UAV Assisted Energy Delivery

PROJECT PLAN

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Table of Contents

1 Introductory Material

1.1 Acknowledgement

With Gratitude and Enthusiasm, we thank Dr. Geiger, Dr. Chen, and the assistance from the ECpE department for the excellent advice that we were given over the project.

1.2 Problem Statement

At the current pace of technological advancement, more and more devices are requiring more energy to operate. Unfortunately, batteries and other energy supplying technology aren't advancing as rapidly. There is even the issues of a device might not even be connected to the power grid, which can be quite costly to connect. This is where our group comes in.

The goal of our team is to solve this energy problem and UAVs or drones are an excellent solution. The basic idea is for a network of drones to deliver energy to these remote devices. Our plan is to acquire a drone which we can customize and reprogram 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 UAV will be expected to survive and operate weather conditions more harsh than our problem statement assumes. Harsh conditions are such: high winds, rain, cold and hot temperatures, etc. However, that is beyond our scope for now. The goal of our group is more proof of concept, than actually implementing weather safety.

1.4 Intended Users and Intended Uses

There are several different users who will have their own specific uses for the UAV. The main users will be individuals in industries who need to deliver energy and data to multiple tethered and untethered nodes. They may want to have more options than an private individual user as to how the drones deliver their energy and data, such as specific ordering of which nodes are delivered first, specifying efficiency of delivery, and delivering to multiple nodes with multiple drones on a large scale.

Additionally, there will also be private, individual users who will be able to call for use of a drone at any time. A drone will then come directly to the user's location, and perform whatever action the user specified. Most often, the action will be to deliver energy to and charge some kind of electronic device.

1.5 Assumptions and Limitations

Assumptions:

- Drones will be able to navigate, dock, and deliver energy or data fully autonomously
- Drones will be able to deliver to multiple nodes before having to return to its base and charge back up
- Power stations for drone recharging can be assumed to be able to gather energy without needing to be recharged themselves, such as connected to the power grid
- System will be low-cost to implement

Limitations:

- Drones must follow regulations already in place, such as avoiding emergency response teams and avoiding no-fly zones
- Drones must avoid obstacles like power lines and buildings
- Due to regulations, we cannot fly the drone within the school zone

1.6 Expected End Product and Other Deliverables

The end product will be a drone that can fly, unassisted, to and from both tethered and untethered nodes. The drone will then attach to the node, transfer either data or energy, and either continue on its delivery path or return to a power station, which will recharge the drone. By the end of the first semester, we will have a prototype of the drone which can autonomously fly from one point to another at a distance of approximately 100 yards. We will also have a prototype of the power transfer system, and will have made visible progress on the autonomous docking system. By the end of the second semester, we will have completed the autonomous docking feature, and the drone will be able to shuttle data or energy between multiple tethered and untethered nodes.

First Semester:

- Autonomous flying prototype: December 3, 2018
- Power transfer prototype: December 3, 2018

Second Semester:

- Final UAV: May 1, 2019

2 Proposed Approach and Statement of Work

2.1 Functional Requirements

For the project, we will need the following devices: a drone that we can fly to deliver energy to the node, a battery that will not power the drone but what will hook up to the docking station, and a landing/docking pad that the drone will fly to and deliver energy to. We expect the drone to fly on its own from a starting position to a predetermined landing pad. We will also need the drone to carry the payload battery safely and have the connector on the battery connect to another connector on the charging station. We will also have the drone send data to us like a telemetry system so we can see what the drone is doing and how we can correct mistakes during the design.

2.2 Constraints Considerations

For our constraints, the biggest one is that we are restricted on where we can fly the drone. Due to FAA regulations, we cannot fly it within 5 miles of the airport, so anywhere on campus is out, and we all have to find another place to fly.

Another big constraint is that there is not a lot of time to fly the drone in good weather, as it is really hard to fly the drone when it is cold and snowy out, which will be most of the year. This means that we need to get as much done as we can before all of that sets in so we can see the big problems we need to work on over the winter.

2.3 Technology Considerations

The drone we are using uses open source software, so we can see what other people have done and see how we can use it for ourselves. We will also be using a battery that is safe to transport, as if the drone would lose control and crash we would run the risk of having the battery catch on fire. The final consideration is that we are using a wired connection from the drone to the landing pad, so this will require the docking procedure to be a lot more precise, and we would have to account for the battery we are attaching to the drone.

2.4 Safety Considerations

The biggest safety consideration is that we need to keep the away from other people, trees, and water. To achieve this, we need to be mindful of where and when we fly the drone, so we can avoid all of these hazards.

2.5 Previous Work and Literature

There is no official product that can deliver energy through a drone to a specific location, but there have been previous projects who have attempted this method of energy delivery.

2.6 Possible Risks and Risk Management

The Intel drone we decided to use is very difficult to operate. We can run into objects and have the risk of breaking the drone. It can be very inaccurate when flying, so we need to be careful of what and who is around us when testing. To manage our risk we are going to take the necessary precautions to avoid any objects when testing our drone. These precautions can include object avoidance, researching safe areas to fly, and utilizing open fields.

2.7 Project Proposed Milestones and Evaluation Criteria

Drone Automation: We plan to be able to have our drone fly completely autonomous using one of the given open source APIs.

Evaluation: Learn either DroneKit or Mavros to program the drone the way we want it to work.

Power Transfer: The base we will have to design and build will transfer power to the drone using a designed plug.

Evaluation: We will have to design the plug and the base to transfer power using Inventor and 3-D printing the parts needed.

Docking Automation: Eventually, this will be the most difficult task, we want to make the drone dock automatically and transfer the power to an untethered node.

Evaluation: We will have to work with the programmers and the power transfer designers of the group to finalize the docking automation.

2.8 Project Tracking Procedures

We are keeping track of where we are in the project by having weekly meetings with our advisors. During these meetings we individually show what we have contributed to the project. We then talk about what will happen in the next week, and how we plan to achieve each goal.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Table of Tasks

TASK	MAIN CONTRIBUTORS	SUBTASKS	TIME ALLOTTED

Power Transfer	Kevin, Brendan	Finding how to carry the extra power, how the power will transfer, Testing, creating the dock	Each subtask in this area needs to be perfected since this is the main goal of the project, we would like to spend the rest of fall semester doing research and testing the most efficient power transfer that way it will be ready to implement in the spring
Auto Nav.	Allie, Connor, Garth, Kaitlyn	Getting GPS working, follow coordinates/directions, testing, minimal obstacle avoidance	These tasks will be taking up most of both the semesters, since to make the power transfer work we will need to have the drone be able to auto navigate to the docking pad and then land on it's own. We will most likely spend the fall semester giving it GPS coordinates to avoid and making sure it can navigate to a signal or GPS coordinates.
Plug Design	Kevin, Brendan	Making the CAD Files, Making sure the drone can land on the plug correctly, Make the plug, testing	These subtasks will mostly get done this semester. We would like to have the plug design testable/tested by December. That can then be implemented and printed in the spring.
Other Code	Allie, Connor, Garth, Kaitlyn	Testing, Motors spin at appropriate speeds, drone has emergency code (manual override), Learning how to use the	These subtasks in this group are all important. However, most of these will go on throughout the entire year. These are things that will need to be improved as we

		API	progress on our project.

3.2 Resource Requirements

We will need replacement parts for our drone, including:

(1) Propeller A - $19.99

(1) Propeller B - $19.99

(4) Carbon Fiber Landing Gear (Airframe) - $14.00

(1) Carbon Fiber Airframe Top Board + Middle Board + Silicon Rubber Protection for FPC (airframe) - $36.00

(1) Carbon Fiber Airframe Bottom Board (Airframe) - $14.00

(1) Aluminium Posts 4 M3 X10 Screw X 8 (Airframe) - $5.00

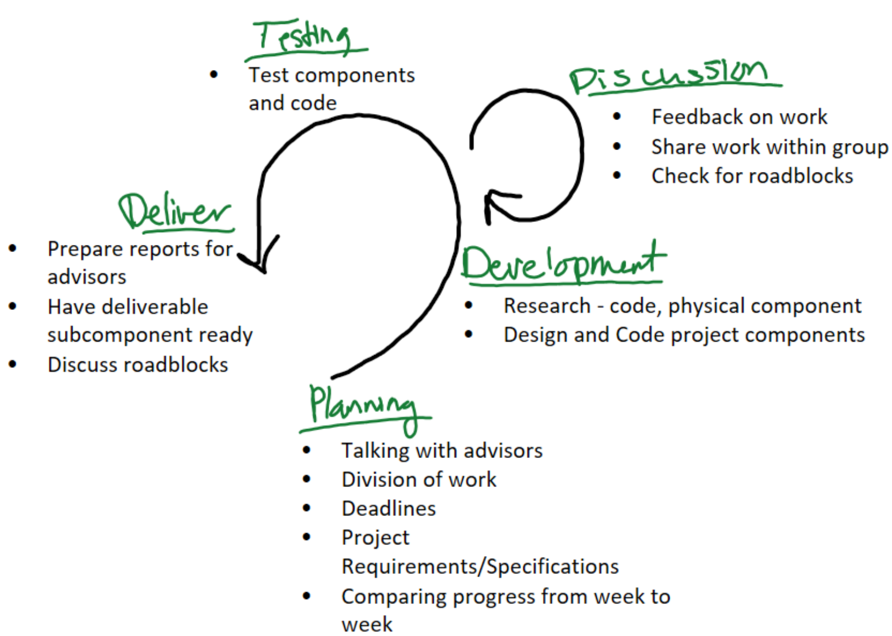
We would also like to purchase a new drone so we have two drones for testing purposes.

Intel Aero Ready Drone - ~$1100

Other materials include coding software (Mavros or DroneKit), and possibly 3D printed parts for the dock or plug.

If all of these parts are used it will be ~$1270 for our project to be completed.

Below is our Agile method that has been working very well for our group thus far:

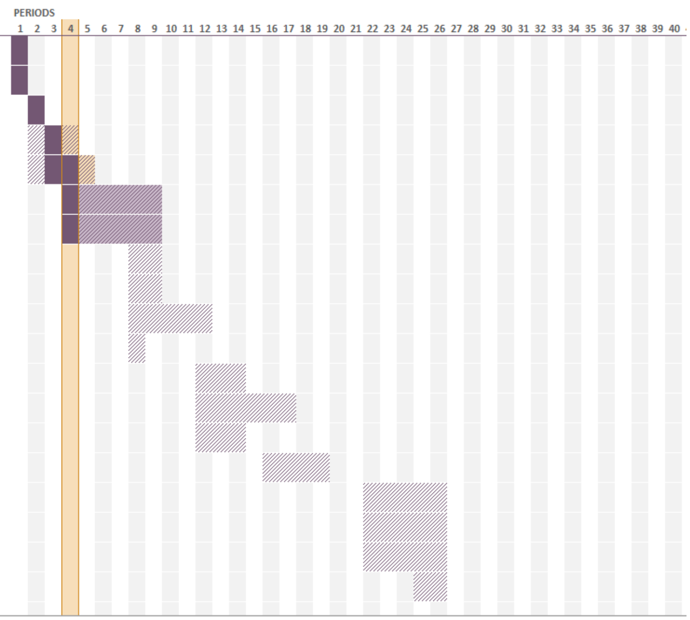


3.3 Project Timeline

Project Planner

Period Highlight: 4 | Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Project Scope	1	1	1	1	100%
Fly Drones	1	1	1	1	100%
Select Drone	2	1	2	1	100%
Meet with sd18	2	2	3	2	50%
Research	2	3	3	3	80%
Schematics	4	6	4	6	10%
Skeleton Code	4	6	4	6	10%
CAD Files	8	2	0	0	0%
Board Ready	8	2	0	0	0%
Auto Navigation	8	5	0	0	0%
Docking Test	8	1	0	0	0%
Plug Protoype	12	3	0	0	0%
Auto Nav. Proto.	12	6	0	0	0%
Dock	12	3	0	0	0%
Semester Demo	16	4	0	0	0%
Finish Auto Dock	22	5	0	0	0%
Finish Auto Nav	22	5	0	0	0%
Power Transfer	22	5	0	0	0%
Final Working	25	2	0	0	0%



4 Closure Materials

4.1 Closing Summary

There are many different situations where delivering power to locations is both crucial and difficult. An easy example is after a natural disaster it would be necessary for there to be power at first aid stations or hospitals or just living areas when the power has been knocked out. However, in such situations it can be difficult to transport batteries or generators quickly to places that would need the power. We will make an automated drone system that will autonomously send drones out to locations holding a payload in order to transfer power over to it. There will be multiple drones that can service multiple different nodes and different locations. This will all be able to be done with as little human input as possible. The drones will be able to fly over and hazardous conditions that would impede ground transport and will return to base to refill their payload to continue to service the different locations as quick and as efficiently as possible.

4.2 References

Past group's work: http://sdmay18-40.sd.ece.iastate.edu/