BARCELONA

Smart Drone Challenge 2020

Competition Rules

Mission and Competition Rules Issue 13, October 2019

Contents

Glossary and Abbreviations

AESA	State Air Safety Agency
AGL	Above Ground Level
BMFA	British Model Flying Association
BRS	Ballistic Recovery Systems
BSDC	Barcelona Smart Drone Challenge
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CAT	Catalonia
CDR	Critical Design Review
COTS	Commercial Off The Shelf
EU	European Union
FMC	Flight Management Computer
FRR	Flight Readiness Review
FSO	Flight Safety Officer
FTS	Flight Termination System
FW	Fixed Wing
GCS	Ground Control Station
GPS	Global Positioning System
KIAS	Knots: Indicated Air Speed
MTOM	Maximum Take-Off Mass
PDR	Preliminary Design Review
PPE	Personal Protective Equipment
QFE	Q-Code Field Elevation - Altimeter zeroed at runway height
RW	Rotary Wing
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System(s)
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
WP	Waypoint

Competition Rules – Revision status

Issue 1, June 2015: Issued to Teams at the start of the 2015 competition

Issue 2, July 2015: incorporates responses to feedback and questions, including:

- Clarification on use and pricing of COTS items;
- Definition of the height of the alphanumeric code in the target area;
- Details of the supplied GPS Tracker;
- Clarification on the target Mission time;
- Clarification on automatic take-off and use of launch / recovery equipment;
- Additional details provided on Flight Termination System functionality;
- Clarification on dropping two payloads in the same sortie;
- Clarification on measurement of payload drop accuracy;
- Clarification on allowable means of protecting the payload;
- Confirmation that UA is not permitted to land whilst deploying the payload;
- Piloting competency requirements added.

Issue 3, March 2016: update to the example demonstration course and airfield map, Figures A2, A3.

Issue 4, April 2016: Extensively revised to incorporate feedback from the 2016 competition, and issued to Teams at the launch of the 2016 competition.

Issue 5, June 2016: incorporates responses to feedback and questions by UPC (Castelldefels).

Issue 6, June 2016: confirmation of demonstration event dates (29 Jun – 2 Jul 2016) in the "Circuit of Catalonia".

Issue 7, June 2016: Demo ….

Issue 8, December 2016: Small changes of date and adjustment of clearer words.

Issue 9, January 2017: Change in the logo of BSDC, place the word "Barcelona".

Issue 10, August 2017: Presentation of new Challenge 2017-18.

Issue 12, September 2018: To streamline the logistics of the demonstration and allow more teams to participate, we review the procedures. The score of the mission is simplified to help the judges. Creation of a new headline. Restriction in the electrical system voltage to 4S to limit the individual power of the motor. Clarifications and guidelines on the execution of the demonstration part. Review of the preparation time of the flight line to 5 minutes (it was 2 minutes). Review the score to reflect the only mission. A brief Preliminary Design Review (PDR) has been reintroduced….

Issue 13, October 28, 2019: revision of the document and updated for the 2020 challenge.

1 Introduction

1.1 Competition Overview

The challenge will engage University and Middle or Higher Cycle Schools undergraduate teams in the design, construction, development and demonstration of an Autonomous Unmanned Aircraft System (UAS). With a Maximum Take-off Mass (MTOM) **of under 7 kg**, and operating within Visual Line of Sight (VLOS), the Unmanned Aircraft (UA) will be we are **detecting over time a natural disaster**.

The system will be required to work automatically, performing a series of tasks such as area search, navigation of waypoints, capture of data and photographs of the area and return to the base through a defined route.

The competition will be held annually over the duration of an academic year, with the competition commencing in October 2019, and the flight demonstration being held in early July 2020. This period will be structured into design, development and demonstration phases, with a Design Review presentation **contributing** to the scoring, as well as the flying demonstration.

1.2 Objectives of the Event

The competition has a number of objectives, in particular to:

1. Provide an opportunity for students to learn practical aerospace engineering skills for industry;
2. Provide a challenge to students in systems engineering of a complex system, requiring design, development and demonstration against a demanding mission requirement;
3. Provide an opportunity for students to develop and demonstrate team working, leadership and commercial skills as well as technical competence;
4. Stimulate interest in the civil UAS field;
5. Enhance employment opportunities in the sector; and
6. Foster inter-university and Middle or Higher Cycle Schools collaboration in the UAS technology area, and to provide a forum for interdisciplinary research.

1.3 Real World Scenario

The real-life scenario is set in the near future. We are detecting over time a natural disaster, with a large area extension of our mountains in Catalonia. It is known that several thousand hectares of forest areas are affected by different situations from problems with snow in winter or parasites in trees such as the processionary, forests are very affected, urgently need emergency supplies forestry, detention and possible supplies of first aid. Time is critical, and a UAS (dron) with a detention mission is launched from the Research Center at a certain distance from the affected area.

The UAS (dron) operates automatically, traveling quickly through pre-planned route points to any affected area, and deliver the information in a safe and accurate way to the Research Center.

During the mission, find other possible observation beneficiaries in defined areas, and transmit location coordinates back to the base so that others can observe on subsequent flights.

The mission can be organized. Return to the base through a different route to ensure conflict with other UAS of surveillance that operate in the area. The mission is repeated in all climatic conditions until the need to abandon the search yields, maintaining a stable line of information in the devastated area and the coordination group sees it as successful completion of the mission.

1.4 Structure of this document

Section 2	presents the overview of the competition, what is involved for participating teams, the schedule of key activities, eligibility and funding;
Section 3	presents the requirement specification for the UAS, with sufficient information for teams to design and develop the system;
Section 4	provides the 'Statement of Work' for the competition, outlining what is required in each of the stages, including the design review deliverables;
Section 5	presents the Adjudication and Scoring criteria. This should help the teams in selecting and designing their concept to maximise their score, especially at the Preliminary Design stage;
Section 6	summarises the Prize categories which will be awarded. These are designed to recognise merit and achievement in a range of areas reflecting the key competition objectives;
Annex A	provides the representative mission to be flown, and around which the UAS is to be designed;
Annex B	gives technical details of the GPS tracker to be fitted to the UA, so that teams can make allowance in the design for installation of this item;
Annex C	provides some general guidance to help the teams develop a practical and competitive UAS;
Annex D	gives templates and guidance for completion of the three design review deliverables, the PDR, CDR and FRR.
Annex E	provides guidance to the teams on autopilot selection.

1.5 Publicity

The Barcelona Smart Drone Challenge (BSDC) publicises the competition during the year to encourage participation and to promote the role of the assosiation and STEMcat. Please note that participants hereby agree that all content submitted to the BSDC may be used for promotional purposes, unless otherwise agreed prior to submission. Images and video taken at the flying demonstration event may be used for promotional purposes by the BSDC and its partners.

During the period of the competition, teams are encouraged to publicise the competition and their participation – via the media, social media, and for example by talking to local schools or other universities, either locally or nationally. A prize is awarded for the most effective use of publicity to promote the competition.

2 Competition Overview

2.1 Context

The competition is structured to replicate a real world aircraft system development programme, with a **phased 9 month design** and development process over the course of an academic year, and culminating in the build, test and demonstration of the UAS. Deliverables have been carefully specified to maintain reasonable technical rigour, yet aiming to keep the workload manageable for student teams.

2.2 Generic Mission Task

The challenge is to design, build and demonstrate a small autonomous UAS to fly a mission which is modelled on the real life humanitarian aid scenario described in Section 1.3. The competition will vary from year to year, but typically seek to test a number of characteristics, such as:

- Innovative concepts;
- Accuracy of payload delivery to pre-determined points on the ground;
- Maximum mass of cargo that can be safely transported in an allocated time;
- Quickest time to compete the payload delivery mission;
- Navigation accuracy via waypoint co-ordinates provided on the day;
- Search object recognition, detecting, recognising and geo-locating objects;
- Extent of automatic operations from take-off to landing;
- Safety, demonstrating safe design and flight operations throughout;
- Minimum environmental impact, notably noise levels and overall efficiency;
- Maximum payload / empty weight ratio.

The representative mission for the 2020 competition is presented at Annex A.

2.3 Development Stages

The UAS development stages comprise:

- Preliminary Design, culminating in the Preliminary Design Review (PDR);
- Detail Design, concluding with the Critical Design Review (CDR);
- Manufacture of the UAS;
- Test;
- Flight Readiness, including the Flight Readiness Review (FRR);
- Demonstration Event, including the Design Presentation, Scrutineering, Certification Flight Test, and the Demonstration (Mission Flight).

Section 4 provides details of the stages and the ‘Statement of Work’ for the competition. Templates for the PDR, CDR and FRR deliverables, together with guidance on what the judges are looking for, are provided at Annex E.

Figure 1 below depicts the competition stages, the key deliverables, the adjudication team leading the assessment in each phase, and the main Prize Categories*.

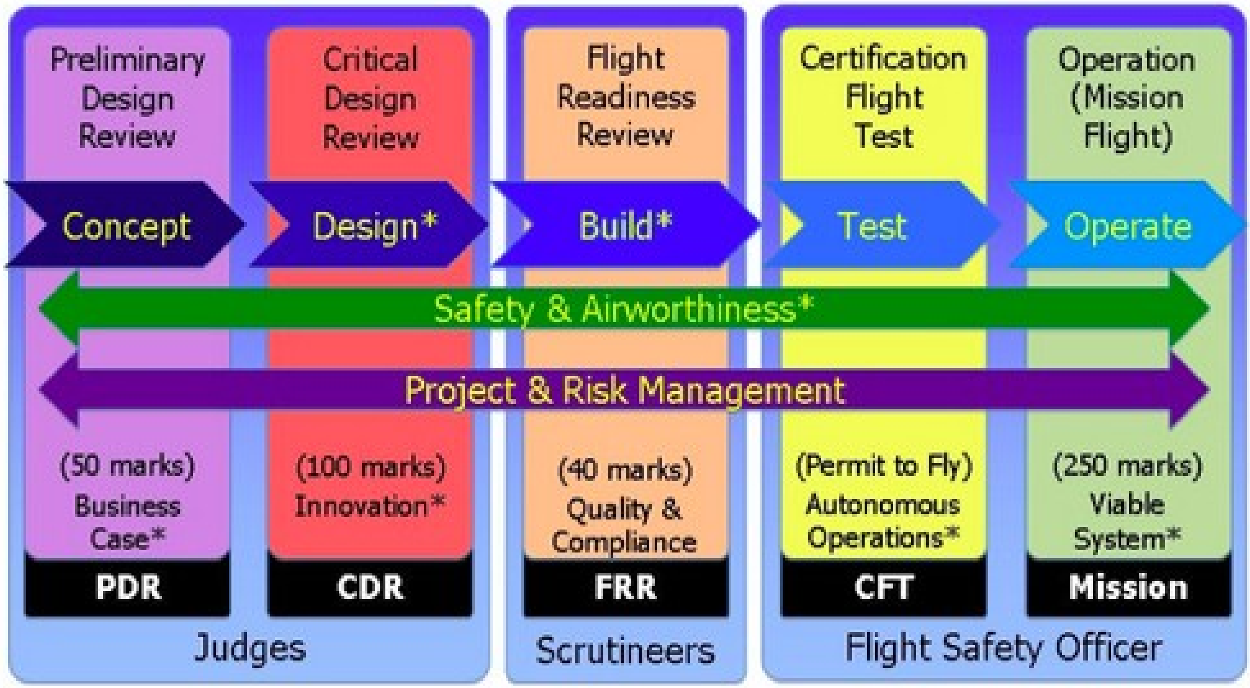


Figure 1: UAS Challenge Competition Stages

2.4 Challenge Schedule

The competition will be launched at the start of the academic year in Octubre. Key activities and dates are as follows:

Date	**Activity**	**Deliverable**
July 2019	2018/19 Competition Launch, coincident with 2019 ; Demonstration event	-
28 Oct 2019	2020 Rules provided to entrants	-
14 Feb 2020	Deadline for entries to be received	Entry form and fee
28 Feb 2020	Preliminary Design Review	PDR report
31 Mar 2020	Critical Design Review	CDR report
22 Jun 2020	Flight Readiness Review submission	FRR report
18, 19, July 2020	Demonstration Event, including: • Design and FRR Presentation • Scrutineering • Certification Flight Test • Mission Flight	Presentation FRR Scrutiny Flight Test Flight Demonstration(s)

Adherence to deadlines is a prerequisite for entry into the next stage, and the organizers retain the right to eliminate a team in the event that deliverables are not submitted on time.

2.5 Engineering Challenges

The competition has been designed to give students exposure to a number of disciplines that they will need in their engineering careers, and the requirement provides a number of engineering challenges. Factors which the judges will be looking for include:

- a methodical **systems engineering approach** to identify the requirements, selection of the concept with a design to meet those requirements, and then test to confirm that the actual system meets the requirements in practice;
- an elegant and efficient **design** solution, supported by an appropriate depth of analysis and modelling;
- **innovation** in the approach to solving the engineering challenges;
- due consideration of the **safety and airworthiness** requirements which shall be addressed from the early concept stage right through into the flying demonstration;
- appreciation of the **practical engineering** issues and sound design principles essential for a successful, robust and reliable UAS; e.g. adequate strength and stiffness of key structural components, alignment of control rods/mountings, servos specified appropriately for the control loads, consideration given to maintenance, ease of repair in the field;
- **construction quality**, paying attention to good aerospace practice for such details as connection of control linkages, use of locknuts, security of wiring and connections, resilience of the airframe and undercarriage;
- good planning and **team-working**; organizing the team to divide up roles and responsibilities. Good communication and planning will be essential to achieve a successful competitive entry, on time and properly tested prior to the Demonstration Event;
- automatic or **autonomous operations**; the UAS should ideally be able to operate automatically, without pilot intervention from take-off to touchdown;
- A strong **business proposition** for your design, demonstrating good commercial understanding of how your design might be developed to generate revenue for an operator.
- Attention to **environmental impact**, including minimising noise, developing an efficient aircraft design which minimises energy consumption, and attention to minimising use of hazardous materials.

The prize categories (see Figure 1 above and Section 6) aim to recognize merit in overcoming these engineering challenges. Guidance notes to help teams are provided at Annex D.

2.6 Eligibility and Team Structure

The Competition is open to **Undergraduates or students from any World University and Intermediate cycles of vocational training (FP & CAS)**. Whilst expected to be predominantly a CAT event, entrants from 'other countries' universities and middle or higher cycle schools are welcomed.

Teams will be put forward by each University and Middle or Higher Cycle Schools, and will constitute members drawn from student cohorts in any year of study.

A pair of Universities or and Middle or Higher Cycle Schools may form an alliance to enter a joint team. Some specialist industry support is to be allowed, where specific skills and knowledge are required outside the scope of the undergraduate students.

The numbers of students in each team will be entirely determined by each University and Middle or Higher Cycle Schools. This is so that the educational objectives can be determined to meet the needs of each University's (and Middle or Higher Cycle Schools) degree programmer. The competition, whilst having a set of defined performance objectives to achieve, is as much about the development and demonstration of team-working skills.

Please note that attendance at the Demonstration Event is limited to no more than **10 members** per team, plus up to **3 support staff**, e.g. pilots or academic staff.

2.7 Sponsorship of Teams

Universities or and Middle or Higher Cycle Schools are encouraged to approach potential commercial sponsors, particularly aerospace companies at any time prior to or during the competition, for both financial support and technical advice. Note that where technical advice is received from sponsors, the judges will need to be sure that by far the majority of the development work has been undertaken by the students themselves. Such sponsorship shall be fully acknowledged in the Design Review submissions.

2.8 Cost and Funding

An entry fee of **950€ (VAT 21% NOT INCLUDED)** per team is payable upon submission of an entry form. This fee contributes towards the cost of putting on the Demonstration Event. It is non-refundable in the event that a team cannot participate in the Demonstration Event.

We also give the option to the teams that need it to be **housed in a campsite** within the infrastructure of the Barcelona Smart Challenge. With the possibility of staying overnight with the rest of the equipment of the electric motorcycle, electric car, electric scooter and drones. The price of this, will be given separately depending on the needs of each team.

Universities and Middle or Higher Cycle Schools shall **NOT** fund the costs of their UAS design and development, and their attendance at the Design Review and Demonstration events.

2.9 Insurance

Teams are required to confirm that adequate insurance is in place, including but not limited to public liability insurance (**minimum XX€**) for the team. Declaration that cover is in place must be made via a liability waiver form which must be submitted with the FRR video and documents. Teams will not be permitted to participate without this confirmation.

Teams from outside of the European Union or Switzerland are required to present evidence of medical insurance covering participation in the UAS Challenge fly-off event. This must be provided with the liability waiver form which must be submitted with the FRR video and documents. Teams will not be permitted to participate without evidence of cover.

3 Design and Operational Requirements

The UAS shall be designed to perform up to three missions whilst being compliant with the specification defined in this section. The term 'shall' denotes a mandatory requirement. The term 'should' denotes a highly desirable requirement. Where a paragraph is in italics and preceded by "Note:" this indicates a point of guidance or clarification rather than a design requirement.

3.1 UAS Requirement Specification

The UAS shall be designed to meet the following constraints and have the following features:

3.1.1 Mission

The 'Natural Disaster' mission to be flown is presented at **Annex A**. Note that details of Waypoint co-ordinates will be provided at the start of the Demonstration Event.

3.1.2 Airframe Configuration and Mass

Either Fixed Wing or Rotary Wing solutions are permissible, with a Maximum Take- Off Mass (MTOM) not exceeding **7 kg**, including the payload(s).

3.1.3 Propulsion

Electric motors or internal combustion engines are permitted for propulsion.

3.1.4 Electric Systems

For Electric propulsion systems, the LiPo battery voltage shall not exceed 4S cells (14.8V nominal voltage, 16.8V maximum voltage at full charge). Batteries shall not be ganged together in series to increase the combined voltage above this limit.

There is no limit on the battery capacity (measured in mAh).

3.1.5 Payload Specification

The payload(s) to be delivered by the UA shall be standard commercially available **250cl of insecticide liquid**, provided to the teams by the organizers at the Demonstration Event.

3.1.6 Payload Carriage and Delivery

The UA shall be designed to carry and release up to **one payload**, as specified in Section 3.1.4.

The payload(s) shall be individually deployable from the UA by either manual or automatic command. Only one payload shall be jettisoned at any one instant, i.e. payloads may **not** be ganged together and dropped simultaneously.

The payload(s) shall be deployed whilst the aircraft is in flight, from any suitable height above the ground. The UA is not permitted to land to deploy the payload.

The UA design may incorporate features to provide protection and cushioning of the payload to keep it intact during the deployment and ground impact, but the payload shall **not** itself be modified, for example by permanent reinforcement with duct tape.

The payload can be inserted into a protective module, but without modifying the flour bags in any way. The flour cannot be decanted into a different container. Protection afforded to the bag of flour shall be removable without the use of any tools and without damaging the original packaging. Thus wrapping in bubble wrap is permitted.

To score maximum points, the payload shall remain intact through the deployment and after impact with the ground.

3.1.7 Autonomy

The UAS shall operate in a fully automatic manner as far as practicable, including automatic take-off and landing. UAS which are manually operated are permitted, although manual operation will score considerably fewer points.

Note: Stability augmentation systems do not classify as 'autonomous' or 'automatic' control, and shall count as part of manual control.

Note: Automatic take-off implies that the system, after it has been started, can be positioned at the runway threshold manually, then when the control transferred to platform, it executes the take-off without human intervention. Auxiliary launch/landing equipment is permitted, so long as it all operates autonomously. Hand launch is also permitted.

3.1.8 Limits on use of COTS Items

The UAS airframe and control systems shall be designed from scratch, and not based upon commercially available kits or systems. This is a qualifying rule, meaning that an entrant based on a commercially available system will not be eligible for consideration.

A guideline maximum value of COTS components used in the UA itself is **1,200€**. A Bill of Materials and costs will be required as part of the design submission. Cost efficient solutions will score more points.

Teams may use COTS components which already exist at the University and Middle or Higher Cycle Schools, but for which no receipts are available. An estimate of the price can be obtained by looking up part numbers or by manufacturer, and a screen shot of the price will suffice.

Teams shall also demonstrate that manufacture of the airframe and integration of the UAS involves a significant proportion of effort from the students themselves, rather than being substantially outsourced to a contractor.

*Note: Permitted Commercial Off The Shelf (COTS) stock component parts include motors, batteries, servos, sensors, autopilots and control boards such as the Pixhawk or Ardupilot platforms. Guidance on potentially suitable autopilots is provided at **Annex E**. Teams are allowed to use the supplied software with COTS autopilots, although it may need modifying to meet the specific mission challenges.*

3.1.9 Radio Equipment

All radio equipment and datalinks shall comply with AESA/EU directives, and shall be licensed for use in the Catalonia (Spain).

Radio equipment, including data links, shall be capable of reliable operating ranges at least of 1 km.

Radio equipment providing control of the UA and the Flight Termination System shall be 'Spread Spectrum' compliant on the 2.4 GHz bandwidth, to allow simultaneous testing of several UAS without interference. Evidence of compliance shall be presented in the CDR submission and at the Flight Readiness Review.

The radio equipment shall include a buddy box transmitter, which as a minimum shall allow the Flight Safety Officer to activate the Flight Termination System should this be required.

If an imagery downlink is incorporated, and if it is central to the safety of flight, control or for Flight Termination decisions, then it shall be suitably reliable and resilient to interference.

3.1.10 Camera / Imaging System

The UA should carry a camera system and target recognition capability to undertake the target search, location and identification exercise set out in Mission, see **Annex A.3.2**.

3.1.11 Location Finder

It is recommended that in the event of the UA making an un-commanded departure and landing outside of the designated Flying Zone, the UA makes an audible/visual warning to improve ease of UA location.

3.1.12 Tracking System

A GPS Data Logger shall be fitted permitting post-flight evaluation of the 3D trajectory. Organizers may ask a team member to provide a file with the GPS tracker for each team at the start of the demonstration event, which operates independently and can be easily integrated into the UA. A full specification for the new GPS tracker is attached at **Annex B**. The tracker shall be easily releasable from the UA, for analysis by the organizers after each flight.

3.1.13 Environmental Impact

In the design process, consideration should be given to environmental impact, including the use of non-hazardous and recyclable materials; low pollution; low energy usage; low noise.

Teams are encouraged to determine the overall energy consumption of the Mission Flight, as a measure of the efficiency of the UA. For IC engines, this could be done simply by measuring the fuel usage, and to facilitate this the fuel tank should be designed to be readily removable from the UA so that it can be weighed (or contents measured) before and after the flight.

For electric powered UAs, the electrical energy consumed could be measured directly, for example via a power logger between the ESC and the electric motor. Points will be awarded both for incorporating into the design the ability to measure the energy consumption, and also for achieving good efficiency.

3.2 Operational Requirements

3.2.1 Missions

A single mission is defined at **Annex A**, testing different capabilities of the UAS which would be important for a humanitarian aid delivery system.

The scoring criteria for the Mission is provided at Section 5.

3.2.2 Take-off and Landing

The UA shall be designed to take off and land from within a 30 m diameter circle. Landing includes touchdown and roll-out, with the UA required to stop within the box.

The UA should be capable of operating from short grass or hard runway surfaces.

Use of an auxiliary launcher, or hand launch is permitted providing the design and operation is deemed satisfactory by the Flight Safety Officer and scrutineers.

3.2.3 Design Mission Range and Endurance

For the purpose of sizing the fuel / battery load, the design team should consider Mission **i**n particular, which is designed to test the endurance of the UAS.

The Mission will **not** require the UA to operate further than 500 m from the pilot.

For resilience of operation, the radio equipment including data links, shall be capable of reliable operating ranges of 1 km.

3.2.4 Weather Limitations

The UA should be designed to operate in winds of up to 20 kts gusting to 25 kts, and light rain. The UA should typically be capable of take-off and landing in crosswind components to the runway of 5 kts with gusts of 8 kts.

3.2.5 Ground Control Station

If a Ground Control Station is used, it is desirable but not mandated that the following information should be displayed and be visible to the Operators, Flight Safety Officer and Judges:

- Current UA position on a moving map;
- Local Airspace, including the Flying Zone;
- Height AGL (QFE);
- Indicated Airspeed (kts);
- Information on UA Health.

In the absence of such live telemetry, the Judges' and / or Flight Safety Officer's decision on boundary breaches is final.

3.3 Safety and Environmental Requirements

3.3.1 Flight Termination System

A Flight Termination System (FTS) shall be incorporated as part of the design and is a mandatory requirement to achieve a Permit To Fly. The purpose of the FTS is to initiate automatically all relevant actions which transform the UA into a low energy state should the data links between the Ground Control Station (GCS) and UA be lost or be subject to interference / degradation. The FTS shall also be capable of manual selection via the Buddy Box, should the Flight Safety Officer deem the UA's behaviour a threat to the maintenance of Air Safety.

The actions of the FTS must aim to safely land the UA as soon as possible after initiation. The throttle shall be set to idle / engine off. Other actions could include, but are not limited to: deployment of a recovery parachute; the movement of all control surfaces to a default position to achieve a glide; the initiation of a deep stall manoeuvre; movement of the relevant control surfaces to achieve a gentle turn.

The FTS shall be automatically initiated after 5 seconds lost Uplink. The Uplink is defined as the data link which provides control inputs to the UA from the GCS (manually or autonomously), including manual initiation of the FTS.

The FTS should be automatically initiated promptly and no longer than 10 seconds after lost Downlink. The Downlink is defined as the data link which relays the UA's telemetry / positional info and video feed to the GCS.

A 'Return to Home' function is **not** acceptable as an FTS.

3.3.2 Other Design Safety Requirements

The design and construction of the UAS shall employ good design practice, with appropriate use of materials and components;

The design shall be supported by appropriate analysis to demonstrate satisfactory structural integrity, stability and control, flight and navigation performance, and reliability of safety critical systems.

Batteries used in the UA shall contain bright colours to facilitate their location in the event of a crash;

At least 25% of the upper, lower and each side surface shall be a bright colour to facilitate visibility in the air and in the event of a crash;

Any fuel / battery combination deemed high risk in the opinion of the judges may be disqualified.

3.3.3 Operational Safety Requirements

The UA shall remain within Visual Line of Sight (VLOS) and no greater than 500m horizontally from the Pilot, and remain below 400 ft AGL;

The UA shall not be flown within 50 m of any person, vessel, vehicle or structure not under the control of the Pilot. During take-off or landing however, the UA shall not be flown within 30 m of any person, unless that person is under the control of the Pilot[1];

The maximum airspeed of the UA in level flight shall not exceed 60 KIAS;

During the entire flight the UA shall remain in controlled flight and within the geofence boundary of the Flying Zone;

Failure of the Pilot to recover promptly a UA appearing uncontrolled or departing from the Flying Zone, shall require activation of the FTS, either by the Pilot or at the direction of the FSO.

3.3.4 Pilot Licencing and Insurance

The team pilot shall have a BMFA-A qualification or equivalent (such equivalence shall be demonstrated to the satisfaction of the BSDC or Educaires). Evidence of qualifications shall be provided with the FRR submission. The team pilot shall have flown the UAS before (including during the FRR video).

The pilot shall have appropriate Civil Liability Insurance and Personal Accident Insurance to cover test flying and the Demonstration Event.

Note: The BMFA offers competitively priced insurance for members.

3.3.5 Environmental Impact

In the design process, consideration should be given to environmental impact, including the use of non-hazardous and recyclable materials; low pollution; low energy usage; low noise.

Teams are encouraged to determine the overall efficiency of the UA, by measuring the energy usage (chemical or electrical) during the testing prior to the Demonstration Event.

4 Statement of Work

This section provides more details of the activities and outputs in each stage.

Templates for the deliverable the concept design, PDR, CDR and FRR reports are provided at **Annex D**. The schedule for the key milestones and deliverables is provided at Section 2.4.

4.1 Challenge Stages

Figure 1 below depicts the stages of the Challenge, and the key deliverables:

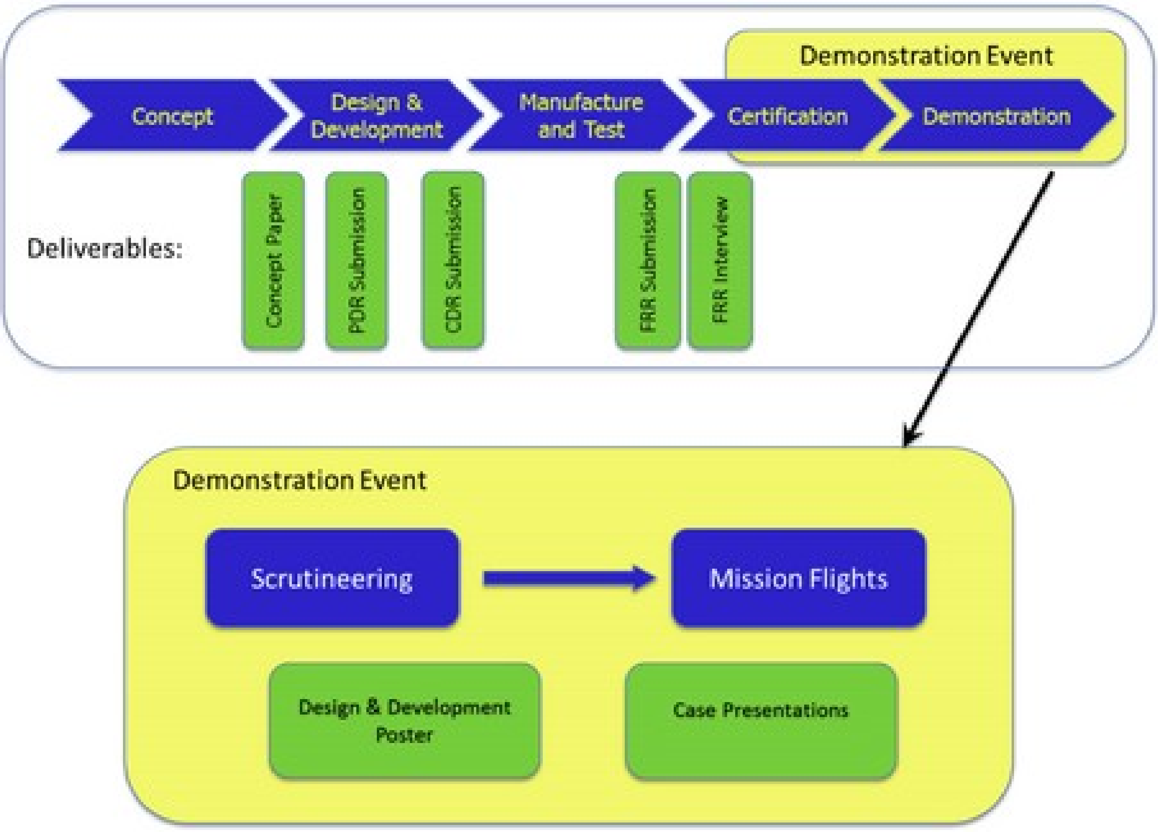


Figure 1: UAS Challenge Stages and Deliverables

Concept: Requirements capture, trade studies, selection of system concept, initial sizing and performance studies, and generation of the outline design. As a guide this stage is around **one months** long and concludes with the Preliminary Design Review (PDR) submission.

Design and desenvolupament: Detailed design for manufacture supported by structural, aerodynamic, system and performance analysis. This stage should include an assessment of how the requirements are to be verified through test, and importantly how the safety requirements are to be met. Some prototyping may also be undertaken. This stage is around 3 months long and concludes with the Critical Design Review (CDR) submission.

Manufature and Test: Construction of the UAS. This may also involve the manufacture of prototypes during the detail design stage to de-risk the design. Demonstration through analysis, modelling and physical test that the design will meet the requirements, and is sufficiently robust and reliable. Physical test should include subsystem test, as well as flight testing of the complete UAS. This stage concludes with the submission of the Flight Readiness Review (FRR) submission.

Demonstration: The flying demonstration event is held over two days and comprises a multi-stage process of qualification and demonstration, including:

- Scrutineering;
- Mission Flights;
- Business Case Presentation.

Further details of the Demonstration Event are provided at Section 4.4.

4.2 Deliverable Items Description

4.2.1 Design Reports

Guidance on the Concept review, PDR, CDR and FRR deliverable items is provided at **Annex D**.

4.2.2 Design Presentation

Early in the Demonstration Event, each team will give a 12 minute presentation on key aspects of the design and development to the judging panel. As a guide, the presentation should include the FRR Video and 5 presentation software slides. There will be up to 8 minutes for questions. Timings will be strictly enforced.

The assessment panel will be looking to test each team's communication skills as well as technical knowledge; demonstrating good teamwork and organization; giving good responses to questions; demonstrating a clear and concise presentation of the concept selection process, key design features and supporting analysis, and the development and test programmed.

4.2.3 Environmental Impact Poster

Teams shall produce an **A3 size** poster summarizing the environmental aspects of the design. The assessors will be looking for evidence that the team has made efforts to minimize the environmental impact of the design.

4.2.4 Manufacturing Poster

Teams shall produce an **A3 size** poster with pictures and summary showing the build, assembly and test. This shall be submitted to the organizers on arrival at the Demonstration Event, and will be displayed at the event. The Judges will review the Poster and the Scrutineering Panel will assess the Manufacturing quality of the physical UA.

4.2.5 Business Case Presentation

During the Demonstration event, teams will be invited to participate in of "Especial invited" event to pitch their Business Case for the UAS. They should give a well-articulated understanding of their market, an outline revenue model and sales projections, and summarize how the UAS capabilities and cost projections align with the target market. Teams will have 5 minutes to present their case, and there will then be 5 minutes of questioning from the Invited.

4.3 Deliverable Items Schedule

The schedule of deliverable items and activities is as follows:

Deliverable	Due Date	Reference
Concept Review Submission	7 Jan 2020	Annex D.1
Preliminary Design Review Submission	28 February 2020	Annex D.2
Critical Design Review Submission	31 March 2020	Annex D.3
Flight Readiness Review Submission	22 June 2020	Annex D.4
Design Presentation	18-19 July 2020	Section 4.2.2
Environmental Impact Poster	18-19 July 2020	Section 4.2.3
Manufacturing Poster	18-19 July 2020	Section 4.2.4
Business Presentation (*)	18-19 July 2020	Section 4.2.5

* At start of Demonstration Event

4.4 Demonstration Event

4.4.1 Scheduling

4.4.1.1 Timetable

A detailed briefing will be given prior to the Demonstration Event covering the logistics and timings for the event, rules and good conduct for safe operations, pre-flight briefings etc.

On the first day of July, July 19th, we will welcome the facilities / camping (for those who have chosen this option) and be able to accompany the time to perform some verification. The second day, July 2, will be reserved for the verification of the UAS. There will also be an opportunity to conduct a flying development test for any team that wishes to do so. The rest of the competition and the entire competition will take place on the 3rd, Sunday, 21st of July.

4.4.1.2 Process

The sequence of events that each team will go through in the preparation and flight operations is as follows:

- Each team will be able to join a queue to be scrutineered as soon as they are ready. It is important to be ready for scrutineering as soon as possible on the first day.
- The scrutineering is conducted in a room adjacent to the hangar. Both the necessary paperwork and the UA will be scrutinised.
- Teams that either fail scrutineering or are not ready will go to the back of the scrutineering queue.
- From Day 2 onwards, those teams that pass scrutineering will proceed outside with the UA and ground station for a safety controls check.
- From there they will then proceed airside for power checks and compass calibration.
- Assuming this is satisfactory up to four members of the team together with the UAS will then be transported to the flightline.

- There is then a short brief by FSO, following which the team will be given the go-ahead and this is when the clock starts ticking. The team then has up to 5 mins to prepare and take-off, and a further 10 mins to fly the mission.
- After the UA has landed, the team has 5 mins to pack up and clear the flight-line. They will then be transported back to the hangar.
- Teams must ensure that all paperwork prepared during the challenge (such as the completed) is submitted to the organizers during the event, and this will be retained by the Educaires. Copies may be retained by the team.

4.4.1.3 Readiness

The scheduling of scrutineering and flying is very tight over the 2 day event. Note that the judges and FSO have ultimate discretion. They will try to ensure that everyone flies, and that no-one is disadvantaged, but this cannot be guaranteed.

Team readiness for scrutineering and flying is imperative in ensuring an efficient schedule, and also to maximise your chances of a successful flight. For example paperwork for the scrutineers needs to be complete and submitted on time.

Note that there may only be time to do one flight per team – so make it count! If all goes well there may be time to do a second flight, but again this cannot be guaranteed.

Teams shall arrive with a fully serviceable UAS that is in good working condition

4.4.2 Scrutineering

4.4.2.1 Scrutineering schedule

Teams will be allowed to register for scrutineering on a self-assessed readiness basis.

Once they pass scrutineering they may (from Day 2) join the queue for the flight mission. The schedule is necessarily tight and teams must take responsibility for their readiness to keep a good tempo of scrutiny and flying.

If a team fails scrutineering they will join the back of the queue and or shall re- register once ready. They will be given guidance on how to rectify the faults, and the organisers will endeavour to slot them in for re-scrutineering and the flying schedule at a later point.

Efforts will be made to retain flexibility in the schedule to allow teams who fail scrutineering to repair, rectify, test and re-apply.

4.4.2.2 Scrutineering process

A panel of expert aircraft engineers will inspect the UAS to ensure that it is safe and airworthy, that any Corrective Actions made following the CDR submission have been addressed, and that any late modifications introduced are reviewed and acceptable.

The scrutineering panel will have reviewed the FRR submission (see **Annex D.4**), which is a key input to the Scrutineering process as it should contain evidence of satisfactory testing. The assessment will include:

- Regulatory Compliance – Pass/Fail criteria;
- Control checks – Communications; Function and Sense:
  - Radio range check, motor off and motor on;
  - Verify all controls operate in the correct sense;

- Airworthiness Inspection – Structural and Systems Integrity:
  - Verify that all components are adequately secured, fasteners are tight and are correctly locked;
  - Verify propeller structural and attachment integrity;
  - Check general integrity of the Aid Package and deployment system;
  - Visual inspection of all electronic wiring to assure adequate wire gauges have been used, wires and connectors are properly supported;
- Verify correct operation of the fail-safe flight termination systems;
- Manufacturing assessment including:
  - Design and Build quality, including use of appropriate materials,
  - systems integration and configuration control;
  - Attention to detail in assembly and aesthetics;
  - Sound and safe workshop practices.

A 'Permit to Fly' is awarded following satisfactory completion of the Scrutineering, and a green sticker (max 10 cm x 10 cm), signed by the safety officer, is applied to the UA. This will allow the team to progress to the Demonstration Flight stage.

4.4.3 Demonstration Flight

4.4.3.1 Preparing for the Mission Flight

Upon successful issue of a Permit to Fly, the Team will have a short time to prepare their aircraft for the Mission Flight. Note that the flying schedule is likely to be dynamic and updated during the event to take account of weather and UAS unserviceability.

The Mission is described at **Annex A.2**, illustrated with example waypoint data. The exact Mission waypoint and package delivery co-ordinates will be briefed to each team at the start of the event.

Note that the UA shall be able to do all tasks within the Mission – Aid Package drop, navigation, reconnaissance, speed, touch and go – without having to land to be reconfigured in any way.

4.4.3.2 Flight Safety and Navigation

During a flight, should the UA stray outside the Geo-fence marking the boundary of the flying area, the UA navigation system shall automatically detect this and activate the Flight Termination System (FTS). Failing this, the FSO shall activate the FTS via the command link. This will result in the termination of the mission.

4.4.3.3 Weather

Weather is a random element – some teams may get good weather over the two days, and others may have to fly in poorer weather. This is the luck of the draw.

4.4.4 Safety of Operations

The Flight Safety Officer (FSO) shall have absolute discretion to refuse a team permission to fly, or to order the termination of a flight in progress.

Only teams issued with a 'Permit to Test' through the Scrutineering process, and a 'Permit to Fly' through the Certification Test Flight, will be eligible to enter the Flying Demonstration stage; Teams shall be responsible for removal of all batteries from the site that they bring to the event, including safe disposal of any damaged batteries.

Note that the assessment of safety includes the team members' attitude to safety of operations, observing safe working practices in the pit lane doing maintenance, doing what the FSO says at all times, not transmitting when not approved to.

5 Adjudication and Scoring Criteria

5.1 Overall Scoring Breakdown

The competition will be assessed across four main elements, themselves broken down into sub-elements:

- Preliminary Design comprising the PDR Submission (**50 points**);
- Completion of Design comprising the CDR Submission (**100 points**);
- A3 poster (**50 points**)
- Flight Demonstration (**300 points**)

A **maximum of 500 points** is therefore available. The detail of scoring the Flight Demonstration is given in the tables below. Note that a satisfactory FRR submission is a prerequisite for entry into the Flight Demonstration.

5.2 Flight Demonstrations (300)

Task	Scoring	Max Score
Navigation		
Navigation accuracy	Score 50 points for successfully navigating the course, with all WP flown around in the specified direction.	50
	Deduct 10 points per WP missed, up to max penalty of 50 points.	
Reconnaissance		
Locate Ground Marker	Score 15 points for each of four Ground Markers for automatically and correctly reporting the alphanumeric character, and the associated GPS co-ordinates.	60
Accuracy	Accuracy of reported Ground Marker GPS position shall be within 30 m of the actual position. Outside this scores zero.	
Manual reporting	Manual reporting of the Ground Marker (such as the judge interpreting the alpha-numeric from a still or video picture) scores zero.	
Aid Package Delivery		
Aid Package Mass Carried	Score max 40 points for 4 kg of Aid Package mass carried. Score pro-rata for lower mass of Aid Package.	40
Aid Package Delivery Accuracy	Score max 40 points for 4 kg of total Aid Package mass dropped successfully on the target and coming to rest intact and within 30 m of the target centre. Score pro-rata for lower mass of Aid Package dropped successfully.	40
	Score 0 points for Aid Package mass dropped near the target but coming to rest either damaged and / or more than 30 m of the target centre.	
Precision Touch and Go / Landing		
	Score 20 points for each controlled approach and landing within the box (total of 40 marks for both the touch and go and the final landing). No part of aircraft to touch the ground outside the box.	40
Speed Challenge		
	Score maximum 40 points for a maximum average speed of 60 kts, defined as the course straight line distance around the waypoints divided by the total time clocked to fly the course. Note the maximum average speed limit of 60 kts must not be exceeded. Score pro-rata to the fastest average speed (e.g. 50 kts average	40

	speed would score 40 pts x 50/60 = 33 points).	
	Penalty of 8 points deducted for each WP missed, up to a maximum penalty of 40 points.	
	Score zero points if maximum average speed limit of 60 kts is exceeded, measured as an average around the course.	
Automatic Operations		
Automatic control	Score 30 points for fully automatic operation including Take-Off, Navigation, Reconnaissance, Aid Package Drop, Touch and Go, and final Landing.	30
	Score zero points if any parts of the flight control or payload drop are performed manually.	
Operational Readiness		
Maximum Mission Time	After 10 minutes from take-off the mission time ends, and no further points can be accrued for any mission tasks underway (e.g. for waypoints, speed, Aid Package drops, touch and go etc).	
	Maximum Score:	**300**

6 Prizes and Awards

There are a number of categories for which prizes will be awarded:

Prize	Award Criteria	Notes
Grand Champion	Highest aggregate score from the PDR, CDR, A3 poster and the Flight Demonstration	50 points PDR, 100 points CDR, 50 points A3 poster, 300 points Mission
Runner Up	2 nd highest aggregate score from the PDR, CDR, A3 poster and the Flight Demonstration	50 points PDR, 100 points CDR, 50 points A3 poster, 300 points Mission
3 rd Place	3 rd highest aggregate score from the PDR, CDR, A3 poster and the Flight Demonstration	50 points PDR, 100 points CDR, 50 points A3 poster, 300 points Mission
Innovation	The most innovative concept taken through to flight demonstration.	Innovative aerodynamic, structures, use of materials, and manufacturing methods.
Design	For the entrant with a well-structured design approach, the most elegant and well thought through design, as described through the Concept Paper, PDR and CDR stages that fully meets all the requirements laid down in the rules.	Evidence of the design tradeoffs considered between systems, structures, aerodynamics etc. Elegant solutions to meeting the mission requirements.
Scrutineer's	The best presented UAS that is fully compliant with the competition rules.	Non-compliant entries will not be permitted to fly.
Safety & Airworthiness	For the entrant developing the best combination of a well-articulated safety case, with evidence that safety and airworthiness have been considered throughout the design and development stages, the UAS exhibiting practical safety features, and demonstrating safe operation and team behaviour.	This will take account of the written inputs (Concept Paper / PDR/ CDR / FRR) and observations at the Demonstration event.
Business Proposition	For the entrant with the most promising business and marketing case presented to a panel of sponsors during the flight demonstration event, reflecting a wellarticulated understanding of the market and good alignment of the UAS capabilities and cost projections with the target market.	Judged by a panel of the event sponsors at the Dragon's Den event.
Most Promise	For the entrant which couldn't quite make it all work on the day, but where the team showed most ingenuity, teamwork, resilience in the face of adversity, and a promising design for next year's competition.	This could either be a team that failed to make it to the flight line or one that did not reach its full promise during the flight trials.
Highest placed new entrant	Highest mission scores for a university that has not previously taken part.	
Media and Engagement	For the team which engages most effectively with local media, schools, and social media to promote participation and engagement with the Challenge.	This is assessed during the Dragon's Den event.

Annex A - Missions

A.1 General Points

A.1.1 Take-off:

Take-off shall be conducted within the designated take-off and landing box, into wind as far as practicable. After take-off the system shall maintain steady controlled flight at any suitable height (*Note heights are quoted in feet Above Ground Level (AGL)*), typically around 50 m – 120 m (20 ft - 400 ft). Take-off under manual control with transition to automatic flight is permitted, though a higher score will be given to automatic take-off.

The mission time starts when the team signal they are ready and the Flight Safety Officer gives clearance for take-off.

A.1.2 Landing:

The UA shall return to and land at the designated take-off and landing zone. The mission is complete when the UA comes to a halt and the engine is stopped.

A.1.3 Navigation:

Each team will be provided with a map of the airfield, showing the Geo-fence boundary within which the UA must remain at all times, together with any other no- fly zones. The map will provide GPS co-ordinates for the Geo-fence vertices, the Waypoints (WPs) and the humanitarian aid package delivery point.

The mission route will define the WP order. The UA should aim to fly **around** each WP leaving the WP correctly to left or right of track as specified, and the accuracy of the navigation will be evaluated by analysis of the GPS data logger after the flight.

The Flight Termination System shall be automatically initiated upon a breach of the Geo-fence.

The UAS shall navigate around the course automatically, manual control is not permitted.

A.1.4 Operating height:

All operating heights between 50 m – 120 m (20 ft - 400 ft) are valid within the allowable flying zone. The UA must drop the payload from a minimum of 50 m (20 ft) height above ground, and cannot land to place the payload (in the case of Rotary Wing UAS). During transit phases between the landing area to the target area, the UA shall maintain a safe height above ground.

A.1.5 Timing:

With many teams flying, it is essential for the smooth running of the event that teams are punctual with their timing, and do not over-run the allocated slot time.

To keep up the flying tempo, there will be at least two teams at the flightline at any one time, so that if one team has to withdraw because of technical problems, another team is immediately ready to fly.

From arriving at the flightline and being given clearance to take off, a maximum of 5 minutes is allowed for pre-flight preparation. Additionally an overall maximum time limit of 25 minutes shall be strictly enforced from a team being given clearance to take-off for a mission flight to departing the flightline area after the mission. Points will be deducted if the team breaches these time limits.

If a team cannot get the UAS ready within the 5 minute allowance, the FSO may direct the team to retire and request another mission slot time, which may be granted at the discretion of the organisers. Note however that the team may be put to the back of the queue.

A.2 Mission Description

The mission includes multiple tasks conducted under automatic control within a single flight. If completed successfully the whole mission should last no more than 10 minutes. As a guide, the distance travelled around the course during the mission may be in the order of 9 - 10 km.

Teams can elect to skip one or more parts of the mission, but they would then score zero for these elements.

Figure A2 shows an example of the flying area and how WPs may be positioned around the airfield flying area; Note that this is illustrative only, and details of the actual Geo-fence boundary to the flying area and WP locations will be provided to the teams at the start of the demonstration event.

A.2.1 Task 1: Take off

Carrying the heaviest allowable Aid Package within the overall mass limit, the UA shall take-off and climb out in a controlled manner and head towards the first WP.

A.2.2 Task 2: Navigation

The UA shall navigate around several waypoints located around the airfield. In the example at Figure A2, the course runs from the Runway to WP1 – 2 – 3 – 4 – 5 – 6 – 7. One or two laps may be specified.

The UA shall fly around the waypoints in a specified direction, i.e. either leaving the WP to the right or the left. 'Cutting the corner' when flying around a WP will incur penalty points.

A.2.3 Task 3: Reconnaissance

During the navigation task above, the UA shall search for, locate and identify four Ground Markers, consisting of an alpha-numeric character on contrasting boards, of dimensions given at Figure A1 in Annex A. These markers will be located around the course at undisclosed locations on the straight lines linking consecutive waypoints. The accuracy of marker placement shall be within 30 m of the nominal course. The UA shall report back automatically the alpha-numeric character within each Ground Marker, and the associated GPS co-ordinates.

If the UA automatically recognises the character through image recognition software, and then the Pilot shows the judge this from the screen, that is acceptable as automatic reporting.

Manual reporting of the marker is when the judge has to interpret the character from the video or still images, and this will not score any points.

A.2.4 Task 4: Aid Package Delivery

Having flown around the defined course above, the UA shall proceed from WP7 (in the example), via WP8 and WP6, to the delivery location and drop an Aid Package (or bundle of Aid Packages) as close to the delivery location as possible. Points are awarded for successful release of the Aid Package, it remaining intact on landing, and coming to rest within 30 m of the delivery location. If the UA has more than one Aid Package bundle, it shall proceed from the target to WP7 – WP8 – WP6 then to the target and drop a second Aid Package, repeating this until all Aid Packages have been dropped.

Aid Packages that come to rest greater than 30 m from the target shall score zero for accuracy.

A.2.5 Task 5: Precision Touch and Go

After delivering the last Aid Package, the UA shall proceed to WP 7 (in the example) and then with due consideration to the prevailing wind, position for an approach to the launch point.

The UA shall land and perform a 'touch and go', with the aircraft aiming to touch the ground and take-off again within a box of 30 m x 30 m square at the Launch Point. Upon alighting on the ground, it shall immediately put the engine power on and take off again in a controlled manner.

Landing (any part of the UA touching the ground) outside the box will not score any points.

A.2.6 Task 6: Speed Challenge

After take-off for the second time, the UA shall navigate around the WPs again; these will be in a different order from the course at Task 2, typically proceeding via WP7–6–5–4–1–2–3–7 and performing two laps of this course. The time to complete this task will be measured, from passing overhead WP7 at the start to passing overhead WP7 at the completion of the final lap.

No payloads shall be dropped during this task. Missing one or more WPs will incur scoring penalties.

A.2.7 Task 7: Precision Landing

With due consideration to the prevailing wind, the UA shall position for an approach and land back at the launch point, landing and coming to a halt within a box of 30 m x 30 m square at the Launch Point. Landing (any part of the UA touching the ground) outside the box will lose the points.

A.3 Ground Marker Description

The ground marker shown below in **Figure A1** is a red 25 cm x 25 cm central square, incorporating an alphanumeric code in white letters, approximately 15 cm high, within the square. To help identification of the ground marker, a 1 m x 1 m white border will surround the central area.

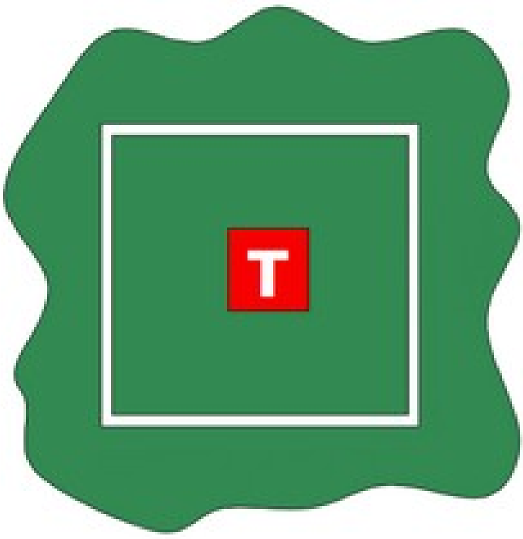


Figure A1: Ground Marker Dimensions.

A.4 Circuit of Castelloli Airfield Site Plan and Typical Mission

Figure A2 below shows the general layout of Circuit of Castelloli Airfield. Of note is the prominent 90 m high mast in the centre of the airfield which must be avoided. In general flying operations are conducted to the east and south of the mast.

Figure A3 below depicts a typical Payload Delivery mission, showing the routeing around waypoints to the target.

Figure A2: Circuit of Castelloli Airfield Site Plan and Typical Mission

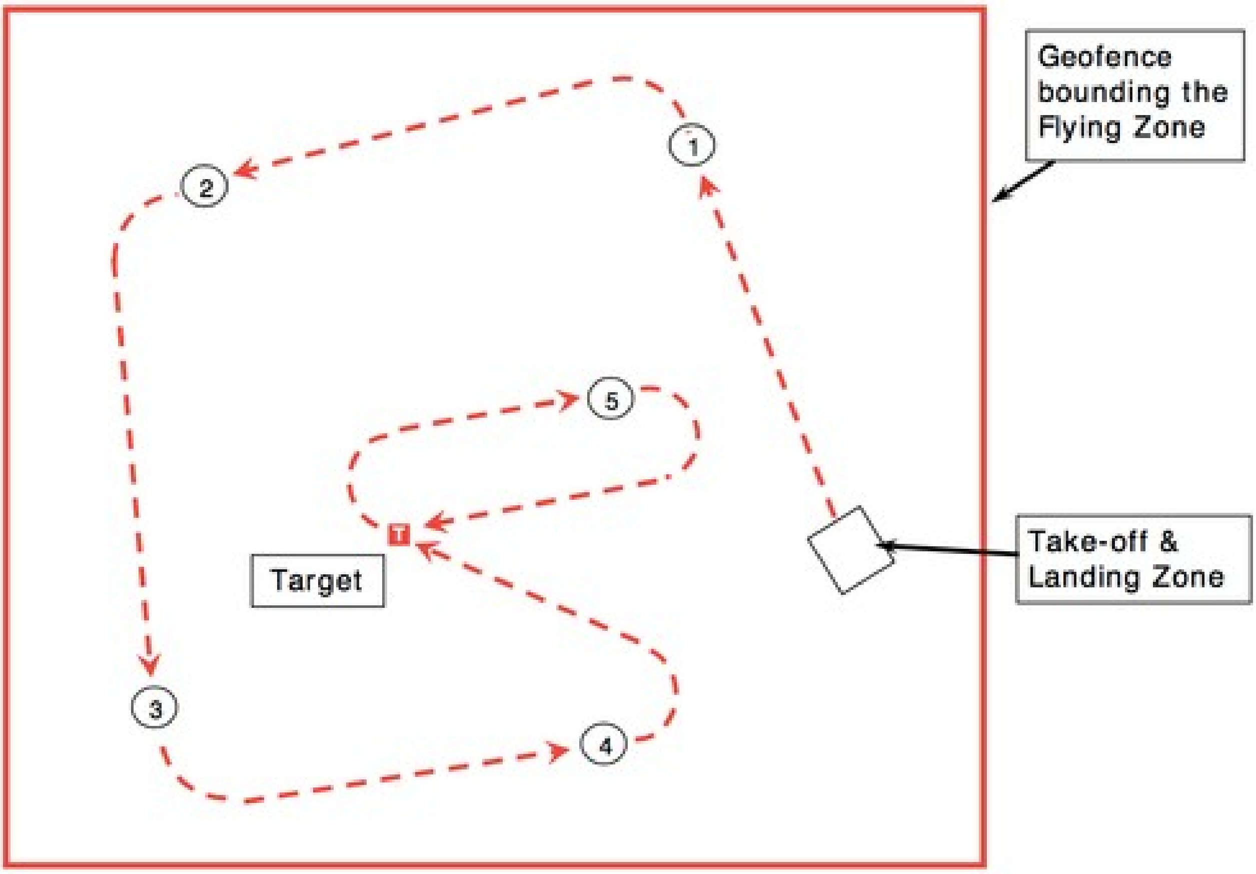


Figure A3: Typical Payload Delivery Mission Scenario

NOTES of Figure A3: In the example mission to the left, after departing the Take-Off zone the course goes via Waypoints 1, 2, 3, 4, then to the Target to drop the first payload. The UAS shall pass the correct side of the Waypoint.

Then out to and around Waypoint 5 and back to the Target to drop the second payload.

After dropping the second payload, the course routes back to the Runway via Waypoints 5 and 4 (course line not shown).

For this example the mission target time would be in the order of 140 seconds.

The actual course will differ from this example.

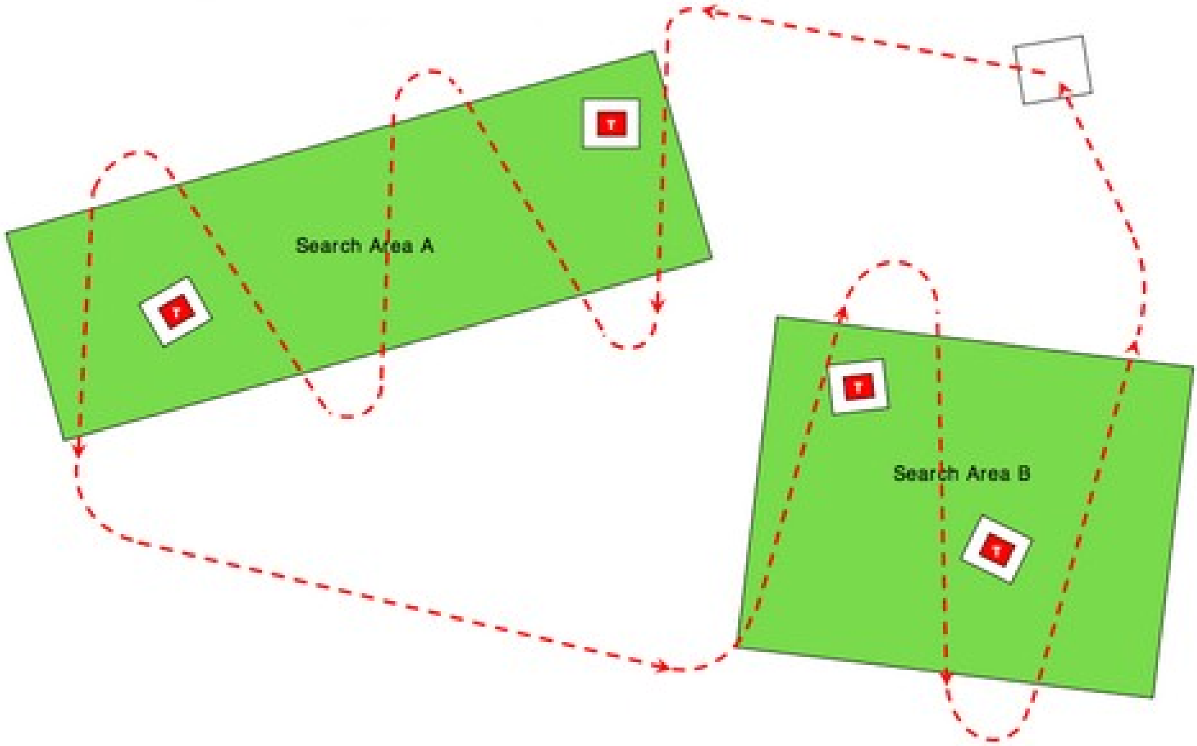


Figure A4: Typical Reconnaissance Mission Scenario

Annex B - GPS Tracker Installation and Operation

The **Quanum GPS Logger V2 with Backlit LCD Display NEO-6 U-Blox** is to be provided to provide a historical track of competitors in the Smart Moto / Bike / Drone Challenge. Because of its accuracy, small size and light weight it is ideal for providing historical navigation data in Unmanned Aerial Systems. The tracker will provide position (Lat & Long), Altitude, Date and Time. In addition it creates a log of estimated accuracy and satellite status throughout the flight.

The GPS Logger is a stand-alone device that packs the power of a U-BLOX NEO-6 GPS receiver, and records everything from; distance traveled, start and end positions, UTC time stamps, course and speed...and the infamous MAX speed the logger reached. The data can be viewed on the integrated backlit LCD or the NEMA data can be downloaded to a PC and plotted out on map sites such as Google Earth. To save weight the logger gets its power from a spare channel from your receiver so no additional battery is needed.

B.1. Instrument position

The tracker shall be positioned on the upper surface of the aircraft with a clear view of the sky above. It may be mounted internally or externally, but there must be a 140 degree field of view above the tracker around the full 360 degree azimuth which is unobscured by metallic or carbon fibre parts. A cover of fabric, plastic, foam or GRP will not affect the reception. In the case of rotary platforms, avoid placing the tracker under the sweep of the rotor(s). If teams cannot meet this specification they should contact the organisers to discuss the requirements further.

B.2. Instrument fixation

The instrument should be secured to the aircraft by means of straps or held firmly in place in an enclosure, while permitting ready access to the two buttons and status LCD Display. It is suggested that a polystyrene "jacket" would provide an ideal method of locating the tracker firmly within the structure. Dimensions are provided overleaf.

B.3. Operation on Day of Competition

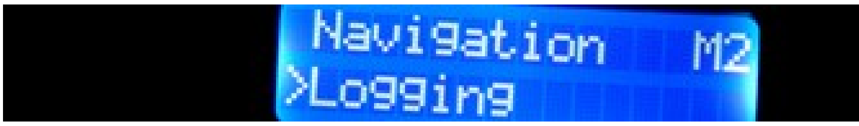
When first switched on in a new position the tracker may take up to 30 minutes to create an up to date almanac. The RIN staff will run the trackers on site for a suitable time before they are issued. The lock-on time for competitors will be between 4 and 32 seconds, thereafter the tracker will operate quite independently. As the information contained within the tracker could be a deciding feature of the competition the RIN staff will be available to assist in priming the trackers throughout. The trackers will be collected on landing and the data downloaded immediately. The data is presented both in tabular format and a superimposed track on a suitable map (Memory Map aviation chart or OS map). Downloaded data can be made available to competitors at the end of the competition.

Before each competition flight teams will be handed a live tracker by RIN staff. It is their responsibility to:

- Attach the tracker securely to the aircraft; and
- Once the tracker is attached, check that the LCD display on the tracker indicate it is logging. If it does not appear to be logging, teams should notify a member of RIN staff but **should not attempt to operate the tracker unless instructed to do so.**

B.4. Tracker description

A description of the device operation is given here for information only, and a diagram of the tracker with dimensions, mass, and status LCD display descriptions is provided below. There are four modes which you scroll through using buttons on the side. The modes are;



1. Navigation - current location information.
2. Logging - basically start the logging.
3. View Data.
4. Connect to PC.

The tracker runs on a continuous data loop lasting the power off GPS/UAV. The plan for the Challenge is that the RIN staff will hand over a live tracker leaving the competitors to position it on the vehicle and double-check the status in the LCD display. Teams should not attempt to operate the trackers unless instructed to do so.

B.5. Tech Specs of GPS

Receiver: NEO-6M U-BLOX

Max Speed Recording: 1000km/h

Sensitivity: -161 dBm (Tracking & Navigation)

Accuracy: 2.5 m (GPS), 2.0 m (SBAS)

Cold Start: 27 s approx.

Navigation: UTC date and time, geographic coordinates, time, speed, course

Logging: geographic coordinates, date and time, speed, course, distance (up to 100km)

Logging time: >1000 hours

Logging ON/OFF Control: Manual, RC (1520us)

Voltage: 4.5V ~ 6.5V

Current: 80mA typical

Size: 24 x 77 x 18mm

Weigh: **43g**

Annex C - General Guidance for Teams

This section offers a few hints and tips to help teams achieve a successful and competitive entry. This is in part based on feedback from the previous competitions.

C.1 Concept Selection

The UA may be designed to carry a single payload, in which case return to the landing site for replenishment will be required to drop a second payload, possibly incurring time penalties. Alternatively it may be designed to carry two payloads, allowing delivery of payloads to be accomplished in a single mission.

Rotary Wing, UAS(R) and Fixed Wing UAS(A) each have their advantages and drawbacks. The UAS(R) may descend to drop the payload onto the ground from a low height accurately and without damage, but may be slower in transit to the target area, and may have reduced payload capacity compared to the UAS(A), requiring two sorties to complete the two payload drops; The UAS(A) pose a greater challenge in achieving a direct hit on the target than for the UAS(R).

The UAS(A) may require a more sophisticated payload protection or retardation system to minimise impact damage compared to the UAS(R). Alternatively it may be decided from looking at the scoring, that some damage to the payload will be tolerated and traded against the additional complexity and weight of a protection system.

Either electric or internal combustion engines are permitted. Note there are marks for quiet and environmentally friendly operations.

The assessment panel will be looking for teams to explain their rationale in making their system design decisions and trade-offs.

C.2 Programmer Planning

Make allowance for things to go wrong – the aircraft will crash on the test flight and need to be rebuilt. Test subsystems early and in parallel. Don't rely on it all being OK on the day – it never is!

C.3 Construction Quality

Do ensure that mechanical systems such as pushrods, control linkages, propellers are properly locked, for example with locknuts or wire locking, and bolts/pins inserted from above (gravity aided), to avoid them failing during flight.

Ensure wiring and fuel lines are retained securely, so as not to interfere with flight controls or fasteners.

Ensure that control linkages operate with minimal lateral load / moments.

Get your UAS inspected during build by an experienced aero-modeller to help with construction details and best practise.

Build a storage box for your UAS to avoid handling damage during transport, and to support the UAS during preparation / test / maintenance.

C.4 Radio Equipment

Note the mandatory requirement for 2.4GHz band, Spread Spectrum compliant systems, and range of 1 km. A good quality receiver is key to ensuring reliable reception at longer ranges.

Note the requirement to bring the buddy box specified at Section 3.1.6.

A range check shall be carried out as part of your system testing prior to the Demonstration Event, and you are reminded allow for the possibility that the RF environment at the Demonstration Event may be more hostile than at your home field.

C.5 Autonomous / Automatic operation

The competition mission will require a flight firstly in manual mode, and then assuming all goes well, in automatic mode. It will also test the switch from manual to automatic, and vice-versa. When testing your UAS pay particular attention to the switch between manual and automatic mode, to ensure the behaviour of the UAS is as expected.

C.6 Payload Specification and Deployment

Note that your design will need to accommodate the slight variability in dimensions of commercially available 1kg bags of flour.

Remember that wind speed and direction must be allowed for when calculating the payload release point.

C.7 Demonstration Event Preparation

Be organized and do be prepared for breakages. Do bring a workbench so that you can safely do maintenance and repairs. Bring plenty of tools and spare parts for your UAS. Ensure that batteries can be changed easily.

There will be limited time in the schedule allowed for testing, so plan to use your time wisely. Refueling and engine run-ups in the pits will be allowed, but only in a segregated area under the supervision of BSDC staff, and availability of slots may be limited.

It is your responsibility to dispose of your rubbish; bring a suitable bag to handle damaged batteries etc. There is no facility provided for this on site.

C.8 The Route to a Permit to Fly

For background reading on the wider regulations applicable to UAS, teams are encouraged to consult the **AESA** for UAS design and operation, and its regulatory framework which is downloadable for free from the AESA website:

http://www.seguridadaerea.gob.es/media/4389070/ley_18_2014_de_15_octubre.pdf

See also the Order of air navigation of each country of origin. But like we're flying in Catalonia, we will consider the legal framework Spain.

AESA - State Aviation Safety Agency is responsible for regulating operations with drones up to 150 kg. To drones above this limit, it has established rules at European level, and the agency responsible for regulating these aircraft is EASA (European Aviation Safety Agency)

Link of Order:

http://www.seguridadaerea.gob.es/lang_castellano/cias_empresas/trabajos/rpas/default.aspx

Annex D - Document Templates and Guidance

This Annex provides guidance on the structure and content of the Concept Paper, PDR, CDR and FRR deliverables. Teams are also encouraged to reflect on the Engineering Challenges summarized in Section 2.4, which indicates what the Judges are looking for throughout the competition.

D.1 Concept Paper Review Submission

The Concept stage culminates with the Concept Paper Review Submission, a written report of no more than 2 pages supported by a 1 page of drawings/sketches. The mandated structure and content is:

Cover page (not included in the page count)

- Team name
- University / High Scool
- List of team members, their courses and year
- Name(s) of supervisor
- Sponsors

Concept description

- A description of the proposed concept including configuration, propulsion power source, aid package carriage target and control system;
- Discussion of the design drivers, the concept generation process, concept options considered, the trade studies undertaken to choose between configurations, and the factors influencing the down select to the chosen concept;
- A description of the design innovations that are included.

Guidance on how the Concept Paper Submission will be assessed

The assessment panel will be looking for a number of factors including:

- Demonstration of a sound systems engineering approach to meeting the design requirements;
- Extent of Innovation in the Outline Design;
- Adherence to the rules;
- Overall Quality of Concept Paper submission.

D.2 Preliminary Design Review Submission

The Concept stage is followed the Preliminary Design Review Submission; a written report of no more than **10 pages** including diagrams and tables. The required structure and content is:

Cover page (not included in the page count)

- As for concept paper

Project Management (2 x A4 pages maximum)

- Project plan with the main activities, lead times and dependencies;
- Table summarising the project risks and their mitigation.

Requirement Verification (1 x A4 page maximum)

- A table with a configured list of the UAS Requirements, including regulatory requirements, and how they will be verified by the design (e.g.):

ID	Requirement	Verification
Req 1	The MTOM shall not exceed 7 kg	Design weight budget supported by component and final assembly measurements

Performance Calculations (2 x A4 pages maximum)

- Preliminary aerodynamic, structural and performance calculations supporting the initial sizing, basic stability and control calculations, together with a Weight and Balance estimate;

Cost Budget (0.5 x A4 page maximum)

- An initial budget allocation for COTS items

Safety (1 x A4 page maximum)

- An overview of the safety risks, presented in a table of hazards and mitigating design features.
- A short description of the approach to RF compliance;
- A short description of the safety features incorporated to mitigate the risks such as the flight termination system;

Design Description (3 x A4 pages maximum)

- Brief Functional Description, and the rationale for selection of each of the proposed systems, including Airframe, Propulsion, Flight Controls, Navigation & Mission Control, Sensors, Image Processing, Autonomy / Automatic Operation, Payload Carriage and Delivery system, and Flight Termination System, highlighting any innovative features;
- A diagram showing the preliminary system architecture and data flow for the navigation and mission control, flight control, vision sensor and the design for automatic operation;
- UAS overall layout & description with a three-view scale drawing.

Test Plan (0.5 page maximum)

- A short summary of any testing that will be undertaken to support the next phase of the design (e.g. wind tunnel testing, structural loads, etc.)

Guidance on how the PDR Submission will be assessed

The assessment panel will be looking for a number of factors including:

- Demonstration of a sound systems engineering approach to meeting the design requirements;

- A structured design process adopted by the team, and how the derived performance requirements are developed for each of the sub-systems such as wing (or rotor), airframe, propulsion, control, navigation, payload handling etc.;
- Extent of Innovation in the Outline Design;
- Adherence to the rules;
- Depth and extent of underpinning engineering analysis;
- Design and planning to meet safety and airworthiness requirements;
- Evidence of sound project management, planning, budgeting;
- Overall Quality of PDR submission.

D.3 Critical Design Review Submission

A key output towards the end of the Detail Design stage is the Critical Design Review Submission, a written report of no more than **18 page**s supported by a maximum of **3 pages** of diagrams and illustrations. The required structure and content is:

Cover Page (not included in the page count)

- As for Concept Paper

Brief summary description of the design (500 words maximum)

- A text description of proposed design including configuration, propulsion power source, cargo carriage target and control system.

Changes from the PDR

- List all significant changes since the

PDR Sponsorship obtained

- List any contributions from sponsors

Design description (8 x A4 pages maximum)

- Describe the aerodynamic, structural, control system, communication system and propulsion system design and performance supported by calculations and assumptions used. This should include the aid package carriage and release system and how autonomous control of the whole missions is to be achieved.
- Highlight any innovative aspects.

This may be supported by up to 3 pages of illustrations and diagrams.

Cost breakdown (1 x A4 page maximum)

- A table listing the bought out items, including their total cost.

Manufacturing description (3 x A4 pages maximum)

- Describe the material selection process and construction techniques to be used.
- Highlight any innovative aspects.

Support description (1 x A4 page maximum)

- Describe any consideration given to the operation and maintainability of the design including any support equipment, handling and storage fixtures.

Qualification Test Plan (2 x A4 pages maximum)

- Using a table format, summarise your test plan indicating how each element will be tested (e.g.):

ID	Objective	Method	Success criteria
QTP 1	Operation of FTS		

Safety Case (2 x A4 pages maximum)

- Describe your approach to safety and how you will establish the airworthiness of the system. This must include a description of a compliant Flight Termination System (FTS) and how the UK's RF regulations will be met.
- This should be supported by a risk assessment matrix detailing at least the top 10 risks.

Guidance on how the CDR Submission will be assessed

The assessment panel will be looking for:

- Technical assessment of UAS Detail Design;
- Integrity and depth of design data and supporting analyses;
- Design and demonstration of key safety features such as FTS;
- Extent of scratch design vs. COTS procurement;
- Overall Quality of CDR submission.

D.4 Flight Readiness Review Submission

The Manufacture and Test stage culminates with the Flight Readiness Review Submission, comprising:

- A video no longer than 10 minutes in duration showing evidence of the test flying undertaken;
- A statement of any changes introduced since the CDR;
- A confirmation that any Corrective Actions required by the judges from the CDR have been fully addressed;
- Confirmation of the team Pilot and the compliance of Pilot Qualifications with the requirements of Section 3.3.4;
- A signed declaration by a suitably qualified Chartered Engineer and Member (or Fellow) of a Professional Engineering Institution, that in their opinion:
    - The UAS appears compliant with the requirements noted in Section 3;
    - The design and build quality is satisfactory;
    - Safety and Airworthiness aspects have been addressed satisfactorily, with appropriate fail safe mechanisms and a risk register completed;
    - The system has been tested, both by modelling and demonstration to evaluate the

performance and reliability;

- The team members preparing and operating the UAS are suitably competent to ensure safe operations.

A 'Permit to Test' will be issued by the Flight Safety Officer for teams that submit a satisfactory Flight Readiness Review, and also satisfactorily complete the scrutineering on the first day of the Demonstration Event. An amber sticker, signed by the FSO shall be applied to the UA denoting that it has been granted a Permit to Test.

Guidance on how the FRR Submission will be assessed

1 week following the submission of the FRR video and paperwork, each team will be given a 15 minute time slot for a video conference with a panel of judges and scrutineer representatives who will go through the FRR submission and assess whether the team has reached the maturity necessary to enter the flight demonstration phase of the competition.

The assessment panel will be looking for evidence in the FRR Video about the extent and rigour of testing to demonstrate the performance and safety features of the UAS.

Annex E - Guidance on Autopilot Selection

To help teams with the selection of COTS components, this Annex provides a list of potentially suitable autopilots, compiled as of August 2017. It is not mandatory for teams to choose one of these, and it remains the teams' responsibility to ensure that the autopilot is fit for purpose and suitable for their UAS application.

Name	Website	Type
NXT AutoPilot	http://diydrones.com/profiles/blogs/n xt-autopilot-v-01-beta	Open Source
ArduPilot	http://ardupilot.com/	Open Source
Pixhawk – Cube 2.1	http://pixhawk.org	Open Source
Pixhawk, PX4 FMU, Arsov AUAV-X2, APM2 etc	http://pixhawk.org/choice	Open Source
Lisa/MX V2.1 Autopilot	http://1bitsquared.com/products/lisa-m-autopilot	Open Source
Arduino UNO R3 UAV V2	https://www.sparkfun.com/products/1 1021	Open Source
Atto Pilot	http://www.attopilotinternational.com	Open Source
Piccolo II Piccolo NANO Piccolo SL	http://www.cloudcaptech.com/product s/auto-pilots	Commercial. Full Integrated solution.
Paparazzi	https://wiki.paparazziuav.org/wiki/Mai n_Page https://wiki.paparazziuav.org	
Albatros	ttp://appliedaeronautics.com/Albatro ss-SP-UAV-Kit_p_17.html	Commercial. The Albatross UAV kits can takeoff, fly and land autonomously via predefined flight paths.
MicroPilot	http://www.micropilot.com/	Commercial
Auav EZI-NAV	http://www.auav.net/ELECTRONICS.html	
Rotomotion	http://www.rotomotion.com/about.ht ml	Open Source, for HELIS
PNav	http://www.hubner.net/pnav-autopilot	Open Source/Hardware
NgUAVP	http://ng.uavp.ch/FrontPage	Open Source for Quads
CC3D/OpenPilot	https://www.openpilot.org	Open Source Very Cheap Sub (20€)
FY 41-AP Panda AP117	http://www.feiyu-tech.com/product- en.php?id=32	Commercial – Low Cost Sub 100€
SC2 SC2R	http://www.skycircuits.com/autopilots	Commercial, Academic, Research and Development Use
Flight Management Systems, Avionics/Autopilot - SNAP®	http://www.bbsr.co.uk/products/Custo mised-UAS	Commercial