Deliverable E – Project Plan and Cost Estimate

GNG 1103[B]

B04-18

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Prototype

The final design of our jig contains many elements. for starters, we went with the body design from Jake’s prototype, as that was the one, we used as a base for the other jigs anyway, and we believe it to be the best body we created. In addition, we incorporated the clamp design from Jonathan's prototype, as we like the added sturdiness that it brings to the design. The two different jigs that we designed differ solely by width of the body component, as well as each fitting the required measurements set out by ambico. Our clamping design includes a support plate, which uses a keyway to secure the jig to the base of the door. As said earlier, the lengths of the plates don’t differ for the two different sized jigs. The same can be said for the c-clamp portion, which also includes a keyway to fasten it to the door and does not differ in size between the two jigs. The screw that we will be using for the clamping has a 0.25-20 thread, with the finisher being applied to finally secure the jig, held in place by a pin. There were concerns throughout prototyping of the jig, that applying too much pressure on the door, possibly damaging the finish. To combat this, we are including a protective surface to cover the jig, eliminating the risk of scraping the finish.

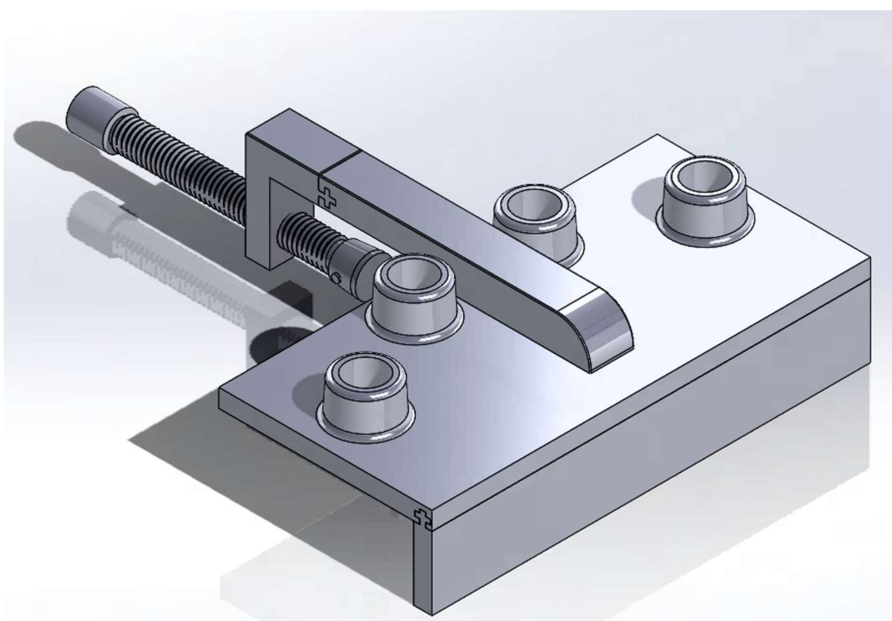

Figure 1 Isometric Hinge Jig

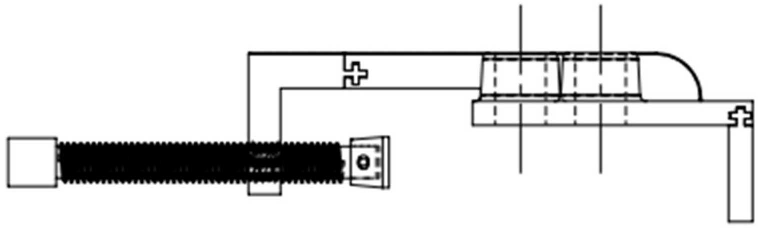

Figure 2 Front View of Jig

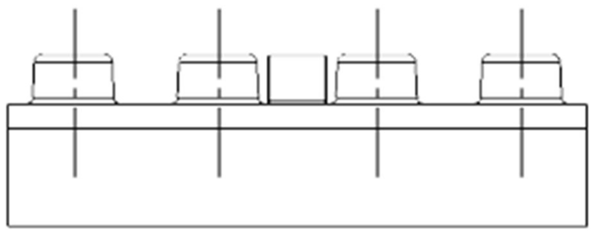

Figure 3: Side View of Jig

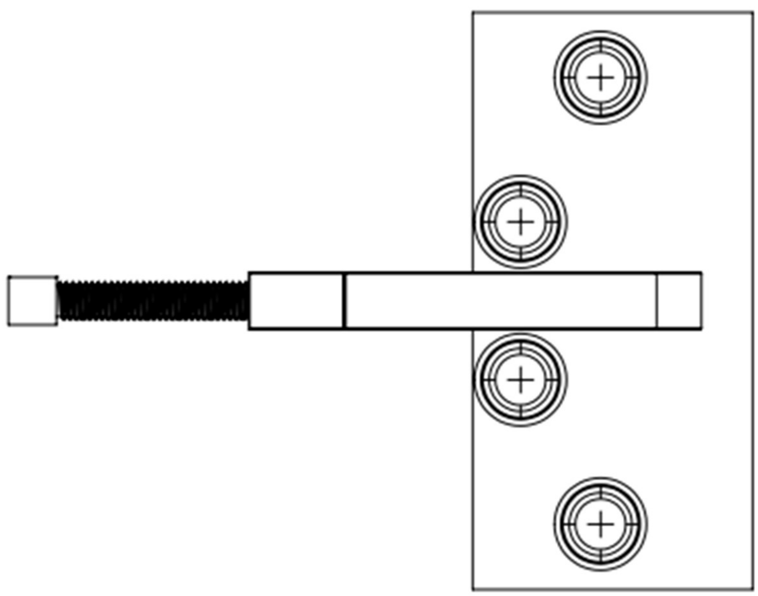

Figure 4: Top View of Jig

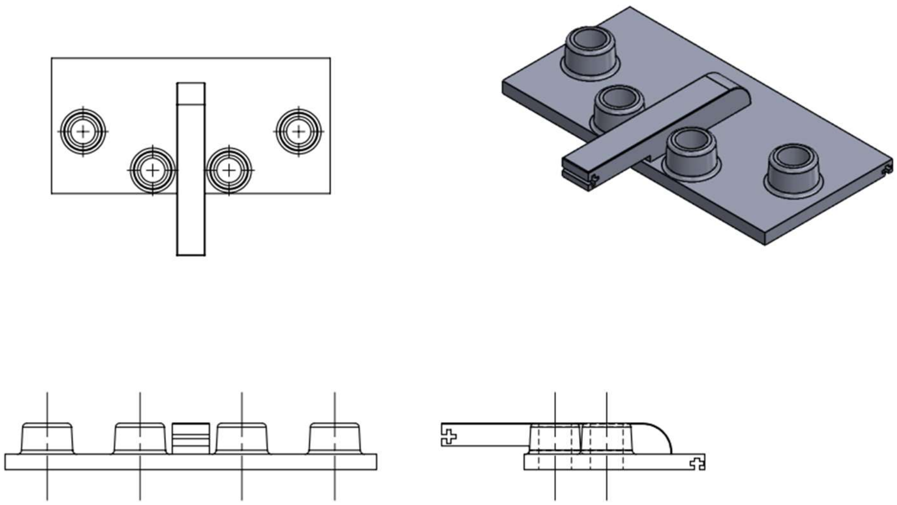

Figure 5: Jig Base Plate

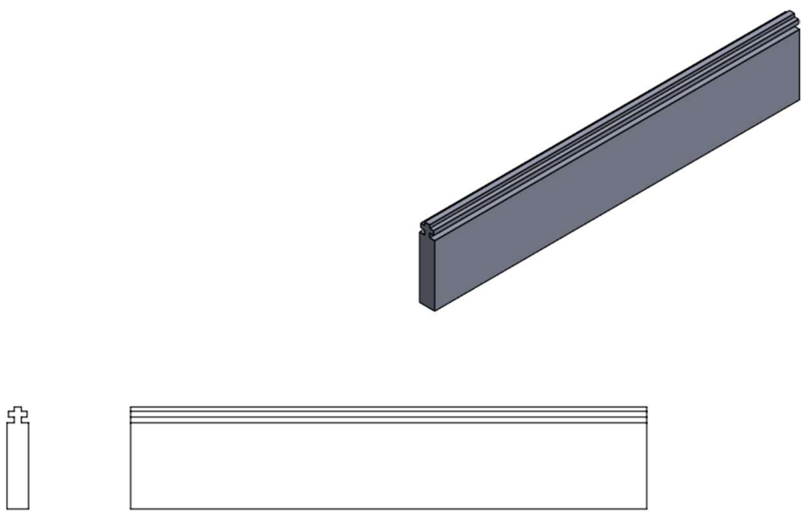

Figure 6: Support Plate

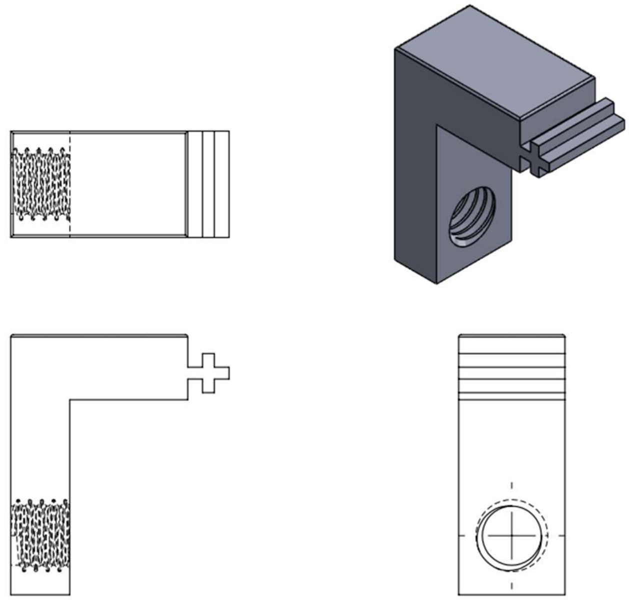

Figure 7: C-Clamp Base

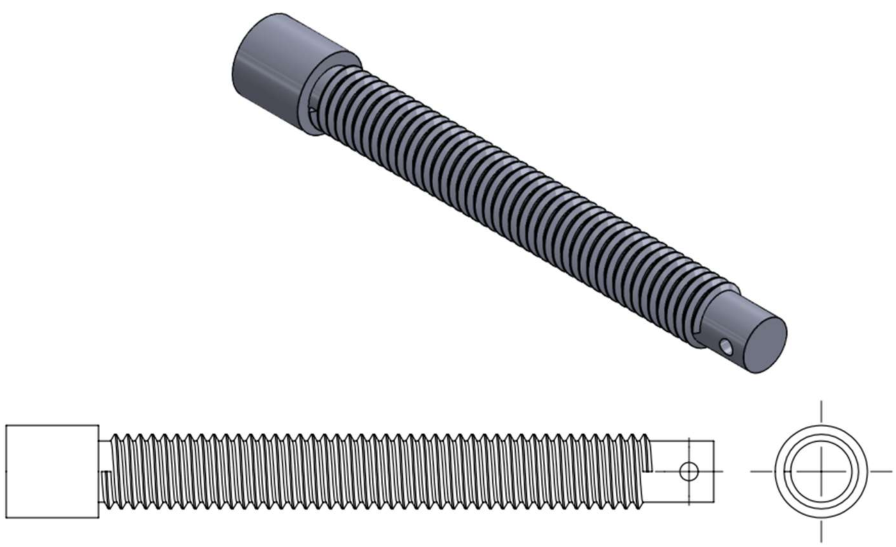

Figure 8: C-Clamp Screw

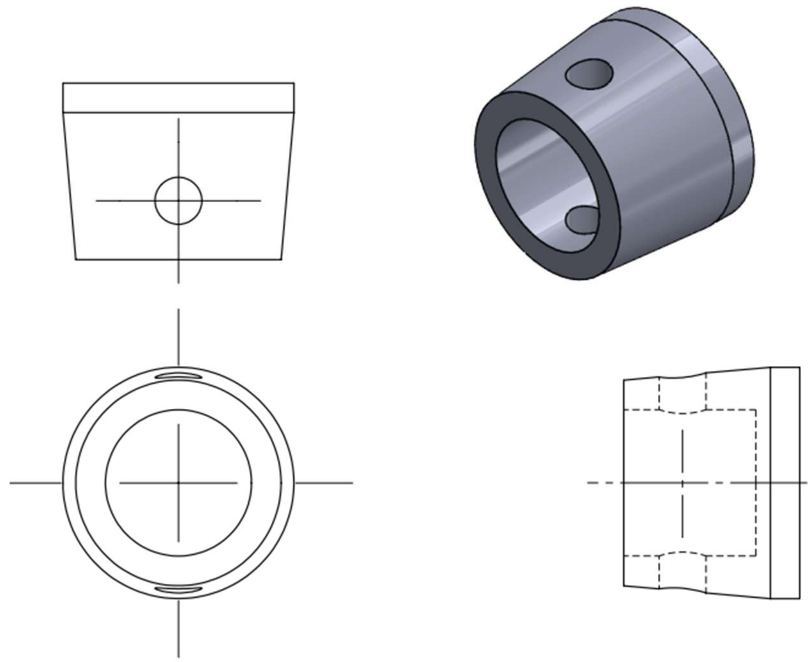

Figure 9: Finisher

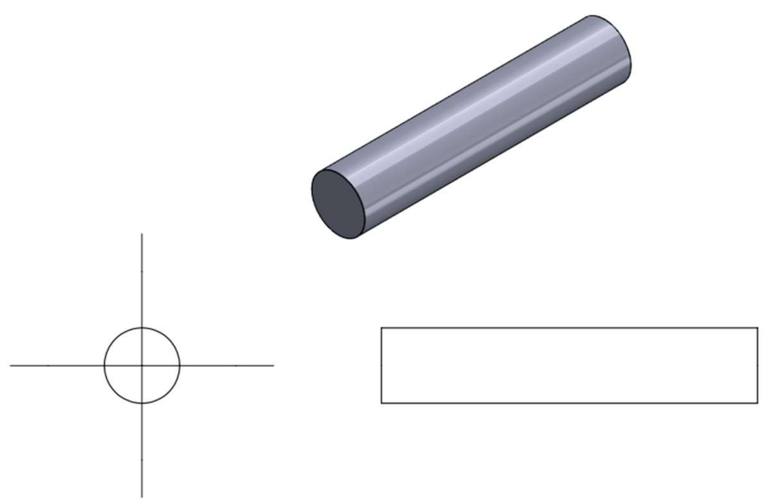

Figure 10: Pin

Figure 11: Stretchable Sealing Cap [1]

Materials/Equipment

Equipment needed:

- Laptop or computer
- 3D Modelling software (SolidWorks)
- 3D-Printer
- 3D Printing filament or resin
- USB
- Laborer
- Calipers and measuring tools.
- A build surface or print bed (Often times included with the 3D printer)
- Adhesion materials (Glue, screws, etc.)
- Safety gear (Glasses and gloves)
- Print removal tools
- Post Processing tools (Sandpaper, files, etc.)
- Brushes and cleaning supplies

Project Risks

Simple: We have made the jig to be a simple design reducing the number of moving parts and points of failure. If there is a failure, we will investigate why the jig failed and attempt to redesign it.

Durable: The jig will be made of a durable material so that it can withstand the hard and rough work that it will be put through. If the jig does not have a high enough durability, we will research better materials to build the jig out of.

Low maintenance: We have made the jig require very little input after initially acquiring the jig. Aside from replacing a rubber buffer on the c-clamp there will be little to no maintenance for the jig. If the jig requires more replacement parts and/or at a more frequent rate, we will investigate either redesigning the jig or changing the material used in the parts.

Easy use: We designed the jig to be easy to use and require little to no prior training to use, this comes from its simple design and the easy-to-change parts. If the jig turns out to be hard to use or the parts become difficult to replace, we will investigate why and adjust the jig accordingly.

Both Jig's prototypes will be made in MLA Plastic for 3D Printing since using plastic in 3D printing is beneficial for prototyping. Indeed, using MLA plastic is more cost-effective than traditional manufacturing methods. In addition, MLA plastic provides design flexibility since it can be tailored to meet different needs. Finally, prototyping in MLA Plastic for 3D Printing will allow our team to make sure the jigs meet performance criteria before investing in expensive tooling and production.

Table 1: Bill of Materials for 4.5" Hinge Jig

Component	Workhours	Labour	Materials	Total
Base	2.25 hours	N/A	2.35in3 (38.51 grams) x $0.13/gram [2]	5.01

Base Plate	1.5 hours	N/A	0.69in3 (11.31 grams) x $0.13/gram [2]	1.47
C-Clamp Base	1 hour	N/A	0.18in3 (2.95 grams) x $0.13/gram [2]	0.38
C-Clamp Screw	0.5 hours	N/A	0.18in3 (2.95 grams) x $0.13/gram [2]	0.38
Finisher	0.5 hours	N/A	0.02in3 (.33 grams) x $0.13/gram [2]	0.04
Pin	.1875 hours	N/A	0.01in3 (0.16 grams) x $0.13/gram [2]	0.02
Sealing Cap	N/A	N/A	1 x $2.88 [1]	2.88
			Total	$10.20

Table 2: Bill of Materials 5" Hinge Jig

Component	Workhours	Labour	Materials	Total
Base	2.5 hours	N/A	2.54in3 (41.62 grams) x $0.13/gram [2]	5.41
Base Plate	1.75 hours	N/A	0.77in3 (12.62 grams) x $0.13/gram [2]	1.64
C-Clamp Base	1 hour	N/A	0.18in3 (2.95 grams) x $0.13/gram [2]	0.38

C-Clamp Screw	0.5 hours	N/A	0.18in3 (2.95 grams) x $0.13/gram [2]	0.38
Finisher	0.5 hours	N/A	0.02in3 (.33 grams) x $0.13/gram [2]	0.04
Pin	.1875 hours	N/A	0.01in3 (0.16 grams) x $0.13/gram [2]	0.02
Sealing Cap	N/A	N/A	1 x $2.88 [1]	2.88
			Total	$10.80

Risk Assessment and Contingency Planning

A primary risk during the fabrication of our prototype would be falling behind schedule. The printing of all the components for our first prototype will take a lot of time and nothing else in the project can be accomplished until the full prototype is completed. The only way to alleviate this is to be as efficient as possible while manufacturing. By using multiple printers to make each component and making sure that jams are kept to a minimum, we can finish this step and move on to the testing phase. We can use 3 printers and have the base printed on the first, the base plate printed on the second and the other components printed on the last printer. This way the prototype can be completed in the time it takes to make the base.

As outlined in the previous paragraph, 3D printers have the tendency to jam and stop printing which causes delays in our plan. Jams can be caused by a multitude of factors, but the main three are; the filament being fed too fast and not being adequately melted, the spool of filament being under a large amount of tension and the spool of filament being under not enough tension. All these factors can lead to delays if a jam goes unresolved for too long. The resolution to this would be to have someone watching the progress of the prototype’s printing constantly, being on standby to fix anything and clean/ prepare finished components for assembly.

A factor to consider as a risk would be the temperature of the plastics, a 3d printer melts the plastic filament to then be extruded. As a result, the finished product will be hot enough to cause burns. The temperature will also affect the strength of the final build quality and should be kept between the manufacturers' recommendations.

Another risk in 3 printing are the byproducts created by the printer. There are small nanoparticles of plastic generated and toxic fumes from the melting plastic, both of which are harmful to humans in large quantities. To mitigate the risks associated with being in contact with these harmful substances, we'll be printing the maker space, a well-ventilated room in Stem which will reduce our contact with airborne substances. We will also only approach the working surface when the printer is off or is jammed.

In conclusion, the risks associated with making the prototype are:

- Wasted time.
- Printing takes a long time.
- Dangerous byproducts.
- Temperature.

Our contingency plans:

- Be efficient.
- Be aware of dangers.
- Double check extrusion temperature.

Total price of prototypes: 4.5" Hinge Jig: $10.20, 5" Hinge Jig: $10.80

Prototyping Test Plan

Table 3: Prototyping Plan

Test ID	***Test Objective (Why)***	***Description of Prototype used and of Basic Test Method (What)***	***Description of Results to be Recorded and how these results will be used (How)***	***Estimated Test duration and planned start date (When)***
1	Functionality	Use both prototypes, drill/tap into a	The holes drilled/tapped will be compared to those in a complete door, and measured for accuracy	Start: Duration: 1 hour

		door to observe results.		
2	Accuracy	Once again using both prototypes	We will be drilling the holes again, but this time we will be comparing the dimensions of the holes, and making sure they line up with the design criteria.	start: Duration: 1 hour
3	Damage	use both prototypes, no need for any drilling.	We will be fastening the prototypes to a door, and applying varying amounts pressure, to see if the coating really does protect the finish.	start: Duration:1 hour

Stopping Criteria

Our team-stopping criteria will depend on acceptance criteria, a series of test cases and data analysis. First, we will use our client criteria as a model for our acceptance criteria. Then, the test cases will assess the performance metrics of the jigs. The performance metrics include hole placement accuracy, consistency, hole diameter, setup time and drilling speed. After we will collect the data and analyze those data to make sure the prototypes consistently meet the acceptance criteria. Finally, when our result are consistent and follows the acceptance criteria, we will stop the tests and it will mean that we achieved our testing objectives.

Acceptable Fidelity

Prototype 1 (Arts and Crafts).

The arts and craft prototype involves the use of 3D modeling so that you have a good visual representation of the prototype to show your ideas effectively and at a cheap cost. Using various materials like carboard, straws, skewers in the physical world modeling the components and ideas of the 3D modeling virtual world. Keeping it at a low cost and following the budget given to ensure you don't fall outside the clients' standards, with this prototype you simply just buy cheap materials. You want to put in as many details as possible into the prototype which could include wires, power supplies, fasteners, connectors and moving parts. If you are using moving parts you want to simulate the motion of the moving part to see if any interference will occur early, so you have the time to fix them without worrying about the time constraint.

Prototype 2 (Blueprint)

When creating a blueprint prototype, you want to have many parts especially If it's a complex system to be able to test out each part. Make sure you have documentation, for example, assembly drawings, electrical schematics, comments in code etc. Keep the documentation and files together for an easy Maker Repo submission. Include any of the calculations for components measurements, material strength etc. Make sure you select the proper manufacturing process for each part keeping in mind the tools that you have or don't have. Try and use parts and materials that are easily accessible.

Prototype 3 (Puzzle)

Assembly and troubleshooting will take longer than anticipated so you will want to give yourself time to work out any kinks or problems that will occur when assembling. You want to compare the prototype to the product. You will be testing the different components than what would be in the final product. For example, you'd be using wood, plastic, glue instead of metal parts and proper materials that you would use in the final product. You want to make sure the aesthetics and finishing are taken into consideration to look like a proper prototype/product and not some arts and crafts workshop. It needs to be presentable, you can use paint, sealant etc.

Our Prototype uses many of these prototype's attributes for example, we use some moving parts like the clamp which we will have to assemble. We also use 3D printing to create our prototype, we might also use different materials with the 3D printing, but we aren't at the creation step yet. The 3D printing material is used to keep the cost low and to mimic a metal/wood material that we would use to create the final product, we are using the 3D printer to have a quick and easy prototype given our time constraint We have however made blueprints on CAD and created a virtual prototype which incorporates assembly drawings/sketches with the dimensions and schematics. We have also made some small calculations of the dimensions for the jig given by our client. We used these calculations when creating the drilling/tapping holes for our jig. We have also done some calculations for the cost of materials for the 3D printing as well as the calculations for the benchmarking. We will be doing/running tests on our jig to ensure it fits the client's needs. We will be testing out the jigs clamping ability so that it creates a strong and secure working area but also ensures that no damage to the wood finish will occur.

Wrike Link:

https://www.wrike.com/workspace.htm?acc=4975842&wr=20#/folder/1215239062/timeline3?viewId=202489442

References

[1] McMaster-Carr, [Online]. Available: https://www.mcmaster.com/3837N13/.

[2] "3D printing cost ABS," MakerSpace, [Online]. Available: https://makerstore.ca/shop/ols/products/abs-per-gram.