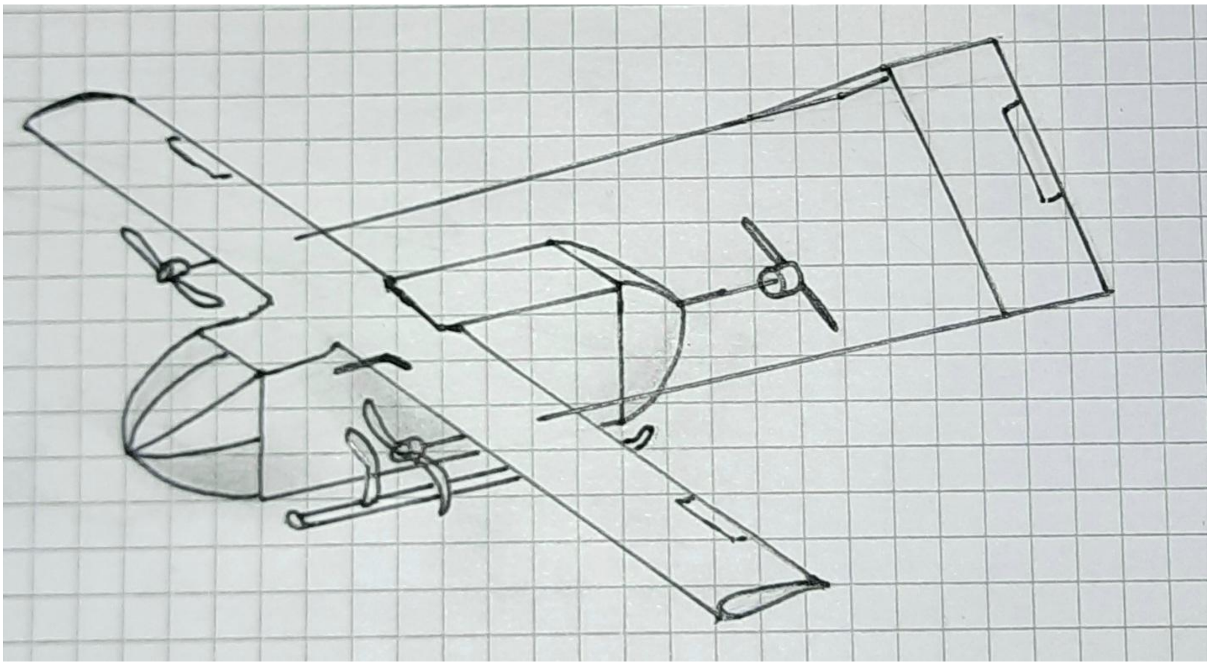
Haggis Aerospace

University Of Dundee
Team 25



Team Members

Chad Barnard	Mechanical Engineering	2nd Year
Maksim Vassiljev	Mechanical Engineering	3rd Year
Anton Parsons	Mechanical Engineering	2nd Year
Himanshu Sharma	Computing Science	2nd Year

Supervisor:
Markus Pakleppa, Dr. of Biomedical Engineering

Signatures:

Team lead:

Supervisor:

Intro

For 2022, Haggis Aerospace will be designing a UAS capable of delivering an aid package weighing up to 2Kg during flight. The UAS will be capable of vertical take off and landing (VTOL) which will increase its operational usefulness when operating without a runway. The UAS will operate autonomously throughout the entire mission completing all aspects of the challenge, which are waypoint navigation, payload delivery, gliding and return to base. The team consists of seasoned members of Haggis Aerospace and will be drawing on our experience gained in previous years to develop the UAS. For the 2022 competition, we will have full access to a workshop enabling us to use more sophisticated manufacturing techniques and iterative development cycles to improve the quality of the drone.

Configuration Choice

To try a different design approach and outclass the opponents in the speed challenge, the focus this year is on the speed of the drone, trying to go as close to the speed limit as possible. The team believes this approach will increase efficiency of the vtol configuration as all motors will be used more during horizontal flight. Focusing on speed will also let us innovate existing design techniques for design of fast drones and make us stand out in the market of existing drones as one of the fastest.
This year, the team has access to a workshop, allowing for use of stronger materials such as composites and cnc cut aluminium, use of which will drastically increase the strength and quality of the Drone.
The above as well as the lessons of previous year lead to the design being drastically changed. After reviewing many different configurations and assessing previous design, A 3-engine Vtol drone with an inverted V-tail configuration with 2 motors being on the wings and 1 on the back of the fuselage was chosen.
Using Vtol provides flexibility to deploy the drone from any terrain quickly as well as to hover in place for precise payload delivery. To address some of the issues of last year's drone and to address higher wing stresses at higher speeds, Instead of rotating the wing, each motor will rotate individually. The wing will be attached to the fuselage more securely as it doesnt need to rotate.The fact that the wing and fuselage will be made out of composites also improves strength and rigidity and allows the wing to be hollow. The battery of the drone can then be placed into the wing itself. This reduces the vibrations in the wings by increasing their mass and providing more space in the fuselage for electronics and other parts and reducing its profile, decreasing drag, which is especially important for speed. The batteries will be custom made from 3.7 LI-ion cells to fit inside the wing and will be made in modules that can be easily replaced. Using separate servos to rotate the motors allows the rotation around the axis during vtol to be accomplished by tilting the wing motors in opposite directions slightly, removing the additional tail servo used for this reducing weight and increasing strength. The tail will be an inverted V shape. This will reduce the amount of disturbed airflow coming from the tail motor going over the tail which in turn reduces vibrations. The speed of the field assembly is as important as the flight speed, so fast cliping-in connectors not requiring screws and wire connection ports that slide in place will be used.

Propulsion

VTOL drones suffer from loss of motor efficiency during horizontal flight, as the amount of thrust required is significantly less than during vertical flight. To reduce this, the number of motors is to be minimised and horizontal flight will be as fast as possible. The drone will use 3 motors to propel the craft. Using two pull propellers on the wings and one push propeller on the back of the fuselage. All the motor mounts will be able to rotate about 105 degrees, between facing upwards(downwards in case of tail motor) or forwards (backwards). Extra 15 degrees of freedom will be used to rotate the drone during vtol by pointing the front motors into opposite directions.

Less motors however means more force required per motor. Considering the estimate of the team of the take-off mass being 8kg, new motors will be chosen that can provide up to 3.5 kg of thrust each. As mentioned before the battery will be stored in the wings, allowing more cells to be included which might provide longer flight time, however further calculations will be made to evaluate if the added weight will be worth it.

Structure

The majority of the drone including the wings and fuselage will be made out of carbon-fiber and glass fiber. For the 2021 drone the fuselage plates were made of foam. They were harder to manufacture and took up a lot of internal space of the fuselage since they were really thick, so a thinner, stronger carbon fibre skin will provide both structural support, a good aerodynamic shape and increase internal space. The use of carbon fiber will also allow us to utilise areas inside the UAS such as the wings which we didn't have use of last year. The carbon fiber body of the UAS will serve as structural support along with carbon fiber struts and plywood guide structures for supporting vital electronic equipment and the payload. There will also be a number of 3D printed parts made of PETG to attach sections together or parts that need to pivot.We also hope to work with CNC machined aluminium to manufacture most stressed joining components like spar connectors. The tail section will also be made of carbon fiber and will be inverted V shaped, this will be attached to the wings using two carbon fiber struts which will double as the base for the wing motors. Carbon fiber will be used for the majority of the structure as it has a high tension and compression strength, however glass fiber might be used depending on the budget estimates.

Control

The control of the drone in hover mode will be achieved by varying the thrust of the rear motors for pitch and wing motors for roll. The control in cruise mode will be achieved with control surfaces on the tail and ailerons of the wings. During the transition phase, both of these will be used

Payload and Delivery

This year the payload is AirDropBox's ADB Micro System model A. This system with a packed parachute dimension are 17 x 17 x 40 cm and empty mass is 0.5kg. We are aiming to have a total mass of 2 kg with the payload. At this weight the package impact velocity is 7 – 13 m/s being dropped at a height of 30m. The drop box is contained in a plywood cargo bay in order to maintain its position within the aircraft at all times. The payload rests on the release hatch which is held shut by a pin controlled by a servo on command. Once the payload is released the strong push of the wind caused by the high velocity of the drone will shut the hatch and a magnet placed on the hatch itself and in the fuselage will keep the hatch shut.

Rapid assembly

The drone will be divided into multiple sections: fuselage, 2 tail booms, 2 wing sections and a tail. Everything will connect together with 3d printed and aluminium parts and held in place with flexible interlocking teeth. The wing electronics will connect automatically during assembly using custom made sliding connectors.the tail and motors will be connected manually with easily accessible connectors behind a small hatch inside the wing. The access to the batteries will be provided through a different hatch in the wings secured by magnets. This will allow the batteries to be replaced with ease to allow for missions back to back.

Image Recognition

Image recognition shall be run on a raspberry pi rather than a Jetson. This is because we will be using lighter neural networks that shall be able to run on a raspberry pi. The previous julia code combines both letter and color recognition into one neural network making it harder to run.
This year instead there will be two neural networks. One network is a black and white letter recognition and the other is a color detection network. Since the networks run on a need by need basis the overall cpu load is lessened allowing us to use a cheaper raspberry pi vs a higher cost Jetson. Other code is largely unaffected as the neural networks stress out the cpu the most.

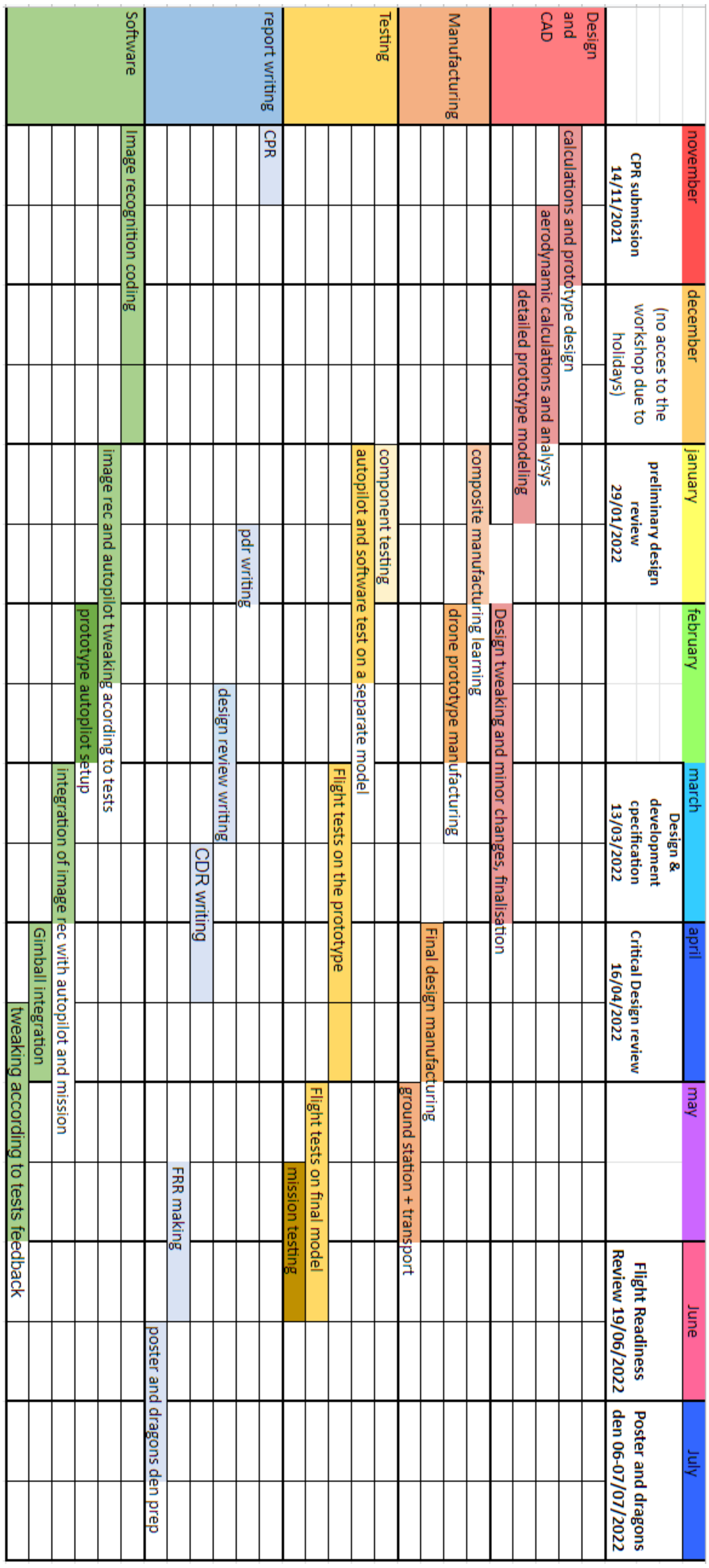
Ardupilot

Ardupilot this year shall remain largely the same and will be running off pixhawk cubeblack. Ardupilot is used by nearly all teams and is very reliable and widely documented making it easier to use.
Ardupilot has built in presets and we shall be using the Vtol QuadPlane preset (even though we have a tricopter). It isn’t perfect but with some modifications it will work to our needs well. In combination with the pixhawk the raspberry pi will also be used to locate markers and relay their coordinates to the ground station. The ground station shall be able to communicate up to 500m away.
This year the design is similar to last year and will share the same flight termination system that Depends on the current flight mode. Once FTS is triggered, during vtol mode, a command to descend immediately is given, in horizontal mode, power to the props is cut and the drone is commanded to glide down in a spiral pattern.

Project Plan

The project begins with the design of the prototype. At this stage most of the calculations will be done and specific characteristics will be determined. Modeling in cad will begin. When enough characteristics are determined the aerodynamics analysis will begin to determine the airfoils and wing dimensions. After detailed modeling begins with design of all parts that will be on the prototype. In the meantime, image recognition software is being coded. Once the winter holiday is over in January, and the cad model is mostly complete, we get wild. New manufacturing technique learning commences, components that can be manufactured like 3d printed parts are put to the test to determine their performance, the software team tests and continues to develop image recognition and autopilot on a separate drone. At the second part of the month PDR is conducted.A Once the team is confident in its composite manufacturing techniques, in february, the prototype manufacturing begins. Manufacturing brings out issues that have not been noticed during design, so the cad model is tweaked along the way. The autopilot is set up on the prototype.at the second half of february the Design and development specifications review will begin and will be written approximately in a month. Once the prototype is finished, tests begin immediately and as well as basic software tests. If all goes well, CDR will start being written in the middle of March. Once enough tests are conducted on the prototype and the design is confirmed, a second, final drone will begin to be manufactured. Same time the software team configures the camera gimbal. Finally, once the second plane is built, tests are run on it, to perfect the software performance and practice the mission, while the transport container for it is manufactured. With the results FRR is made and the dragons den video and posters are prepared for the challenge

Project Plan



Graphics

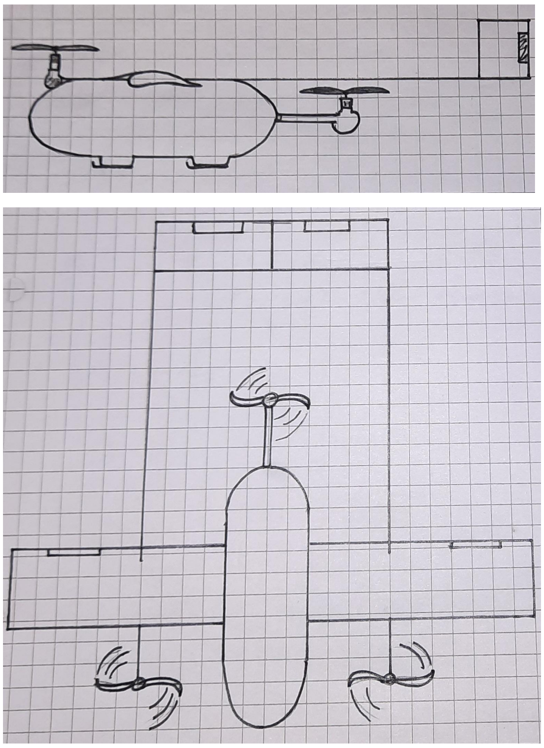


fig 1. Current design top and side view

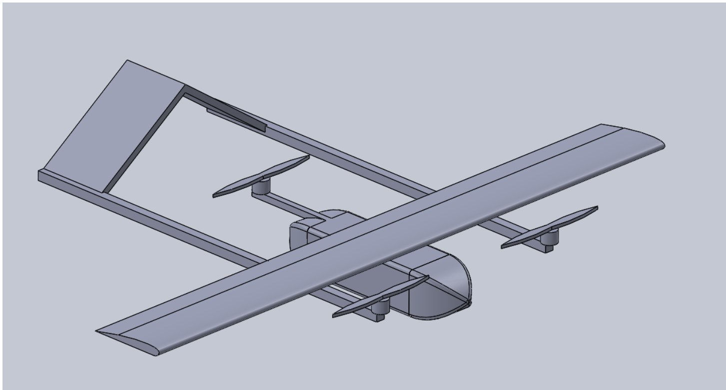


fig 2. Chosen concept model

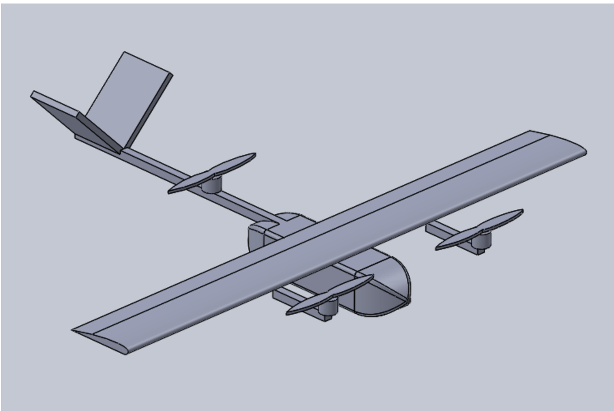


fig 3. Declined concept 1

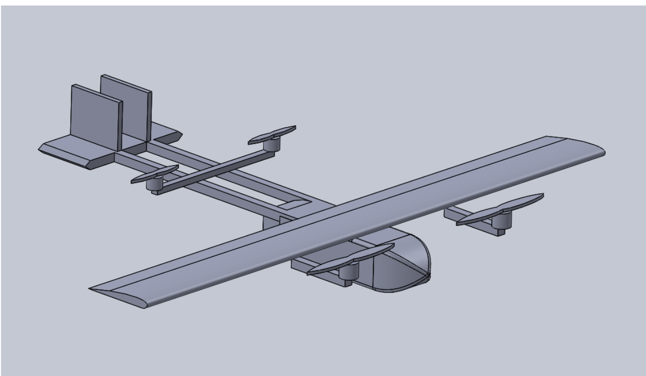


Fig 4. Declined concept 3