GNG2101

Design Project Progress Update

Group B 2.5

Submitted by:

Rowan Kovacs, 300349509

Olivia Chiang, 300357955

Abdul Rasool, 300363106

Yinhui Wu, 300258115

Daniel Sohrabi, 300351607

September 22, 2024

University of Ottawa

Table of Contents

Project Deliverable Report Instructions..... i

Table of Contents.....ii

List of Figures..... iii

List of Tables..... iv

List of Acronyms and Glossary..... v

1 Introduction..... 1

2 Sustainability Report and DFX.....2

2.1 Sustainability report.....2

2.2 Design for X.....2

3 Problem Definition, Concept Development, and Project Plan..... 3

3.1 Problem definition..... 3

3.2 Concept development.....3

3.3 Project plan..... 3

4 Detailed Design and BOM..... 4

4.1 Detailed design.....4

4.2 BOM..... 4

4.3 Project plan update.....4

5 Conclusions..... 5

6 Bibliography..... 6

List of Figures

Insert your list of figures here (right-click to update this field).

List of Tables

Table 1. Acronyms vi

Table 2. Glossary vi

Table 3. Triple bottom line for the soft cervical collar x

Table 4. Turning client statements into needs xv

Table 5. Metrics xix

Table 6. Bill of materials xlv

List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
BOM	Bill of Materials- used to breakdown project budget
LCA	Life Cycle Assessment- used to assess the net impact of the product on the environment
TBL	Triple Bottom Line- used to assess the positive and negative impacts of the product on the environment, society, and economy

Table 2. Glossary

Term	Acronym	Definition

1 Introduction

The task for this project is to design a soft cervical collar that is water resistant and durable. After client meetings, a number of design characteristics were determined, and a few assumptions needed to be made in order to guide the team. These assumptions (currently) include collar size and circumference, adjustability range, and material preferences. As the client was unsure about these aspects, educated assumptions were made, which will be updated and modified as the project continues and the team becomes more familiar with the project.

This document outlines the design process of the team, and is also used to analyse the social, environmental, and economical impacts of the product. A sustainability report will detail the net impacts of the product on society using a triple bottom line method and LCA assessment. This will guide the team in the goal of achieving a sustainable product that fits the client's needs.

A design for X approach is then used to isolate and focus the project on a few crucial aspects, after which concept development is presented based on the design for X characteristics chosen. The concept development lists all ideas the team has for the product, which will later be analysed to assess the feasibility of the concept given the allotted time for the project. These concepts will also be modified based on client feedback and more research.

2 Sustainability Report and DFX

This section analyses the environmental, social, and economical impacts of the product in order to assess the overall sustainability of the design and its effects on society. This includes a triple bottom line (TBL) table outlining the positive and negative impacts of the product on the environment, society, and the economy, and an LCA which analyses the net impact of the product on the environment throughout its lifespan.

2.1 Sustainability report

Social impact - In a medical setting the current selection of medical devices, and in particular cervical collars, are backed by a one dimensional way of thinking, with today's selection of products prioritizing immobilized/stationary patients. This excludes individuals who wish to remain active, participating in various sports and activities. By providing the right medical services, this issue can be resolved with ease. Offering a wide selection of foam cervical collars to accommodate not only for all body types but providing specialized collars (ie. waterproof/chlorine resistant collars, and aerated/summer collars) for more active individuals. Now it is understood that mass producing these products is not sustainable, but by allowing requests to be made for order, patients can have the satisfaction of being able to remain active while remaining safe. Expanding the variety of medical cervical collars has the possibility of improving the quality of life for the populations that use them-by addressing the needs of more active individuals that tend to be overlooked. This push towards a more active lifestyle promotes positive psychological

benefits by allowing these individuals to continue on with their lives as regular, without compromising physical health and safety.

Economic impact - There is a sizable economic impact to be made by capitalizing on the soft cervical collar market, and with the medical industry valued at billions, the opportunity is boundless. As stated previously, the current market for cervical collars is very linear so by providing these extra services and expanding into these various areas, new revenue streams can be generated. This diversification would infer market competition, driving further innovation and cost reductions.

Environmental impact - Because soft cervical collars are intended to be worn at all times, they tend to degrade after a prolonged period of use; and with the materials used to produce them often not being made from renewable resources, an ever increasing contribution to the medical industries carbon footprint is made. Over time, transitioning to biodegradable materials and introducing recycling/take back programs to help alleviate environmental strain would help lower the ecological footprint these collars create.

Table 3. Triple bottom line for the soft cervical collar

Triple Bottom Line	Positive Impacts	Negative Impacts
Social	-accessible devices for people with physical disabilities -brings awareness of disabilities to others	-can create misconceptions about the person using the collar - can make people with disabilities stand out more,

		possibly subjecting them to prejudice
Environmental	-durable materials allow long term use and less waste - natural sourced materials	-materials used are usually not renewable -use of foam and plastics create un-sustainable waste -increases carbon footprint of medical industry
Economic	-potential to create job opportunities if produced on a large scale	-materials degrade fast creating higher costs
Inclusivity	- Inclusive lycra cover for different minority groups - Cost effective for those less economically fortunate	Trying to include everyone dilutes the specific focus of the project. It makes the product more general.
Awareness in Society	-	

Life Cycle Assessment

Objective and Scope:

The goal of this LCA is to assess the environmental impact of a soft cervical collar, used daily, throughout its life cycle. The system boundary used will be cradle-to-grave, including the materials and manufacturing, packaging and transportation, use, and end-of-life disposal.

Inventory Analysis:

Soft cervical collars are made of foam, rubber, polyethylene, or inflatable cuff. The manufacturing process involves cutting, molding, and assembly of the collar using the listed materials. For packaging and transportation, it is assumed that the collars are packaged with a plastic covering/case or in cardboard boxes. Transport and distribution is assumed to occur via truck to stores, hospitals, etc. During use of the collar, no direct energy sources are used. Once collars have been used, they are disposed of via garbage disposal and end up in landfills.

Impact Assessment:

Based on this LCA, the soft cervical collar can become more sustainable in a manner of ways. The materials used are currently non-renewable and contribute significantly to the environmental impact. Soft cervical collars wear down quickly, especially when used on a daily basis. Additional wear and tear comes from washing, extensive use, and non-durable materials. By finding alternative materials (biodegradable plastics, recycled materials, etc), this impact can be reduced.

Once soft cervical collars are no longer usable, it is assumed that they will be disposed of by garbage disposal.

Interpretation:

Improving recycling mechanisms or implementing ‘take-back’ programs can help reduce the environmental impact by recycling old materials. Designing a soft cervical collar that uses

renewable and more durable materials can significantly reduce the environmental impact by reducing waste.

2.2 Design for X

Design for X is a process used to focus on a few specific design aspects of a product, where X represents a quality or characteristic of the design. This section will determine the main design objectives for this project, which the group will strive to achieve for the final product.

a. Design for Comfort

- Allows for natural neck movement, ventilation, and unrestricted breathing and speaking.
- Remains light after periods in the water.
- Weight of the dry and wet collar (Kg)
- After 1 hour in the water, the weight of the collar can be a maximum of 10% more than its dry weight.

b. Design for Durability

- Resists damage from sweat, chlorine, and heat.
- Maintains its structure after physical activities such as swimming, aikido, and dancing.
- Tensile strength (the force it can withstand) in Newtons.
- The collar must have a minimum tensile strength of 100N.

c. Design for Portability

- Compactible to 50% of its unfolded size allowing easy storage in small spaces.
- Volume of compressed collar to be measured in litres.

- Lightweight when fully dry, allowing the user to easily carry the collar around without physical strain.
- Quickly dryable, allowing for the collar to be stored immediately after being exposed to liquids.
- Soft and flexible materials, allowing it to be folded without physical distress from the user, but to also prevent creasing/material blemishes after taking out of storage.

d. Design for Safety

- Collar provides strong neck support without becoming undone/unattached during daily activities.
- Easy 1-2 second unattachment process to allow users to quickly take off the collar in emergency situations.
- 300N of impact resistance to create a protective layer around the neck during falls, and or collision with objects.
- Use of skin-friendly materials that avoid neck irritation and excessive sweating.

e. Design for Environment

- Sustainable Materials: Employ organic, non-polluting, non-corrosive, and long lasting materials that are reusable or can be recycled.
- Water Resistance: Only use materials that are waterproof and chlorine resistant to get maximum durability and minimize the amount of waste.
- Easy Maintenance: Choose products that can be washed in a washing machine and do not require complicated and time consuming cleaning.
- Eco-Friendly Packaging: Choose environmentally friendly packaging materials such as minimalistic, recyclable or biodegradable packaging for transport.

3 Problem Definition, Concept Development, and Project Plan

3.1 Problem definition

Problem Statement:

The client is in need of a soft cervical collar that is durable, resistant to chlorine and sweat, provides the proper support without constriction of the neck, and is made of flexible and soft material that is comfortable to wear. The collar is adjustable in size and is portable.

Table 4. Turning client statements into needs

#	Need	Imp
1	The collar is waterproof and resistant to chlorine for swimming activities.	5
2	The collar is the correct height (around 11 cm in the front, and 7.5 cm in the back).	5
3	The collar is adjustable in size (e.g., Velcro straps) for comfort and flexibility.	5
4	The collar is flexible and soft to allow for natural neck	4

	movement and comfort.	
5	The material is durable against wear from sweat, chlorine, and heat.	5
6	The collar does not cause vascular constriction, especially if the height is incorrect.	5
7	The collar is portable, easy to carry on a walker, in a backpack, or folded compactly.	3
8	The collar is breathable and prevents overheating during long-term use.	4
9	It is easy to clean and maintain, ideally washable without breaking down.	4
10	The material is comfortable against the skin—smooth, soft,	4

	and non-scratchy.	
11	The collar can withstand hot tub use and other high-moisture activities.	3
12	The collar does not become too heavy when wet, and it must dry quickly.	4
13	The design is aesthetically pleasing (e.g., racing stripes) for client satisfaction.	2
14	The collar supports physical activities like aikido, dancing, and everyday movement.	4
15	The collar has a loose fit to allow for breathability and prevent tightness.	3

Benchmarking:

1. Vive Neck Brace:

Strengths:

Convenient and gentle on the skin, has a foam-like structure, and has a lightweight neck support.

Cheap and can easily be obtained in different dimensions.

Weaknesses:

This product is not waterproof or chlorine resistant, and thus it cannot be used while swimming.

Sweat or water will damage the foam material diminishing the product's durability.

2. Aspen Vista Cervical Collar:

Strengths:

Features unique customer preferences such as strong neck support and adjustability features.

It has a rigid type of design to ensure better immobilization is achieved.

Some of the models are portable and flexible to move or change when needed.

Weaknesses:

Stiff; which becomes inconvenient for those clients who need to twist or turn on the garment.

Not designed for water use.

Reduced breathability and not very easy to wash.

3. Philadelphia Collar:

Strengths:

Splash proof so one can put it on while showering for instance.

Adjustable with velcro closure.

Very comfortable for short term wear and very lightweight.

Weaknesses:

Not resistant in water for longer periods, specifically water that contains chlorine.

Foam wears out with usage due to chlorine, sweat and dirt, etc.

It may not offer the kind of flexibility that is needed to support dynamic activities.

Table 5. Metrics

#	Need #s	Metric	Imp	Units
1	1, 5,12	Collar weight (dry and wet after 1hr in water)	5	g
2	1	Water absorption (percentage increase in weight)	5	%
3	3	Maximum adjustment range	5	cm
4	6	Maximum collar tensile strength	4	N
5	6	Minimum time for detachment in an emergency	3	S
6	9	Maximum cleaning time	3	min
7	7	Time to fold and store collar	4	s
8	7	Minimum folded size	4	cm^3
9	8,15	Maximum breathability (air permeability)	4	m^3/h

10	5,11	Heat resistance (maximum temperature without deformation)	3	°C
11	10	Skin irritation (rating from users)	5	subjective
12	5	Abrasion resistance (weight loss after standardized test)	4	mg
13	5	Chlorine resistance (number of cycles before degradation)	5	cycles
14	2	correct height	5	cm
15	4	Range of Motion	5	Degrees
16	4	Softness Measurement	4	Scale of 1 to 10 (subjective)

Target Specifications:

Evaluating the metric table above, several notable values will ideally have priority to ensure the designed collar is what is envisioned by the client. Material selection, dimensions/weight, and range of motion are the three characteristics that the foundations of the collar are built upon.

The materials used will determine its effectiveness in water, chlorine resistance, and skin irritability. Ideally, all three characteristics will be found in a singular material. however, if this is not feasible, water use/chlorine resistance will take priority as other methods can prevent skin irritability (ie. covers). Although it is a subjective scaling, the material softness will ideally sit at

least 5/10 (comparable to a firm pillow). The material must be strong enough to keep the neck upright, but soft enough that blood flow to the neck is not restricted (As is common with rigid, plastic collars).

The dimensions and weight will determine how the collar feels around the client's neck. This target is the most restrictive out of the three listed because if the collar is not dimensioned correctly, it will not fit the client thus not properly providing support. For the client, the height of the collar around the chin must be approximately 11cm tall, and 7.5cm at the back. The circumference of the collar will remain adjustable either with velcro or other various straps but will remain at about 36 ± 3 cm. Additionally, the ideal specifications of the collar would have the maximum weight after 1 hour in the water at 10% greater than the dry weight. At a minimum, the collar size when folded will be half the regular size; as the foam material can be rolled up and compressed.

Finally, the range of motion. Ideally, the collar will only restrict movement when the neck is close to being fully flexed (roughly 60° to the horizontal). But at a bare minimum, it would support the neck against gravity; minimizing muscle use and ensuring the head is kept upright.

Reflect on the Results and the Process:

After going through the above, examine our discoveries and the efficacy of the undertaking. Reflect on anything that could be useful for improved design or interacting with users in the future. Modify the project approach as needed.

3.2 Concept development

This section will focus on the concept development process of the product. The team lists ideas and concepts for subsystems, as well as the whole system, for the project and analyses the benefits and possible issues which may arise.

Sub-systems

1. Durability/Materials **DFX:** Durability, Safety
    - Use liquid silicone it can withstand high temperatures and is flexible like rubber
    - Use lycra blend with polyester for the fabric, it is water resistant, sweat and chlorine resistant.
    - Use foam lining inside the fabric.
2. Portability **DFX:** Portability
    - Bend, compress, and fold into a compact form
    - Has creases that allow the collar to fold into itself
    - Deflatable and inflatable collar
3. Resistance to sweat and chlorine **DFX:** Durability
    - Lycra blended fabric that covers silicone and is sweat and chlorine resistant
    - Fabric cover is attached via a waterproof zipper
4. Water-proof **DFX:** Comfort, durability
    - Fabric silicone cover has to be thin and tight, this will not allow water to get trapped inside (through absorption or zipper).

- Lycra has water resistant qualities and absorbs minimal water.

5. Comfortable/Doesn't constrict the neck **DFX:** Comfort, safety
    - Use dense foam in between fabric cover and silicone, this will ensure that the neck collar is comfortable, and have a similar surface to a pillow.
    - Adjustable buckles and extensions to allow for size changes
    - Different sizes are offered, different clients may specify diameter and thickness.
    - Detachable foam/pillow like material lined on the inside of the collar that interacts with the neck. Can be removed for swimming
    - Belt buckle like system with holes on the collar and a pin to select which size fits best

Full-System

1. Liquid silicone cervical collar covered by chlorine-resistant Lycra polyester blended fabric that can be taken off using the zipper when not in the water. For adjustability, a belt-like system on the rear end of the collar where there is a pin and different holes for different sizes. The inner part of the collar that interacts with the neck has a detachable foam/pillow-like material. Is attached using adhesive. It can be rolled into a compact form.
2. Silicone collar covered with Lycra blend fabric, that can be attached via a hooking system. The whole inside lining of the Lycra fabric will be filled with water resistant foam, giving it the client's preferred feel of a pillow. Belt buckle like system to allow for adjustments in size.

3. Foam cervical collar with the Lycra blended fabric lining. Velcro attached pillow like material on the part of the collar that interacts with the neck. Product designed with multiple different sizes.
4. The collar has a silicone outer shell covered by Lycra fabric that can be taken off using a zipper. It can be deflated and inflated for portability. Between the fabric and silicone, there is foam for comfort. Different range of sizes offered.
5. Collar made from entirely polyester with polyfill for the inner filling. Rolls up into a compact form for portability. A protective layer of Lyca blends throughout the exterior of the collar to prevent chlorine and sweat deterioration. Backpack-like buckles on the rear end of the collar to allow for adjustments to the size to be made.

Concept Evaluation Against Target Specifications

Concept 1 (Feasible)

- Neck Collar Base: **Silicone** is a strong, durable, and flexible material. According to research performed by the group, it has a tensile strength of 800N (8x) what was described in the initial specifications.

  (Resource: https://www.tblsilicone.com/article/detail/what-is-high-tensile-strength-silicone-rubber.html)
- Fabric: **Lycra** blends are chlorine, water and sweat resistant fabric materials.
- Fabric Attachment: **Zippers** are water resistant and will hold the collar fabric together.
- This concept can be easily stored. The fabric cover comes off with a zipper system, and the silicone base can be folded/compressed.

- The base, fabric and fabric attachment are chemical and water resistant as mentioned in the material evaluation.
- Sits comfortably on the neck due to adjustable foam padding.
- Will not restrict the neck as there is adjustability with pins.

Concept 2 (Feasible)

- Neck Collar Base: **Silicone** is a strong, durable, and flexible material. According to research performed by the group, it has a tensile strength of 800N (8x) what was described in the initial specifications.

  (Resource: https://www.tblsilicone.com/article/detail/what-is-high-tensile-strength-silicone-rubber.html)
- Fabric: **Lycra** blends are chlorine, water and sweat resistant fabric materials.
- Fabric Attachment: **Hooks** will hold the collar fabric together.
- This concept can be easily stored. The fabric cover comes off with a hook, and the silicone base can be folded/compressed.
- The base and fabric are chemical and water resistant as mentioned in the material evaluation. Depending on the configuration, it is likely that the hooks will allow water to enter the collar.
- Sits comfortably on the neck due to adjustable foam padding.
- Will not restrict the neck as there is adjustability with belt buckles.

Concept 3 **(Not Feasible)**

- Neck Collar Base: Foam is not as strong as previous concepts where silicone was proposed to be used and has weak tensile strength.
- Fabric: **Lycra** blends are chlorine, water and sweat resistant fabric materials.
- Fabric Attachment: **Velcro** will hold the fabric together, however is weaker than previous concepts, and will allow water to enter the neck collar. It is also not durable, and will likely need replacement often.
- This concept can be easily stored. The fabric cover comes off with velcro, and the silicone base can be folded/compressed.
- Sits comfortably on the neck due to an abundance of soft materials (foam and lycra cover)
- May restrict the neck as no adjustment mechanism is included.

Concept 4 **(Not Feasible)**

- Neck Collar Base: Inflatable material is not durable, and can easily be damaged and be unusable if any holes are poked in the material.
- Fabric: **Lycra** blends are chlorine, water and sweat resistant fabric materials.
- Fabric Attachment: **Zippers** are water resistant and will hold the collar fabric together.
- This concept can be easily stored. The collar can be deflated and take up less place when not used.
- Sits comfortably on the neck due to an abundance of soft materials (foam and lycra cover)
- May restrict the neck as no adjustment mechanism is included.

Concept 5 **(Not Feasible)**

- Neck Collar Base: Polyester is not a water resistant material.

- Fabric: **Lycra** blends are chlorine, water and sweat resistant fabric materials.
- Sits comfortably on the neck due to adjustment, but lacks soft material.
- Will not restrict the neck as there is adjustability with buckles.

Solutions to Develop Further

Concepts 3, 4 and 5 are not feasible for this project. After theoretical simulations, and comparisons against target specifications, the group has decided to go forward with concepts 1 and 2.

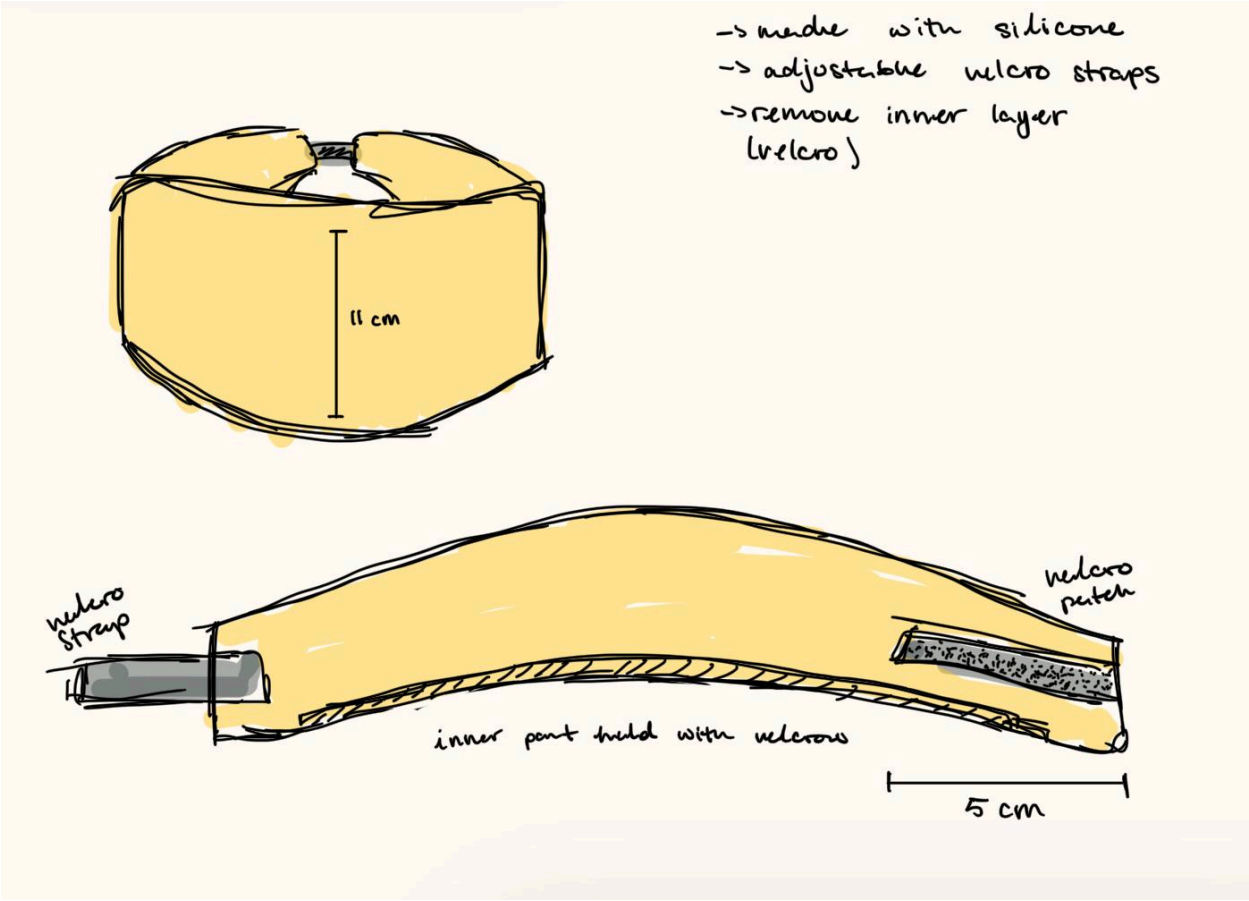
Global Design Concept

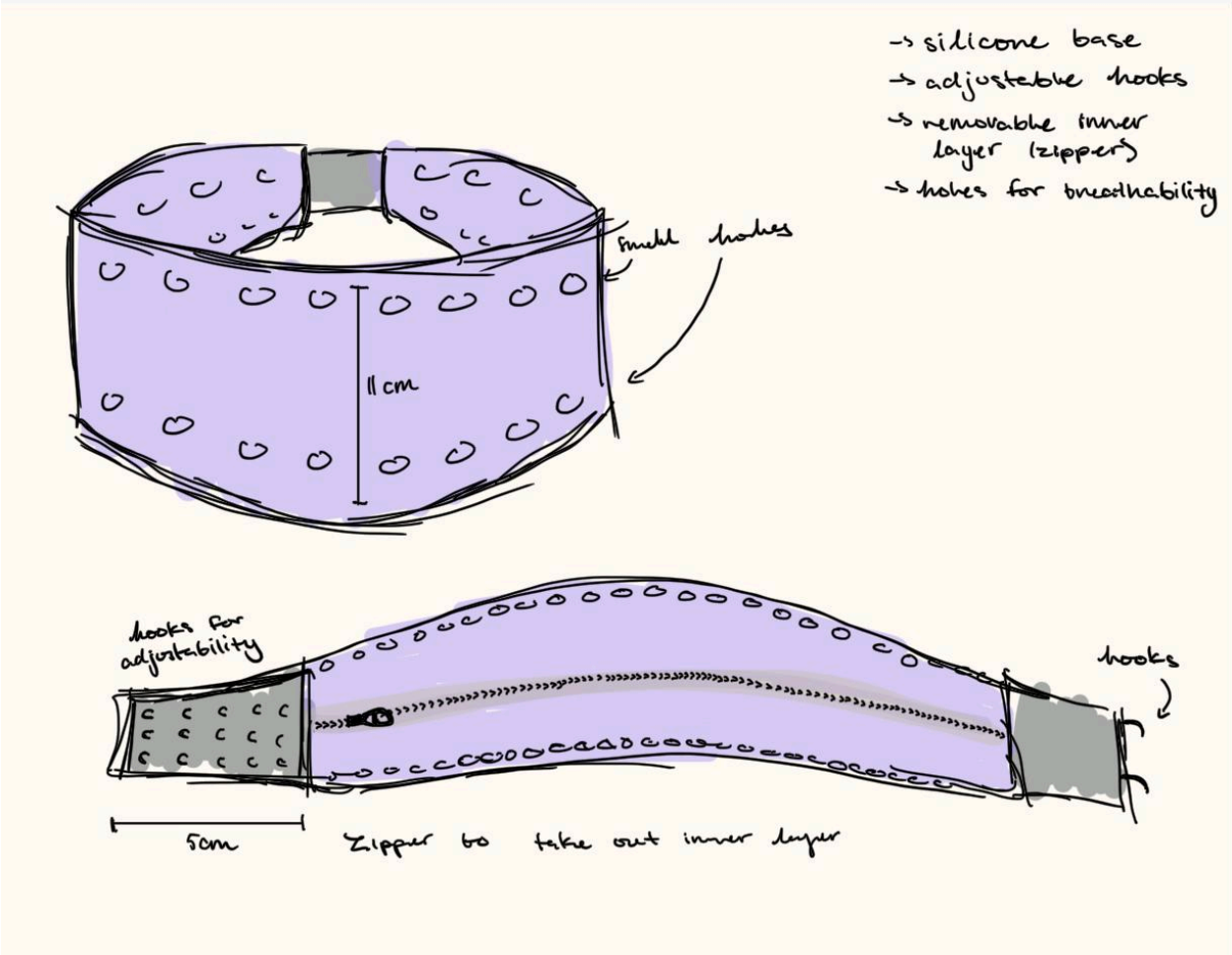
The approach we are taking to curate a global design concept is to combine elements from each solution.

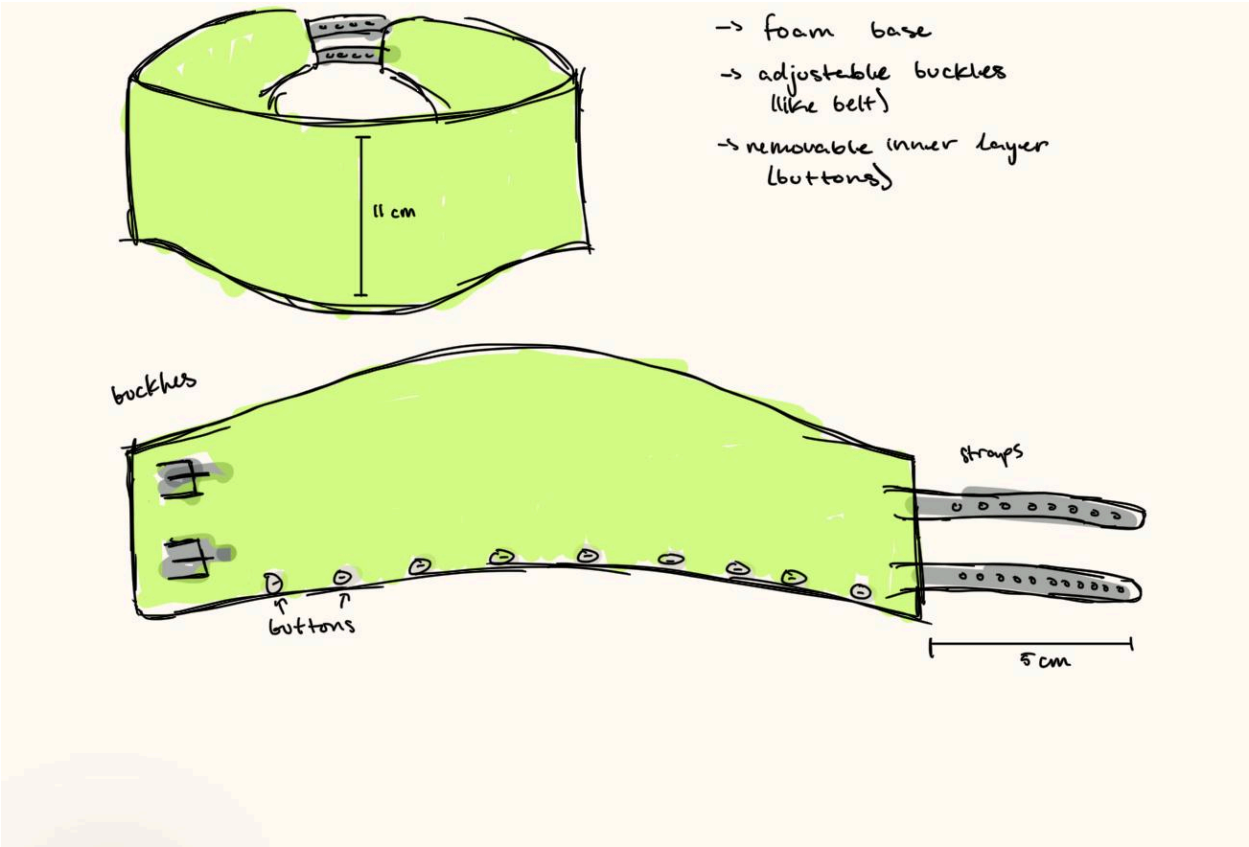
The cervical collar will be created primarily of liquid silicone. Liquid silicone is the perfect balance of durability and flexibility allowing for comfort. Specifically, it has around 800N of tensile strength. To prevent deterioration from chlorine and sweat the exterior of the collar will be lined with a Lycra polyester blend. Specifically, it will be in the form of a cover that can be taken on or off with a zipper. The inner part of the collar that interacts with the user's neck will have foam padding. This will minimize the amount of total foam used so the collar doesn't get heavy in water but it will still provide comfort. For adjustability, the collar will have a belt buckle-type system. Where there are holes drilled into the backside of the collar and a pin to select the

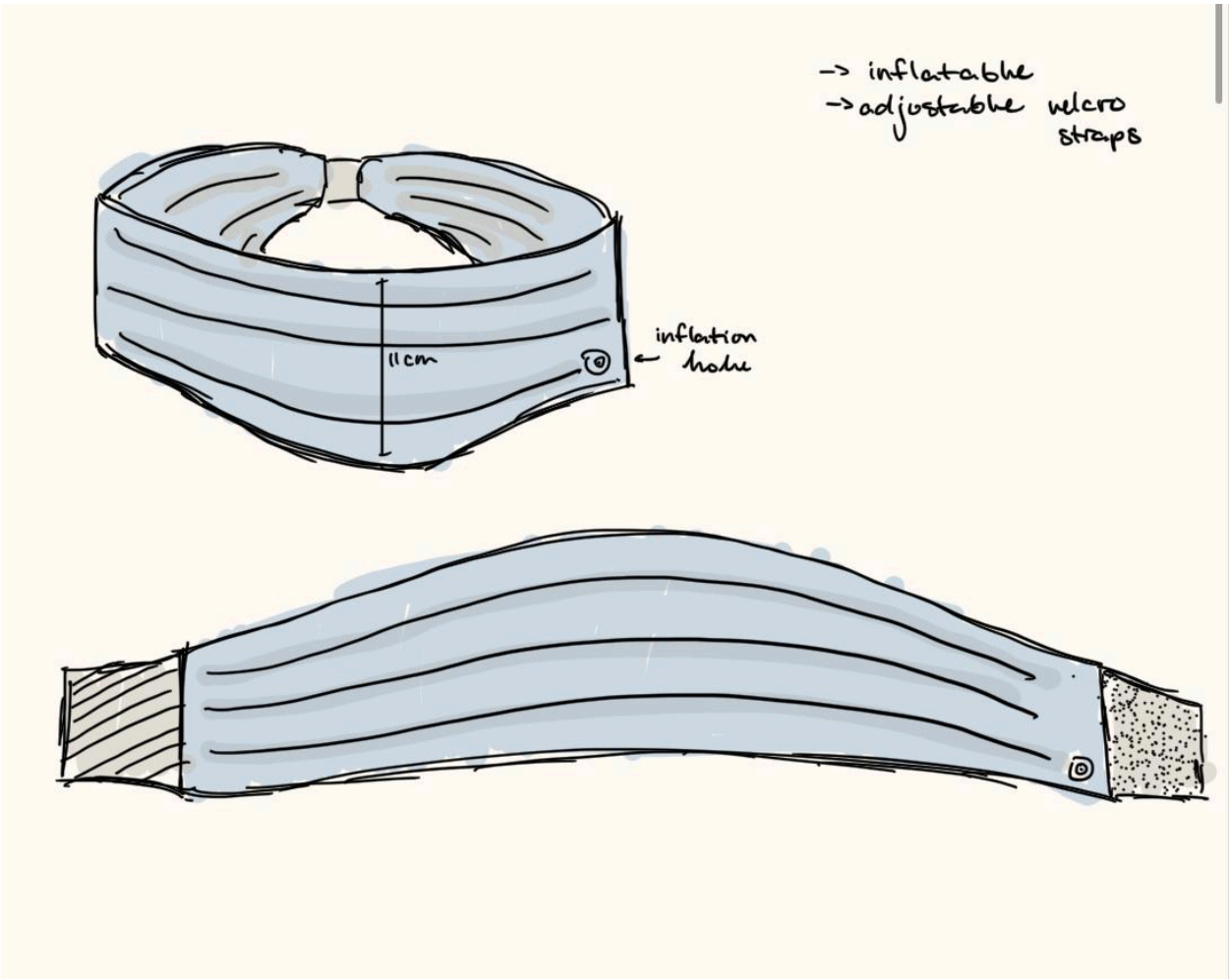
appropriate size. The user can simply roll up the collar due to the nature of liquid silicone for portability.

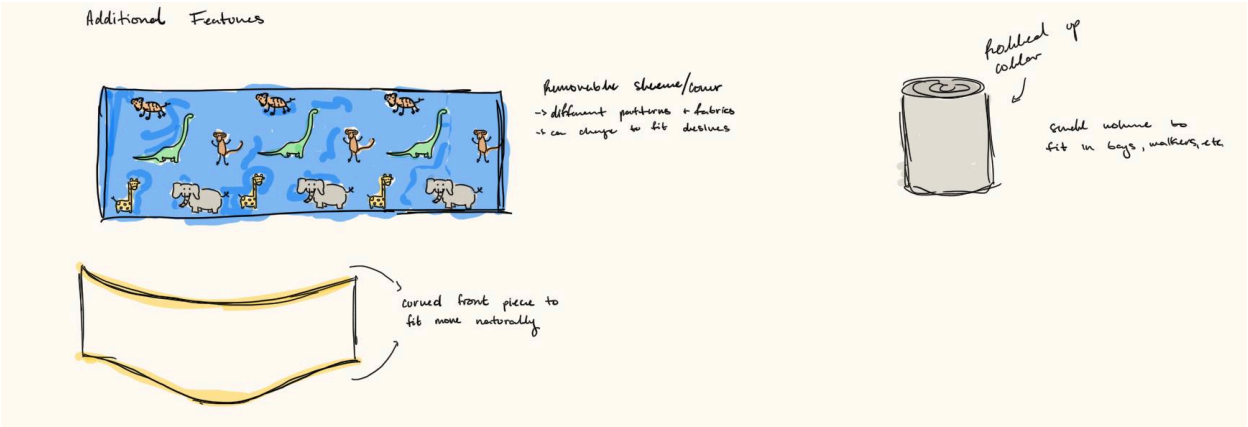
Visuals




-> silicone base
-> adjustable hooks
-> removable inner layer (zippers)
-> holes for breathability
mouth holes
11 cm
hooks for adjustability
hooks
5cm
Zipper to take out inner layer


-> foam base
-> adjustable buckles (like belt)
-> removable inner layer (buttons)
11 cm
buckles
straps
buttons
5 cm

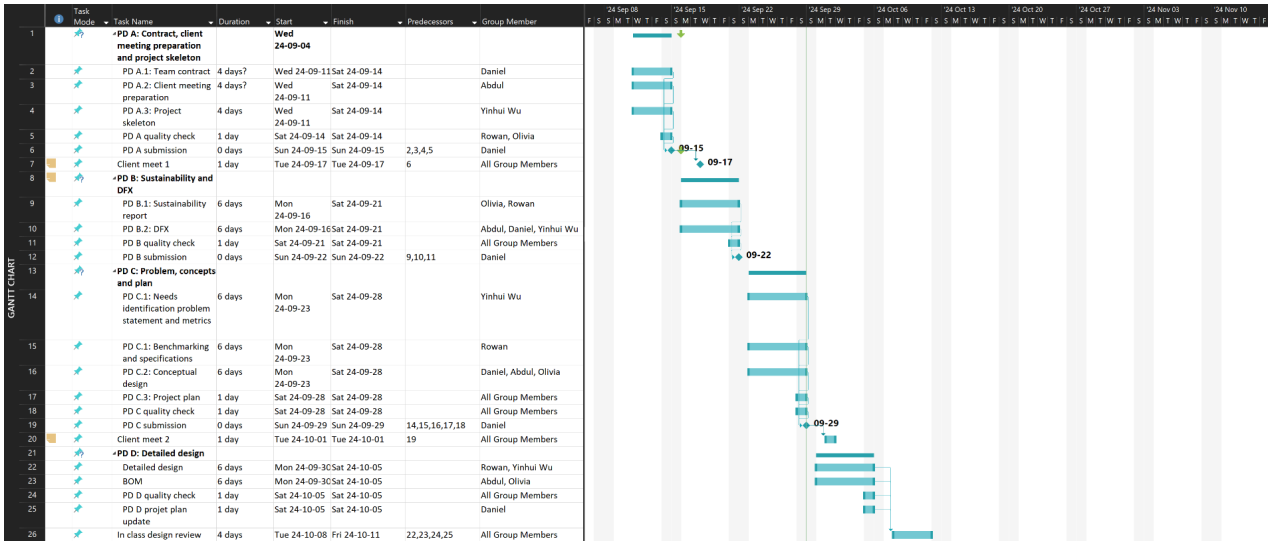




Concept's Relationship to Specifications and DFX

The concepts developed were created using the metrics and target specifications as a basis. The chosen materials and adjustability mechanisms were chosen based on the specifications made, using them as a guide to ensure that the clients needs are met. For example, the choice to use silicone as the basis for the collar was due to the specifications of weight and water resistance as silicone is a durable, flexible, and lightweight material. Overall, the target specification and metrics helped guide the concept development to guarantee that the clients needs are met and improve the quality of the product.

3.3 Project plan



	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Group Member
1		**PD A: Contract, client meeting preparation and project skeleton**		**Wed 24-09-04**			
2		PD A.1: Team contract	4 days?	Wed 24-09-11	Sat 24-09-14		Daniel
3		PD A.2: Client meeting preparation	4 days?	Wed 24-09-11	Sat 24-09-14		Abdul
4		PD A.3: Project skeleton	4 days	Wed 24-09-11	Sat 24-09-14		Yinhui Wu
5		PD A quality check	1 day	Sat 24-09-14	Sat 24-09-14		Rowan, Olivia
6		PD A submission	0 days	Sun 24-09-15	Sun 24-09-15	2,3,4,5	Daniel
7		Client meet 1	1 day	Tue 24-09-17	Tue 24-09-17	6	All Group Members
8		**PD B: Sustainability and DFX**					
9		PD B.1: Sustainability report	6 days	Mon 24-09-16	Sat 24-09-21		Olivia, Rowan
10		PD B.2: DFX	6 days	Mon 24-09-16	Sat 24-09-21		Abdul, Daniel, Yinhui Wu
11		PD B quality check	1 day	Sat 24-09-21	Sat 24-09-21		All Group Members
12		PD B submission	0 days	Sun 24-09-22	Sun 24-09-22	9,10,11	Daniel
13		**PD C: Problem, concepts and plan**					
14		PD C.1: Needs identification problem statement and metrics	6 days	Mon 24-09-23	Sat 24-09-28		Yinhui Wu
15		PD C.1: Benchmarking and specifications	6 days	Mon 24-09-23	Sat 24-09-28		Rowan
16		PD C.2: Conceptual design	6 days	Mon 24-09-23	Sat 24-09-28		Daniel, Abdul, Olivia
17		PD C.3: Project plan	1 day	Sat 24-09-28	Sat 24-09-28		All Group Members
18		PD C quality check	1 day	Sat 24-09-28	Sat 24-09-28		All Group Members
19		PD C submission	0 days	Sun 24-09-29	Sun 24-09-29	14,15,16,17,18	Daniel
20		Client meet 2	1 day	Tue 24-10-01	Tue 24-10-01	19	All Group Members
21		**PD D: Detailed design**					
22		Detailed design	6 days	Mon 24-09-30	Sat 24-10-05		Rowan, Yinhui Wu
23		BOM	6 days	Mon 24-09-30	Sat 24-10-05		Abdul, Olivia
24		PD D quality check	1 day	Sat 24-10-05	Sat 24-10-05		All Group Members
25		PD D projet plan update	1 day	Sat 24-10-05	Sat 24-10-05		Daniel
26		In class design review	4 days	Tue 24-10-08	Fri 24-10-11	22,23,24,25	All Group Members

Milestones and their roles, due dates, and notes have been updated.

4 Detailed Design and BOM

This section will outline the final detailed design for the product which will be followed by the group as the project continues. Characteristics and aspects of the design will be described in greater detail, and the chosen concept will also be described based on client feedback and team consensus. A bill of materials (BOM) is also given to breakdown the budget for the project and how it will be used. All materials and machines used are listed in the BOM.

4.1 Detailed design

- Client feedback
    - **Concerns about Buttons:** The client mentioned that buttons cause chafing on the jawline, chest, and collarbone and thus could not be incorporated into the design.
    - **Difficulties with the Belt System:** The belt mechanism was considered inconvenient due to the clients' hand functionality. The client also considered the simpler adjustment system as a priority.
    - **Preference for Pant Adjusters or Velcro:** As for the adjustability mechanism, the client rejects belts or complicated locks and instead offers pant adjusters or Velcro.
    - **Mobility Issues:** One of the main issues was mobility over the shoulder, and anything that restricts that should be questioned and requiring the collar to allow some neck movement while keeping the head straight.
    - **Limited Dexterity:** The lock or any other complex mechanisms were out of the question said the client, because they are hard to operate.

- **Concerns about the Inflatable Design:** Despite this, the client had an interest in the inflatable concept incorporating it into the design, but the practicality of the design particularly for water activities was questionable. For instance, the client asked who would blow up the collar or how the collar would operate while immersed in water.
- **Portability:** The strengths identified by the client include foldability as well as the fact that the collar can be clipped onto other items, which should therefore not be changed.
- **Material Preferences:** The client had little knowledge regarding the materials presented but preferred natural, breathable types of material.
- **Collar Dimensions and Thickness:** The current collar dimensions were quite good but the client prefers a slimmer collar to enhance comfort.

- Changes and Improvements Needed:

- **Adjustability Mechanism:** Eliminate the belt and buttons for pant adjusters or Velcro at the collar area to ease alteration and avoid chafing.
- **Material Choice:** Find more natural and breathable fabrics for the inside of the mask while keeping silicone on the exterior side for mega durability and water-repellent properties.
- **Reduce Thickness:** Thin out and reduce the collar's bulk to make it thinner, while maintaining the support and comfort the client needs.
- **Mobility:** Make sure that the design of the garment permits the client to move her arm over her head or at least over her shoulder so that she can swim comfortably.

- **Inflatable Concept:** Eliminate the inflatable type because it becomes cumbersome for the client's underwater exercises as well as the dexterity issues.

Key Considerations:

- **Durability**:

  - Material Selection: It is flexible and very durable for use when designing the base of the collar as liquid silicone. The outer cover must also be made from a blend of Lycra that is chlorine, water, and sweat-resistant for the intended use.

  - Fabric Attachment: It is recommended that the fabric be sewn on with water-resistant zippers or pant adjusters, so they do not wear out over time and let water in.

- **Safety**:

  -Design Avoidance of Chafing: As buttons were found to have chafing potential, sharp edges should be eliminated and replaced with rounded components such as pant adjusters or Velcro.

  -Secure Fit: Below the adjustable mechanism should afford proper support of the neck and head but should not be too tight to cause harm during water activities.

- **Comfort**:

  - Padding: Padding the inside of the collar with a dense foam will create a soft layer for the skin to touch in order to provide comfort while swimming.

  -Thickness Optimization: Focus should be made on endeavoring little thickness of the collar so that the user does not find it burdensome to wear.

- **Portability**:

  - Compact Design: Another requirement is that in its usage the collar should be foldable or rollable to fit in a compact area when not in use. Lightweight materials will be used more extensively to also improve portability.

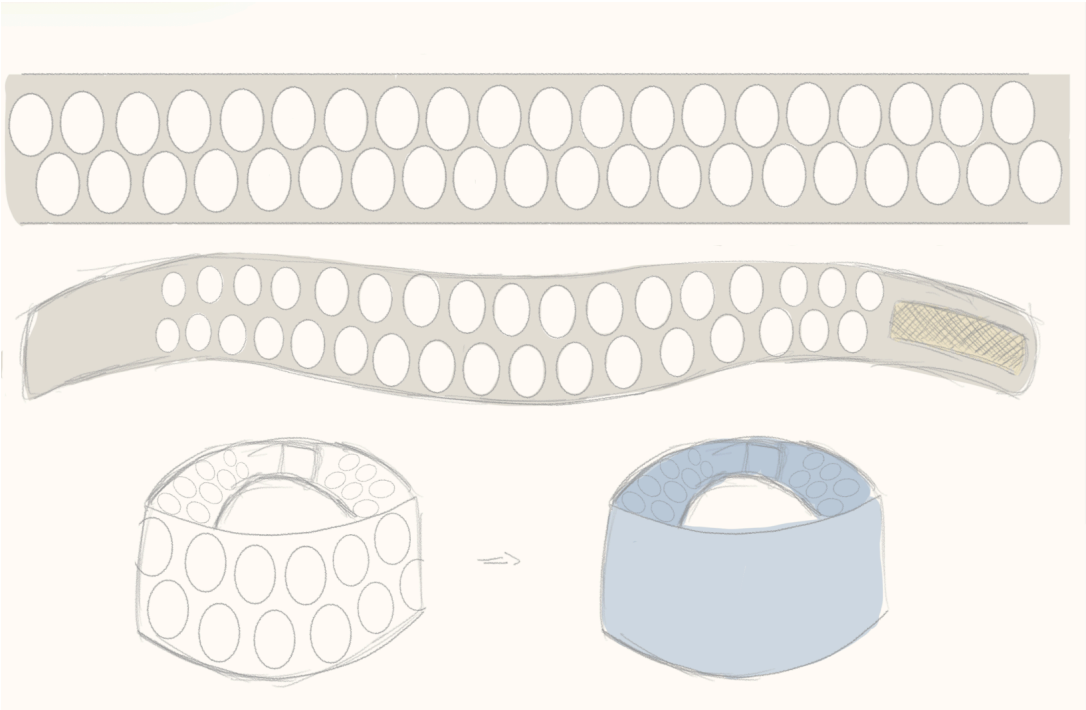
  -Clipping Mechanism: As to the collar, it should to used in combination with a clipping system which enables the collar to be carried easily in bags or other corresponding accessories.

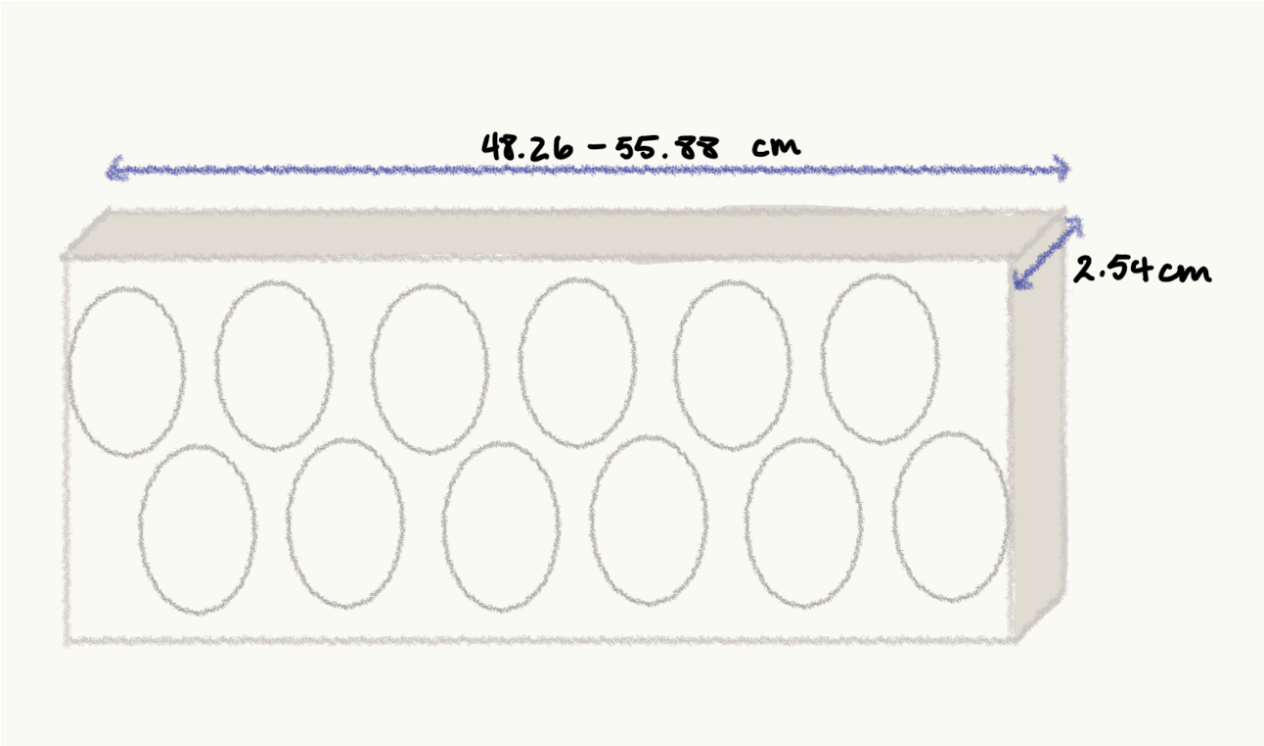
- **Environmental Sustainability**:

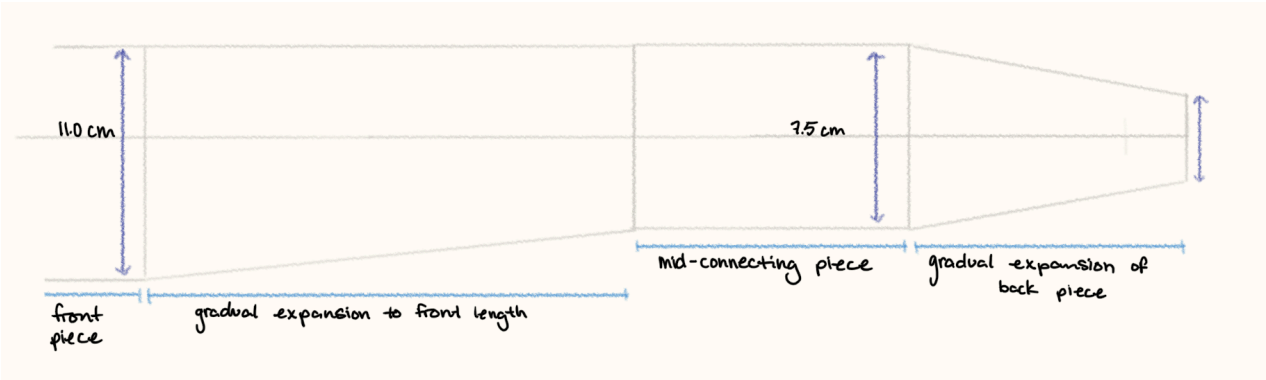
  -Material Choices: When it comes to the new product development, consider the possible Lycra blend and the foam padding based on environmentally safe materials reducing the environmental impact.

  -Manufacturing Processes: Adopt environmentally friendly production systems which include; minimizing the use of raw materials and practicing efficiency in power use.

Detailed Design:




48.26 - 55.88 cm
2.54cm



In consideration of the client's feedback and additional research, the team has decided to go with a design that is lightweight and more breathable. Following client feedback, the skeleton of the collar will have gaps allowing breathability and flexibility of the collar while maintaining the proper support. The adjustment mechanism will be velcro to allow greater ease for putting on and taking off the collar. In addition to this, the team has decided that a single sleeve will be the best for an outer covering as this avoids velcro and other materials chafing the chin and clavicle areas.

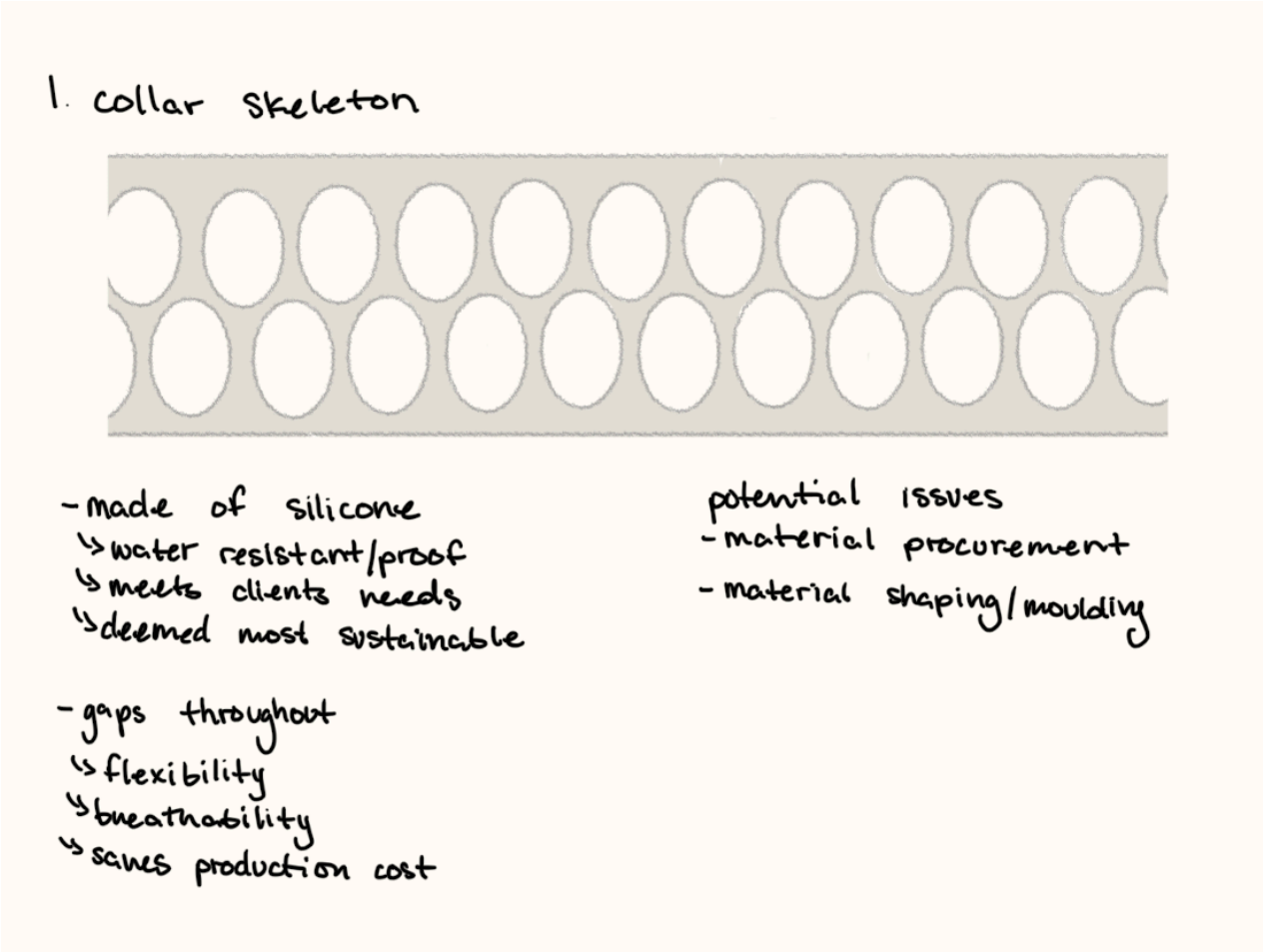
In regards to materials, silicone was determined to be the best solution as it is soft, waterproof, durable, and flexible. Using silicone for this project may have some potential issues due to procurement and molding, in which case the team may opt for foam or foam-like materials instead.

There are three subsystems within our design;

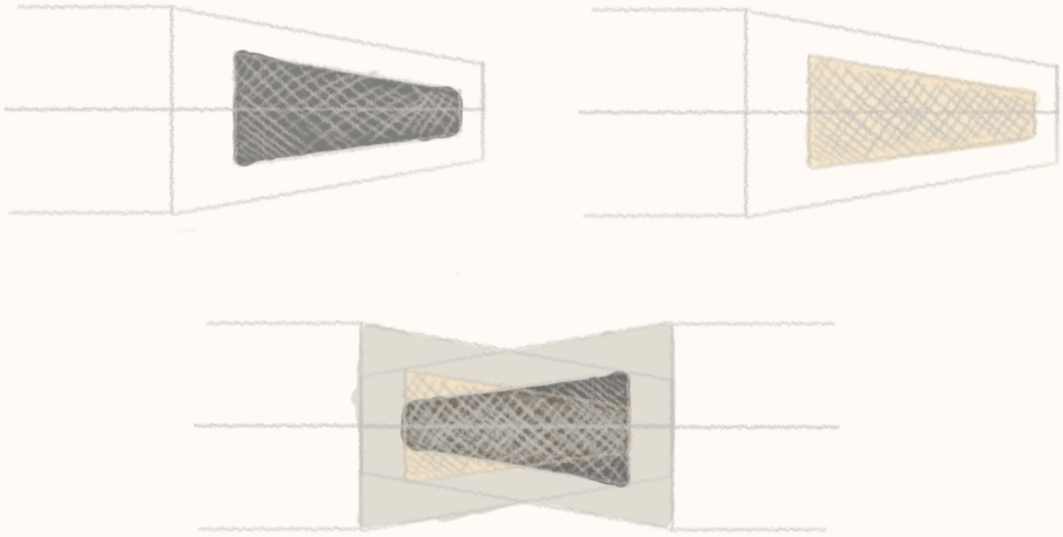
1. The skeletal base
2. The adjustment mechanism
3. The sleeve cover

The skeletal base is the largest component of the soft cervical collar. It will be made with silicone and feature gaps along the structure to allow for breathability and flexibility. The adjustment

mechanism chosen was velcro as this allows the easiest use for putting on and taking off the collar with reduced mobility/dexterity. Finally, the sleeve cover will be made with a single piece of fabric, and be removable by a slide-in-slide-out method. This was chosen since it will prevent chafing due to extra materials around the neck.

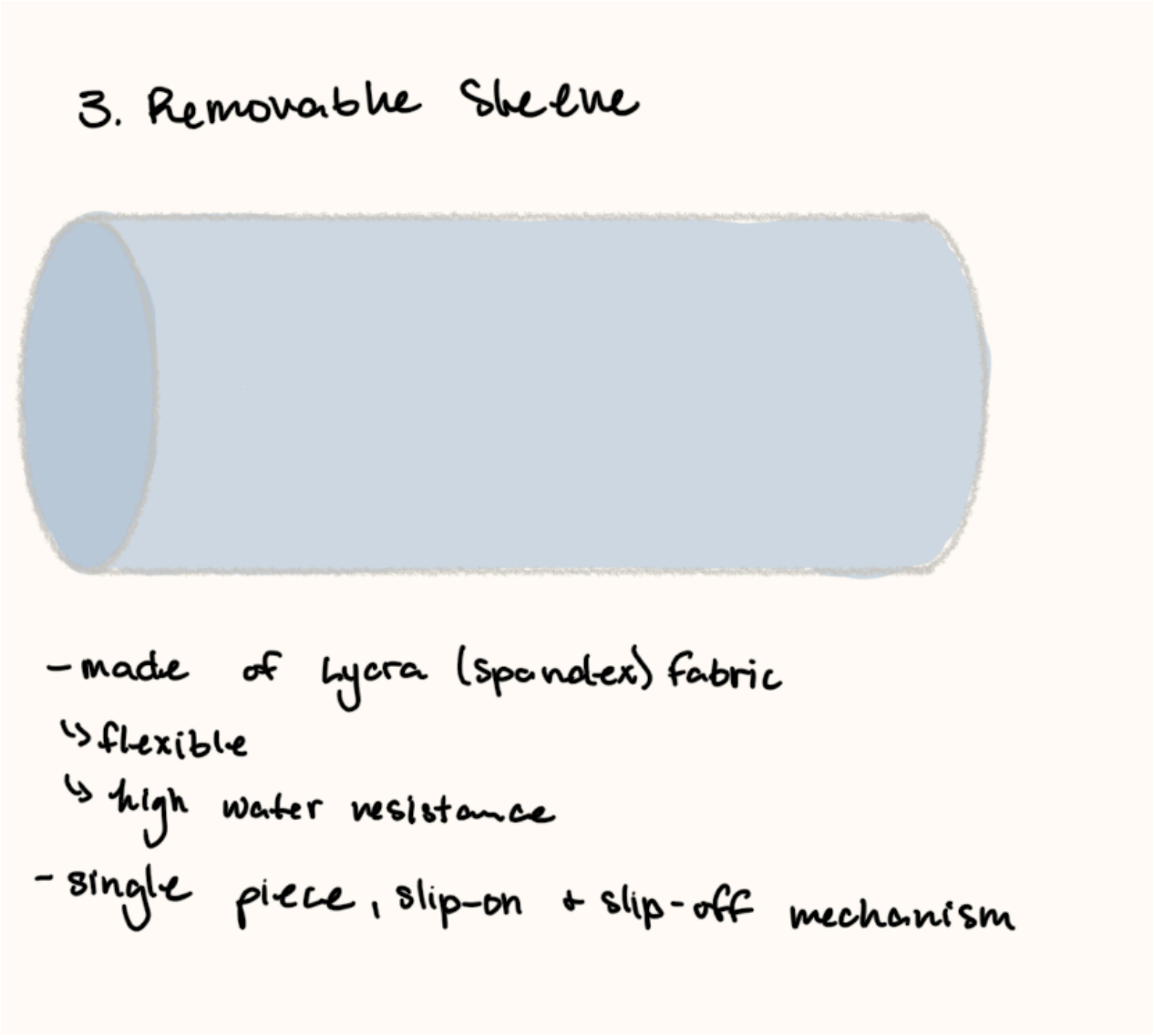


2. Adjustment Mechanism



- uses velcro
  - ↳ easy to use
  - ↳ simple

possible issues
- wears out quickly



Prioritization of DFX Factors

- **Comfort and Safety:**

  These aspects are crucial since they are going to wear a collar throughout the various rigorous exercises. Comfort and the absence of chafing properly affect user experience and are safety-oriented in their effect.

- **Durability:**

Since the collar will mainly be used in water activities it is paramount to consider how long it will last without getting spoilt or completely damaged.

- **Portability:**

  Since the client appreciates portable and foldable designs, the collar should also be easy to transport and store, particularly for people who might be on the move in different ways.

- **Environmental Sustainability:**

  However, this factor may not be as critically significant as the other factors. However, the use of sustainable practices shall improve the appeal of product to the group of consumers who are sensitive to the environment.

4. Provide a detailed list of skills and resources you have at your disposal that will enable you to create your design. If there are skills or resources missing to complete your design, describe how you will obtain them.

The group has CAD software accessible and will use this to visualize the final design and simulate it in different scenarios. In terms of practical tools for manufacturing the product, the group has access to machines such as the mill, lathe, drill press, and sewing machines. The group has the required skills and certifications to use the machines in the CEED workshop. The group is currently missing skills to simulate and create effective CAD designs. We will obtain these skills through online courses and tutorials. The group is also missing certain skills required in the manufacturing process of the prototype, such as sewing, and shaping the liquid silicone.

Realistic Design Timeline

By sectioning off the time required into groups and identifying project milestones; a rough timeframe for how long it may take to implement the design can be made. First up, initial designs and any extra material/design specifications. The initial designs made; will be done on CAD software, and aid in visualizing the product. In reality, the model won't provide much help as the collar remains primarily a subjective rating scale, with input from the client on a physical piece providing the primary feedback. A realistic timeframe would be 1-2 weeks. Material sourcing and testing for the collar piece is the next big milestone; the largest constraint with this section is obtaining the material. A Realistic timeframe for this section would be 1-2 weeks. Next, creating a first prototype for the straps to hold the collar around the neck. Once again with a material constraint and the need for the straps to be fabricated by the group. This section can be worked on alongside the material sourcing and testing and has an estimated 1-2 week timeframe. As for the actual time the group has at their disposal to work on these design implementations, An estimated 5-10 hours a week seems fitting, enough time to complete the work within the given timeframes.

Any Extra Product Assumptions

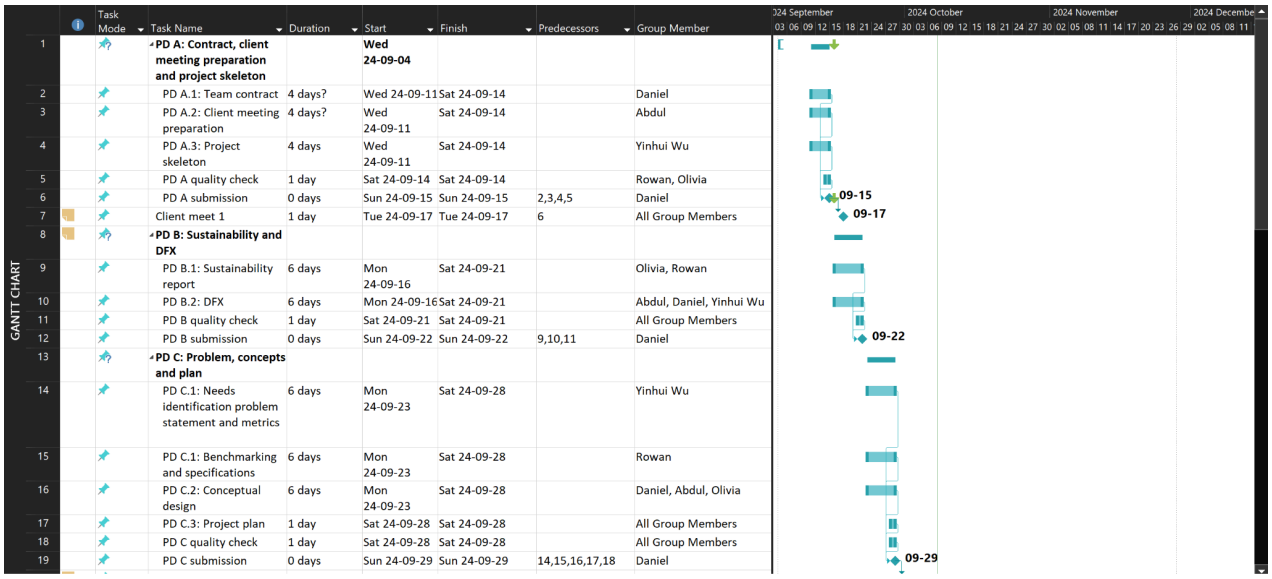
A critical product assumption that could affect the ability to implement our design is the availability of materials. At its core, material selection is one of the project's foundations and must be done correctly. The ideal material must be chosen which could result in extended wait times; in return backing up the rest of the project. Additionally, Any skills group members may need to learn to manufacture the collar. CAD software skills and sewing skills are the two primary applications in need of learning. On the topic of manufacturing, gaining access to the CEED equipment to allow the group to manufacture the collar may take time, depending on whether or not there are wait times for the equipment, given the limited number available.

4.2 BOM

Table 6. Bill of Materials

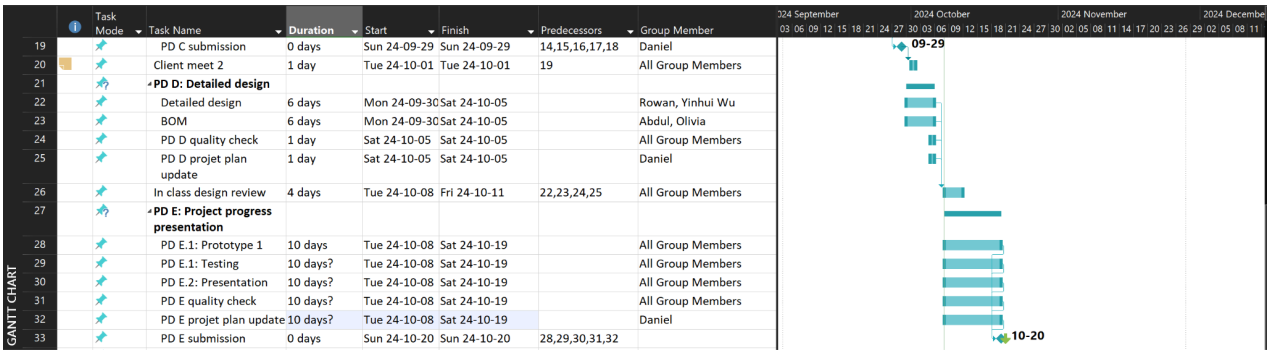
Item	Quantity	Estimated Cost
lycra fabric	1 yard	$14.23 Amazon
liquid silicone	500 g	$16.13 AliExpress
Foam	22in x 22in	$9.88 home depot
sewing materials (thread, needles, etc)	1-2 small spools 1-2 needles	$5.00 dollar store
Velcro	75 cm	$3.00 dollar store
		TOTAL: =14.23+16.13+9.88+5+3 = $48.24

4.3 Project plan update



GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Group Member
1		**PD A: Contract, client meeting preparation and project skeleton**		**Wed 24-09-04**			
2		PD A.1: Team contract	4 days?	Wed 24-09-11	Sat 24-09-14		Daniel
3		PD A.2: Client meeting preparation	4 days?	Wed 24-09-11	Sat 24-09-14		Abdul
4		PD A.3: Project skeleton	4 days	Wed 24-09-11	Sat 24-09-14		Yinhui Wu
5		PD A quality check	1 day	Sat 24-09-14	Sat 24-09-14		Rowan, Olivia
6		PD A submission	0 days	Sun 24-09-15	Sun 24-09-15	2,3,4,5	Daniel
7		Client meet 1	1 day	Tue 24-09-17	Tue 24-09-17	6	All Group Members
8		**PD B: Sustainability and DFX**					
9		PD B.1: Sustainability report	6 days	Mon 24-09-16	Sat 24-09-21		Olivia, Rowan
10		PD B.2: DFX	6 days	Mon 24-09-16	Sat 24-09-21		Abdul, Daniel, Yinhui Wu
11		PD B quality check	1 day	Sat 24-09-21	Sat 24-09-21		All Group Members
12		PD B submission	0 days	Sun 24-09-22	Sun 24-09-22	9,10,11	Daniel
13		**PD C: Problem, concepts and plan**					
14		PD C.1: Needs identification problem statement and metrics	6 days	Mon 24-09-23	Sat 24-09-28		Yinhui Wu
15		PD C.1: Benchmarking and specifications	6 days	Mon 24-09-23	Sat 24-09-28		Rowan
16		PD C.2: Conceptual design	6 days	Mon 24-09-23	Sat 24-09-28		Daniel, Abdul, Olivia
17		PD C.3: Project plan	1 day	Sat 24-09-28	Sat 24-09-28		All Group Members
18		PD C quality check	1 day	Sat 24-09-28	Sat 24-09-28		All Group Members
19		PD C submission	0 days	Sun 24-09-29	Sun 24-09-29	14,15,16,17,18	Daniel



GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Group Member
19		PD C submission	0 days	Sun 24-09-29	Sun 24-09-29	14,15,16,17,18	Daniel
20		Client meet 2	1 day	Tue 24-10-01	Tue 24-10-01	19	All Group Members
21		**PD D: Detailed design**					
22		Detailed design	6 days	Mon 24-09-30	Sat 24-10-05		Rowan, Yinhui Wu
23		BOM	6 days	Mon 24-09-30	Sat 24-10-05		Abdul, Olivia
24		PD D quality check	1 day	Sat 24-10-05	Sat 24-10-05		All Group Members
25		PD D projet plan update	1 day	Sat 24-10-05	Sat 24-10-05		Daniel
26		In class design review	4 days	Tue 24-10-08	Fri 24-10-11	22,23,24,25	All Group Members
27		**PD E: Project progress presentation**					
28		PD E.1: Prototype 1	10 days	Tue 24-10-08	Sat 24-10-19		All Group Members
29		PD E.1: Testing	10 days?	Tue 24-10-08	Sat 24-10-19		All Group Members
30		PD E.2: Presentation	10 days?	Tue 24-10-08	Sat 24-10-19		All Group Members
31		PD E quality check	10 days?	Tue 24-10-08	Sat 24-10-19		All Group Members
32		PD E projet plan update	10 days?	Tue 24-10-08	Sat 24-10-19		Daniel
33		PD E submission	0 days	Sun 24-10-20	Sun 24-10-20	28,29,30,31,32	

5 Conclusions

6 Bibliography

Insert your list of references here.