Hingineers

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Abstract

This deliverable is about the conceptual design of our project, within the conceptual design the reader will understand the subsystems that were created for the project, pros and cons of each idea, ideas that were chosen to be used on the prototypes, and ideas that did not work out or make it to the final prototype's. There will be 6 subsystems of which at least 3 of them will be transferred over to the final design. This document also contains group 17's rating of how well the design fits our benchmarking specifications from deliverable C.

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1. Hinge-Jig Sub-systems

The design of our prototype of the hinge-jig is built up from six different subgroups. These subgroups are the jigs attachment to the door, changing between various hinge sizes, an

automated vs. manual design, switching between drilling wood and tapping, drilling straight holes in the door frame, and how the jig is going to be operated.

1.1 Jig Attachment to the Door

This sub-system focuses on the part of the final jig that will hold on to the door. This is crucial to the final jig as it is necessary for the jig to come in contact with the door in order for it to be steady while in operation and or just easier to use.

1.2 Changing Between Various Hinge Sizes

This sub-system in the design allows the user to change the sizes between each hole drilled in the door to fit any sized hinge. This is crucial to the final product as the main goal of the client is to save time by having a jig that can easily be adjusted to any size on the spot.

1.3 Automated vs. Manual Design

For this sub-system, the group focused on finding a design that can accommodate a jig for both using it automatically or manually. This is important to look at as the client may want to have an automatic design that can create all the holes easily in one go rather than having someone hold the jig manually and do it or vice versa.

1.4 Switching Between Drilling Wood and Tapping the Door

This sub-system focuses on how the door hinges will be drilled knowing that there is a thin piece of wood attached to a steel frame. By including this sub-system, we can find a way that this very important because tapping and drilling are very different processes and without having an efficient way to tap holes in the door, a drill will slip without piercing the steel.

1.5 Drilling Holes Straight Through the Door

This sub-system focuses on finding a way to easily drill holes into the door frame without it going in at an angle. This is very important to the final jig as some holes and doors must be redone if holes do not match the same spec as the screws being screwed into them causing overall efficiency of the business to go down.

2. Designs

2.1 Subsystem 1: How is the Jig Attached to the Door?

Chayton Munro

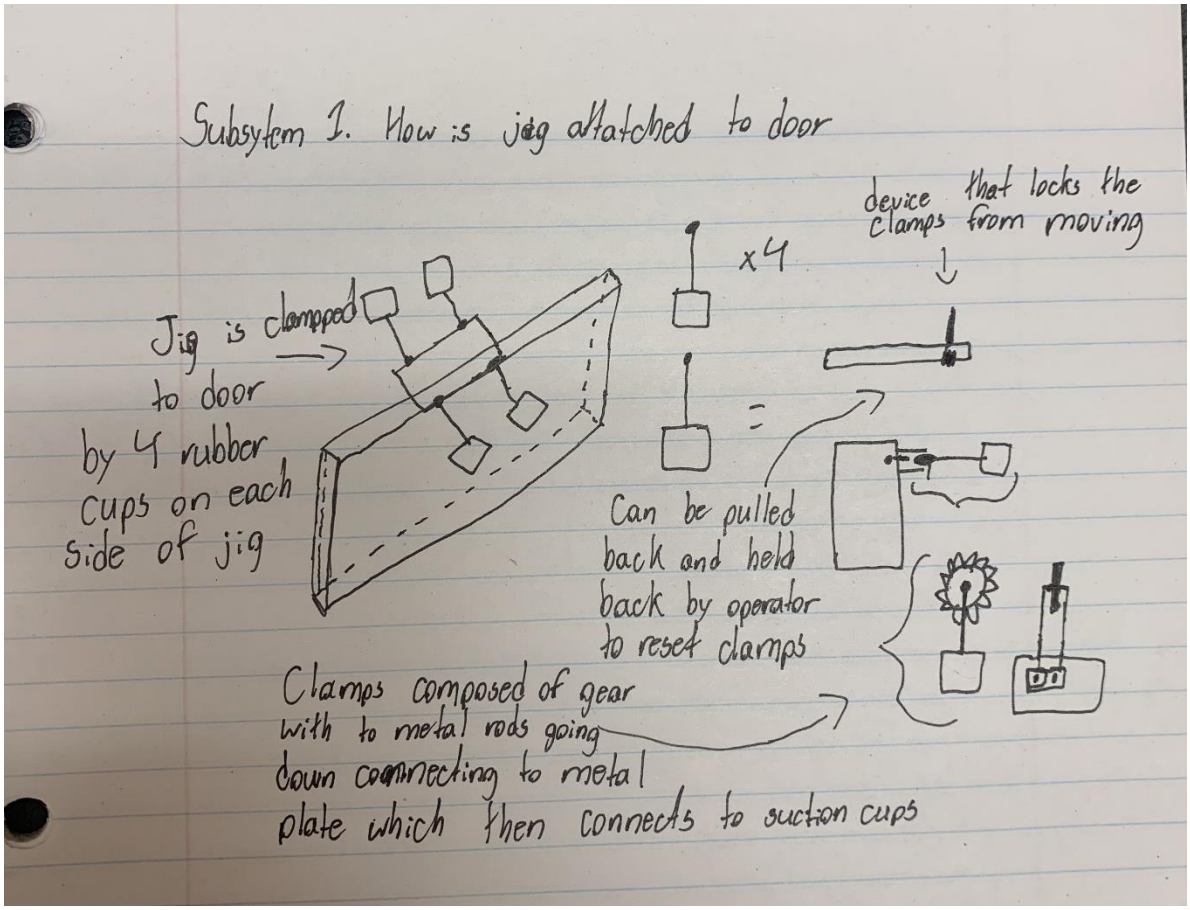


Figure 1: Subsystem 1 - Chayton

Pros:

This design is more mechanical than a simple slide-over jig but being mechanical means that this can be tightened more or loosened if needed and can be adjusted based on the door or other factors.

Cons:

Is more mechanical so therefore more moving parts which means more things more likely to fail and break.

If clamped to tight this device could damage the door resulting in starting the door-making process all over.

Evan Trainor

The jig will simply slide over the door and slide into the cut out.

The pros of this are that it is very simple and quick to set up and remove the jig. A con is that if the jig contains any extrusions from poor manufacturing or damage then the jig will have the potential

to damage the door.

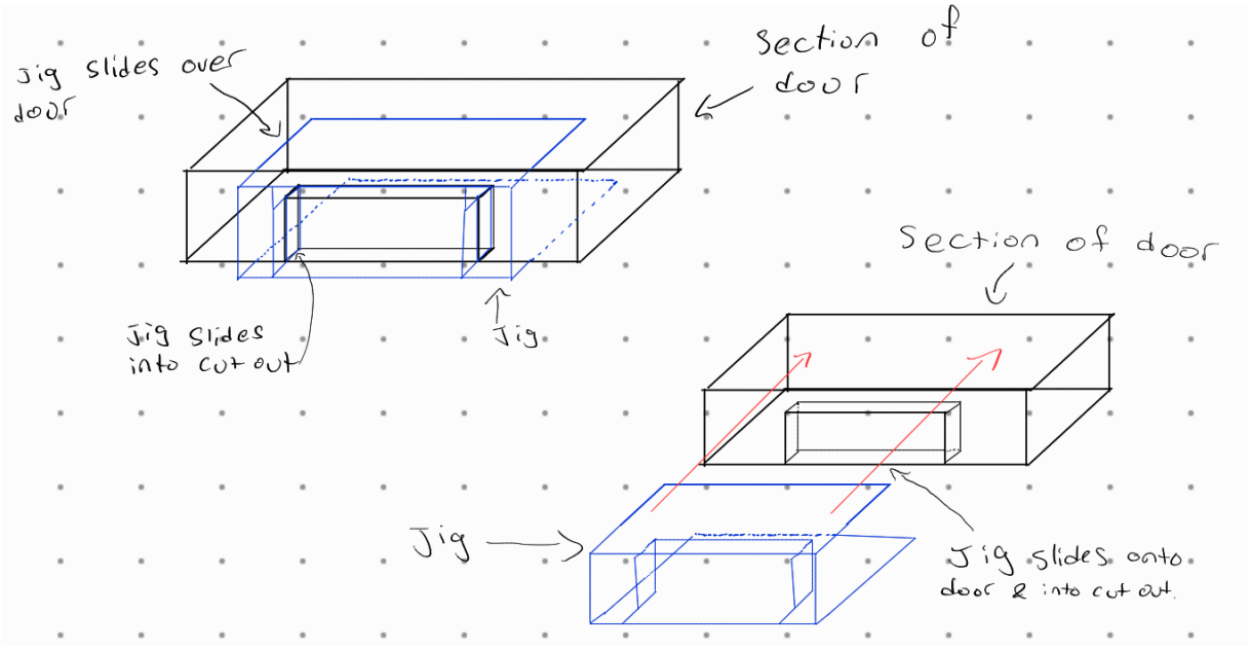


Figure 2: Subsystem 1 - Evan

Mehdi Boudjemline

The jig will feature friction clamps that feature adjustable straps that can account for different widths of many doors. The straps can then be tightened around the door to hold the jig in place to keep it stable enough for drilling/tapping.

A pro is that the jig can be used on doors with varying widths and can loosen/tighten clamps when necessary, however a con is that the adjustable length of the straps may not be secure enough to withstand extra potential movement caused by the drill.

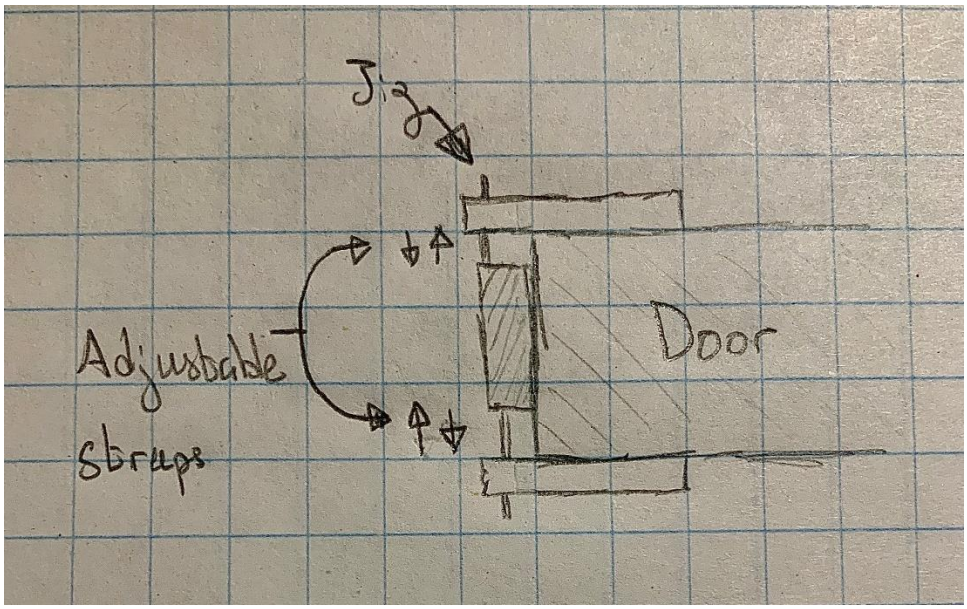


Figure 3: Subsystem 1 - Medhi

George Omoregie

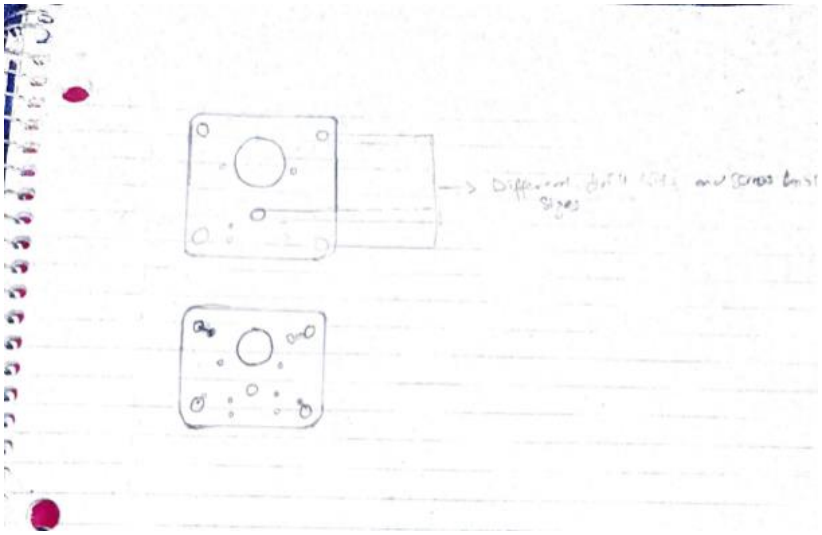
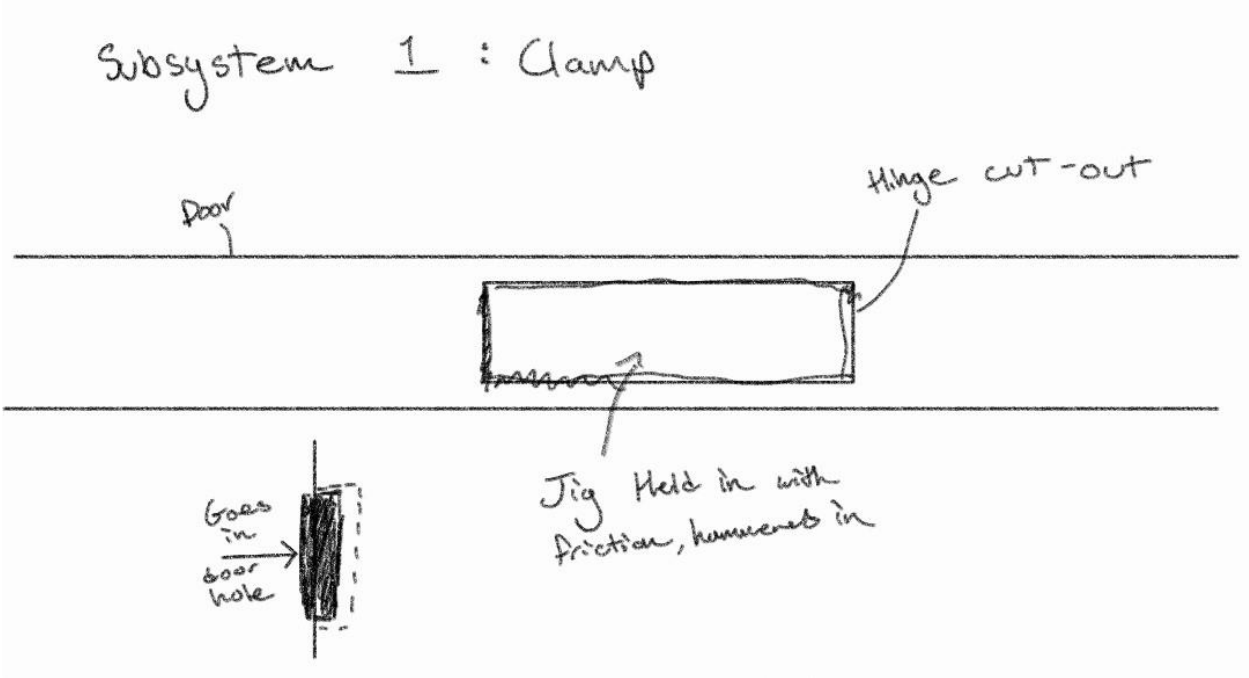


Figure 4: Subsystem 1 - George

To attach this jig to the door, position it where you want the mounting plate, secure it using clamps, drill holes through the jig guides, and then fasten the mounting plate using the holes you drilled. This ensures precise alignment and accurate hole drilling for mounting.

Andrew Stepanenko



This jig design will have friction clamp design such that you can just push it into the frame of the cutout in the door that is created before drilling. This way there is no clamps to clip on and waste time on.

Pros:

- easy to attach
- very simple
- no moving parts

Cons:

- will wear the material over time
- might ruin the door frame

2.2 Subsystem 2: How to Change Between Various Hinge Sizes?

Chayton Munro

Pros:

Quick and easy to swap between settings.

Cons:

The swapping mechanism could easily stop working or move whenever you're drilling/tapping.

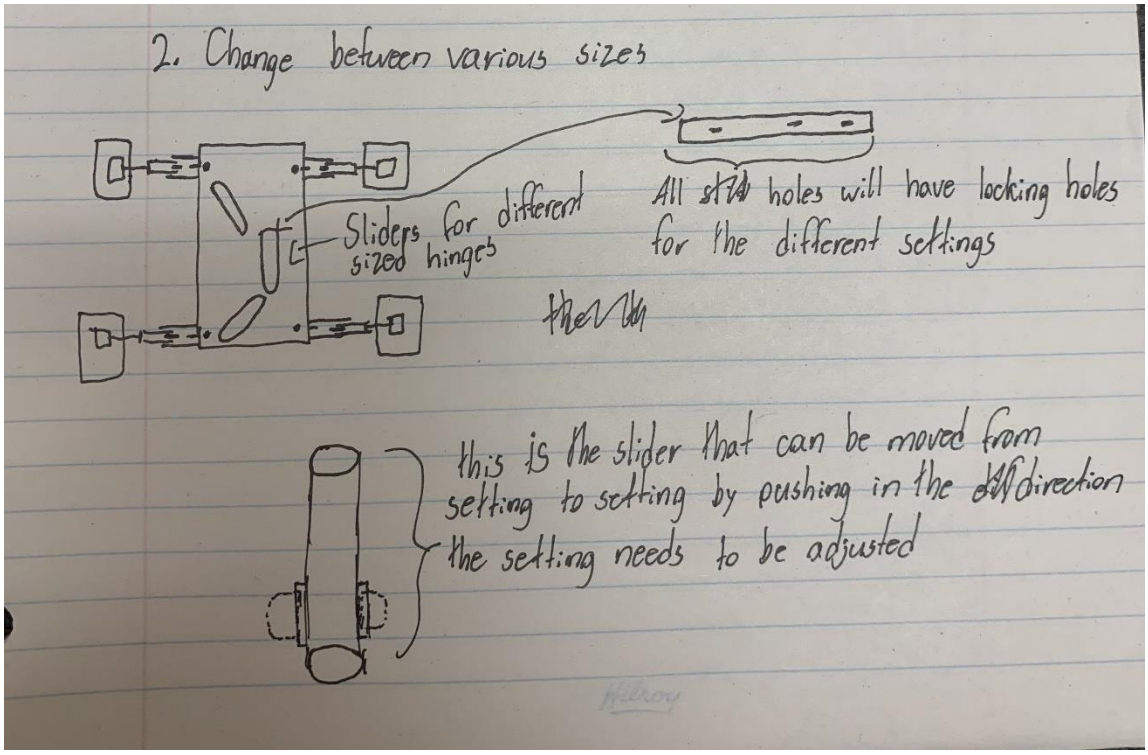


Figure 5: Subsystem 2 - Chayton

Evan Trainor

A new jig will be needed to accommodate the various hinge styles and back set lengths. The jigs will be marked with their size and/or they will be colour coded to make the size clear.

The pro is that it there is no complicated system needed to switch between the hinge sizes. A con is that between the drilling and tapping jigs, the two different hinge sizes and the two different back set lengths there will be 8 different types of jigs needed. It may be challenging to store all of this in the work area.

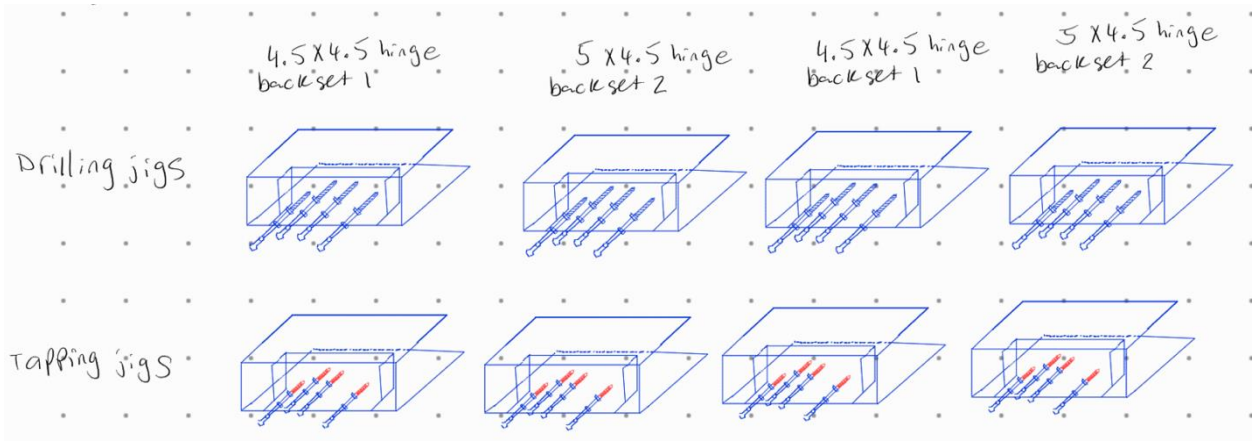


Figure 6: Subsystem 2 - Evan

Mehdi Boudjemline

My proposed jig features two molds that are exact replicas of the two common door hinges used by AMBICO that can slide in and out of the frame of the jig when needed. Because its straps are adjustable, the jig can thus account for different backsets required by the labourer/customer. The frame of the jig should be large enough to work for the largest door hinge commonly used.

An alternative to this is inserting the molds directly into the inner frame of the jig to minimize the size of the jig, but a notable con of this is that the molds will naturally be detached from the jig itself, as opposed to the sliding mold idea proposed above.

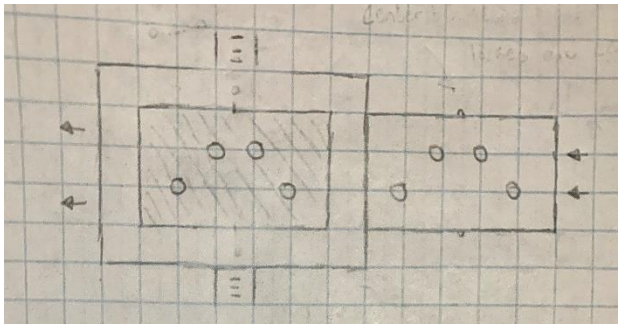


Figure 7: Subsystem 2 - Medhi

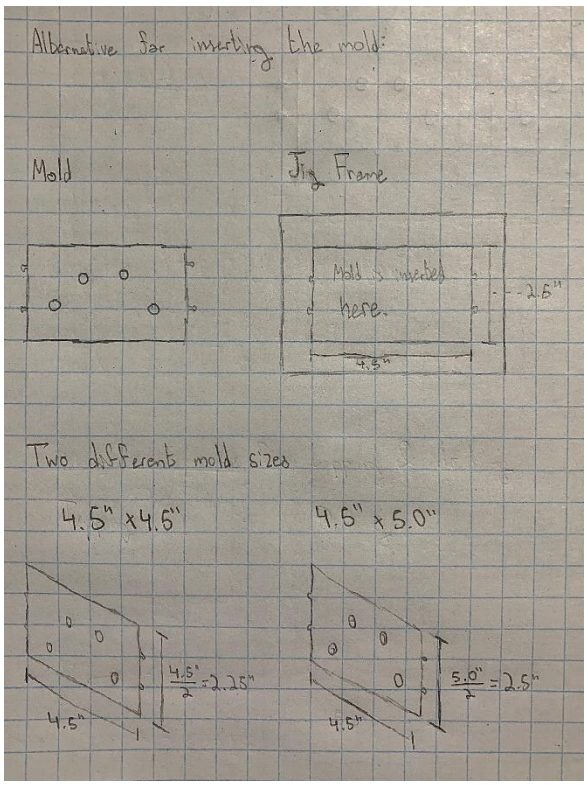


Figure 8: Subsystem 2 - Medhi

George Omoregie

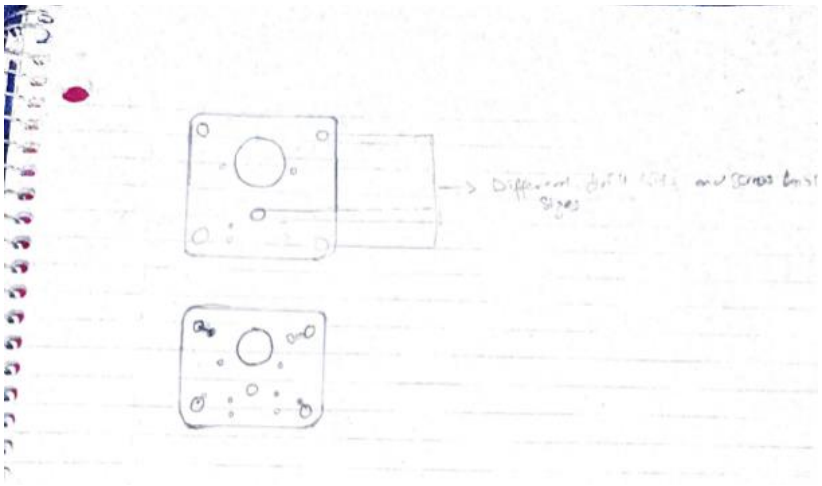


Figure 9:Subsystem 2 - George

We'll need a new subsystem to handle the wide variety of hinge styles and back set lengths found in cabinet hardware. I propose structuring it with a neat marking system, perhaps size labels or color codes on the jigs for easy identification.

The beauty here is in its simplicity—no intricate mechanism needed to switch between hinge sizes. However, the challenge face with this subsystem with multiple jigs is due to varying hinge sizes and back set lengths. We're looking at eight distinct jig types when we factor in all the hinge possibilities. Wrangling these jigs in the work area could be a very difficult.

Andrew Stepanenko

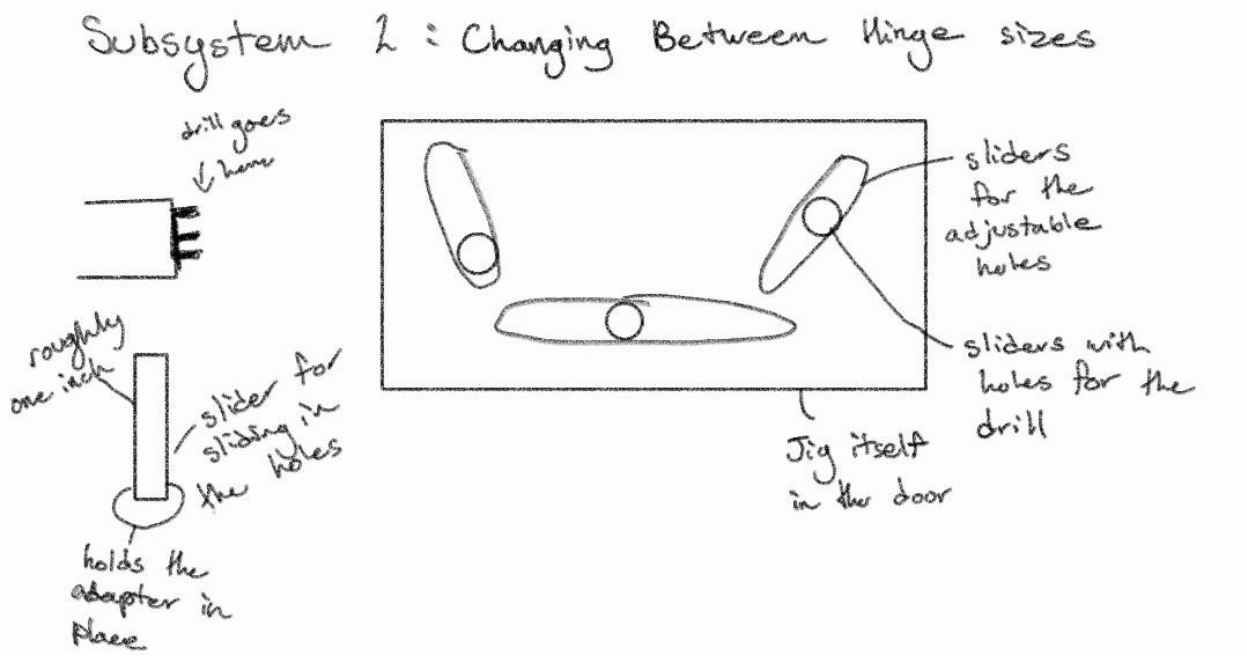


Figure 10: Subsystem 2 Andrew

This design will adapt to various hinge size screws by moving the holes individually with your hand or a machine. By having a cutout for the adapters to move around in 3 different cutouts, you can find endless sizes and variations in hinge sizes by doing this.

Pros:

- Endless variations in distances between the screws
- Easy to move parts
- Cant fallout

Cons:

- Possibility to move around while using from friction of the door vibrating.

2.3 Subsystem 3: Automated vs. Manual Design

Chayton Munro

Pros:

Cost efficient as you only have to have a handheld drill and make sure the batteries are charged.

Don't have to have a fully separate drilling machine for the jig.

Cons:

Operator still has to be there doing things.

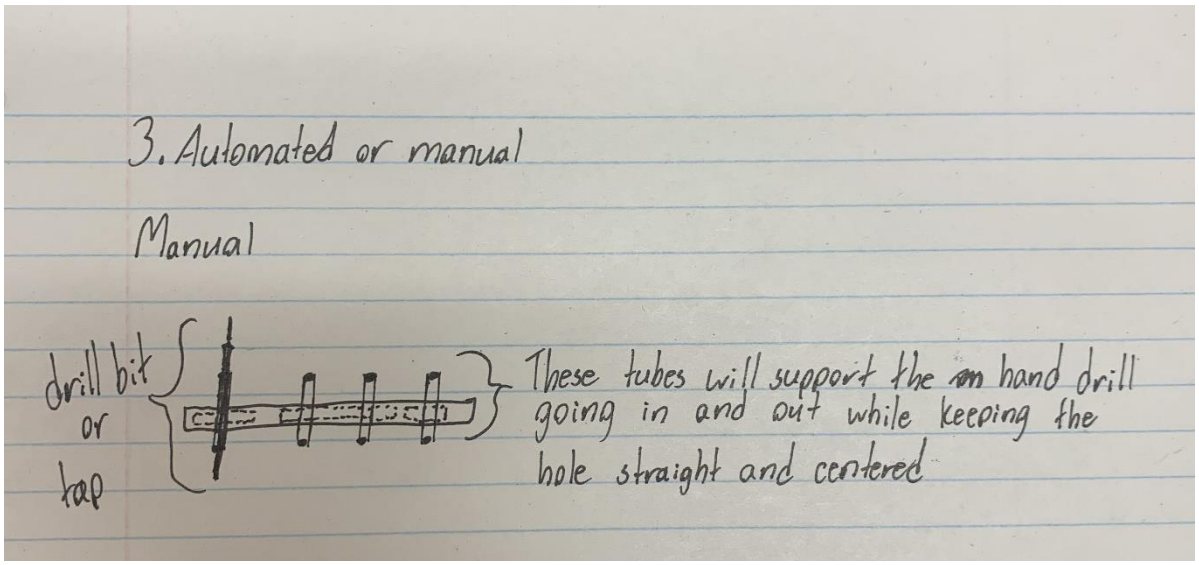


Figure 11: Subsystem 3 - Chayton

Evan Trainor

This jig requires manual operation. The labourer will slide the drilling jig into position, then use the hex quick connect to attach the drill to the individual holes. Once the holes have been drilled the labourer

removes the drilling jig. The labourer will apply grease to each tap on the tapping jig and slide the tapping jig into position. From there, the labourer can attach the drill to the taps using the hex quick connect and tap each hole.

A pro of this design is that there it is very simple meaning, there is almost no additional training needed for the labourers. A con is that there is a possibility of a labourer grabbing the wrong sized jig and drilling the wrong holes.

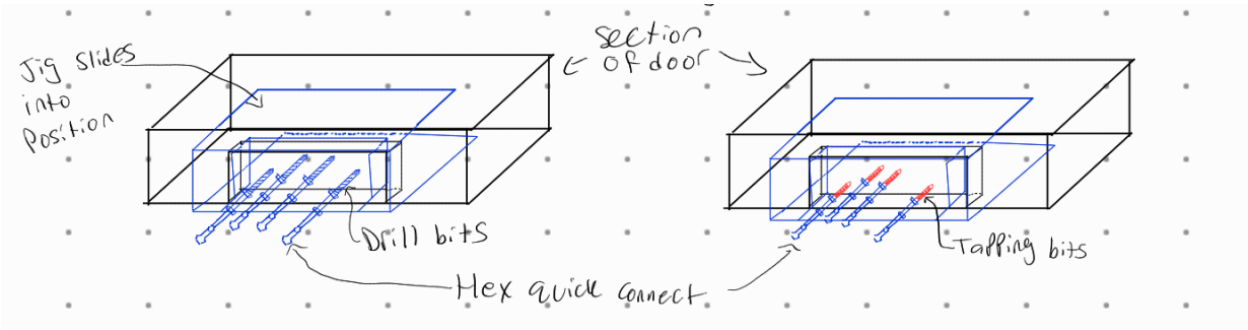


Figure 12: Subsystem 3 - Evan

<u>Mehdi Boudjemline</u>

This jig will be manually used but will still be easy to use. The labourer must simply adjust the clamps to be a tight fit on the front and back of the door while the frame of the jig is to be pressed against the side of the door for maximum stability, with straps adjusted for the relevant backset. Once the jig is in place, the appropriate mold size can be slid in.

A potential con of this is that there is no indicator for which mould is what size, therefore the labourer must look closely to find the difference in size, or a label must be carved into the mould.

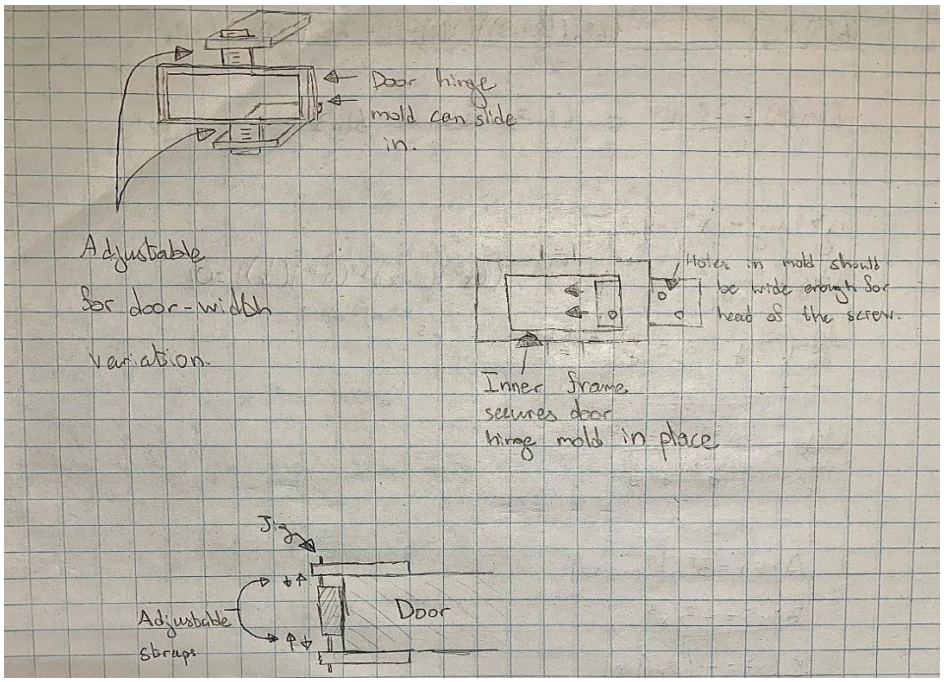


Figure 13: Subsystem 3 - Medhi

George Omoregie

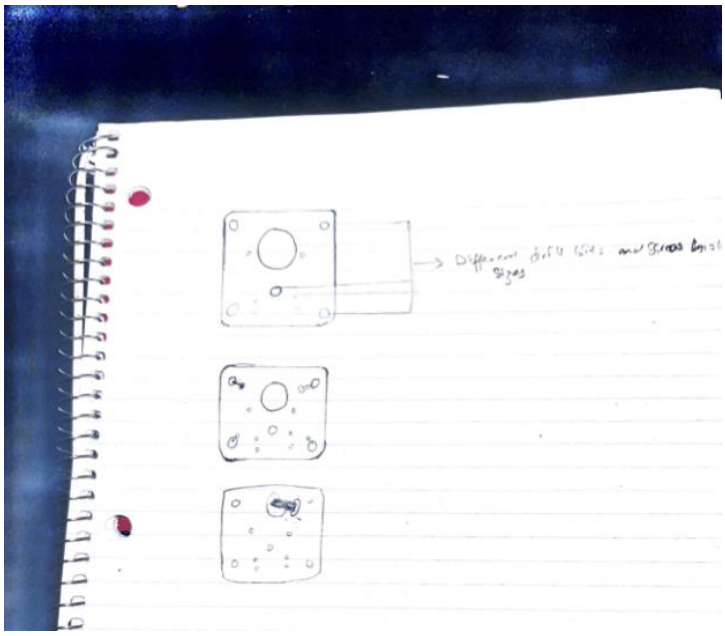
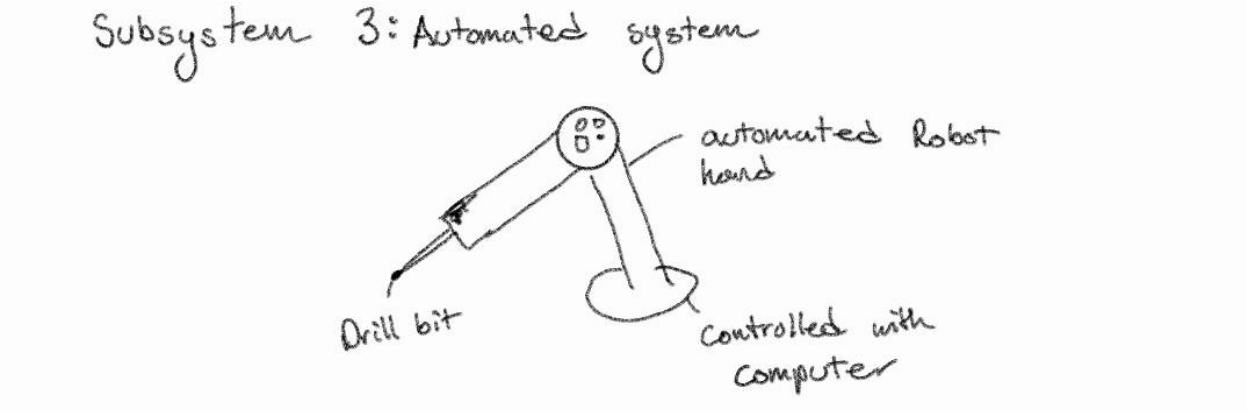


Figure 14: Subsystem 3 - George

The jig will support both automated and manual operations. It can integrate with computer-aided drilling systems for precise drilling controlled by a computer. Alternatively, it will have ergonomic features for easy manual handling and drilling by the user. This design ensures flexibility in operation based on user preferences and specific drilling requirements

Andrew Stepanenko



By having a robot to drill the holes, you can have an arm that is super steady, and drills straight controlled from any part of the world through the internet. This option is expensive but depending on how much they want to use it, it could be beneficial to invest to save time on each door.

Pros:

- Steady
- Accurate

- Controlled from anywhere
- Versatile

Cons:

- Expensive
- Needs power to work
- Takes up a lot of space

2.4 Subsystem 4: How do we Switch Between Drilling and Tapping it?

Chayton Munro

Pros:

Quick and easy.

Cons:

Not automated.

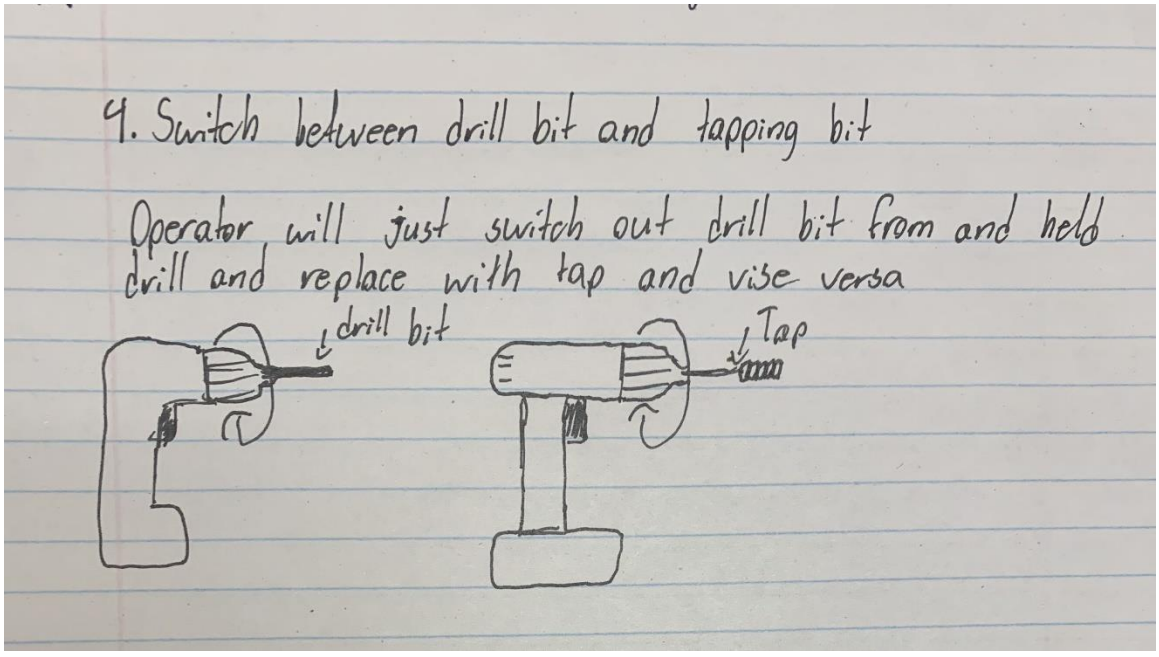


Figure 15: Subsystem 4 - Chayton

Evan Trainor

Once finished drilling the labourer will select the appropriate tapping jig, apply grease to each tap. Then, the jig will slide onto the door and the drill can be connected to the taps using the hex quick connects.

A pro of this design to this design is that each tap can be greased at the same time, thus reducing the total time to tap each hole. A con is it may be difficult to grease taps if the labourer has poor dexterity.

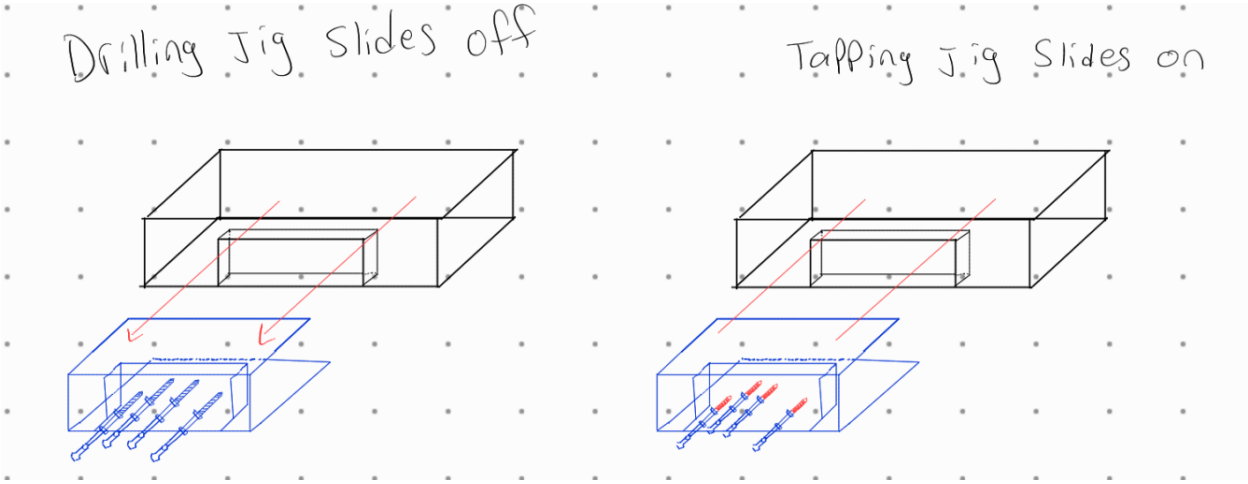


Figure 16: Subsystem 4 – Evan

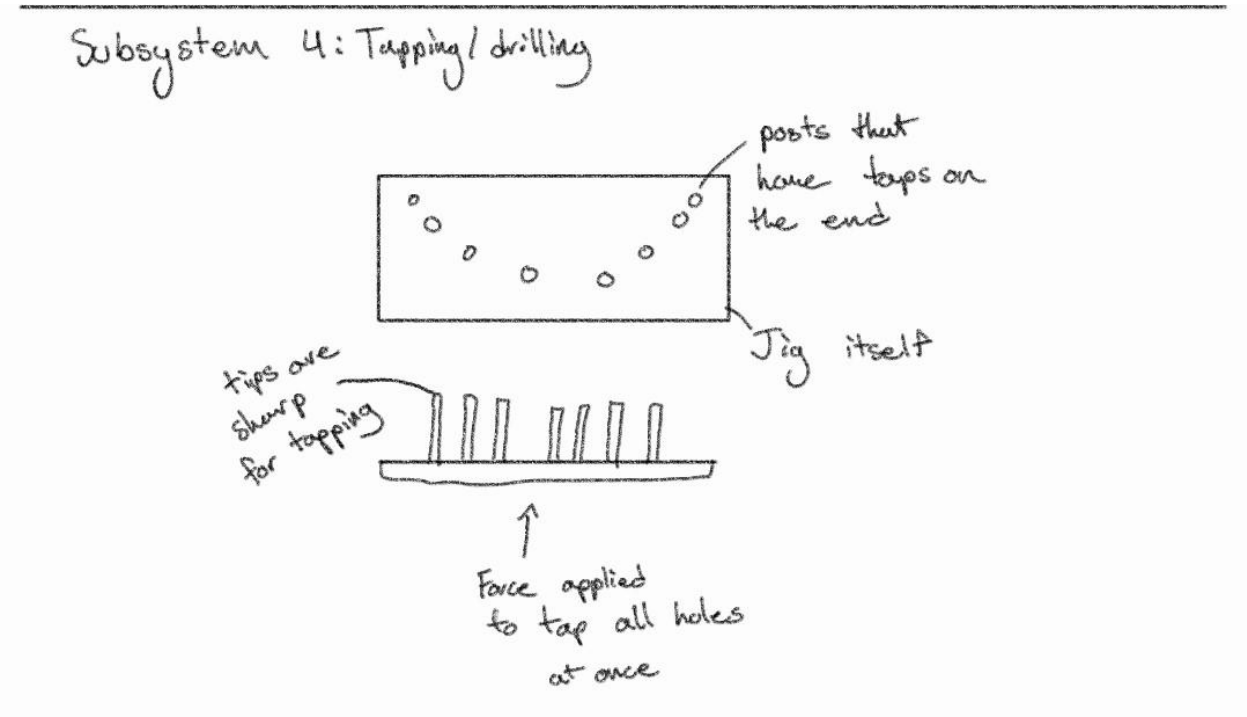
Mehdi Boudjemline

The jig is only able to help stabilize the position of the tapping tool and does not possess any actual feature to improve on the tapping process itself. However, the mold that holds in place must not be damaged by the greasing process and should be able to withstand accidental scratches and such by the tapping tool.

George Omoregie

To switch between drilling and tapping the door, a new subsystem is needed to handle the diverse hinge styles and back set lengths in cabinet hardware. This subsystem will utilize a clear marking system like size labels or color codes on the jigs for easy identification. The advantage is its simplicity, requiring no intricate mechanism to switch between hinge sizes. However, managing multiple jigs for various hinge sizes and back set lengths presents a challenge. Eight distinct jig types will be required to cover all hinge variations, and organizing them within the work area may pose difficulties

Andrew Stepanenko



This subsystem design is on flat piece that can tap all the holes at once. The jig also has adjustable tapping sticks out such that it can be used on any hinge design. The tapping works by applying a pressure with your hand from the back and that will activate all of the tapping tips and create multiple indents in the door.

Pros:

- Easy to use
- No movable parts other than the tappers
- Adjustable
- 1 step usage

Cons:

- Adjusting will be difficult to implement easily
- Oiling all of the tips at once could be difficult

2.5 Subsystem 5: How to Drill the Holes Straight in the Door?

Chayton Munro

Pros:

Easy to keep the drill and tap in line when starting to drill.

Cons:

Tubes may have to be replaced after a while from the drill and taps

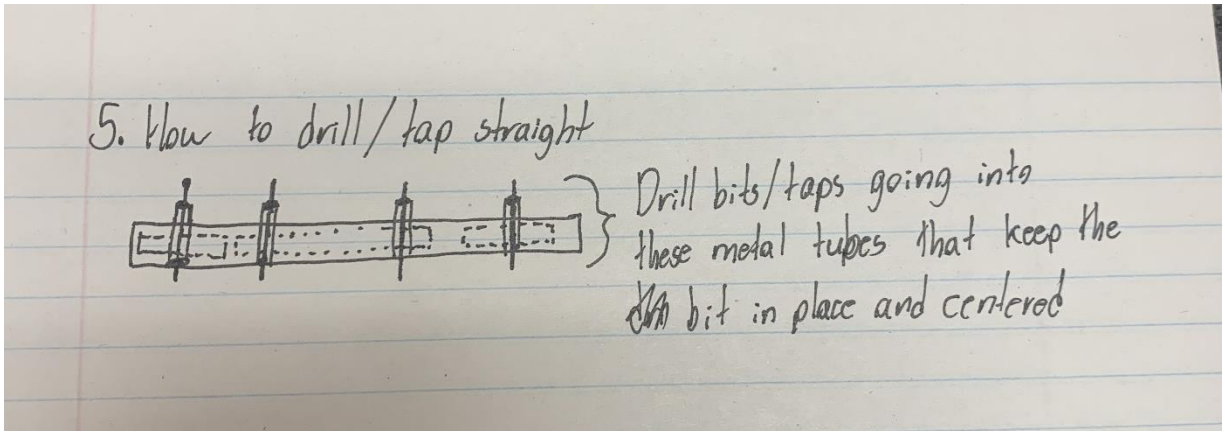


Figure 17: Subsystem 5 - Chayton

Evan Trainor

The jig will have the drill bits built into them. This will keep the bits straight as the labourer drill through the door.

The pro to this is that it is very simple, it will require very little extra training to operate. A con is that if the jig gets warped or damaged then the holes could be drilled in the wrong spot.

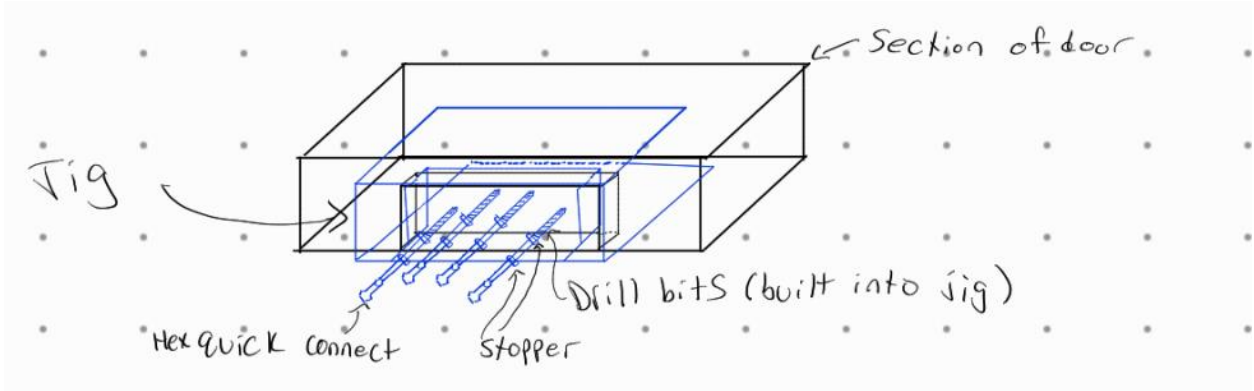


Figure 18: Subsystem 5 - Evan

Mehdi Boudjemline

The molds may feature elongated holes to ensure that the screws stay as close to being perpendicular to the door as possible. A con of this idea is that if the sliding molds are used, it may be more difficult to slide the taller molds in and out of the frame.

Figure 19: Subsystem 5 - Medhi

George Omoregie

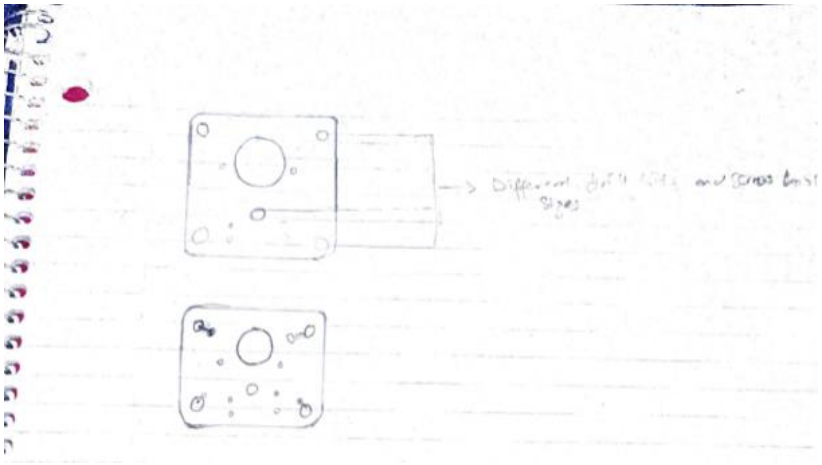
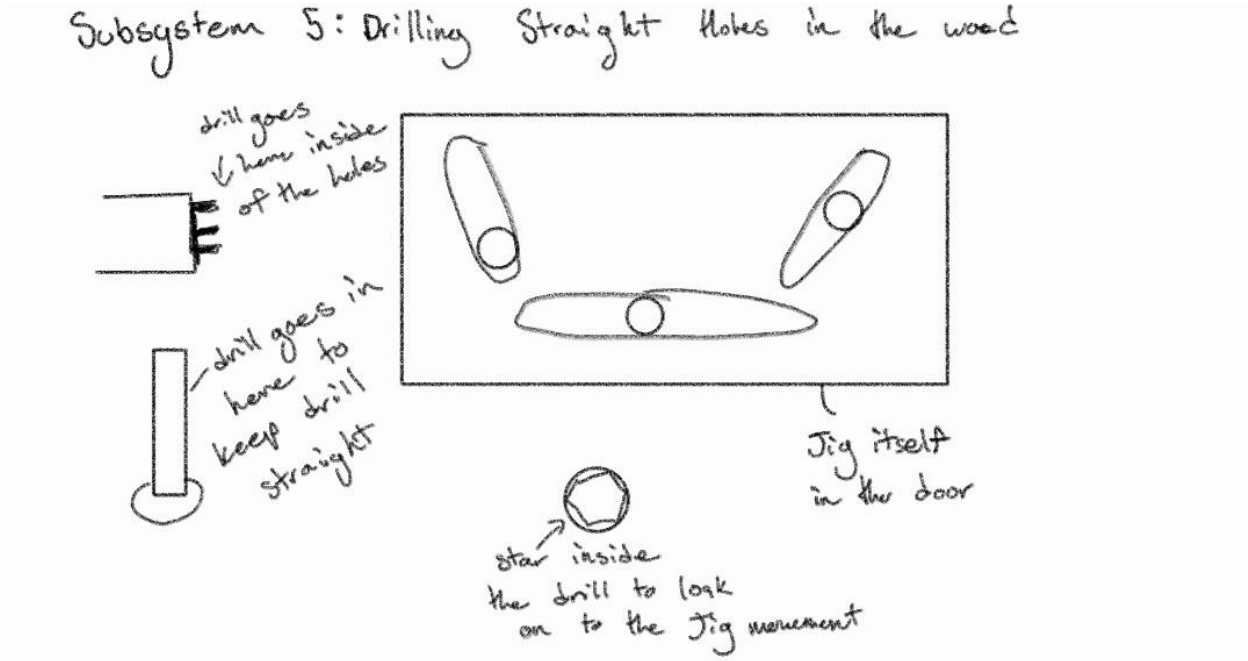


Figure 20: Subsystem 5 - George

To drill holes straight in a door for mounting hinges or hardware, start by accurately marking hole positions using a square and pencil. Use a center punch to create starting points for drilling. Choose an appropriate drill bit size for the holes. Secure the door firmly to prevent movement during drilling. Set the drill to a medium speed and drill perpendicular to the door. Control the depth to avoid drilling too deep. Clean the holes from wood shavings after drilling. Finally, double-check hole alignment and positions for accuracy.

Andrew Stepanenko



This design of the subsystem uses metal posts to hold the drill bit straight as it gets drilled into the door. The posts are adjustable and can be implemented easily with the other subsystems. The holes will have a cutout inside so that the drill cannot be moved side to side, only be used up and down for drilling.

Pros:

- Easy to use
- Adjustable
- Fits with other designs
- Compact

Cons:

- Could get jammed
- Lots of moving parts can cause part to shake a lot

3. Evaluation of the Sub-Systems Designs

Given that we have many ideas for each sub-system, the concepts from each sub-system is ranked based on the design criteria created in the previous deliverable. The rank is determined by how well the subsystem can solve the issues that were evaluated in the design criteria. The rank range consists of a value between 1 and 3, which are represented by green for 1, yellow for 2, and red for 3.

Table 1: Jig Attachment to the Door

Design Criteria / Global Concepts	Importance	Chayton Munro	Evan Trainor	Andrew Stepanenko	George Omoregie	Mehdi Boudjemline
Speed	1	2	1	1	2	2
Ease of use	1	2	1	1	1	2
Damage to door	1	1	2	2	3	1
Effectiveness	1	2	2	1	2	2
Durability	2	2	3	1	2	1
Will dust affect the subsystem?	1	2	2	3	1	1
Safety	1	1	1	1	1	1

Table 2: Changing Between Various Hinge Sizes

Design Criteria / Global Concepts	Importance	Chayton Munro	Evan Trainor	Andrew Stepanenko	George Omoregie	Mehdi Boudjemline
Speed	1	1	1	2	1	2
Ease of use	1	1	1	1	1	2
Damage to door	1	1	2	1	1	1
Effectiveness	1	2	2	1	2	2
Durability	2	3	3	3	2	2
Will dust affect the subsystem?	1	3	2	2	2	1
Safety	1	1	1	1	1	1

Table 3: Automated Vs. Manual Operation of Jig

Design Criteria / Global Concepts	Importance	Chayton Munro	Evan Trainor	Andrew Stepanenko	George Omoregie	Mehdi Boudjemline
Speed	1	2	2	1	1	1
Ease of use	1	1	1	1	1	2
Damage to door	1	1	2	1	1	1
Effectiveness	1	2	2	1	2	2
Durability	2	1	3	3	2	2
Will dust affect the subsystem?	1	2	2	3	2	1
Safety	1	1	1	2	1	1

Table 4: Switch Between Drilling and Tapping the Door

Design Criteria / Global Concepts	Importance	Chayton Munro	Evan Trainor	Andrew Stepanenko	George Omoregie	Mehdi Boudjemline
Speed	1	1	1	1	n/a	2
Ease of use	1	1	1	1	n/a	1
Damage to door	1	1	2	2	n/a	1
Effectiveness	1	1	2	1	n/a	1
Durability	2	1	3	3	n/a	2
Will dust affect the subsystem?	1	2	2	2	n/a	1
Safety	1	1	1	1	n/a	1

Table 5: Drilling Holes Straight Through the Door

Design Criteria / Global Concepts	Importance	Chayton Munro	Evan Trainor	Andrew Stepanenko	George Omoregie	Mehdi Boudjemline
Speed	1	1	2	1	2	2
Ease of use	1	1	1	2	2	1
Damage to door	1	2	2	3	2	1
Effectiveness	1	1	1	1	3	1
Durability	2	3	3	2	1	2
Will dust affect the subsystem?	1	2	2	2	2	1
Safety	1	1	1	2	1	1

4. Functional Solutions

4.1 Functional Solution 1

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4.1.1 Subsystem 1

Chayton Munro's design.

4.1.2 Subsystem 2

Mehdi Boudjemline's design.

4.1.3 Subsystem 3

Chayton Munro's design.

4.1.4 Subsystem 4

Andrew Stepanenko's design.

4.1.5 Subsystem 5

Evan Trainor's design.

4.2 Functional Solution 2

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Mehdi Boudjemline's design.

4.2.2 Subsystem 2

Andrew Stepanenko's design.

4.2.3 Subsystem 3

Andrew Stepanenko's design.

4.2.4 Subsystem 4

Chayton Munro's design.

4.2.5 Subsystem 5

Andrew Stepanenko's design.

4.3 Functional Solution 3

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4.3.1 Subsystem 1

Evan Trainor's design.

4.3.2 Subsystem 2

Chayton/Andrew's design.

4.3.3 Subsystem 3

Chayton Munro's design.

4.3.4 Subsystem 4

Mehdi Boudjemline's design.

4.3.5 Subsystem 5

Chayton/Andrew's design.

5. Best Functional Solution.

We chose functional solution 1:

It is important for the drill to be securely mounted. Any movement or vibration could change to positioning of the holes. It is also important for the jig to leave the door undamaged. In this design rubber clamps will be used to secure the jig. This is a good option because the rubber will have a lot of friction, thus ensuring a secure fit without having to worry about damage.

To accommodate for the different hinge and backset sizes we will use the clamps to secure the jig in the correct position in relation to the backset. To switch between different hinge sizes our jig will include two plates that accommodate the two hinge sizes. These plates can be interchanged by sliding them in and out of the jig. A further explanation of the plates is below.

A manually operated design has been selected for simplicity and ease of use. The jig can be adopted by the labourer easily without much learning. The labourer will simply turn on the drills and manually apply pressure until the holes have been drilled or tapped.

Using the same system for the tapping and the drilling is a key component to this design to improve ease of use and reduce training. Also, the main goal of the jig is to reduce the time it takes to drill and tap the holes. So, this design will feature two plates, one for drilling and one for tapping. The plate will contain four drilling or tapping bits that all spin at once. Drilling or tapping all holes at once will drastically increase the speed of the operations.

The drill bits will be secured in the plates in a way that makes them level and straight. The labourer will not need to do additional work to drill straight holes. This will help improve the quality of the doors and reduce the time it takes to drill the holes.

This design was selected for the following reasons.

- The design is simple and safe to use with a very small learning curve.
- The design improves the speed at which the labourer can drill and tap the holes at each step of the process. And the labourer can complete each step faster than the other designs.
- This design offers the most secure fit to the door.

6. Solutions that Didn't make it

6.1 Functional Solution 2

This design will include straps to secure the jig in place. The benefit of using a strap is that there is no worry about damaging the door and once fully tightened there won't be any movement of the jig.

To accommodate between different hinge sizes sliders will be used. There will be guide holes on sliders that can be moved to different locations based on the size of the jig.

This is an automated design. A robotic arm will be mounted to the floor. The robot will locate the holes that have been set up with the slider and proceed to drill the holes. The robot will always drill a perfect hole, meaning there is no need to worry about quality.

To switch between the drilling and taping the laborer will need to change the drill bit on the robotic arm for a tapping bit. Then the robot will begin tapping each hole.

Once the robot is correctly aligned and calibrated it will be able to tap drill the holes straight every time. There will be no concern about the holes slightly off their mark or slightly angled.

This design was not selected for the following reasons.

- Having a robotic arm mounted to the floor could get in the way of the labourer in the work area. This could result in the labourer tripping and getting injured or accidentally hitting and damaging the work arm.
- It will be difficult to seamlessly run wires to the arm. The most cost efficient way to run the wires will be to lay them on the ground and then protect them with a cover but that cover will also be a tripping hazard.
- The design is not fully automated and the labourer is still needed for a few steps. The speed at which the robot can drill the holes will not be fast enough to justify the price of the arm.

6.2 Functional Solution 3

This design will feature no clamping or locking mechanism. The jig will simply be slid on the door and into the cut out. This is a very simple design that will be quick to put on and take off but has potential to be unsecure. A prototype will be needed to test it.

This jig will include guide holes in sliders. The labourer will set the guide holes in the correct position which will allow the labourer to drill holes for each hinge size easily without needing a new part.

This will be a manually operated design. It primarily focusses on improving the speed at which the operator can drill the holes because AMBICO said this was the slowest step in the drilling/tapping process.

To tap the holes the operator will swap the drill bit for a tapping bit and proceed and remove the jig from the door. From there the labourer will follow the current procedure for tapping the holes.

The jig will have long guide holes that the labourer places the drill bit into. The guide holes will be used to stabilize the drill bit. Without excessive force the labourer won't be able to angle the drill bit or move it out of position. Not having to be careful about drilling straight holes will greatly improve the speed of drilling them.

This design was not selected for the following reasons.

- It is unclear if the jig will be able to withstand the vibrations of the of the drilling. If it can't and the holes are misaligned or at an angle the jig is useless to the client.
- If the jig is imperfect and has an extrusion on a piece in contact with the door then it is possible that it may damage the door.
- This design only improves the time to drill the holes. It does not offer an time improvements for the tapping process. We believe the labourer will be able to completer the drilling and tapping faster with the first suggested functional design.

7. Conclusion

In conclusion the designs are mainly aimed at improving the speed of the drilling and tapping while keeping the labourer safe. We chose our final functional design by deciding which design will save the most time and make the job easiest for labourer. Overall we believe our design accomplishes those objectives and follows the rest of our design criteria. Once we receive criticism from the client and make a prototype we will make changes as needed to produce the high quality jig meets all the demands of AMBICO.