TOPDRONE

Autonomous Aircraft Carrier Operations

Description, Rules and Procedures v0.2 20150511

Task Description

The objective is to build a system capable of launching and landing miniature aircraft autonomously. The system must complete three key tasks without human intervention, with a fourth bonus task for extra credit.

Launch: A miniature aircraft will take off from a specified launch zone on the deck of the carrier. The aircraft will clear a "high bar" obstacle between 0.75 m and 1.5 m high, and no closer than 3 m from the front edge of the carrier deck.

Landing: The aircraft will be released from between 0.75 m and 2 m height and at least 4 m from the rear edge of the carrier deck. The aircraft must be directed to land on and come to a complete stop on the carrier deck. The deck landing must minimise airframe g-loading, as measured by a carried inertial sensor package.

Circuit: The carrier front and rear sections will be separated and placed in a straight line, no less than 4 m apart. The aircraft will take off from the launch zone of the front section of the carrier deck, clear a "high bar" obstacle and then land on the rear section of the carrier deck, while staying within g-limits.

A final bonus task will be made available to teams that demonstrate a successful circuit during an incremental demo:

Dummy strike: While completing a circuit, the aircraft will release a marker while passing over a target. The closer the marker lands to the target, the more bonus points will be awarded. The aircraft must launch and land successfully for marks to be awarded.

All-up system testing will occur during scheduled demonstration sessions in week 13. There will be incremental demos from weeks 7 to 11, allowing partial functionality to be demonstrated.

Testing Procedure

Each demonstration session will run for 25 minutes, during which students must complete all required setup, conduct launches and landings. Teams may conduct as many test flights as they can manage within this time. After 25 minutes, the students must cease flight operations and will have 5 minutes to pack down and clear the deck ready for the next team. Build quality must be assessed during the 25 minute slot.

During each test flight, the team will configure the carrier decks as necessary for the particular test being undertaken; tape on the ground will indicate the required deck positions. Prior to launching or releasing the aircraft, the team must **ensure that all team members and bystanders are behind the flight line tape**. The team must not initiate a flight (i.e. trigger a launch mechanism or release an aircraft) until given clearance by the instructor – unauthorised flights will not be scored. Launch and landing tests that include an instrument package must have the package fitted, and reset by the instructor prior to launch. Team members must not interfere with the aircraft or deck equipment prior to the instructor scoring the flight.

Scoring

Task performance will be assessed by a points system based on demonstrated performance and build quality. Refer to the separate build quality rubric and guidelines for build quality specifications. Only the performance of the overall system will be considered; no part will be considered separately. No marks will be awarded for aircraft build quality. No points will be awarded for buzzing the tower.

Build Quality	**10/10 Points**

Launch Functionality	**40/40 Points**
Aircraft leaves the deck	15
Aircraft clears the high bar	25

Landing Functionality	**30/30 Points**
Aircraft touches the landing deck	10
Aircraft at rest on deck	5
Aircraft at rest on deck ‘stable wheels down’	5
Aircraft does not exceed 16 G	1
Aircraft does not exceed 8 G	2
Aircraft does not exceed 4 G	3
Aircraft does not exceed 2 G	4

Circuit Functionality	**20/20 Points**
Aircraft touches the aft deck	5
Aircraft at rest on the aft deck	5
Aircraft at rest on deck ‘stable wheels down’	5
Aircraft does not exceed 8 G	2
Aircraft does not exceed 4 G	3

Bonus Functionality	**10/10 Points**
Dummy drop within 50 cm	1
Dummy drop within 30 cm	2
Dummy drop within 20 cm	3
Bullseye (within 10 cm)	4

Definitions

Instructor:	The course coordinator (or duly appointed representative) overseeing testing.
Aircraft:	The airborne part of the system. Any unattached component of the system that may leave the surface of the carrier is deemed to be part of the aircraft.
High bar:	The high bar is an obstacle that aircraft must fly over. It will take the form of a suspended cotton line to limit damage to aircraft that do not fly high enough to pass.
At rest:	The aircraft has zero velocity in all axes.
On deck:	The aircraft is in contact with the painted deck surface, with no part of the aircraft touching the ground or any object other than the carrier or its deck equipment.
Stable wheels down:	The aircraft is at rest on deck, oriented right-side-up with its landing gear (or appropriate bottom surface) in direct contact with the deck.
Flight line	The floor tape demarcating the flying space from the safe area. For safety, during test flights all team members and bystanders must be behind the flight line.

HMAS Gatton

The Autonomous Naval Aviation Academy operates from HMAS Gatton, a straight-deck light aircraft carrier custom built for launching and recovering unmanned aerial vehicles. It operates a single launch bay and recovery deck, and features fixtures for modular deck equipment.

Key Features

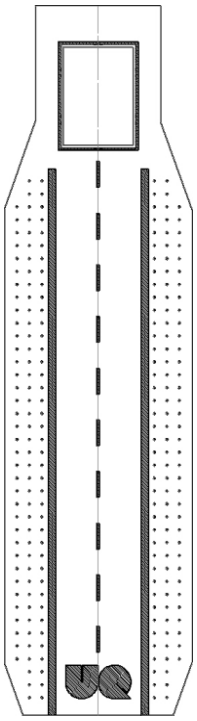
Carrier: The carrier comprises two sections: the bow and aft. The surface is composed of a wood deck fitted onto a standard table frame.

Deck: The deck is the flat, painted landing surface of the carrier. The deck is drilled with pegboard holes to which launch, arrest and sensor systems may be fitted. The deck will be between 0.5 and 1 m above the floor.

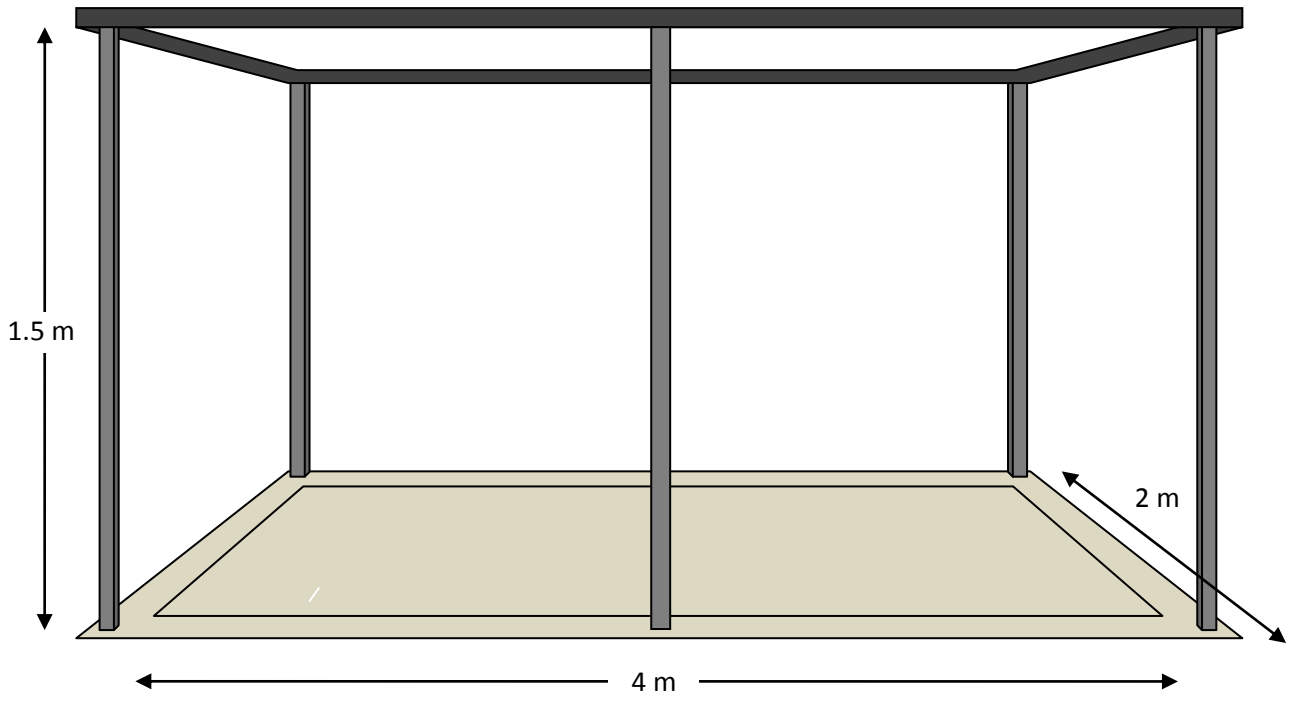
Launch zone: The launch zone is demarcated by a coloured box. No part of the launch system may move outside the launch zone.

Launch bay: A cut-out in the centre of the launch zone has a rebated edge for mounting different modular launch mechanisms. Launch mechanisms are held in place with clips around the edge. Vertical shield panels under the deck provide protection in case of catastrophic mechanism failure.

Landing strip: Painted landing surface demarcated by white guide lines and "UQ device" at the aft. The landing strip has no pegboard holes.



For testing, the bow and aft of the carrier can be separated, allowing an aircraft to launch from the bow and then land on the aft deck. As part of the landing strip runs onto the bow section, during circuit testing the available landing strip will necessarily be shorter. The ship will be set up in Mansergh Shaw 207, in the METR4810 testing arena. The arena consists of a 4 m x 2 m open space surrounded by framework to hold up netting. The frame is 1.5 m high.



Instrumentation Package

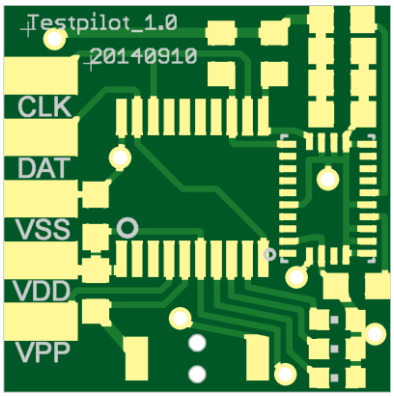
The landing and circuit tasks will require the aircraft to carry a small instrumentation package that measures g-force loadings. The package is 16 mm x 16 mm, and weighs less than 5 g. It incorporates a Bosch BNO-05S 9-DOF MEMS inertial suite, and reports the maximum experienced g-force measurements using a set of indicator LEDs. No data or measurements from the sensor will be made accessible to the team. The aircraft may provide the sensor power with a 3.0 to 3.6 V supply, or it may be powered by the lithium polymer cell provided.

On start up, the circuit will light up each of its LEDs in sequence as part of its boot process. It will then go into standby mode, as indicated by the amber LED flashing. To start the measurement process, press the tact switch once. After a 3 second delay to allow the sensor to come to rest, it will then enter calibration mode and flash its green and amber LEDs repeatedly for up to 45 seconds. When calibration is complete, the sensor will enter standby mode until armed. Touching the tact switch again will arm the device; after three seconds to allow the sensor to come to rest the sensor will start measuring.

Once armed, the sensor will light up LEDs in response to maximum measured acceleration:

<2 g	Green LED flash every 5 seconds
2 – 4 g	Green LED lit
4 – 8 g	Amber LED lit
8 – 16 g	Red LED lit
>16 g	Red LED flashing

After activation, be careful in moving the sensor to read its output as rough handling may trigger higher g measurements. The circuit is reset manually by pressing the tact switch.



System Design Guidelines

Each team must construct one set of launch equipment, landing arrest equipment, telemetry and sensors systems and an aircraft, using a limited budget. At least one component must be machined from metal, using milling, turning, water-jet cutting or any combination thereof. At least one custom PCB must be produced. The instructor shall be the final arbiter of whether the any part of the system, or the system as a whole, is legal within the guidelines. Two MS Livecam Studio Pro webcams will be made available to the class for use.

Launch System

Dimensions

The entirety of the launch system must fit within the boundaries of the launch zone: 400 mm x 300 mm, with a maximum height of 500 mm above the deck and depth down to the floor (est. > 500 mm). No part of the launch system may exceed the boundaries of the launch zone at any time, with the exception of wires for arming and trigger switches.

Construction

The launch system must have a solid wood or metal 'top cover' that fits into the launch bay receptacle. The cover must completely enclose the energetic parts of the launch mechanism. Small holes for arming status indicator lights and power switches, and a single slot to allow a force transfer device to engage with the aircraft, provided the perforations do not compromise the structural integrity of the cover.

Activation and Power Source

The launch system must be capable of remotely arming and triggering, using two separate switches or wireless transmissions. The system must be absolutely incapable of activating in the unarmed state. Stored energy for the launch system in the unarmed state must take the form of gravitational energy or a charged electrical device, in series with an isolator switch; no external power may be provided. **Li-poly batteries may total no more than 15 kJ maximum energy capacity.**

Arrest System, Sensors and Telemetry

Dimensions

The landing arrest system, sensor array and telemetry system must fit within the planform of the carrier deck. No part of the deck systems may overhang the sides of the deck. The deck systems may extend up to 500 mm above the deck, with depth down to the floor.

Construction

Deck equipment, markings, tags, lights and other fittings may be attached to the deck, either through the provided pegboard holes or using non-permanent, non-marking adhesive. The permission of the instructor must be obtained prior to using any adhesive on the deck surface. No equipment may be attached to the deck support frame. Self-contained computing hardware (such as a desktop tower with UPS or laptop) may rest on the ground under the deck or, if connecting wirelessly, outside of the testing arena. No wires may run to/from the carrier.

The arrest system must be passive, with no capacity to add stored energy to the aircraft, except with express permission of the instructor.

Aircraft

Dimensions

The aircraft must fit within a 750 mm diameter footprint, and have a total weight of no more than 150 g fully loaded, including any payload.

Construction

The aircraft may not contain metal airframe structural components, except by permission of the instructor. The leading edges of the aircraft must be sufficiently rounded so as not to pose a cutting or puncturing risk in case of accidental launch. The aircraft must be incapable of penetrating a piece of office paper when dropped from 2 m. A rubber or foam nose is strongly recommended. Depron or foam core cardboard laminate sheets make excellent light-weight building materials.

Power Source and Propulsion

If the aircraft is propelled by onboard power, electrical energy stored in batteries is strongly recommended. No form of compressed fluid energy storage, chemical fuel or nuclear energy source may be used, except with express permission of the instructor.

Only ducted fans that come with an integrated rigid safety duct may be used. **At no point during the semester may any spinning propulsive element be energised outside of a safety duct.** This rule must be adhered to at all times, whether in the lab or during testing, and will be ***strictly enforced***.

Budget

The total cost of materials, parts and components incorporated in the product shall be no more than $150 (excluding the MS Livecams and off board computation, e.g. laptops). Regardless of actual cost to construct, the team must demonstrate that the product produced *could* be constructed from parts costing less than or equal to $150. Up to $150 will be provided for purchase orders through ETSG. **Reimbursements will *not* be permitted.**

Cost of parts shall be calculated on a per-item basis; parts that are purchased in multiple units may be costed per unit – e.g. a bag of 10 nails for $10 may be charged at $1 per nail used. Bulk unit discounts from suppliers may be applied, provided the quantity of items used in the product is sufficient to earn the discount. Items sourced for free (i.e. not paid for) may be costed at half the market purchase price. While it is not necessary to have circuit boards manufactured at ETSG, any boards produced by outside fabricators must be purchased via ETSG in order to be paid out of budget.

Each team will be provided with 500 g of 3D printer filament in a unique colour. Once this material has been exhausted, no further filament will be provided or nor may be purchased with the build budget. Only the provided filament may be used in submitted work.

Specific Prohibitions

- **No unshielded propellers, rotors or fans**
  At no point during the semester may any spinning propulsive element be energised outside of a safety duct. This rule will be ***strictly enforced*** as part of the lab safety requirements. Failure to abide by this rule will lead to immediate barring from the lab for the remainder of the semester.

- **No human input**
  Remote control, tele-operation or other input devices must be removed or disabled prior to the start of demos. The instructor may elect to have the disabled or removed state of any input device demonstrated prior to a flight. The instructor shall be the final arbiter of whether the steps taken to disable a device are adequate.

- **No additional off-board sensing**
  Only sensors mounted on the aircraft and carrier may be used. Sensors on off-board computers, such as webcams, must be disabled. The instructor may elect to have the disabled status of any sensor demonstrated prior to the start of a flight. The instructor shall be the final arbiter of whether a sensor is adequately disabled.

- **No outside markers or alterations**
  No signs, structures, markers, radio beacons may be installed outside of the carrier deck. No alterations may be made to the carrier deck. Aircraft, launch systems or arrest equipment that cause damage to the deck may be prohibited from operating.

- **No internet connection**
  No part of the aircraft, support equipment or off-board processing facility may be connected to the Internet. Where wifi or similar wireless protocols are used to connect between the aircraft and another computer, it must be demonstrated that no computer on its network is connected to the Internet. The instructor may elect to have the connection status of any input device demonstrated prior to a flight. The instructor shall be the final arbiter of whether a connection constitutes connection to the Internet.

The Aim of the Project and the Spirit of the Rules

Without a doubt, engineering students are extremely creative and talented at finding clever solutions to difficult problems. This project aims to teach you about the practical trade-offs encountered by engineers when facing a multi-faceted challenge with broad scope and many possible solutions. It is recognised that no set of rules could cover every possible edge-case without becoming cumbersome fodder for 'rules lawyers'.

Thus, the two cardinal rules are:

1. The instructor's decision is final.
2. Stay within the spirit of the problem.

If you think what you are attempting might not be in accordance with the spirit of the rules… it probably isn't. However, there is no harm in asking! The instructor will rule whether a particular approach is permissible. It is best to ask these sorts of questions early in the semester!

Other Miscellanea

By-laws, clarifications and addenda go here. This used to be a short section, but previous years' students have shown that it is *depressingly* necessary to spell-out exactly what you should not be doing. But you're going to be smarter and better dressed than them, *right*? ☺

1. All OH&S inductions and procedures *must* be adhered to. You **WILL** be ejected from the lab if you are unsafe or in violation of footwear requirements. Repeat offenders will be barred from the teaching labs for the remainder of the semester.

2. It is the responsibility of all students to keep the teaching labs in clean, functioning condition. Lab cleanliness will be arbitrated by a warning system, as posted on the class blackboard site and class website.
    a. The lab status starts at GREEN.
    b. If the condition of the labs deteriorates and becomes messy, status will change to YELLOW, indicating that a clean-up is needed.
    c. If conditions do not improve or deteriorate further, the status will be changed to RED and the labs will be set to fixed-hours, with after-hours access prohibited.
    d. If conditions still do not improve or deteriorate further, the status will be changed to BLACK and the labs will be locked to students until the next practical session, whereupon the labs must be completely cleaned before any work may resume.

3. The following are specifically prohibited:
    a. Eating in the lab
    b. Sleeping in the lab
    c. Leaving the lab door open (all students have access cards)
    d. Giving non-enrolled students/non-students access to the lab
    e. Non-work related activities (e.g. computer games)

    Students found to be violating these rules will have lab access revoked.

4. Under no circumstances may project infrastructure, test equipment, tools, supplies, furniture, etc. be removed from the teaching labs. 'Vegas rules' are in effect: what happens in c404/c403 *stays* in c404/c403. Transgressors will be barred from the teaching labs for the remainder of semester.

5. No grade will be awarded until all assigned tools and equipment are returned and accounted for. Students are separately and collectively responsible for their group's tools.