Deliverable B: Problem Definition and Concept Design

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1 Introduction

For the project of developing a communication pointer this document addresses the problem analysis and concept generation following the first client meeting. The problem analysis includes needs identification, problem statement, metrics, and target specifications. Concept generation is the basic ideation process, where each subsystem has a list of generated ideas and best designs are collected into a decision matrix.

2 Problem Definition

This section covers how the team determined the problem statement, needs, metrics, and target specifications for our project.

2.1 Need Statements

Translated from the notes gathered during the first client meeting, the team gathered succinct general needs that can be developed into specifications or metrics. Each individual need was assigned an importance value which ranges from 1 to 5, with 5 being the most important. The importance values were determined by analyzing the notes from the first client meeting. The needs and their importance value can be found in Table 1.

Note that whenever the term laser is used in this section, it usually refers to a light source. To keep the terminology similar to the ones used in the interview, laser will be used to describe all possible light sources that can used as a pointing device.

Table 1: Client Needs

Number	Need	Importance
1	The product is a hands-free device.	5
2	The laser can be reliably turned on and off without the use of arms and hands.	5
3	The mount is compatible with various glasses frames.	2
4	The mount allows controlled and steady movement of the laser pointer	4
5	The product is lightweight	3
6	The product is small in size	2
7	The mount allows attachment to the temples (arms) of the glasses	5
8	The product is comfortable during extended use.	3
9	The product allows easy replacement of batteries or easy charging of batteries	4
10	The laser pointer can survive a whole day of operation before needing to be replaced/recharged	5
11	The product is safe to use	5
12	The laser has a few feet of range	5
13	The product is functional in different environments including different ambient lighting	3
14	The product is water resistant (rain, etc.)	1
15	The laser is usable (visible and safe to use) on laminated surfaces	1

16	The mount allows secure attachment to glasses	5
17	The product allows operation by persons with limited range of head motions	3
18	The mount is easily detachable from the glasses frame	5
19	The mount design stays true to what the customer suggested	5
20	The product costs less than 100 CAD	3
21	The product is aesthetically pleasing	1

2.2 Problem Statement

From the need statements and their importance in section 2.1, our group developed the following problem statement:

The problem is to design a battery-powered mountable laser source, that will be used with glasses and activated via head movement. The product allows the users to point to words and diagrams on a communication board with their head, to allow non-verbal users with limited hand mobility to communicate efficiently.

2.3 Metrics

With the help of need statements in section 2.1, a list of metrics by which we could measure every aspect of the product was created. To ensure that every need was accounted for in the target specifications, the need number column was included to help keep track of all the needs accounted for. Each metric was assigned an importance value similar to those used in section 2.1. The values were calculated by taking the average of the corresponding need importance values. The metrics and their corresponding importance values are listed in Table 2.

Table 2: Metrics

Metric #	Need #	Metric	Importance	Unit
1	9	Time to charge/time to replace batteries	4	s
2	5	Product mass on frames	3	g
3	18	Time to mount	5	s
4	4, 16	Laser reliability	4.5	cm
5	12, 15	Laser beam range	3	m
6	20	Manufacturing cost	3	CAD
7	6	Product size	2	cm^3
8	3, 7, 16	Mount compatibility with frames	4	Frame dimensions (range)
9	10	Battery life	5	h
10	13, 15	Laser beam visibility	2	# of environments
11	1, 2	Hands-free activation	5	Y/N
12	2, 17	Activation sensitivity (error rate)	4	%
13	8	Time before discomfort	3	h
14	14	Water Resistant	1	Y/N

15	18	Time to detach	5	s
16	21	Aesthetically pleasing	1	Y/N

2.4 Benchmarking

Only one similar design to our product was found (from 2 sources) [1] [2]. We suspect this is because the nature of the disability of our client is too specific. This results in the product being too niche and expensive for the market. The metrics that were listed in the product description were aggregated in Table 3: Benchmark Specifications from Bridges and 4 below. Question marks are used to indicate unclear or unspecified information.

Table 3: Benchmark Specifications from Bridges

Specs	
Weight	7.1 g + battery pack
Light Source Type	Class II Laser Diode
Batteries	2 AA, external battery box
Mount	2 spring wire clips (?), adjustable
Activation	unknown
Cost	$300

Table 4: Benchmark Specifications from Low Tech

Specs	
Weight	1.25 lb total
Light Source Type	?
Batteries	?
Mount	1 spring clips, adjustable
Activation	Switch, or button
Cost	$150

Figure 1: Collection of images from the Low-Tech page

2.5 Target Specifications

From the benchmarked products (section 6) and our list of metrics (section 5), we compiled a list of target specifications in Table 5.

Table 5: Target Specifications

Metric #	Need #	Metric	Target	Unit
1	9	Time to charge/time to replace batteries	120	s
2	5	Product mass on frames	20	g
3	18	Time to mount	30	s
4	4, 16	Laser stability	5	cm
5	12, 15	Laser beam range	2	m
6	11	Laser safety grade	Class II	class
7	20	Manufacturing cost	100	CAD
8	6	Product size: • Laser and accelerometer casing • Hip mount case • All integrated casing	L x w x h 2cmx1cmx1cm 8cmx9cmx4cm 6cmx2.5cmx2.5cm	cm
9	3, 7, 16	Mount compatibility with frames (Frame cross section dimensions)	3mmx3mm to 5mmx10mm	mm
10	10	Battery life	10	h
11	13, 15	Laser beam visibility	2m indoors,	# of environments
12	1, 2	Hands-free activation	Y	Y/N
13	2, 17	Activation sensitivity (error rate)	15	%
14	8	Time before discomfort	12	h
15	14	Water Resistant	Y	Y/N
16	18	Time to detach	30	s
17	21	Aesthetically pleasing	Y	Y/N

3 Design Concepts

In this section, a set of possible design concepts were created using the problem statement from section 2.1. In section 3.1, the product was broken down into subsystems and we generated as many possible ideas as possible. Then in section 3.2, these ideas were filtered by what our judgment thought met our specifications to create our two final design concepts, which can be found in section 3.3.

3.1 Concept Generation

To help generate ideas for our product, the product was broken down in the following subsystems:

- Battery Location: Possible location of the battery.
- Battery Type: To power the product.
- Light Source: The light source that will act as the pointer.
- Mount Type: For specifically attaching the product to a glasses frame.

- Casing: To protect the product on the glasses frame (laser and possibly microcontroller).
- Shut Off Options: Hands free activation/deactivation of the product.
- Add-Ons: Quality of life additions to the product.

Possible ideas were generated for each subsystem as shown in Table 6.

Table 6: Concept Subsystem Ideas

Concept Subsystem Ideas	
Battery Location	Hip mounted
	Opposite side of head/frames from the product
	All integrated: single casing on one side of the head
Battery Type	Rechargeable • Polymer • USB Power Bank • Lithium ion
	Non-rechargeable • CR batteries
Light Source	LED
	Laser Diode
Mount Type	Spring/wire clip: spring loaded clips.
	Zip ties
	Molded to glasses and light source: make the mount part of the frames.
	Plastic brackets and screws
	Elastic attachment system: attaching with looped elastic bands.
	Velcro system: Velcro glued to casing and fastener on frames
	Magnet attachment system: magnets glued to frames that connect to magnets in casing
	Tape
Casing	3D printed casing fit to each concept (Arduino, accelerometer, laser, batteries)
	Plastic cutting box
	Injection molded casing
	MDF box
Shut Off Options	Arduino controlled Accelerometer: Accelerometer will measure large change in acceleration and the Arduino will send the control signal
	Arduino controlled Gyroscope
	Flip Flop controlled Accelerometer
	Flip Flop controlled Gyroscope
	Custom made PCB hosting microcontroller and sensor
	Accelerometer switch: accelerometer has no micro controller control just sensor limit
	Motion Sensor and Timer
	Detect Blinking

	Smart Pointer (Wi-Fi controlled)
	String and clutch system: tension in string due to movement of the head causes activation
Add-ons	Shirt Clip
	Polarizer: polarize the laser light
	Lenses
	Wireless Charging
	Different laser colours

3.2 Concept Selection

To help generate possible concepts, individual ideas from Table 6 were first screened in section 3.2.1. The results were then analyzed in section 3.2.2 to help select the two final concept designs.

3.2.1 Concept Screening

To help reduce the number of solutions we need to evaluate, each subsystem was first screened to remove ideas that will clearly not meet our target specifications. This was done by analysing each solution proposed in Table 6 and comparing them with the target specifications in Table 5. The result of this analysis can be found in Table 7.

Table 7: Concept Screening

Concept Subsystem Ideas		Assessment
Battery Location	Hip mounted	Pass
	Opposite side of head/frames from the product	Pass
	All Integrated (Single mount)	Pass
Battery Type	Rechargeable • Polymer • USB Power Bank • Lithium ion	Pass
	Non-rechargeable • CR batteries	Pass
Light Source	LED	Fail
	Laser Diode	Pass
Mount Type	Spring/wire clip: spring loaded clips.	Pass
	Zip ties	Fail
	Molded to glasses and light source: make the mount part of the frames.	Fail
	Plastic brackets and screws	Pass
	Elastic attachment system: attaching with looped elastic bands.	Pass
	Velcro system: Velcro glued to casing and fastener on frames	Fail
	Magnet attachment system: magnets glued to frames that connect to magnets in casing	Fail

	Tape	Fail
Casing	3D printed casing fit to each concept (Arduino, accelerometer, laser, batteries)	Pass
	Plastic cutting box	Pass
	Injection molded casing	Fail
	MDF box	Pass
	Metal casing box	Fail
Shut Off Options	Arduino controlled Accelerometer: Accelerometer will measure large change in acceleration and the Arduino will send the control signal	Pass
	Arduino controlled Gyroscope	Fail
	Flip Flop controlled Accelerometer	Fail
	Flip Flop controlled Gyroscope	Fail
	Custom made PCB hosting microcontroller and sensor	Fail
	Accelerometer switch: accelerometer has no micro controller control just sensor limit	Fail
	Motion Sensor and Timer	Fail
	Detect Blinking	Fail
	Smart Pointer (Wi-Fi controlled)	Fail
	String and clutch system: tension in string due to movement of the head causes activation	Fail
Add-Ons	Shirt Clip	Pass
	Polarizer: polarize the laser light	Fail
	Lenses	Fail
	Wireless Charging	Fail
	Different laser colours	Fail
	External hip mounted battery pack	Pass

The explanation as to why some of the more promising solutions were failed are as follows:

- Battery Location: Since all three concepts proposed in Table 6 seemed valid, they were all passed. In fact, since all concepts are very different from each other, they will be used as a base to create the possible concepts for analytical analysis.
- Battery Type: Since the battery type will depend on the solution that is implemented, they will both be passed.
- Light Source: LEDs tend to not come pre-collimated like lasers and are harder to collimate requiring the addition of lenses to make the light focus on a single spot. This collimation requirement will make LEDs less efficient (not as bright or focused) at a distance, while a laser will maintain a large amount of its visibility at further distances. This means that using an LED will make the system more difficult to construct and possibly not as visible.
- Mount Type: The mount must hold the laser pointer sturdy enough on the glasses to prevent the pointer from wobbling when in use. Thus, the sturdiness of the proposed

grip solutions was considered to help decide which solutions would move on to the next step.

  - The spring clip was passed because its grip can keep the mount steady enough for better use of the product.
  - The zip ties were failed because they are irreversible. The mount needs to be attachable and detachable to different glass frames, and this mount type wouldn't fill that requirement.
  - Making the mount part of the frames was failed as well because it adds complexity to the manufacturing process. It would also prevent the client from reinstalling the mount on a different pair of glasses.
  - The plastic brackets and screws were passed because they have the capability of securing the mount to the glasses enough to prevent wobbling.
  - The elastic attachment system was passed because it can maintain a tight grip of the pointer to the glasses. It could be used in addition with another attachment system, for increased grip.
  - The Velcro system was failed because it wouldn't keep the mount secure to the glasses. Therefore, the laser would deviate a lot more (from the target) than intended. In addition, the grip strength of Velcro would decrease with use.
  - The magnet attachment system was failed because the mount would be hard to use. Should the magnet or the laser pointer fall off, the customer would have difficulty in finding the small pieces and mounting them back on the glasses. In addition, a magnet that would provide the needed stability would be hard to find within the budget as it would have to have a high magnetic strength.
  - Tape was failed because the grip would not be strong enough. In addition, the customer will have to consistently buy tape, then roll in around (and off) their glasses if they want to detach our product from their glasses. Tape is also not reliable as its strength deteriorates faster than the other proposed solutions over time.

- Shutoff options: Since the product must be developed and tested within 3 months, all electrical implementations that are lower level than an Arduino were automatically failed because of the complexity of those implementations. In addition, gyroscope was failed because it only allows us to measure the tilt, which is not accurate enough to differentiate between a shake versus regular head movements. All mechanical options were also failed due to them being unreliable.
- Casing: The casing holds everything that is mounted to the glasses. This includes the laser and the accelerometer. Depending on the different configurations of the product, the casing may also need to hold an Arduino and battery. Although an injection moulded casing would be most ideal due to precision of shape, versatility, compatible materials, and aesthetics, it was rejected due to the high cost and the lack of resources for this project. The metal casing was rejected due to the higher weight compared to the other proposed concepts as well as the increased risk of injury due to its hardness and potentially sharp edges. The plastic box, 3D printed casing, and MDF box were all passed due to their light weight and ease of manufacturability.

- Add-Ons: Most add-ons were rejected as they did not help achieve any important target specifications. As such, they would be a time sink without having much payoff in the end. Shirt clip was kept as it can be easily implemented with the help of a third-party clip should it be required. In addition, the external hip battery pack was also passed to allow for a system with a different battery location. This would decrease the load on the glasses by removing the battery from the casing which would decrease the chances of the glasses displacing with use of the product.

3.2.2 Concept Analysis

A high-level concept was developed in section 3.2.2.1 to analyze the following subsystems: battery location, battery type, light source, shut off options and add-ons. Next, the mount subsystem was analyzed in section 3.2.2.2. Finally, the casing subsystem was analyzed in section 3.2.2.3. Note that the analysis of mounts and casings were done separately since they can be determined independent of the high-level concept. Excluding those subsystems reduced the number of distinct concepts that were generated by the morphological table in section 3.2.2.1.1.

3.2.2.1 High-Level Concept Analysis

Using the three battery placements from Table 7 as anchor points, three distinct high-level concepts were developed using a morphological table in section 3.2.2.1.1. These distinct concepts were then analyzed using a weighted decision matrix in section 3.2.2.1.2. Note that the mount subsystem and the casing subsystem were omitted from the high-level concept analysis. For more information, please consult section 3.2.2.

3.2.2.1.1 Morphological Analysis

The morphological table in Table 8 was made to help generate possible high-level concepts. All ideas that passed from Table 7 were aggregated as shown below.

Table 8: Morphological Analysis

Battery Location	Battery Type	Light Source	Shut Off options	Add-ons
Hip mounted ①	Rechargeable ①②	Laser Diode ①②③	Arduino controlled Accelerometer ①②③	Shirt Clip ①
Opposite side of frame (Two mounts) ②	Non-rechargeable ③			None ②③
All Integrated (Single mount) ③				
			Concept #1	①
			Concept #2	②
			Concept #3	③

Using the morphological analysis performed in Table 8, the 3 following possible concepts were generated:

- Concept #1
    - Hip mounted: Rechargeable battery bank and Arduino Nano.
    - Frame Mounted (Either Side): Laser Diode and Accelerometer.
    - Cable: Connects components on hip and frame.
    - Add-On: Shirt Clip.

- Concept #2
    - Left Frame Mounted: Rechargeable battery bank.
    - Right Frame Mounted: Arduino Nano, Laser Diode and Accelerometer.
    - Cable: Connects components on left and right frame.
    - Add-On: None.
- Concept #3
    - Frame Mounted (Either Side): Non-rechargeable battery, Arduino Nano, Laser Diode and Accelerometer.
    - Cable: None.
    - Add-On: None.

Shirt clip was only required for concept #1 since that is the only concept that has a long wire running from the glasses to the hip of the user. This wire can become quite a nuisance if not held in place by a clip.

Also, concept #3 was the only concept that uses a non-rechargeable battery since using a rechargeable battery with that design would cause the total weight on the frame to exceed the target specifications. As such, we opted for non-rechargeable batteries.

3.2.2.1.2 Weighted Decision Matrix

The concepts generated in section 3.2.2.1.1 were analyzed using a weighted decision matrix to see whether they would meet all the target specifications. As the concepts were fleshed out enough, it made sense to analytically observe each option and compare them with each other. The selection criteria that were considered includes:

- Weight (per glass arm): Since most of the weight of the product will be felt on the user's ear, it makes sense to look at the weight per glass arm and pick the maximum one.
- Setup Complexity: The various concepts are made up of different number of parts, and each part will have varying amount of complexity to setup at the start of each day. All this needs to be accounted for. In addition, the complexity and frequency of recharging/replacing batteries will be observed here as well.
- Size (on glasses): Since most of the size of concept #1 will be hidden beneath the waist, it did not make sense to include it in this category. As such, the size will be limited to visible elements that exist on the glasses.
- Implementation Feasibility: Since we are limited in time and knowledge and we aim to release a fully functional product by the end of the semester, we must ensure that any concept that gets picked can be implemented in time.
- Comfort: The comfort section will try to measure how intrusive the product is. Things like wires hanging around and undistributed weight will affect this selection criteria.

The weights for each of the categories were calculated using the related needs' importance. Said number was converted into a percentage out of a hundred. The needs were averaged in case of multiple needs applied to one category. Note many important needs such as activation method and laser requirements were ignored since all three possible concepts will be the same in that regard.

The ranking for most options were generated after conducting preliminary research on possible metrics on each implementation. The results of this research can be found in section 5.1 and section 5.2. Since comfort is more subjective, a vote was conducted within the team to obtain a useable result for the selection criteria.

Using both the weights and ranking, a weighted decision matrix was generated as shown below.

Table 9: Weighted Decision Matrix

Selection Criteria	Weight	Concept #1		Concept #2		Concept #3	
Weight (per glasses arm)	0.17	10	1.71	2	0.34	6	1.03
Setup Complexity	0.26	4	1.03	4	1.03	10	2.57
Size (on glasses)	0.29	10	2.86	2	0.57	4	1.14
Implementation Feasibility	0.11	7	0.80	5	0.57	9	1.03
Comfort	0.17	5	0.86	5	0.86	8	1.37
	Total Score	7.26		3.37		7.14	

From Table 9, it is evident that concept #2 must be eliminated from consideration. This makes sense because concept #2 is heavier and bigger than the other two without providing any additional benefits.

Since concept #1 and concept #3 scored similarly, they will both be presented to the client for feedback.

3.2.2.2 Mount Analysis

The mount types that were passed in section 3.2.1 were analyzed below in Table 10. The three mount types were compared to related needs and their respective weights (see Table 1) to find the most compatible solution. This analysis was done with the help of a weighted decision matrix (consult section 3.2.2.1.2 for more information).

The spring wire clip uses a 3-point contact system with a wire with elastic properties and rubber grip to attach the casing to the glasses frames securely. Although the spring wire clip in theory has the potential to provide great stability, this requires great precision in manufacturing which may not be possible for the scope of this project. The screw and fitted bracket fastener system uses a plastic bracket fastener with a rubber inner grip shaped similarly to the cross section of the glasses arm with a tightening screw for mounting. The elastic band system uses a thick elastic band to hold the casing in place. Although attaching an elastic band is relatively easy, attaching it in a way that the casing and glasses do not slide and stay in place would be difficult. Although the elastic band system results in the lowest score, it can be used in parallel with other mount types for additional securing and possible additional damping of the laser movement. As seen in Table 10 the results show that the screw and fitted bracket fastener aligns the most with the need for a stable laser.

Table 10 Mount Concept Analysis

Selection Criteria	Weight	Spring wire clip		Screw and fitted bracket fastener		Elastic band mount system	
Lightweight	0.19	6	1.13	6	1.13	10	1.88

Provides stability for laser	0.25	6	1.50	10	2.50	2	0.50
Compatible with different frames	0.13	8	1.00	8	1.00	10	1.25
Aesthetically pleasing	0.06	8	0.50	6	0.38	4	0.25
Water resistant	0.06	8	0.50	8	0.50	8	0.50
Ease of attachment	0.31	10	3.13	8	2.50	6	1.88
Final scores:		7.75		8.00		6.25	

3.2.2.3 Casing Analysis

The casing types that were passed in section 3.2.1 were analyzed below in Table 1. This analysis was done with the help of a weighted decision matrix (consult section 3.2.2.1.2 for more information).

The 3D printed casing was found to be the most compatible solution. In addition to the client needs listed, 3D printing also allows the design of complex shapes and ease of manufacturing at low cost. This would aid in designing a casing that is fitted to its inner components (the laser, accelerometer, Arduino, and battery).

Table 11 Casing Concept Analysis

Selection Criteria	Weight	3D printed casing		Plastic cutting box		MDF box	
Lightweight	0.21	10	2.14	6	1.29	8	1.71
Comfortable	0.21	8	1.71	8	1.71	6	1.29
Small in size	0.14	10	1.43	10	1.43	10	1.43
Aesthetically pleasing	0.07	10	0.71	10	0.71	4	0.29
Water resistant	0.07	6	0.43	8	0.57	2	0.14
Ease of replacing batteries	0.29	10	2.86	10	2.86	10	2.86
Final scores:		9.29		8.57		7.71	

3.3 Final concepts and Justification

Analysis from section 3.2.2.1 revealed that concept #1 and concept #3 are the best options based on the target specification and our level of competence as a group. In addition, analysis from section 3.2.2.2 and section 3.2.2.3 revealed that the mount will be made using screws and fitted bracket fastener, and the casing will be 3D printed.

The primary advantages for concept #1 on the electrical side are that it is the least complex design making it the easiest to prototype and calibrate. This lack of complexity also helps the team meet the manufacturing cost target spec due to its simplicity. Additionally, the battery life, rechargeability of the battery and the target weight specifications can be easily met with this design as the battery is hip mounted. The hip mount allows for a much larger battery, who's weight can be support by the user's waist rather than the frames.

On the other hand, since concept #3 is an all-in-one system, it will be easier to use and have a sleeker design when compared to the other options. Furthermore, there will be no cables between the components as they will all be soldered to one system. This will allow the user the ability to move their head freely without having to worry about a cable getting snagged.

The reason we decided to remove concept #2 as a possible option is that the disadvantages outweigh the advantages. Some of the major disadvantages include the extra weight on the frames, since all the components are on the frames. Another major problem is that the battery, although rechargeable, will have to be much smaller than the one in concept #1 to keep it from being too heavy. This will make it difficult to balance both the 20g mass target on the frames and the 12 hours of use per day target.

During the next client meeting, we will discuss with the client which option they prefer or possibly a combination of the two concepts.

3.4 Final Design Concept Sketches

This section contains the sketches for the final design of high-level concepts, mount and casing.

3.4.1 High-level Design Sketches

As described in the previous section, two overall concepts were chosen. Concept #1 includes a glasses mounted laser with a hip mounted battery pack while Concept #3 is an all integrated product with the all the components mounted in a casing on the glasses. These two overall systems can be seen in Figure 2.

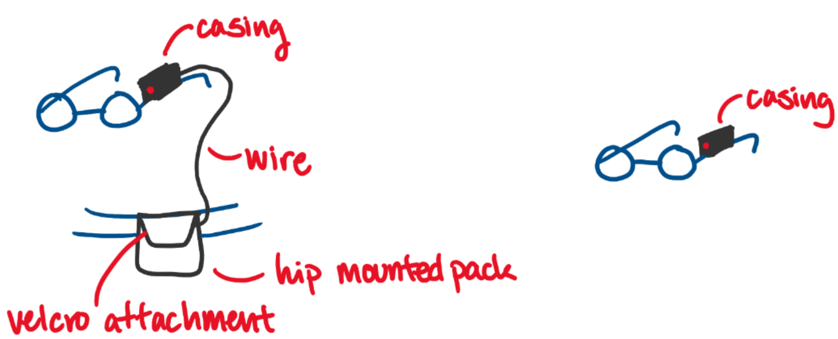

Figure 2: System concept design sketches. Left: Concept #1, Right: Concept #3

The casing to be mounted on the glasses may be 3D printed for both final designs as described in section 3.4.3. In both cases, the 3D printed casing may be designed to fit the inner components with small chambers or notches. For simplicity, these have not been included in the following sketches.

As seen in Figure 2, concept #1 includes a hip mounted battery pack that holds both the battery and the Arduino Nano. A small fabric pouch is proposed to hold a casing that holds the battery, Arduino Nano, and any necessary connection wires. The fabric pouch may be opened and closed with a Velcro seal. This design allows a wire to run to the glasses mounted casing through an opening in the pouch. A clip can be used to mount it onto the waistband, or a belt may be looped through a fabric loop for securing. The pouch may also be mounted elsewhere if it is more convenient for the client.

Figure 2 also depicts concept #2 which is an all-integrated system. The casing sizes of the two designs look identical due to the sketches not being in scale. In reality, concept #2 will contain a bigger casing since it will include both the Arduino Nano and batteries in addition to everything from concept #1.

3.4.2 Mount Design Sketches

For both concept #1 and #3, a similar mounting system may be used to fasten the casing onto the glasses. Several types of mounts were considered for this casing. A wire clip mount, a fastener with a screw, as well as a 0000. All would have a gripping material where it is in contact with the glasses frames. The wire clip mount would use a three-point system to clamp onto the glasses frames. The fastener with screw may also use approximately 3 fasteners, depending on the relative size of the casing. To provide additional securing of the device and lessen vibrations, a fabric elastic band may be used with grooves in the casing. These bands may be placed around the cross section of the casing, mount, and glasses. The proposed mount can be seen in Figure 3 below.

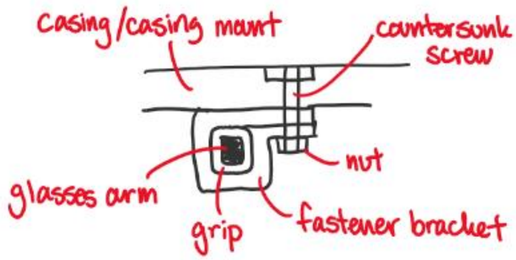

Figure 3: Mount concept

The mount concept of Figure 3 attaches the glasses to the casing or to a casing mount. The option of attaching the mount to a casing mount is provided to allow easy unmounting of the casing. One possible attachment system for the casing and casing mount is by using a snapfit system as seen in Figure 4. If the mount is attached directly to the casing, the countersunk screw will be screwed directly into the casing. If the mount is attached to the casing mount, the countersunk screw is screwed into the casing mount.

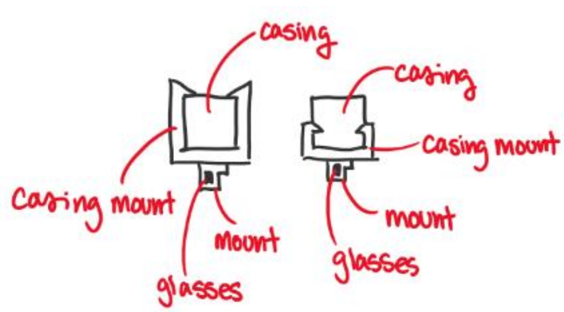

Figure 4: Casing mount concept design

The glasses mount may be attached to the casing using a rail and slider system, snap clip system, adhesive, or screws and gaskets. The rail and slider system as well as the snap clip system would involve a second 3D printed piece that stays mounted to the glasses while the casing may be removed. Grip material may be added to increase stability of this design. Both designs may be created using CAD.

3.4.3 Casing Design Sketches

For concept #1, the laser and accelerometer will be place in one casing to be mounted on the side of a pair of glasses. This casing will consist of a chamber in which the accelerometer will be secured to the inside with adhesive. The laser will be fitted into an opening at the end of the casing using rubber gasket as seen in Figure 5. Finally, an opening for wiring that connects the mounted casing to the hip mounted pouch will be designed on the back side of the casing. The wiring will ideally be fed along the glasses behind the client's ear; small elastic bands may be used on the glasses to keep the wiring in place. This casing is permanently sealed as access to the inner compartment is not necessary due to having an external battery.

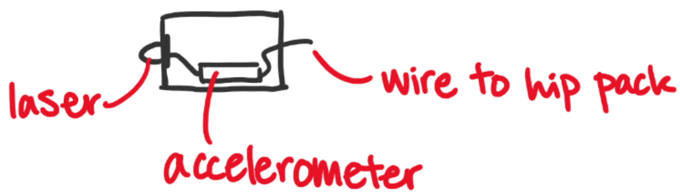

Figure 5: Concept #1 casing design

The casing for concept #3 houses the Arduino, accelerometer, battery, and laser as seen in Figure 6. Except for the battery, these parts may be fastened to the inside of the casing with adhesive. Like concept #1, the laser will be placed in an opening at one end of the rectangular casing and will be fitted with a rubber gasket.

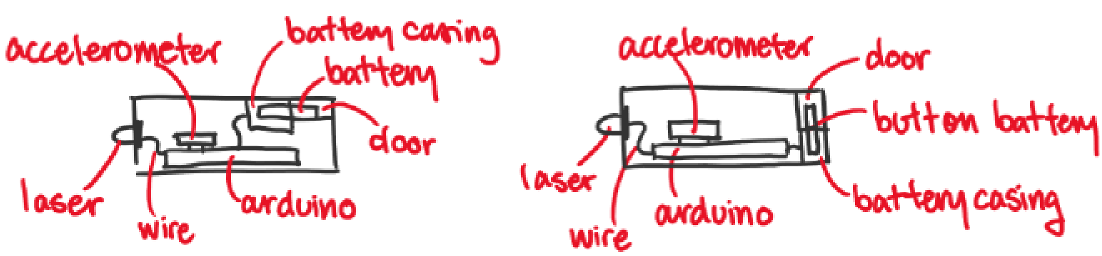

Figure 6: Concept #3 casing design. Left: horizontal battery placement, Right: vertical battery placement

Unlike concept #1, no opening for wiring will be necessary at the back of the casing. Instead, a door will be provided for access to replace the battery. Two designs for battery placement are proposed as seen in Figure 6. The chosen orientation of the battery may change the design of the access door.

Many snapfit casing designs can be found for 3D printing online. One possible design for the access to the battery is seen in Figure 7 [3]. This design incorporates a snapfit sliding door that can easily be opened and closed.

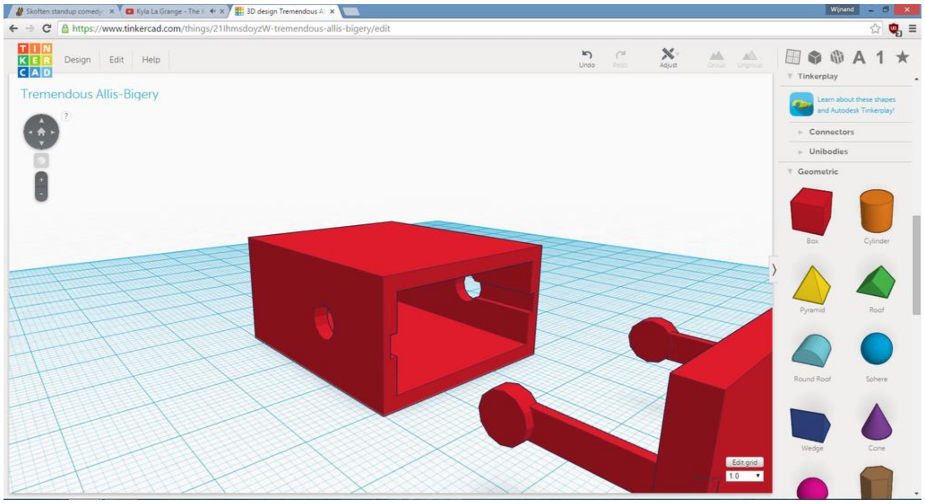

Figure 7: Accessible casing design [3]

3.5 Relation to Specifications

The concepts provide the hands-free activation with safety and function in mind. The concepts also focus on comfort and being discreet, while still completing the job and being suable for all day use. In other words, hits many of the specifications. The downside to the hip-mounted design is the wire that will run down the wearer's body, possibly being a minor inconvenience. While the head mounted design has the risk of being a little heavier on the glasses.

4 Conclusion

In this document, we outlined the problem and needs of the client, relating to wanting a head activated laser pointer mounted on a pair of glasses. Given this our team created a series of concepts of which our best two will be presented to the client at the next meeting. These concepts despite their drawback appear to meet all specifications we have for our design. As well, the reasoning behind our decisions to the concepts chosen to present.

5 Appendix

5.1 Justification for Size Ranking

Table 12: Component Sizes

Component	Size	Volume
Arduino Nano [4]	18 mm x 45 mm x 7.05 mm	5710.5 mm^3
Accelerometer [5]	3 mm × 3.25 mm × 1.06 mm	10.335 mm^3
Laser Diode [6]	Diameter: 10 mm, Length: 31 mm	2434.73 mm^3
Battery Replaceable [7]	1.98 cm x 1.98 cm x 0.25 cm * 3	980.1 mm^3 * 3

From Table 12, we can conclude the following:

- Concept #1 size: 2445.07 mm^3
- Concept #2 size: 8155.57 mm^3
- Concept #3 size: 11095.87 mm^3

As such the ranking of concept 1 should be the highest, with concept 2 and concept 3 being significantly lower.

5.2 Justification for Weight Ranking

Table 13: Component Weights

Component	Weight
Arduino Nano [4]	7 g
Accelerometer [5]	0.020 g
Laser Diode [6]	6.3 g
Battery Replaceable [7]	2.83 g *3

From Table 13, we can conclude the following:

- Concept #1 weight: 6.32 g
- Concept #2 weight: 13.32 g
- Concept #3 weight: 21.81 g

As such the ranking of concept 1 should be the highest, with concept 2 and concept 3 being halved each time.

6 References

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