Project Closeout Assignment

Team 36: Vertical Flight Society (VFS) Design Build Vertical Flight (DBVF) Student Challenge

William Otos, Kevin Chau, Chih-Hsuan Su, Andrew Sunderland, Gregory Oertli

Table of Contents

Design Impact Statement

The Vertical Flight Society (VFS) Design-Build-Vertical-Flight (DBVF) Student Competition challenged students to build an aircraft capable of vertical flight, with an endurance and maneuverability course to be performed with and without a payload. Teams from mechanical engineering, electrical and computer engineering, and computer science majors worked together with our project partner and technical advisor, Dr. Roberto Albertani, to build an unmanned aerial vehicle (UAV) for competition. Upon completion of the project a design impact assessment was done to assess the impact that the aircraft will have on 5 categories:

public health, safety and welfare, cultural and social impacts, environmental Impacts, economic factors, and any additional impacts of importance. public health, safety and welfare impacts of this aircraft, follow that of other vehicles and drones that you might find in the public. There is a danger to crashing, losing control, or another form of failure. However this aircraft will follow laws for recreational flight as defined by the FAA [2] and has safety measures built in that allow for slow descent in the event of a loss in signal or power.

Cultural and social impacts of this aircraft may be most challenged by the camera contained in the aircraft for privacy concerns. For this project, the aircrafts camera is solely for the pilot's sight and is not designed to record and save videos for public viewing. According to 'How to Resolve Issues over Privacy When Flying Drones', the community-based organization drafted a set of voluntary best practices[6] for drone pilots to avoid privacy-related issues. Many members of the industry and community, along with the National Telecommunications and Information Administration (NTIA), generally agreed with the guidelines[5].

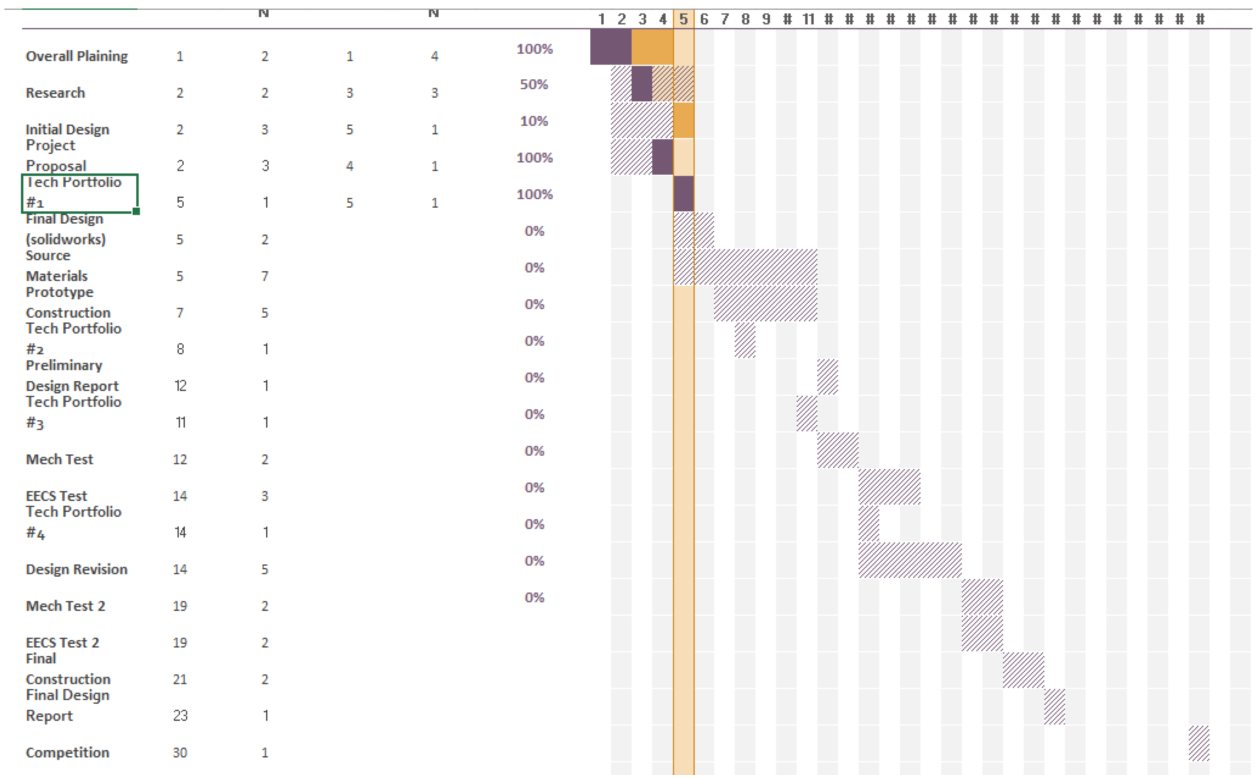
Environmental factors on wildlife and noise pollution are the largest impacts that may arise from this aircraft. The aircraft does have 4 large blades and takes up space that will produce noise in the environment and potentially disrupt birds or other wildlife in the area. According to the article 'Using a Drone around Wildlife: How to avoid conflict', there are many rules to learn how to use a drone safely around wildlife[3]. And, in the other way, this should be less of an issue with flight really only happening for the competition and tests leading up to actually competing. Flights will also be held to their respective testing grounds and competition site to avoid environmental harm that may occur.

Economic impacts go to our sponsors AIAA club and OSU. This project is financed by the AIAA club at Oregon State University. A significant portion of parts had to be purchased for this project on both the mechanical engineering side and the electrical and computer engineering and computer science side. However everything purchased should be reusable for future iterations of this team for the competition and could be seen as an investment in materials for those future teams. In the other view, if this project is globalized, transportation costs can be reduced.The drone does not require human resources and can fly to designated locations. This can reduce labor costs and transportation costs. The disadvantage is that the package risk is higher. However, in this project, a camera is installed on the drone. If any accident occurs during transportation, it will be recorded and uploaded to the cloud at the same time. And, significantly improves worker safety when deployed properly. According to the article, 'Research conflicts on drone delivery costs, efficiency as parcel carriers scale operations', the operational costs are at least 70% lower than a van delivery service[4]. Thus, drone transportation has a great impact on the transportation market.

In conclusion, the team and aircraft have overall positive impacts and minimized negative impacts on the 5 categories covered by this design report. The aircraft is made for a student competition and will not see much use outside of testing and the actual competition which lowers its overall impacts in these categories.

Project timeline

Below is a Gantt chart that plans out the project up to the competition. Each row is a step to completing the competition and each column is a school week. From left to right we plan the activity, our initial planned start, our planned duration, the actual start week, actual duration, and finally the percent complete.



Overall Plaining	1	2	1	4	100%
Research	2	2	3	3	50%
Initial Design	2	3	5	1	10%
Project Proposal	2	3	4	1	100%
Tech Portfolio #1	5	1	5	1	100%
Final Design (solidworks)	5	2			0%
Source Materials	5	7			0%
Prototype Construction	7	5			0%
Tech Portfolio #2	8	1			0%
Preliminary Design Report	12	1			0%
Tech Portfolio #3	11	1			0%
Mech Test	12	2			0%
EECS Test	14	3			0%
Tech Portfolio #4	14	1			0%
Design Revision	14	5			0%
Mech Test 2	19	2			0%
EECS Test 2	19	2			
Final Construction	21	2			
Final Design Report	23	1			
Competition	30	1			

Fig: 1 Gantt Chart

Scope and engineering

For the Vertical Flight Society's (VFS) Design-Build-Vertical-Flight (DBVF) competition, we are to build a drone for flight around a course. This competition requires us to build a drone that weighs no more than 18lbs. A maneuverability test will be conducted involving the drone to fly around a course and land each time before each lap. It will have to hover in place for 60 seconds, and fly with a weighted payload. A minimum payload of 2 lbs is required for the weight to be met. However the better ratio of drone weight to payload weight we can get increases the amount of points we receive. Achieving autonomous flight is the final way to receive additional points. If we have the time to implement it before competition in April, our drone will have autonomous flight. If we do not have the time, then autonomous flight will be a way to improve our drone after competition for spring term. Below is a table of these requirements from the competition and the 3 sub teams each requirement may belong to, Mechanical engineering (ME), Electrical Computer Engineering (ECE), and Computer Science (CS).

Requirements summary

Name	**CR**	**ER**	**Verification Method**	**Test Pass Condition**
Arming Switch	Safety measure that will allow power to the motors.	The system will respond to an arming signal that will allow powering the motors	Analysis	If the ground control system shows the arming signal, this requirement will be met.
Battery Life	Have enough to power the aircraft for the entire duration of the competition.	The system drone will be able to drive the main propeller for at least 4 minutes with a single battery charge.	Test	If the main rotor is able to function for at least 4 minutes on a single battery charge, this ER is met
Docume-ntation	Documentation is good	The project will produce documentation that has at least 8 areas for improvement on the project for future teams and is approved by the project partner.	Analysis	If the project partner approves the documentation this ER will be met.
Lightwei-ght	The general aircraft requirements are restricted to the unmanned aircraft system	The sub-system drone will be lightweight, not exceeding a mass of 20lbs loaded (with a 2lb weight)	Analysis	If the measured mass of the drone and payload is less than 20lb, then this ER will be met.

	(UAS) Group 1, which limits the maximum take-off weight (MTOW) to no more than 20 lb (9.1 kg)			
RC Kill Switch	The Drone will be able to be instantly deactivated with a Kill Switch	The system will show confirmation of a kill switch being activated on the ground control station software, qgroundcontrol	Analysis	If the ground control system shows recognition of the kill switch then this ER is satisfied.
Remote Control	Control the aircraft remotely.	The system will accept and respond to wireless commands from remote controller.	Analysis	If the ground control station shows the movement in the channels, then this ER will be met.
Telemetr-y Data	Get data from the aircraft.	The system will show the telemetry on the ground control system.	Test	If the ground control system shows telemetry data, this requirement will be met.
Thrust Test	Hover in place.	The system will maintain a constant thrust output greater or equal to 8 lbf, for 1 minute minimum.	Test	If the system maintains a thrust output greater or equal to 8 lbf, for 1 minute minimum, this ER has been met.

Table 1: Requirements Summary

Risk Register

Risk ID	Risk Description	Risk category	Risk probability	Risk impact	Performance indicator	Responsible party	Action Plan
Risk 1	Material delivery delay	Timeline	50%	M	COVID will delay delivery sometimes.		Retain,deliver earlier than the deadline.
Risk 2	Material price	Cost	20%	M	Price change because the COVID		Reduce, buy the material on budget. If not, just change the mertial.
Risk 3	Autonomous being too time consuming or too hard	Technical/ Timeline	70%	L -- its a bonus section	Can the drone perform autonomous actions	CS	Avoid, if necessary
Risk 4	Drone design ends up not being stable	Technical	10%	M	Can't hover in place	ME, ECE, CS -- can occur anywhere	Reduce, design built with stability in mind.
Risk 5	Drone weighs too much for lift off	Technical	5%	L	Lift off with and without weight	ME, CS	Reduce, this should not happen.
Risk 6	Inefficient memory code	Technical	5%	M	Memory Loss	CS	Reduce
Risk 7	Incompatible Interface	Technical	30%	H	Unresponsive Drone	ECE	Reduce, maintain upkeep to ensure operation.
Risk 8	New Sensor Developed	External	20%	M	Team buys and works with a new sensor.	ECE	Retain, ensure the sensor is powered.
Risk 9	Team gets a grant	External	10%	M	Another stakeholder in project		Retain, make use of extra funding.

Table 2: Risk Register

Future Recommendations

Project Scope
The project has a large scope for the time allotted to complete it for the competition. Before the project can even be considered to move forward, the scope needs to be worked out. There are two possible choices that can be made here which affect the project scope:

Recommendation

Either require ECE and CS to build a custom flight controller, or have less ECE and CS people on the project and let them use off the shelf parts. Their project should just be about the flight controller.

Class Timeline
The students from mechanical engineering were on a different timeline than the computer science and electrical engineering because of the way their senior project course is scheduled. Mechanical engineering worked on the project starting in Summer term and finished by the end of Winter term. Computer science and electrical engineering started in the Fall term and finished at the end of Spring term. Due to this time split between the three disciplines, it is really difficult to finish the project in a cohesive manner.

Recommendation

Either put the mechanical engineering students into the electrical engineering classes or have electrical engineering and computer science students move into the mechanical engineering class.

Project Timeline
Our project with VFS DBVF's student competition had deadlines of its own, that the classes timeline didn't account for. ECE and CS joined the project a couple of weeks into fall quarter and the competition had its final deadlines in the beginning of April, the first weeks of Spring Quarter, for the competition. This essentially negates the efforts to put the students in one class to have the same timeline because the teams timeline didn't match the class's. Due to the expedited nature of the project, students following the class schedule fall behind on their project.

Recommendation

Require the class to adapt to the expedited schedule of the project and have the teachers run a special course for this project or change this project to just building a flight controller.

Leadership
This project is a mechanical engineering project and somewhat of an electrical and computer engineering project, computer science is solely there to help. Our group had a lot of ME leadership that really helped get the project moving and in the right direction. CS students took on more of a leadership role that would have been better suited to an ECE student in regards to what needed to be done for this project, because it meant CS students were making decisions on hardware without the same knowledge ECE has. ECE Students also have more experience in a capstone class because of their junior capstone that CS students have not taken.

Recommendation Make a ME student take charge of the project overall, have an ECE student take charge of the hardware subsystem and then tell CS students what they are working with and what they need to achieve so they can get started solely on that.
Flight Controller The Pixhawk 4 had bugs that made it difficult to configure with the provided software QGroundcontrol and PX4. This wouldn't have been as much of a problem with a quadcopter drone design, but for a helicopter it was simply incompatible and would have been too difficult to fix the software bugs in the short time available. If the team decides to build their own custom flight controller, there will be a monumental amount of work ahead of them. **Recommendation** Start with a team that has experience in the RC hobby flying area already, or do a lot of research into how to build and fabricate a custom flight controller as well as design custom software to control it.
Project work vs Class work The project required reports to be made for the competition that did not count towards the class work. This meant that time spent working on the projects and reports was time partially wasted towards the class work side of the project. By having the work split between the project and the class work, there is a disconnect that forces the team members in computer science and electrical engineering to do double the work. **Recommendation** Incorporate project specific deadlines and project work into the school work. This would make the time spent working on the project feel more beneficial.
Remote Work Not all team members were in close proximity to each other to be able to work on the project. During the project, one of the computer science students and one of the electrical engineering students were working on the project remotely and unable to work in person on the project. This project requires a finished physical product that needs people to work on it in person. **Recommendation** Future teams working on this project will need a method in place to deal with team members who are not physically located near the other team members. A possible solution to this problem is to only allow team members who live in the Corvallis area to be on the project.
Prerequisite Courses This project required a lot of experience and knowledge in the aerospace area. The majority of this knowledge was brought forth from the mechanical engineering students and they handled a lot of the physics involved with making an aircraft that can actually lift off of the ground. For the computer science and electrical engineering students, there was a severe lack of knowledge in this area and while they may not be building the physical materials to make the aircraft fly, there is knowledge required to understand how to run the propellers and rotors. **Recommendation** Research can be done to fill this gap in knowledge, but another recommendation is to have one or two prerequisite courses in this area to make sure that the students are prepared to work on this project.

Table 3: Future Recommendations

References

[1] “Drone Laws in Oregon (2021),” *UAV Coach*, 14-Apr-2021. [Online]. Available: https://uavcoach.com/drone-laws-oregon/. [Accessed: 17-Apr-2021].

[2] *Recreational Flyers & Modeler Community-Based Organizations*, 11-Mar-2021. [Online]. Available: https://www.faa.gov/uas/recreational_fliers/. [Accessed: 17-Apr-2021].

[3] ‘*Using a Drone around Wildlife: How to avoid conflict*’, April 8th, Available: https://www.expeditionwildlife.com/using-a-drone-around-wildlife/

[4] ‘*Research conflicts on drone delivery costs, efficiency as parcel carriers scale operations*’, May 21, 2020, Available: https://www.supplychaindive.com/news/drones-energy-efficient-delivery-vans-experts-disagree/578418/#:~:text=Using%20electric%2C%20autonomous%20drones%20for,savings%20come%20from%20avoiding%20traffic.

[5] ‘*How to Resolve Issues over Privacy When Flying Drones*’, July 31 2020, Available: https://pilotinstitute.com/drone-privacy/

[6] ‘*Voluntary Best Practices for UAS Privacy, Transparency, and Accountability*’, Available: https://www.ntia.doc.gov/files/ntia/publications/voluntary_best_practices_for_uas_privacy_transparency_and_accountability_0.pdf