Project Deliverable C:
Design Criteria and Target Specifications

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Group 10

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Abstract

This report details the benchmarking, design criteria and target specifications developed to provide a solution for a climate sensor module as proposed by the client JAMZ. The clients are looking for a way to monitor the climate condition of their drone's package throughout the delivery flight. This information will be used by both the operator of the drone and the user of the delivery service. As a result of the prioritized interpreted needs of the clients generated in the initial client meeting, a problem statement was proposed. From both the problem statement and the interpreted needs, several benchmarks were identified. Using the client's needs, design criteria were developed and used to make target specifications for the design of the device.

Table of Contents

Abstract 1

Table of Contents 2

1.0 Introduction 3

2.0 Client Needs 3

3.0 Design Criteria 4

4.0 Benchmarking 4

5.0 Target Specifications 6

6.0 Conclusions and Recommendations for Future Work 7

7.0 References 8

1.0 Introduction

Delivery service to rural areas is much more costly than to urban areas. Therefore, JAMZ intends on opening the door to a cost-efficient drone delivery system. However, to do so they require our help to create a module for a climate sensing system that will be attached to the drone. This is to ensure that the integrity of the package, while the drone is en route to its destination, can be monitored and be in good condition upon arrival. The goal is that the temperature reading from our sensor will be relayed back to the drone operator and the client so they will know the temperature of the package the entire time the drone is in flight. Since the sensor must be inside the container to get an accurate reading, we must find a way for the sensor to be retractable when the drone is in the process of dropping the package off to its point of interest.

2.0 Client Needs

Based on the client meeting, the importance of the client's needs has been interpreted and ranked using an importance scale from 1 to 5, 1 being least important and 5 being most important. This allows for the analysis of the features on the design that will best incorporate the clients needs.

Table 1. Customer statements and interpreted needs.

#	Client Statement	Interpreted Need	Importance
1	Safety of the package	Follow safety regulations	5
2	Drone will operate in rural and urban areas of Ontario, Canada	The device should be robust to handle variable conditions	4
3	Module will be flying on a drone	Module should be compact and sleek for aerodynamics	2
4	Single plug and play module	The device will be in a single assembly mounted on the frame	5
5	Drone has a total weight limit of 20 kg	Module should be lightweight	3
6	Track the climate of the package throughout the flight	Data output must be constant	5
7	Data will be used for further testing of the drone design	Data output must be reliable and accurate	5
8	The sensor must collect information	The device should be placed inside	4

	on the package	the package	
9	Cost of materials	The device should be inexpensive	2
10	The module will connect to an onboard Raspberry Pi	The device should output serial data	5

3.0 Design Criteria

A design criterion has been identified for each interpreted client need, as represented in the Table 2. These criteria will then be further translated into design metrics and classified as functional, non-functional or as a constraint. These are identified in Table 4.

Table 2. Interpreted needs translated as design criteria.

#	Interpreted Client Need	Design Criteria
1	Accurate data	Placement and quality of the sensor.
2	Continuous communication with the operator	Relay loop (no timestamp needed already programmed in drone)
3	Compact	Small in volume.
4	Light weight	Weight supported and stability of the food.
5	Safety	Module does not overheat, and cause electrocution or explosions
6	Relays package temperature	Within $\pm 0.5℃$ of accuracy given by the sensors
7	Relays package humidity	Target humidity between 50 and 55%RH $\pm$ 5%*RH*
8	Low-cost	Software choice: ArduinoUno board

4.0 Benchmarking

Drone Delivery Canada has its package inside the drone, thus completely sealing it. This allows for better insolation of the food, which allows the package to lose less humidity, keeping its temperature more stable. This extra insulation also blocks outer elements from interfering with the sensors thus allowing the temperature module to record more accurate data. However, the downside to putting the package within the drone is that many people will be handling the drone, which implies higher risks of damaging the drone. Drone Delivery Canada also has 3 drone models with a fourth that will be released soon, that all have their corresponding weight

and distance capacities. As such, clients are not restricted to a specific order weight, nor a specific distance.

Amazon Prime Air drops the package directly on the floor, thus does not use a cable like JAMZ and Flirtey. Consequently, there are lower risks of breaking the package and requires much less stability from the drone motors while descending the package. When using a cable to descend the package, it creates an enormous strain on the drone and if the drone was to sway a little, the distance of the package by relation to its weight would cause an enormous moment which could lead to the crashing of the drone. Elsewhere, Amazon Prime Air does not manually attach the package to the drone, minimizing the risks of breaking the drone as nobody should be touching it.

Aretas Aerial is a Canadian company which provides technology and solutions that can be equipped to drones and UAVs. Aretas has a humidity and temperature sensor which has an operaterating temperature range -25°C ~ +85°C. This wireless sensor depending on the speed of the drone/UAV has a response time of 5-30 seconds. The accuracy of the sensor is ± 1.0℃. This is a great example of how sensors should be expected to operate. It should give accurate temperature readings and be able to relay the information back to the drone operator as quick as possible.

Precision hawk is a drone company that also creates data systems. Precision hawk's thermal sensor identifies overheating equipment (packages). Quantified heat data is sent to the operator to evaluate the humidity. The sensor is also paired with a visual camera for capturing clear thermographic data. The long wave radiation (8-12 micrometers) is detected by the thermal sensor which initiates a chain reaction of electrical resistance. The electrical resistance (data) is then relayed back to their team of thermographers.

After analysing drone models from Drone Delivery Canada, Amazon Prime Air and Precision Hawk we have conducted a chart to clarify the differences and similarities between these companies and JAMZ.

Table 3: Benchmarking differences and similarities between drone companies.

Company / Specifications	Drone Delivery Canada	Amazon Air	Precision Hawk (does not carry a package)
Package Weight	Multiple models for different weights, base model (4.5kg)	Multiple models for different weights, base model (2.26kg)	Does not apply

Cost	Depends on the model.	Depends on the model, base model (1000$ - 3000$)	Base price of 1,500$
climate sensor	No	No	Yes (Gives readings from -25°C ~ +85°C)
Relays package temperature	No	No	Does not apply
Placement of Box	Inside the drone	Inside the drone	Does not apply
Delivery System	Lands on the floor, the package must be manually taken out.	Lands on the floor, automatically drops the package.	Does not apply
Risk of people touching the drone	High	Low	Low
Material	Rotorcraft, VTOL Hybrid Multirotor and a Helicopter.	Carbon fiber wings and legs with a metal frame.	Carbon fiber, metal, plastic.

5.0 Target Specifications

The target specifications are defined after both the design criteria and metrics are defined. Table 4 details the target values of the final prototype to be presented on design day. It also includes how each of these metrics can be verified in the future.

Table 4. Target specifications of the climate sensing module.

	Design Specifications	Relation (=, < or >)	Value	Units	Verification Method
	Functional Requirements				
1	Constant data output	=	Yes	N/A	Analysis
2	Sense package humidity	=	20-90	%RH	Analysis, final test
3	Sense package temperature	=	-20 to 40	°C	Analysis, final test
	Constraints				

1	Device receives power externally through drone battery system	<	200	mA	Analysis
2	Device is small enough to mount on drone	<	10x10 x10	cm	Analysis
3	Operating conditions: temperature	=	-15 to 40	°C	Analysis
4	Device weight	<	500	g	Test
	Non-Functional Requirements				
1	Device is inexpensive	<	50	$	Estimate
2	Safety	=	Yes	N/A	Test
3	Aesthetics	=	Yes	N/A	Test

6.0 Conclusions and Recommendations for Future Work

After meeting with the client, the client's statements were analyzed, and their needs were identified, organized and prioritized to then formulate an effective problem statement. This problem statement encompasses the main goal of the device. With the client's need statements interpreted, a benchmarking analysis was conducted to examine how present solutions address the problem and in which ways our device could improve on those solutions to address the specific needs of our client. Future work will consist of the formulation of various conceptual designs. These designs will then be analyzed and ranked according to their suitability and fulfillment of customer needs.

7.0 References

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