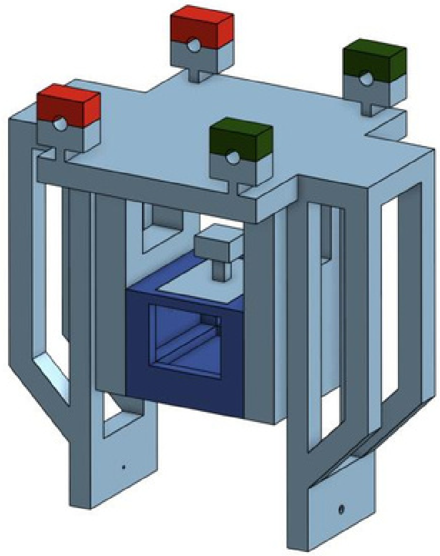
DJI M600 Final Report



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Summary

This report details the design and development of anadjustable, vibration-damping mount for the DJI M600 drone, the team designed a mount with priority in security for supporting the RADAR and LIDAR sensors while maintaining stability during flight. This project overviews and defines the solution created by Design Team 9 for the problem addressed while stating background motivation and addressing issues found during development. Problems became evident when researching objectives like data accuracy, angle adjustment, and weight challenges, all critical for optimal drone performance.

The team identified required specifications and constraints during the research phase, such as payload weight limits, vibration-damping requirements, and possible material properties. The ideation and brainstorming stages utilized team meetings, concept sketches, and scoring matrices to evaluate potential solutions. The final design features a friction-locking hinge, snap-fit attachment system, and four-support configuration to ensure stability and adaptability.

Initial calculations confirmed compliance with weight and strength targets, and the design minimizes vibrations effectively. While testing confirmed many objectives were met, further refinement is recommended for attachment security and ease of use. The report concludes with recommendations for material upgrades, enhanced prototyping, and field testing to optimize the design.

1 Introduction and Problem Definition

This reportprovidesan overviewofthe problem introducedbytheMUN Intelligent Systems Lab and the solution decided on by Design Team 9.

The MUN intelligent systems lab approached the Engineering 1030 class to design custom mounting hardware to safely mount an odometry sensor and custom payload on a Drone. Specifically, the DJI M600 drone will carry out tasks involving custom payloads mounted to the drone. Then, the custom payload includes unique systems like radar and odometry sensors for surveying and environmental monitoring. In this context, safety and stability are critical while carrying out these tasks.

To address the problem, the team began by researching SZ DJI Technology Co., Ltd, what the M600 drone is designed for, and what common challenges the mount will face. The design must allow for the ability to adjust the tilt angles of the mount that can be fixed before take-off and minimize vibrations during flight so the sensor can accurately collect data while being stable and secure. At the same time, the design must be lightweight and robust enough to support the custom payload without affecting the drone's center of gravity and safety. The mount should also include redundant safety features to prevent mechanism failure during flight.

A preliminary investigation of the problem revealed the drone manufacturer's website, which provided the specifications, mounting points, dimensions, maximum weight limit, and a CAD model of the drone. Research on adjustable hinge designs provided ideas for sketches that achieve the required ability without affecting the center of gravity. Research on three-dimensional printable materials appointed possible materials that fit into the three categories of being lightweight, solid, durable, and able to minimize vibrations.

This report details four main sections. First, the report addresses the problem definition, provides the context, and describes the motivation behind the work. Next, it includes the background research and shows evidence of the team investigating relevant current research on the topic and existing solutions, including any initial specifications or constraints. It also describes the function of the design and includes requirements such as the design objectives, restrictions, and specifications. Finally, the ideation was done by summarizing all the idea generation methods and brainstorming activities the team performed, as well as morphological charts, concept sketches, and a description of each sketch.

2 Background Research

Inthis 1030 project, some key challengeshave been identified that will need to be investigated, mainly the material choice and hinge designs from which the team can take inspiration.

2.1 Materials

Two primary materials must be considered when making the bracket: ABS or PLA.

ABS is known for its sturdy, durable properties, which are needed in the bracket/hinge design to have a structurally integral bracket [1]. The following positives of ABS are its flexibility property and high melting point [1]. Additionally, ABS is considerably lighter than PLA and boasts four times the impact resistance [2]. ABS does, however, have some drawbacks. One of the main drawbacks is that printing is more challenging than PLA filament. This is primarily because you need a heat bed for printing ABS [2]. ABS filament costs $14 to $60 per kilogram [1].

PLA is another material that is widely recognized in 3D printing. PLA is a stiffer, more robust material that is much easier to print, leading to a more aesthetically pleasing look [1] [2]. However, PLA has some limitations, such as being brittle and easily deformed when exposed to heat, which affects the overall structural integral material [1]. PLA filament costs $19 to $75 per kilogram [1].

In conclusion, there are positives to ABS, and there are also positives to PLA filament. The main deciding factors are discussed below. ABS is durable, flexible, heat-resistant, lightweight, and impact-resistant. PLA is a stiff, strong, aesthetically pleasing, and easy-to-print material [1]. For this project-specific application, the team requires a lightweight bracket design that can minimize vibrations, be durable, and be cost-efficient to fit this project's budget. The material that fits these requirements more is ABS due to the flexible properties that will help minimize vibrations to keep the sensor steady, whereas PLA is stiff and would increase vibrations [1] [2]. Another reason ABS is more suitable than PLA is the lower density; this lets us use more and keep it lighter than if the team chooses PLA, which keeps the bracket's weight down [1] [2]. ABS filament is minimally cost-effective than PLA, coming in at only $14 to $60 per kilogram, while PLA comes in at $19 to $75 per kilogram. The cost advantage makes ABS a more practical choice, contributing to a lower project cost [1]. While PLA is stronger, ABS still provides durability that is required to be structurally integral to hold the bracket’s payload [1]. Ultimately, ABS’s combination of properties and cost-effectiveness makes it the best choice for this bracket design.

2.2 Design Features

The next problem when designing a structurally integral bracket for this drone is having the right hinge for the payload to hold onto.

A hinge design the team can consider a simple hinge. Simple hinges can be 3D printed using ABS filament, much like the bracket. This hinge design is structurally integral, has many mounting holes to attach the payload, and can be opened and closed repeatedly, which works for the project's application [3]. The cost of making this bracket is also low, considering the filament needed to produce this hinge [3]. However, constraints must be considered when designing it, such as dimensional accuracy and how the layers are oriented when 3D printing [4]. One main issue that does not work for this application is being able to lock at any angle; this will require a simple hinge design mixed with some way to lock the payload at a specific spot.

Another design that is a possibility for a hinge is a friction locking mechanism. This system allows a very structurally integral, durable design made from ABS filament for the mounting points to the LIDAR and RADAR, which is crucial. The friction-locking mechanism uses the coefficient of friction between two surfaces, enabling this system to lock in any desired position [11]. Another critical aspect of the friction locking mechanism is its withstanding performance and ease of use [12]. The cost and safety of this system also need to be considered. The price is meager using ABS filament, and safety is also a very big positive, being very durable and structurally integral and being able to withstand vibrations caused by the drone [12].

The next hinge design to consider is the spring articulated hinge. This design is much like the simple hinge but uses springs to its advantage, making it more secure and holding the payload much more securely. The Spring articulated hinge opens to 180 degrees, which is needed in this application [13]. This design is also versatile because it can put as many holes as required to be structurally integral and safe while using ABS filament to increase these factors. The spring articulated hinge faces the same issues as the simple hinge because it cannot lock at any desired angle and will require modification for this to work in the application required.

The team decided from all the research that the friction-locking mechanism best fits the application required for the project. Some critical considerations made when choosing this were durability, vibration minimizing, lightweight construction, ability to secure at different angles, safety, ease of use, and being able to withstand repeated use. When designing the friction locking mechanism, it will be made durable using ABS filament and have vibration damping features due to the properties of ABS filament [1]. Another thing that the team considered when choosing this type of hinge is safety and longevity, which is very important. It is the safest out of the choices due to not needing to make any modifications like what would have to be done to the simple hinge or the spring articulated hinge, and it has the best longevity out of the three choices due to its simplicity. This hinge requires no modification to lock at any angle needed in our application [11]. The team's final consideration was the lightweight build and ease of use of the friction locking mechanism [12]. The friction locking mechanism was the most optimal choice considering all these factors.

2.3 Factors Considered

Several key factors were considered when designing this bracket/hinge, including safety, economics, and usability. Safety was a primary concern when designing this bracket/hinge. When designing this bracket/hinge, the team incorporated many safety nets, such as extra points to hook onto so that if one fails, it will not impact the bracket. The team repeated this when designing the hinge by adding additional safety points for the payloads to connect to. This design is very economical mainly because of the cost of ABS filament, which ranges from $14 to $60 per kilogram. The whole bracket/hinge is designed using this material, making the project very economical [1]. The main goal of this project is to have a smooth working bracket/hinge that can withstand use over time; all the background research on materials and design has made the goal possible.

2.4 Lidar and Radar

When designing the LIDAR and RADAR bracket, the masses and dimensions were considered for the slot sizing made for the LIDAR and the holes placed in the bracket for the RADAR to lock into. The lidar has a mass of 498 (without cables) and a dimension of 91×61.2×64.8 mm [5]. The radar has a mass of 817 g (Natural Convection) and a dimension of 187 mm x 120 mm x 40 mm [6].

2.5 Drone Mount Design

Inthe drone payload mounting systems field, several design options are available. An excellent place to start is a bracket made for hooking its payload to the bottom of the drone using a hook lifting the payloads, but this does not apply in this application since this project requires a solid mount along with being able to rotate [7]. There is also a PSDK mount manufactured by DJI, which is made to connect a payload by screwing it into the bracket designed for the bottom of the drone parts like brackets, and other accessories can be added [8]. Another mount design is one

where a camera is placed inside a holder,the camera being the LIDIAR in this situation [9].

2.6 Drone Connection Points

There are many options for choosing the best design for the critical connection point to the drone, and many factors come into play in safety, functionality, and printability. Some options are snap fit, modular hook, and adhesive slots. Snap-fit is known to be a cost-effective, secure way to join two components while quickly holding weight, such as the payload [10]. Due to the significant research, snap-fit is also very durable and straightforward to manufacture [10]. The modular hook design is easy to use and looks like a C. It just hooks over the mounting points on the M600. Modular fit also has drawbacks as it is not overly secure to the drone and can sway back and forth easily. The following design would be adhesive slots. This non-durable connection system takes more work than the others as it will need the connection points removed before it can slide.

In conclusion, the best fit for this application would be a snap fit due to its positive aspects. It has many positives compared to the adhesive slots and the modular hooks design. It is more straightforward, cost-effective, and secure [10].

3 Requirements

Thefunctionof this designisto create a secure, adjustable, vibration-damping mount for a custom payload on a DJI M600 Drone.

3.1 Design Objectives

The main design objectives are to be lightweight, strong, and stable, vibration dampening while not affecting the center of gravity, and it must allow adjustable tilt angles.

Primary

- The mounting system must be evenly weighted so the center of gravity is not significantly altered.
- The design must be lightweight to avoid affecting the drone's center of gravity.
- The design must have sufficient strength to withstand the operation forces faced while carrying out its purpose of ensuring durability.
- The design must minimize vibration so the sensor can accurately collect data without being affected.
- The design must allow the payload tilted and fixed at determined angles before flight.
- The design must include redundant securing mechanisms to ensure safety in the situation of mechanism failure occurring during flight.

Secondary

- The design allowing for easy installation and removal of the payload and the mount would be excellent since it would minimize preparation time between missions.
- The aerodynamically efficient design would be excellent since it would decrease drag and increase performance.
- The design is resistant to environmental conditions such as dust and moisture, which would be nice to have since it would increase the lifespan of the mount.
- The design accounting for its aesthetics would be excellent since it would make it more visually appealing.
- The design accounting for the material used and its cost would be lovely since it wouldn't be costly to create if it needed another mounting system.

3.2 Design Constraints

Physical

- The mounting system and payload have a weight restriction and must stay under the drone's maximum payload capacity.
- The mount has a dimension restriction and must fit in the space under the drone without interfering with any sensors or propellors.

Economic

- The mount has a budget limit, and the material used to create it should be accounted for and fit into the budget while fitting into the required categories.

Functional/Operational

- The mount has a useability restriction and should account for this by allowing easy assembly and removal.
- The mount has a functional restriction that includes the adjustable hinge while keeping the payload secure at steeper angles.

Legal

- The drone, mount, and everything included during flight have a legal restriction and should follow all drone-related laws in Canada, specifically those set by Transport Canada.

3.3 Design Specification

Weight: Targetof≤ 750 gramsforthe mount without the payload; this will maximize efficiency and improve battery life.

Tilt Adjustment: The target is to adjust between 0°-90° and lock into a designated angle, allowing data to be collected from any angles within the range.

Material Tensile Strength: The target of 40MPa-70MPa tensile strength should be strong enough to endure the possible environments without being too solid and dense and causing issues with weight.

Securing Mechanisms: Target 2-4 safety redundant points; in mechanism failure, there should be another point to hold the mount until landing.

Vibration: The target of ≥ 70% vibration dampening allows the sensors to avoid experiencing the vibrations from the rotors and allows for accurate data collection.

4 Ideation

During design development, the team stopped and looked at the general view of the task given before starting any idea-generation methods. Which is designing a practical adjustable, vibration-damping mount for the DJI M600 drone; the team employed various ideation methods. Such as team brainstorming meetings, research into existing solutions, and using a morphological chart to make a final decision flow are the concepts generated during this stage:

4.1 Brainstorming Activities

The team conducted brainstorming sessions to explore any possible solutions or elements that could be implanted into the design. These sessions involved:

Firstly, listing the team's desired attributes, such as vibration damping, adjustability, lightweight construction, and safety.

Then, I will research hinge designs, attachment mechanisms, and structural supports from existing drone mounts and similar applications that fit or include these attributes.

A morphological chart was used to systematically combine the attributes, generate ideas of the options, and finally, plan what would be included.

4.2 Concepts Generated

The ideas generated during the brainstorming process were categorized based on critical attributes of the design:

4.2.1 Attachment to the Drone

Snap-fit Clamp System: Uses tolerances for the supports and allows them to snap together and clamp the mount directly to the drone's frame.

Modular Hooks: Integrates with the drone’s pre-existing structure and securely attaches to the mount.

Adhesive Slots: Lightweight adhesive metal pads designed for minimal interference with drone operations that could be heated into the ABS material and fixed to the drone.

4.2.2 Number of Supports

Two Supports: Minimal design to reduce weight but has a possible risk instability.

Four Supports: A balanced approach offering increased stability while ensuring safety in case of failure of one support.

Six Supports: Enhanced support and redundancy for critical payloads but increases the weight and makes the design more complex.

4.2.3 Adjustable Hinge Design

Simple Hinge: A traditional hinge with fixed tilt adjustment points but does not allow full tilt range, just preselected angles.

Friction Hinge with Locking Mechanism: Allows tilt adjustments to be locked at specific angles, providing flexibility and stability. Still, this design does call for extra materials, such as heated inserts and screws for the attachment.

Spring Articulated Hinge: Features multiple pivot points for a broader range of motion but is more complex, with the need to account for a spring, increasing the possibility of failure in the hinge and other parts.

4.2.4 Orientation of Supports

Vertical Supports: Optimized for minimizing vibrations from the drone's propellers by having a direct line of force parallel to them.

Angled Supports: Designed to enhance aerodynamic efficiency, more straightforward support can be used for this task.

4.3 Morphological Charts

Below is the team's morphologicalchart for their possible options and functions.

Function	**Concept 1**	**Concept 2**	**Concept 3**
Connection to the Drone	Snap-fit Clamp System	Modular Hooks	AdhesiveSlots
Hinge Design	Friction Locking Mechanism	Spring Articulated Hinge	Simple Hinge
Support System	Four Supports	Six Supports	Two Supports

4.4 Concept Sketches

During the brainstormingmeetings, the team created concepts to visualize the design better. Below are the sketches and a description from the team member who drew them.

4.4.1 Concept 1 Sketch and Description

Concept 1, shown in Appendix A Fig. 1, includes four supports, a friction hinge for the shelf and LIDAR Sensor, and the snap-fit clamp connection to the drone's pre-existing bars. The snap-fit clamp part features an extended slot that has a slightly larger tolerance, and due to this tolerance, it allows the top section to snap to the bottom part with the bar fitting through the circular slot; this design keeps the mount securely attached while having the ability to disassembly when a force pulls the sections apart in a certain way. This design does not include any extra parts, such as screws for connection, unlike other possible solutions. The concept incorporates the RADAR Sensors mounting inserts. It allows it to be mounted below the shelf, and due to them being separately mounted, both sensors can be adjusted to separate angles.

4.4.2 Concept 3 Sketch and Description

Concept 3, shown in Appendix A Fig. 3. includes features such as two supports, a simple hinge, and adhesive slots. The simple hinges in this design are connected to a bar that connects the two supports and would secure both the RADAR and LIDAR sensors. Due to this only being simple hinges, it wouldn't have the adjustability desired for specific angles. The mount features adhesive metal slots, the method of connection works by having one slot stick to the top baseplate of the design and then one to the bottom of the drone, and the slots feature a slit that allows the two sections to slide together and stay secure.

4.4.3 Concept 2 Sketch and Description

Concept 2, shown in Appendix A Fig. 2. includes features such as six supports, a spring articulated hinge for the shelf, and a modular hook that would allow the mount to hang from the drone's support bars. Unlike other solutions, this concept includes a shelf that houses the LIDAR and RADAR sensors together. The spring articulated hinge is a purchasable hinge that the team would connect to an extended part of the shelf; it would have adjustable angles but would be limited to specific angles that the hinge manufacturer decided.

5 Selection of the Best Solution

Theteam executed theselection of thebest solution by evaluating and scoring the various concepts based on specific selection criteria. Each idea was rated according to how well it performed on the requirements, and these ratings were then given a weight based on what the team decided was most important and then used to determine the most optimal design. This process was conducted for three distinct design elements: the connection to the drone, the hinge design, and the support system.

5.1 Scoring Matrices

Below are the scoring matrices that the team created to finalize the decision of which feature and concept

5.1.1 Connection Concept

Selection Criteria	**Weight**	**Snap-fit Clamp System**	**Modular Hooks**	**Adhesive Slots**
Ease of handling	5%	4 (0.2)	3 (0.15)	4 (0.2)
Ease of use	15%	4 (0.6)	4 (0.6)	3 (0.45)
Accuracy	25%	4 (1.0)	3 (0.75)	2 (0.5)
Durability	15%	4 (0.6)	4 (0.6)	2 (0.3)
Easeof manufacture	20% 10%	4 (0.8) 4 (0.4)	3 (0.6) 3 (0.3)	3 (0.6) 4 (0.4)
Portability	--	**3.6**	**3.4**	**2.45**
Total Score	--	1	2	3
Rank	--	Yes	No	No
Continue?				

When evaluating the connection method to the drone, the following concepts from the matrix above were considered. The scores for each option were calculated based on the selection criteria. The snap-fit clamp system received the highest score of 3.6; the team decided its key areas, like ease of handling and ease of use, were more important than the other concepts, making it the best option for connecting the device to the drone.

5.1.2 Hinge Concept

Selection Criteria	Weight	Simple Hinge	Friction Locking Mechanism	Spring Articulated Hinge
Ease of handling	5%	4 (0.2) 4 (0.2)	4 (0.2) 4	3 (0.15) 3
Ease of use	5%	3 (0.75)	(0.2)	(0.15)
Accuracy	25%	3 (0.45)	5 (1.25)	4 (1.0)
Durability	15%		5 (0.75) 3	4 (0.6) 3
Ease of manufacture	20%	4 (0.8) 3 (0.3)	(0.6) 3 (0.3) **3.7**	(0.6) 2 (0.2) **3.3**
Portability	10%	**3.1**	1	2
Total Score	--	3	Yes	No
Rank	--	No		
Continue?	--			

For the hinge design, the evaluation included the concepts above. The team collectively found that the friction locking mechanism exceeded as the best option with a score of 3.7, performing strongly in durability, accuracy, and ease of use, making it a secure and reliable choice for the hinge design.

5.1.3 Support Concept

Selection Criteria	Weight	Two Supports	Four Supports	Six Supports
Ease of handling	5% 15% 25%	4 (0.2) 3 (0.45) 3 (0.75)	4 (0.2) 4 (0.6) 3 (0.75)	3 (0.15) 3 (0.45)
Ease of use	15%	3 (0.45) 3 (0.6)	4 (0.6) 4 (0.8) 4	4 (1.0)
Accuracy	20%	5 (0.5) 2 (0.2)	(0.4) 4 (0.4)	5 (0.75) 2
Durability				
Ease of manufacture	10% 10% --	**3.15** 3	**3.75** 1	(0.4) 3 (0.3) 5 (0.5) **3.55**
Portability	--	No	Yes	2
Redundancy Safety	--			No
Total Score				
Rank				
Continue?				

In terms of the support system, the following concepts above were evaluated. The four supports design scored the highest with 3.75, balancing ease of handling, durability, and redundancy safety. The team considered it the most effective solution for ensuring stability while maintaining ease of manufacture and keeping solutions simple with fewer possible orientations but still completing their intent.

5.2 Overall Decision

Through the team's thorough evaluation of all design options using scoring matrices and selection criteria, the team finalized the design that best meets the project's objectives. The clamp system emerged as the optimal solution for connecting to the drone. This design ensures a firm connection without compromising the overall performance. For the hinge design, the team selected the friction locking mechanism because of its durability and simplicity and viewed it as the most practical choice for the application. The support system will utilize four supports, as this option offers the ideal balance between the criteria. This combination of the clamp system, locking mechanism, and four supports achieved the highest scores in the evaluations.

5.3 Preliminary Plan for Evaluation

Firstly, the team will verify the secure attachment of the mount and record the effect on the drone's stability. Then, the friction locking mechanism will be tested to ensure its functionality and reliability fulfill its expectations. Finally, the team will evaluate its vibration-damping capabilities' support stability and effectiveness.

6 Detailed Design

The chosen design by the team offers balance in stability, vibration dampening, and ease of use. Below is a detailed refinement of the concept.

6.1 Design Calculations

The calculations for the solution created by the team below comply with the project's requirements, including weight, vibration dampening, and load capacity. Some calculations, such as volume and weight estimations, were given directly from the CAD model created using OnShape. The software provided precise values and allowed the team to ensure the design remained within the specified ranges.

6.1.1 Weight Analysis

- Target Weight: $\leq$ 750 grams (excluding payload)
- Material Density (ABS): 1.04 g/cm^3
- Estimated Volume: Approx. 700 cm^3
- Calculated Weight: $\approx$ 728 grams

6.1.2 Vibration Dampening

Using ABS properties for flexibility and damping, combined with the multi-point support system, the team's design has a target reduction of $\geq$ 70%.

6.2 Design Assembly

Multiview of the entire project assembly, including the front view, right view, isometric view, pictorial view, and exploded view, are featured in Appendix B.

6.3 Part Drawings

Drawings of each separate part, such as the baseplate and supports part, the shelf and cover parts, and the connection part, are featured in Appendix C.

6.4 Bill of Quantity

Item	Name	Quantity	Material
1	Baseplate and Supports	1	ABS
2	Connection Part 4	1	ABS
3	Connection Part 3	1	ABS
4	Connection Part 2	1	ABS
5	Connection Part 1	1	ABS
6	LIDAR Shelf	1	ABS
7	Shelf Cover	1	ABS
8	M3 Heat-Set Insert	2	Aluminum
9	M3 x 0.5mm Socket Head Screw	4	Steel Alloy

6.5 Cost Estimate

Assumingacost of ABS filament of ≈ 22$ per kilogram and accounting for the price of four socket screws, which comes out to 0.96$ and two heat-set inserts, which comes out to 0.38$ the project comes out to an estimated cost of 29.06$

6.6 Remaining Detailed Design Work

The final remaining detailed design work for the solution and prototype would include

6.6.1 Prototype Testing

- Weight and load distribution.
- Hinged tilt adjustments with fixed lock positions.

6.6.2 Final Assembly Verification

- Confirm fit and tolerances between manufactured parts and drone structure.
- Set the heat-inserts and assembly parts together with the screws

6.6.3 Simulation Testing

- Small drone testing with the mount to validate that the dampening performance meets expectations.
- Analyze the aerodynamic impact.

7 Solution Testing and Evaluation

A survey was distributed to the client to gather feedback on the mount solution. Feedback from the client is in Appendix D. Key responses include

7.1 Positive Feedback

Below are the areas where the solution fulfills the expected results

7.1.1 Interference with Drone Parts

Using CAD and a response from the client, the solution is expected to have no interference, while minor adjustments were noted in the shelf part.

7.1.2 Payload Protection

The client’s response indicated that the solution meets protection objectives.

7.1.3 Lightweight Expectations

The client's response and research indicate that the design will meet weight goals.

7.1.4 Space & Support

CAD shows that the attachment doesn't affect flight performance.

7.2 Negative Feedback

Below are the areas where the solution doesn’t fulfill the expected results

7.2.1 Security of Attachment

Further testing through prototyping is needed to ensure secure attachment.

7.2.2 Ease of Attachment/Removal

More CAD work is required to optimize ease of attachment and removal.

7.2.3 Further Development

Clients suggest additional CAD detailing and verification for improvement.

7.3 Strengths

- Very Lightweight: The design effectively minimizes weight, ensuring minimal impact on drone performance and flight time.
- Balanced Design: The well-balanced component contributes to stable flight and ease of use.
- Secure Attachment: The attachment mechanism securely connects the component to the drone, ensuring it remains in place during flight.

7.4 Areas for Improvement

CAD Software Detailing: Further refinement and detail within the CAD software will help improve precision and optimize the design for manufacturing.

- Vibration Suppression Testing: Additional testing and simulations are necessary to assess and enhance vibration suppression better, ensuring smooth operation in varying conditions.
- Secondary Retention Mechanism: The secondary retention system requires further refinement to increase safety and provide additional security during operation.

7.5 Conclusion

The testing and evaluation phase confirmed that the design meets most key objectives, particularly weight, stability, and vibration suppression. However, feedback from surveys and testing highlights areas where improvements are needed. These insights will guide the next iteration of the design, ensuring even greater functionality, durability, and safety to meet client needs.

8 Conclusion

Thisreport has outlined the design process for creating an adjustable, vibration-damping mount tailored to a custom payload on the DJI M600 drone. The primary goal of this project was to develop a mount that enables exact tilt angle adjustments while minimizing the vibrations, ensuring accurate data collection by the sensors during flight. The initial phases of the project focused on defining the problem, researching existing solutions for the mount's needs, and establishing precise design requirements.

Through background research, the team was able to identify critical specifications, such as mounting points on the drone, weight limits, and the materials that balanced the strength and lightness of the drone with the mount attached. The design objectives, including a weight limit of 750 grams, tilt adjustment from 0 to 90 degrees, and vibration dampening of over 70%, were aligned with the project's overall goals of ensuring safety, durability, and performance. Additionally, safety mechanisms, including the redundant securing points, were prioritized to prevent failure during flight.

The brainstorming stage led to developing multiple concepts for the mount, including different hinge mechanisms and support structures. Testing and evaluation for the four adjustable hinge designs and the support orientations were approached in hopes of finding the most suitable option for this project's goals. Concept 1 was selected over the others since it addressed more of the objectives for the mount. The project also considers the environmental factors for which the drone will be flying, such as dust and moisture resistance, and the final design will also comply with the legal regulations at Transport Canada.

In conclusion, the project has successfully addressed the primary challenges, focusing on achieving lightweight, durable, and safe design features. While testing continues to refine the mount's functionality, hopefully, the team will improvise on any objectives that are still lacking without a proper solution. The vibration reduction, safety, and ease of use goals have been met. Ensuring the mount's potential for effective integration with the DJI M600 drone.

9 Recommendations

Based onthe analysis and conclusions in this report, extending testing in various real-world flight environments is recommended. This may include testing under extreme weather conditions such as high winds, rain, or extreme temperatures to ensure the mount's durability and performance in all operating scenarios.

Although the vibration reduction has been achieved around 70%, further exploration should be into more advanced vibration-damping materials that could enhance performance. Materials that increase energy absorption and durability should be considered for future iterations to reduce vibrations during flight further. Such materials must be lightweight, as the maximum weight load is standing at 750 grams, and must stay relatively high, or performance and durability will decrease.

To increase the versatility of the mount, it is recommended that modular components be designed to allow for easy customization or upgrades in the future. For example, different hinge mechanisms or vibration-dampening components could be swapped to accommodate various payloads or adapted to other drones.

Conducting real-world field tests with drone operators to gather user feedback on the mount's ease of use, assembly, and performance is recommended. This feedback will provide valuable insights into any practical issues users face and inform future design improvements, particularly in mounting, adjusting tilt angles, or securing the payload.

Given the complexity of the mount's design, it is also recommended to explore alternative manufacturing methods, such as injection molding, like 3D printing, that can lower the production costs and time to assemble a mount for the drone. Collaborating with manufacturers could help streamline production while ensuring the mount remains within budgetary constraints.

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Appendix A: Concept Sketches

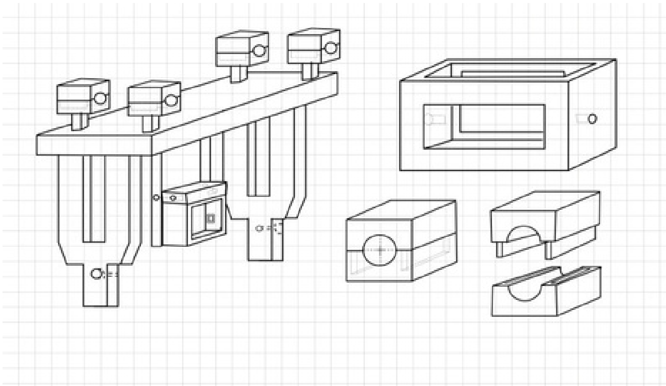

Fig. 1. Concept Sketch 1

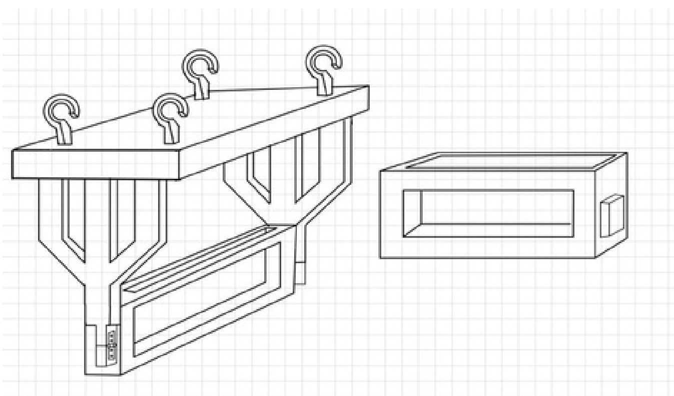

Fig. 2. Concept 2 Sketch

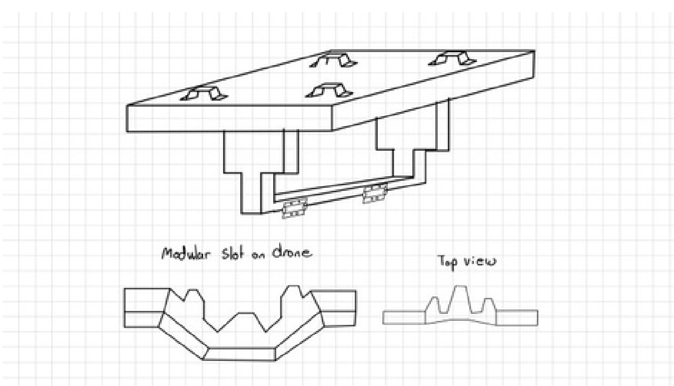

Fig. 3. Concept 3 Sketch

Appendix B: Design Assembly

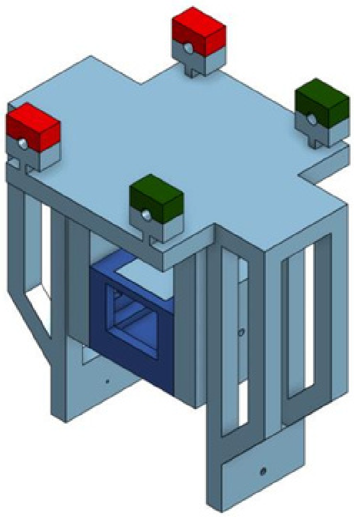

Fig. 4. Isometric View

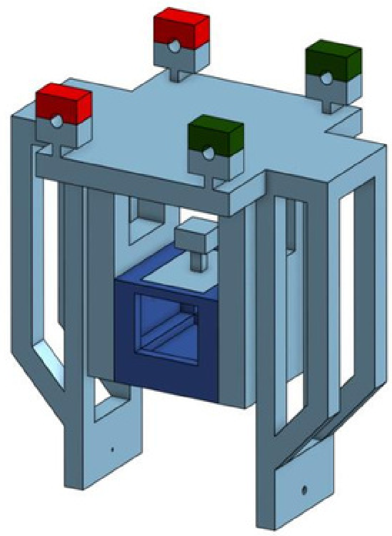

Fig. 5. Pictorial View

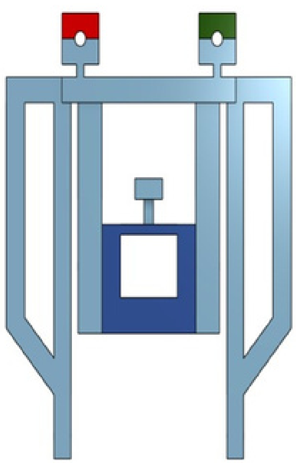

Fig. 6. Front View

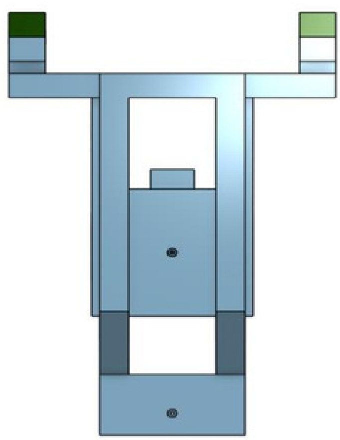

Fig. 7. Right View

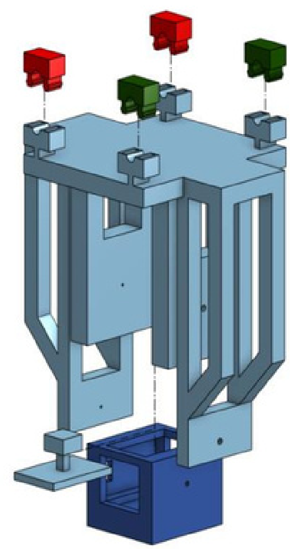

Fig. 8. Exploded View

Appendix C: Part Drawings

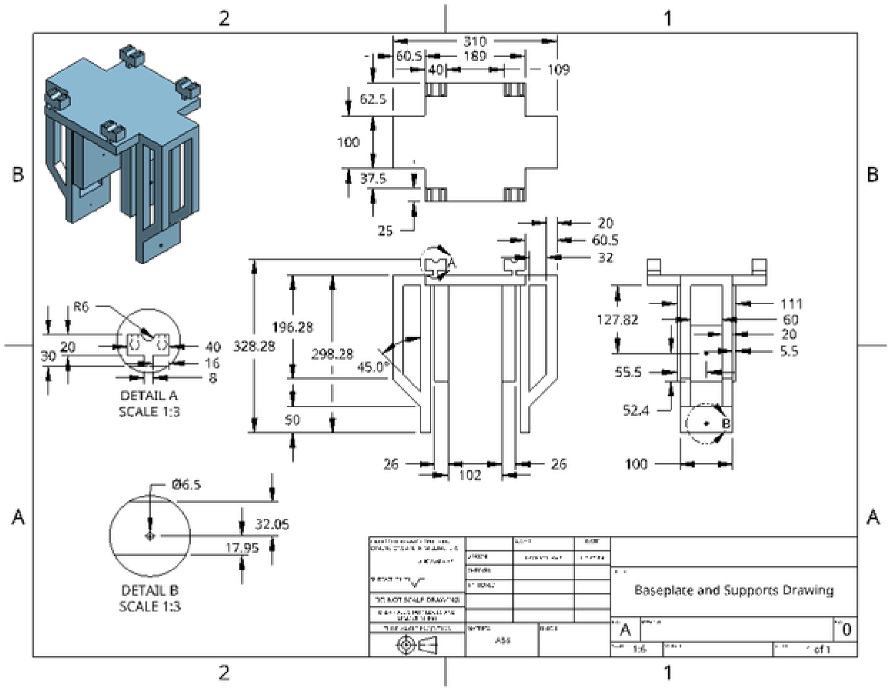

Fig. 9. Baseplate and Supports Drawing

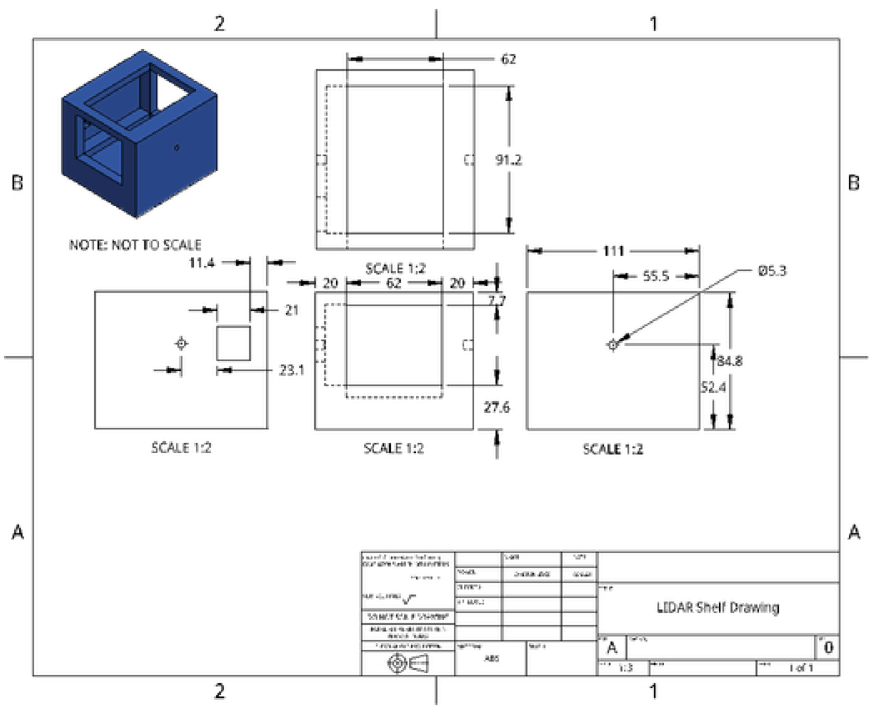

Fig. 10. LIDAR Shelf Drawing

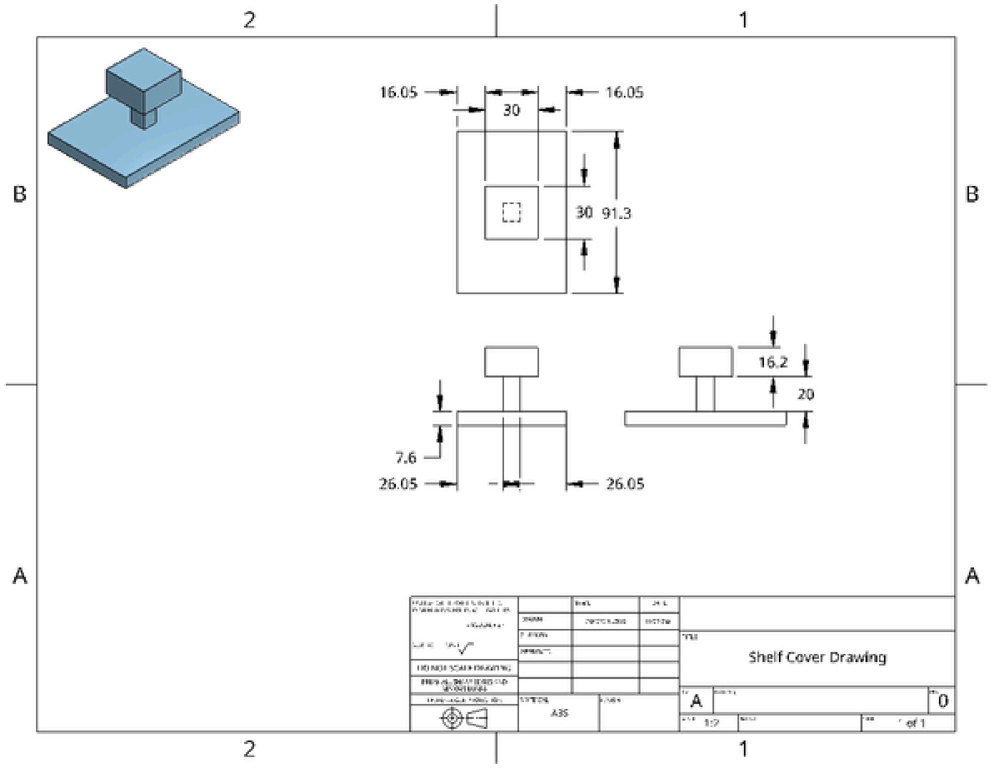

Fig. 11. Shelf Cover Drawing

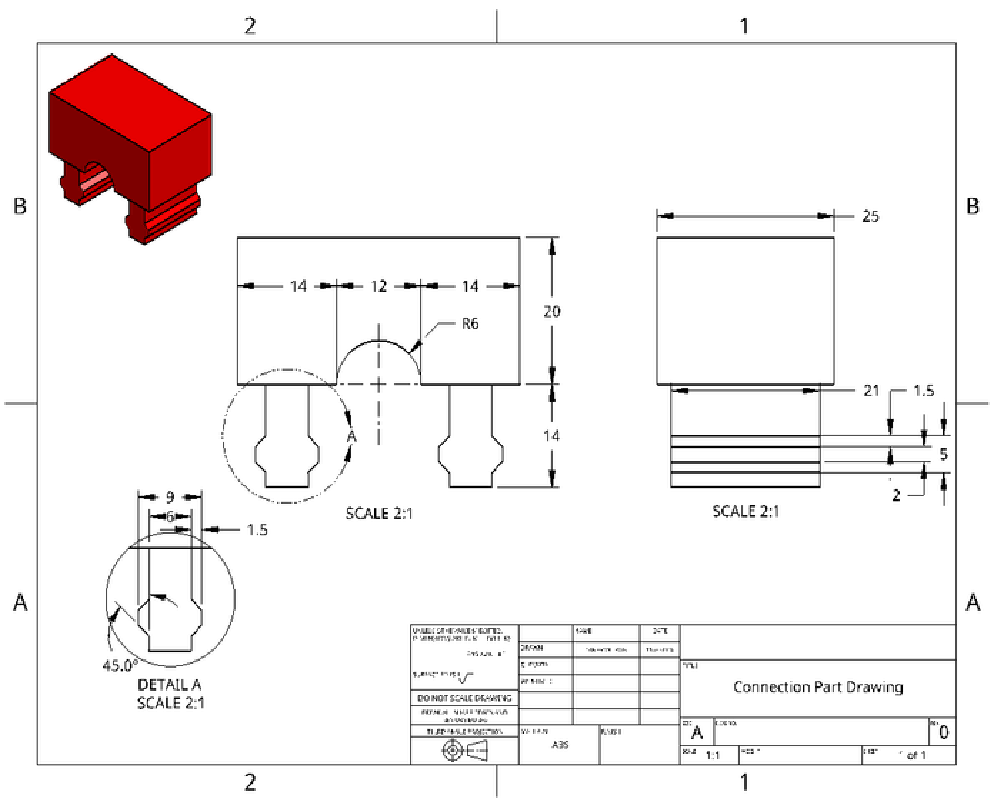

Fig. 12. Connection Part Drawing

Appendix D: Design Survey Response

Question 1: Does the attachment design interfere with other drone parts?

Client Response: Your prototype answered this. 3D printing or rechecking dimensions would help. By the looks, it will not be.

Question 2: Do you believe that mount attachment will protect the payload and sensor from potential damage during drone operations?

Client Response: Through prototype testing, it is believed to protect and meet expectations.

Question 3: Does the attachment allow easy access to the sensor for maintenance or adjustments during or between flights?

Client Response: By testing the prototype's attachment, the solution fits accessibility desires for possible adjustments.

Question 4: Do you believe the attachment design will maintain the drone's balance and stability when the payload and sensor are attached?

Client Response Design seems balanced but might require refinement.

Question 5: Do you think the drone attachment provides adequate space and support for the payload amid the sensor without affecting the drone's flight performance?

Client Response: By utilizing CAD, it's found that the attachment does provide adequate space for the sensors.

Question 6: How confident are you that the attachment securely holds the payload and sensor during flight?

Client Response: This can only be found through a physical test of the prototype.

Question 7: Would you recommend this drone attachment design for further development

Client Response: Improvements in details and verifications in CAD are necessary without a physical prototype test.

Question 8: What areas need the most improvement in the current design?

Client Response: CAD detailing, drone interface, sensor interface point verification, vibration suppression.