Drone Assisted Energy Delivery

PROJECT PLAN

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1 Introductory Material

1.1 Acknowledgement

Thank you to Dr. Geiger and Dr. Chen for your advice throughout this project. You have, and will continue to be a huge help in designing and drone automated energy delivery system.

1.2 problem Statement

The number of electronic devices is increasing at a rapid pace. With so many new devices, it is becoming more and more difficult to supply energy to each one. Some of these devices may be located far away from the power grid, have no practical methods of supplying energy, or may be too expensive to connect to the power grid. A new method of energy delivery is required to power this increasing demand of electronics.

Our team is working on solving this energy crisis through the use of drone automated energy delivery. In the near future it is possible that a large network of drones will be used to delivery energy to surrounding devices. We will begin working on a simple proof of concept to bring this idea to life. Our plan is to acquire a drone which we can customize and program for automated flight. This drone will need to be able to fly from one location to another, assuming no obstacles, land safely, deliver lasting energy to an electronic device, and return home. This project will also require the design of a charging station for the drone, as well as a method for the drone to dock with a device in order to supply energy.

1.3 Operating Environment

The Drone Automated Energy Delivery system will be expected to survive harsh weather conditions. A final goal would be to have inexpensive smaller drones, which if destroyed, would easily be replaced. These drones still need to be able to navigate under harsh weather conditions such as: high winds, rain, low and high temperatures etc. Our goal is more of a proof of concept, and we will not be focusing on this aspect of the project unless time allows it.

1.4 Intended Users and Intended uses

Two broad types of users are intended for the use of this product. The first user type is a typical consumer. A consumer will have the ability to call a drone for energy delivery at any given time. The drone then flies to the consumer, charges their electronic device, and leaves.

A second type of user is Industry. Industry users will be wanting to delivery energy to many stationary and non-stationary devices. An industry user may want additional customizable options to allow more efficient energy delivery, and delivery on a large scale. Bringing energy delivery to an Industry user will require a large network of drones all working together.

1.5 Assumptions and Limitations

This product has no scaling limitations. The end product will be flexible, allowing for large networks, and various sizes of drones. Power stations for recharging the drone will be assumed to have connection into the power grid, or some other means of gathering energy. Each device needing to be charged will require a nearby docking station for the drone to land on while delivery energy. Due to drone regulations, the use of drone automated energy delivery must follow all of these regulations. For example, these drones cannot fly within five miles of an airfield.

Assumptions:

1) **The internet of things will expand rapidly:** Our project is built on the idea that the rapid expansion of IoT will continue and nodes will be placed in locations far away from the power grid.

2) **Autonomous Drone flights will be legal:** We expect that the US government will remove the ban on autonomous drone flights in the near future.

3) **Drone prices decline:** Drone technologies is improving continuously which is leading to prices dropping steadily. Cheapness of drones makes our project economically feasible

Limitations:

1) **Weight carrying ability:** Our drone can carry a maximum of 2 extra lbs. This limit the weight (size) of battery it can carry, and in turn limit the amount of power we can deliver.

2) **Obstacles:** Our focus in this project is on the energy delivery, so will use an obstacle-free flight paths. Maneuvering around object is difficult to account for in an autonomous system and we do not want our senior design to turn into a drone coding project.

3) **Extreme conditions:** We will be utilizing an uncovered magnetic device to establish an electric connection to transfer power. Conditions that can destroy our magnet includes extreme heat, presence of a strong magnetic field, etc.

1.6 Expected End Product and other Deliverables

The final end product will consist of a drone which can automatically fly from one location to another. The drone will be able to land, charge a device, and return to the original location. The charged device will continue to be powered after the drone leaves through the use of a battery. In order to accomplish this, a custom docking station will be built to allow the delivery of energy to the drone and electronic device. Lastly, a proposal will be made to guide the next group through a list of tasks which will need to be done next.

Drone automation: Drone automation will be an ongoing process. We will first focus on very basic drone automation such as taking off and landing. Next we can focus on getting the drone to fly from one location to another. Once the drone arrives at its location it will need to be able to accurately land on the target location. After a reliable connection is made, there will need to be a time frame where the drone charges the device before leaving. When the device is done charging, the drone should take off, and return home.

- Automate takeoff and landing - 10-27-17
- Automate flight to another location - 11-17-17
- Sequential flight paths/Return Home - 12-8-17
- More accurate landing - 2-2-18
- Testing with power and docking stations - 2-23-18
- prepare for final presentation - 3-30-18
- Propose improvements - 4-6-18
- Document improvements and set new goals - 4-30-18

Docking station: The docking station is necessary for the drone to land at the target device and make a reliable connection to delivery energy. To do this, we will first need to create prototypes for establishing a reliable connection. Once connection can be made, that connection must also be broken so the drone can take off. Once these tasks are achieved, the physical docking station can be designed.

- Research power methods - 10-6-17
- Connection Made - 10-27-17
- Connection Broken 11-17
- Physical docking station designed - 12-10-17
- Docking station built - 2-2-18
- Testing with Drone - 2-23-18

- Polish stations for presentation and practical use - 3-15-18
- Prepare for final presentation - 3-30-18
- Propose improvements - 4-6-18
- Document improvements and set new goals - 4-30-18

2 Proposed Approach and Statement of Work

2.1 Functional requirements

Functional Requirements

Our goal for this drone project is to deliver energy from point A to point B, in order to do that we need a few functional requirements that involves coding skills and circuit knowledge skills. Our itemized goals and required project deliveriers are coding the drone to do specific requirements like flying the drone from point A to point B, landing the drone safely, and automatically flying the drone without the need of human interaction. Another important goal and requirement is connecting the drone to the device that needs energy and disconnecting smoothly from the device when needed. We can do that using magnet connections where magnets will make it easier to connect and disconnect from the device without the need of human interference. This requires circuit knowledge and testing the connection. Lastly, to help us achieve our goals and requirements, we need to keep track of our data by reporting the data, this will help us understand our problems and troubleshoot them. Reporting data will also help future groups use our data and information, which will benefit them to improve our project later on.

2.2 Constraints considerations

One of the biggest constraints we have is the drone license. We cannot fly a drone without having a license, which could hold us back from testing the project. According to the FAA(Federal Aviation Administration), It is considered unethical and illegal to fly it near airports.

We need to follow standard protocol and provide safety for us and the people around us. Meaning we need to test the drone away from the public and in a safe environment so that it doesn't danger people.

Another small constraint is learning how to fly the drone, we need to have knowledge and experience on how to fly the drone before we start coding and developing the drone.

2.3 Technology considerations

The strengths we have is that the drone we plan on purchasing and working on can be developed by us to do many requirements like flying and landing (open source). The weakness we are planning to fix is the energy delivery method. We were trying to do wireless charging of devices, however that technology hasn't been developed well yet. One of the trade offs is that we chose a physical method for energy delivery, which is more efficient than wireless energy delivery but it will make our drone landing much more difficult since we have to account for the physical device (battery bank) attached to the drone.

2.4 Safety considerations

The major safety concern is flying the drone, flying the drone where there is a lot of people could affect their safety, so we need to be careful while flying the drone and choose the appropriate area. It is also important to test the drone in an environment that is away from the public and keep a safe distance. Also, we need to keep the drone at a distance where we can see it with our own eyes just in case an emergency happens where we need to reach the drone location as fast as possible to fix the problem.

2.5 Previous Work and Literature

A previous design group for microcart had some aspects similar to our project where they used embedded systems. We have met the group and we learned a lot from them about coding a drone and safely flying the drone. However, their project focuses more on developing modular framework that allows a researcher to independently create and test their own work such as control algorithms. They have used a drone called DJI FlameWheel F450 for their project, however after talking to them and researching more about drones, we deciding that the intel aero ready to fly drone is a better fit for our project which focuses more on energy delivery and that it due to its battery efficiency and camera which will allow us to navigate the drone to certain places if needed.

2.6 Possible Risks and risk management

Approval of drone cost: We proposed an expensive drone to purchased ($1100), the team before us purchased a cheaper drone ($500). Justifying the difference in price and obtaining the approval have delayed our project for a week. We created a long presentation explaining the needs for a better (and more expensive) drone that is designed towards programmers. Through our detailed and thorough proposal we managed to persuade our advisors and department to approve our choice of drone and purchase it for us

Charging and discharging methods: The main goal of our project is to transfer power from drone to and from the drone without human supervision. The drone should autonomously make electrical contact that allows power transfer. Our original design to overcome this issue was a wireless power transfer circuit, but this idea was soon shot down by our advisors. Therefore, we switched to physical connection using magnets to improve the connection resolution. We had a good results with our first prototype of our design and we ordered a new, improved one.

Full automation: Programming the drone to carry its tasks is the biggest challenge we will face with our senior design. The drone programming language and interface is new to all of our members. After researching, we were able to identify the softwares we need to be able to access the drone network and start coding it, but we ran into two issues. All the softwares we need are on a Linux platform, so we ordered access to a VM to a linux device from the ECPE department. The second issue was with connecting the drone to ISU network; one of our members is currently working with a person from ETG on solving this problem.

2.7 Project Proposed Milestones and evaluation criteria

Flying the drone: Being able to fly our drone from point A to point B using the desired navigation method, current primary method is GPS.

Evaluation: take the drone to a nearby field and conduct successful test runs.

Obtaining Drone License: We plan that at least one of our members will obtain a UAS license to avoid any legal issues with our drones operation.

Evaluation: Obtain UAS license from Federal Aviation Administration from the DOT office in Ankeny.

Successfully transferring power: Being able to transfer power from the drone, or a portable source that can be attach to the drone, to charge an electronic device.

Evaluation: demonstrate the ability to run an LED, then a lightbulb, then charge and actual battery.

Transfer must be stable for an appropriate amount of time

Landing Drone: We believe that the most difficult part of controlling the drone is the landing part. The accuracy of our drone landing will dictate the power transfer method we plan to use.

Evaluation: Must be able to land the drone successfully and safely.

Must land within the accepted accuracy regarding distance and orientation.

2.8 Project tracking procedures

We conduct two weekly meetings. During the second meeting, the team members present a slideshow that demonstrates what he have accomplished in the respective week and how we are planning to move forward.

All of these slideshows are saved in our group's google drive.Comparison of the content of the slide shows will show the weekly progress, or lack of it, and provide a great tool to track our progress.

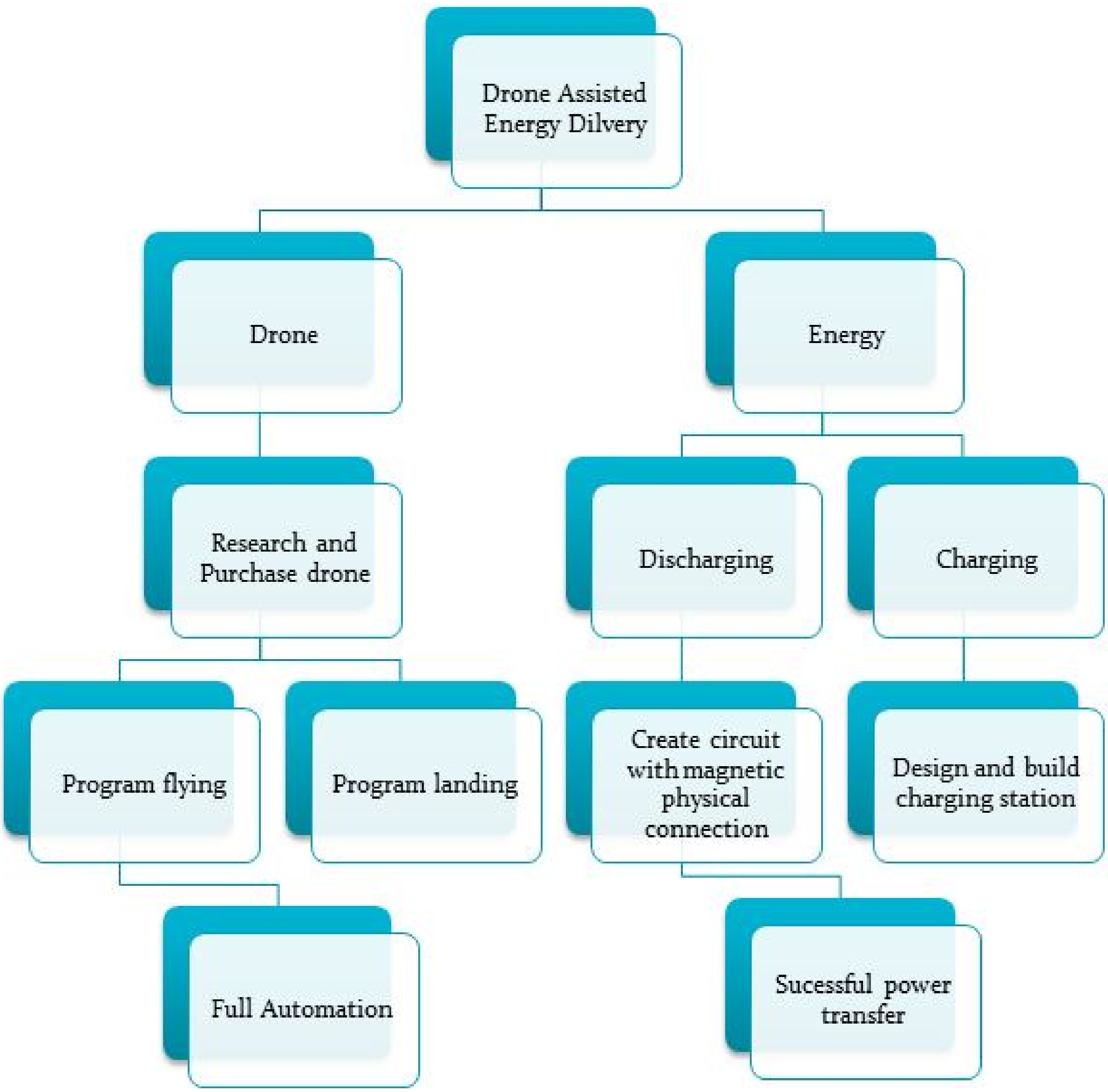
2.9 Objective of the task

Software product: We will design a program that will allow our drone to autonomously fly from point A to point B and land safely and accurately. This program takes in a GPS location as an input, and flies the drone to that location. The drone will be preprogrammed to identify the object to be charged, and will in such a way to establish electrical connection with that object, charge it, and fly back to the drone's charging station.

Hardware product: We will apply small modification to a purchased drone that allows it charge and be discharged without human supervision. We will add parts that allows to establish a magnetic and electrical connection with the device we are trying to charge. We are also considering adding sensors to improve our landing process, but we must conduct a couple of landing tests first before we finalize this idea.

Service Provided: When the whole project is done, we should be able to charge an electronic device using our drone via a fully automated process. The user will identify their device and input its GPS location. The drone should fly to the desired location, charge the device, and fly back.

2.10 Task approach



2.11 Expected Results and Validation

Expected Result: A fully automated process through which an electronic device sends a request and the drone will fly to and charge it.

Validation: We will send the location of a battery to the drone. The drone should be able to fly the specified location, land as close as possible to the battery as to make a physical connection, charge it, and fly back to its original location. If the drone performs all these tasks successfully, this confirms our solution works.

3 Estimated Resources and Project Timeline

3.1 Personnel effort requirements

Name	Main Tasks	Hours/week
Abdullah Al Obaidi	Design charging and discharging circuits	average of 6.5 hours per week
Ahmed Al Hulayel	Design charging and discharging circuits	average of 6.5 hours per week
Drew	Drone flight and Automation	average of 6.5 hours per week
Garrett	Drone flight and Automation	average of 7 hours per week
Khalifa	Obtain UAS license, Help	average of 6 hours per

	with coding	week

3.2 Other resource requirements

In order to successfully make the project work perfectly, there are couple parts and materials that we need to have and combine them together to do a beneficial task in the project.

- First, we are planning to order a programmable drone with open sources in the web, so we can easily modify it to stability fly with a clear vision of the surroundings.
    - Drone charging stations.
- Second, in the energy delivery point of view, we are planning to deliver the energy in two ways, mainly wire connection (physical) and wireless.
    - wire connection: we are planning to buy a portable battery charger and connect the end of it to a magnet to automatically charge itself.
    - wireless: we will need to use board design program to make a circuit to transfer the energy to the devices.

3.2 Financial requirements

- $1099 for the Drone.
- $60 Drone Battery.
- $150 Drone License.
- $160 Portable charger.
- ~$70 components for the landing station (e.g. magnets, usb wires, etc)
- $unknown charging station.

3.3 Project Timeline

<table>
<tr><th>MONTHS</th><th>DATES & TASKS</th><th>HOURS</th></tr>
<tr><td>September 17</td><td>14-21 :
Research:
Drone. (1)
Charging methods.(2)
21-30:
Research
wire-charging methods(3)
Drone web accessible documentations
Purchasing:
Drone.</td><td>(1) 6 hrs
(2) &(3) 6 hrs a week</td></tr>
<tr><td>October 17</td><td>Charging: (4)
Exploring USB wires.
connection testing.
Drone License (5)
Studying
Taking the test.
Flying and exploring the drone. (6)</td><td>(4) 6 hrs a week
(5) 5 hrs a week
(6) 6 hrs.</td></tr>
</table>

	○ learning how to fly and land.	
November 17	● programming: ● flying drone from point A⇒ B using GPS. ● Purchasing ○ physical charging portable.	Still in progress (starting next week)
December 17	● purchasing the charging station for the drone.	
January 18	● Programming: ○ Landing the drone at point B. ● Charging : ○ Connect the physical portable to USB. ■ From USB to actual outlet(with magnet) .	
February 18	● Programming: ○ Fully Automation: ■ going from point A⇒ B. ■ Landing. ● Testing the connection and energy	

	delivery from the charging portable to any device(e.g. phone).	

March 18	• Programming:
	  ○ Fully Automation:
	    ■ going from point A⇒ B.
	    ■ Landing.
	• charging
	  ○ delivering the energy to the user when drone lands.	

April	• Testing with different destinations. ○ analyze the problems & solve. • Write the documentation for the project.	

May	• demonstrate the results!
	  ○ show the challenging parts
	  ○ what we could have been done better.
	  ○ what we can add to the project.	

Month		
Spetember 17	Purchese the drone	Charging methuds
October 17	Drone -Have a drone license. - learn how to use drone.	Charging (explore USB wires).
November 17	Flying drone from A to B using GPS.	Purches charging portable.
December 17	Purches charging station for the drone.	Testing the drone using GPS
January 18	programming drone to land at point B.	Able to connect the portable to USB then from USB to actuall outlet
February 18	Start programming for Full automation	Able to charge from partable to actual device using USB.
March 18	Finish up with full automation	deliever energy to user
April 18	Test automation & solve problems	Finish up the documentation
May 18	Demonstrate the results!	

4 Closure Materials

4.1 CONCLUSION

Our project is entirely aimed to design a proof of concept drone which can fly - fully automated - from a docking station to a specified GPS coordinate. The drone will then lock into a position and deliver energy to the specified device. A breakdown of our project divides our team into three parts: docking station which allows the drone to dock and charge itself, full autonomy through open source software and GPS guidance to a destination and then return back home, and a method of delivery for when the drone reaches its destination.

The oncoming IOT (Internet Of Things) boom demands a way to supply its energy needs, and our team aims to be fully prepared to meet those demands. Fully automated, drone assisted energy delivery is the preemptive solution.

4.2 REFERENCES

[1]"DroneKit by 3D Robotics", *DroneKit*, 2017. [Online]. Available: http://dronekit.io/. [Accessed: 05- Dec- 2017].

[2]"intel-aero/meta-intel-aero", *GitHub*, 2017. [Online]. Available: https://github.com/intel-aero/meta-intel-aero/wiki. [Accessed: 05- Dec- 2017].