

**University of Toronto**  
**Faculty of Applied Science and Engineering**  
**APS112**  
***Conceptual Design Specification (CDS)***

Team #	078	Date	22nd March 2025
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Please check off which components you are submitting for your assignment.

- ✓ CDS submitted as a PDF to Quercus with the following components:
- ✓ Cover Page
- ✓ Executive Summary
- ✓ Introduction
- ✓ Problem Statement
- ✓ Service Environment
- ✓ Stakeholders
- ✓ Detailed Requirements (FOCs)
- ✓ Generation, Selection and Description of Alternative Designs
- ✓ Alternative Designs Selection Process
- ✓ Alternative Design Descriptions
- ✓ Proposed Conceptual Design Specification
- ✓ Measures of Success (MOS)
- ✓ Conclusion
- ✓ Reference list
- ✓ Appendices
- ✓ Attribution Table

\_ Y\_ AI used Y/N?\*

\*If you answered "Yes" refer to the GenAI Policy document for proper usage and documentation guidelines (Go to Quercus > Syllabus and Course Documents > Course Policies)

If any required components are missing, your assignment is considered incomplete. It will accrue standard late penalties until completed.

## Executive Summary

Photographers using camera straps as their primary method to carry and secure a camera on the body frequently experience interruptions with their workflow due to straps tangling or the fixed strap length. These factors limit a photographer's range of motion and prevent them from capturing spontaneous moments quickly. Furthermore, the pressure from the strap induces stress and discomfort on the user when worn for longer than thirty minutes. The client, Omar Alzahed, is interested in a comfortable alternative to camera straps that allow unobstructed and quick access to the camera in spontaneous moments. Therefore, the gap is the lack of a method that provides easy access to a camera. Hence, there is a need for a design that allows for secure, quick, and unobstructed access to a camera that is adjustable and comfortable in extended photography sessions. The scope is limited to DSLR cameras and lenses with a maximum mass of 1.21 kilograms and 1.54 kilograms respectively.

The team has determined that the primary function of the design is to carry a camera. Subsequently, the secondary functions were developed to support the primary function, which required the design to be secured and unsecured from the camera and the body, simultaneously allowing quick retrieval and a method to return the camera to its secured position. The design must perform these functions while considering the environment around it such as the climate and motion, and the photographer's clothing. As such, seven objectives were developed to measure the design's capability of achieving these secondary functions. Furthermore, the team created a list of relevant stakeholders whose potential interest or influence on this project should be considered in the design process. Additionally, the design must comply with the constraints imposed by the client, legal and ethical authorities.

After laying out the project requirement, the team generated ideas, first through means generation and then through solution generation. In the means generation phase, each member used different creativity methods, which resulted in the generation of 97 means in total for the six secondary functions. Then, the means were organized and combined to create 62 full solutions in total. Afterwards, these solutions were consolidated, and sorted into sections with duplicates and infeasible solutions removed, leaving 48 full solutions for the multi-voting stage. After three rounds of multi-voting were conducted, seven solutions were left. Then, the solutions were compared against the top objectives, "secure" and "minimize time to access", on a graphical decision chart. Finally, the three highest-scoring solutions were chosen as the alternative designs.

The first design employs a padded flexible strap that clips onto the camera to secure it to the photographer's body. The second design uses a padded harness to secure itself to the body. The camera is secured by mechanical locking tabs and a magnet and can be freed by pressing a button. The third design uses a polyester vest with nylon straps to secure itself to the photographer.

A Pugh chart was used to determine that design 2 should be chosen as the proposed conceptual design as it performed better in 3 of the 7 objectives. The measure of success was to calculate the time it takes to access the camera using the proposed conceptual design. For the design to be successful, it should take less than 3 seconds to raise the camera from the resting position to the eye position.

## 1.0 Introduction

Camera straps often obstruct workflow by tangling and limiting motion. The client, Omar Alzahed, a photographer who carries their camera using straps, seeks a solution for unobstructed camera access during photography [1]. This document presents key elements of this problem, including stakeholders, service environment, detailed requirements, the generation of ideas and the process of selecting a recommended solution from three alternative designs tested through the Measure of Success. ChatGPT generated, organized solutions and created images in three sections: idea generation process, alternative idea selection process, and alternative design descriptions.

## 2.0 Problem Statement

A camera is often carried using a camera strap or stored in a camera bag, which hinders immediate access to the camera. Regular straps are usually worn around the neck or shoulder, causing discomfort on the body when worn longer than thirty minutes. They restrict movement in fast-moving environments for photography as they are not secured, making them prone to slipping or bunching up the clothes it comes into contact with (Appendix B)[76]. They come in three fixed lengths, ranging from 24-36 inches, 36-50 inches, to 50-60+ inches, [2][77]. Each length allows for different shooting styles [2], however, a photographer can have multiple styles requiring multiple straps so a design with adjustable lengths would be convenient [78]. Regular straps, such as the Nikon F5 strap used by the client (Figures 1-2) (Appendix B), can cause high point concentration of pressure on the body due to their narrower width [76]. Wider straps distribute pressure over a greater area on the shoulder, improving comfort while avoiding injury [3].



Figure 1. Nikon F5 Camera Strap [4].



Figure 2. Client's Strap [5].

Thus, the gap is the lack of a method to provide easy access to a camera. There is a need for a design that ensures quick, unobstructed access to a camera that is adjustable, ergonomic, safely secured on the body, and does not restrict movement. The project's scope is limited to DSLR cameras and lenses with a maximum mass of 1.21 kilograms and 1.54 kilograms respectively (Appendix J).



Figure 3. Camera Lens [6].



Figure 4. Triangular Split Ring [7].

### 3.0 Stakeholders

Table 1 presents relevant stakeholders ranked by importance using an influence/impact chart shown in Appendix C. Less relevant stakeholders are outlined in Appendix K.

Table 1. Ranking of Stakeholders and Justification

Rank	Stakeholder	Justification
1.	Photographers/Potential Users	Social: The design could improve photographers' photography experience by making cameras easier to access.
2.	Existing patent holders	Economic: New solutions may impact existing patents. Legal: Legal action may arise from patent breaches.
3.	Consumer Product Safety Program [8]	Legal: Ensures safety and quality of product if the design is made into products.
4.	Camera Manufacturers [9]	Economics: A design significantly outperforming existing solutions improves the consumer experience.
5.	Camera Accessory Manufacturers [10]	Economic: A superior design may impact existing products, while accessory manufacturers could help market entry.
6.	Responsible Sourcing Network [11]	Environmental: Ethical material sourcing.

## **4.0 Service Environment**

The service environment provides information on the environmental conditions in which the design will be utilized.

### **4.1 Physical Environment**

The physical environment includes the weather conditions the design may experience. The client indicates the temperature that the design may be used in ranges from -15 – 30°C (Appendix B). However, this range is expanded to include a larger range of temperatures in Toronto to account for other potential users.

Table 2. Climate Conditions

<b>Weather Condition</b>	<b>Data (Last 20 years)</b>
<b>Temperature Range (°C) [12], [13]</b>	-22.7 to 38.2
<b>Maximum Rainfall in 1 day (mm) [14]</b>	128.3
<b>Maximum Snowfall in 1 day (cm) [15]</b>	26.4

The camera is secured through the triangular split rings which mostly have side length/diameter of <12mm [16]. Additionally, based on the list of cameras provided by the client, the weight of the cameras that the design caters to is 1.21 kg and under.

The client photographs in indoors and outdoors fast-paced environments. Hence, they will oftentimes be surrounded by changing characteristics in their settings. Appendix D shows examples of settings in which the design could be used.

### **4.2 Potential Users**

Photographers are the primary users of the product. Hence, the design must factor in the range of motion including the clothing (Table 7) of a human body to keep the camera secure during any movement. Figure 9 and Table 3 show areas on the body that the design can be secured to, and their range of motion.

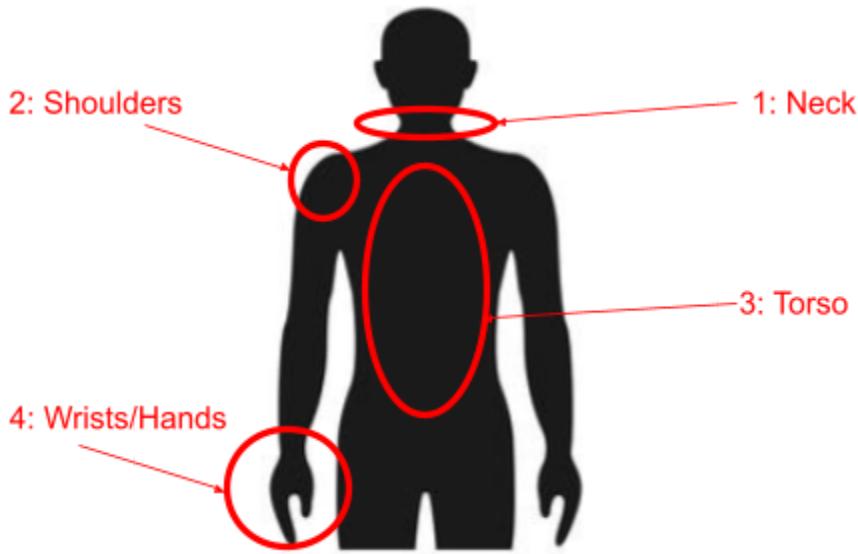


Figure 5. Anatomic Description of the Body [17] (5 words).

Table 3 uses Figure 5 to explore the human body's range of motion.

Table 3. Body's Range of Motion

<b>Body Parts</b>	<b>Range of Motion (degrees)</b>
#1 [18]	Flexion: 50 Extension: 80 Right and Left Lateral Flexion: 45 Right and Left Rotation: 80
#2 [19]	Flexion: 180 Extension: 45 to 60 Internal and External Rotation: 70 to 90 Abduction: 150
#3 [20]	Flexion (Back to Front): -30 to 45 Lateral Bending (Left to Right): -40 to 40 Transverse Motion (Rotation): -50 to 50
#4 [21]	Flexion: 80 to 90 Extension: 70 to 90 Deviation (Left to Right): -15 to 45

A lower coefficient of friction indicates a slippery fabric making it harder for the design to grip clothes made from it (Table 4).

Table 4. Fabrics of Clothing and Their Coefficients of Friction

Fabric	Clothing	Coefficient of Friction
<b>Skin</b>	None	0.31-0.61 [22]
<b>Nylon</b>	Winter Jackets [23], Gloves [24]	1.0-2.0 [25]
<b>Wool [26]</b>	Winter Jackets [23], Gloves [24], Scarves [27]	0.48-1.86 [28]
<b>Cashmere [29]</b>	Gloves, Scarves, Sweaters	0.1-0.3 [30]
<b>Polyester [31]</b>	Winter Jackets, Gloves, T-shirts	0.2-0.55 [32]
<b>Cotton</b>	Scarves [27], T-shirts [33]	0.3 [34]
<b>Linen [35]</b>	Scarves [27], T-shirts [33]	0.8-0.95 [36]

## 5.0 Detailed Requirements (FOCs)

This section outlines how the design will achieve quick, unobstructed access to the camera. The design must follow all requirements to be successful.

### 5.1 Functions

The functions listed below outline the design's behaviour, addressing its core purpose(s) according to the client's wishes (Appendix B). The primary and secondary functions were derived through the Functional Basis (Appendix E) and Black Box Method (Appendix F).

#### Primary Function:

The design will carry a camera.

#### Secondary Functions:

The design will:

- secure to the camera,
- unsecure from the camera,
- secure to the body,
- unsecure from the body,
- allow access to the camera, and
- return the camera to its resting position.

## 5.2 Objectives

The objectives reflect the client's vision of an accessible, ergonomic, and adaptable design (Appendices A and B). These high-level objectives were developed into specific descriptors with measurable metrics using a How-Why Tree, and ranked using Pairwise Comparison (Appendices G and H).

Table 6. Objective Metrics and Goals

Rank	Objective	Metric	Goal	Justification
1	Minimize time to access	Time to raise the camera to eye level	< 3 seconds [37]	Capture spontaneous moments (Appendix A).
2	Secure	Force to prevent slipping on body  (Calculated using the lowest coefficient of friction of clothing and maximum camera and lens weight)	> 24.3N [38]	Carry a camera in moving environments (Appendix B).
3	Maximize durability	Fatigue strength of material under 10 million cycles	36-66MPa [39]	Fracture-safe design for long-term use (Appendix B).
		Material resistance to water damage from snowfall/rainfall rating  Ingress Protection rating for electronic's resistance to water and dust intrusion	Acceptable - Excellent [39]  IPX6-IPX9 [40]	Exposure to snowfall and rainfall in the service environment (Appendix B).
4	Maximize compatibility	Width of non-screw-type attachment	< 12mm [41]  6.35mm [42]	Attach design onto cameras' existing eyelets and tripod mount (Appendix B).

		Diameter of screw-type attachment		
5	Maximize the design's range of motion	Vertical extension  Horizontal extension  Degrees of freedom to support full body motion.	2.10m [43]  0.82m [43]  180° [19] (Table 3)	Flexible reach for different shooting positions (Appendix B).
6	Comfortable	Pressure threshold applied by design	$< 5.56 \times 10^5$ Pa [44]	Less sore for 30+ minute shooting sessions (Appendix B).
7	Quick attachment mechanism	Time to attach and detach design	< 60 seconds [45]	Need to separate camera from design (Appendix B).

### 5.3 Constraints

The constraints were derived from the client meeting (Appendix B) to comply with client's needs, regulations, service environment conditions, and stakeholders' concerns, and ranked using Pairwise Comparison (Appendix I).

Table 7. Constraint Metrics and Limits

Rank	Constraint	Metric	Limit	Justification
1	Safe for skin contact	SIN List indicator of toxic substances in design materials and manufacturing.	Rating of 0 [47]	Secured to the user's body (Figure 5).
2	Support the mass of heaviest camera in the scope	Mass (Camera + Lens)	2750g [48], [49]	Avoid accidental drops (Appendix B).

3	Withstand temperatures in service environment	Extreme temperatures	High: 38.2°C Low: -22.7 °C [12], [13]	Remain functional when shooting outdoors (Appendix B).
4	Meet client's budget	Maximum production cost	\$300CA	Budget for camera straps would be \$200-300 CA (Appendix B).

## 6.0 Generation, Selection and Description of Alternative Designs

The team developed ideas using means and solution generation, then refined them through consolidation, feasibility check, multi-voting and a graphical decision chart to select three alternative designs.

### 6.1 Idea Generation Process

The idea generation process is outlined in Figure 6.

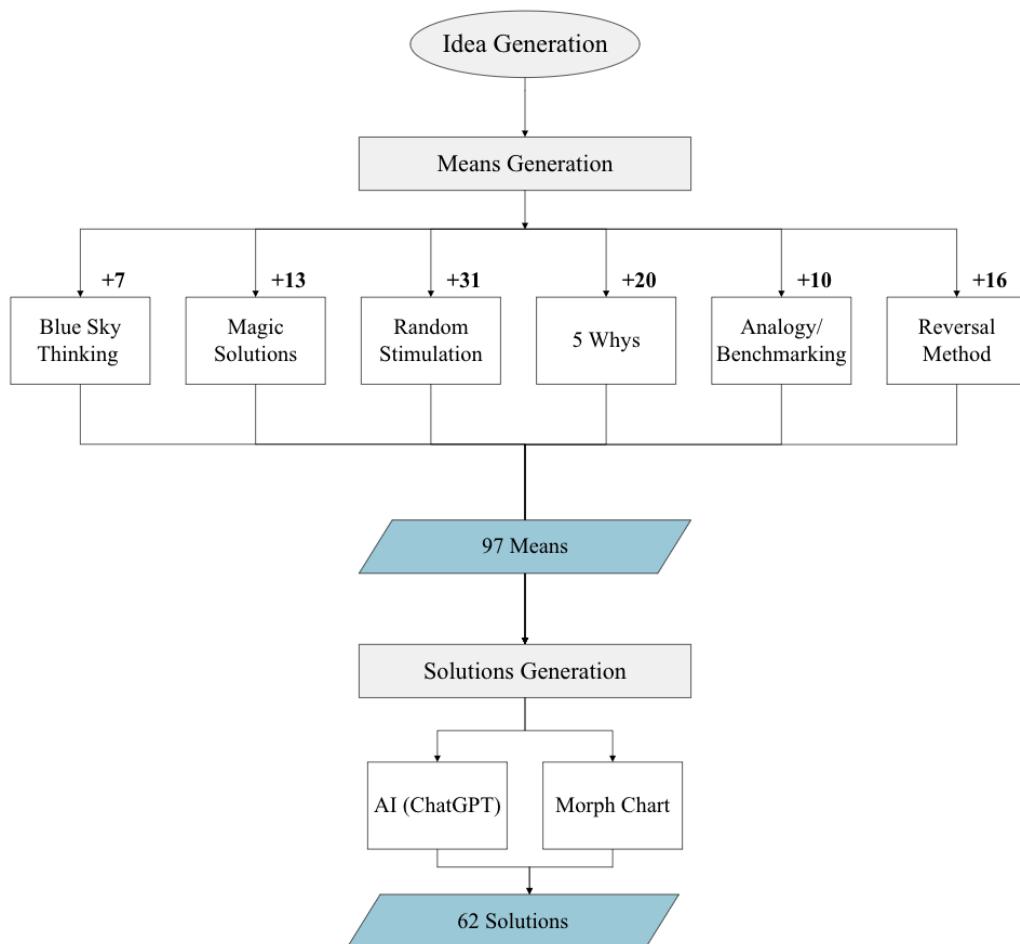


Figure 6. Idea generation process (33 words).

During individual brainstorming, each member used one of six creativity methods (Appendix L), generating 97 means for six secondary functions (Appendix M). This strategy enabled lateral thinking and reduced overlapping ideas. Means were organized using a morphological chart or GenAI (Appendix N). ChatGPT generated and synthesized means into descriptive solutions (Appendix X), categorized into nine wearable technology types (Appendix O).

## 6.2 Alternative Design Selection Process

Figure 7 summarizes the decision-making process for alternative design selection. The 62 solutions were consolidated and reviewed. After modifying two solutions to meet all functions, ChatGPT grouped them into nine categories based on commonalities (Appendix X). Following group discussion and feasibility research (Appendix P), 11 duplicates and three infeasible solutions were removed, leaving 47 for multi-voting.

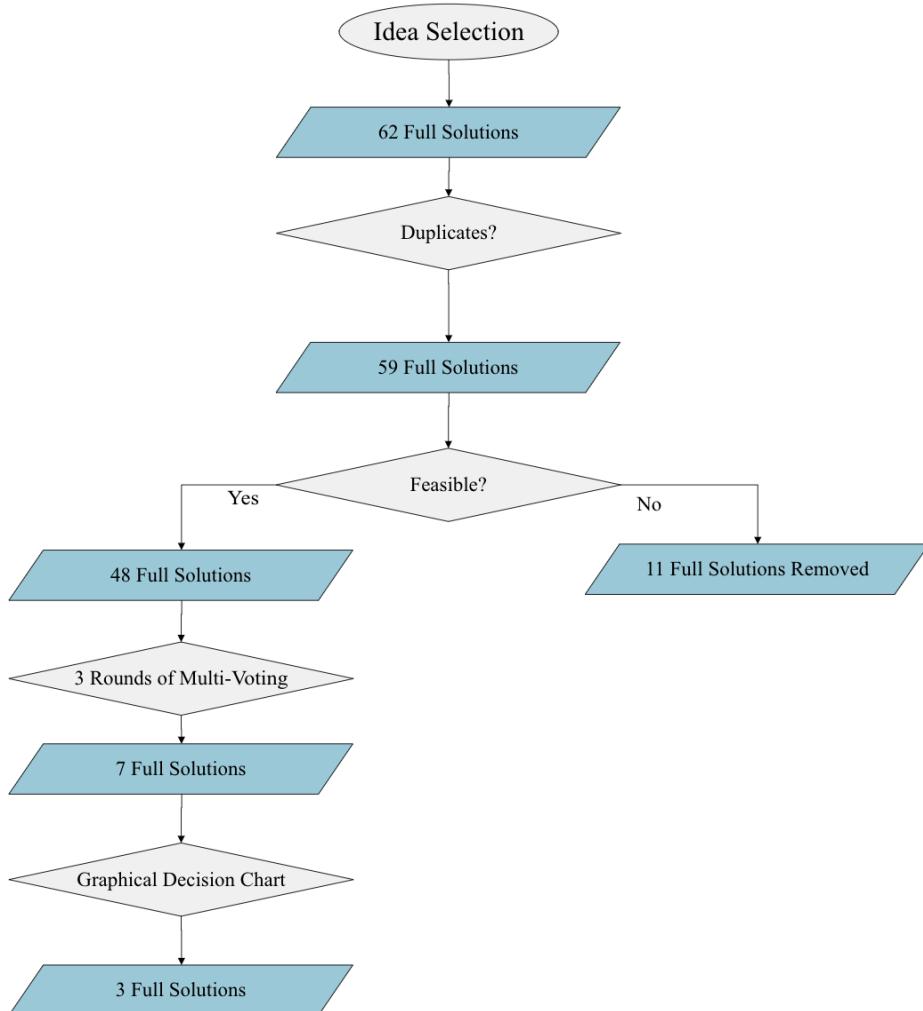


Figure 7. Idea selection process (32 words).

Each member cast five, three and two votes over three multi-voting rounds (Appendix Q), with no duplicate. A solution needed one vote to advance. The remaining seven solutions, featuring torso-based and automated camera systems, were plotted on a decision chart (Figure 8) to assess their effectiveness in meeting top objectives. The three highest scoring solutions were chosen as alternative designs.

Minimize Time to Access vs. Secure

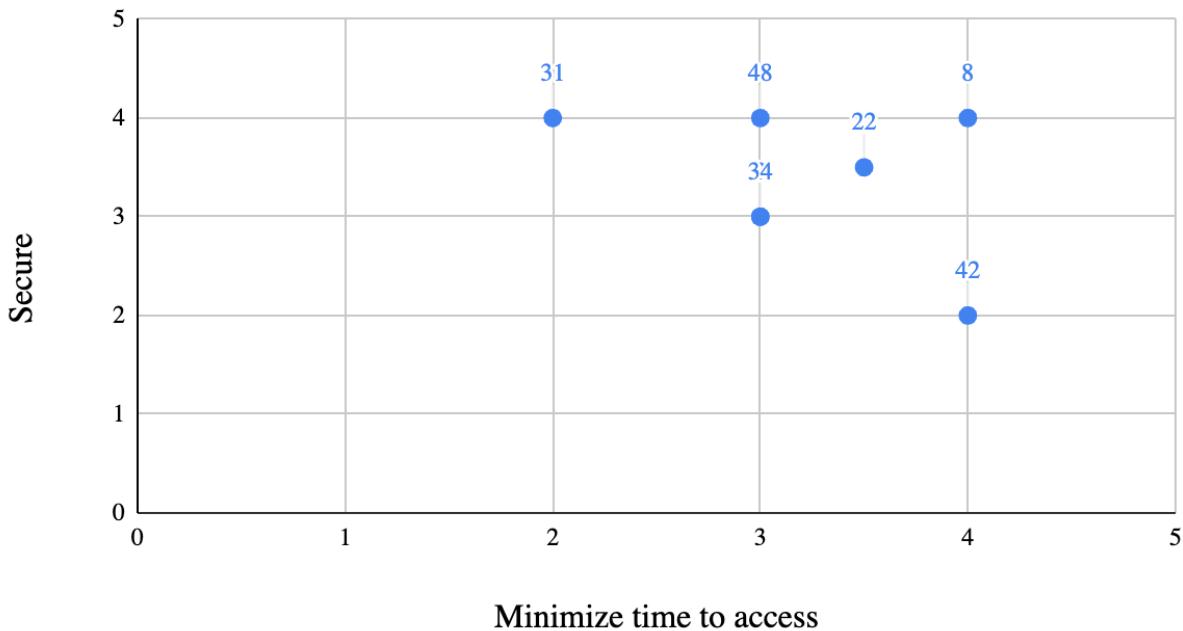


Figure 8. Graphical decision chart (11 words).

### 6.3 Alternative Design Descriptions

This section discusses how the three designs meet secondary functions and objectives. ChatGPT generated images for the first two designs, but due to inaccuracies of the generated image for design 3, it was manually drawn on a plain model.

#### 6.3.1 Design 1: Padded Strap

Padded Strap employs a durable, adjustable, nylon strap to secure the camera on the photographer's body. To keep the strap secured, the layer that makes contact with the photographer is soft rubber. Furthermore, the strap uses shock-absorbing flexible polymer foam cushioning pads between the nylon and rubber layers to provide comfort and reduce stress during prolonged use. Ensuring maximum compatibility, the strap is clipped onto the camera's built-in eyelets (<12 mm [40]), providing a balanced weight distribution and stability. Additionally, the section of the strap connected to the camera is unpadded and equipped with a length adjustment mechanism, which allows the camera to be placed near the photographer's chest, minimizing access time while maximizing the design's range of motion.



Figure 9. 3D model of Padded Strap. (17 words) (Appendix X).

Table 8. Design 1 Means Analysis

Objective	Means Analysis
Minimize time to access	<ul style="list-style-type: none"> <li>Time to Access: 0.977s</li> </ul> <p>Calculated with the average maximal value of hand movement speed towards a target [64] and the height difference between fingertip and elbow, where the design sits, and the height difference between the elbow to eyes. (Appendix T)</p>
Secure	<ul style="list-style-type: none"> <li>Friction Force: 20.7N (Appendix U)</li> </ul> <p>Calculated with the friction coefficient of rubber [66] and combined mass of the camera and the design.</p>
Maximize durability	<ul style="list-style-type: none"> <li>Fatigue Strength (the material's ability to resist cyclic loading in MPa) [39] <ul style="list-style-type: none"> <li>Nylon: 36 - 66</li> <li>Flexible polymer foam: 0.15 - 0.7</li> <li>Butyl Rubber: 0.9 - 1.35</li> </ul> </li> <li>Water Resistance [39] <ul style="list-style-type: none"> <li>Nylon: Acceptable</li> <li>Flexible polymer foam: Excellent</li> <li>Butyl Rubber: Acceptable</li> </ul> </li> <li>IP rating not applicable</li> </ul>

Maximize compatibility	<ul style="list-style-type: none"> <li>• Compatible with built-in eyelets (&lt; 12mm)</li> <li>• Screw-type not applicable</li> </ul> <p>The design is equipped with eyelet clips that are compatible with the camera's built-in eyelets.</p>
Maximize design's range of motion	<ul style="list-style-type: none"> <li>• &gt; 2.1m at maximum adjustment</li> </ul>
Comfortable	<ul style="list-style-type: none"> <li>• Pressure applied on shoulder  <math>\leq 4.598 \times 10^4 \text{ Pa}</math></li> </ul> <p>Uses the smallest point of pressure for the worst-case scenario which is <math>8 \text{ cm}^2</math> (Appendix S)</p>
Quick attachment mechanism	<ul style="list-style-type: none"> <li>• Attaching/Detaching Strap: &lt; 10s</li> <li>• Attaching/Detaching Camera: &lt; 20s</li> </ul>

### 6.3.2 Design 2: Magnetic Mount

Magnetic Mount uses a cushion padded, nylon, and polyester harness to secure itself to the photographer's body. The harness contains 8cm wide fastening straps [3] padded by flexible polymer foam and a camera mount with a magnetic dock. The camera is secured by mechanical locking tabs and a magnet and can be unlocked by tapping a sensor twice or pressing a button. When released, the camera remains attached by a retractable cord made of Dyneema® fibers attached to the camera using a screw at its bottom which allows the camera to move freely. When released from the photographer's hand, the dock produces sufficient force to retract the cord slowly, pulling the camera up. The design is estimated to weigh at most 1kg.



Figure 10. 3D model of magnetic mount (11 words) (Appendix X).

Table 9. Design 2 Means Analysis

Objective	Means Analysis
Minimize time to access	<ul style="list-style-type: none"> <li>Time to Access: 1.976s</li> </ul> <p>Calculated with the average maximal value of hand movement speed towards a target [64] and the height difference between fingertip and where the camera is, and the height difference between the camera to the eyes. (Appendix V)</p>
Secure	<ul style="list-style-type: none"> <li>Friction Friction: 16.8N</li> </ul> <p>Calculated using the maximum weight of the camera and the lowest friction coefficient of the design's material (Appendix W)</p>
Maximize durability	<ul style="list-style-type: none"> <li>Fatigue Strength (the material's ability to resist cyclic loading in MPa) [39] <ul style="list-style-type: none"> <li>Nylon: 36-66</li> <li>Polyester: 16.6-35.8</li> <li>Dyneema®: 2500-3000</li> <li>Flexible polymer foam: 0.15 - 0.7</li> </ul> </li> <li>Water Resistance [39] <ul style="list-style-type: none"> <li>Nylon: Acceptable</li> <li>Polyester: Excellent</li> <li>Dyneema®: Excellent</li> <li>Flexible polymer foam: Excellent</li> </ul> </li> <li>IP67 waterproof sensor [40]</li> </ul>
Maximize compatibility	<ul style="list-style-type: none"> <li>Uses a 6.35mm screw [42]</li> </ul>
Maximize design's range of motion	<ul style="list-style-type: none"> <li>&gt; 2.1m retractable cord</li> </ul>
Comfortable	<ul style="list-style-type: none"> <li>Pressure applied on shoulder <math>\leq 4.598 \times 10^4 \text{ Pa}</math></li> </ul> <p>Uses the smallest point of pressure for the worst-case scenario which is <math>8 \text{ cm}^2</math> (Appendix S)</p>
Quick attachment mechanism	<ul style="list-style-type: none"> <li>Attaching/Detaching harness: &lt; 10s</li> <li>Attaching/Detaching Camera: &lt; 5s</li> </ul>

### 6.3.3 Design 3: Shoulder Ring

Shoulder Ring employs a polyester posture vest with nylon straps to secure itself to the photographer's body. The vest focuses on the upper back with an open front. The strap system involves separately adjustable shoulder straps and two back straps secured with a buckle extending from the back to the front. Aluminum [50] ring shaped as a  $\frac{3}{4}$  circle with multiple neodymium magnets mounted at its back is attracted to the magnets located inside the vest's shoulder straps. The ring has an aluminum rod within it with a sliding mechanism secured using a clamp. The clamp is open when the sliding mechanism is pressed on. The top of the clamp has a rectangular-shaped neodymium magnet that attaches to the bottom of the camera and secures it in place, allowing it to move freely along the ring.

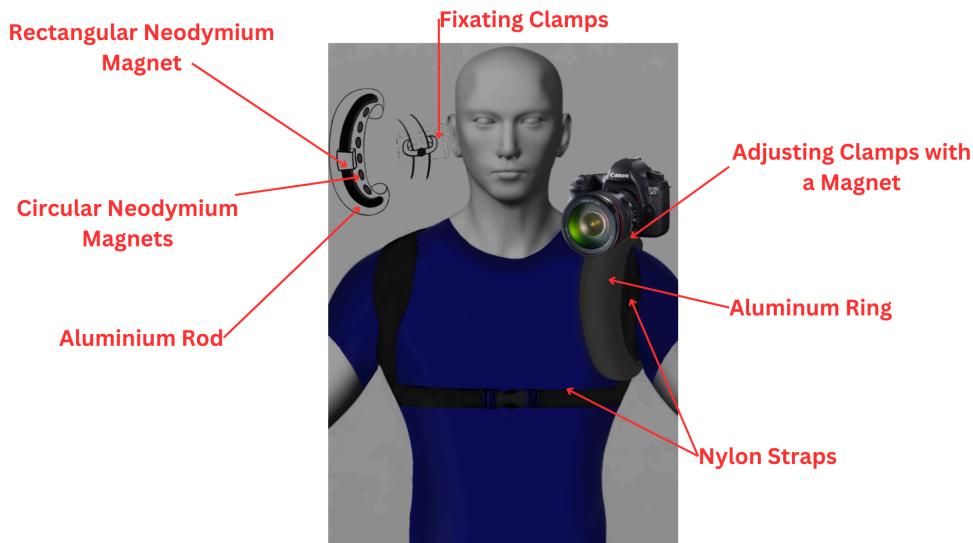


Figure 11. 3D model of shoulder ring (19 words) [74][75].

Table 10. Design 3 Means Analysis

Objective	Means Analysis
Minimize time to access	<ul style="list-style-type: none"> <li>Time to Access: 2.976s</li> </ul> <p>The estimated time to detach camera from shoulder ring and raise it to eye level (Appendix Y)</p>
Secure	<ul style="list-style-type: none"> <li>Friction Force: 2.06N</li> </ul> <p>Force exerted by the mechanism on the human body. Calculated using the maximum weight of the camera and the lowest friction coefficient of polyester (Appendix R)</p>
Maximize durability	<ul style="list-style-type: none"> <li>Fatigue Strength (the material's ability to</li> </ul>

	<ul style="list-style-type: none"> <li>resist cyclic loading in MPa) [39] <ul style="list-style-type: none"> <li>○ Polyester (Vest): 16.6 - 35.8</li> <li>○ Nylon (Strap): 36 - 66</li> </ul> </li> <li>● Water Resistance [39] <ul style="list-style-type: none"> <li>○ Polyester: Excellent</li> <li>○ Nylon: Acceptable</li> </ul> </li> </ul>
Maximize compatibility	<ul style="list-style-type: none"> <li>● Adjustable straps of the vest</li> </ul> <p>The adjustable clamp mechanism adjutants from 50-79 mm allowing to attach a wide range of cameras to the design [51][52]</p>
Maximize design's range of motion	<ul style="list-style-type: none"> <li>● Sliding mechanism secured 360° on the ring around the shoulder</li> </ul>
Comfortable	<ul style="list-style-type: none"> <li>● Adjustable straps</li> <li>● Shoulder vest eases pressure on the spine [53]</li> <li>● <math>3.3637 \times 10^4</math> Pa</li> </ul> <p>Pressure exerted on one area of the shoulders with the surface area of 18.75 cm<sup>2</sup> (Appendix Z)</p>
Quick attachment mechanism	<ul style="list-style-type: none"> <li>● Attachment/Detachment of the camera: &lt; 2s</li> <li>● Attachment/Detachment of the ring: &lt; 2s</li> <li>● Attach/Detach vest: &lt; 15s</li> </ul>

## 7.0 Proposed Conceptual Design Specification

The client's wants and needs are interrelated with emphasis on creating a quick-to-access and secure design to carry and use their camera. The client wants an adjustable and ergonomic design, providing unrestricted movement while in use. This aligns with practical considerations such as meeting the client's budget and creating a design that can withstand extreme temperatures in the service environment. These requirements are achieved through solutions that can carry a camera and fulfill various objectives reflecting the client's wants. Therefore, the team Pugh Method was utilized to compare the three alternative designs (Table 11) and select a solution.

Table 11. Pugh Chart

Objectives	<u>Alternative Design</u> 1: Padded Strap	<u>Alternative Design</u> 2: Magnetic Mount	<u>Alternative Design</u> 3: Shoulder Ring
	Datum	Score	Score
Minimize time to access	S	-1	-1
Secure	S	0	-1
Maximize durability	S	+1	+1
	S	+1	0
Maximize compatibility	S	0	0
Maximize design's range of motion	S	0	-1
	S	+1	+1
Comfortable	S	0	+1
Quick attachment mechanism	S	+1	+1
Sum	0	3	1

The method involves scoring designs against the datum, Padded Strap, based on the seven objectives. In each category, a design receives +1, 0, -1, if it performs better, same, or worse than the datum. The points were then summed to determine the best design.

The proposed solution, Magnetic Mount, features a harness attached to a camera mount that includes a magnetic docking station with mechanical clamps where the camera can rest. The camera is attached to a retractable cord that is assembled into DSLRs' standardized tripod holes. The camera can be released using a sensor or button. Magnetic Mount excels in durability, range of motion, and quick camera attachment to the design while performing similarly to Padded Strap in areas such as comfort and compatibility.

Magnetic Mount exceeds all durability metrics. The design is constructed with nylon, polyester for the straps, polymer foam for padding, and Dyneema® fibers for the retractable cord. The CES Edupack database [39] lists material fatigue strength and rates the water resistance from unacceptable to excellent. The fatigue strength of Nylon is 36-66 MPa, polyester is 16.6-35.8 MPa, and Dyneema® is 2500-3600 MPa [39]. Polyester has lower strength but undergoes less stress-intensive applications. For water resistance, nylon, polyester, Dyneema® scores acceptable, excellent and excellent respectively [39]. Additionally, the design includes a

waterproof sensor with a rating of IP67, indicating that the product is protected against water immersion for 30 minutes up to a one-meter depth [40].

Magnetic Mount meets all range of motion metrics and exceeds particularly in degrees of freedom. It has a vertical extension of 2.1 metres from the dock and has 180 degrees of freedom in movement as the cord moves freely in all directions. It is also quick to assemble with the maximum time to attach the design estimated to be 15 seconds.

However, Padded Strap outperforms Magnetic Mount in minimizing time to access and Shoulder Ring outperforms Magnetic Mount in comfortability as it applies less pressure. Despite these disadvantages, Magnetic Mount scored higher than other designs. While other designs may excel slightly in comfort and ease of access, Magnetic Mount meets most of the client's objectives. Furthermore, the Shoulder Ring falls short in security and range of motion. These results indicate that Magnetic Mount is the best design.

## 8.0 Measures of Success

A prototype will be built to test the highest-ranked objective, “minimize time to access”. This objective will be measured since quick, unobstructed access is critical for the client [1]. We will buy the necessary materials noted in the design description through Amazon on March 30th, 2025. Then, it will be built on April 1st and 2nd, 2025 at MYFab facility. The proposed test will measure the time to access and raise the camera to eye level after securing the design and camera to the body. An observer records at 30 frames per second [54] for accuracy. This test will be repeated six times each on four different testers, a pair of male and female from the team and people not related to the project. Three tests will be conducted both indoors and outdoors with each tester. The following steps describe the measurement plan:

1. Testers keep their hands in resting position as shown in Figure 12.



Figure 12. Hands in resting position [72].

2. Tester raises hand towards the camera as quickly as possible while an observer starts the timer.

3. Tester taps the sensor twice to unlock the camera.
4. Tester raises the camera towards eye level.
5. Observer stops the timer as soon as the viewfinder eyepiece reaches the tester's eye [55].
6. Repeat the process from step 1 until all iterations are completed

After the six iterations for each tester are concluded, calculate the average time taken to access the camera using the camera footage. An average will be calculated for each tester, indoor and outdoor.

The test will be carried out on April 3, 2025 in the Gerstein Library at 6:10 PM with all team members present. The success of the test will be determined by whether the average time taken to access a camera is less than 3 seconds.

## **9.0 Conclusion**

The proposed design will improve workflow by eliminating strap interference while accessing the camera. After multiple evaluations, the Magnetic Mount was selected as the final design via the Pugh chart. A prototype will be built to test its effectiveness in minimizing access time, the top-ranked objective.

## 10.0 References

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## Appendices

### Appendix A: Camera Solution Client Statement

Figure 10 shows the client statement that contains information on the context and client's needs for the project.

<b>Project Title:</b>	Camera Solution
<b>Project Description:</b>	
Regular camera straps that come with the camera in the box are uninspiring and oftentimes annoying. As a photographer, I require quick and unobstructed access to my camera; camera straps often tangle, restrict motion, and interfere with capturing spontaneous moments, especially in dynamic shooting environments. There is a need for an innovative, portable, and adaptable solution to allow me to securely carry my camera that allows fast, unhindered access across different types of cameras. The solution should also be preferably durable and ergonomic.	

Figure 10. Client statement for the camera solution project [1].

### Appendix B: Notes from First Client Meeting

The team asked questions about the client statement and took notes during the first client meeting on January 29, 2025. It provided the team with additional information on the design problem, scope, service environment, objectives, and constraints as detailed in Figure 18.

## Client Meeting #1 with Omar Alzahed

Jan. 29, 2025, 13:00 - 14:00, Robarts Library 4265 Group Study Room 4G  
Attendees: Margarita, Irene, Aadit, David, Harry, Brendon, Omar

### **Objectives:**

Quick to access, not in bag  
No obstructions, shoulder often gets in the way  
Ergonomic, tiring on the shoulder, want to be comfortable  
Secure to body, avoid accidental drops  
Usable for different types of models and brands, range of lens in the future

### **Camera attachment points:**

Two eyelets at the top on the side  
Tripod hole

### **Preferences:**

Only uses shoulder strap  
Camera usually rests on the waist  
Doesn't use small cameras such as a gopro

- What is the range of the types of cameras you shoot with? - **Audit**
  - Owns many cameras and lens
  - No preference, needs to be suitable for many camera models
  - No unusual camera types
- Can you show us exactly how the straps tangle and restrict movement? - **Margarita**
  - Large lens can get in the way of the strap
  - Strap not long enough to raise to eye level, slow down
- What about the straps do you dislike besides restriction of movement? (Do we want to keep straps that fit the requirements or get rid of them completely?) - **Irene**
  - Gets tired in half hour
  - Can't adjust strap length, more flexibility
  - Need to take off the strap sometimes, but hard to take off
- What is your budget for designing a new camera strap? - **David**

- What is your budget for designing a new camera strap?- **David**
  - Less than \$200 - \$300
- What are some strategies that you have tried in the past to address the inconvenience of regular camera straps? -**David**
  - Not yet, only use tripod for wildlife photography
- What kind of environment will the camera straps be used in? (Weather conditions, the setting) - **Harry**
  - Outdoor, sunny, snowy, no rain
  - Indoor, school dance
  - Cold and warm temperatures (-15 to 30 degree celsius)
- What do you mean by ergonomic? How do the current straps feel? Are they uncomfortable, painful, etc.? - **Harry**
  - Pressure distributed, wider strap
  - Want feel less sore
- What dynamic environments are you shooting in? Or what do you mean by dynamic environments? - **Aadit**
  - Quick to access in an busy environment such as an event, need to capture spontaneous moments such as moving animal shots
  - Moving environment
- What type of camera strap do you currently use and why? (neck, wrist, shoulder...) - **Brendon**
  - Came with the camera, mainly shoulder strap
- What do you desire in terms of “durability”? e.g. What good or bad experiences have you had with the quality of camera straps? - **Margarita**
  - Current strap doesn't snap but rough on bare skin
  - No bad experiences so far
  - Want a strap that doesn't snap carrying any kind of camera
- You said you want an inspiring design. Do you have any examples of what you consider an inspiring design solution to your problem? - **Aadit**
  - Look online for ideas, no restrictions, want team to be creative
  - Like clip-on idea
  - Don't like camera bags
  - Open to solutions other than having a camera strap or camera accessory to secure camera to body

Figure 18. Notes taken during the client meeting by designated note-takers.

## Appendix C: Stakeholder Influence and Impact Chart

Figure 17 shows the influence and impact chart used to rank the importance of each stakeholder.

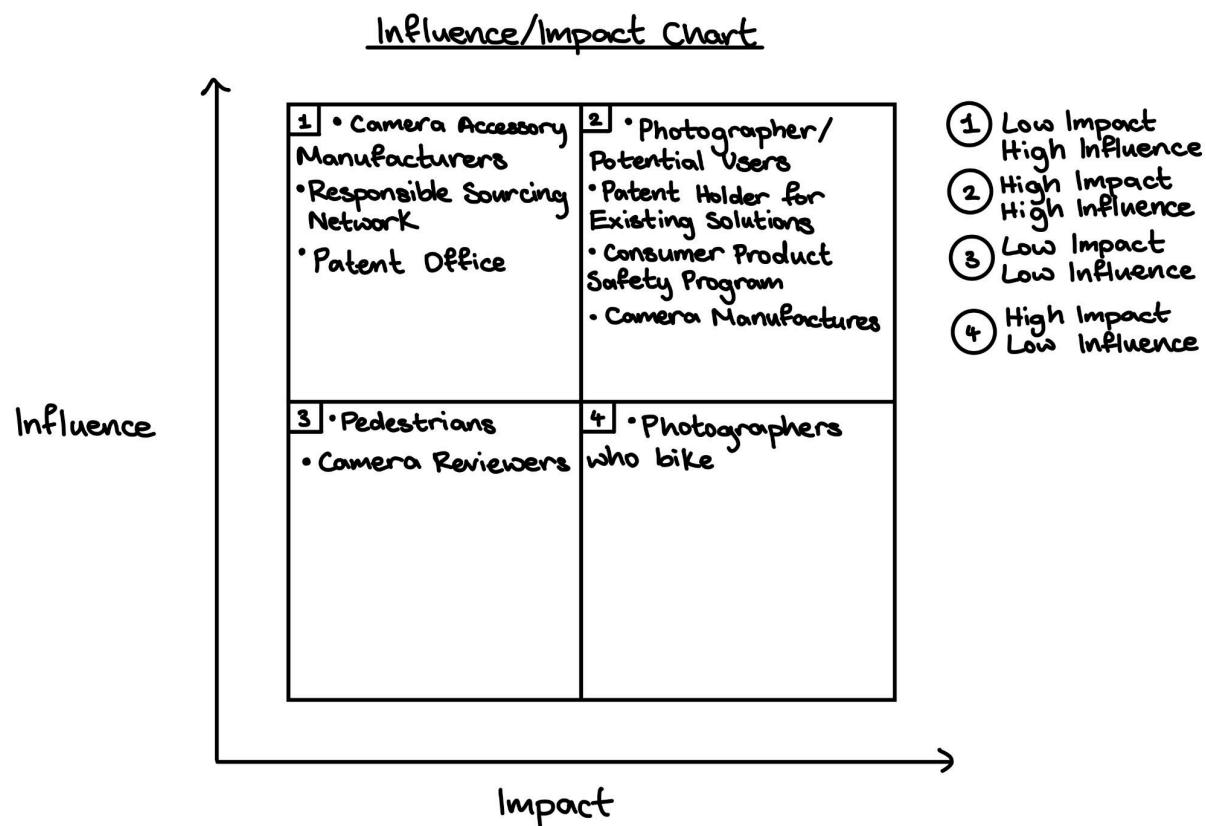


Figure 17. Influence/Impact Chart for Stakeholder Ranking

## Appendix D: Description of the Environment Where Camera Can Be Used

Table 7 showcases a variety of images showcasing environments the camera may be used. It includes short descriptions of each photo on the side.

Table 7. Description of the Settings.

Setting	Picture	Description
City		Large density of people in one area which leads to difficulty in movement.

Figure 20. City Crowd [56].

Park/Places  
with  
Vegetation



Free range space allowing for  
easy movement

Environment contains trees,  
bushes, grass

Figure 21. Environment with trees [57].

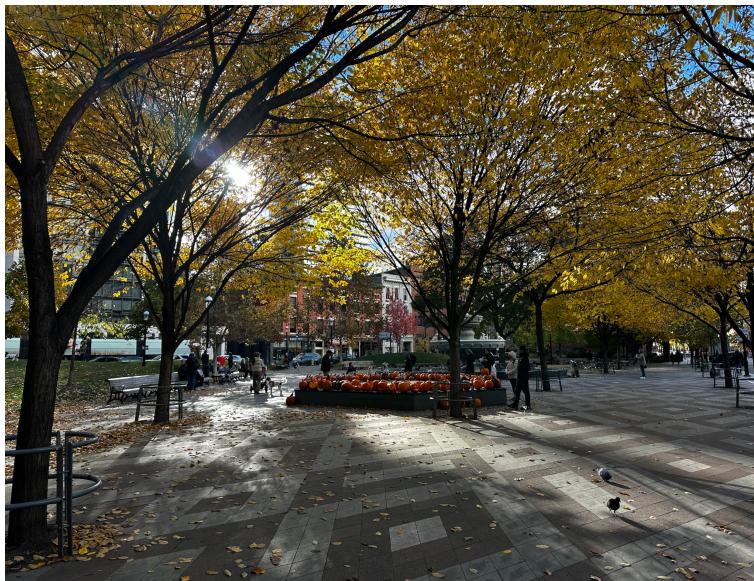
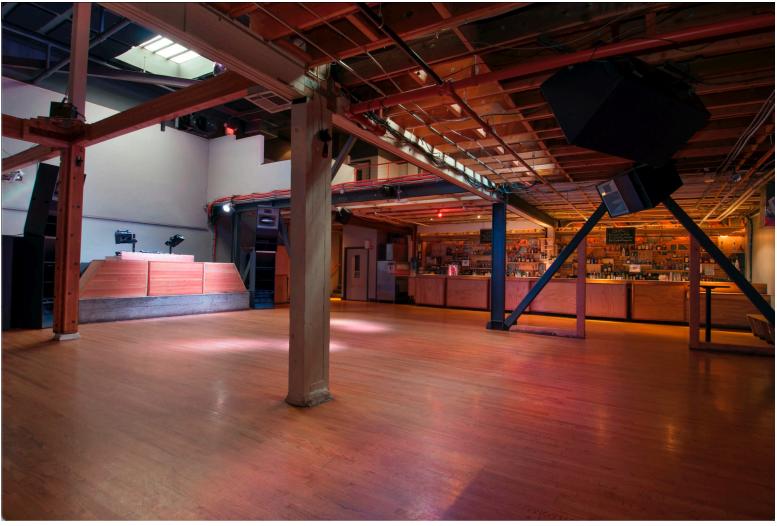


Figure 22. Outdoor space in the city [58].

Furnished Indoor Space		<p>Most commonly present furniture pieces: Chairs, tables, shelves</p> <p>Furniture prevents user from free movement indoors</p>
Unfurnished Indoor Space		<p>A free range space without people</p> <p>If people are present in the space, it will be crowded and harder to move</p>

## Appendix E: Functional Basis Method for Action Words in Functions

Figure 13 shows the action words that were derived through functional basis to describe the primary and secondary functions.

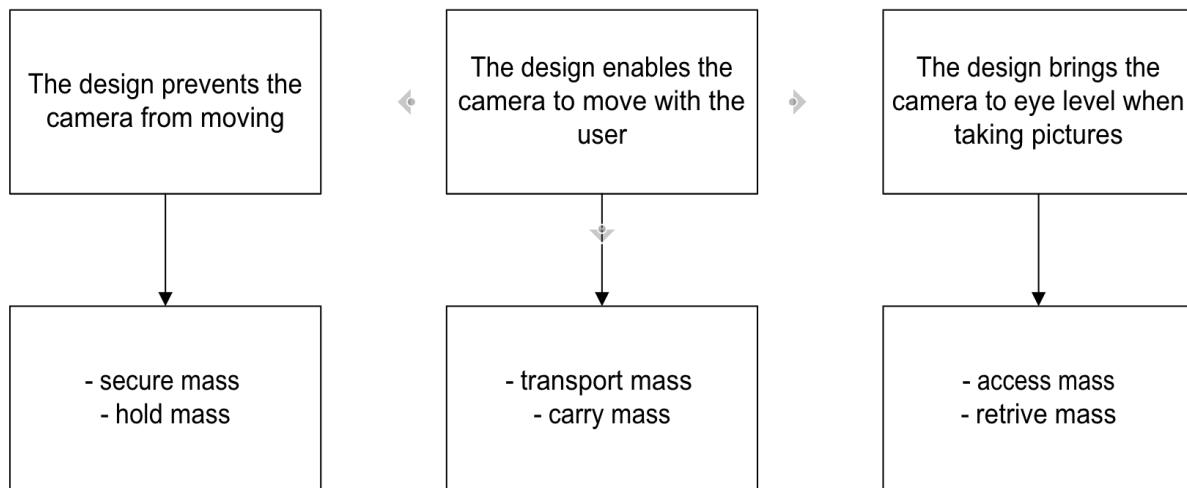


Figure 13. Functional Basis Method for generating action words in functions.

## Appendix F: Black Box Method Diagram for Secondary Functions

As shown in Figure 14, the team decomposed the functions into mass, energy, and information then considered how their states would change through the design.

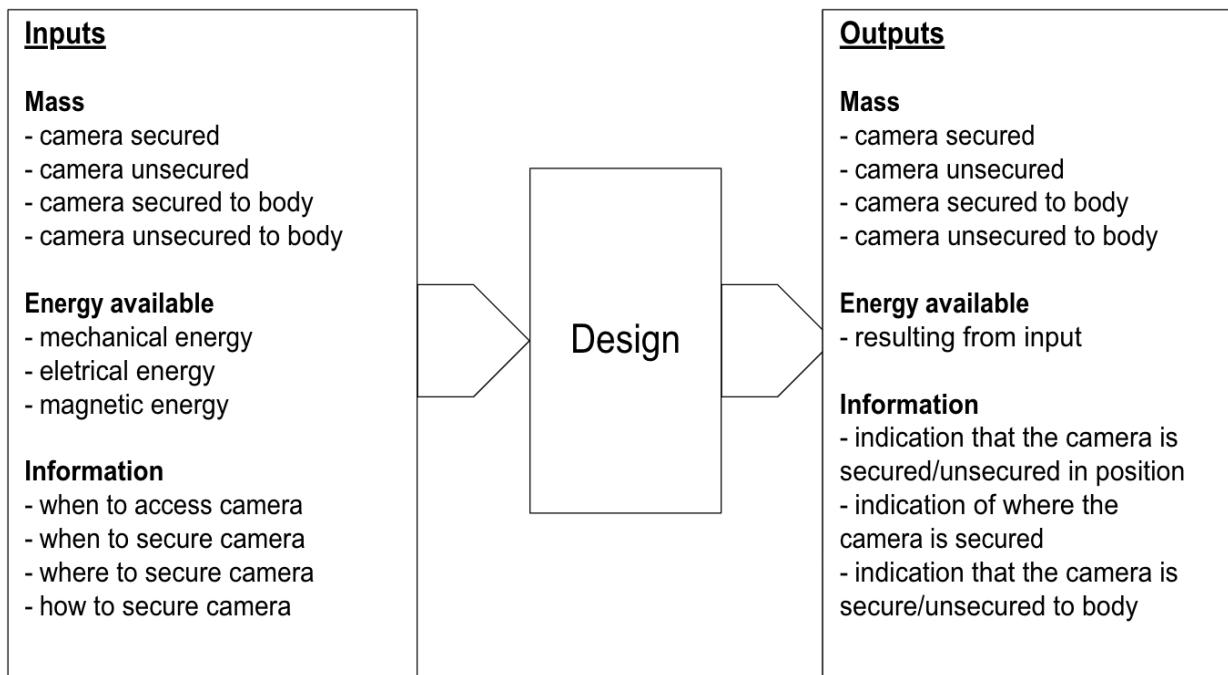


Figure 14. Black Box Method for brainstorming secondary functions.

## Appendix G: How-Why Tree for Objective Generation

Figure 15 shows the How-Why Tree used to define the project's objectives. The team identified quick access, ergonomic, and adaptable as the high level objectives through the client statement, and brainstormed more specific descriptors after receiving information in the client meeting.

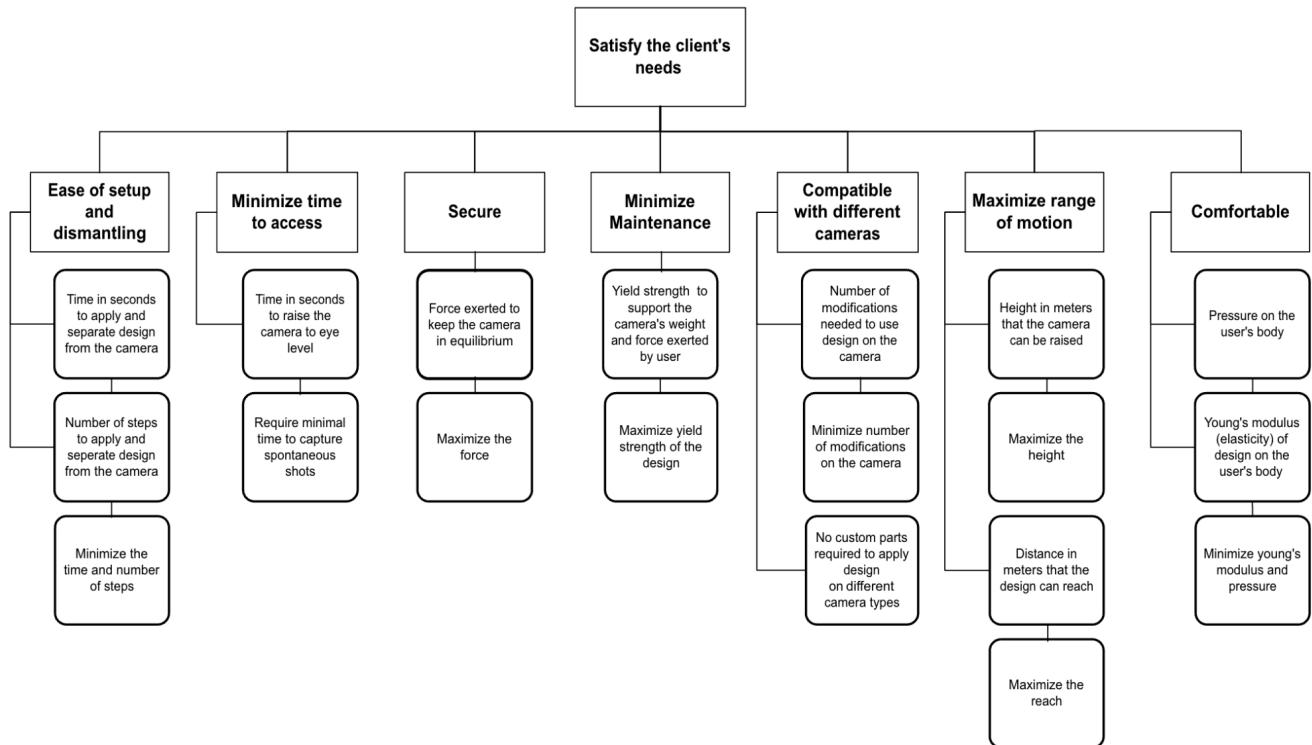


Figure 15. How-Why Tree with objectives at the top and corresponding metrics below them.

## Appendix H: Pairwise Comparison for Objectives

Table 8 below is a pairwise comparison table used to rank each objective based on their importance.

Table 8. Pairwise Comparison Chart Ranking the Objectives with Score

Objectives	Ease of setup and dismantling	Minimize time to access	Secure	Minimize maintenance	Compatible with different cameras	Maximize the range of motion	Comfortable	Score
Ease of setup and dismantling	-	0	0	0	0	0	0	0
Minimize time	1	-	1	1	1	1	1	6

to access								
Secure	1	0	-	1	1	1	1	5
Minimize maintenance	1	0	0	-	1	1	1	4
Compatible with different cameras	1	0	0	0	-	1	1	3
Maximize the range of motion	1	0	0	0	1	-	0	2
Comfortable	1	0	0	0	0	0	-	1

### Appendix I: Pairwise Comparison for Constraints

Table 9 below is a pairwise comparison table used to rank each constraint based on their importance.

Table 9. Pairwise Comparison Chart

Objective	Affordable	Support camera	Adaptable to temperature changes	Safe for humans and the environment	Score
Affordable	-	0	0	0	0
Support Camera	1	-	1	0	2
Adaptable to temperature changes	1	0	-	0	1
Safe for humans and the environment	1	1	1	-	3

### Appendix J: PLR Research

Figure 16 shows research results for the masses of cameras that the client uses. Figure # shows research results for the masses of lens that the client uses, except for two larger lenses that can be excluded from scope according to client in appendix #.

#### **Constraints**

- What are the weights of Nikon F5, Nikon D850, Nikon Z6iii, and Olympus OM-1 DSLR cameras? (Brendon)

Nikon F5 (**1210g** without the battery)

<https://www.nikon-image.com/products/sl/r/lineup/f5/spec.html>

Nikon D850 (**1005g** with battery and memory card but without body cap)

<https://imaging.nikon.com/imaging/lineup/dslr/d850/>

Nikon Z6III (**760g** with battery and memory card but without body cap)

[https://onlinemanual.nikonimglib.com/z6III/en/specifications\\_384.html](https://onlinemanual.nikonimglib.com/z6III/en/specifications_384.html)

Olympus OM-1 (**599g** with battery and memory card but without body cap)

<https://jp.omsystem.com/product/dslr/om-omd/om/om1/spec.html>

Figure 16. Weights of cameras used by the client.

#### **Appendix K: Less Relevant Stakeholders & Their Justification**

The table below explains the justification behind the stakeholders excluded from the main document and the reason for their exclusion.

Table 12. Less Relevant Stakeholders (Not Ranked)

Stakeholders	Justification	Why irrelevant?
Pedestrians	Involves pedestrians that may be at risk of being hit by the product as it is in use.	Chances of the product having enough range to hit a passerby is low unless the user is in a crowded area.
Photographers Who Bike	Photographers who bike may require additional camera protection.	Is a subset of the main stakeholder of Photographers included in the original document.
Camera Reviewers	Includes sites and content reviewers that may test the product.	They do not have influence on the final design as they only review and test the product after completion.
Patent Office	Are in charge of approving or	They represent the interest of

	disapproving the potential patents for the final product produced.	patent holders whose interests/influence has already been considered in the stakeholder section of the main document.
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## Appendix L: Creativity Methods Used in Idea Generation

Table 13 shows different creativity methods employed by each team member to generate means for the six secondary functions. The team recorded their ideas and idea generation processes in a shared document during individual brainstorming sessions and highlighted the means in blue.

Table 13. Idea Generation Methods and Descriptions

Creativity Method	Description of Use
Blue Sky Thinking	Imagine what is possible without any constraints (ideal solutions if there were no limits). It helps to ignore any preconceived notions about what is possible or impossible. For this design project, there were too many existing solutions that the team found themselves struggling to think beyond. Therefore, blue sky thinking was extremely useful.
Magic Solutions	Create ideas that seem impossible or use fantasy-like technology in order to solve the design problem. These magical ideas will then be reworked into feasible ideas or discarded.
Random Stimulation	Seeks random words or ideas and incorporates them within our line of thinking. May or may not give solutions, but may open our mind towards many divergent solutions. Due to preconceived notions, it was difficult for the team to exercise lateral thinking, so using blue sky thinking and random stimulation helped us explore the design space.
5 Whys	Asks questions beginning with why in multiple iterations to challenge assumptions. This is to get to the root cause of a problem in order to generate ideas that will help solve that root cause.
Benchmarking	Uses the analysis of an existing design to set goals for a new design. For this design project, a variety of camera straps and other existing solutions were benchmarked to generate ideas. This also includes performance analysis and task analysis since we did not physically dissect the example designs themselves.
Reversal	Reverses the direction or sequence of things (e.g. instead of worrying about how a strap is going to carry a camera, think about what the camera has to do/is doing and incorporate it within the solution).

## Appendix M: List of Creativity Methods and Ideas Generated

Table 14 shows ideas generated using the six creativity methods that were documented in the team idea generation document during individual brainstorming sessions. AI generated and original ideas are labeled and means to accomplish each secondary function are underlined and colored in blue (Appendix X).

Table 14. Notes on Ideas Generated Using Each Creativity Method

Type of Ideas	Ideas
Reversal Method	<p><u>Questions asked:</u></p> <ul style="list-style-type: none"> <li>• What is the movement of the camera when the user is moving?</li> <li>• How will the camera react when design is implemented?</li> </ul> <p><u>Ideas:</u></p> <ul style="list-style-type: none"> <li>• The camera has to be pulled to the user when needed <ul style="list-style-type: none"> <li>◦ A method of easily extending to be able to accessed by the user during a fast paced movement</li> </ul> </li> <li>• Camera is returned to its original position near the body <ul style="list-style-type: none"> <li>◦ The persons product will be attached to a body while the camera is being taken away from the body during the action of photography</li> </ul> </li> </ul> <p><u>AI Ideas:</u></p> <ul style="list-style-type: none"> <li>• A <u>wearable harness</u> that securely holds the camera while allowing quick access for photographers <ul style="list-style-type: none"> <li>◦ System has a <u>locking clip</u> and <u>spring loaded mechanism</u></li> </ul> </li> <li>• <u>Magnetic docking station</u>, that holds a camera in place <ul style="list-style-type: none"> <li>◦ A magnetic plate attached to the camera</li> <li>◦ Strong neodymium magnets ensure a firm grip</li> </ul> </li> <li>• An <u>automated motorized robotic arm</u> <ul style="list-style-type: none"> <li>◦ Stores the camera, and extends it when needed</li> <li>◦ Camera is mounted on a robotic arm</li> </ul> </li> <li>• A <u>holster-based system</u> attached to a belt or backpack strap that locks and unlocks the camera with a <u>push mechanism</u> <ul style="list-style-type: none"> <li>◦ Has an <u>auto-locking latch</u> to prevent the camera dropping</li> <li>◦ <u>Belt</u> is attached to the holster</li> </ul> </li> <li>• A <u>backpack-integrated camera holder</u> that allows quick sliding access while keeping the camera secure <ul style="list-style-type: none"> <li>◦ Compartment like storage for the camera</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>● A <a href="#">retractable sling</a> that can be attached to a users belt or any other piece of clothing or material, allowing an easy and flexible movement           <ul style="list-style-type: none"> <li>○ Rectatable cable made out of durable materials</li> <li>○ Push release mechanism for each access</li> </ul> </li> <li>● An <a href="#">adjustable camera strings</a>, with cussing and made out of durable materials</li> <li>● A <a href="#">telescopic rod</a> extends the camera outward when required           <ul style="list-style-type: none"> <li>○ Similar to a selfie stick</li> </ul> </li> <li>● <a href="#">Wrist mounted camera holder</a> <ul style="list-style-type: none"> <li>○ A <a href="#">bracelet like mechanism</a> that is able to hold the camera when needed</li> </ul> </li> <li>● <a href="#">Shoulder-Mounted Camera Dock</a> <ul style="list-style-type: none"> <li>○ A camera holder on a shoulder, closer to the head</li> </ul> </li> </ul>
Magic Solution	<p><b><i>AI and Original Ideas:</i></b></p> <ul style="list-style-type: none"> <li>● Secondary Functions:           <ul style="list-style-type: none"> <li>○ Secure to the camera               <ul style="list-style-type: none"> <li>■ Monster claws</li> <li>■ Invisible Hands/Fingers</li> <li>■ A tiny creature like a pixie wraps itself around</li> <li>■ <a href="#">Adaptive claw-like grip or mechanical petals</a> automatically secure the camera when placed near the mount</li> <li>■ <a href="#">Magnetic ring around the base of the camera</a> will lock into a clasp</li> <li>■ <a href="#">Thin layer of adhesive material</a> activates when the camera makes contact and secures it in place</li> </ul> </li> <li>○ Unsecure from the camera               <ul style="list-style-type: none"> <li>■ Tied with and enchanted knot that unravels on command</li> <li>■ <a href="#">Sensors detect release commands</a> like double tap, twist or voice activation</li> <li>■ Disengages with tap or swipe gesture</li> </ul> </li> <li>○ Secure to the body               <ul style="list-style-type: none"> <li>■ User wears a special <a href="#">necklace that has a magnetic field</a> which keeps the design on the body</li> <li>■ <a href="#">Auto adjusting straps</a> conform to different body positions while keeping the camera stable</li> </ul> </li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>■ A <a href="#">rigid, adjustable exoskeleton-like frame</a> locks around the user's torso or shoulder</li> <li>○ Unsecure from the body           <ul style="list-style-type: none"> <li>■ The user can clap twice and the camera will levitate</li> <li>■ <a href="#">Hidden release button or touch mechanism</a> detaches the camera smoothly</li> <li>■ Pull a tab that instantly detaches the camera mount from the body</li> </ul> </li> <li>○ Allow access to the camera           <ul style="list-style-type: none"> <li>■ A <a href="#">strong tether that allows free movement of the camera</a> while keeping it secured</li> <li>■ A <a href="#">floating gimbal arm</a> extends and pivots the camera outward when needed</li> <li>■ A <a href="#">dock</a> allows the camera to be flipped</li> </ul> </li> <li>○ Return the camera to its secured position on the body           <ul style="list-style-type: none"> <li>■ The camera will have memory of its last secured position and it'll teleport back when activated</li> <li>■ The <a href="#">tether automatically retracts or magnets</a> guide the camera back into place when released</li> <li>■ A <a href="#">spring-loaded arm</a> automatically swings the camera back to its docking position</li> </ul> </li> </ul>
Random Stimulation	<p><b><i>Original Ideas:</i></b></p> <ul style="list-style-type: none"> <li>● Must include the word: "rubber band"           <ul style="list-style-type: none"> <li>○ A rubber band attached to the user's wrist that stretches with the camera's movement</li> <li>○ A wrist strap made of rubber band but has adjustable length</li> </ul> </li> <li>● Must include the word: "velcro"           <ul style="list-style-type: none"> <li>○ A velcro patch attach camera to clothing</li> <li>○ A camera case attached to clothing with velcro</li> </ul> </li> <li>● Must include the word: "vacuum cleaner"           <ul style="list-style-type: none"> <li>○ A vacuum cleaner that secures the camera through suction</li> <li>○ A vacuum cleaner that transfer the camera to user's hand</li> </ul> </li> <li>● Must include the word: "spring"           <ul style="list-style-type: none"> <li>○ A spring launches the camera into user's hand</li> <li>○ A spring secures the camera like a vice</li> </ul> </li> <li>● Must include the word: "magnetic field"           <ul style="list-style-type: none"> <li>○ A device that makes camera float in a magnetic field</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>○ A magnet that attaches camera to body</li> <li>● Must include the word: “overall” <ul style="list-style-type: none"> <li>○ An overall that carries the camera in front of user’s chest</li> <li>○ An camera case that looks like an overall</li> </ul> </li> <li>● Must include the word: “railroad” <ul style="list-style-type: none"> <li>○ A railroad that transports the camera from secured position to user’s hand</li> <li>○ A rail that looks like a railroad track for camera to clip on</li> </ul> </li> <li>● Must include the word: “pulleys” <ul style="list-style-type: none"> <li>○ A pulley system that brings the camera up from user’s waist to their hands and return it</li> <li>○ An electric motor that tightens a pulley system to make the camera slide across body</li> </ul> </li> <li>● Must include the word: “holster” <ul style="list-style-type: none"> <li>○ A holster on the waist that camera can fit into and quickly be drawn</li> <li>○ A holster vest for camera</li> </ul> </li> <li>● Must include the word: “VR headset” <ul style="list-style-type: none"> <li>○ A helmet with camera attached that can be flip up and down like a VR headset</li> </ul> </li> <li>● Must include the word: “life ring” <ul style="list-style-type: none"> <li>○ A life ring for user to carry camera around their neck</li> <li>○ A life ring for user to carry camera around their shoulder and hold onto when moving</li> </ul> </li> </ul>
5 Whys	<p><b><i>Original Ideas:</i></b></p> <ul style="list-style-type: none"> <li>● Why do photographers use camera straps? <ul style="list-style-type: none"> <li>○ To secure and transport a camera.</li> </ul> </li> <li>● Why do photographers need a camera strap specifically to secure and transport a camera? <ul style="list-style-type: none"> <li>○ Camera strap allows the photographers to access the camera quickly while allowing photographers to secure and transport a camera.</li> </ul> </li> <li>● Why do photographers need to access the camera quickly? <ul style="list-style-type: none"> <li>○ To quickly take photos in fast moving scenery.</li> </ul> </li> <li>● Why is a strap needed if the goal is to quickly take photos, secure and transport the camera when the photographer can simply hold the camera? <ul style="list-style-type: none"> <li>○ So that the photographer does not need to hold the camera at all times to keep the camera secure.</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>• Why is a strap needed to hold the camera at all times to keep the camera secure and allow the photographers to access the camera? <ul style="list-style-type: none"> <li>◦ The strap is not strictly needed and there are other ways to allow photographers to secure the camera while allowing for quick access and transport.</li> </ul> </li> </ul> <p>Generated based on each objective.</p> <ul style="list-style-type: none"> <li>• Secure: <a href="#">bag</a>, <a href="#">string</a> (extension cord), <a href="#">cage</a>, <a href="#">backpack</a>, <a href="#">pocket</a>, <a href="#">camera harness</a>, <a href="#">magnet</a>, <a href="#">clip</a>, <a href="#">vest</a></li> <li>• Quick access: <a href="#">strap</a>, <a href="#">holding the camera</a>, <a href="#">jacket attachment</a>, <a href="#">belt attachment</a>, <a href="#">vest</a></li> <li>• Transport: <a href="#">bag</a>, <a href="#">string</a>, <a href="#">RC car</a>, <a href="#">drones</a>, <a href="#">car</a>, <a href="#">bicycle</a>, <a href="#">vest</a></li> </ul>
Analogy/Benchmarking	<p><b><i>Original/Researched Ideas:</i></b></p> <ul style="list-style-type: none"> <li>• A <a href="#">handbag</a> - Made of leather, Can be stretched, Adjustable</li> <li>• A <a href="#">tripod</a> - A tripod can be attached to the body</li> <li>• <a href="#">Go pro</a> - The go pro holder can be adjusted to be able to carry bigger cameras</li> <li>• <a href="#">Headphones</a> - attach camera on top of headset-like design</li> <li>• <a href="#">Safety harness</a> - attach camera to the body how a harness would be attached</li> <li>• <a href="#">Helmet</a> - attach camera on a helmet</li> <li>• <a href="#">Wrist Strap</a> - Carry camera on wrists</li> <li>• <a href="#">Backpack</a> - carry camera like a backpack and accessing it would be like how you might use swords</li> <li>• <a href="#">Clip onto clothing</a> - a clip attached to the camera can hang onto a part of clothing</li> <li>• <a href="#">Gloves</a> - camera can be attached to gloves which highly improves accessibility</li> </ul>
Blue Sky Thinking	<p><b><i>Original Ideas:</i></b></p>  <ul style="list-style-type: none"> <li>• <a href="#">Elastic tape structure</a> (like this) , and <a href="#">shoulder pad</a> can storage <a href="#">staps</a>, strap instead of <a href="#">measuring tape</a>. A clip will stop strap moving when strap got the appropriate length(can be controlled by different people)</li> <li>• <a href="#">Ruler print</a>, with fluorescence, to do microfocus photography.</li> </ul>

	<ul style="list-style-type: none"> <li>• aluminium alloy and nylon material</li> <li>• A <a href="#">hidden pocket</a> on the strap</li> <li>• A strong fixed method on pad, like a <a href="#">clip</a> or sth.</li> <li>• The side of the strap should be smooth.</li> </ul>
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Table 15 shows an instance where a morphological chart was used to create full solutions by combining means generated through random stimulation.

Table 15. Morph Chart Combining 31 Means Generated by Random Stimulation

Secondary Functions	Means	Means	Means	Means	Means	Means	Means
Unsecure/ Secure the camera	<a href="#">velcro patch</a>	<a href="#">magenet</a>	<a href="#">case with snap fasteners</a>	<a href="#">pocket</a>	<a href="#">vacuum cleaner</a>	<a href="#">joy-con rail</a>	<a href="#">workbench vice</a>
Secure to the body	<a href="#">vest harness</a>	<a href="#">elastic band</a>	<a href="#">holster</a>	<a href="#">overall</a>	<a href="#">inflated ring</a>	<a href="#">shoulder straps</a>	<a href="#">Front-loading backpack</a>
	<a href="#">fanny pack</a>	<a href="#">belt</a>	<a href="#">helmet</a>				
Unsecure from the body	<a href="#">quick -release buckles</a>	<a href="#">adhesive tape</a>	<a href="#">suction cup</a>	<a href="#">clamps with length-adjusting knobs</a>	<a href="#">fishing hooks</a>	<a href="#">fasteners</a>	<a href="#">clips</a>
Allow access to the camera/ return the camera to its secured position	<a href="#">pulley system</a>	<a href="#">tactical goggles</a>	<a href="#">conveyor belt</a>	<a href="#">lanyard</a>	<a href="#">gravity</a>	<a href="#">clock spring retraction</a>	<a href="#">badge reel</a>

## Appendix N: 62 Solutions Before Consolidation

Table 16 contains all 62 solutions generated by the team at the end of the idea generation process.

Table 16. 62 Solutions Generated Before Revision & Consolidation

Solution Number	Solution
1	A wearable harness that can be either a form of a whole body harness or just the waist harness, that securely holds the camera while allowing quick access for photographers. The camera will be attached to the harness, allowing it to be attached to different body parts. System has a locking clip and spring loaded mechanism allowing a secured position of the camera, not allowing it to break.
2	Magnetic docking station that holds a camera in place. Two small magnetic plates can be created as a locking mechanism. Hence a new attachment system of the magnetic will be created, compatible to all of the different camera types. Strong neodymium magnets ensure a firm grip on the camera, not allowing it to fall. An additional holding mechanism will be attached to the strings of the camera straps, in order to ensure safe transportation aside from dynamic camera uses.
3	An automated motorized robotic arm that can be both controlled by a remote and by an arm. The robotic arm can be attached to any piece of clothing available as it will have a claw on the other side of it too attached to different fabrics. It can both store the camera, and extend it when needed to the user. It adjusts itself, (smart adjustment) depending on the environment of the user. Furthermore, the camera is mounted on a robotic arm, it is secured using the arm, not allowing it to fall.
4	A holster-based system attached to a belt or backpack strap that locks and unlocks the camera with a push mechanism. It is an attached belt that also has a compartment to hold the camera. Has an auto-locking latch to prevent the camera dropping. Hence, when it is needed to be used the main straps that hold the camera on the hoster can be removed and the camera can be easily removed from the hoster safely. Belt is attached to the holster-based and if needed the whole holster can be removed from the belt.
5	A backpack-integrated camera holder that allows quick sliding access while keeping the camera secure. The backpack can be worn either on front of the body or on the back. The camera holder can be easily disattached from the camera. It is a compartment like storage for the camera.
6	A retractable sling that can be attached to a user's belt or any other piece of clothing or material, allowing an easy and flexible movement. The sling will have a clamp attached to one of its ends. Hence, it can be easily attached to any body part or clothing. Rectatable cable made out of durable materials hence preventing any rips or malfunctions of the sling when the camera retracts. A little button push

	release mechanism for each access at the end is placed which will unlock the retractable mechanism, allowing more security and easier pull when taking the camera.
7	An adjustable camera straps, with cussing and made out of durable materials. Are regular camera straps that have designed an improved attachment mechanism using clips/carabiners for easier attachment, needing less time. The strap will have cushioning for the straps for more comfortable uses and adjustment mechanism for easy adjustment of the length.
8	A telescopic rod, similar to a selfie stick, extends the camera outward when required. It will most likely be a shorter version which is attached to a belt. It can be easily moved in different directions for a more comfortable wear. The rod will be made of out metal, light for less chances of breaking.
9	Wrist mounted camera holder which is a bracelet-like mechanism that is able to hold the camera. The wrist mounted mechanism will have multiple grips that will extend up to an elbow to elevate pressure from the only one spot on the wrist. Hence, the mechanism will be more comfortable for the user to wear. It can be adjustable using multiple adjustment mechanisms of the width, hence it can be compatible with different arm widths and clothing.
10	Shoulder-Mounted camera dock, which is a camera holder on a shoulder, closer to the head. Attached on the shoulder the camera can be held in one place securely. However, it can be disattached from the shoulder with an easy push mechanism which will release the camera when needed and taken off of the mechanism.
11	The product will be a metal “box” with clamps on the inside that will automatically clip onto the camera when it is placed/pushed inside of it. The clamps will unsecure when the user pushes a button on the side of the “box”. The user will wear a jacket as an accessory which will have a strong velcro strip that can attach itself to the product also containing velcro. The user can secure and unsecure the product from the body by connecting and disconnecting the velcro strips. When removing the camera from the product, there will be adjustable straps attached to the camera’s eyelets which will allow shooting at multiple lengths and protect the camera from falling to the ground. The straps will guide the camera back into the “box” when the use of the camera is over.
12	The product will be a harness that can attach multiple cameras at its ends using strong rings and the existing eyelets on the camera. The camera can be unsecured from the harness by detaching from the rings. The harness will have wide straps and fit around the user like a backpack to help with pressure distribution. The harness can be removed by simply taking it off the body. The ends of the harness will be adjustable so that the camera can be used at multiple lengths and will come to rest around the hip area when not in use.

13	<p>The product will be a set of clamps you can attach to the back of the camera that will have an additional set of clamps on its back that can lock with an accessory. You can unsecure the clamps from the camera by pulling a tab. The user will wear a belt like accessory with a lock mechanism that will allow the securing of the product onto their pants/the belt. The product can be unsecured by unlocking the clamps by hand. Returning the camera to its position will be the user's responsibility and access to the camera is implied.</p>
14	<p>A moving tripod mechanism will have a controller that the user can use to control its motion. The tripod stand will attach to the camera as many standardized cameras have a tripod hole at its bottom. You can unsecure the camera by detaching it from the tripod stand and return it by reattaching.</p>
15	<p>The camera has a magnetic plate with mechanical locking tabs that secure it when placed near the mount. The locking tabs release when the user performs double-taps the mount. A lightweight harness holds the dock in place. A release button on the strap detaches the dock instantly. A strong retractable strap allows the camera to move freely while remaining attached. The retractable strap automatically goes back, guiding the camera into the dock.</p>
16	<p>A mechanical claw-like grip locks the camera securely. The claw opens when the user twists a tab. A rigid belt with adjustable torso straps stabilizes the mount. A quick release buckle will detach the mount from the body in one motion. A spring loaded pivot arm extends the camera outward when needed and automatically swings the camera back.</p>
17	<p>A physical lock keeps the camera stable when it is attached to the user's clothing. The user simply pulls the camera outward, disengaging the lock. A chest harness holds the lock and the camera firmly in place. A hidden push-release button releases the lock instantly from the clothing. A spring-loaded auto-recoiling arm extends the camera forward.</p>
18	<p>A small motorized locking ring clamps around the camera's base, holding it in place. A gesture sensor disengages the motorized lock. A gyroscopically stabilized chest mount keeps the camera level, reducing unwanted movement. A detachable magnetic plate allows the entire mount to be removed quickly. The gyro stabilizer allows smooth panning and tilting, letting the user adjust angles without removing the camera. A motorized guide realigns the camera to its original locked position when released.</p>
19	<p>A spring-loaded mechanical latch automatically grips the camera when inserted into the mount. A dual-button safety release prevents accidental detachment. A heavy-duty tactical vest mount with shock-absorbing padding keeps the camera stable. A twist-lock mechanism allows the user to remove the entire mount from the vest. The strap acts as a hinge, allowing the user to flip the camera forward or sideways. The elastic nature of the strap gently pulls the camera back to its resting position.</p>

20	<p>The camera attaches to the dock using a hybrid locking system, combining low-energy electromagnets with small mechanical clasps that engage when the camera is placed into position. A proximity sensor or manual button disengages the electromagnets and releases the mechanical lock, allowing for smooth removal without excessive force. A slim, form-fitting vest with embedded magnetic plates provides a stable mounting base. The vest ensures even weight distribution and prevents unwanted shifting. A hidden quick-release buckle allows the user to easily detach the mount from the vest when needed. The dock features a pivoting hinge or sliding rail system, enabling the user to pull the camera forward or adjust angles while keeping it tethered to the mount. A spring-assisted or magnet-guided alignment system helps the camera return smoothly into place when repositioned near the dock.</p>
21	<p>A holster attached to the user's waist with belt clips that secures the camera using snap fasteners and has a badge reel connecting it to the holster.</p>
22	<p>A helmet with a night vision mount that secures the camera and enables the user to pull it down by hand when taking pictures. The helmet will have quick-release buckles and the mount will have rails that the camera can slide onto for attachment/detachment.</p>
23	<p>A vest harness with a pocket for storing the camera and a lanyard for securing it to the pocket. The vest harness can be removed with quick-release clips.</p>
24	<p>A fanny pack worn around the user torso and secured using buckles that have a pocket for storing the camera and a retractable badge reel connected to the camera.</p>
25	<p>A nylon belt covered in velcro with a badge reel that secures the camera to the user's waist. The belt can be removed by releasing a buckle.</p>
26	<p>A front-loading backpack filled with foam cushion that stores the camera and uses a clock spring to retract the camera back to the backpack after use. The backpack can be removed by taking off the shoulder straps.</p>
27	<p>A camera case secured to the user's waist using belt clips that automatically unsecure and transport the camera from waist to chest using a motorized conveyor belt worn across the torso like a sash.</p>
28	<p>A life ring with a pocket for storing the camera that secures the camera by inflating around the user's torso or shoulder and deflates to unsecure the camera. A badge reel connects the camera to the ring.</p>
29	<p>A vest harness equipped with a built-in vacuum motor and suction tube that secures the camera in front of the user's chest. The suction tube can be turned on or off by pressing a button to drop the camera into their hands with gravity and a lanyard will connect the camera to the vest to prevent accidental drops.</p>

<b>30</b>	30. An overall with hidden magnet sheets that secure the camera to the fabric and has a badge reel connecting the camera to the overall. The overall can be removed by unfastening the shoulder straps.
<b>31</b>	The camera will be secured by connecting the eye-lids to a retractable string that is secured in place in an open-lid box. The box is attached to the photographer's body via a belt/strap. The camera can be detached from the string at any time but is not necessary during photography sessions as the camera can be used with the retractable string.
<b>32</b>	Photographers can wear a vest with multiple magnetic secure points on which the camera can be mounted. The camera will be modified to add magnets so that it can be secured safely. The camera can be accessed anytime by detaching it from the magnetic secure points.
<b>33</b>	Photographers can wear a camera harness but with magnetic secure points. The camera will be modified so that it can be safely secured. The camera can be accessed anytime by detaching it from the magnetic secure points.
<b>34</b>	Photographers can wear a belt with magnetic attachment points, integrated to the belt, where the camera can be clipped and secured. The camera can be accessed anytime by detaching it from the clip.
<b>35</b>	A belt with the additional function of securing a string that can be extended and retracted similar to one found in a tape measure. The string can be attached to the camera to secure it or the photographer's body and during use, the photographer can simply extend the string without removing the camera from the security mechanism.
<b>36</b>	A clip-on system that attaches to the straps of a backpack. The clips themselves are completely integrated to the straps of the backpack. This system allows the camera to be immediately accessible within reach allowing for faster access by detaching it from the clip.
<b>37</b>	A hard hat with a magnetic attachment platform for a camera. The camera will be modified to have a magnet or metal platform to attach to the magnetic platform. The hardhat can be secured and unsecured from the photographer's body/head at any time and the camera can be secured and unsecured from the magnetic platform at any time as well.
<b>38</b>	38. A drone programmed to follow the photographer that carries the camera. Camera can thus be accessed anytime while not applying any pressure on the photographer's body.
<b>39</b>	A bicycle basket with additional padding to keep the camera protected. A photographer who bikes may find this solution useful.

<b>30</b>	An RC car that holds the camera with a basket that can be raised to the user's reach, allowing the camera to be accessed at any time which does not require the photographer to carry the camera.
<b>41</b>	The product will be an elastic camera band with a built-in fluorescent ruler printed to improve visibility in low light conditions for precise microfocus photography. The band will be made of a combination of aluminum alloy and durable nylon for increased strength and flexibility. A hidden pocket will be integrated into the gadget storage strap. The shoulder pads will have a storage room for excess strap length, and a secure clip mechanism will allow users to lock in the length they want to customize the fit for the strap. The edges of the band will be smooth to ensure comfort during prolonged use. In addition, the pad will have a strong attachment system, such as a sturdy clip, to keep it firmly in place during movement.
<b>42</b>	The product will be a nylon camera strap designed for durability and flexibility, with elastic construction, comfort and adaptability. The strap will be attached to the side of the camera closest to the user, ensuring better weight distribution and stability. To prevent the camera from causing discomfort or injury, a soft rubber layer is placed inside to act as a protective pad between the camera and the user's body. In addition, the shoulder area will be equipped with shock absorbing pads to reduce stress and increase comfort during prolonged use.
<b>43</b>	A dynamic self-retractable camera strap with a built-in spring-loaded tension system that keeps the camera close to the body but can be lifted immediately when needed. The strap is made of high-strength nylon with a smooth sliding mechanism for seamless movement. Breathable, non-slip shoulder pads ensure comfort, and a magnetic quick-release lock on the strap allows for immediate disengagement when switching cameras.
<b>44</b>	Double elastic shoulder straps lined with low friction allow the camera to slide easily into shooting position. The band features an adjustable tension lock to suit different user preferences, as well as a comfortable shoulder area with a gel pad. The reinforced anchor points ensure stability while maintaining smooth movement.
<b>45</b>	An ergonomic air channel padded shoulder strap with a carbon fiber reinforced quick slide system minimizes friction when lifting the camera. The strap has a hidden pocket for storing memory cards and a self-adjusting tensioner that maintains optimal slack for quick access.
<b>46</b>	A counterweight assist strap with an innovative automatic balancing system keeps the camera stable while walking, but quickly lifts it when needed. The shoulder pads feature shock-absorbing technology, while a quick latch system allows for an instant adjustment of the straps on the go.

<b>47</b>	A retractable strap with a tension-controlled pulley system allows the user to smoothly pull the camera up without slack interference. Made of lightweight and durable nylon, it comes with non-slip rubber shoulder pads and a safety lock that holds the camera in place when not in use.
<b>48</b>	The highly elastic strap is designed to absorb sudden movements and minimize camera bounce when running or moving quickly. It features a thin shoulder pad with impact-resistant foam and a magnetic release system for one-handed adjustment of the shoulder strap.
<b>49</b>	A hybrid belt with a rail system integrated into the shoulder pad allows the camera to glide smoothly along a controlled track while maintaining a natural shooting position. The strap is made of reinforced elastic webbing with a fine-tuning dial for precise length control
<b>50</b>	The smart tension control strap with an automatic recoil mechanism gently pulls the camera back to a stationary position while keeping the camera ready for quick use. The straps are made of an enhanced stretch fabric with ergonomic shoulder pads infused with gel and locking clips for added security.
<b>51</b>	A solution that uses handbag straps to mimic camera straps. They provide comfort and security as they are strong and soft materials. They allow access to the camera and it is portable. They are stretchable to allow for more movement.
<b>52</b>	A tripod offers stability to a camera user. Hence, we can attach a tripod with shortened legs to the user's body with a mechanism to extend the camera from the body to the hands using a string or a magnet.
<b>53</b>	Modify a GoPro mount to be able to hold a camera close to the chest. It will be accessed using a magnet, extendable string or a 3D printed hole.
<b>54</b>	Headphones with cameras attached on either side of the headphones. It will be detachable from the headphones using a magnet or an extendable string.
<b>55</b>	Using a harness, attach a camera onto the straps. Detach using a magnet or a string.
<b>56</b>	Using a biker helmet, replace the glass shield with a mechanism to attach a camera. It can also be attached on the sides.
<b>57</b>	Use a harness clip to attach and detach a camera from a wrist strap. The harness clip can be detachable to allow free access to the camera. The camera could also be attached to the wrist strap using springs.
<b>58</b>	Attach the camera to one of the sides of a katana holder type of backpack. Use an extendable string to allow access to the camera.

<b>59</b>	Attach the camera to a harness clip that is attached to the body using a spring. The clip will be secured onto clothing and be detachable to provide camera access. A clip could also be 3D printed to match the requirements.
<b>60</b>	Camera attaches to a robotic glove which can secure and unsecure the camera using a hand gesture.
<b>61</b>	A vest that will have a holder on the chest to provide support from the bottom. The holder will have magnets to be able to secure the camera. The vest is secured onto the body and can be removed from the body.
<b>62</b>	A vest more focused on the back of the user's shoulders. The system can detach itself and be moved between shoulders. It will also be constantly moving to prevent entanglement of the strap. One strap that is attached will diverge in the end to secure to both sockets of the camera.

#### Appendix O: List of Solutions Before the Multi-voting Process

Table 17 lists all 48 solutions after consolidation where duplicates and infeasible solutions are removed. They are renumbered for the multi-voting process and categorized by different types of wearable technology.

Table 17. Consolidated Team List of 48 Solutions

<b>Category</b>	<b>Solution Number</b>	<b>Solution</b>
Harness-Based Solutions	<b>1</b>	The product will be a harness that can attach multiple cameras at its ends using strong rings and the existing eyelets on the camera. The camera can be unsecured from the harness by detaching from the rings. The harness will have wide straps and fit around the user like a backpack to help with pressure distribution. The harness can be removed by simply taking it off the body. The ends of the harness will be adjustable so that the camera can be used at multiple lengths and will come to rest around the hip area when not in use.
	<b>2</b>	A physical lock keeps the camera stable when it is attached to the user's clothing. The user simply pulls the camera outward for use. A chest harness holds the lock and the camera firmly in place. A push-release button releases the lock instantly from the clothing.
	<b>3</b>	A vest harness with a pocket for storing the camera and a lanyard for securing it to the pocket. The lanyard can be

		unclipped to be removed from the camera. The vest harness can be removed from the body with quick-release clips. The lanyard will be extendible to allow access to the camera while it is secured.
	4	A life ring with a pocket for storing the camera that secures the camera by inflating around the user's torso or shoulder and deflates to unsecure the camera. A badge reel connects the camera to the ring. The shoulder area has an inflatable mouth, the user can blow into the air to inflate, the inflatable mouth has a valve.
	5	A vest harness equipped with a built-in vacuum motor and suction tube that secures the camera in front of the user's chest. The suction tube can be turned on or off by pressing a button to drop the camera into their hands with gravity and a lanyard will connect the camera to the vest to prevent accidental drops.
	6	Use a harness clip to attach and detach a camera from a wrist strap. The harness clip can be detachable to allow free access to the camera. The camera could also be attached to the wrist strap using springs.
Magnetic Docking and Attachment Systems	7	Magnetic docking station that holds a camera in place. Two small magnetic plates can be created as a locking mechanism. Hence a new attachment system of the magnetic will be created, compatible to all of the different camera types. Strong neodymium magnets ensure a firm grip on the camera, not allowing it to fall. An additional holding mechanism will be attached to the strings of the camera straps, in order to ensure safe transportation aside from dynamic camera uses.
	8	The camera has a magnetic plate with mechanical locking tabs that secure it when placed near the mount. The locking tabs release when the user performs double-taps the mount. A lightweight harness holds the dock in place. A release button on the strap detaches the dock instantly. A strong retractable strap allows the camera to move freely while remaining attached. The retractable strap automatically goes back, guiding the camera into the dock.
	9	Photographers can wear a vest with multiple magnetic secure points on which the camera can be mounted. The camera will be modified to add magnets so that it can be secured safely.

		The camera can be accessed anytime by detaching it from the magnetic secure points.
	<b>10</b>	Modify a GoPro mount to be able to hold a camera close to the chest. It will be accessed using a magnet which will allow access to the camera as well as allowing the camera to be secured onto the body.
	<b>11</b>	Attach the camera to a harness clip that is attached to the body using a spring. The clip will be secured onto clothing and be detachable to provide camera access. A clip could also be 3D printed to match the requirements
	<b>12</b>	A vest that will have a holder on the chest to provide support from the bottom. The holder will have magnets to be able to secure the camera. The vest is secured onto the body and can be removed from the body.
Belt-Based Solutions	<b>13</b>	The product will be a set of clamps you can attach to the back of the camera that will have an additional set of clamps on its back that can lock with an accessory. You can unsecure the clamps from the camera by pulling a tab. The user will wear a belt like accessory with a lock mechanism that will allow the securing of the product onto their pants/the belt. The product can be unsecured by unlocking the clamps by hand. Returning the camera to its position will be the user's responsibility and access to the camera is implied.
	<b>14</b>	A holster attached to the user's waist with belt clips that secures the camera using snap fasteners and has a badge reel connecting it to the holster.
	<b>15</b>	A nylon belt covered in velcro with a badge reel that secures the camera to the user's waist. The belt can be removed by releasing a buckle.
	<b>16</b>	Photographers can wear a belt with magnetic attachment points, integrated to the belt, where the camera can be clipped and secured. The camera can be accessed anytime by detaching it from the clip.

	<b>17</b>	A belt with the additional function of securing a string that can be extended and retracted using a spring loaded reel similar to one found in a tape measure. The string can be attached to the camera to secure it or the photographer's body and during use, the photographer can simply extend the string without removing the camera from the security mechanism. (modified to be more precise during feasibility check)
Retractable Systems	<b>18</b>	The smart tension control strap with an automatic recoil mechanism gently pulls the camera back to a stationary position while keeping the camera ready for quick use. The straps are made of an enhanced stretch fabric with ergonomic shoulder pads infused with gel and locking clips for added security.
	<b>19</b>	A retractable sling that can be attached to a user's belt or any other piece of clothing or material, allowing an easy and flexible movement. The sling will have a clamp attached to one of its ends. Hence, it can be easily attached to any body part or clothing. Retractable cable made out of durable materials hence preventing any rips or malfunctions of the sling when the camera retracts. A little button – push release mechanism for each access – at the end is placed which will unlock the retractable mechanism, allowing more security and easier pull when taking the camera.
	<b>20</b>	A fanny pack wore around the user torso and secured using buckles that have a pocket for storing the camera and a retractable badge reel connected to the camera. The badge reel allows for securing and unsecuring the camera while also allowing access to the camera.
	<b>21</b>	The product will be an elastic camera string. The band will be made of a combination of aluminum alloy and durable nylon for increased strength and flexibility. A hidden pocket will be integrated into the gadget storage strap. The shoulder pads will have a storage room for excess strap length, and a secure clip mechanism will allow users to lock in the length they want to customize the fit for the strap. The edges of the band will be smooth to ensure comfort during prolonged use. In addition,

		<p>the pad will have a strong attachment system, such as a sturdy clip, to keep it firmly in place during movement.</p> <p>The highlighted part is not feasible as it adds extra cost for a situation already accounted for using a camera's flashlight.</p>
	<b>22</b>	<p>The product will be a nylon camera strap designed for durability and flexibility, with elastic construction, comfort and adaptability. The strap will be attached to the side of the camera closest to the user, ensuring better weight distribution and stability. To prevent the camera from causing discomfort or injury, a soft rubber layer is placed inside to act as a protective pad between the camera and the user's body. In addition, the shoulder area will be equipped with shock absorbing pads to reduce stress and increase comfort during prolonged use.</p>
	<b>23</b>	<p>A dynamic self-retractable camera strap with a built-in spring-loaded tension system that keeps the camera close to the body but can be lifted immediately when needed. The strap is made of high-strength nylon with a smooth sliding mechanism for seamless movement. Breathable, non-slip shoulder pads ensure comfort, and a magnetic quick-release lock on the strap allows for immediate disengagement when switching cameras.</p>
	<b>24</b>	<p>A retractable strap with a tension-controlled pulley system allows the user to smoothly pull the camera up without slack interference. Made of lightweight and durable nylon, it comes with non-slip rubber shoulder pads and a safety lock that holds the camera in place when not in use.</p>
	<b>25</b>	<p>Headphones with cameras attached on either side of the headphones. It will be detachable from the headphones using a retractable string. The camera will be secured to the string and rest on the user's shoulder using shoulder pads for easy access. The headphones will be secured onto the head and can be removed.</p>
Holster/Box-Based Systems	<b>26</b>	<p>A holster-based system attached to a belt or backpack strap that locks and unlocks the camera with a push mechanism. It is an attached belt that also has a compartment to hold the camera. Has an auto-locking latch to prevent the camera dropping. Hence, when it is needed to be used the main straps</p>

		that hold the camera on the hoster can be removed and the camera can be easily removed from the hoster safely. Belt is attached to the holster-based and if needed the whole holster can be removed from the belt.
	27	The product will be a box with clamps on the inside that will automatically clip onto the camera when it is placed/pushed inside of it. The clamps will unsecure when the user pushes a button on the side of the “box”. The user will wear a jacket as an accessory which will have a strong velcro strip that can attach itself to the product also containing velcro. The user can secure and unsecure the product from the body by connecting and disconnecting the velcro strips. When removing the camera from the product, there will be adjustable straps attached to the camera’s eyelets which will allow shooting at multiple lengths and protect the camera from falling to the ground. The straps will guide the camera back into the “box” when the use of the camera is over. (Modified, removed part that is not skin-safe)
	28	A spring-loaded mechanical latch automatically grips the camera when inserted into the mount. A dual-button safety release prevents accidental detachment. A heavy-duty tactical vest mount with shock-absorbing padding keeps the camera stable. A twist-lock mechanism allows the user to remove the entire mount from the vest. The strap acts as a hinge, allowing the user to flip the camera forward or sideways. The elastic nature of the strap gently pulls the camera back to its resting position.
	29	The camera will be secured by connecting the eye-lids to a retractable string that is secured in place in an open-lid box. The box is attached to the photographer’s body via a belt/strap. The camera can be detached from the string at any time but is not necessary during photography sessions as the camera can be used with the retractable string.
Shoulder/Chest-Mounted Systems	30	Shoulder-Mounted camera dock, which is a camera holder on a shoulder, closer to the head. Attached on the shoulder the camera can be held in one place securely. However, it can be disattached from the shoulder with an easy push mechanism

		which will release the camera when needed and taken off of the mechanism.
31		A small motorized locking ring clamps around the camera's base, holding it in place. A gesture sensor disengages the motorized lock. A gyroscopically stabilized chest mount keeps the camera level, reducing unwanted movement. A detachable magnetic plate allows the entire mount to be removed quickly. The gyro stabilizer allows smooth panning and tilting, letting the user adjust angles without removing the camera. A motorized guide realigns the camera to its original locked position when released.
32		Double elastic shoulder straps lined with low friction allow the camera to slide easily into shooting position. The band features an adjustable tension lock to suit different user preferences, as well as a comfortable shoulder area with a gel pad. The reinforced anchor points ensure stability while maintaining smooth movement.
33		An ergonomic air channel padded shoulder strap with a carbon fiber reinforced quick slide system minimizes friction when lifting the camera. The strap has a hidden pocket for storing memory cards and a self-adjusting tensioner that maintains optimal slack for quick access.
34		A counterweight assist strap with an innovative automatic balancing system keeps the camera stable while walking, but quickly lifts it when needed. The shoulder pads feature shock-absorbing technology, while a quick latch system allows for instant adjustment of the straps on the go.
35		A solution that instead of camera straps uses handbag straps to fulfill the process of holding the camera. They provide comfort and security as they are strong and soft materials. They allow access to the camera and it is portable. They are stretchable to allow for more movement.
36		An electric connecting railway system between a shoulder pad and a belt. The camera will be able to slide smoothly over the body using the railway system, controlled either manually or

		by a phone. The camera is secured using strings that are attached to the mechanism that slides the camera when it slides over the user's body.
Robotic & Automated Systems	<b>37</b>	A moving tripod mechanism will have a controller that the user can use to control its motion. The tripod stand will attach to the camera as many standardized cameras have a tripod hole at its bottom. You can unsecure the camera by detaching it from the tripod stand and return it by reattaching.
	<b>38</b>	A camera case secured to the user's waist using belt clips that automatically unsecure and transport the camera from waist to chest using a motorized conveyor belt worn across the torso like a sash. The whole strap is a bit elastic and slack to make sure there is more space for the photographer to move the camera. There is also a soft shoulder pad fixed on the shoulder part.
	<b>39</b>	An RC car that holds the camera with a basket that can be raised to the user's reach, allowing the camera to be accessed at any time which does not require the photographer to carry the camera.
	<b>40</b>	Camera attaches to a robotic glove which can secure and unsecure the camera using a hand gesture. The glove will be secured on the hand using a tightening lock. The robotic glove will allow for tracking hand movements and will be connected to a mobile app. The mobile app will also allow for automatic locking and unlocking for the camera.
Helmet-Mounted Systems	<b>41</b>	A helmet with a night vision mount that secures the camera and enables the user to pull it down by hand when taking pictures. The helmet will have quick-release buckles and the mount will have rails that the camera can slide onto for attachment/detachment.
	<b>42</b>	A hard hat with a magnetic attachment platform for a camera. The camera will be modified to have a magnet or metal platform to attach to the magnetic platform. The hardhat can be secured and unsecured from the photographer's body/head at

		any time and the camera can be secured and unsecured from the magnetic platform at any time as well.
	<b>43</b>	Using a biker helmet, replace the glass shield with a mechanism to attach a camera using a retractable string with a lock for securing the camera. The side of the helmet will have a flat stand for the camera to rest on. The helmet can be removed from the head to be able to detach the camera from the helmet.
Backpack-Based Solutions	<b>44</b>	A backpack-integrated camera holder filled with a foam cushion that stores the camera and uses a spring to retract the camera back to the backpack after use. The backpack can be worn either on front of the body or on the back and can be removed by taking off the shoulder straps.
	<b>45</b>	A clip-on system that attaches to the straps of a backpack. The clips themselves are completely integrated to the straps of the backpack. This system allows the camera to be immediately accessible within reach allowing for faster access by detaching it from the clip.
	<b>46</b>	The camera attaches to the dock using a hybrid locking system, combining low-energy electromagnets with small mechanical clasps that engage when the camera is placed into position. A proximity sensor or manual button disengages the electromagnets and releases the mechanical lock, allowing for smooth removal without excessive force. A slim, form-fitting vest with embedded magnetic plates provides a stable mounting base. The vest ensures even weight distribution and prevents unwanted shifting. A hidden quick-release buckle allows the user to easily detach the mount from the vest when needed. The dock features a pivoting hinge or sliding rail system, enabling the user to pull the camera forward or adjust angles while keeping it tethered to the mount. A spring-assisted or magnet-guided alignment system helps the camera return smoothly into place when repositioned near the dock.
	<b>47</b>	Attach the camera to one of the sides of a katana holder type of backpack. Use an extendable string to allow access to the

		camera. The camera would rest on the user's shoulder and can be locked and unlocked from the string. The string will be stored in the backpack and the backpack can be removed from the body using the backpack straps.
	<b>48</b>	A vestest more focused on the back of the user's shoulders. The system can detach itself and be moved between shoulders. It will also be constantly moving to prevent entanglement of the strap. One strap that is attached will diverge in the end to secure to both sockets of the camera.

## Appendix P: Feasibility Check After Consolidation

Table 18 shows a list of infeasible solutions out of the ones shown in Appendix L. Justification supported by research is given for why they were discarded by the team.

Table 18. Solutions Found Infeasible Through Research

Solution Number	Solution	Justification
3	An automated motorized robotic arm that can be both controlled by a remote and by an arm. The robotic arm can be attached to any piece of clothing available as it will have a claw on the other side of it too attached to different fabrics. It can both store the camera, and extend it when needed to the user. It adjusts itself, (smart adjustment) depending on the environment of the user. Furthermore, the camera is mounted on a robotic arm, it is secured using the arm, not allowing it to fall.	Over the client's budget. The minimum cost of a robotic arm is around \$5000 alone. With the rest of the requirements, this design would not be feasible. [61]
38	A drone programmed to follow the photographer that carries the camera. Camera can thus be accessed anytime while not applying any pressure on the photographer's body. The drone has a magnetic clip that holds the camera in place. The camera's Bluetooth system will connect to the user's remote control to control the shooting.	Over the client's budget as camera drones cost at least \$500 [62]
52	A tripod offers stability to a camera user. Hence, we can attach a tripod with legs that are shortened to one inch that is attached to the user's body using a 3D printed clip with a	Shortening the legs of a tripod is very difficult to do and is challenging to secure to the body [63].

	mechanism to extend the camera from the body to the hands using a retractable string.	
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## Appendix Q: Multi-voting Process

Figure 8 shows the multi-voting process with vote tallies for each solution. There were three rounds and each member had five, three and two votes respectively. In order to proceed to the next round, each solution needed at least one vote. In the end, seven solutions remained and were plotted on the graphical decision chart.



Figure 8. Multi-voting process with each solution numbered and color-coded squares representing vote tallies.

## Appendix R: Calculation for The Force of Friction From the Design

The friction coefficient of polyester ranges from 0.2 to 0.55 [32]. The following calculation will take the value as 0.2. Additionally, the mass of the design is assumed to be 0.25kg, which is much smaller than the realistic mass, and the maximum mass of the camera without lens is used to account for the worst-case scenario.

$$\text{mass} = \text{max. camera mass} + \text{design mass}$$

$$\text{mass} = 1.21\text{kg} + 0.25\text{kg}$$

$$\text{mass} = 1.46\text{kg}$$

$$\text{weight} = 1.46\text{kg} \times 9.81 \frac{\text{N}}{\text{kg}} = 14.3\text{N}$$

Normal force assumed to be equal to weight.

$$\text{Friction} = 14.3\text{N} \times 0.2 = 2.06\text{N}$$

## Appendix S: Calculation for Pressure Exerted on Body by Alternative Design 1 and 2

Accounting for the worst case scenario:

Minimum contact area

- Design 1: 8cm × 1cm (Assuming 1 cm of contact length) = 8 cm<sup>2</sup>
- Design 2: 8cm × 1cm (Assuming 1cm of contact length) = 8cm<sup>2</sup>

In order to account for the worst case scenario, the mass of the design itself used in the calculation is 1.00 kg and the shoulder-strap contact area used in the calculation is 8 cm<sup>2</sup> and. As the actual contact area will be much greater, the actual value for pressure would be a smaller value.

$$\text{max. mass} = \text{max. camera mass} + \text{max. lens mass} + \text{max. strap mass}$$

$$\text{max. mass} = 1.21\text{kg} + 1.54\text{kg} + 1.00\text{kg}$$

$$\text{max. mass} = 3.75\text{kg}$$

$$\text{weight} = 3.75\text{kg} \times 9.81 \frac{\text{N}}{\text{kg}} = 36.7875\text{N}$$

Design 1:

$$\text{pressure applied} = \frac{36.7875\text{N}}{8 \times 10^{-4}} = 4.598 \times 10^4 \text{Pa}$$

Design 2:

$$\text{pressure applied} = \frac{36.7875\text{N}}{8 \times 10^{-4}} = 4.598 \times 10^4 \text{Pa}$$

## **Appendix T: Calculation for the Minimum Time Required to Access a Camera For Design 1 – Padded Strap**

The average maximal value of hand movement speed towards a target is around 1.01 m/s [64], and the 50th percentile eye height is 64.57 inches, the 50th percentile elbow height is 42.64 inches, and the 50th percentile fingertip height is 25.75 inches [65].

From fingertip to elbow:

$$\Delta Height = 42.64 \text{ in.} - 25.75 \text{ in.} = 16.89 \text{ in.} = 0.4290m$$
$$time = \frac{\Delta height}{speed} = \frac{0.4290m}{1.01\frac{m}{s}} = 0.4248s$$

From elbow to eye:

$$\Delta Height = 64.57 \text{ in.} - 42.64 \text{ in.} = 21.96 \text{ in.} = 0.5578m$$
$$time = \frac{\Delta height}{speed} = \frac{0.5578m}{1.01\frac{m}{s}} = 0.552s$$

$$Total time = 0.977s$$

## **Appendix U: Calculation for Force of Friction Created in the System in Design 1 - Padded Strap**

The friction coefficient of rubber ranges from 1.5 to 3 [66]. The following calculation will take the value as 1.5. Additionally, the mass of the design is assumed to be 0.20kg, which is much smaller than the realistic mass, and the maximum mass of the camera without lens is used to account for the worst-case scenario.

$$mass = max. camera mass + design mass$$
$$mass = 1.21kg + 0.20kg$$
$$mass = 1.41kg$$

$$weight = 1.41kg \times 9.81\frac{N}{kg} = 13.8N$$

Normal force assumed to be equal to weight.

$$Friction = 13.8N \times 1.5 = 20.7N$$

## Appendix V: Calculation for the Minimum Time Required to Access a Camera for Design 2 – Magnetic Mount

Figure 9 shows the calculations done to find the time to access the camera for alternative design 2.

$$\begin{aligned}
 \text{Fingertip Height} &= 25.75 \text{ in} \\
 \text{Shoulder Height} &= 56.65 \text{ in} \\
 \text{Eye Height} &= 64.57 \text{ in} \\
 \text{Fingertip} \rightarrow \text{Shoulder} &= 56.65 - 25.75 = 30.9 \text{ in} = 0.78486 \text{ m} \\
 t &= \frac{0.78486}{1.01} = 0.777 \text{ s} \\
 \text{Shoulder} \rightarrow \text{Eye} &= 64.57 - 56.65 = 7.92 \text{ in} = 0.20117 \text{ m} \\
 t &= \frac{0.20117}{1.01} = 0.199 \text{ s} \\
 \text{Total } t &= 0.976 \text{ s}
 \end{aligned}$$

Figure 9. Calculation for time taken in an engineering notebook.

## Appendix W: Calculation for Force of Friction Created in the System in Design 2 – Magnetic Mount

The friction coefficient of nylon ranges from 1.0 to 2.0 [25]. The following calculation will take the value as 1.0. Additionally, the mass of the design is assumed to be 0.50kg, which is much smaller than the realistic mass, and the maximum mass of the camera without lens is used to account for the worst-case scenario.

$$\begin{aligned}
 \text{mass} &= \text{max. camera mass} + \text{design mass} \\
 \text{mass} &= 1.21\text{kg} + 0.50\text{kg} \\
 \text{mass} &= 1.71\text{kg} \\
 \text{weight} &= 1.71\text{kg} \times 9.81 \frac{\text{N}}{\text{kg}} = 16.8\text{N}
 \end{aligned}$$

Normal force assumed to be equal to weight.

$$\text{Friction} = 16.8\text{N} \times 1.0 = 16.8\text{N}$$

## Appendix X: GenAI Use for Idea Generation, Idea Selection, and Alternative Designs

Shown in Table 19, the team used ChatGPT to generate content in three sections of the document: idea generation process, alternative idea selection process, and alternative design descriptions. First, this tool was used to generate some means and synthesize brainstormed means that accomplish each secondary function into full solutions in complete sentences. Second, it was used to quickly consolidate full solutions into a list with distinct solution categories. Finally, it was used to generate visual representations of three alternative designs using the descriptions written by members of the team.

Table 19. Descriptions of GenAI Use in Specific CDS Sections

Section	Idea Generation Process
Nature of Use:	To generate 10 full solutions with the prompts brainstormed using the reversal method.
Prompt:	<p><b>Primary Function:</b></p> <ul style="list-style-type: none"><li>● To carry a camera.</li></ul> <p><b>Secondary Functions:</b></p> <ul style="list-style-type: none"><li>● Secure the camera</li><li>● Allow access to the camera</li><li>● Return the camera to its secured position</li></ul> <p>based on these functions create design solutions for a camera</p> <p><b>Design Solutions for a Camera Carrying System</b></p> <p>Based on the provided primary and secondary functions, here are potential design solutions for a camera carrying system:</p>

Results:

can you generate me more ideas

## 20 Design Solutions for a Camera Carrying System

Expanding on the previous list, here are 20 unique design solutions for securely carrying, accessing, and retrieving a camera:

### Wearable & Personal Carrying Solutions

#### 1. Camera Harness with Quick-Release (Chest/Shoulder)

- Wearable harness that holds the camera securely and allows for quick access.
- Spring-loaded or magnetic release system for one-handed use.
- Retractable elastic strap to prevent dropping.

#### 2. Magnetic Chest Plate with Camera Mount

- A chest-mounted plate with a magnetic docking system.
- Allows easy snapping in and out of position.
- Auto-aligning design ensures camera security.

#### 3. Belt-Mounted Camera Holster

- A holster-style camera holder attached to a belt.
- Press-to-release locking system to secure the camera.
- Auto-locking return mechanism when docked.

#### 4. Leg Strap or Thigh Camera Mount

- Designed for adventurers or hikers, this leg-mounted holder keeps the camera accessible.
- Flexible strap system keeps it in place during movement.
- Spring-loaded release for quick access.

#### 5. Backpack Shoulder Strap Mount

- Clip-on attachment for backpack straps.
- Rotational hinge allows adjusting angles.
- Slide-and-lock mechanism prevents accidental drops.

## **Retractable & Automated Storage Solutions**

### **6. Motorized Camera Arm**

- Retractable robotic arm extends the camera on command.
- Electromechanical lock for secure storage.
- Controlled via remote or gesture commands.

### **7. Retractable Camera Sling (Auto-Reel)**

- Cable-based sling system that allows free movement.
- Spring-reel mechanism automatically pulls the camera back when released.

### **8. Auto-Stowing Camera Dock (Hidden Storage)**

- Camera slides into a hidden compartment when not in use.
- Motorized system pulls the camera out when needed.

### **9. Telescopic Camera Holder**

- A telescopic rod extends the camera outward when required.
- Auto-collapsing feature brings the camera back securely.

## **10. Suction-Based Wall or Car Dock**

- Strong suction cup base for attaching to walls, cars, or helmets.
- Push-release mechanism for easy detachment.

## **Hands-Free & Tactical Mounts**

### **11. Helmet-Mounted Camera Dock**

- Ideal for action sports and filming.
- Clip-in mount with a secure locking feature.
- Allows quick access while keeping the camera stable.

### **12. Wrist-Mounted Camera Holder**

- A wearable wristband with a 360-degree rotating dock.
- Magnetic or clip-in attachment for fast retrieval.

### **13. Camera Clip for Glasses or Headgear**

- Small mount that attaches to eyeglasses, hats, or headgear.
- Great for POV (point-of-view) shots.
- Lightweight and adjustable.



#### **14. Drone-Based Camera Retrieval**

- A dedicated drone carries and returns the camera.
- Automated storage dock allows hands-free operation.
- Great for surveillance or outdoor photography.

#### **15. Shoulder-Mounted Camera Dock**

- A camera holder on the shoulder, allowing hands-free use.
- Pivoting hinge for adjusting the angle.
- Lock-in mechanism for secure carrying.

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### **Vehicle & Fixed-Mount Solutions**

#### **16. Car Dashboard Magnetic Mount**

- A magnetic docking system for a camera inside a car.
- Auto-locking clamp prevents accidental drops.
- Adjustable angles for flexible shooting.

#### **17. Bicycle or Motorcycle Camera Holder**

- Handlebar-mounted dock for hands-free shooting.
- Shockproof padding ensures camera stability.
- One-click release button for quick detachment.

#### **18. Wall-Mounted Camera Security Dock**

- Home or office-based dock to store and lock cameras.
- Biometric access ensures only authorized use.
- Motorized release for quick access.

#### **19. Car Trunk Slide-Out Camera Storage**

- Camera compartment integrated into the car trunk.
- Push-button release extends the camera outward.
- Ideal for security, vlogging, or filming.

#### **20. Floating Waterproof Camera Holder**

- Designed for water sports or underwater filming.
- Floating grip with a wrist strap prevents sinking.
- Quick-release attachment for easy removal.

Integration Process:	First, a screenshot of the functions list was uploaded into ChatGPT. Then, it was asked to generate more ideas that it initially provided from which I began to choose design solutions. Before choosing any solutions I have read through all of them. When reading through them I kept an idea in mind whether they are implementable/feasible in the real world. In addition, I considered the scope of the project when choosing my solutions. Hence, ideas such as floating waterproof camera holders were out of the scope and I refrained from choosing them. Furthermore, if I liked a solution and it fits the scope and secondary functions, I would either include all of it or partially. However, if only a part of it is feasible or implemented into the real world while fulfilling the scope, I would add that part and complete the rest of the solution with my own imagination.
Section	Idea Generation Process
Nature of Use:	To generate means and 6 full solutions using the prompts brainstormed using magic solution
Prompt 1:	<p>Secondary Functions: Secure to the camera</p> <p>Unsecure from the camera Secure to the body Unsecure from the body Allow access to the camera</p> <p>Return the camera to its secured position on the body</p> <p>It looks like you're listing secondary functions for a device or accessory related to a camera. Could you clarify what kind of device this is for? Are you designing a camera harness, a wearable mount, or something else?</p> <p>can you generate magical ideas on how i may be able to fulfill these functions</p>

Results 1:

## ☀️ Enchanted Design Concepts ☀️

### 1. Magneto-Gravitic Arc (Magnetic + Gyroscopic Locking System)

- Uses **magnetically charged nodes** that allow the camera to snap into place effortlessly.
- A **gyroscopic stabilization feature** keeps the camera aligned when mounted.
- With a hand gesture or voice command, the lock disengages, releasing the camera smoothly.

### 2. Arcane Tether (Retractable Suspension System)

- A **thin but strong enchanted thread** (high-tech retractable cable) secures the camera to the body.
- The thread can **extend and retract automatically**, keeping the camera accessible but tethered.
- When released, the thread pulls the camera back into its locked position.

### 3. Spirit Hand (Auto-Clamping Mechanism)

- The mount has an **adaptive claw or mechanical petals** that "grip" the camera when placed near it.
- **Sensors detect motion**, automatically tightening or loosening the grip.
- Could be **voice-activated**: "Secure" locks it, "Release" unlocks it.

### 4. Etheric Gate (Teleportation Dock)

- A **docking system with magnetic or electromagnetic locking** simulates a "teleporting" effect.
- When near the dock, the camera **automatically aligns and snaps into place**.
- Releasing it involves a **double-tap or twisting motion** for security.

### 5. Phantasmal Shift (Self-Adjusting Harness)

- A camera harness that **auto-adjusts** to different body positions.
- The camera **floats slightly** (gimbal-like feature) to prevent sudden jerks.
- To detach, press a hidden release button disguised as a decorative rune or emblem.

### 6. Elemental Shell (Magnetic & Suction Hybrid)

- Uses a combination of **vacuum suction and micro-magnets** to hold the camera.
- A **pressure-sensitive touch** releases the suction, freeing the camera smoothly.
- Reattaching it is as simple as bringing it near the dock.

Prompt 2:

can you specify for which functions these ideas are for

Great point! Here's a breakdown of which **design ideas** correspond to each **specific function** in your camera-mounting product:

Results 2:

### 🛠 Function Breakdown with Magical Design Concepts

Function	Design Concept	How It Works
Secure to the camera	Spirit Hand (Auto-Clamping Mechanism)	Adaptive claw-like grip or mechanical petals automatically secure the camera when placed near the mount.
Unsecure from the camera	Spirit Hand (Auto-Clamping Mechanism) or Etheric Gate (Teleportation Dock)	Sensors detect release commands (double-tap, twist, or voice activation) to loosen the grip.
Secure to the body	Phantasmal Shift (Self-Adjusting Harness)	Auto-adjusting straps conform to different body positions while keeping the camera stable.
Unsecure from the body	Phantasmal Shift (Self-Adjusting Harness) or Elemental Shell (Magnetic & Suction Hybrid)	Hidden release button or touch-sensitive mechanism detaches the camera smoothly.
Allow access to the camera	Arcane Tether (Retractable Suspension System)	A thin but strong retractable tether allows free movement of the camera while keeping it secured.
Return the camera to its secured position	Arcane Tether (Retractable Suspension System) or Magneto-Gravitic Arc (Magnetic + Gyroscopic Locking System)	The tether automatically retracts or magnets guide the camera back into place when released.

Prompt 3:

Would you like me to refine any of these concepts further or explore a different approach? 🧩

think of more ideas and add them to the table

Here's an expanded list with more creative and functional design concepts for your camera-mounting product:

Results 3:

### Function Breakdown with Design Concepts

Function	Design Concept	How It Works
Secure to the camera	Spirit Hand (Auto-Clamping Mechanism)	Adaptive claw-like grip or mechanical petals automatically secure the camera when placed near the mount.
	Eldritch Lock (Magnetic & Mechanical Hybrid)	A magnetic ring around the camera base locks into a mechanical clasp, ensuring double-layered security.
	Luminous Seal (Electro-Adhesion)	A thin layer of electro-adhesive material activates when the camera makes contact, securing it in place.
Unsecure from the camera	Spirit Hand (Auto-Clamping Mechanism) or Etheric Gate (Teleportation Dock)	Sensors detect release commands (double-tap, twist, or voice activation) to loosen the grip.
	Luminous Seal (Electro-Adhesion)	Disengages with a tap or swipe gesture, breaking the adhesion and releasing the camera.
	Phantom Key (RFID or NFC Unlocking)	A small RFID or NFC tag in a glove, ring, or badge unlocks the mount when waved near it.
Secure to the body	Phantasmal Shift (Self-Adjusting Harness)	Auto-adjusting straps conform to different body positions while keeping the camera stable.
	Titan's Grip (Exoskeleton Mount)	A rigid, adjustable exoskeleton-like frame locks around the user's torso or shoulder for stability.
	Gravity Anchor (Weighted Counterbalance)	A magnetized weight-balancing system ensures a comfortable and stable fit without excessive straps.
Unsecure from the body	Phantasmal Shift (Self-Adjusting Harness) or Elemental Shell (Magnetic & Suction Hybrid)	Hidden release button or touch-sensitive mechanism detaches the camera smoothly.
	Aether Buckle (One-Pull Release System)	A single pull-tab or quick-release buckle instantly detaches the camera mount from the body.
Allow access to the camera	Arcane Tether (Retractable Suspension System)	A thin but strong retractable tether allows free movement of the camera while keeping it secured.
	Nimbus Float (Gimbal-Integrated Pivot Arm)	A floating gimbal arm extends and pivots the camera outward when needed, then retracts when not in use.
	Chrono Shift (Rotating Dock Mechanism)	A swiveling dock allows the camera to be flipped forward for use and back for storage.
Return the camera to its secured position	Arcane Tether (Retractable Suspension System) or Magneto-Gravitic Arc (Magnetic + Gyroscopic Locking System)	The tether automatically retracts or magnets guide the camera back into place when released.
	Eclipse Hook (Auto-Recoiling Arm)	A spring-loaded arm automatically swings the camera back to its docking position.
	Gravity Recall (Magnetic Dock with Weighted Pivot)	The mount uses a counterweight-assisted hinge that naturally guides the camera back into place when released.

Integration Process:	ChatGPT was first fed the primary function and all secondary functions of the design in order to be familiarized. It was then asked to generate some otherworldly ideas on how these functions in the design may be fulfilled. ChatGPT then proceeded to list multiple magical solutions that it generated. However, these ideas were hard to follow and so the AI was asked to organize these within a table according to the secondary functions that they solve. Once the table was generated, it was asked to create more ideas and add them to the table. These ideas were analyzed and reviewed before being put into the team document for idea generation. They were then edited to be turned into feasible solutions.
Section	Idea Generation Process
Nature of Use:	To generate 10 full solutions with ideas generated using blue sky thinking
Prompt:	<p>I would like you to help me organize the following ideas into a relatively complete design scheme of camera belt for generation ideas, which requires shoulder straps. 41.Elastic camera strap, Simple elastic band, lightweight strap. 42.nyton, comfortable as basic objective, stable. 43.Retractable, pulley-used, convenient. 44,Elastic, shoulder padding, stable, two straps. 45. Shoulder pad, sliding, comfortable, pocket. 46. Counterweight for balance, latch. 47. Pulley, Retactable, pad. 48. Elastic, shock-absorbing, lightweight, pad. 49. Like a rail, smooth. 50. Recoil-controlled, clips-locked.</p> <p>Here's a complete design scheme based on your input:</p> <hr/> <p><b>Generating Idea (Camera Belt Design Scheme)</b></p>

Results:	<p><b>41. Basic Elastic Camera Band</b> A simple elastic camera band made from nylon and aluminum alloy for strength and flexibility. It features a basic clip mechanism for adjusting length and a straightforward strap attachment system.</p> <p><b>42. Nylon Camera Strap</b> A standard nylon camera strap designed for durability and comfort. The strap attaches to the camera with basic clips, providing weight distribution and simple padding for user comfort.</p> <p><b>43. Retractable Camera Strap</b> A basic retractable strap using a simple pulley mechanism to keep the camera close to the body when not in use. Made from lightweight nylon with basic shoulder pads.</p> <p><b>44. Dual Elastic Shoulder Straps</b> Double elastic shoulder straps designed for simple adjustment and stability. It features a basic gel pad for comfort and reinforced points for strength.</p> <p><b>45. Padded Shoulder Strap</b> A shoulder strap with basic padding and a simple sliding mechanism to help lift the camera. Includes a small pocket for memory cards.</p> <p><b>46. Counterweight Camera Strap</b> A strap with a basic counterweight system to help balance the camera while walking. Includes a simple latch system for strap adjustment.</p> <p><b>47. Pulley-Style Strap</b> A retractable strap with a simple pulley mechanism to smoothly pull the camera up. Basic non-slip padding for user comfort.</p> <p><b>48. Elastic Shock-Absorbing Strap</b> A highly elastic strap designed to reduce impact during sudden movements. Includes a thin shoulder pad with basic foam padding.</p> <p><b>49. Rail System Belt</b> A belt with a basic rail system to help glide the camera along a fixed path. Made from reinforced elastic webbing.</p> <p><b>50. Recoil-Controlled Strap</b> A strap with a simple recoil mechanism to pull the camera back into position. Made from stretch fabric with simple locking clips.</p>
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Integration Process:	A member used ChatGPT to summarize ideas in incomplete sentences that were generated using blue sky thinking. The ideas were described to ChatGPT, which was asked to turn them into logical and detailed solutions. Since the prompt given to ChatGPT was incomplete, the paragraphs were reviewed by the member to ensure his original ideas were correctly communicated in the generated content. In addition, profound words and complicated sentences were also changed to be described in the user's own words. This step made the solutions easier to read and true to the member's original content.
Section	Alternative Design Selection Process
Nature of Use:	To quickly categorize 40 solutions contributed by 4 members of the team

Prompt:

1. A wearable harness that can be either a form of a whole body harness or just the waist harness, that securely holds the camera while allowing quick access for photographers. The camera will be attached to the harness, allowing it to be attached to different body parts. System has a locking clip and spring loaded mechanism allowing a secured position of the camera, not allowing it to break.
2. Magnetic docking station that holds a camera in place. Two small magnetic plates can be created as a locking mechanism. Hence a new attachment system of the magnetic will be created, compatible to all of the different camera types. Strong neodymium magnets ensure a firm grip on the camera, not allowing it to fall. An additional holding mechanism will be attached to the strings of the camera straps, in order to ensure safe transportation aside from dynamic camera uses.
3. An automated motorized robotic arm that can be both controlled by a remote and by an arm. The robotic arm can be attached to any piece of clothing available as it will have a claw on the other side of it too attached to different fabrics. It can both store the camera, and extend it when needed to the user. It adjusts itself, (smart adjustment) depending on the environment of the user. Furthermore, the camera is mounted on a robotic arm, it is secured using the arm, not allowing it to fall.
4. A holster-based system attached to a belt or backpack strap that locks and unlocks the camera with a push mechanism. It is an attached belt that also has a compartment to hold the camera. Has an auto-locking latch to prevent the camera dropping. Hence, when it is needed to be used the main straps that hold the camera on the hoster can be removed and the camera can be easily removed from the hoster safely. Belt is attached to the holster-based and if needed the whole holster can be removed from the belt.
5. A backpack-integrated camera holder that allows quick sliding access while keeping the camera secure. The backpack can be worn either on front of the body or on the back. The camera holder can be easily disattached from the camera. It is a compartment like storage for the camera.
6. A retractable sling that can be attached to a user's belt or any other piece of clothing or material, allowing an easy and flexible movement. The sling will have a clamp attached to one of its ends. Hence, it can be easily attached to any body part or clothing. Retractable cable made out of durable materials hence preventing any rips or malfunctions of the sling when the camera retracts. A little button – push release mechanism for each access – at the end is placed which will unlock the retractable mechanism, allowing more security and easier pull when taking the camera.
7. An adjustable camera straps, with cussing and made out of durable materials. Are regular camera straps that have designed an improved attachment mechanism using clips/carabiners for easier attachment, needing less time. The strap will have cushioning for the straps for more comfortable uses and adjustment mechanism for easy adjustment of the length.

15. The camera has a magnetic plate with mechanical locking tabs that secure it when placed near the mount. The locking tabs release when the user performs double-taps the mount. A lightweight harness holds the dock in place. A release button on the strap detaches the dock instantly. A strong retractable strap allows the camera to move freely while remaining attached. The retractable strap automatically goes back, guiding the camera into the dock.

16. A mechanical claw-like grip locks the camera securely. The claw opens when the user twists a tab. A rigid belt with adjustable torso straps stabilizes the mount. A quick release buckle will detach the mount from the body in one motion. A spring loaded pivot arm extends the camera outward when needed and automatically swings the camera back.

17. A physical lock keeps the camera stable when it is attached to the user's clothing. The user simply pulls the camera outward, disengaging the lock. A chest harness holds the lock and the camera firmly in place. A hidden push-release button releases the lock instantly from the clothing. A spring-loaded auto-recoiling arm extends the camera forward.

18. A small motorized locking ring clamps around the camera's base, holding it in place. A gesture sensor disengages the motorized lock. A gyroscopically stabilized chest mount keeps the camera level, reducing unwanted movement. A detachable magnetic plate allows the entire mount to be removed quickly. The gyro stabilizer allows smooth panning and tilting, letting the user adjust angles without removing the camera. A motorized guide realigns the camera to its original locked position when released.

19. A spring-loaded mechanical latch automatically grips the camera when inserted into the mount. A dual-button safety release prevents accidental detachment. A heavy-duty tactical vest mount with shock-absorbing padding keeps the camera stable. A twist-lock mechanism allows the user to remove the entire mount from the vest. The strap acts as a hinge, allowing the user to flip the camera forward or sideways. The elastic nature of the strap gently pulls the camera back to its resting position.

20. The camera attaches to the dock using a hybrid locking system, combining low-energy electromagnets with small mechanical clasps that engage when the camera is placed into position. A proximity sensor or manual button disengages the electromagnets and releases the mechanical lock, allowing for smooth removal without excessive force. A slim, form-fitting vest with embedded magnetic plates provides a stable mounting base. The vest ensures even weight distribution and prevents unwanted shifting. A hidden quick-release buckle allows the user to easily detach the mount from the vest when needed. The dock features a pivoting hinge or sliding rail system, enabling the user to pull the camera forward or adjust angles while keeping it tethered to the mount. A spring-assisted or magnet-guided alignment system helps the camera return smoothly into place when repositioned near the dock.

21. A holster attached to the user's waist with belt clips that secures the camera using snap fasteners and has a badge reel connecting it to the holster.
22. A helmet with a night vision mount that secures the camera and enables the user to pull it down by hand when taking pictures. The helmet will have quick-release buckles and the mount will have rails that the camera can slide onto for attachment/detachment.
23. A vest harness with a pocket for storing the camera and a lanyard for securing it to the pocket. The vest harness can be removed with quick-release clips.
24. A fanny pack worn around the user torso and secured using buckles that have a pocket for storing the camera and a retractable badge reel connected to the camera.
25. A nylon belt covered in velcro with a badge reel that secures the camera to the user's waist. The belt can be removed by releasing a buckle.
26. A front-loading backpack filled with foam cushion that stores the camera and uses a clock spring to retract the camera back to the backpack after use. The backpack can be removed by taking off the shoulder straps.
27. A camera case secured to the user's waist using belt clips that automatically unsecure and transport the camera from waist to chest using a motorized conveyor belt worn across the torso like a sash.
28. A life ring with a pocket for storing the camera that secures the camera by inflating around the user's torso or shoulder and deflates to unsecure the camera. A badge reel connects the camera to the ring.
29. A vest harness equipped with a built-in vacuum motor and suction tube that secures the camera in front of the user's chest. The suction tube can be turned on or off by pressing a button to drop the camera into their hands with gravity and a lanyard will connect the camera to the vest to prevent accidental drops.
30. An overall with hidden magnet sheets that secure the camera to the fabric and has a badge reel connecting the camera to the overall. The overall can be removed by unfastening the shoulder straps.
31. Secure and transport the camera in a bag/open-lid box that attaches to the photographer with a strap. Camera can be taken out anytime without obstruction.
32. Photographers can wear a vest with multiple magnetic secure points on which the camera can be mounted. The camera will be modified to add magnets so that it can be secured safely. The camera can be accessed anytime by detaching it from the magnetic secure points.

33. Photographers can wear a camera harness but with magnetic secure points. The camera will be modified so that it can be safely secured. The camera can be accessed anytime by detaching it from the magnetic secure points.

34. Photographers can wear a belt with attachment points where the camera can be clipped and secured. The camera can be accessed anytime by detaching it from the clip.

35. A belt with the additional function of securing a string that can be extended and retracted similar to one found in a tape measure. The string can be attached to the camera to secure it or the photographer's body and during use, the photographer can simply extend the string without removing the camera from the security mechanism.

36. A clip-on system that attaches to the straps of a backpack. This system allows the camera to be immediately accessible within reach allowing for faster access.

37. A hard hat with an attachment point for a camera. This allows the camera to be secured on the user's body and be accessed anytime.

38. A drone programmed to follow the photographer that carries the camera. Camera can thus be accessed anytime while not applying any pressure on the photographer's body.

39. A bicycle basket with additional padding to keep the camera protected. A photographer who bikes may find this solution useful.

40. An RC car that holds the camera with a basket that can be raised to the user's reach, allowing the camera to be accessed at any time which does not require the photographer to carry the camera.

Results:

#### **Retractable Systems**

- #6: Retractable sling with a clamp and push-release mechanism.
  - #15: Retractable strap that moves freely but returns to dock.
  - #24: Fanny pack with a retractable badge reel.
  - #26: Backpack with a *clock spring* to retract the camera.
  - #35: Belt with **extendable/retractable string** (similar to tape measure).
  - #36: Clip-on backpack system for quick access.
- ◆ **Summary:** Various **retractable** systems for **securing and pulling the camera back**.
- 

#### **Holster/Box-Based Systems**

- #4: Belt holster with a push mechanism.
- #11: Metal box with clamps that secure/release via button.
- #19: Tactical vest mount with twist-lock and flip-forward hinge.
- #27: Camera case on the waist with a **motorized conveyor belt**.
- #31: Bag or open-lid box with a strap for securing and accessing the camera.

◆ **Summary:** Many involve a **secure box/holster** for storing and quickly retrieving the camera.

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#### **Shoulder/Chest-Mounted Systems**

- #10: Shoulder-mounted camera dock with a push-release mechanism.
- #17: Chest harness with a spring-loaded arm.
- #18: Gyroscopic chest mount with motorized locking ring.
- #20: Slim vest with magnetic plates.
- #29: Vest harness with suction tube release.

◆ **Summary:** Several **shoulder or chest-mounted** camera holders with different attachment/release methods.

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#### **Robotic & Automated Systems**

- #3: Motorized robotic arm for extending/retracting the camera.
  - #14: Moving tripod with user-controlled motion.
  - #27: Motorized conveyor belt to transport the camera.
  - #28: Inflatable life ring that secures and releases the camera.
  - #38: Drone that follows the photographer, carrying the camera.
  - #40: RC car with a camera basket that raises to the user's reach.
- ◆ **Summary:** Various **robotic, automated, or remote-controlled** camera holders.

	<p><b>Tripod/Extendable Stick Systems</b></p> <ul style="list-style-type: none"> <li>• #8: Telescopic rod (short selfie stick-like attachment).</li> <li>• #14: Moving tripod mechanism.</li> </ul> <p>◆ Summary: Extendable/tripod-based solutions for moving the camera.</p> <hr/> <p><b>Helmet-Mounted Systems</b></p> <ul style="list-style-type: none"> <li>• #22: Helmet with a night vision mount.</li> <li>• #37: Hard hat with an attachment point.</li> </ul> <p>◆ Summary: Both are helmet-mounted camera holders.</p> <hr/> <p><b>Backpack-Based Solutions</b></p> <ul style="list-style-type: none"> <li>• #5: Backpack-integrated camera holder.</li> <li>• #26: Front-loading backpack with a retractable camera system.</li> </ul> <p>◆ Summary: Both use backpacks with quick access and storage mechanisms.</p> <hr/> <p><b>Alternative Carrying Methods</b></p> <ul style="list-style-type: none"> <li>• #39: Bicycle basket with padding.</li> <li>• #40: RC car carrying the camera.</li> </ul> <p>◆ Summary: These focus on transporting cameras without wearing them.</p> <hr/> <p><b>Conclusion:</b></p> <p>Many ideas have overlapping mechanisms with slight variations. If you want a more refined list, consider combining similar concepts while keeping unique ideas.</p> <p>Would you like me to merge ideas into categories and simplify the list? 😊</p>
Integration Process:	A list of 40 full solutions generated by 4 members of the team was fed into ChatGPT to organize them into 9 categories of wearable technology. However, since ChatGPT put some solutions with a variety of features into multiple categories, the team reviewed the generated content and assigned each solution to only one category based on the technology that is more dominant in the design. Three additional categories were created for magnetic docking/attachment solutions, harness-based solutions, and belt-based solutions by refining the AI generated categories. Finally,

	solutions in the “alternative carry methods” category were distributed to other categories with more specific names.
Section	Alternative Design Selection Process
Nature of Use:	To generate a visual representation of alternative design 2
Prompt 1:	<p>This is a copy of a conversation between ChatGPT &amp; Anonymous.  <a href="#">Report content</a></p> <p>could you generate an image based on the design solution below</p> <p>The camera has a magnetic plate with mechanical locking tabs that secure it when placed near the mount. The locking tabs release when the user performs double-taps the mount. A lightweight harness holds the dock in place. A release button on the strap detaches the dock instantly. A strong retractable strap allows the camera to move freely while remaining attached. The retractable strap automatically goes back, guiding the camera into the dock.</p>
Results 1:	 <p>Here is the generated image of the wearable camera docking system based on your design solution. Let me know if you'd like any modifications!</p>
Prompt 2:	<p>could you generate images to structurally decompose it</p>

Results 2:



Here is an exploded view of the wearable camera docking system, showing its structural components.  
Let me know if you need any adjustments or additional details!

Integration Process:	After the description of alternative design #2 was fed into ChatGPT to create an image, a second prompt was used to generate the decomposed version of the design. This step was implemented to ensure that all components in the design were included in the first image and their mechanism is feasible in the real world.
Section	6.3 Alternative Design Descriptions
Nature of Use:	To generate a visual representation of alternative design 1

Prompt:

Generate an image based on this prompt:

The padded flexible camera strap employs a durable, adjustable, nylon strap to secure the camera on the photographer's body. To keep the strap secured in place, the strap is constructed with a padding layer made of soft rubber. Furthermore, to provide additional comfort and reduce stress during prolonged use, the shoulder area is equipped with shock absorbing pads. To ensure maximum compatibility, the strap is clipped onto the built-in eyelets (<12 mm [40]) of the camera, providing a balanced weight distribution and greater stability. Additionally, the section of the strap connecting to the camera is unpadded and equipped with a length adjustment mechanism, allowing the length of the strap to be adjusted on the fly so the camera can be placed near the photographer's chest, minimizing access time while maximizing the design's range of motion.

Results:



Here's the generated image of the padded flexible camera strap based on your description. Let me know if you'd like any modifications!

Integration Process:

ChatGPT was fed the entire design description of Padded Strap and asked to generate an image. The generated image was then incorporated into the CDS after reviewing the design mechanism shown.

## Appendix Y: Calculation for the Minimum Time Required to Access a Camera For Design 3 – Shoulder Ring

Figure 19 shows the calculations that were done to find the time needed to access the camera from the design. Due to lack of appropriate research, it was assumed that the time it will take, in the worst case scenario, to take the camera off of the design is around 2 seconds.

$$\text{Finger tip Height} = 25.75 \text{ in}$$

$$\text{Shoulder Height} = 56.65 \text{ in}$$

$$\text{Eye Height} = 64.57 \text{ in}$$

$$\text{Fingertip to Shoulder} = 56.65 - 25.75 = 30.9 \text{ in} \rightarrow 0.78486 \text{ m.}$$

$$t = \frac{0.78486}{1.01} = 0.777 \text{ s}$$

$$\text{Shoulder to Eye} = 64.57 - 56.65 = 7.92 \text{ in} \rightarrow 0.20117 \text{ m.}$$

$$t = \frac{0.20117}{1.01} = 0.199 \text{ s}$$

Assuming / accounting for time to remove the camera from a strong magnet ~2 s

$$\text{Therefore, Total time: } 0.777 + 0.199 + 1 = 2.976 \text{ s}$$

Figure 19. Calculation for time taken in an engineering notebook.

## Appendix Z: Pressure Applied on the Users Shoulder by the Design

Calculating on the pressure that will be exerted on the shoulder:

Due to the lack of any similar designs made before, it was assumed for the design purposes that the width of the ring would be 5 cm. Additionally, for the calculations 2.75 cm is the length of top to back of the shoulder. The 2.75 cm was found based on the width of the scapula is typically 7.5 mm [67] and due to lack of appropriate research we will assume 2 cm of thickness of skin, and muscles hence in total the distance from front to the back of a shoulder is 2.75 cm.

Minimum contact area

$$\text{- Design 3: } 5\text{cm} \times 2.75\text{cm} = 18.75 \text{ cm}^2$$

In order to accommodate for the worst case scenario the maximum possible weight is calculated including the masses of the camera, the camera lens, the ring system and its components. To specify the weight of the aluminum ring was found using a calculator [68], with the diameter as the the thickness of a person's area between armpit and shoulder is 26.5 cm [69] + the thickness of the rod inside which is 2.5 cm per each side, accumulative 5 cm in total [70].

$$\begin{aligned} \text{max. mass} &= \text{max. camera mass} + \text{max. lens mass} + \text{max. ring system mass} * 3/4 \\ &\quad ((\% \text{ of an aluminum ring's weight}) [71]) \end{aligned}$$

$$+ \text{max. mass of magnets} + \text{max. mass of clamp systems} [73]$$

$$\text{max. mass} = 1.21 \text{ kg} + 1.54 \text{ kg} + 2.32 \text{ kg} + (3 * 0.28 + 0.27) + 0.25 \text{ kg}$$

$$\text{max. mass} = 6.43 \text{ kg}$$

$$\text{max. density of neodymium magnet N33} = 7.5 \times 10^4 \text{ kg/m}^3 [67]$$

$$\text{volume of circular magnet} = \pi \times (40\text{mm}/2)^2 \times (3 \text{ mm}) = 3.7699 \times 10^{-6} \text{ m}^3$$

$$\text{volume of rectangular magnet} = (30\text{mm}) \times (20\text{mm}) \times (6 \text{ mm}) = 3.6 \times 10^{-6} \text{ m}^3$$

$$\text{max. mass of circular magnet (density * volume)} = 0.2 \text{ kg}$$

$$\text{max. mass of rectangular magnet (density * volume)} = 0.27 \text{ kg}$$

$$\text{weight} = 6.43 \text{ kg} \times 9.81 \frac{\text{N}}{\text{kg}} = 63.07 \text{ N}$$

Design 3:

$$\text{pressure applied} = \frac{63.07 \text{ N}}{18.75 \times 10^{-4} \text{ m}^2} = 3.3637 \times 10^4 \text{ Pa}$$