Aerial Evolution Association Canada
Student UAS Competition
2022

Concept of Operations (CONOPS) and Rules

Version 1.2

Contents

This Document

1. This is Version 1.2 of the document, released on 11 March 2022. The CONOPS is subject to change at the discretion of the competition committee. Changes since previous versions are highlighted.

2. Questions posed by student teams, with appropriate responses, are at the end of the document. Where required, the CONOPS has been modified as a result of the questions.

3. The following terms are used in the document:

    a. Unmanned Aerial System – Set of all stuff including UAV(s), UGV(s), control station(s), antennae, etc.

    b. Unmanned Aerial Vehicle – Refers to aerial vehicle(s) that are part of your UAS.

    c. Unmanned Ground Vehicle – Refers to ground vehicle(s) that are part of your UAS.

Mission

4. The mission for the 2022 competition is to provide security for a large diplomatic installation in Canada, by responding to delivery of a suspicious item and to intrusion at a remote perimeter.

Competition Format

5. The competition is organized in two Phases, including:

    a. Phase 1 Technical Competition, in which teams complete a Design Paper based on the Task requirements detailed below, due 16 January 2022 at 5pm EST; and

    b. Phase 2 Airborne Competition, in which teams conduct the Tasks, as described later in this document. Phase 2 takes place 6-8 May 2022 in Southport, MB; the competition schedule is in Para 18.

6. All teams must complete Phase 1 by submission of a Design Paper to be eligible to participate in Phase 2. There will be separate prizes awarded for each Phase.

Eligibility

General

7. All competitors must be enrolled part- or full-time at a Canadian College or University for Fall 2021 and/or Winter 2022.

Team Size and Composition

8. Traditionally, there is no maximum or minimum team size and no maximum crew size in the preparation area, but a maximum of 5 people in the flight-line crew. However, it is possible that COVID-19 considerations will limit the number of team members allowed to attend the competition in Southport. Availability of accommodation may also limit team numbers, at the discretion of the Southport organizer. Any such limitations will be communicated with teams as soon as possible.

9. Teams may be organized internally at the discretion of their members, and may include graduate and undergraduate students. It is suggested that students from multiple years be encouraged to participate. Joint teams consisting of students from more than one institution are also permitted; for example, a joint university-college team is allowed.

10. The competition is not open to commercial entities; however, sponsorship of the teams by commercial entities is encouraged.

11. Each individual vehicle, ground or air, must have a separate operator while being flown or moved, e.g, concurrent operation of vehicles requires separate operators. Yes, one person could fly a UAV, then after landing, control a UGV. **All UAV pilots must hold an Advanced Pilot certificate.**

Number of Teams

12. There is no restriction on the number of teams from any one institution; however, no individual student may be on more than one team, and submitted projects from different teams at the same institution must be substantially different. Teams will be accepted at the discretion of the Judges. Depending on registrations and accommodation or COVID-19 restrictions, it may be necessary to limit institutions to one team, or to limit the number of teams in the competition.

Applications and Registration

13. Teams must send an email indicating their interest to competition@unmannedsystems.ca, and complete the online registration on www.unmannedsystems.ca, including paying the team registration fee of $500+tax. Registration is non-refundable. Once fully registered, teams will have access to more information from USC. The registration deadline is **9 November 2021** at 5pm EST.

14. Teams are strongly encouraged to seek sponsorship opportunities for their project. There is no restriction on the level or type of sponsorship that may be provided.

15. Teams are responsible for their own costs, including travel to/from and during the Phase 2 competition. The onsite participant cost is **$250+tax** and includes most meals and lodging. Accommodations will be arranged by Southport, and teams are not allowed to stay other than in the provided rooms. Food will be provided most days, excluding Saturday evening. This payment and team list is due by **25 March 2021** and is not refundable.

16. The competition ends at about 2200 hrs after the awards banquet on Sunday night. Departing immediately following the banquet is NOT endorsed by USC; plan to leave on Monday to ensure safe driving home. Ensure that all drivers on a rental car have a full driver's license in good standing. The awards banquet is planned to be held at a different location than the accommodations – teams must plan appropriate transportation.

Key Dates

17. The following are the key deadlines for the 2022 competition:

    a. **9 November 2021 at 5pm EST** – Submit expression of interest to competition@unmannedsystems.ca and complete online registration, which includes paying the $500+tax registration fee;

    b. **16 January 2022 at 5pm EST** – Submit Phase 1 Design Paper;

    c. **25 March 2022** – Submit team list and pay $250+tax fee for onsite participants;

    d. **11 April 2022** – Submit video proof of successful flight, as described in Para 54; and

    e. **6-8 May 2022** – Attend the competition in Southport!

Competition Schedule

18. The schedule for Phase 2 in Southport is shown below; detailed timings and order of the teams will be provided by email on the Thursday evening of the competition.

    a. Friday morning:
        a. Teams give the Chief Judge their presentation **on a USB stick in PowerPoint format NLT 0715.** Starting at 0800, teams conduct an 8-minute scored oral presentation to present their team and their plan for conducting the Tasks.
        b. Following the team presentations, the head of Embassy Security will brief teams on intelligence about threats for the weekend, and will provide the perimeter of the embassy grounds and aerial images and video of the building and surrounding area. Technical requirements and UAS capabilities will be according to the Mission Requirements contained in the following paragraphs. Teams may ask any questions they wish to clarify Task requirements

    b. Friday following the presentations – teams conduct Flight Readiness Review to demonstrate compliance with aircraft safety requirements per FRR Checklist in Para 47. Depending on forecast weather for the weekend, operational tasks may begin on Friday afternoon, or there may be practice flight time allocated;

    c. Friday evening – Pizza reception. Meet the sponsors, plan the work you need to do overnight to get ready for tomorrow's flying ☺.

d. Saturday – Teams respond to the delivery of a suspicious package on the embassy site (Task 1);

e. Sunday – Teams respond to an intrusion at the perimeter of the embassy grounds (Task 2); and

f. Sunday evening – Competition banquet and awarding of prizes.

Covid Considerations

19. At the time of writing this document, it is believed that it will be possible to conduct an in-person competition in Southport; however, the evolving situation vis-à-vis Covid will be monitored over the coming months and decisions about the feasibility of the Southport competition and Covid protocols will be made as required.

20. Covid protocols including vaccine requirements will be in accordance with Manitoba government direction as in place at the time of the competition. At a minimum, **the competition will require all participants to be appropriately vaccinated**.

Scenario

21. There are many different types of facilities considered to be 'Critical Infrastructure', due to their importance to the functioning of society (eg, power plants), the housing of important government institutions (eg, Parliament, National Archives) or important people (embassies, Rideau Hall), and the like. Governments are increasingly using UAS to aid in securing Critical Infrastructure and respond to threats.

22. A foreign embassy in Ottawa has hired your company to provide security to their buildings and extensive grounds. Your contract requires that you respond to intrusion by persons at the perimeter of the grounds, and detect and respond to the delivery of any suspicious items on or near the building.

Mission Requirements

23. An Intelligence assessment, map of the perimeter of the grounds, and disposal point ('Secure Drop Off') for suspicious packages will be provided by Embassy Security. Unmanned Aerial Systems which meet the Mission Requirements in the following paragraphs will be capable of accomplishing all competition Tasks.

24. The intention of this competition is that teams have multiple opportunities to gain points, to make strategic decisions about how to accomplish the Tasks, and, if necessary, to decide which sub-tasks to discard or emphasize to maximize points, based on the capabilities of your systems. Teams may choose in advance to not attempt any given sub-task(s); however, clearly you would be forgoing the points for any missing sub-task(s). In the spirit of innovation and challenge, we encourage teams to attempt all challenges in both Tasks.

25. There will be one flight window for each team on each day of the competition, with Task 1 on Saturday and Task 2 on Sunday. Within each flight window, you may operate your UAS as many times as you wish to achieve the requirements of the relevant Tasks. However, you may not attempt Task 2 on Saturday, or redo Task 1 on Sunday.

26. Teams may use any desired combination of vehicle types (rotary wing, fixed wing, hybrid, UGV, etc) to accomplish the Tasks, and you may use different vehicle(s) or vehicle type(s) for the two Tasks if you choose.

    a. UGV's will not be able to access the entire site via the ground. Nominally, you should consider that there is a 3-meter-high fence around the embassy (see Figure 1, and the perimeter will be shown in the images provided by Embassy Security).

Task 1: Device Detection and Disposal

27. Teams will have been provided (at the Embassy Security briefing) with images and video of the building and the area within 50m of the building (total area not more than 10,000 m^2). The briefing will also provide Intelligence about the delivery of a 'device' within this area, including information about the Device size, weight, and shape. The Device will be rigid, not be larger than 20 cm on any one axis, and weigh no more than 2 kg. The device will be largely of a single material, and may…or may not…be a regular shape.

28. Given that the Device may be an explosive, it could be placed as close as 1m to vertical structure. Teams will be tasked with using their UAS to remotely detect, collect, and dispose of the Device. The briefing will specify the location of the Secure Drop-Off into which teams will dispose of the Device.

    a. For clarification, the Device may be placed between 1m and 50m from the embassy building (see yellow area on Figure 1).
    b. The device will be placed on a hard surface, dirt, or mowed grass (approx. 2" length).

29. The embassy property will be between 200m and 500m from the GCS. Thus, the property will be within VLOS of the pilots/operators posted at the GCS; however, the Device may be BVLOS from the GCS location. (Pilot/operator will be able to see the embassy but may not necessarily be able to see the Device from the GCS).

30. The Secure Drop-Off location will not be further than 200m from the GCS. The Secure Drop Off will be visible from the GCS, and one member of the flight team may be at least 20m from the Secure Drop-Off (device might be an explosive…)

    a. Clarification: A member of the flight team may approach to not closer than 20m of the Secure Drop-Off (indicated by the red dashed circle around the Secure Drop-Off on Figure 1). Teams may not approach closer to the Device pickup location than the GCS.

31. The UAS and operator(s) must be able to meet the following requirements:

a. Detect the Device within the prescribed area near the building. Detection may be by comparison to the provided reference video/images of the embassy and area or by direct observation (looking for the Device). Note that no promises are made about the quality or resolution of the reference images.

b. Pick up the Device and transport it to the Secure Drop-Off location. Attachment of the Device to the vehicle must be accomplished remotely.

c. Drop off the Device in the Secure Drop-Off and return the UAS to the GCS location.

   i. The Device must be remotely released from the vehicle.

   ii. The Secure Drop-Off will be a standard 45 gal/200 litre metal barrel, or of equivalent size and properties, 87cm high by 58cm in diameter, as shown in red in Figure 1. The barrel will be firmly attached to the ground. UAS may land or attach to the barrel if desired.

   iii. Since the Device is assumed to potentially be an explosive, it is critical to softly lower it into the barrel and that it remain upright.

      a. Device delivery impulse will be measured by an IMU inside the Device. The maximum allowed impulse is nominally 3g, see c.
      b. 'Level' is defined as no more than 45 deg tilt in any direction; this will be measured by the same IMU.
      c. The 'IMU' will be an Android phone with the 'Sensor Logger' app, recording the *Accelerometer* and *Orientation* parameters. The actual acceleration measurement for judging the vertical impulse will depend on the sensor characteristics of the phone used, the design of the Device, and the mounting of the phone. As such, it may be necessary to amend the maximum allowed measured impulse for judging, but with the goal of representing approx 3g externally-observed impact. Once the Device has been constructed, further guidance will be given on empirical observation of a 'maximum' impact (ie, 'max impact is consistently observed by a drop of X cm onto a layer of X cm of foam/cardboard/etc')…then you can just make sure you lower/drop it more gently than that 😊.

   iv. No part of the UAS may be left on embassy grounds (green, yellow or blue in Figure 1).

32. Teams will be scored on the following, with further scoring details in Para 77.

a. Ability to detect the Device;

b. Delivery of the Device to the Secure Drop-Off location;

c. Force with which the Device is placed (dropped?!) in the Secure Drop-Off;

d. Maintaining the Device level (within 45 deg) at all times, and delivering the Device upright;

e. Successful UAS return to the launch location; and

f. Time to complete the Task.

33. A schematic of the Task 1 Mission Requirements is below. Note that this figure is not to scale and the embassy building/perimeter/GCS shapes and positions reflect just one possible configuration. The UAS may land or manoeuvre anywhere on the Embassy grounds.

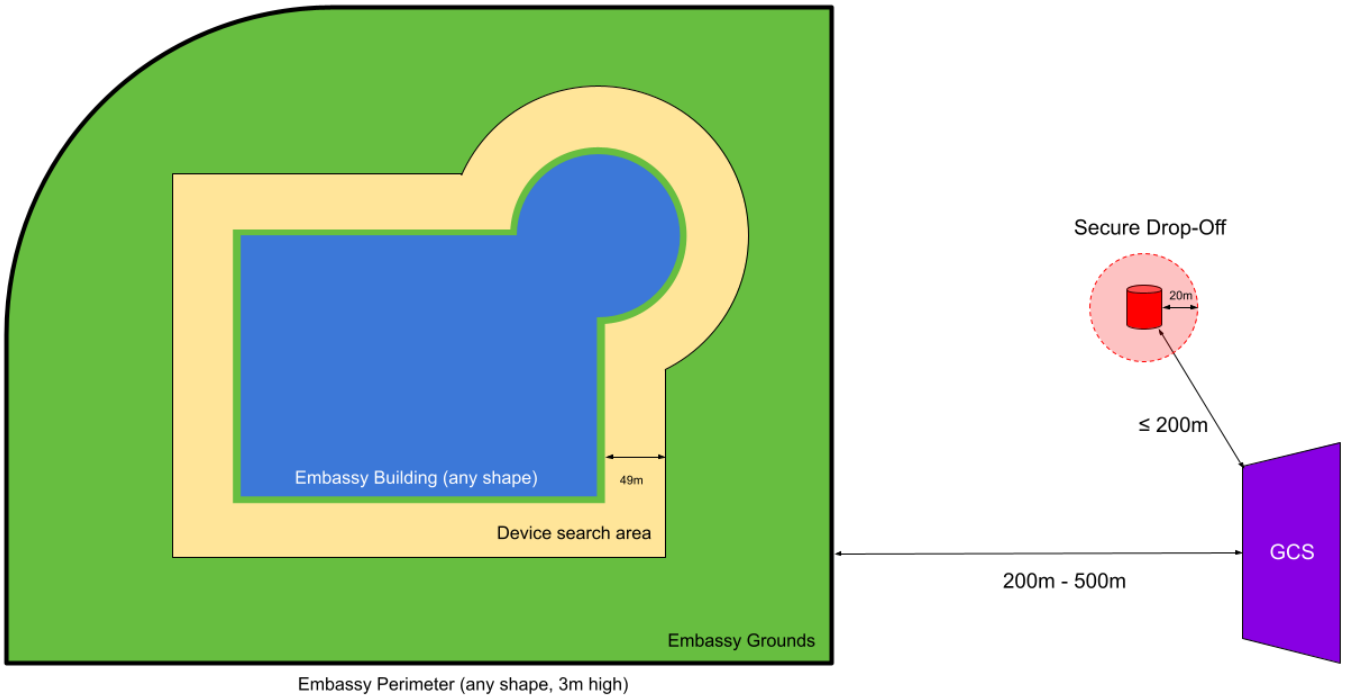

Figure 1 - Task 1 Schematic for Device Detection and Disposal

Task 2: Detection and Tracking of Perimeter Intruder

34. Teams will have been provided at the Embassy Security briefing with a map showing the layout and perimeter of the embassy grounds. At the start of the team's flight window, they will be provided with a QR code as shown in Figure 2, giving notice of an intrusion detection on the perimeter, a set of questions to answer about the intruders, and a link to an annotated team-specific Google Map showing the intruder area. The intruder(s) will be people.

Figure 2 - Sample QR Code with Message Format

a. The QR code has the following code format:

Questions:\n
Word word? Word word? Word word?\n
Date; Time; device_id; sensor_id; longitude; latitude

b. Note "\n" is a newline character. "Date" is in YYYY-MM-DD format. "Time" is in HH:MM 24-hour format in the CST timezone (Manitoba). Sensor and device IDs are strings.

Note that the QR code above uses a comma to separate the long and lat – this is wrong.

35. The UAS and operator(s) must be able to meet the following requirements:

a. Launch from the GCS location and fly to the specified intrusion location, which will be no further than 3 km from the GCS.

i. Any path may be taken to the intrusion location, but there will be points awarded for minimizing the noise signature of the UAS.
ii. Maximum points will be awarded if the launch and flight to the intruder location is done automatically and autonomously on receipt of the message (a team member stationed at the GCS may scan the provided QR code and the vehicle must automatically understand the code and autonomously fly to the indicated location). For safety, initiation of the autonomous flight must incorporate a confirmatory action (push button, step-raise throttle, etc) by the pilot which does not in any way directly control the UAS.

b. Detect and track the intruder(s) over a path of up to 500 m, keeping a camera fixed on the intruders and viewable at the GCS location. For safety, the minimum altitude of the UAS over the intruder is 50m. Determine key physical or clothing features or activities of the

intruders per the questions provided by the QR code. The team will be provided with an obvious indication in real time that the tracking is complete (Intruder stands up, looks at the UAS, and waves hands over head). Provide a copy of the GCS video to the judges on a USB stick for review from detection of the intruder to end of tracking (with the final report).

c. Minimize the likelihood of the intruders noticing the UAS by minimizing its noise signature.

   i. Noise measurements will be taken, using the Sensor Logger app previously mentioned recording *Microphone*, at the intruder location specified in the message and at a point 500m from the intruder location on a straight line connecting the GCS and intruder location.
   ii. The scored noise value will be the sum of the maximum instantaneous noise measured at the two locations.

d. Modify the provided Google Map to show the path of the intruders relative to the layout of the grounds and perimeter, and to show the location of intruder actions. The response will be evaluated based on the overall correct shape of the path and its path relative to easily-identified ground features. Great precision is not required.

36. Teams will be scored on the following, with further details in Para 78.

a. Correctly interpreting the intrusion message and flying to that location, with maximum points for automatic launch and flight to the location;

b. Detection and correct identification of the intruder(s);

c. Correct responses to questions about key physical/clothing features and intruder activities;

d. Correctness and presentation of the map trace; and

e. Noise signature of the UAS.

37. A schematic of the Task 2 Mission Requirements is shown in Figure 3. Note that this is just one possible configuration. The intrusion can be detected at any location on the security perimeter and follow any path inside, outside, along or across the security perimeter. The shape and dimensions of the security perimeter around the embassy is classified and will be revealed during the on-site Embassy Security briefing. Prepare for VLOS and BVLOS operations. The UAS may land or maneuver anywhere.

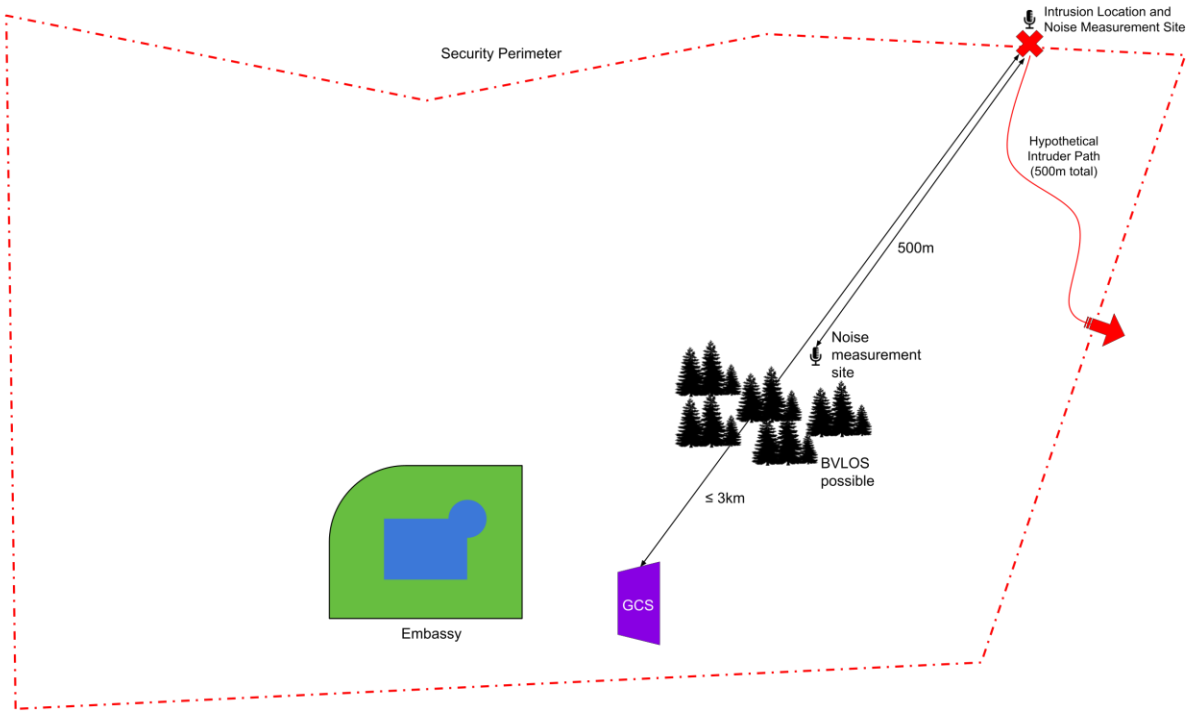

Figure 3 - Task 2 Schematic for Intruder Detection and Tracking

Unmanned System Design Constraints

38. The following UAV design restrictions will be verified prior to being allowed to fly:

    a. Maximum take-off weight of 10 kg (any payload and batteries included, but not including retrieved Device weight) for each individual UAV;

    b. Only electric propulsion (including solar cells, batteries or fuel cell) may be used;

    c. UAV must have a flight termination system to safely end flight as described in Para 45.

    d. Vehicles must clearly display the team name;

    e. Data links can be by radio, infrared, acoustic or other means so long as no tethers are employed. Unmanned Systems may operate autonomously, semi-autonomously, or under manual control at the discretion of the teams;

    f. Radio frequency usage in Canada is defined by ISED. If a licensed band is used, the license must be obtained and provided to the judges before being allowed to fly. Since all transmitters will have to be OFF on the entire airport property during the competition, except for the team flying, it is highly recommended that the teams develop an alternative (wired) method to pre-flight and test their system. Teams may assume that high-speed internet will

NOT be available on the field; and

g. This is an Unmanned Aerial System design competition. Using completely off the shelf UAVs (example DJI Phantom) is not allowed.

Flight Operations

Flight Schedule

39. Teams will have one flight window for each of the 2 Tasks, each of which will be approximately 30-45 minutes. The actual amount of time allotted will be announced prior to the start of the competition flights; the allocated time is subject to number of registered teams and may require change due to uncontrollable factors such as weather.

40. The schedule for team presentations and two flight windows will be determined by random lottery. The schedule will be provided to the teams on arrival at the competition.

41. Teams may be (and are encouraged to be!) setting up while another team is flying.

Flight Teams

42. Teams will designate a 'flight crew' consisting of maximum 5 team members. Only the flight crew may be present while the team is on the flight deck (pre-flight and flight).

43. Each individual UAV or UGV requires a dedicated Operator. All Operators must remain at the launch point for the complete Task, and the focus of an Operator's attention must be on the vehicle. Pilots of UAVs must hold an Advanced Pilot certificate.

44. After their last flight of the competition, teams have 90 minutes to give their report in PDF format to the judges on the provided USB stick. The USB stick must be returned to the judges at the specified time and the contents will be judged according to the report criteria.

Safety

45. All UAVs must be equipped with a safety flight termination system that can be activated either automatically or remotely (kill switch). For fixed wing, this could consist of using a parachute, or shutting down the engine and performing aerodynamic termination, which corresponds to full aileron, elevator up, full rudder and no motor. Circling down is not acceptable. For rotary wing, a quick vertical descent of a minimum of 2 m/s and touchdown must be performed. The flight termination mechanism must be operational at all times. **If the flight termination method is not working, the aircraft must terminate the flight itself automatically and rapidly.** In other words, if unable to kill the aircraft, the aircraft should have already killed itself. Under no possible situation should the UAV be in flight with the crew unable to activate a kill mechanism. This is valid for all flight modes. For instance, losing C2 link while in auto mode shouldn't remove the capability to kill the aircraft. Aircraft must be in termination mode

within 10 seconds of the termination function being activated. The flight termination mechanism will be validated during the Flight Readiness Review (FRR) check.

46. In case of a crash, a Corrective Action Plan (CAP) must be provided to the Air Program Director and approved before being allowed to fly again. The CAP must include at least:

    a. The exact cause(s) of the crash; and

    b. An explanation of why it will not happen again, including changes to equipment, procedures, etc.

47. The Flight Readiness Review performed on the Friday is represented in the Table below:

Table 1: FRR Checklist

Please have all the documents ready, and be ready to weigh the aircraft (7) and demonstrate the kill switch (8)

Team Name:		**Yes**
1	Provided a copy of the Advanced RPAS pilot certificate for Canadians?	
2	Provided copies of: proof of training (a), flight review (b), and SFOC(c) for Non-Canadian RPAS Pilots?	
3	Provided copy of the RPAS Safety Assurance Declaration and its acceptance by TC, for controlled airspace compliance.	
4	Provided a copy of the RPAS registration?	
5	Provided copy of the insurance certificate? (If required, TBD)	
6	Provide a copy of the email where the proof of flight was submitted to USC.	
7	We will weigh the aircraft. Is the aircraft weight is under 10kg?	
8	Demonstrate that the flight termination system is functional at all times and in all flight modes. Propellers should have been removed already. Make the motor(s) spin, and show that at all time, it is possible to kill the aircraft in all flight modes. Also show this kill mechanism has already been activated if the datalink for the kill switch is lost (this is often the RC controller, based on previous years).	

48. **Teams may turn on transmitters at the start of their flight window. Teams must turn their transmitters OFF after their flight window has elapsed. NO transmissions of any sort are allowed outside the flight window, including Wi-Fi hotspots and the like.**

49. During flight, the GCS must always show the aircraft and the competition flight area.

50. Rehearsals are not permitted unless specifically authorized by the judges.

51. If the aircraft leaves the flight boundaries, the operator will be asked to bring it back within the boundary. If the operator is unable to do so, they will be asked to activate the kill mechanism.

52. All anomalies with respect to the GPS, Datalink, RC and flight boundaries must be reported to the Air Program Director.

53. Teams must have an electrical or mechanical way of preventing propellers from accidentally spinning when the aircraft is not in takeoff position and ready for takeoff (i.e. when working on the aircraft).

54. Video proof of previous successful flight of the aircraft in the configuration planned for the competition must be presented to judges by **11 April 2022**. It must show at least the following elements:

    a. Takeoff;

    b. Fly by, circle, and (if applicable) hover to demonstrate the stability of the UAV;

    c. Approach; and

    d. Full-stop landing.

Advanced RPAS Pilot Certificate

55. All flying, including flight testing at local test site and at the competition, is to be performed under Part IX regulations for RPAS.

56. Southport is a certified airport, and consequently each pilot (not each team member, only pilots) must hold an Advanced RPAS Pilot Certificate. To be clear, the Basic operator certificate is not sufficient. It is recommended to initiate this process as soon as possible, as a relatively difficult online exam, in addition to a flight review at a UAV training school, must be passed successfully to obtain the Advanced Operator Certificate. A copy of the Advanced RPAS Pilot Certificate for each pilot must be provided to the Air Program Director as part of the flight readiness review.

57. Since Southport is in controlled airspace, each RPAS needs to be Controlled Airspace Compliant; AC 922-001 details the process. The requirement mostly concerns minimum precision requirements for onboard GPS. It should be noted that it is not necessary to comply with the requirements for flying near people (between 5 and 30m), nor the requirement to fly above people, because sufficient separation will be provided during the competition, and teams will not be asked to fly near or over people. The certificate of compliance to AC 922-001, for the RPAS to be flown, for operations in controlled airspace, needs to be provided to the Air Program Director as part of the flight readiness review.

58. Each RPAS must be registered in accordance with Part IX regulations. It is best if registration is done by a Canadian citizen, under the name of the University, through the Transport Canada portal. For each RPAS to be flown, the registration certificate must be provided to the Air Program Director as part of the flight readiness review.

59. To Confirm: No SFOC is required. Instead, all pilots and UAVs must conform to Part IX – for which a high level overview is provided above. USC will independently apply for a Special Aviation Event Certificate; no action is required from the teams.

60. Non-Canadian Citizens acting as RPAS pilot at the competition must provide proof of completing Ground School training to TP15263 Standard; this step replaces the online advanced exam. Non-Canadians must also pass a flight review, with results on paper instead of being in the portal. Non-Canadian Citizens will then apply for a SFOC in their name; for testing, training and operations for USC 2022 Competition. There is no fee, but the process takes 30 business days.

61. Insurance requirements for flying in Southport have not been determined – to be communicated to teams later.

62. If you need any assistance with regulatory approval, please contact us as soon as possible.

Evaluation Criteria

63. All teams must complete Phase 1, as described above, to be eligible to participate in Phase 2. Phase 1 and 2 are scored and awarded prizes separately.

64. You will not be evaluated on what you put in the Phase 1 Reports versus what you demonstrate in the Phase 2 Competition.

65. Phase 2 has a total possible score of 260 points. The individual criteria are detailed in the following paragraphs, and a summary of the Phase 2 scoring is shown in Table 9.

Phase 1 Design Paper

66. The Phase 1 Design Paper will consist of a written proposal submitted by each team describing the technical details of their proposed competition design. Design papers may be submitted in English or French.

67. The design paper will be evaluated according to the criteria in Table 2. Each criterion is awarded either 0, 4, 7 or 10 points, and each category of criteria are weighted as shown, for a maximum score of 100 points.

Table 2: Phase 1 Design Paper Scoring Criteria

DESIGN PAPER	**Score**
Days Late	
Overall Presentation	Weight: 15
Grammar/Spelling Structure/Organization Use of Figures/Charts/Tables References Provided/Correct	

Technical Description of Unmanned System	Weight: 50
Analysis of Alternate Solutions Features and Capabilities Pick-Up/ Drop-Off Methodology Automation Noise Signature Safety System Level Testing	
Technical Innovation and Novelty	Weight: 10
Novel Approach to Mission Requirements Novel Elements	
Safety and Risk Management	Weight: 15
System Level Safety Issues Single Point Failure Modes Risk Management Plan	
Project Management	Weight: 10
Milestones Schedule for Design/Construction/Testing Phases Budget	
TOTAL DESIGN PAPER SCORE	**100**

68. The following describes suggested content for each evaluation criteria, and provides advice for maximizing the quality of your paper. Note that hints have been provided for content in most of the criteria – this is NOT to suggest that those specific bits of information are required, or, alternatively, that they're sufficient. They're just hints.

    a. Days Late – The score will be reduced by 10% for each day that the paper is late. 'Late' starts immediately at 1700 EST!

    b. Grammar/Spelling – There is no excuse for illegible grammar or spelling mistakes. Get someone from the team with very good English or French writing skills to create or review the paper, and don't forget that Word does a pretty good job of review.

    c. Structure/Organization – Word can unfortunately not review this! Make sure the reader is presented with a clear story of what your system will do and how it will meet the competition requirements. Organize the paper according to the evaluation criteria…judges should not have to search through the paper to determine if you've responded to a criterion.

    d. Uses of Figures/Charts/Tables – Sometimes a picture is worth 1000 words. However, it needs to be large enough to be read, have appropriate titles and labels, and be referenced from the text so the reader knows what it's trying to show.

    e. References – Provide some! Your references might be technical, operational, or…?

    f. Analysis of Alternate Solutions – You will have decided on a design solution to meet the CONOPS requirements, both from an operational point of view and a technical one. As

engineers, whether you realized it or not, you must have done an options analysis to consider other ways to approach the problem(s). Tell us about these other options, and why you chose the solution you did.

g. Features and Capabilities – What makes your vehicle special? Don't forget that 'Unmanned System' isn't just the vehicle(s).

h. Pick-Up/ Drop-Off Methodology – What features does your system have to allow for pick-up and drop-off of a range of Device shapes? How are you going to be gentle and accurate, and pick up at a distance?

i. Automation – How are you going to meet the requirement for automated launch/flight to the intruders?

j. Noise Signature – What UAV features or navigation strategies will you used to minimize the noise?

k. Safety – Part of Task 2 involves flying near an "intruder", and Task 1 near a building. How do you intend to avoid colliding with things? Describe any other safety systems implemented.

l. System Level Testing – What testing will you do during development and in preparation for practice flights and scenarios? Consider the complete system – Vehicles, controls, cameras, delivery mechanism, etc.

m. Novel Approach to Mission Requirements – Explain how your overall <u>strategy</u> for accomplishment of the Tasks, and the individual strategy for each Task, are novel. This is NOT talking about the technologies required, which is evaluated in the next criteria.

n. Novel Elements – This criterion speaks to novel technology solutions in the overall System. Think of the baseline as a manually-controlled DJI Phantom – what does your Unmanned Aerial System have that makes it novel in the execution of the Tasks?

o. System Level Safety Issues – Based on the scenario and on your proposed design, what safety issues do you think are important and how are you planning to address them?

p. Single Point Failure Modes – Given your technical solution, what failure modes do you anticipate and how are you addressing them?

q. Risk Mitigation Plan – During design and development of your system, what risks exist that may affect your ability to successfully compete in Southport, and how are you addressing the risks? Risk categories should include technical, programmatic, budget, and/or others. Risk planning must include:

    i. Identification of the risk;

ii. Likelihood that the risk will happen;

iii. Impact on the project if the risk occurs; and

iv. Measures you will take to reduce the likelihood of the risk and to mitigate its effects if it does happen.

r. Milestones – Key events in the project that signal things are progressing as planned…or not.

s. Schedule – You are mostly engineers. Give us a Gantt chart of all significant activities in the development of your system and planning for the event.

t. Budget – Don't forget to include travel and other things, in addition to purchase of 'stuff' for the System.

69. Phase 1 Design Papers are due **16 January 2022 at 5pm EST**. 10% will be deducted from the score for each day late.

70. Papers are limited to **15 pages total, including any appendices, title page, table of contents, list of figures, etc. Pages above the 15-page limit will be ignored in the scoring.** Yes, this applies to your team too.

71. The paper must be emailed to **competition@unmannedsystems.ca in PDF** format.

Phase 2 Team Presentation

72. Teams present, to the judges and all other teams, their team and how they are going to accomplish the Tasks. This is not a technical presentation, but it is intended to give the client confidence in your team and to 'sell' the planned method of completing the Tasks. Presentations should include:

    a. Who your team is;

    b. The expertise of each team member;

    c. What equipment you propose to use for the work;

    d. How you propose to conduct the required Tasks; and

    e. Why the clients should put their confidence in your team.

73. All teams are expected to attend all presentations.

74. Teams must present a memory stick to the Chief Judge on Friday morning by 0715 with the presentation in Microsoft PowerPoint. It is your job to find him.

75. The length of this presentation should not exceed 8 minutes. You may give your presentation in English or French; whichever language is chosen, there must be at least one slide presented in the other language.

76. Presentations will be scored on the criteria in Table 4. Evaluations will be conducted by audience members and the Captain of competing teams, and criteria scores will be averaged.

Table 4: Pre-Flight Presentation Scoring

Criteria	Score
Presentation is well organized; most team members participate; other language is used.	4
Presentation includes all elements in Para 72.	4
Slides are well-prepared, easy to read, contain appropriate media, are not overly technical.	4
The presentation is clear and understandable, with limited jargon or technical terms; good speaking quality.	4
The client would be convinced this is the right team for the job.	4
Total Possible Score	**20**

Phase 2 Task 1 – Device Detection and Disposal

77. An overview of Task requirements is in Para 31, and further details will be provided in the pre-flight briefing by Embassy Security. Teams will be scored on the criteria shown in Table 5:

Table 5: Device Detection and Disposal (Task 1) Scoring

Criteria	Score
Device Detection: • Correct Device found = 10 pts • Device not located = 0 pts	10
Package Delivery: • Device is picked up and becomes airborne = 10 pts • Device is delivered into the barrel = 20 pts	30
Device Orientation: • Device remains upright at all times (< 45 deg tilt in any direction) = 20 pts • Device tilts 45 deg or more but is delivered upright = 10 pts • Device is not delivered upright = 0 pts	20
Force of Delivery: • Device does not touch sides of barrel on delivery = 10 pts • Device vertical impulse does not exceed 3g (note caveat in Para 31) = 10 pts	20
Time: • Team with quickest delivery (UAS launch to Device delivery) = 15 pts • Team with slowest delivery = 0 pts • Other points allocated in proportion	15
Land safely following delivery:	5

• The UAV lands safely at the launch location = 5 pts	
Total Possible Score	**100**

Phase 2 Task 2 – Detection and Tracking of Perimeter Intruder

78. An overview of the Task requirements is in Para 35, and further details will be provided in the pre-flight briefing. Teams will be scored on the criteria shown in Table 6:

Table 6: Detection and Tracking of Perimeter Intruder (Task 2) Scoring

Criteria	Score
Flight to Intruder Location: • Arrive at correct intruder location = 10 pts • Arrival at intruder detection location conducted entirely automatically and autonomously based only on the QR code and no human input or intervention = 20 pts • Time to detect intruder less than 10 minutes from receipt of alarm message = 10 pts. Less than 15 minutes = 3 pts	40
Tracking Performance: • Intruder(s) are in FOV 100% of the time = 20 pts; or • Intruder(s) are in FOV 50% of the time = 5 pts • Correct responses received about intruder characteristics = 20 pts • Half of responses correct = 10 pts	40
Map Trace: • The map with trace of path is appropriately labelled and readable = 3 pts • The map trace is accurate = 7 pts	10
Noise: • The sound level as measured at the initial intruder location and at a point 500 m from that location to the GCS. Quietest team = 10 pts, noisiest 0, others on a scale.	10
Total Possible Score	**100 pts**

Flight Preparation

79. Teams will be scored on their preparation for the flight window, according to the criteria in Table 7:

Table 7: Flight Preparation Scoring

Criteria	Score
Team is on the flight line with all required equipment 30 minutes before their flight window, and ready to fly at the start of the flight window (yes/no).	5
Team is well organized, with an obvious and effective leader and obvious tasks for team members, good cooperation between team members, good problem solving.	10

• All characteristics observed = 10 pts • Some disorganization, lack of leadership or cooperation = 5 pts • Disorganized, no real leader, arguing, poor problem solving = 0 pts	
Unmanned System is designed for easy set-up, with easily assembled components, use of switches rather than connectors at flight line, logical and efficient set-up/initialization procedures, etc. • All characteristics observed = 10 pts • Some flaws in design for easy set up, but overall well designed = 5 pts • Easy set up clearly not part of the design = 0 pts	10
Checklists are used for flight preparation: • Effective and organized use of written checklists = 5 pts • Ad-hoc semi-use of checklists = 2 pts • No checklists = 0 pts	5
Total Possible Score	**30**

Post-Flight Report

80. Teams must submit a report no later than 90 minutes following the close of their last flight window of the competition. The report will be scored according to the criteria in Table 6, which includes how well it is written and how clearly the results are presented. The accuracy of the results, which are evaluated in other criteria, will not be scored in this report. The video file from Task 2 must accompany the report.

81. The report should contain the following information at a minimum:

    a. Title Page;

    b. Overview of the required Tasks;

    c. Results of each Task;

    d. For Task 2, the map trace;

    e. Overall comments on the flights – how well things went, lessons learned, etc.; and

    f. Conclusion

82. The Report may be in English or French.

Table 8: Post-Flight Report Scoring

Criteria	Score
Content: • All required information is present and thoughtful comments are made about the flights = 5 pts • Information is missing or comments are lacking = 2 pts	5

• Majority of information is missing or no comments = 0 pts	
Presentation: • The report is well formatted, with good grammar, effective presentation of the results = 5 pts • Some formatting or grammar issues; results presentation is not effective = 2 pts • Report is poorly formatted, grammar is difficult to understand, results are difficult to understand = 0 pts	5
Total Possible Score	**10**

Overall Phase 2 Scoring

83. To summarize the above scoring, the total score available for Phase 2 is 260, weighted as shown in Table 9:

Table 9: Overall Phase 2 Scoring

Criteria	Score
Presentation	20
Task 1 – ***Device Detection and Disposal***	100
Task 2 – ***Detection and Tracking of Perimeter Intruder***	100
Flight Preparation	30
Report	10
Total Possible Score	**260**

How to Maximize your Success!

84. Winning a competition is like doing well on an exam; the results reflect the effort that was spent preparing for the event. By the time the teams arrive at the competition site, development work should be complete and systems tested and backed up. The actual competition should be an extension of the ongoing proof of your system design. Teams must apply proven project management techniques and procedures that will allow them to manage both time and resources effectively. The following are comments based on experience from previous competitions; ignore them at your peril!

Planning

85. The first and most important suggestion: **Read the CONOPS and Rules!** Understand exactly what you must accomplish and how much each component of each Task is worth! Deliver the results that are asked for!

86. Now would be a good time to **develop a schedule with clearly identified milestones that will serve as go/no-go points**. Regularly review the schedule and adjust the timelines. This will allow the team to change direction before additional effort is expended working on a sub-optimal solution and ensure effort will not be concentrated at the end of the academic year.

87. **Implement a sound risk management process.** As a first step, create a risk register that will serve as a basis for the initial risk assessment, evaluating risks based on probability and impact. Revisit the risk analysis to reassess items and identify new risks. Many of the failures observed at the competition could have been avoided has the team used a more disciplined project management approach during their system development process.

System Design

88. **Create a design that is simple to prepare and operate.** Minimize the use of connectors and maximize switches. Have access panels that are easy to operate… and then have them completely closed before the flight window. In previous competitions, it was amazing how much time was wasted by teams, either in the tent or on the runway, hooking things up and taping panels, etc., during their flight window! Make sure your design makes it easy to swap key components, like, say, batteries!

89. **Think about the flow for setting up and conducting the flight, and how your design can minimize the time required once the flight starts.** You should have everything plugged in, ready to go, and tested well before your flight window, such that when your flight window opens and you're able to transmit, you can quickly check to confirm things you already know are working are still working… then get airborne.

90. Consider **off-the-shelf components** where possible into the design. For example, teams may consider the use of an "almost ready to fly" radio-controlled system as the basic airframe with custom avionics, or they may choose to use a small-scale commercial autopilot in a custom designed airframe.

Preparation at Home

91. As the competition date approaches, conduct a risk management process specific to the venue and event. This is critical because there are certain risks – high winds, for example – that could easily make requirements other than UAV performance the deciding factor in winning the competition. Prepare contingency plans.

92. **Prepare PRINTED procedures and checklists, and PRACTICE using them.**

93. Make sure you have a leader… who can orchestrate all activities in a calm manner according to procedures you've planned… and who understands the systems and people to make calm decisions when things don't go according to plan.

94. Consider potential failure modes and crash breakage and create a 'medical kit' of extra parts and supplies to enable you to get back in the air as soon as possible.

95. Conduct extensive testing of all aircraft and other systems, including all integrated together.

96. **Be ready to fly in all weather/wind conditions!** One year, the entire weekend had howling winds and most teams crashed at least once. Google and understand 'dynamic rollover' – in high winds you need to transition the UAV from solidly on the ground to away from the ground quickly… and the reverse on landing.

97. **Conduct actual flight trials simulating the entire competition from start to finish**, including set up and initiation of systems within the flight window. Make sure every member of the team knows exactly what they are supposed to do and when they're supposed to do it. Make sure the required technical and flight procedures are known by EVERY member of the team.

98. Just a suggestion: Skydivers practice 'dirt diving', where a jump is rehearsed on the ground so everyone is clear on the sequence of the formations, the grips they need to take, etc. Use the Dirt Dive concept to prepare for the competition; get your whole team together and mentally run through the entire scenario, from arrival at the set-up site to completion of the mission, including every action that every member of the team must take, talking through it in as close to real time as possible.

On the Flight Line

99. Arrive on the flight line no later than 60 minutes before your flight time.

100. **Use your checklists to make sure everything gets done in the proper sequence!** Use cables to test all telemetry/RC if possible.

101. Be ready to move to the flight line at least 10 minutes before your flight window.

102. Move the aircraft to a location where it can be immediately moved onto the field at the start of your flight window. Many teams in previous years did final checks in the tent and then wasted time moving the System out to the field.

103. At the start of your flight widow, establishing wireless communications between components and confirmation that they all work should take no more than a minute. There should be no hooking up of connectors at this point! **If you must connect, assemble, close or tape anything during your flight window, you screwed up your system design or your pre-flight preparations.**

Papers and Presentations

104. When the judges are scoring your Phase 1 Papers, they are looking for the requirements outlined in this document... the easier it is for them to find the requirements in your paper, the better!

105. The Pre-Flight Presentation is intended for an audience of clients… they're not interested in a lot of technical detail. They need to be told exactly how you're going to accomplish **their** mission and how you're going to meet **their** requirements. The presentation should not mention the competition! In essence, play the game – it's important to embrace your role as the service provider of a drone solution and pretend that you're actually conducting the briefing to a client.

Questions from Teams

Where appropriate, the responses will be incorporated in the CONOPS, with appropriate cross-references from the questions.

If in doubt, READ the CONOPS and understand the rules…

Date	Team	Question	Response

Annex 1: Acronyms

UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
USC	Unmanned Systems Canada
FRR	Flight Readiness Review
CI	Critical Infrastructure
GCS	Ground Control Station
VLOS	Visual Line-of-Sight
BVLOS	Beyond Visual Line-of-Sight