Deliverable G

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Abstract

This document explores significant advancements made in the development of our second prototype, with the primary goal of achieving improved functionality. Driven by valuable feedback from our client, we sought to create a prototype capable of essential functions, including door clamping, drill guidance, and maintaining drill perpendicularity. We made thoughtful choices in selecting materials, incorporating 3D-printed PLA and durable sheet metal for the casing. Prototype 2 focused on refining dimensions to ensure the drill fits smoothly in the jig while enabling unhindered hole drilling. Key areas of attention were the casing and guide hinges. We also considered the clamping mechanism's speed and opted for C 3-D printable C-clamps, striking a balance between quick operation and effective performance. Beyond this, we actively sought feedback and commentary on our ideas and prototype from prospective clients and users and represented it in both numerical and written modality, allowing us to refine our approach based on external perspectives. Our solution is designed to be adaptable, allowing for future adjustments to advance the project in Prototype 3, and in time, for Design Day.

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1 Introduction

During the development of our second prototype, the objective is to reiterate and reproduce a testable prototype capable of performing critical tasks, including its clamping mechanism, guiding a drill, and maintaining perpendicularity during drilling. To achieve this, our team used client feedback gathered from our first prototype. In response to this feedback, we carefully selected materials, opting for PLA from 3D printing, supplemented by sturdy sheet metal for the casing. Our primary focus during the development of Prototype 2 revolved around ensuring that the prototype's dimensions were optimized to house a drill effectively and facilitate unobstructed drilling. The casing of the jig and the guide hinges took center stage, playing pivotal roles in the functionality of the prototype. Furthermore, our approach emphasized balancing clamping speed with efficacy. This report also highlights the scalability of the design, along with user-feedback; represented in a numerical model, providing flexibility for future adjustments, allowing for further refinements in Prototype 3 and our final design.

2 Feedback on Prototype 1

The client provided feedback regarding the attachment system in prototype 1, seeing as it came across unclear in a nonfunctional prototype. Once clarified how the functional version of the jig would ideally work, the persisting confusion of the client and the raised concern of added unnecessary complexity prompted the design team to change the design to a standard, easily sourced screw c-shaped clamp.

Client apprehension about unnecessary complexity prompted the design team to implement other changes as well. The plates, initially unstable and varying in size, underwent a transformation to feature a flared-out design at the bottom. This modification ensured that the plates aligned uniformly with the jig casing at their base. Originally starting at 6 inches along the base, both plates were extended to incorporate a cutout section aligning with the desired preset size (either 4.5” or 5” inches), ensuring a secure fit with the jig casing and preventing the smaller plate from sliding around on a rod. Furthermore, the shift from using rods or pins to secure the plates to bolts was made for enhanced flexibility. This change facilitates easy adjustment of plate positions and allows for straightforward sourcing of nuts and bolts, making them readily available for potential modifications or replacements in the future. This alteration not only addresses immediate concerns but also ensures long-term adaptability and usability for both the design team and the client.

3 Prototype 2

The goal of Prototype 2 was to create a functional Prototype as the previous prototype was to understand scaling only. This means that the 2nd prototype can clamp/unclamp from a door, can be used as a guide for a drill, and can maintain the drill perpendicular to the door. To ensure functionality sturdy materials such as PLA from 3D printing were used combined with the use of sheet metal for the casing. The focus of Prototype 2 was to ensure that the dimensions of the prototype were adequate and that a drill would be able to fit inside of the cavity. This ensures that the jig is able to drill holes without another mechanism getting in the way. For this reason, the casing of the jig and the drill guides was prioritized during this prototype. The clamping mechanism will be further tested in Prototype 3 so a temporary solution was devised. The team decided to 3-D print C-clamps found online. The drawback is that the screw mechanism will make time to clamp and unclamp longer; however, this choice ensured that more time could be spent on measuring the other aspects of the jig. The design was also created to scale so that dimensions can be adjusted if needed. The C-clamps are not visible on the detailed drawings in CAD as it could not be converted from the STL file. It is also not the main aspect of the prototype.

Figure 1 Screw clamp
https://www.thingiverse.com/thing:1673030

The test plan for the prototype involves three key aspects: time efficiency, ease of use, and durability. Firstly, the time efficiency of the jig is assessed by timing an individual's process of clamping, unclamping, moving, and re-clamping the jig. The goal is to complete this sequence in under 10 minutes. Secondly, the ease of use is evaluated through practical testing with four individuals who are given simple instructions to use the jig. Their experience is rated on a scale of 0-10, providing insights into the jig's user-friendly aspects. Lastly, the durability of the prototype is tested by employing it to drill into wood slabs. This process is repeated three times, and the overall assessment revolves around the jig's continued usability for its intended purpose. The testing phase is scheduled between November 21 and November 24, ensuring a comprehensive evaluation within this timeframe. The stopping criteria for each test are defined, such as completing the clamping process in under 10 minutes or achieving a satisfactory ease-of-use rating. These tests collectively aim to address key performance aspects and provide valuable feedback for further refinement and optimization of the prototype

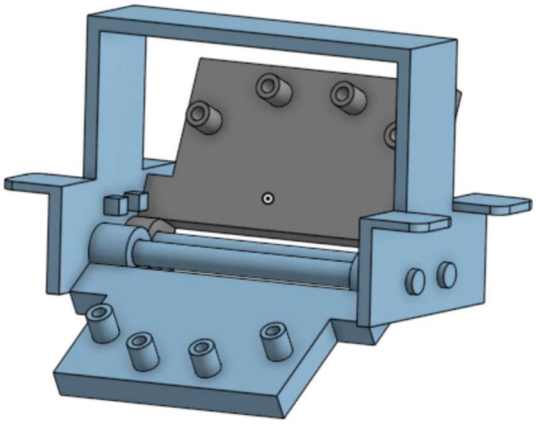


Figure 2 Jig Design

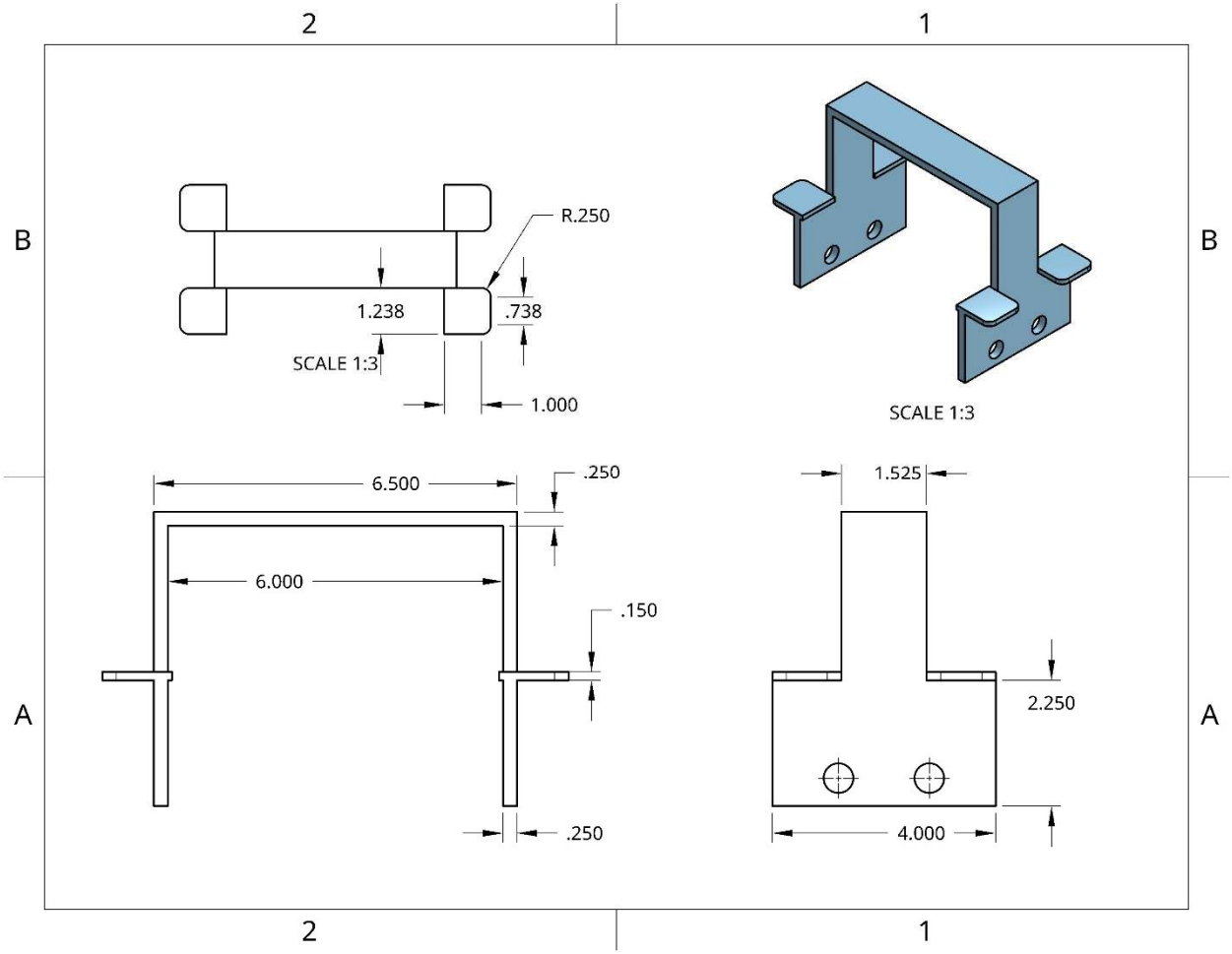


Figure 3 Jig Casing

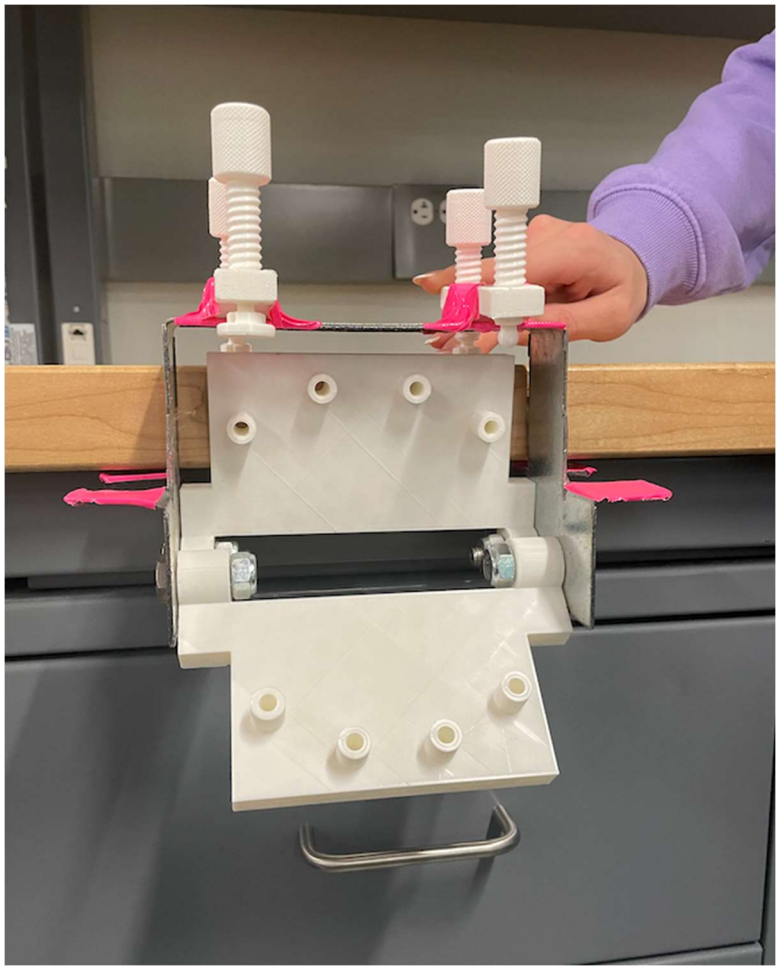


Figure 4. Completed Jig Prototype #2

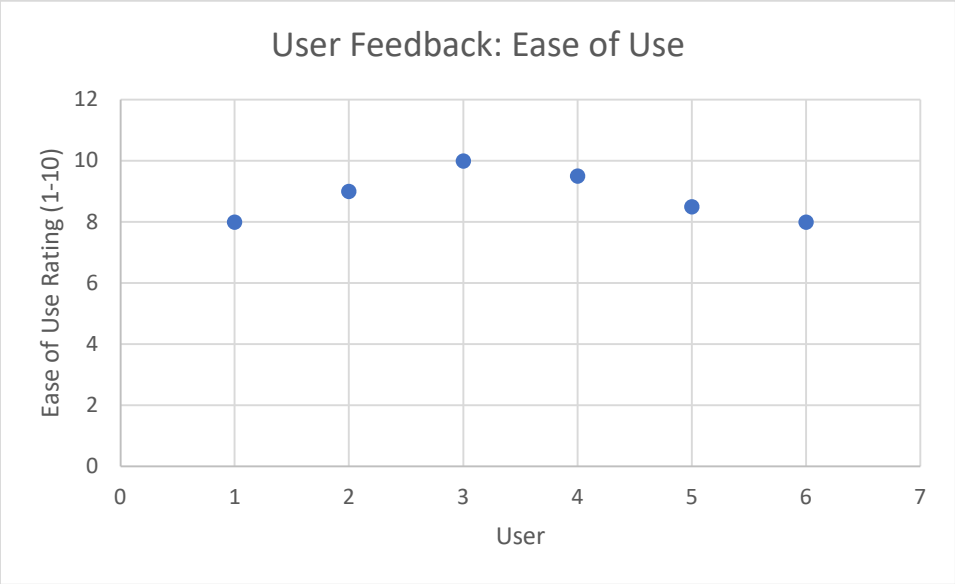
4 Testing and Numerical Model

4.1 Prototype 2 Test Plan

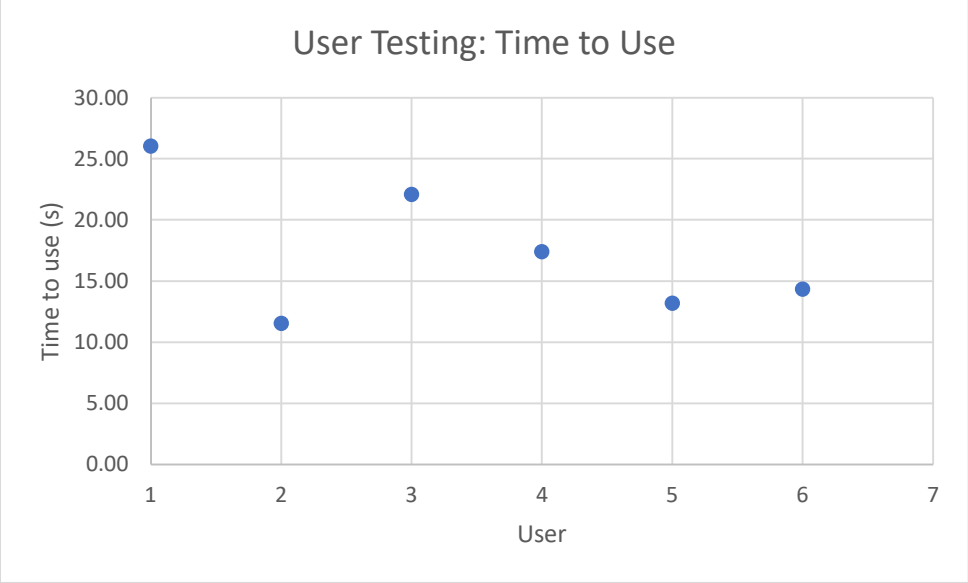
ID	Design Specification	Test Method	Measurement	Timeline
1	Drill can fit into the cavity	A standard drill will be inserted into the drill holes on the guide plates	Yes or No, If no what is the margin of error in inches	Nov 14, 5 minutes
2	Time to use the jig	A team member will be timed clamping and unclamping the jig	Time measured in minutes	Nov 14 10 minutes
2	Ease of use	4 individuals will be surveyed on how easy they think the jig is to use	Rating of 0-10	Nov 14, 10 minutes

4.2 Feedback on Prototype 2

A survey, conducted around the University of Ottawa, was used to identify critical usability factors, evaluate operational time for both professionals in engineering design and the general public (with the goal of achieving a 5-minute timeframe), and ascertain ease of use, with a target usability rating of 6 or higher.



Graph 1: User Feedback: Ease of Use



Graph 2: User Testing: Timed Use of Jig

User feedback on the prototype, gathered from undergrad engineering students, a graduate student, a teacher education participant, and a STEM Professor, emphasizes key aspects of usability. The upper-year undergrad student (Ease: 8) suggests improving clamp tightness, while 1st-year undergrads (Ease: 9, 10) propose avoiding tape for sturdiness in the next prototype. The graduate student (Ease: 9.5) recommends the use of resin, welding, or sawdering to bind the parts together. The teacher education participant (Ease: 8.5) appreciates convenience and suggests welding for added sturdiness as well. The STEM Math Prof (Ease: 8) textured handle, allowing for an overall ergonomic, good grip. Quick survey times (11:55 seconds - 26:07 seconds) align and exceed the 5-minute goal. The average ease of use rating of 8 indicates a positive experience. To enhance usability further, addressing clamp tightness, stability, and sturdiness through material improvements and welding is suggested, which we have already discussed to reiterate for Prototype 3, aiming for an even higher target rating.

5 Updated specifications:

5.1 Prototype 2 Bill of materials and forecasted budget

Material	**Quantity**	**Extended cost (CAD)**	**Explanation**
Filament	447g	15.15	Material was selected for prototype 2 due to simplicity of accurate representation, cost effectiveness and availability.
ABP A4-70 bolt	4	1.10	Facilitate rotation and replacement of hinges, as necessary.
Steel sheet	80.515 in^2	33.79	Steel sheet used for general-purpose fabricating and machining jobs, generally solid for prototype testing purposes.
Duct tape	1'	0.03	Material was selected for reinforcement.

Material	**Quantity**	**Extended cost (CAD)**	**Explanation**
BESSEY Light Duty Clamp with Wood Handle	4	31.92	-Design materials suitable for easy integration into the design. -Light-weight, no major bulk added. -Acme threaded spindle for quick, smooth clamping operations. -Non-marring plastic cap on the pressure pad for delicate surfaces. -Zinc die cast jaws are light in weight but offer a nominal 330 Lbs. of clamping force. -Serrated rail enhances the positive grip of the cast arm to the rail during clamping activity. From https://www.homedepot.ca/product/bessey-bessey-1-1-2-inch-750-lb-drop-forged-c-clamp-with-1-1-2-inch-throat-depth/1000816968

ABP A4-70 bolt	4	1.10	Facilitate rotation and replacement of hinges, as necessary.
Steel sheet	80.515 in^2	26.99	This steel sheet is often used for general-purpose fabricating and machining jobs.; matching hinge backset -Ideal for general-purpose fabricating and machining, such as building home appliances, metal furniture, sheds and more. -Plain steel is considered appropriate for the factory working conditions observed during the workshop tour, priority is ability to be fashioned into the final design, as described by the product. -16 Gauge chosen to avoid redundancy in the final design. From hhttps://www.canadiantire.ca/en/pdp/steelworks-weldable-steel-sheet-16-gauge-assorted-sizes-0616149p.0616250.html?rrecName=Similar%20Items%20&rrecReferrer=product&rrecProductId=0616149P&rrecProductSlot=1&rrecSchemeId=product1_rr&rrec=true
Press-Fit Drill Bushings	8	41.76	-Mount flush with jig plates for precise drilling.steel From https://www.mcmaster.com/96511A796/
EPDM Commercial Grade 60A Rubber Sheet	36 in^2	0.34	-EPDM materials work great as an outdoor liner or pad -Made of high-quality EPDM rubber for long-lasting use -Oil- and weather-resistant EPDM material is easy to maintain from>https://www.homedepot.com/p/Rubber-Cal-EPDM-1-16-in-x-36-in-x-288-in-Commercial-Grade-60A-Rubber-Sheet-Black-20-109-0062-36-288/303366665
Total		102	

5.2 Updated Design:

As a result of the tests conducted in prototype 2, multiple changes will be made to the design. Firstly, adding rubber to the paddles will be something implemented in prototype 3. Currently, duct tape is used to protect the wood from the paddles of the jig. So for more cushions, this will be switched to rubber. Secondly, a rod was supposed to hold the hinges in place; however, it added unnecessary bulk to the design. Therefore, bolts will be used instead, and this will allow potential replacement of the guide plates. The decision was also made to keep the plates 3D printed to cut down on cost and manufacturing. The holes for the bolts also need to be moved outward so that the guides can fit into the pre-routed hole of the door. Lastly, the team is looking into using a form of quick-release C clamp to cut down on time. The method of adhesion to the main casing is still being considered. Some options include soldering or welding them on. The paddles were also made slightly smaller so that it may be easier to cut. A small handle is in consideration to being added (for ease of transportation). The design of the handle is not yet finished.

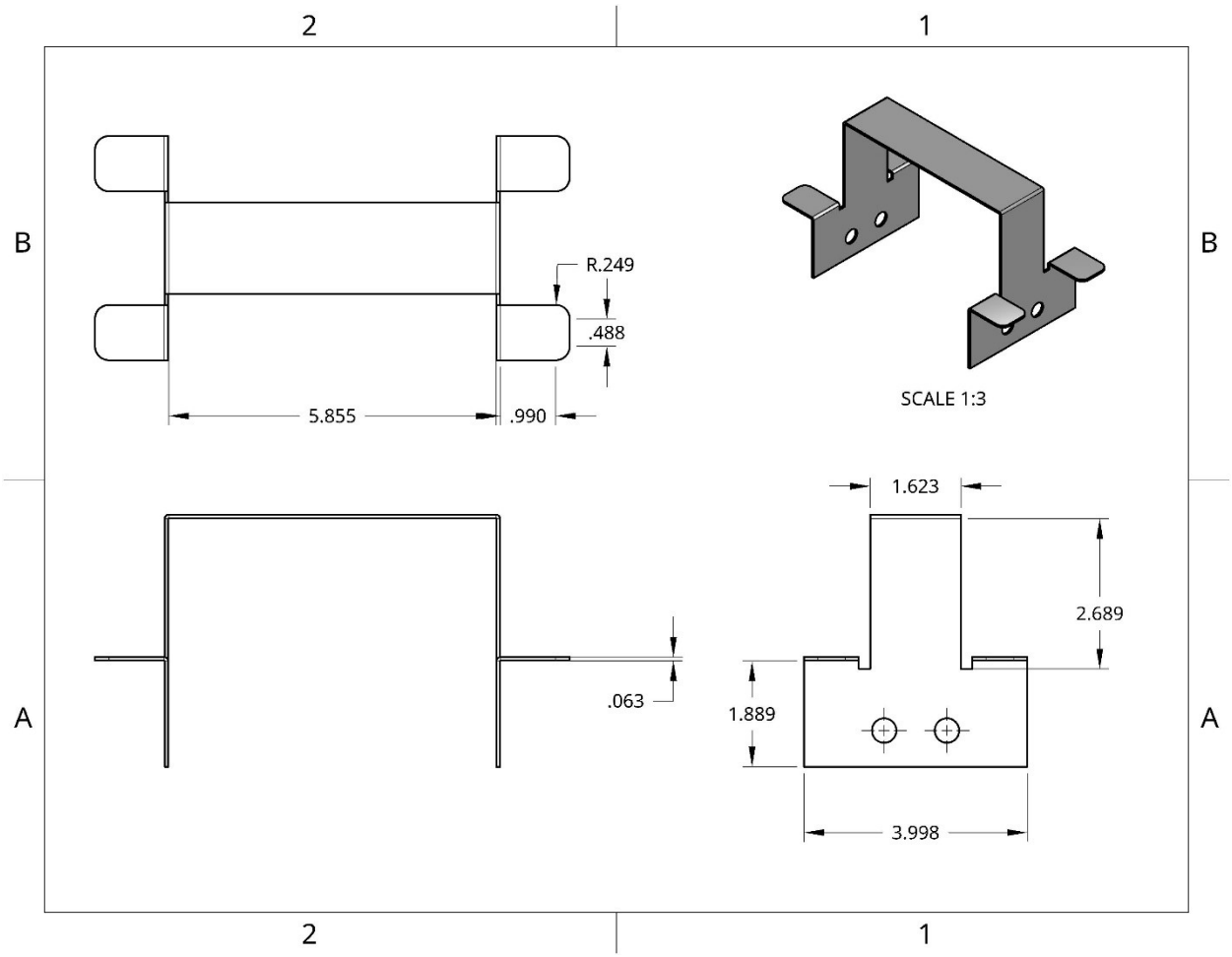


Figure 4 Jig Casing

6 Prototype 3 Test Plan

ID	Design Specification	Test Method	# of Tests	Measurement	Stopping criteria	Timeline
1	Time to use the jig	An individual will be timed clamping and unclamping the jig moving it down and then re-clamping it	3	Time measured in minutes	<10mins	Nov 21-24 20 mins
2	Ease of use	Jig given to 4 people and given simple instructions	4	Rating of 0-10 and	4 ratings of 8 or higher	Nov 21-24 30 mins

		to use. They will try to use it				
3	Durability	The jig will be used to drill into wood slabs and visual evaluation of any damage will be reported	3	Visual inspection	No visual damage reported when completing test	Nov 21-24 30 mins
4	Straight Drilling	The angle of the drilled hole will be measured	3	Degrees	90 degrees ± 0.1	Nov 21-24 10 mins
5	Clamping	While clamping and unclamping ensuring that the jig can hold it's weight and not move while drilling	3	Visual Inspection	Minimal to no movement detected	Nov 21-24 10 mins

The test plan for the prototype involves three key aspects: time efficiency, ease of use, and durability. Firstly, the time efficiency of the jig is assessed by timing an individual's process of clamping, unclamping, moving, and re-clamping the jig. The goal is to complete this sequence in under 10 minutes. Secondly, the ease of use is evaluated through practical testing with four individuals who are given simple instructions to use the jig. Their experience is rated on a scale of 0-10, providing insights into the jig's user-friendly aspects. Lastly, the durability of the prototype is tested by employing it to drill into wood slabs. This process is repeated three times, and the overall assessment revolves around the jig's continued usability for its intended purpose. The testing phase is scheduled between November 21 and November 24, ensuring a comprehensive evaluation within this timeframe. The stopping criteria for each test are defined, such as completing the clamping process in under 10 minutes or achieving a satisfactory ease-of-use rating. These tests collectively aim to address key performance aspects and provide valuable feedback for further refinement and optimization of the prototype. This general test plan is similar to that of prototype 2, but will have some different aspects and focuses involved in the testing process.

Testing for prototype 3 will focus on the functionality of all subsystems and their interactions. The clamping system, guiding system, facilitation of straight drilling and overall ease of use will be rigorously tested. There may be tests conducted where multiple criteria are tested at once. For example, when testing the time of use, the perpendicularity of the resultant drilling can be inspected afterwards, as well as a visual inspection of any potential damage done to the jig

7 Conclusion

In conclusion, the development of our second prototype represents a significant leap forward in achieving enhanced functionality based on valuable feedback from our client. Through material selection, incorporating 3D-printed PLA and robust sheet metal for the casing, Prototype 2 aimed to

excel in critical functions such as door clamping, drill guidance, and maintaining drill perpendicularity. The careful consideration of dimensions, particularly in the casing and guide hinges, underscores our commitment to optimizing the drill's fit in the jig and facilitating unobstructed drilling. User feedback from a diverse group highlighted the prototype's positive aspects, including quick survey times and an overall ease of use rating of 8. To address feedback, Prototype 3 will incorporate changes such as using rubber instead of duct tape for cushioning, welding or sawdering the jig casing, and exploring quick-release C-clamps for efficiency. The report emphasizes the design's scalability, adaptability for future adjustments, and the ongoing commitment to refinement, setting the stage for further advancements in Prototype 3 and eventual completion on Design Day.

Wrike Snapshot:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=j1WPoMTURZhRj9wHFHgkRvylEZpVEAHO%7CIE2DSNZVHA2DELSTGIYA