

GNG2101 - Lab Section B03

Deliverable D:
Detailed Design

Submitted by
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Abstract

The following document outlines the results of the *First Prototype* made by team B31 for their GNG 2101 term project: the wheelchair arm panels.

Given the nature and constraints of this deliverable, the team opted to create a low-fidelity physical prototype, as a means of verifying, proving or disproving their assumptions with respect to the nature of the design they have decided to follow. Every aspect of the prototype is covered: First, any changes to the design following the second client meeting. Then, the detailed schematics of the final design. Afterwards, there is a brief description of the philosophy behind the first prototype, followed by the showcase and test results of this initial unit. The team also included a Bill of Materials for their ideal prototype.

The team found that their initial, low-fidelity prototype was able to showcase that their design was generally sound, and their assumption on the mark, whilst also illuminating unforeseen potential flaws that they may need to watch for in upcoming prototypes, such as the reliability of flexible velcro as a fastening mechanism.

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1. Introduction

There are many different facets in the process of creating a product. One, very important among them, is prototyping. Prototyping is a central part of the product creation process and serves many uses. For one, it allows for “proof-of-concept”, which gives a design team the ability to start properly testing the validity of the ideas that they have brainstormed. It also allows them to begin fleshing out the intricacies of the product they are creating. A physical prototype also gives them the opportunity to give the client a glimpse into what the final product might be like.

In prototyping, each unit can be placed on a spectrum that measures its fidelity to the final design, ranging from low to high. Commonly, the first prototype created for a product is one of relatively low fidelity. Such is exactly what has been done by our design team, and detailed in this document. The members of team B31 have utilized the group design chosen, in the previous deliverable, to create a low-fidelity physical prototype, which will be, in majority, using spare materials that the team already has on-hand.

After the prototype has been created, it will then be put through tests, already designed in preparation for this unit. These tests will be used to learn more about the wheelchair panels the team will be creating, and thus understand further changes which may need to occur. Finally, a bill of materials for the final prototype is also featured in this document.

2. Engineering Design Process

One of the common stages in most engineering design process models is the prototype and testing stage. This stands true for the team’s chosen mode, the Iterative Engineering Design Process as well.

Prototyping and testing is one of the most crucial stages of an engineering design process. It finally allows for a true proof-of-concept and an understanding of the validity for the target specifications and design chosen for the product.

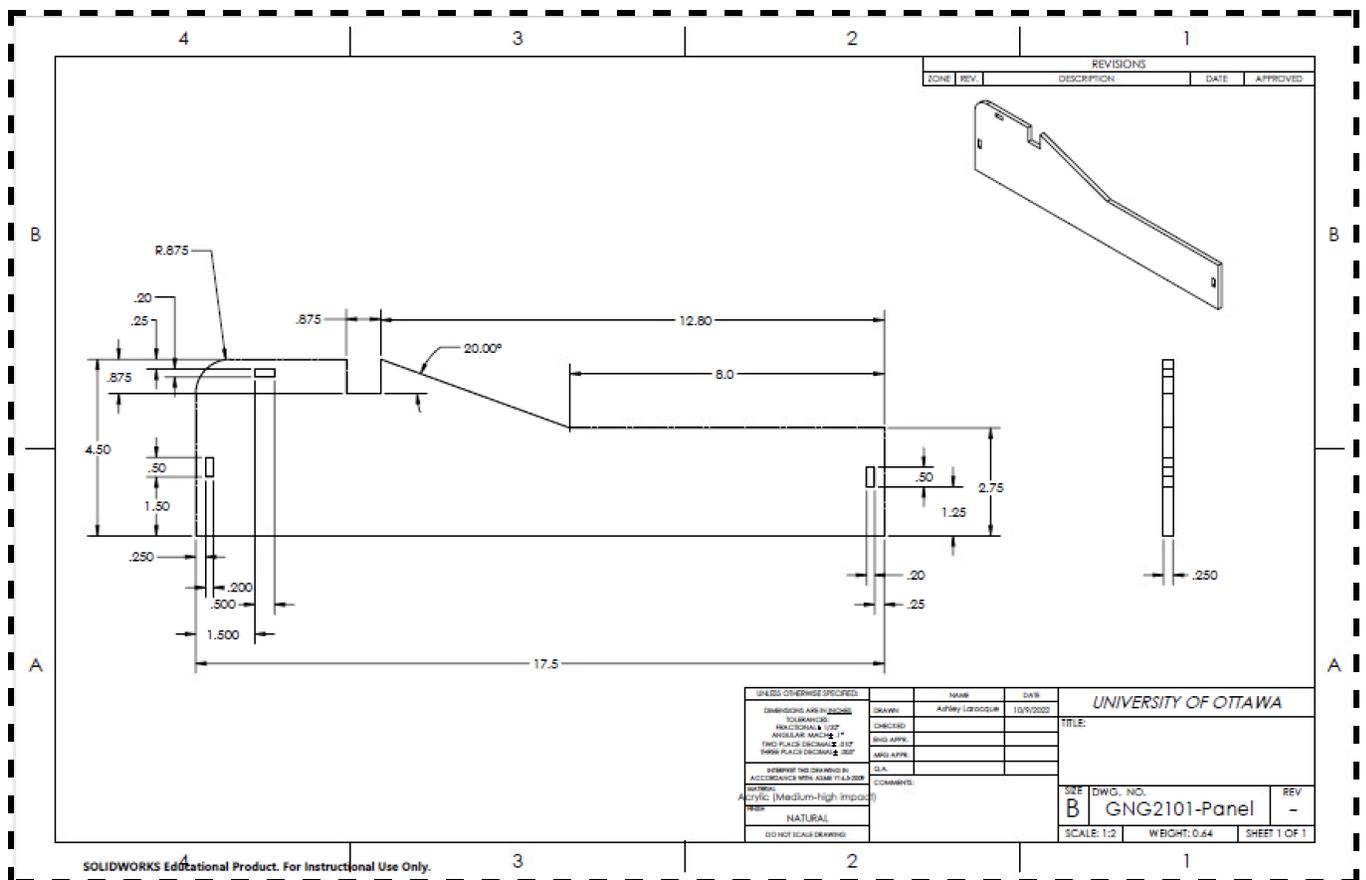
3. Detailed Design

3.1 Client Statements

On the 3rd of October, the team conducted their second meeting with the designated client for the project. This meeting, much like the 1st one, took the form of a short interview, in which the client answered a set of questions formulated to assist the engineering design team in refining the metrics and target specifications devised in Deliverable B. The following are notes the team compiled during the interview:

- The client has confirmed that they would like the panel to be moved back with the armrests when they are flipped back.
- They have stated that they would like no cushioning, and instead would like the panel to be completely rigid.
- The client would like the panel to last for at least 5 years
- The client doesn't have a particular preference between metal or plastic but has reiterated that they would like the panel to be as rigid as possible.
- The client has stated that they would like the panel to be smooth.
- Finally, they have mentioned that they would like to be able to clean the panel simply by wiping it.

Most of the client statements gathered in this client meeting match with the metrics and target specifications developed in previous deliverables. The only major change, which would be required to be made to the group design from Deliverable C, is the removal of the cushioning around the panel.



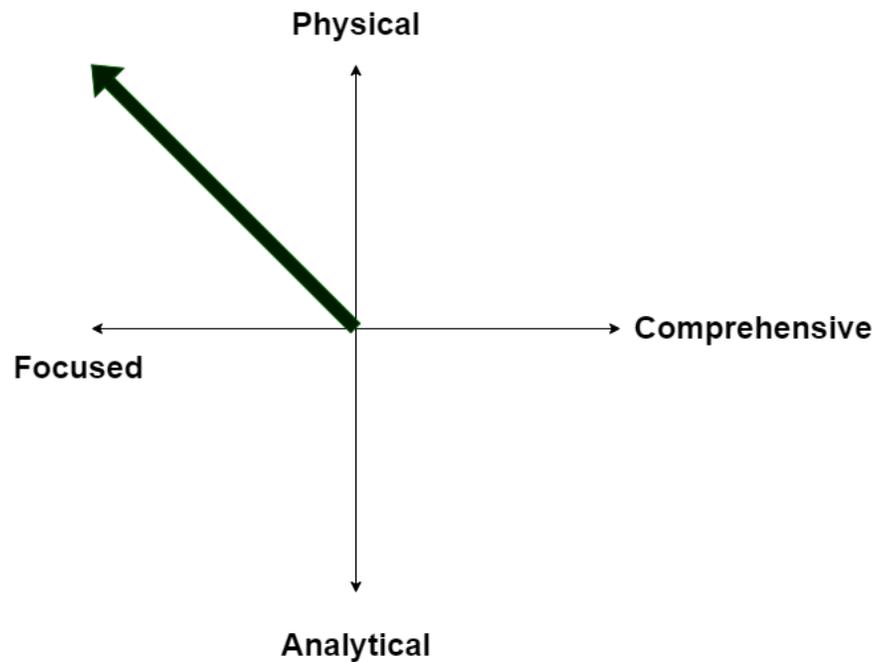
*see appendix for a full-size rendering of the drawing

Figure 1: Technical Drawing

3.2 Physical Prototype

The first prototype created by the team is a low fidelity physical focused prototype. The first prototype served as a mechanism to test the two major sub-functions of the panel, the attachment and detachment method.

Graph 1: Type of Prototype



As decided in the previous deliverable, the method of attachment and detachment chosen in the group design was velcro. Thus, the prototype created was one that implemented velcro in it. Since the prototype being made was a focused physical prototype of low fidelity, the material for the panel itself was cardboard and duct tape.

The following is a photograph of the prototype at completion:



Figure 2: Prototype 1

As we can see, it is a rather crude rendition of our schematic, made from commonly available materials, at almost no cost to the team. Despite this, it remains fairly loyal to the general concept behind our product, which is the goal. It was surprisingly stiff and mostly to scale. It is an impressively effective model for our first round of tests.

Table 1: Attributes of Prototype 1

Use	Learning and Reduction of Risk
Type	Focused Physical
Fidelity	Low

4. Bill of Materials

The bill of materials for the detailed design is summarized in Table 2. The items included for prototype 1 were mostly supplies the group already had to minimize the cost since it is a low fidelity, focused prototype. The items with listed cost values are the supplies necessary to produce the final prototype. The BOM is subject to change as is the detailed design. The team will continue to receive feedback and conduct testing and make appropriate changes to ensure the needs of the client are met.

Table 2: Bill of Material

Item number	Part Name	Description	Quantity	Unit Cost [\$CAD]	Extended Cost [\$CAD]
1	Cardboard	Scrap cardboard boxes of various sizes	2	N/A	N/A
2	Duct Tape	Rubber-based adhesive	1	N/A	N/A
3	Velcro	Black double sided ties	1	4.99	5.74
4	Scissors	Cutting material	1	N/A	N/A
5	Utility knife	Cutting material	1	N/A	N/A
6	Acrylic Sheet	24" x 12' 'x ¼" black	1	13.00	13.00
7	Fabric	PUL polyester fabric Black	1	5.95 [/yard]	5.95
Total Cost :					\$24.69

5. Testing Results

Table 3: Target Specifications

Metric #	Metric	Unit	Marginal Value	Ideal Value
1	Aesthetics	Subj	Any color	Black
2	Flatness	Binary	Yes	Yes
3	Ease to install	Subj	Moderate ease	With ease
4	Comfortability	Subj	Comfortable	Very Comfortable
5	Water resistance	Binary	No	Yes
6	Thickness	in	< 1.5	< 7/8
7	Durability	years	>3	>5
8	Cost	\$\$CDN	<50	<30
9	Rigidity	Subj	A bit of flex	No flex at all
10	Mobility	Subj	Requires some adjustment when returned to down position	Requires no adjustment when returned to down position

The first prototype is a low fidelity, focused prototype. The goal of this prototype is to prove the proposed concept will meet the clients basic needs. The qualities that were tested are attachment, shape, mobility, and detachment. The prototype was created using cardboard and duct tape to replicate the shape of the design with low-cost materials and to reduce the risk of waste. Rigidity, water resistance, flatness, thickness, comfortability, and durability testing is beyond the scope of this prototype, and will be tested in future iterations when more comprehensive prototypes are produced.

5.1 Test 1: Attachment

The first test was a focused, qualitative, functional test to determine if the proposed method of attachment satisfies the required ease-of-use. The test was done using the physical prototype and the wheelchair available for testing. The test included attaching the panel independently while sitting in the chair to determine if it is possible for a lone user to install.

It was found that velcro attachment can be accomplished with moderate ease, which is the marginally acceptable value for ease-of-installation. It was also found that velcro allowed for the panel to be stabilized well, with little movement.

5.2 Test 2: Shape

The second test conducted was a qualitative, functional test to determine if the proposed shape closes the arm gaps of the wheelchair. The test included fastening the panel to the chair and sitting down to see if there was any visible gap remaining for the user's legs to go through.



Figure 3: Panel installed on armrest.

From this test it was concluded that the design does fill the gaps. With this information the next prototype can be made from the material for the final prototype.

5.3 Test 3: Mobility

The third test conducted was to determine if the panel can move with the flip-back arm installed on the clients wheelchair. This test was a focused, qualitative, functional test. The panel was fastened to the frame of the arm-rest, not the chair, to ensure it is free to move with the arm.

This test revealed that the panel can move with the flip-back armrest of the chair. When flipped back, the panel stays attached and requires little adjustment when returned to the down position. This test satisfies the marginally acceptable value for the mobility of the panel but still leaves room for improvement in future iterations.

5.4 Test 4: Detachment

The final test conducted on prototype 1 was for the ease-of-use in terms of detachment. This test was conducted by sitting in the chair and removing the panel independently to mimic the process the lone user would have to go through to remove the panel. This test was a qualitative test of the functionality for the design.

It was found that the velcro is very easy to remove, taking less than 5 seconds to detach. This result satisfies the ideal value for the ease-of-use target specification. However, since the attachment of the panel is more difficult than detachment, there is still room for improvements in further iterations of prototyping. Thus other methods of attachment may be considered.

5.5 Test Results

Table 4: Summarized Results

Test no.	Test Name	Target Specification	Functional or non-Functional	Units	Marginal Value	Ideal Value	Result*
1	Attachment	1	Functional	Subj	Moderate ease	With ease	3.5
2	Shape	N/A	Functional	Subj	Fits with some room	Fits well	4
3	Mobility	10	Functional	Subj	Requires some adjustment when returned to down position	Requires no adjustment when returned to down position	4
4	Detachment	1	Functional	Subj	Moderate ease	With ease	5

**The result has been evaluated from a scale of 1 to 5, the value 5 being a successful testing while 1 being not successful*

To review the test results, based on Table 3, the attachment test was the least successful among the other tests. It was also noted that the method of attachment using velcros led to little adjustments needed at the back, near the back-rest of the wheelchair, once the armrest was flipped back. Since this caused little dissatisfaction in the use of the product, the test was mostly successful. The prototype fitted well within the arm gaps, covering the holes efficiently. Some measurements are scheduled to be reviewed for a better fit within the arm rests but the shape still served its purpose. The method of detachment was the most successful test, the team found no inconvenience when detaching the product from the arm rests. Overall, the prototype testing was a success, allowing the team to evaluate the product functionalities.

6. Conclusion

Using the group design created in Deliverable C, the team has produced their first physical prototype. The first prototype was a low-fidelity physical prototype focused predominantly on the attachment and detachment method of the panel. This prototype was then tested on a sample wheelchair where it was discovered that the attachment method needs a bit of work. The learnings here will be used to make changes in future prototypes.

The client meeting which took place on October 3rd has also given us valuable feedback that can be used to further improve the design of the panel. This feedback that the team has received, alongside the learnings from the testing of the first prototype will be used to modify and improve future iterations of the panel.

Appendix

Figure 1: Technical Drawing

