MULTI-ROTOR UAV

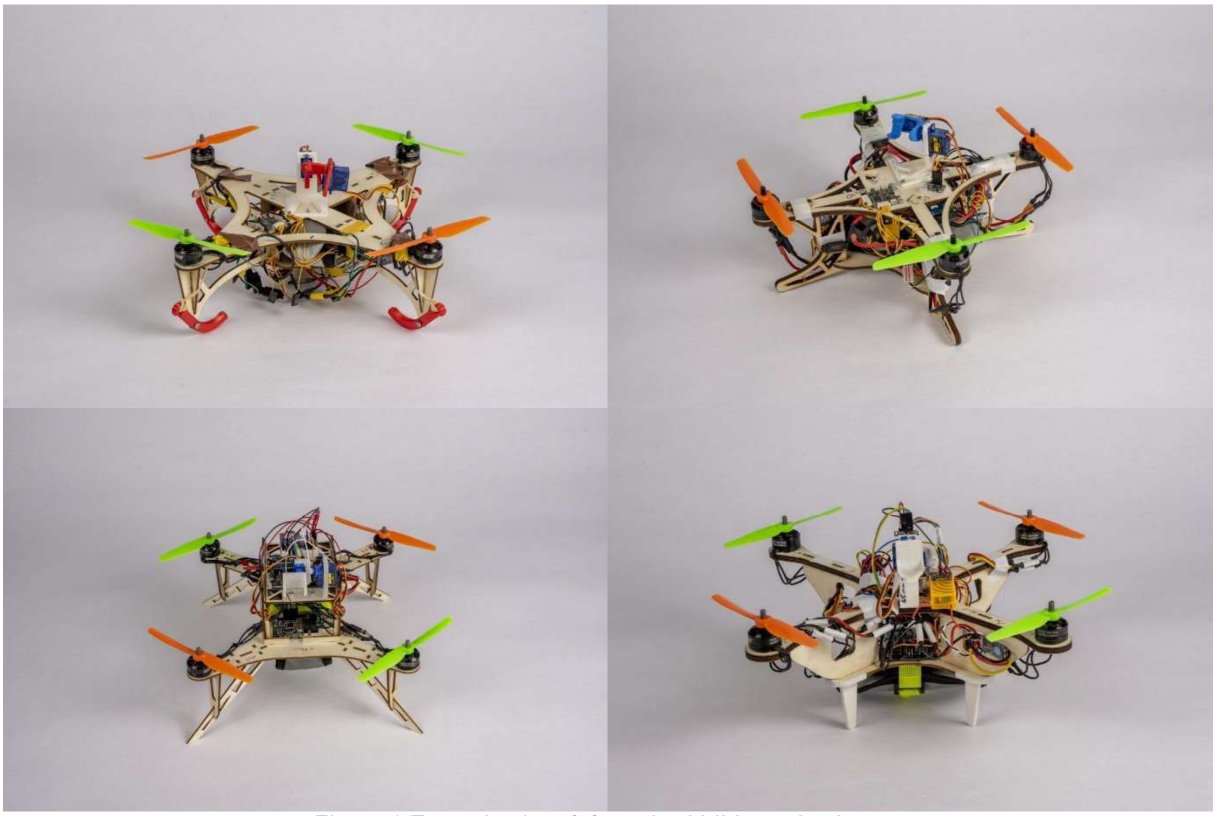

Figure 1 Example aircraft from the 22/23 academic year

Overview and Design Context

Multirotor aircraft have increased in popularity over the past decade. While not having the range and endurance of their fixed wing counterparts they more than make up for this with their vertical take-off and landing capabilities with their ability to hover making them extremely versatile camera platforms. Camera equipped multirotor aircraft have found uses in television and film, search and rescue and the inspection of engineering systems and infrastructure. The overall aim of this project is to design the main structure, flight recorder and a stabilised camera gimbal for a quadcopter which could be used for inspection purposes. Examples of previous aircraft are presented in the Figure 5 above.

Performance requirements

There are a number of important design constraints which must be met when designing your system.

Structural Design:

Each group is free to design the structure of their aircraft as they see fit but the final design must meet the design constraints outlined below. Aspects of the structure to consider include:

1. The housing for the electronics, sensors and batteries. This should be modular allowing easy access to the components and therefore easy replacement of damaged parts and the battery.
2. The arms and/or connectors for the motors. The motors should be attached to these and they should be capable of resisting all torque and bending loads.
3. A set of landing gear/legs/struts should be designed and capable of surviving hard

landings.

All of the designed structures should be lightweight and capable of withstanding any loads that the aircraft may encounter. Particular emphasis should therefore be placed on performing a structural analysis of the components, the selection of materials and design optimisation of the components for strength, vibration response and mass. Evidence of an analysis-based iterative structural design process will therefore be expected.

Gimbal Mechanism:

Each group is free to design the camera gimbal as they see fit as long as it meets the following design constraints:

1. The mechanism should be capable of housing a mini HD FPV camera (dimensions will be provided). The fit against these dimensions (including screw position) will be part of the assessment of your build.
2. The mechanism should have at least two axis of movement (minimum of pitch and roll).
3. The mechanism and associated control system should be capable of self-levelling.
4. The mechanism and associated control system should be capable of locking the gimbal to the axis of the aircraft.
5. The pilot should be able to switch between the above two modes of operation remotely through a switch on the transmitter.
6. The gimbal must be of your own design. Off-the-shelf systems cannot be used.
7. The camera should be positioned above the plane of the rotors.

As with the aircraft's main structure, this mechanism should be both strong and light. Appropriate structural analyses and assessments of the motion of the gimbal should therefore be performed. Automation and control will be assessed as part of a combination of bench and flight tests.

Arduino Flight Computer:

Each group must develop an Arduino-based flight computer and control system. This system should adhere to the design constraints given below but should be capable of:

1. Recording as much useful flight data as possible to a SD card from any sensors on board the aircraft.
2. Controlling the gimbal as per the gimbal design requirements.

General Design Constraints:

There are a number of additional general design constraints which must be met when designing this aircraft:

1. The motors for the quadcopter should be placed in a square planform with the axis of each motor 235.0mm apart, see Figure 6 below.
2. The footprint of landing gear/legs/struts should be no greater than 275mm square.
3. Two motors should be configured to spin clockwise and two anticlockwise.
4. Motors spinning in the same direction should be placed along the diagonal of the planform (the red propellers in Figure 6 below, for example, should spin in the same direction).
5. Only the provided flight systems may be used e.g. batteries, flight controller, power distribution board, speed controllers, motors and propellers.
6. Arduino components and sensors can be used in any combination or configuration. Additional sensors or breakout boards can be used but the project is restricted to the

use of an Arduino UNO board.

7. The battery should be housed within the provided li-po battery bag with the bag secured to the aircraft using the provided Velcro strap. This will mitigate battery damage from propeller strikes, crashes etc. Aircraft not meeting this safety requirement will not be permitted to fly.
8. The flight controller should be capable of being remotely armed/disarmed (see the flight controller guide for further information on this).
9. The total aircraft mass should be less than 0.65kg.
10. The aircraft, including electronics, should be assembled and ready for flight within 5 minutes.

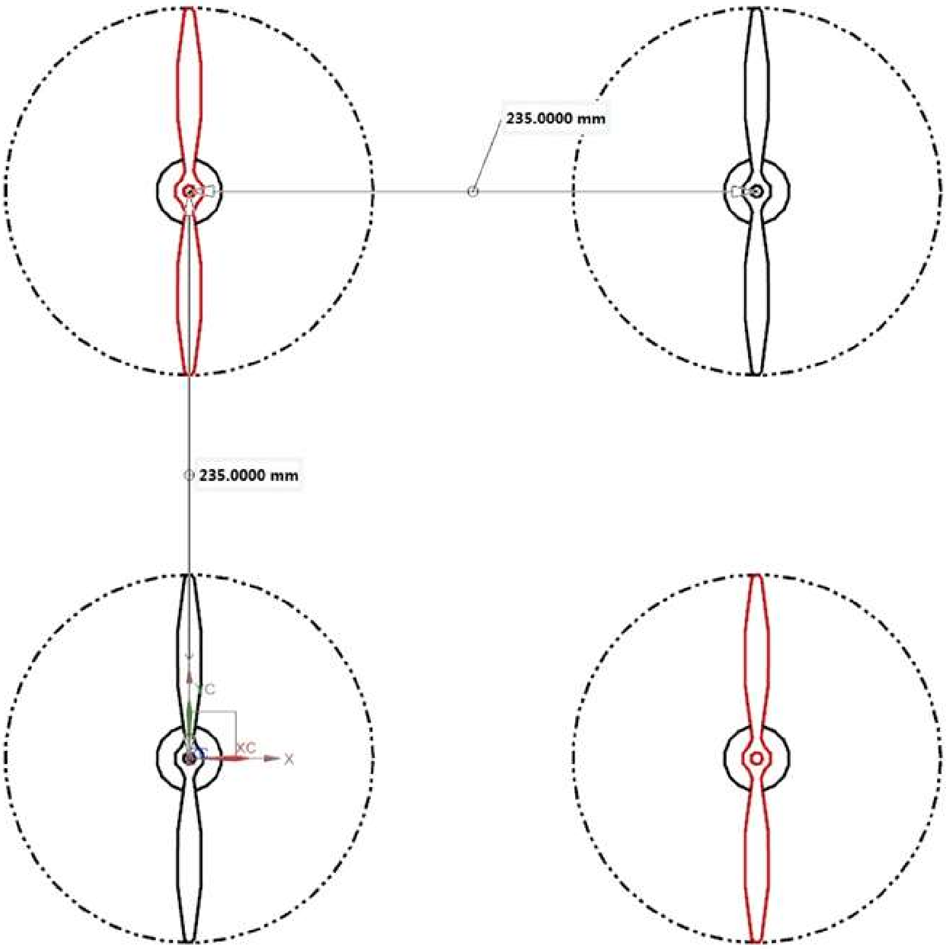

Figure 2 Quadcopter bounding dimensions

Performance Assessment

Testing of the final prototype aircraft and gimbal system is based on four areas, outlined in Table 2 below along with the marks awarded.

Testing of final prototype element	Percentage of prototype testing
Design innovation	15%
Adherence to design brief	15%
Prototype build quality	20%
Flight & bench test performance	50%

Table 3 - Breakdown of multirotor prototype testing marks

Flight and bench test performance is further broken down to consider the:

- Gimbal performance when encountering slow and rapid step changes in aircraft attitude
- Performance of the gimbal when locking and unlocking remotely
- Structural performance of the aircraft during both bench tests and in flight
- General flight performance of the aircraft encompassing take-off, a set of manoeuvres to induce a step-like response in the aircraft's attitude and landing
- Gimbal performance during flight

Performance of the aircraft and gimbal will be recorded through a combination of HD video and motion capture. Motion capture data will be provided to each team for comment upon within their final report (see Figure 7 for an example).

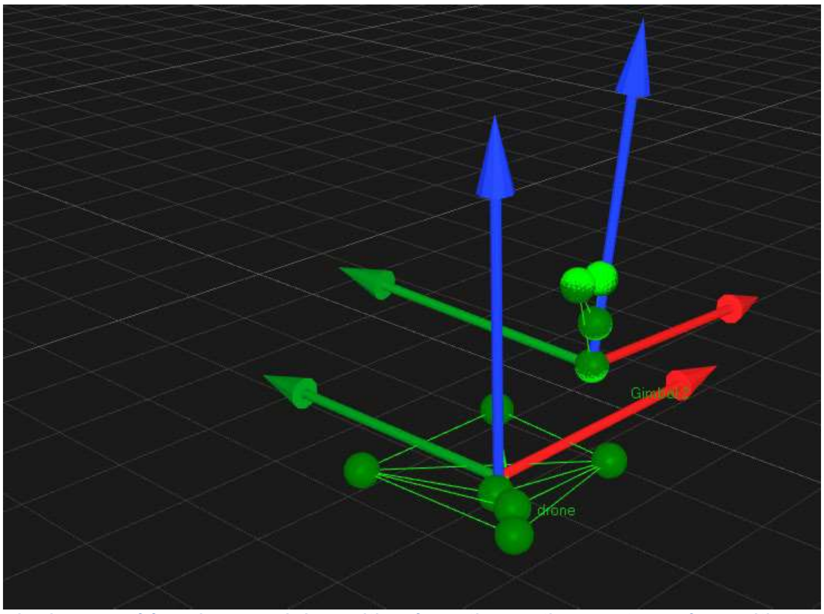

Figure 3 Example six degree of freedom model resulting from the motion capture of a multirotor aircraft in flight

Project-specific Components & Materials

You will not be provided with any structural components these should all be designed and manufactured by your group. However, you will be provided with a number of electronic components which must be returned at the end of the project. These include:

1. One flight controller & USB cable
2. Four speed controllers
3. Four brushless motors
4. One 1800mAh 3S 40C lipo battery pack (borrowed from B177 workshop and to be returned after every lab session)
5. A 2.4Ghz, 6 channel receiver
6. Four Gemfan 6030 propellers (6" diameter) (2 clockwise & 2 anticlockwise)
7. One power distribution board
8. One 6 DoF sensor board (accelerometer and gyroscope)
9. One li-po battery bag and Velcro battery strap
10. One Arduino SD breakout board with SD card and USB reader

In addition to this each student should already have an Arduino Uno board and the contents of the kits handed out in semester 1. Groups will also have access to a number of consumables such as wire, wood, stripboard etc.

To assist with the design of the aircraft a number of additional resources have been provided including:

1. Transmitter/receiver binding instructions.
2. Manuals (where available) for all provided electronic components and transmitters.
3. Schematics for a basic quadcopter wiring loom.
4. A document on getting started with the flight controller.