another week for testing and manufacturing. After determining the optimal materials, we can start to think about secure, durable, cost-efficient, and compatible fasteners with the materials that we selected. The fastener selection process should include a one week design process, then a one week implementation and product adjustment process. Finally, I would give one more week to finalize and fix any small problems with the design, and add any small details like

a ski size indicator for the slider. After this cumulative five week extension process, I would be confident to release the product to the public, and we hope to see our ski backpack attachment thrive.

Reflection

When designing our prototype one thing that went well was that we came up with a lot of different ideas early. That really helped us keep an open mind to different ways of looking at our problem. This was an aspect of the process we all enjoyed as it was really fun to just brainstorm. Some ideas were really technical and complex while others were simple. In the end we reached a good balance of complexity and simplicity to make our project technical and effective. One thing that went just ok when manufacturing the prototype. We ran into some problems with the supplies in the Taylor Design Studio as we wanted wood glue, but could find it anywhere. We had to improvise and use epoxy instead. Overall, it was very fun and interesting to see what parts of our design did not work in reality and what parts worked very well. Testing is where we had a lot of fun and did very well. We wanted to really test the limits of our prototype and try to break it, but we just couldn't. We put more weight on than our tests specified, did many drop tests, and impact tests from the side, but we just could break it without being unreasonable. Redesigning was one area where we ran into some trouble as the fixes we made created new problems that we should have seen. It was also a bit tiring to try to come up with ways to modify our design that wouldn't just completely change it.

We learned a lot about project management especially after ODP 3. During ODP we were a bit all over the place and really had to rush to get the prototype made. We did not get orders into RPL early enough so we were getting them last minute and had to rush to get stuff assembled. Additionally we had some trouble with the type of wood we used for our gears. The laser cutter could not get through it so we have to switch the wood type and try again. We learned a lot about planning and making sure all the little details would work. This really helped us in ODP 5 as we were much more efficient and actually finished early instead of last minute. Our team dynamic was solid the whole time, we got along well and most of our improvement came from just getting to know each other better. We learned how the others worked and to trust that the others would do their work.