User Research Report

Team N

Drone Fleet Management System

Members

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Tutorial 02

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Links:

Link to Portfolio: https://teamlepinee.wixsite.com/cpsc481teamn
Link to GitHub: https://github.com/stephanedorotich/TeamN.git

Project Description

Figure 1: An example of a delivery drone

Our idea is a Drone Fleet Management System (DFMS). This will be a desktop application that allows the user to manage a fleet of drones, while they receive packages and deliver them to customers. This application will go between retailers that need to deliver items and the customers that purchase them. A trained operator that understands the protocol for the drone management system will manage the system. After a customer places an order, the drone will be sent to the retailer to retrieve the package. Once received it will transport the package over to the customer. The operator will be overseeing the entire delivery from pick up to drop off with the ability to monitor the drones, see the status of the drones, where they are currently, where they are headed and many more tasks. The system will notify the operator when there are dangers or issues, and it is up to the operator to manage the drones appropriately. We hope this will be used by companies such as Amazon that do drone deliveries, to allow for a simple and effective way of managing their drone deliveries.

Stakeholders

Customer	The customer uses the service to deliver the goods they order from a retailer. They do not need experience to use the service.
Retailer	The retailer uses the service to deliver their goods to the customer. They have specific knowledge of managing a virtual catalog of goods and of how to load goods into the delivery drones.
Operator	The operator uses the DFMS to monitor the service and resolve issues. They have extensive experience flying remote drones and are knowledgeable of the DFMS.
Maintenance Personnel	Maintenance personnel are responsible for the physical operation of the drones. They have experience maintaining and repairing drones and are familiar with some aspects of the DFMS.
Transport Canada	Transport Canada is the national organization responsible for all transportation policies and programs. The operation of drones must abide by their regulations. They have extensive knowledge of the transportation industry and the regulation of Unmanned Aerial Vehicles (UAVs).
Developer	The developer is the organization responsible for the design, development, and maintenance of the DFMS. They would have extensive knowledge of the software as well as the requirements for managing a fleet of drones.

IDEO Method 1: Activity Analysis (Learn)

We began by applying the Activity Analysis research method, the results of which can be found in Appendix A. It helped us learn about the stakeholders of our application and possible system requirements. This process was done through group conversations about each main stakeholders' tasks and interactions. Our findings primarily consisted of the tasks to be performed and various interactions that take place. Moreover, by analyzing the whole system (retailer to drone to customer and not just the drone management operation, we acquired surrounding knowledge about specific conditions which the operator's tasks should tend to. The most valuable information we discovered was pinpointing the main functionality required for the operator, such as checking the drone status, checking aggregate drone statistics, and viewing the map of all drones in the area.

Figure 2: An example of an Air Traffic Control interface

IDEO Method 2: Error Analysis (Learn)

Next, we chose to apply the Error Analysis method. Using the activities, we came up with a list, found in Appendix B, of potential errors and problems that could occur for our DFMS. Our biggest issue was human error. Customers are not trained with drones and thus can cause many problems. To limit user interaction, our solution was a specified landing pad where the drones can drop off deliveries. The end user can come out and pick up their package after it is dropped off. Another issue was drones being damaged, whether it's through user interaction or weather etc. For this we decided that we will always prioritize the drone, making sure not to send it through risky paths, dangerous weather conditions, or risk battery failure. We also thought of making drones controllable by the operator when the package drop might risk damaging the drone. While these were the main issues, we also had some smaller problems that could occur such as drone malfunctions. For these issues we came up with maintenance personnel that briefly check each drone before they take flight and have a monthly intensive check up on each drone.

IDEO Method 3: Scenarios (Try)

Our use of the activity and error analysis methods provided a better context for the use of our system. By applying the Scenarios method, we were able to explore different functionality that we believed would improve our system. To use the method, we brainstormed possible use cases for our system which helped us discover new additions to activity and error analysis. This shows how well our methods complimented each other. Working versions of our proposed system currently do not exist, although the technology to make this system viable does exist. We incorporated aspects from current delivery systems and the research about drones from our other methods, to create an exceptionally detailed scenario, included in Appendix C.

Figure 3: An example of a drone flight center

Justification of Methods

The three IDEO method cards we chose, namely, Activity Analysis, Error Analysis, and Scenarios, complement each other well and the usage of these cards is justifiable. From Activity Analysis, we get a list of all the tasks involved in the delivery process. This is necessary because it gives us a better understanding of the problem domain and how different entities interact with the system. In Error Analysis we list ways in which each task from the list generated during Activity Analysis could go wrong. Error Analysis is important because many of our user tasks involve mitigating these errors. We chose Scenarios to represent the user tasks of our system with concrete examples. Scenarios are derived from both the tasks from Activity Analysis that are within the scope of our system and ways to mitigate the errors found in Error Analysis.

Reflection

Applying these three research methods helped us understand our design space and will inform our design decisions moving forward. We completed these research methods in a collaborative way, generating and discussing ideas as a group. Doing so helped us elucidate our project and develop a collective understanding of it. The variety of methods we applied allowed us to explore the customer, retailer, operator, and maintenance personnel perspectives helping us understand what considerations need to be made for each group of stakeholders.

Brainstorming remotely proved somewhat challenging. It took longer than expected to discuss all the ideas we had come up with, and consequently, not all our team members were able to spend the full time considering each idea that had been put forth. Additionally, due to our team's overall inexperience with drones, we think it's difficult to know if our Activity Analysis and Error Analysis are comprehensive.

If we conduct further research, we believe that a focus on the operator perspective is important. Our primary user (the operator) is not someone we can learn readily about by asking our friends or family. Consequently, we think involving drone enthusiasts or air traffic controllers in our research would be useful as they are perhaps the best parallel for our primary user.

User Task Descriptions

Task	Importance	Description
View Drone Status	**Must be Included**	Display a summary of a drone's status including serial number, status keyword, velocity, battery, payload weight, dispatch time, retailer name, destination, GPS coordinates, and drop-off time
Drone Recovery Request	**Must be Included**	If a drone is unable to return to the flight center, the operator can send a Drone Recovery Request to the maintenance personnel so they can go recover it. Among other information, this includes the drone's GPS coordinates and access to its video feed.
Register New Drone	**Must be Included**	This task adds a drone to the DFMS. The serial number and model are input by the operator which indicates details of battery type, body type, propellor type, acceleration, etc.
View Drone History	**Important**	The operator sees information about a specific drone, including maintenance history, kilometers on the drone, number of deliveries, average speed of deliveries, and drone health depreciation.
View Map	**Important**	The operator sees a map of their service area with icons representing all the active drones and their trajectories. These icons can be selected to view drone status. The map can be overlaid with a weather map.
Aggregate Fleet Statistics	**Important**	Displays information about all drones in the fleet, including the total number of deliveries, number of active/dormant/out-of-order drones, average delivery time, average kilometers on drone, total flight time, and common errors.
Issue Advisory	**Could be Included**	The operator can issue an advisory alerting customers and retailers of an expected disruption in service, updating the expected pick-up/drop-off time or cancelling the order entirely.

Appendix A: Activity Analysis

Objects

- Drones
- Drone system
- Drone carry baskets (different baskets are needed for different sized packages)

Actors

- Operator
- Maintenance personnel
- Retailer
- End user

Interactions and/or Tasks

- Maintenance personnel with the drones
    - Receive damaged drones and make repairs
    - Perform standard maintenance checks of the drones
        - Check propellors
        - Check for body damage
        - Check battery
    - Check batteries plug them in
    - Attach carry baskets
    - Store and charge drones
- Maintenance personnel with the drone system
    - Receive an order and prepare drone
    - Receive drone rescue flags
- Retailer with the drones
    - Prepare package
    - Load payload
- Retailer with the drone system
    - Indicate pick-up time
    - Indicate package readiness
    - Indicate package dimensions
    - Indicate package weight
    - Enter product information
- End user with the drone
    - Receive package. Don’t touch the drone!
- End user with the drone system
    - Browse catalog and place order
    - Receive updates of drone status
    - Satisfaction survey
- Drone with drone system
    - Recall/pick up another item
    - Verification of the pick-up and drop-off of packages
    - Connect/disconnect

- Operator with the drone system
    - Check delivery and drone status
        - See pick-up times (can be estimated or real)
        - See drop-off times (can be estimated or real)
        - See delivery completion
        - Current battery life
        - Current flight status
        - Current delivery weight
        - Current delivery status
        - Speed
    - Change drone delivery
        - Route delivery to different route
        - Cancel a drone delivery
    - Require drone to be picked up (notify maintenance personnel)
    - View map
        - See all drones, trajectories, can select drones, quick status,
        - Filter/overlay capabilities with weather map
        - Weather summary including wind speed, precipitation, and temperature
    - Analyze drone traffic to minimize bottlenecks
    - View drone history
        - Previous maintenance history
        - Kilometers on drone
        - Number of deliveries
        - Depreciation of drone life
    - Register a drone
    - Retire a drone
    - Aggregate drone fleet statistics
        - Number of total deliveries
        - Average speed of drones
        - Average delivery time
        - Average km on drone
        - Total airtime
        - Common errors
    - Issue disruption notice to customers or retailers based on any expected delays
    - Accept or decline deliveries that are larger(kg) and longer(km) than typical deliveries
        - This may be due to lack of old age of drones available
        - Bad weather conditions

Appendix B: Error Analysis

- Unexpected weather, delivery cannot be completed
    - Can return to base
    - Requires pick up
- Drone malfunctions
    - Loses GPS signal
    - Drone runs out of power

    - Too much interference
    - Drone is too far away
    - Drone enters an area with thick barriers
    - Freezing blades
    - Drone delivery basket does not open
- Drone crashes into an object
    - Drone fails to detect nearby object
    - Blown by strong wind
    - Collision with another UAV
    - A person/pet tries to grab the drone
- Drone gets stolen or damaged
- Drone drops the package
    - Drone delivery basket detaches
    - Retailer fails to close package compartment
- Delivery package does not fit in container
- Delivery gets stolen

Appendix C: Scenarios

Scenario 1:

Alice, an operator at a drone delivery service company, has been told that her company wants to expand its drone delivery service by adding more drones, increasing the number of deliveries that can be made each day. She is tasked to add 60 new drones to the drone fleet management system handling the deliveries. For each drone, she enters the serial number and model of the drone, attaches a unique barcode to it, and proceeds to connect the drone to the system. Then she indicates for Bob, a maintenance person, to perform a standard maintenance check on the new drone. Bob logs the maintenance check to the system. After that, he swaps the battery pack of the drone for a fully charged one. Now that the drones have been added to the system, they are able to make deliveries.

Scenario 2:

Christie works at a drone command center. She's an operator there and it's her job to help the automatic delivery system resolve unexpected issues. It's mid-October and the weather has finally turned cold. It started snowing this morning and still was by the time Christie arrived at the command center. She notices Bob hurriedly insert a battery pack into one of the new drones while Kaden fetches a delivery basket to attach. She gives a friendly wave and heads into the command hub.

Taking a sip of her coffee, she greets Shuhei, her colleague she has come to relieve. "How's the weather looking?" She asks. "Not great." He replies. "It was fine this afternoon, but there's a snowfall warning for tonight and the wind is picking up, so you'll probably have to issue an advisory. Have a good one!" Shuhei grabs his gloves and jacket and leaves the command center, saying goodbye to Bob and Kaden on his way out.

Sitting down at the command hub, Christie starts by pulling up today's status report.

Temperature: 3°C.

Chilly, but no problem for the drones.

Wind: 22 km/h from the northwest.

That'll reduce drone range, but not by much. It might affect a few deliveries to the far northwest and southeast of the city.

Humidity: 82%.

Pretty high for Calgary! But no problem for the drones.

Drones active: 57 (36%).

That's busy for 4 pm! No wonder Alice and Kaden looked slammed! It's a good thing we got those new drones last week. This place just keeps getting busier and busier and the larger fleet has helped us keep up with deliveries without getting backlogged.

Deliveries complete: 314.

Looks about right. We'll probably fulfill another 600 or so tonight.

Deliveries failed: 0.

No news is good news.

Avg Delivery Time: 12.4 min.

Longer than usual, but probably because of the snow and wind today.

Closing the status report, Christie pulls up the map overlay. She sees Calgary and several dozen drone icons moving along their trajectories. Something catches her eye. One of the drone icons is flashing yellow. An alert! Christie clicks on the drone to display its status report. Everything from the drone's serial number, its status, its velocity, its battery level, its payload weight, its dispatch time, the name of the retailer, the time the package was received from the retailer, to the destination is shown and still more. Christie quickly absorbs this information.

The status of this drone is 'over encumbered' and 'delivering'. Looks like the actual package weight is 1.92 kg, even though the maximum for that drone type is supposed to be 4 lb (1.8 kg). No problem! It's a good thing the drones can carry 5 lb. Shuhei must have OK'ed the order before he left. Lots of battery left, so the drone won't have a problem getting back. She closes the drone report.

She flips to the weather overlay. Their system collects data from several weather nodes across the city and displays it on the map. Monitoring it for about a half minute, she observes that one of the nodes in the northwest is recording wind gusts in the mid and high 30's. Not good. Their smaller drones don't fly well in winds like that, and if the average windspeeds go above 35 km/h, they must ground all the small drones and are only allowed to use the big drones in the fleet. It's a big pain and really slows down service for the night, but hey, that's the job.

Following Shuhei's advice, she issues a Service Advisory. All customers who place an order tonight will be notified that there may be a disruption to the delivery of their order due to inclement weather.

The minutes pass. Christie continues to monitor the system. There are 37 batteries charging and 164 fully charged. There are now 82 active drones, but fortunately, still lots more that are ready to fly. It appears that 4 drones are currently out of service and 13 still need a maintenance check. I guess Bob couldn't get to them this afternoon.

A drone starts flashing red! Clicking on it, she discovers that it is having trouble landing for delivery. Clicking on the status alert, Christie is shown the drone's video feed and is given control. The drones are programmed to drop off on porches or on the sidewalk leading to a building, but sometimes they get confused, and when they do, it's her job to give them direction.

From her bird's eye view, Christie sees a suburban home. It looks like it's built on a hill. She can't see the porch and rather than a sidewalk, there seems to be a staircase leading up to the house. No wonder the drone couldn't land!

The sensors aren't picking up any people or animals in the area and Christie doesn't see anything from the video feed. The sidewalk by the road seems clear.

Rather than land the drone manually, she presses the "Sidewalk" button. This instructs the drone to deposit the package on the sidewalk nearest to the destination. Not the preferred deposit location, but acceptable for this kind of situation.

The remainder of Christie's evening proceeds rather uneventfully. She overrides a couple of weight warnings and OK's a delivery to a customer who's on the edge of the recommended delivery range given the conditions. Around 8 pm they grounded the small drones due to strong winds, but fortunately that was after the dinner rush, so they didn't get backlogged too much. However, at around 11 pm, another drone flashes red. Clicking on the icon, she sees that its status is "damaged", and velocity is 0 km/h.

She sighs. Probably a gust of wind. Hopefully it didn't crash into someone's property. She notices that the drone had already dropped off its package and was returning to the command center. She's glad that she doesn't have to deal with the delivery. She pushes this drone's status to the maintenance personnel. Knowing that they're busy, she gets out of her chair, pokes her head into the flight center and tells Kaden to check the computer, they've got one for pick-up tonight. Kaden jumps in the company truck and goes to retrieve the drone. She hopes for his sake that it doesn't take too long.

At midnight, all the drones are either finishing their last delivery, or on their way back to the command center. Christie must wait for all of them to return before she can go home. Kaden returns with the damaged drone. Looks like it was blown into a tree as it was taking off from delivering a package. They don't have time to inspect it tonight, but they quarantine both the battery and the drone for inspection later. Grateful that her shift is over, Christie heads home.

Appendix D: Resource Material

- https://tc.canada.ca/en/aviation/drone-safety/flying-your-drone-safely-legally
    - Legal requirements when flying drones

- https://www.dji.com/ca/flighthub
    - A broader use of drone management but might be cool to look at
- https://www.americasjobexchange.com/air-traffic-controller-job-description
    - This links task of air traffic controller which has similarities
- https://www.mediapost.com/publications/article/324703/golf-course-starts-drone-delivery-of-food-orders-t.html
    - Figure 1 image
- https://www.ros.org/news/robots/uavs/
    - Figure 2 image
- https://www.mirs-innov.com/project-360-panorama
    - Figure 3 image

Figliozzi, M. (2018). Drone Deliveries Logistics, Efficiency, Safety, and Last Mile Trade-offs. Retrieved 2018, from https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1570&context=cengin_fac