**Graduate Projects**

University of Colorado at Boulder

Aerospace Engineering Sciences

ASEN 5018/6028 –Spring 2015

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| **Drones Versus Zombies (DVZ)**  **Hardware Element (HWE)**  **Summary/Continuity Document** |

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# Introduction & Summary

The Hardware Element of this project is responsible for the overall hardware system functionality. This includes selecting components to be used on the drone, making sure all components can be mounted safely and securely, making sure all components interface with each other and the main power system on the drone, repairing or replacing broken parts, and any other tasks related to keeping the drone in a functional state.

The major tasks for this semester included choosing a 2nd base platform (the drone), updating the mass and power budget for the drone and components, improving and making more blade guards, and upgrading to a 4S battery. The new platform selected was the 2014 3DR RTF X8+. Testing has shown that the new drone has an endurance of over ten minutes (14 minutes during flight with Vicon control input). Blade guards were strengthened with metal splints and foam blocks.

# Semester Report

## Objectives and Tasks List

Completed:

1. Chose X8+ as 2nd platform
2. Upgrades to 4S lipo battery on original platform
3. Made new hardware mounts where necessary on both platforms
4. Made FTDI cables for data transfer between Pixhawk and Odroid
5. Made blade guard improvements (splint and foam)
6. Made optional-use tether setup for added safety
7. Replaced data cables with new, shorter ones

Incomplete:

1. Make tether setup better if it is needed very much
2. Order new equipment for Fleming lab
3. Replace broken Hokuyo (It has been sent back to the company for evaluation and repair or replacement, but they have been slow in responding to us)

## Issues

Uncompleted tasks above were not finished for the following reasons:

1. Tether setup was only a last minute addition and has not been used/needed yet. If a permanent tether setup is desired, the current design could be improved.
2. Time constraints led to some tasks not being completed by the end of the semester
3. Staff at Sentek Solutions (Hokuy) are slow and it may be another few weeks before the sensor is done being evaluated by their engineering team.

## Lessons Learned

1. Local hardware companies do not carry very many metric options for the size of hardware used on the drone. Nearly all of the screws, nuts, and standoffs used are size M3, and nobody in Boulder sells M3 hardware of this size. Make sure replacement hardware is available before a fix is needed. (Screws and nuts are mostly available at McGuckins, but standoffs have to be ordered online.)
2. Plastic screws and standoffs with plastic male threaded parts tend to break, especially on the legs. Use small metal screws to prevent breaking.
3. Parts will break. At some point you will crash the quad or an electrical component will burn up, so be ready to fix it. Extra ESCs, motors, and especially props are good to have around.
4. Take off expensive hardware when not needed during any flight! (i.e. Hokuyo)
5. Use CU resources. James Mack is extremely knowledgeable and helpful in solving drone-related issues. Ask for his advice when unsure!
6. Look over the hardware list and understand how the system works and what each component is for.
7. There is a fire extinguisher near the main entrance to the Fleming indoor flight lab room.
8. Treat LiPo batteries nicely!!! Do not drain the batteries too low. Check the level regularly to avoid this. It can easily happen during on-the-ground testing without flying. Plug batteries into the charger to see how much they have left. The voltage is not necessarily a good indicator of the amount of life left. Store batteries at nominal charge and use balance charge mode regularly.
9. eCalc seems to predict our system poorly, as far as endurance at least.

## Procedures

### Blade Guard Updates

As mentioned, the blade guards were improved this semester by adding metal splints and foam blocks to make them stronger and more protective for the quad. The older blade guards were breaking upon crashes because they would split where the stress is concentrated at the hole drilled through them. The splint seems to solve this problem well. Info about how to make the blade guards can be found here:

* Dropbox > DVZ > Hardware Element > Blade\_Guard\_Design.

The part drawing for the blade guard can be found here:

* Dropbox > DVZ > Hardware Element > Solidworks Drawings

### Tether

The safety tether was created to keep the quad from crashing into the ceiling and potentially causing damage to the environment if it was flown in the engineering center autonomously. Since it used a cart that had to be returned to the Aero Machine Shop, the tether was disassembled. Information about the tether and how to remake it can be found here:

* Dropbox > DVZ > Hardware Element > Tether Design

### Component Mounts:

There is some acrylic sheet in the Fleming Conference room that is owned by DVZ. the easiest way to make mounts is to laser cut acrylic in the ITLL. Some part drawings for making mounts are already made and can be found in the DVZ Hardware Element folder.

### FTDI cable:

The following link provides a reference for creating the FTDI cable:

* <http://dev.ardupilot.com/wiki/companion-computers/odroid-via-mavlink/>

# Next Semester/Future Expectations

## Prioritized List of Tasks and Objectives

Here are the tasks I would suggest you do to get a good feel for the hardware in this project regardless of the goals for the semester.

1. Review the Mass\_Power\_Budget.xlsx (DVZ > Hardware Element) and read up about each component if you are unsure of its use or purpose.
2. Read (skim) the reports about past issues that have been solved to get an idea of what hardware problems have already been tackled.
3. Organize all the hardware for the project.
4. Get access to the Aerospace Machine Shop
5. Get access to the ITLL shop and Laser Cutter. Laser cutting is way faster than machining if applicable.

## Starting Points

For each one of the tasks and objectives in 3.1, this is how I suggest you start:

1. Read through the document at that location.
2. Past issues are documented here: DVZ > Hardware Element > Issues
3. This requires going through all the boxes in the Fleming Conference room and getting a feel for what hardware is there. There are lots of spare parts. Your job will be easier later if you organize all of this and don’t let anyone else move it around.
4. Talk to Matt Rhode. He will want you to watch some videos about the machines in the aerospace machine shop if you haven’t used them before.
5. Take safety orientation tour for the aerospace machine shop. Take another orientation tour for the Laser Cutter. Sign up for both at the ITLL.

## Improvement, Updates, Verification

A significant amount of the hardware work so far has been making sure the whole system is working properly. Some power issues have been the only mishaps that have not been solved. These issues have not been addressed since the Fall 2014 semester because they have not been a problem this semester. Solutions have been implemented even though the problem was never fully understood

1. Power: A detailed power diagram has not been made for this system. Doing this may help to solve some issues and allow better decisions to be made regarding how each component is getting power and transferring data. Questions I have are: How much power is the USB hub actually receiving and sending? How does the USB hub actually transfer data appropriately from one component to another one? Why is the Pixhawk working while only powered through the USB hub?