# The 5th International Competition of the Military Technical College

# Lt. General Ibrahim Selim Award For Innovation in Unmanned Systems

# Unmanned Systems Innovation Competition (UMSIC 2021)

**Details, Rules and Format**

***Student teams are invited to compete and demonstrate their vehicles at the Unmanned Systems Innovation Challenge held at the Military Technical College in***

***Kobry El-Kobba, Cairo, Egypt, on August 7 - 12, 2021***

**November 21st, 2020**

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# Unmanned Aerial Vehicle Challenge

# (UAVC 2021)

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# Glossary and Abbreviations

| | |
|---|---|
| AGL | Above Ground Level |
| BVLOS | Beyond Visual Line of Sight |
| CDR | Critical Design Review |
| COTS | Commercial off-the-shelf |
| EPAF | Egyptian Parachuting and Air-sports Federation |
| FMC | Flight Management Computer |
| FRR | Flight Readiness Review |
| FSO | Flight Safety Officer |
| FTS | Flight Termination System |
| GCS | Ground Control Station |
| GoE | Government of Egypt |
| GPS | Global Positioning System |
| MTOW | Maximum Take-off Weight |
| PDR | Preliminary Design Review |
| VLOS | Visual line of sight |
| FRR | Flight Readiness Review |
| RC | Radio Control |
| UAV | Unmanned Aerial Vehicle |
| VTOL | Vertical Take-Off Landing |
| WP | Waypoint |
| IFF | If and only If |

# 1. Structure of this document

***Section 1*** presents an introduction and overview.

***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 UAV, 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 maximize their score.

***Annex A*** provides the representative missions to be flown, and around which the UAV is to be designed.

***Annex B*** provides document templates and guidance for completion of the three design review deliverables, the PDR, CDR and FRR.

***Annex C*** introduces in details the interoperability system.

# 2. Introduction

## 2.1 Overview

The competition will engage university undergraduate/graduate students in the design, construction, development and demonstration of an autonomous UAVs with a MTOW of 10kg and operating within VLOS. The competition awards, named in honor of co-founder of the MTC, Lt. General Ibrahim Selim, aim to encourage students at all levels of education to participate in teams and gain hands-on experience. Students will experience how to work in organized team and there will be roles for team members from non-engineering disciplines such as business, management, media, etc. The system will be required to operate automatically, performing a series of tasks such as area search, navigating waypoints, accurately dropping payloads and returning to base via a defined route.

## 2.2 Objectives of the event

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

- Provide an opportunity for students to learn practical aerospace engineering skills for industry.
- Provide a challenge to students in systems engineering of a complex system requiring them to follow an industry-recognized engineering development lifecycle (design, development and demonstration) against the demanding mission requirements.
- Provide an opportunity for students to develop and demonstrate team work, leadership and commercial skills as well as technical competence.
- Enhance employment opportunities in the sector and foster inter-university collaboration in the UAV technology area, and to provide a forum for interdisciplinary research.

# 3. Competition Overview

## 3.1 Context

The competition is structured to replicate a real UAV design, development process, build, test and demonstration. Deliverables have been carefully specified to maintain reasonable technical accuracy, yet aiming to keep the workload manageable for student teams.

## 3.2 Generic mission tasks

The competition is to design, build and demonstrate an autonomous UAV to fly a number of missions. The competition seeks to test a number of characteristics, such as:

– Accuracy of payload delivery to pre-determined points on the ground.
– Maximum mass of payload that can be safely transported in an allocated time.
– Shortest time to complete the payload delivery mission.
– Navigation accuracy via waypoint co-ordinates provided on the day.
– Object recognition, detection and geo-location.
– 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.

## 3.3 Schedule

Key dates and activities are as follows:

| Activity | Date |
|---|---|
| 2021 Rules provided to entrants | 21st November 2020 |
| Entries submitted to MTC | 11st February 2021 |
| Complete Concept Stage & PDR Submission | 25th March 2021 |
| Complete Detail Design Stage and CDR Submission | 27th May 2021 |
| Complete Manufacture and Test and FRR Submission | 17th June 2021 |
| Acceptance from the Technical Committee | 1st July 2021 |
| Demonstration Event | 7 - 12 August 2021 |

* Tentative dates: noting that adherence to deadlines is a prerequisite for next stage entry, and the organizer retains the right to eliminate any team in the event who will not submit all required deliverables on time.

## 3.4 Engineering events

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 events. 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 modeling.
- **Innovation** in the approach to solving the engineering events.
- Due consideration of the **safety and airworthiness** requirements which must 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 UAV; 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-work**; 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.
- **Autonomous operations**; the UAV 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 minimizing noise, developing an efficient aircraft design which minimizes energy consumption, and attention to minimizing use of hazardous materials.

## 3.5 Eligibility and team structure

The competition is open to **graduate / undergraduate students (minimum 18 years old)** from any Egyptian or overseas universities and research centers. Universities may form an alliance to enter a joint team. Industry specialists' support may be allowed where specific skills and knowledge are required outside the scope of the undergraduate students. The extent of such support must be clearly declared in the CDR submission.

The numbers of members in each team will be entirely determined by the participating entity, whilst having a set of defined performance objectives to achieve, is as much about the development and demonstration of team-working skills.

The development team must consist of graduate and undergraduate students which attend universities full-time for at least one semester during the academic year. The team may have at most 1 graduate student participate during the academic year. While the team members who attends the competition, and participates in Mission Demonstration event is limited to no more than **7 members** per team, plus up to **3 support staff**, e.g. pilots or academic staff

One member of the competition team will fill the role of team leader. This student will be the primary point of contact for the judges. All questions, comments, statements, and deliverables must be submitted by the team leader. The judges must be immediately notified of any team leader change.

The assigned safety pilot for whom a safety pilot log is required, can be either a student, the advisor or non-student of the university. At competition, each team can have their own safety pilot or request a competition volunteer safety pilot. The safety pilot will count as **1 of the 10 team members,** regardless of whether he is an advisor or volunteer. For non-member safety pilot his role is only limited to safety related functions and communication, and may not advise or participate in other roles.

## 3.6 Sponsorship of teams

Participating entities are encouraged to approach potential sponsors, at any time prior to or during the competition, for both financial support and/or 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 must be fully acknowledged in the design review submissions.

## 3.7 Registration Information

- The official source for all information concerning rules, interpretations, and information updates for UAVC is the World Wide Web home page at: *http://www.mtc.edu.eg/mtcwebsite/Competition.aspx*
- **Teams' registrations will be online via the following URL:** http://uavc.conferences.ekb.eg/
- Teams' entry forms also will be submitted online no later than February 11st 2021.
- An entry fee of **3000 EGP** for residents (**300 USD for internationals**) per team (maximum 10 members) is payable upon submission of an entry form (Registration). 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. MTC will not fund the costs of the UAV design and development, nor the team attendance at the Demonstration event.
- Entry fee payment **date** and **options** will be posted online or emailed to the successfully registered teams later.
- An extra fee of **500 EGP** for residents (**50 USD for internationals**) per person for any extra team members and up to 5 members is payable on registration day (first day in the competition).
- **Any payments will be refunded ONLY in case of rejected teams.**
- Team proposal form must be submitted **online through UAVC website** no later than **February 11st 2021.** The main team supervisor must sign the team proposal form, and certifies that all student team members are currently registered in academic year 2020/2021.
- Registered teams will submit their future deliverables (PDR, CDR, FRR,….etc.) on a shared google drive created by the competition board. Competition board will provide each registered team with their google drive shared link.
- Teams deliverable via shared google drive include the following team information that must be provided after registration **immediately**:
    - Name of the team (and name of the vehicle, in case it's different).
    - Team members' full names.
    - Photocopy of the national ID (for Egyptian team members).
    - Photocopy of the passport (for non-Egyptian team members).
    - Personal cell phone no., email and address.
    - List of sponsors.

– **All forms will be available on the competition google drive and are to be uploaded using the assigned google drive link for each team.**

# 4. Design and Operational Requirements

The UAV must be designed to perform up to three missions whilst being compliant with the specification defined in this section the term ‘must’ 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.

## 4.1 UAVC design requirements

### *4.1.1 Airframe configuration and mass*

Fixed wing, multi-rotor drones, fixed wing with vertical take-off landing (VTOL) or other air frame configurations are permissible for the missions, each have their advantages and drawbacks. Thus, different airframes will certainly achieve different scores in the three missions. The teams’ main challenge is to optimize their air frame choice and design in order to achieve high scores in the missions.

**For all airframes, the MTOW must not exceed 10 kg, including the payload(s). In case of VTOL, a 20% of the total earned score (VTOL Bonus) will be added over the total score. ONLY one air frame design per team is allowed to complete all the competition missions.**

### *4.1.2 Propulsion*

Electric motors or internal combustion engines are permitted for propulsion.

### *4.1.3 Payload specification*

The payload to be delivered by the UAV is flour bags rapped with a colored tape for identification of minimum weight 500 gm./bag and its integral multiplication, (For example: delivered payload is 2.2 kg will be counted as 4 bags, delivered payload is 3.9 kg will be counted as 6 bags). Tapes will be provided by teams themselves as well as their flour. Teams will be assigned the colors in UAVC orientation session. For more details, please refer to section ***5.2.3 Mission 3: Endurance in the presence of obstacles.***

### *4.1.4 Payload carriage and delivery*

The UAV should be designed to carry and deliver multiple payloads onto a target area. A greater mass of payloads delivered, scores more points. The payloads must be individually deployable from the UAV by either manual or automatic command. The payloads must be deployed whilst the UAV is in flight, from a minimum height of 50 m to a maximum of 100 m AGL. The UAV is not permitted to land to deploy the payload.

### *4.1.5 Autonomy*

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

**Notes:**

- Stability augmentation systems do not classify as 'autonomous' or 'automatic' control, and must count as part of manual control.
- 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.

### *4.1.6 Radio equipment*

Radio equipment, including data links, must be capable of reliable operating ranges of 1-2 km. Radio equipment providing control of the UAV and the Flight Termination System must be 'Spread Spectrum' compliant on the 2.4 GHz band, to allow simultaneous testing of several UAV without interference. Evidence of compliance must be presented in the CDR submission and at the scrutineering. The radio equipment must include a RC transmitter. This is to allow the flight safety officer to activate the flight termination system via the RC 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 must be suitably reliable and resilient to interference.

### *4.1.7 Camera / Imaging system*

The UAV should carry a camera system and target recognition capability to undertake the target search, location and identification exercise set out in **A.3.2 Mission 2: Search, locate, identify and Rescue**.

### *4.1.8 Location finder*

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

### *4.1.9 Limits on use of COTS items*

The UAV airframe and control systems must 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 bill of materials and costs will be required as part of the design submission. Low cost efficient solutions will score more points. Teams may use COTS components which already exist at the University, 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 must also demonstrate that manufacture of the airframe and integration of the UAV involves a significant proportion of effort from the students themselves, rather than being substantially outsourced to a contractor.

Note: Permitted COTS stock component parts include motors, batteries, servos, sensors, autopilots and control boards such as the Pixhawk or Ardupilot platforms.

## 4.2 Operational requirements

### *4.2.1 Missions*

Three separate missions can be flown, each testing different performance characteristics of the UAV. These are payload delivery in the presence of obstacles, reconnaissance (Search, locate, identify and rescue) and endurance in the presence of obstacles. Details of the three missions are set out at Annex A. The scoring criteria for these missions are presented at section 5.2 Flight Demonstration.

### *4.2.2 Takeoff and landing*

The UAV must be designed to take-off and land from within a 30 m side length square. The UAV should be capable of operating from short grass, sand 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.

### *4.2.3 Design mission range and endurance*

The UAV should be designed to operate not further than 500 m from the pilot. For resilience of operation, the radio equipment including data links, must be capable of reliable operating ranges of 1 km. For the purpose of sizing the fuel / battery load, the design team should consider Mission 3 in particular, which is designed to test the endurance of the UAV. For more details, please refer to section ***5.2.3 Mission 3: Endurance in the presence of obstacles***

### *4.2.4 Weather limitations*

The UAV should be designed to operate in winds of up to 10 m/s gusting to 15 m/s, and light rain. The UAV should typically be capable of take-off and landing in crosswind components to the runway of 5 m/s with gusts of 8 m/s.

### *4.2.5 Ground control station*

In the Ground Control Station, 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 UAV position on a moving map.
– Local Airspace, including the Flying Zone.
– Height AGL.
– Indicated Airspeed.
– Information on UAV Health.

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

### *4.2.6 Interoperability system*

The Interoperability System is a network and web server that teams should interact with during the flight demonstration. This system provides the required missions details and receives missions' deliverables. The system provides automatic evaluation for scoring, and is available to teams for testing. UAVC 2021 provides the following GitHub repository link for a similar system as a guide for teams to test their integrations. This repository contains all code and documentation for similar interoperability system developed by the ***Association for Unmanned Vehicle Systems International (AUVSI) Student Unmanned Aerial System (SUAS)***.

**Note: teams that will use the interoperability system with the judge server will gain bonus points percentage of their total earned score. In addition, teams should declare their interoperability readiness in the orientation session.**

*Interaction with System:*

This section provides a high-level overview of the interaction with the Interoperability System. Teams should refer to Annex C for details.

*Network Connection:*

At setup time, teams will receive a single Ethernet cable with which to connect to the Interoperability System. This connection will provide a single static IP address. The IP addresses will be on the subnet 10.10.130.XXX with subnet mask 255.255.255.0. Teams will typically connect this to their Ground station network (router/switch). Teams will then connect to the Interoperability server given the server IP address/port number, username, and password that is provided at Check-In and Orientation. Teams may then use this connection until the end of the mission demonstration.

*Mission Download:*

Through this connection, teams must download certain mission details from the Interoperability System, e.g., Geo-fence, search grid coordinates… etc.

*UAV Telemetry Upload:*

In order to get maximum points for waypoint accuracy, teams will need to upload valid UAV telemetry while the UAV is airborne. Telemetry must not be duplicated, interpolated, or extrapolated beyond what is generated by the autopilot. Data dropouts will count against the team.

*Object Upload:*

Teams need to submit identified objects via the Interoperability System to earn more points. Teams should refer to Annex C for more details regards the identified object format.

## 4.3 Safety and environmental requirements

### *4.3.1 Flight termination system*

A FTS must 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 UAV into a low energy state should the data links between the GCS and UAV be lost or be subject to interference / degradation. The FTS must also be capable of manual selection via the RC, should the FSO deem the UAV's behavior a threat to the maintenance of air safety. The actions of the FTS must aim to safely land the UAV as soon as possible after initiation. The throttle must 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 maneuver; movement of the relevant control surfaces to achieve a gentle turn. The FTS must be automatically initiated after 5 seconds lost uplink. The uplink is defined as the data link which provides control inputs to the UAV 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 UAV's telemetry / positional info and video feed to the GCS. A 'Return to Home' function is **not** acceptable as an FTS.

### *4.3.2 Other design safety requirements*

The design and construction of the UAV must employ good design practice, with appropriate use of materials and components; the design must 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 UAV must contain bright colors to facilitate their location in the event of a crash; At least 25% of the upper, lower and each side surface must be a bright color 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.

### *4.3.3 Operational safety requirements*

The UAV must remain within VLOS and no greater than 500m horizontally from the Pilot, and remain below 100 m AGL. The UAV must 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 UAV must not be flown within 30 m of any person, unless that person is under the control of the pilot; The maximum airspeed of the UAV in level flight must not exceed 90 m/s; During the entire flight the UAV must remain in controlled flight and within the geophone boundary of the flying zone; Failure of the pilot to recover promptly a UAV appearing uncontrolled or departing from the flying zone, must require activation of the FTS, either by the pilot or at the direction of the FSO.

### *4.3.4 Pilot qualifications*

The team pilot must have a qualification or equivalent (such equivalence must be demonstrated to the satisfaction of MTC). Evidence of qualifications must be provided with the FRR submission. The team pilot must have flown the UAV and tested it before the competition.

### *4.3.5 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 UAV, by measuring the energy usage (chemical or electrical) during the testing prior to the Demonstration Event.

### *4.3.6 Flight course*

The orientation (direction) of the flight course will be adjusted based on the prevailing winds as determined by the Flight Line Judge. The flight course will be positioned to maintain the greatest possible safety to personnel and facilities. (refer to Annex C for Airfield pam and flying zone boundaries figures)

### *4.3.7 Protest procedure*

Submitting a protest is a serious matter and will be treated as such. Teams may submit a protest to the contest judicial board any time during the competition. Protests may not be submitted after the conclusion of the competition. Protests must be submitted in written format and signed by the team leader, designees are not allowed for protest submissions.

Protests and penalties (up to disqualification from the contest for deliberate attempts to misinform officials, violate the contest rules, or safety infractions) will be decided by the Contest judicial board. Protests submitted but not upheld by the judges may be given a penalty of the loss of one flight score to the team submitting the protest. The decision of the Contest judicial board is final.

# 5. Statement of Work

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

## 5.1 Competition stages

Below, the stages of the competition, and the key deliverables:

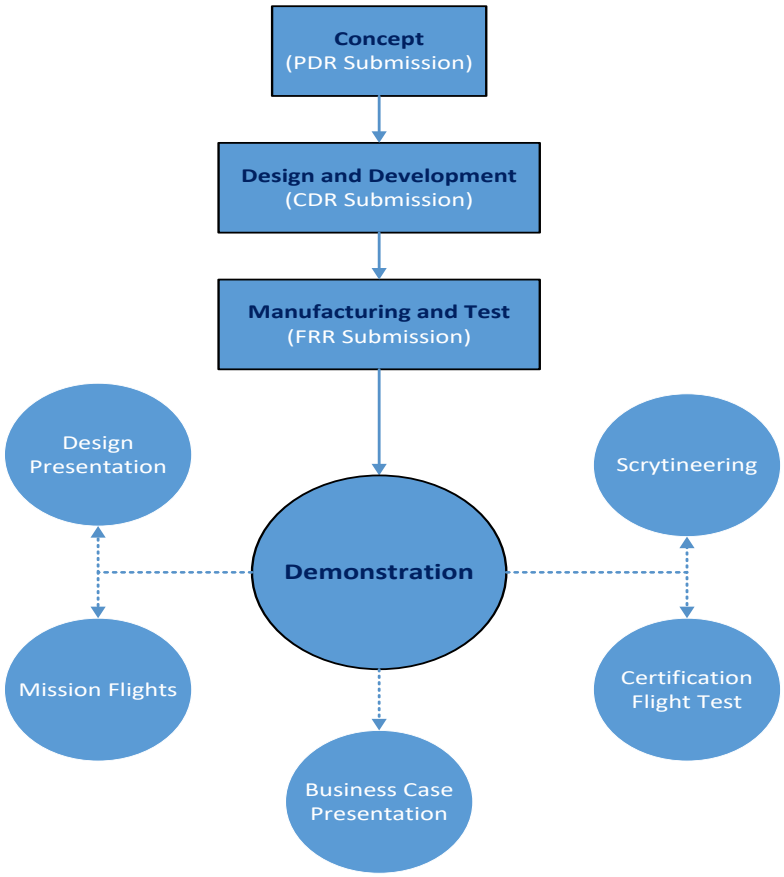



**Figure 1** UAVC Stages and Deliverables

**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 concludes with the Preliminary Design Review (PDR) submission.

**Design and Development**: 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 concludes with the Critical Design Review (CDR) submission.

**Manufacture and Test**: Construction of the UAV. This may also involve the manufacture of prototypes during the earlier design stages to de-risk the design. Demonstration through analysis, modeling 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 UAV. 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:

- Design Presentation.
- Scrutineering.
- Certification Flight Test.
- Mission Flights.

Further details of the Demonstration Event are provided at section 5.3 Demonstration Event.

## 5.2 Deliverable Items Description

### *5.2.1 Design Reports*

Guidance on the PDR, CDR and FRR deliverable items is provided at Annex B.

All elements of the competition will be conducted in English. Each registered team will receive an invitation to a google drive with team deliverables instructions, which will be provided after successful registration. All the team's deliverables, i.e., design reports will be submitted via the shared google drive.

### *5.2.2 Design Presentation*

Early in the Demonstration Event, each team will give a 15 min presentation on key aspects of the design and development to the judging panel. As a guide, the presentation should include the FRR Video and 10 PowerPoint slides. There will be up to 10 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 program.

### *5.2.3 Manufacturing Poster*

Teams must produce an A1 size poster with pictures and summary showing the build, assembly and test. This must be submitted to the organizers on arrival at the flight 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 UAV.

## 5.3 Demonstration Event

### *5.3.1 Logistics*

A detailed briefing will be given at the beginning of the Demonstration Event covering the logistics and timings for the event, rules and good conduct for safe operations, pre-flight briefings etc. Teams will also be given a running order and strict time schedule for the qualification process, including presentation, scrutineering, certification flight test, and flight missions. The schedule is necessarily tight and teams who are not ready to fly at their appointed slot time will have to re-apply for a later slot, at the discretion of the organizers. Note that the flying schedule is likely to be dynamic and updated during the event to take account of weather and UAV unserviceability.

It is expected that Teams will arrive with a fully serviceable UAV that is in good working condition. Efforts will be made to retain flexibility in the schedule to allow teams who fail to pass one of the qualification events time to repair, rectify, test and re-apply, but scoring penalties may apply.

### *5.3.2 Scrutineering*

Following the presentation, a panel of expert aircraft engineers will inspect the UAV to ensure that it is safe and airworthy, that any Corrective Actions made following the CDR submission or at the Design presentation have been addressed, and that any late modifications introduced are reviewed and acceptable.

The scrutineering panel will have reviewed the FRR submission, 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 payload 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.

Should the UAV fail the scrutineering, the team will be given the chance, if practical and if time permits, to rectify the issues and re-apply for scrutineering.

### *5.3.3 Manufacturing assessment*

The scrutineering panel will also conduct the manufacturing assessment (a marked prize) and look for:

- 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.

### *5.3.4 Certification flight test*

The certification flight test will assess the basic operation, to include:

- Take-off from the designated Take-off and Landing area. After take-off the UAV must maintain steady controlled flight at altitudes above 50 m and less than 100 m AGL. Take- off under manual control with transition to automatic control is permitted.
- Demonstrate maneuverability by flying a figure of eight, in the same flight.
- Loiter in a ‘race-track’ pattern over the airfield at a defined point for a period of 2 minutes at a height of 100 m.
- Land, back at the take-off point.
- An element of ground-based assistance for take-off and landing is acceptable, but the aircraft should operate automatically during other phases of flight.
- Demonstrate switch between automatic and manual flight.

The assessors will be looking to confirm that the team operating the UAV is competent as well as confirming the airworthiness of the UAV itself.

### *5.3.5 Flight demonstration missions*

Upon successful issue of a Permit to Fly, the Team will have a short time to prepare their aircraft for each mission flight.

Three missions comprise payload delivery; reconnaissance and endurance will be detailed illustrated with example & waypoint data in Annex A. The exact mission waypoints, target co-ordinates and obstacles will be communicated through the interoperability system and briefed to each team at the start of the event.

### *5.3.6 Safety of operations*

The Flight Safety Officer must 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 must be responsible for removal of all batteries from the site that they bring to the event, including safe disposal of any damaged batteries.

# 6. Adjudication and Scoring Criteria

## 6.1 Overall scoring breakdown

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

| | |
|---|---|
| **Design (100 points), comprising:** | |
| □ PDR Submission | (25) |
| □ CDR Submission | (75) |
| **Flight Readiness (150 points), comprising:** | |
| □ FRR Submission | (25) |
| □ Design Presentation | (100) |
| □ Scrutineering and Manufacturing Poster Flight | (25) |
| **Demonstration (350 points), comprising:** | |
| □ Mission 1 – Payload Delivery in the presence of obstacles. | (150) |
| □ Mission 2 – Search, locate, identify and rescue | (100) |
| □ Mission 3 – Endurance in the presence of obstacles. | (100) |

A maximum of 600 points is therefore available. The detail of scoring the Flight Demonstration is given in the tables below.

## 6.2 Flight demonstration

### *6.2.1 Mission 1: Payload delivery in the presence of obstacles*

Carrying the heaviest possible payload mass, after take-off navigate within the flying zone to visit the given way points WP 1,2,3,4,5 avoiding the given static and dynamic obstacles, then drop the payload on the target located on the delivered drop off location via interoperability system, and finally return to the launch point to land. Repeat until 10 min are finished. Number of takeoffs, landings, weight of total payload dropped with their positions relative to the center of drop area are evaluated. The

complete successful way points visit is also evaluated. Telemetry information should be reported to the interoperability system for assessment during the mission demonstration time

Through the Interoperability System, the teams will be given a set of stationary obstacles. Each stationary obstacle will be a solid cylinder, with height axis perpendicular to the ground, and bottom face on ground. The cylinders will have a radius between 3 to 5 meters, and height of 100 meters.

| Test | Scoring | Max Score |
|---|---|---|
| Payload Delivery***/Accuracy | • 12 points per 500g of payload mass dropped within 5 meters of target center.<br>• 10 point per 500g of payload mass between 5 m and 10 m from target center.<br>• 7 points per payload between 10 and 15 meters from target center. | 72* |
| Navigation Accuracy | • 5 points per WP successfully navigated up to maximum 25 points for one successful trial.<br>• Halve Navigation score for single extended breach of Geo-fence (> 5s).<br>• Zero Navigation points for persistent or repeated breach of Geo-fence. | 25 |
| Autonomous Operations | • 28 points for fully autonomous operation including Take-Off, Navigation, Payload Drop, and Landing<br>• Deduct:<br>▪ 7 points for manual take-off.<br>▪ 7 points for manual landing.<br>▪ 7 points for no payload delivery<br>▪ 7 points if flight is manual. | 28 |
| Obstacles Avoidance | Score 5 points per obstacle successfully navigated and avoided up to maximum 25 points. | 25 |
| Flight level 50>100 | Deduct 2 points for each time UAV go below 50 m | |
| Landing out | Deduct 5 points for failing to land back at the designated take-off and landing point. | |
| Maximum Preparation Time** | Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line and mission will be terminated after 20 minutes. | |
| Maximum Mission Time** | Deduct 5 points for every minute over the 10- minute maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt. | |

| | | |
|---|---|---|
| Maximum Flight line Time | For each attempted mission, whether successful or not, the maximum time limit is 20 minutes from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20-minute limit. | |
| Maximum Score: | | 150* |
| Interoperability Points | Teams that able to deliver their telemetry information to judge server. | 20 |

* Maximum score assumes 3kg payload mass deployed. Note that 3kg is not a maximum payload mass limit within the rules (though it may be challenging technically). Thus, the maximum score achieved could be greater than 150 if more than 3kg payload mass were successfully deployed.

** Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

*** Payload safely delivered.

### *6.2.2 Mission 2: Search, locate, identify and rescue*

Search, locate and identify four human body targets within a given search area. Search area boundaries will be submitted to teams in the field. Report back the GPS co-ordinates of each identified human body via the interoperability system for evaluation. Also, identify and report back whether the identified target is on one of the ally's victims or enemy based on uniform cam color. Teams must submit identified target via the Interoperability System (see annex C for Object file format example). Teams may additionally provide identified target via the Object File Format over USB drive, which will be used only in the event of an unplanned failure of the judging system.

Within the search grid there will be a number of QR code figures. Teams are required to capture and decode these QR codes and automatic report these codes to ground station before landing in order to claim the bonus.

Friend

Foe

### Mission Leg 1: Body Identification

In the first part of the mission, it is essential that for specific geographic areas, the UAV platforms should cooperatively scan large regions in an attempt to identify injured persons. Generating a map pinpointing potential victim, their geographical coordinates and sensory output such as high-resolution photos and/ or thermal images of potential victims.

The resulting saliency map would be generated as the output of such a cooperative UAV mission and could be used directly by emergency services or passed on to other UAVs as a basis for additional tasks.

### Mission Leg 2: Supplies Delivery

In the second part of the mission, the saliency map generated in Leg I would be used as a basis for generating a logistics plan for the UAV with the appropriate capabilities to deliver food, water and medical supplies to one location of the injured identified in Leg I.

| Test | Scoring | Max Score |
|---|---|---|
| Locate Target Accuracy | • 8 points for each target identified within 5 meters' accuracy<br>• Deduct 1 point per meter error with maximum of 9 points.<br>• score Zero for target reported within 14 m or greater error | 32 |
| Reporting Time | • Score as a percentage of the fastest competitor's time.<br>• Maximum of 12 points for achieving the shortest time, defined as the mission time from take-off to landing and including reporting the WP positions, divided by the number of successfully identified targets (i.e. those targets reported within 5 m accuracy).<br>• Reporting Time score for Team B = 12 x S / B, where 'S' is shortest time, and 'B' is time for Team B. | 12 |
| Identified Allies victims | Score additional 4 points per Allies Human body target identifying correctly through uniform color. (2 of them are enemies and 2 allies) | 16 |
| Identified alphanumeric | Score additional 4 points per correctly recognized alphanumeric in identified target through the reported object files. (2 of them are enemies and 2 allies) | 16 |
| Allies victims Supply Delivery | Score additional 4 points per Allies supply delivery for each 500g dropped within 20 m of the identified victim location. | 4* |
| Manual/Automatic Reporting | Deduct 2 points per target for manual reporting of position and / or alphanumeric. | |

| Test | Scoring | Max Score |
|---|---|---|
| Autonomous Operation | • 20 points for completing the mission fully automatically from take-off to landing,<br>• Deduct:<br>  • Deduct 5 points for manual take-off.<br>  • Deduct 5 points for manual landing.<br>  • Deduct 5 points if flight is manual.<br>  • Deduct 5 points for no payload delivery | 20 |
| Landing out | Deduct 5 points for failing to land back at the designated take-off and landing point. | |
| Flight level 50>100 | Deduct 2 points for each time UAV go below 50 m | |
| Maximum Preparation Time** | Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line. Mission will be terminated after 20 minutes. | |
| Maximum Mission Time** | Deduct 5 points for every minute over the 10-minute maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt. | |
| Maximum Flight line Time** | For each attempted mission, whether successful or not, the maximum time limit is 20 minutes from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20-minute limit. | |
| Maximum Score | | 100 |
| QR Bonus Points | For each captured, identified and automatic reporting to ground station before landing | 30 |
| Interoperability Points | Teams that able to deliver their telemetry information as well as the identified targets | 20 |

*Maximum score assumes 500g payload mass deployed. Note that 500g is not a maximum payload mass limit within the rules (though it may be challenging technically). Thus, the maximum score achieved could be greater than 100 if more than 500g payload mass were successfully deployed

*Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

### *6.2.3 Mission 3: Endurance in the presence of obstacles*

Team declares the mission payload mass, which is validated by the judges before the mission flight, also ensuring maximum all up mass limit not exceeded. Take-off, fly a prescribed 1 km course identified by given way points around the airfield for as

many laps as possible up to a maximum of 6 laps and land at the designated landing point. A successful lap is counted if UAV successfully visits all the identified waypoints in its prescribed 1 km course and return back to the start point

Through the Interoperability System, the teams will be given a set of stationary obstacles. Each stationary obstacle will be a solid cylinder, with height axis perpendicular to the ground, and bottom face on ground. The cylinders will have a radius between 3 to 5 meters, and height of 100 meters.

| Test | Scoring | Max Score |
|---|---|---|
| Payload Mass | Score 4 points per 500g of payload mass carried. UAV must complete at least one full lap to score points. | 24* |
| Endurance/ Navigation Accuracy | • Score 5 points per lap completed successfully<br>• Deduct 1 point for unsuccessfully navigated waypoint per lap<br>• Halve score for single extended breach of Geo-fence (> 5s).<br>• Score zero points for persistent or repeated breach of Geo-fence | 30** |
| Lap Time | • Score as a percentage of the fastest competitor's time, with a maximum of 16 points for achieving the fastest average time, defined as mission time from take-off to landing divided by the number of successfully completed laps.<br>• Score 0 if all the laps are not completed successfully. | 16 |
| Obstacles Avoidance | • Score 3 points per obstacle successfully navigated and avoided up to maximum 15 points.<br>• UAV must complete at least one full successful lap to score points. | 15 |
| Autonomous Operation | • 15 points for completing the mission fully automatically from take-off to landing,<br>• Deduct:<br>  • 5 points for manual take-off.<br>  • 5 points for manual landing.<br>  • 5 points for if flight manual | 15 |
| Landing out | Deduct 5 points for failing to land back at the designated take-off and landing point. | |
| Flight level 50>100 | Deduct 2 points for each time UAV go below 50 m | |
| Maximum Preparation Time*** | Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line. Mission will be terminated after 20 minutes. | |

| | | |
|---|---|---|
| Maximum Mission Time*** | Deduct 5 points for every minute over the 10-minute maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt. | |
| Maximum Flight line Time*** | For each attempted mission, whether successful or not, the maximum time limit is 20min. from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20 min. limit. | |
| Maximum Score | | 100 * |
| Interoperability Points | Teams that able to deliver their telemetry information as well as the identified targets | 20 |

* Maximum Payload Mass score assumes 3kg payload mass carried. Note that 3kg is not a maximum payload mass limit within the rules (though it may be challenging technically). Thus, the Maximum Score could be greater than 100 if more than 3kg of payload mass were carried.

** Maximum endurance score shown above assumes six laps, though this is not a limit within the rules. The practical limit may be dictated by the Maximum Mission Time. The maximum number of laps could thus be greater than six, with an Endurance score greater than 30.

***Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

# Annex A Missions

## A.1 Objective

Three separate missions must be flown, each testing different performance characteristics of the UAVC.

a. *Payload Delivery in the presence of obstacles* - testing the UAV load capacity; ability to carry and accurately deploy a number of payloads; navigation around a preset course; autonomous operations in ten minutes (no limitation for how many takeoff and landing).
b. *Search, Locate, Identify & rescue* - testing ability to search one or more areas and locate Allies and enemy targets in the shortest time; autonomous operations.
c. *Endurance in the presence of obstacles* – testing the UAV endurance around several laps of a preset course; UAV load capacity; teams' knowledge of their UAV's performance.

The scoring criteria for these Missions is presented at section 5.2 Flight Demonstration.

## A.2 General Points

### *A.2.1 Takeoff*

Take-off must be conducted within the designated take-off and landing box, into wind as far as practicable. After take-off the system must maintain steady controlled flight at any suitable height, typically between 50 - 100 m. 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 signals they are ready and the Flight Safety Officer gives clearance for take-off.

### *A.2.2 Landing*

The UAV must return to and land at the designated take-off and landing zone. Transition to manual control is permitted for landing, though a fully automatic landing will score more points. The mission is complete when the UAV comes to a halt and the engine is stopped.

### *A.2.3 Navigation*

Each team will be provided with a map of the airfield, showing the Geophone boundary within which the UAV must remain at all times, together with any other no-

fly zones. The map will provide GPS co-ordinates for the Geophone vertices, the Waypoints (WPs) and the Target(s).

A mission route will define the WP order. The UAV should aim to fly directly overhead each WP, and the accuracy of the navigation will be evaluated by analysis of the GPS data logger after the flight. Points will be deducted for breach of the Geophone. At the Flight Safety Officer's discretion, the Flight Termination System may be initiated upon such breach, or the team may be directed to land the UAV as soon as it is safe.

### *A.2.4 Operating Height*

All operating heights between 50:100 m are valid within the allowable flying zone. The UAV must drop the payload from a minimum of 50 m height above ground, and cannot land to place the payload. During transit phases between the landing area to the target area, the UAV must maintain a safe height above ground.

### *A.2.5 Timing*

With many teams flying multiple missions, 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 sequence, there will be at least two teams at the flight line 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 flight line and being nominated first in line to fly a mission, a maximum of 10 minutes is allowed for pre-flight preparation. Each mission is a maximum of 10 min duration, from take-off to landing with the UAV stopped. Additionally, an overall maximum time limit of 20 minutes must be strictly enforced from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Points will be deducted if the team breaches these time limits. If a team cannot get the UAV ready within the 10 min allowance, it must retire and request another mission slot time, which may be granted at the discretion of the organizers.

# Annex B Document Templates and Guidance

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

## B.1 Preliminary design review submission

The Concept stage culminates with the Preliminary Design Review Submission, a written report of no more than **15 pages** in the body of the report supported by a maximum of 3 pages of schematics or tables. The submitted report should describe the preliminary design of the team's airframe and the rationale behind their design choices. The purpose of the report is to show the systems engineering process, design analysis and tradeoffs, final solution, tests which were conducted and performance data, and expected task performance. The report must address the mission tasks the team is capable of achieving during flight by their selected airframe type, and if a team elects not to include certain elements (e.g. air drop) it should be so stated. The suggested structure and content should be:

**Introduction**

**Team Details**

- Chart showing the team organization and roles;

**Project Management**

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

**Requirement Capture**

- Summary of UAV Requirements, including regulatory requirements.
- Summary of competition missions' requirements.

**Concept Selection**

- The Systems Engineering approach adopted to develop compliant solutions;
- Discussion of the design drivers, the concept generation process, concept options considered, the trade studies undertaken, and the factors influencing the down select to the chosen concept;
- UAV overall layout & description with a three-view scale drawing.

**Performance Calculations**

- Preliminary aerodynamic, structural and performance calculations supporting the initial sizing, basic stability and control calculations, together with a weight and balance estimate.

**Weight Budget**

**Cost Budget Safety**

- 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**

- 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;
- 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, FTS.

**Test Plan**

- A short summary of the approach to 'Certification and Qualification', which could include design and analysis evidence to be generated in the next stage, and the outline elements of the test program to demonstrate the integrity of the system.

## B.2 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 **25 pages** supported by a maximum of 5 pages of diagrams and appendices. The suggested structure and content should be:

**Introduction**

**Changes from PDR**

Note any ***update*** to the information presented in the PDR.

- Team organization and roles;
- Project plan including main activities, lead times and dependencies;
- Project risks and their mitigation;
- System concept
- Performance, weight and cost

**Detailed Design and Manufacturing Description**

- UAV overall layout & description with a three-view drawing showing dimensions and center of gravity, summary of the rationale for the layout and key design features.
- Description of the Aero-mechanical Design, including where appropriate the materials and construction techniques for each of the elements. This should include:
  - Arrangement of flying surfaces and major components.
  - Airframe structural design including consideration of flight, ground, handling and transport requirements.
  - Aerodynamic design and performance, including stability and control.
  - Control actuation system providing roll, pitch and yaw control.
  - Propulsion system.
  - Fuel system / propulsion battery.
  - Undercarriage.
  - Payload carriage and release system.
  - Payload protection system.
  - Flight termination system.
  - Description of the avionics, mission system and electrical power.
  - Mission planning and performance analysis.
  - Autopilot design and automatic operation.
  - Avionics, navigation and mission control system.
  - Sensors and image processing system.
  - Radio control system, including data link and telemetry.
  - Ground control station.
  - Brief description of any consideration given to support equipment, such as test equipment, handling or storage fixtures.
  - Analysis and modelling. Provide a summary of the analysis and test undertaken to support the design and development, e.g.
  - Structural performance.
  - Aerodynamic performance.
  - Payload release dynamics.
  - Navigation and mission performance.

**Qualification Test Plan**

Summary of the proposed test plan for the UAV, which may include physical testing supported by modeling, and including:

- Structural testing.
- Subsystem testing.
- Flight testing.

**Safety Case**

The safety case should show an understanding of the main regulations relevant to this UAV. It should present the argument demonstrating the airworthiness of the UAV, summarizing the main safety risks and their mitigation, with arguments supported by evidence from design, analysis or test.

One of the mitigations to a number of safety risks is the incorporation of the FTS. The safety case should describe how the FTS mitigates each of the identified risks that it is designed to address. The approach to compliance of the RF requirements should be described. The safe operation of the UAV should be discussed, in addition to the technical design.

**Verification & Validation Register**

A short description of the approach to Verification & Validation supported by a detail table of results.

**Conclusions**

## B.3 Flight readiness review submission

The Manufacture and Test stage culminates with the FRR Submission, comprising:

- A video no longer than 4 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 Pilot Licensing and Insurance;
- A signed declaration by supervisor, that in their opinion:
- The UAV appears compliant with the requirements noted in section 3 Design and Operational Requirements; 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 UAVs 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.

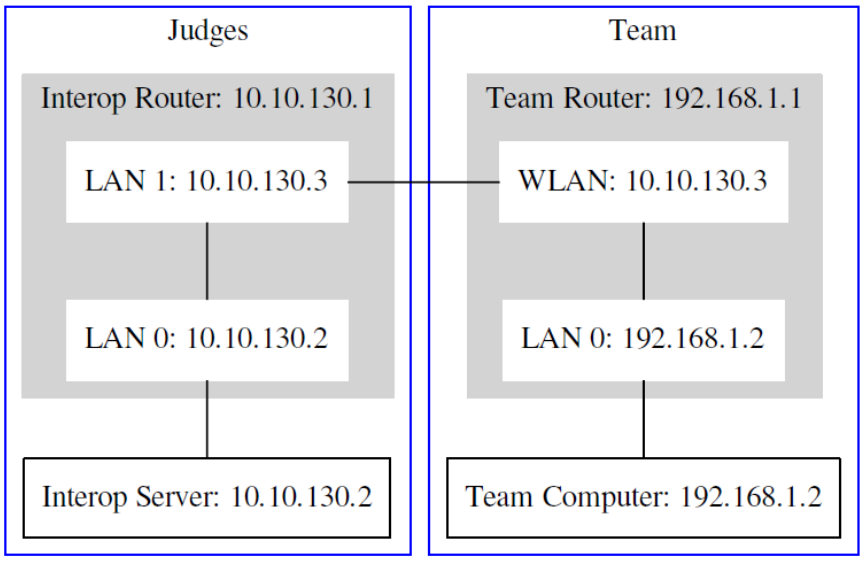
# Annex C Interoperability System

This Annex describes the computer and networking setup at competition. The teams should replicate this setup to test their integration. In addition, this annex illustrates examples of the teams' deliverables during mission demonstration.

**Note: teams that will use the interoperability system with the judge server will gain bonus points.**

## C.1 Computers and networking

At Check-In and Orientation, teams will be given a static IP address, a DHCP IP address range, the server IP address and port, a username, and a password. During Mission Setup, the teams will be provided a single Ethernet cord. This cord will connect the team's system to the interop router, which will be connected to the interop server. The following figure shows how the Interoperability System will be connected, and the recommended means of connecting the team's system. Note the IP addresses are examples.




It is recommended that teams use a router to have a separate subnet. The competition board provided Ethernet cord will then connect a LAN port on the interop router to the WAN port on the team's router. This will allow multiple team computers to communicate with the interop server at the same time. This will also allow a single computer to simultaneously communicate with the interop server and other team computers.

The teams will need at least one computer to communicate with the interop server. Competition Board will provide client library and tools with documentation for communication. Teams may also integrate directly via the HTTP + JSON protocol.

### Sample Mission Map

At Check-In and Orientation, teams will be able to check the connectivity with the judge interoperability server with their accounts. GPS locations of the Geo-fence boundaries and the Waypoints will be delivered in the field demonstration day via the judge interoperability server (**if they are ready**). Otherwise, GPS locations of the Geo-fence boundaries and the Waypoints will be delivered in paper.

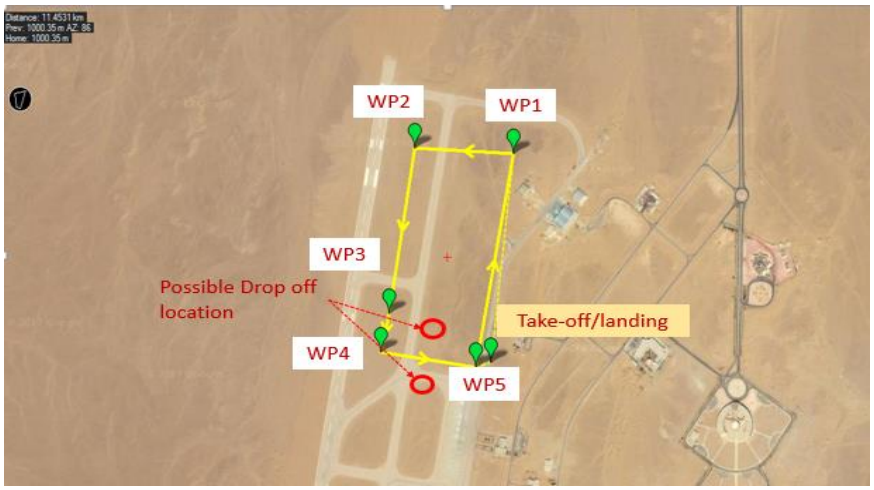



**Figure 2 Waypoints, possible Air Drop Location & Boundary**

### Deliverables submission

According to the competition rules, all deliverables will be submitted to the judges via the Interoperability System during the flight demonstration. Teams should declare their readiness for connecting and submitting deliverables via the Interoperability system before the flight demonstration. Teams failed to declare their readiness are allowed to submit their deliverables manual or in USB with deduction in their score points.

The required deliverables are the UAV telemetry information during flight, the identified targets colors and alphanumeric identification in the following object file format. On the other side, the Interoperability server sends the obstacles GPS coordinates to the teams' ground stations.

### Object File Format

The Object File Format is a folder containing object detection files. Each object submitted by the team gets 2 files in the folder, both of which start with a number unique to the object, where one has the extension “json”, and the other has either the extension “jpg” or “png”. The “json” extension file must contain a JSON formatted object data. A “jpg” extension file must be a JPEG image, and a “png” extension file must be a PNG image. The team will copy this folder to a USB drive provided by the judges. If the team is attempting actionable objects, the team will be provided 2 USB drives.

Example folder structure for 2 objects:

- myteam/
  - 1.json
  - 1.jpg
  - 2.json
  - 2.png

Example JSON file format:

```
{
"type" : "Enemy" ,
"latitude" : 38.1478 ,
"longitude" : -76.4275 ,
"orientation" : "n" ,
"shape" : "star" ,
"background_color" : "orange" ,
"alphanumeric" : "C" ,
"alphanumeric_color" : "black"
}
```

Note: UAVC 2021 will use the developed server side from the Interoperability server published code for teams’ evaluations. Please, keep updated with the code repository from SUAS updates including the commands and the file format. It is well known that the judge server will ignore and will not receive any file (JSON or image) not compatible with the published server from SUAS in their GitHub repository.

It is worth mentioning that the interoperability server GitHub documentation includes the set of commands specification that the teams can use to test their client library. Through these HTTP commands, teams will be able to acquire the Waypoints GPS coordinates, check the availability of the server, receive obstacles GPS coordinates, and submit their deliverables automatically.

## C.2 Target description

The following figure demonstrates an **example** of identified target in a red 1 m x 1 m central square, incorporating an alphanumeric code in white. Background and alphanumeric colors are subjected to change.

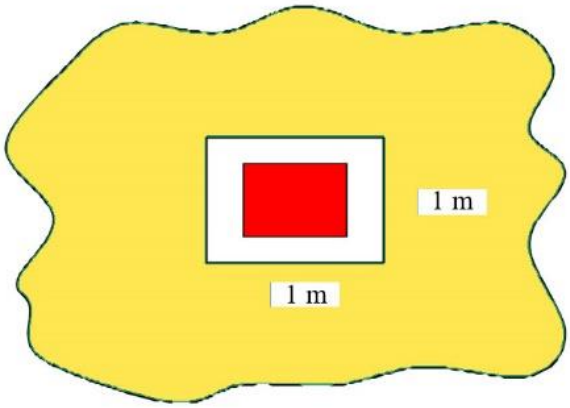



**Figure 3 Target Dimensions.**

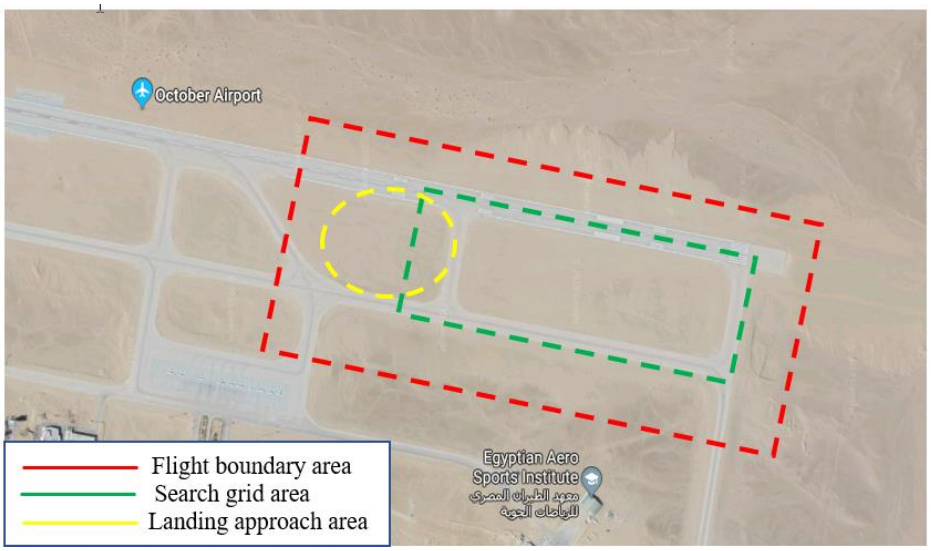



**Figure 4 Airfield Plan.**