GNG1103[D] – Engineering Design
Course Project
Group C7

Project Deliverable C: Design Criteria and Target Specifications

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Abstract

Previously, we gathered much essential information during the initial client meeting with JAMZ and recorded a list of specific customer statements; these statements were then refined into an organized list of non-technical customer needs to be addressed in our design. This document will continue the design process by translating the customer needs into concrete design criteria which will describe what the final design needs to be or have. Additionally, competitive benchmarking based on relevant design criteria will be performed on various viable sensors to gain a better understanding of the telemetric and sensory market. By the means of the knowledge and research collected to date, ideal target specifications on measurable criteria will also be set appropriately. Having a defined set of design criteria and respective benchmarking will be the foundation to which the potential solutions are developed.

Design Criteria

In order to properly continue our efforts of developing a solution to our team's problem statement, we need to define specific design criteria that are relevant to our plans moving forward. These design criteria are a precise description of what the product must be, based on interpreted needs. They can be split into three different categories: Functional requirements which determine how the product will work; non-functional requirements that do not impact how the product will work; and constraints that are a set of important considerations that must be taken into account in the products design. *Table 1.1* displays the interpreted needs detailed in our previous deliverable alongside their new corresponding design criteria. Likewise, *Table 1.2* goes into further detail about each design criteria and their metrics and potential testing methods.

Table 1.1: Interpreted Needs and Design Criteria

#	Interpreted Need	Design Criteria
1	Real time telemetric data collection via sensors and microcontroller	Data Collection
2	Communicating the real time data from microcontroller to drone via communication protocol (Likely UART)	Data Transfer
3	Reliable and Precise climate sensor	Data Precision (Standard Deviation)
4	Retractable sensor that detaches from package upon arrival	Retractable Component
5	Module needs to be easily detachable and can function independently from the drone	Modularity

6	Keep things within a reasonable budget while maintaining an efficient balance between quality and price	Cost ($)
7	Compact design to introduce minimum drag	Surface Area (cm^2) Cross sectional Area (cm^2)
8	Precise Orientation sensor (Accelerometer/Gyrometer)	Additional Data Collection
9	Organization of implemented technology to enhance visual appeal	Aesthetics
10	Light-weight yet durable materials	Lifespan (Years)

Target Specifications

In defining the key design criteria, we have established a list of clear goals to achieve with our design. In the following table, the design criteria will be further developed and sorted into functional, non-functional, and constraint groups. While some criteria are binary in nature, many are also measurable quantities. Units of measure will be established for measurable criteria, and, using the knowledge we have thus far from our research and academic background, preliminary and ideal specifications will also be defined. Though these target specifications may be subject to change as the project progresses, they will serve to be a useful gauge when designing initial prototypes.

Table 1.2: Details of Design Criteria

#	Design Criteria	Relation	Value	Units	Testing Method
Functional Requirements					
1	Data Collection	=	True		Simulation/Prototype Testing
2	Data Transfer	=	True		Simulation/Prototype Testing
3	Data Accuracy	<	5.0	%Error	Sensor Testing
4	Retractable Component	=	True		Prototype Testing
5	Modularity	=	True		Prototype Testing

Non-Functional Requirements					
6	Aesthetics	=	True		Client and Peer Feedback
7	Lifespan	>	2	year	Simulation/Analysis/ Prototype Testing
8	Additional Data Collection	=	Pending		Simulation/Prototype Testing
Constraints					
9	Cost	<	50	$	Estimation/Final Calculation
10	Weight/Mass	<	250	g	Prototype Testing
11	Surface Area	<	1000	cm^2	Analysis
12	Cross sectional Area	<	100	cm^2	Analysis

Technical Benchmarks

Since the launch of Uber Eats in 2015 and similar food delivery services, the companies have done many things to carve out a market for themselves. With an average delivery time of 30-40 minutes depending on location, delivery services are currently a swift method of food delivery. Due to the lack of comparable technical aspects to our design with direct competitors in the food delivery industry, a technical benchmarking on potential viable sensors is performed instead.

For temperature sensing, there are a few options, including mechanical options such as thermochromic paint, bimetallic strips, or electronic solution using various temperature sensors. Since the prevalent requirement is real time communication of data, the best solution is via electronic data. While it is possible to translate mechanical data to electronic data with additional sensor(s) (that is additional complexity not desired), the better and simpler option would be an analogue temperature sensor that is capable of producing data electronically. Such options are compared against each other, with the winner being the thermistor, as it has a modest cost, with acceptable precision and faster response time of the four. It is also end user-calibratable, making it serviceable and thus expanding its lifespan.

For a Humidity sensor, the only viable option that can satisfy our purpose and requirement would be models that work on variance of capacitance. Since options working on acoustic or resistive effects require high humidity and possess a greater degree of complexity, they are unfavourable for this application.

For orientation, other drone companies simply fix the cargo storage to the drone, making it the responsibility of the onboard computer to relay the orientation data to the controller. Since our job is to monitor the orientation of the food, we have decided to benchmark different options of sensors that can be used to detect orientation. Since the requirement is real time data, mechanical solutions such as the tilt watch sticker are excluded. After benchmarking, it is determined that a gyrometer would be a good candidate for orientation sensing as most of the motion the package will experiencing are some form of rotation along X,Y and/or Z axis; Accelerometer will included to detect sudden change in the position of the content as a backup.

Table 2.1: Technical Benchmarks of Temperature Sensors

Type→ Parameter↓	Thermistor (Hermetically Sealed/ Epoxy Coated)	Resistance Temperature Detector (RTD)	Thermocouple	Semiconductor Based ICs
Cost($ per unit)	~0.5 / ~0.2	~6.0	~0.5	~0.9 In Large Quantity
Output type	Resistance	Resistance	Voltage	Variable*
Power Requirement	Any DC CC/CV PSU	Any DC CC/CV PSU	Self Powered	4 ~ 30 V DC
Sensing Range(°C)	-50 ~ 250	-200 ~ 600	-200 ~ 1750, Depends on material	-70 ~ 150
Response Time(s)	0.12 ~ 10	1 ~ 50	0.2 ~ 50	5 ~ 60
Drift (°C per year)	0.2 / 0.02	0.05	>1	2
Accuracy(°C)	0.05 ~ 1.05	0.1 ~ 1	0.5 ~ 5	1 ~ 5

*Depends on each particular IC, But most are capable of output of an signal via voltage or protocol

Table 2.2: Technical Benchmarks of Orientation Sensors

Parameter→ Type↓	Reference Frame	Power Requirement	Data Type	Issues
Gyrometer	On Startup	3 ~ 40V DC	Angular position relative to a reference point	Not Sensitive to sudden Linear movement
Magnetometer	Earth's Magnetic North	3 ~ 40V DC	Orientation of the device with respect to magnetic field	Susceptible to Strong magnetic Interference
Accelerometer	Absolute direction downward	3 ~ 40V DC	Acceleration via Capacitance change	Not sensitive to Rotation
Tilt Switch	Predetermined via Placement	none	Switch Closing /Opening if tilted beyond an angle	Only possible to measure if the package was tilted over the predetermined angle or not.

User Perception

The focal characteristics that pique or subdue the curiosity and interest of our target users/clients generally gravitate towards appearances and non-quantifiable elements of the drone delivery system. Our competitors of note are the delivery magnates *UberEats* and *SkipTheDishes*, as well as the colossal retailer, *Amazon.* These companies were chosen due to their scope of data and their relevance to our project. In keeping with the COVID-inspired roots of JAMZ, maintaining the quality of clean and persists as the primary concern for customers of these corporations.

In terms of keeping the food security, at least ~59% of *UberEats* orders are considered acceptable/undamaged, according to review aggregator *Review.io*. *Uber Eats* and *SkipTheDishes* both have bright and vibrant colour palettes including a few eye-catching colours that contribute to the ~34% of customers that primarily associate food delivery with *UberEats.* As for the statistical analyses of the delivery-chains' services, 31% expect their order to arrive at their door within 30 minutes, with a maximum wait-time tolerance of 40 minutes. It is also important to account for the preferences of the user regarding the current methods of food maintenance. According to *Choicehacking.com*, 64% of customers are more likely to enjoy and recommend a business that provides a simplistic experience. This includes, but is not limited to, the responsibilities and anticipated work appointed to the customer. Customers seem to enjoy a hands-off experience that requires little effort; hence the purpose of a delivery service in general. As the drones will be operating in environments populated by consumers, the presence of the drones must be unobtrusive.

The average sound level of a drone is 70 decibels, just shy of the 85 decibel mark that becomes uncomfortable for humans. Fortunately, due to the high flight ceiling the drones are expected to operate at, the relative loudness will be unnoticeable. It is worth mentioning that a comparable delivery service drone used by *Drone Delivery Canada* flies up to almost 90 decibels, a significant finding, as increased drone weight will cause the rotors to use more energy and the drone to be louder.

In one survey conducted by a news organization, it was found that nearly a quarter of delivery drivers who smell the tempting scent of their delivery, consume some of the food. On a scale of 1 to 10, 1 being "completely fine" and 10 being "absolutely unacceptable", customers rated this fact as an 8.4, indicating that the trust and confidence held to delivery drivers is quite low. Naturally, the relationship between a customer and the delivery driver is one that bestows authority to each other; the customer can complain about the quality of service, and the driver is the representation of the company. However, in a study containing a group of 8,370 individuals, 64% said they would prefer an A.I. or a robot to their manager or current authority figure, citing increased trust and reliability as their reasons.

Finally, studies have shown that at least 19% of consumers fear that their delivery drone will be stolen or tampered with in some way. The current working model of the JAMZ team indicates that the drone will lower the food package via a cable. There will thus be a connection at some point between the customer and the drone in which force can be applied to the cable.

Conclusion

The information detailed in this deliverable is another step forward in the design thinking process. Using the interpreted needs from our last deliverable alongside technical benchmarking and user perception, we have narrowed down our path to presenting our solution to the JAMZ team. The next step in our project will use the functional and non-functional design criteria as well as the constraints that we must take into consideration when designing our prototypes and final proposal. The research done surrounding other competitive products and similar sensors will also aid in preparing a reasonable solution that can be added to the JAMZ team's drone model(s). With this deliverable being completed, our team will be able to move on to developing conceptual designs of possible solutions.

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