9th Unmanned Systems Canada Student Unmanned Aircraft System (UAS) Competition 2016-2017

Competition Concept of Operations (CONOPS) and Rules

Revision 2: November 23th 2016.

This competition CONOPS and rules is subject to change.

Change record

2016-09-05, Initial release.

2016-10-08, Revision 1, Flight area modified page 6.

2016-11-23, Revision 2, Egg retrieve area added to page 7.

1 Foreword

This document provides details on a "made in Canada" BVLOS UAS Student Competition.

The basic mission for the competition is to address problems commonly faced by **environmental and wildlife research personnel.**

The competition takes place in two phases, with the Phase I design report from each team due on **January 13th 2017**, and the Phase II operational demonstration taking place on **28, 29, 30 April, 2017** in **Alma, Quebec**. Teams will be graded on the quality and completeness of their design reports and the results of their flight demonstrations. There will be separate prizes for each phase.

2 Scenario

The vast Canadian northern wilderness is the breeding area for numerous species of waterfowl including the Lesser Snow Goose, the "Blue" Snow Goose, and the Canada Goose. These geese nest in open tundra areas. Researchers typically conduct a census (count and categorize) of the birds using manned aircraft. Transects are flown and the birds are counted using direct observation or digital imaging techniques followed by post processing of the data. Statistical methods may be used to estimate the total population over the desired area and the distribution of nests. The flights are often flown at low levels increasing the risks for the observers. Accurate information is critical for the management of the populations and the environment. In addition, from time to time, nesting samples are required to test for pesticides in the environment or other issues analyzed by retrieving eggs from the nests of the birds under study.

This monitoring can provide information essential in determining the status of the flocks and the health of the environment. Terrain often makes it difficult for the researchers to get close to the birds to determine a good nest count, distribution and to retrieve samples. A small UAV should be able to fly over this terrain to provide quality data and samples for analysis.

This competition will focus on the development of a low-cost prototype system capable of providing timely information concerning the number and nesting successes of the birds in question. Your team will be rewarded according to the results contained in the census report that you will submit within one hour of your flight. Points will be attributed according to the Judging Guidelines given in Annex C. Your report will be judged on the following results:

-Ability to fly the appropriate search patterns;

-Determination of the total number of birds of each species in the search area;

-Measuring the number of nesting pairs, hence the number of nests by species;

-Determining the geo-location and the statistical distribution of the nests;

-Retrieving an egg of any species for analysis purposes.

For the purposes of the challenge, the targets will be accessible with a daylight camera.

In addition, your team's UAS, including the air vehicle(s), associated ground systems, and egg retrieval devices, will be assessed for technological readiness, user characteristics, and performance.

3 Purpose of the competition

The purpose of the competition is to promote and develop Canadian expertise and experience in unmanned systems technologies at the university and college levels. Even small scale unmanned vehicles are complex systems requiring a well planned and executed design and rehearsed operational approach. In addition, safety considerations are important factors in this competition as in any other vehicle design project.

4 Eligibility

4.1 General

The competitors shall be teams from a recognized Canadian university or college, organized internally at the discretion of their respective members.

4.2 Team Composition

Teams 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. All students must be full-time students at a college or university for Fall 2016 or Winter 2017. If a safety pilot is used, only the safety pilot can be a non-student or can be from another team. This competition is not open to commercial entities.

4.3 Team Size

There is no maximum or minimum team size. There is no maximum size for the number of crew in the flight pit during the preparation period. When the team is on the flight deck, the flight crew is limited to 5 people. Note that accommodations and meals will be provided to everyone attending for a nominal fee of **200$/student**.

4.4 Number of Teams

There is no restriction on the number of teams from any given institution. However, no individual student may be on more than one team. Also, the submitted projects must be substantially different. Teams will be accepted at the discretion of the Judges.

5 Competition Format

The UAS Competition is organized in two Phases. Details of the format and structure of each Phase will be provided in subsequent sections.

The Phase I Technical Competition consists of a written technical proposal that is submitted by each team. The proposal shall describe the technical details of the proposed competition design. During the Phase II Airborne Competition, teams will use their UAS to complete the assigned mission. Each Phase will be judged separately. Prizes will be awarded accordingly for the top teams in each Phase.

All teams must complete the Phase I Technical Competition in order to be eligible to participate in the Phase II Airborne Competition.

At the Phase II competition, teams will be allowed 10 minutes to give a scored oral presentation. This presentation is a sales pitch and not a technical presentation. It is the type of presentation that a contractor would give to a client in order to convince them that their team offers the right solution and thus conclude a sale. The team's objective for this presentation is to convince the judges that they are the best team to perform the work.

6 Applications and Registration

Teams should send an email showing their interest to **competition@unmannedsystems.ca** and complete the online registration process on www.unmannedsystems.ca including paying the team registration fee of **500$** to complete registration. Once fully registered, teams will have access to more information. Registration deadline is **November 9th 2016**.

7 Competition Website and Email

All relevant competition information will be located on www.unmannedsystems.ca. Check the competition website regularly for updates. Registered teams have access to more information and documents in a shared folder. All questions should be addressed to: **competition@unmannedsystems.ca**

8 Sponsorship

Student teams are encouraged to seek out any and all available sponsorship opportunities for their project. There is no restriction on the level or type of sponsorship that may be provided to teams. Teams are responsible for covering their own costs including travel for the demonstration phase. Accommodations and meals will be provided to registered team members at a cost of **$200** per member, payable by April 28th 2016.

9 Mission Requirements

9.1 Summary

Teams will design (Phase I), build and demonstrate (Phase II) a small UAS including Unmanned Aerial Vehicles (UAVs), launch and recovery systems and a ground control station for a wildlife monitoring and sample collection application.

9.2 Design Requirements and Restrictions

9.2.1 Phase 1 Design Paper

The Phase 1 Technical Competition will consist of a written technical proposal submitted by each team describing the technical details of their proposed competition design. All teams must complete the Phase I Technical Competition in order to be eligible to participate in the Phase II airborne Competition. The report should include, but not be limited to:

- Presentation and analysis of the problem;
- Analysis of the possible solutions and the ones selected;
- Presentation of the design;
- List of Radio Frequencies used;
- Novel features and benefits of the proposed UAVs;
- Budget;
- Safety issues and features;
- Schedule and risk management;
- UAV performance and safety test plan;
- Target detection, classification and location strategy;
- Data analysis and statistical calculations;

- Methodology for retrieving a sample egg;
- Draft SFOC for local flight test.

The design paper will be evaluated on presentation, technical merit, including analytical treatment, technical level, rationale behind the design, innovation, safety, budget and project management. Each design paper is limited to 10 pages, excluding appendices. The design paper is due January 13th 2017. **It must be in pdf format and be emailed to** competition@unmannedsystems.ca. Note that the SFOC application is not counted in the 10 page limit.

9.2.2 UAS Design Constraints

Below is a list of the design restriction for the UAS. All UASs must be designed within these restrictions or disqualification will result.

1. Maximum take-off weight of 10 kg (payload included). The aircraft will be weighed prior to flight.

2. Only internal combustion engines and electric propulsion (solar cells, batteries or fuel cell) methods are permitted. Micro gas turbines and pulsejets are not permitted. Any other form of propulsion is acceptable if deemed safe in the Phase I Technical Competition by the judges.

3. All flight operations will be unrehearsed as would be the case in typical field applications.

4. All 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). The entire system must be easily transportable.

5. Vehicles must have a flight termination system to safely terminate flight as described in the section 9.6.

6. All vehicles must be brightly colored so as to be visible from the ground and to be easily located in the event of a crash. Safety orange day glow paint is recommended. Vehicles must also clearly display the team name.

7. Data links will be by radio, infrared, acoustic, or other means so long as no tethers are employed.

8. It is highly recommended that teams consider including off-the-shelf components where possible into the design of their unmanned aircraft system. 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. In any case, the use of off-the-shelf equipment will simplify the design process and greatly improve the likelihood of successfully completing the assigned missions.

9. Multiple aircraft can be used, if approved by the Transport Canada SFOC for the competition, as long as there is one person who has full control for each aircraft at all times. In other words, one person cannot be controlling multiple aircraft at the same time.

9.2.3 Data link Frequency Restrictions

Radio frequency usage in Canada is defined by Industry Canada. If a licensed band is used, the license must be obtained and provided to judges before being allowed to fly. Because 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 teams develop an alternate (wired) method to pre-flight and test their system. The mission simulates a rural operation so fast Internet may not be available.

9.2.4 Levels of Autonomy

Different levels of autonomy are allowed for the competition:

Level V0: Manual (direct R/C control)

Level V1: Manual auto-stabilized flight

Level V2: Automated flight (Autopilot following waypoints)

9.3 Flight operations

Weather permitting, the intent is to provide two flight windows for each team. Only one team will fly at a time. A rain day program consisting of a mini-expo day will be implemented in case weather prevents flight activities as per SFOC restrictions (minimum conditions are to be determined locally and are typically: ground visibility of 3 statute miles, clear of clouds and a ceiling of 1500ft AGL.). Teams should note that if there is neither wind limitation nor rain limitation, flight activities will continue if SFOC weather minima are respected.

Figure **1** shows the approximate SFOC area and the competition flight areas which contain the geese to be studied and Figure **2** shows the area of nests with eggs to be retrieved. It should be noted that the team's GCS will be just south of the runway boundary by the launch and recovery location and will be outside of the competition flight boundary. Precise SFOC and competition flight boundaries will be given to teams at a later time. Maximum altitude will depend on the SFOC but should be around 1000ft AGL.

Red: Allowed Flight Area
Green: SFOC Flight Area

Figure 1 - Competition flight area, Alma airport

Figure 2 – Egg retrieval area

The time allowed to teams is to be determined but should be 30-45 minutes for preparation and flight. The actual amount of time allowed to teams for flight will be announced prior to the start of the competition flights. The allocated time is subject to change due to uncontrollable factors.

Time starts when teams are allowed to turn their transmitters ON. Teams must turn their transmitters OFF after their preparation and flight window has elapsed. After their last flight of the competition, teams then have 60 minutes to give their report to the lead judge. A team may be setting up while another one flying. Teams are encouraged to have a quick setup time as this has proven to be very successful in the past. It is intended that all teams be given two flight attempts; however, this will depend on weather and other factors.

9.4 Safety

Safety is of primary concern when operating UASs. All UASs 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 accepted. For rotary wing, a quick vertical descent of minimum 2m/s and touchdown should be performed. The following is a list of emergency procedures that each UAS must comply with. These safety features should be mentioned in Phase 1 design report.

During the competition, teams must have visible on their GCS at all times, their aircraft, the SFOC approved area and the competition flight area.

9.4.1 Flight Termination System

The flight termination mechanism must be operational at all times. If the remote flight termination trigger is not working, the aircraft must terminate the flight itself automatically and rapidly. Aircraft must be in termination mode maximum 5 seconds after the termination

function is activated. The flight termination mechanism will be validated during the Flight Readiness Review (FRR) check.

Note:

a. Propellers must be removed from the aircraft during FRR checks.

b. 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, he will be asked to activate the kill mechanism.

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

Teams must comply 100% to be allowed to fly.

9.4.2 General safety rules

A video proof of previous successful flight of the aircraft in the configuration planned for the competition must be presented to judges three weeks prior to the competition to be allowed to fly (8th of April 2017). It shall at least contain the following elements:

a. Takeoff

b. Fly by or circle to demonstrate the stability of the UAV

c. Approach

d. Full-stop landing

2. Teams will be required to present a valid SFOC to be allowed to fly. Teams should apply for a SFOC for their test site at least **6 months** before the competition and ensure the local inspector is processing it in time.

a. The competition or the team's SFOC can give additional limitations to those listed in this CONOPS. A copy of last year's competition SFOC is available upon request to registered teams.

3. Teams are required to have hands free bilateral communication between the GCS operator and the safety pilot (if a safety pilot is used) for a range of 100+ m. Unaided voice will not be sufficient.

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

Annex A - Transport Canada Points of contact for obtaining mandatory Special Flight Operation Certificate (SFOC).

Each team is required to obtain a SFOC. The SFOC application is to cover flight-testing their UAS at their test location and also mention flying during the demonstration early in Alma. A separate SFOC will be obtained by the Competition organization for the flight demonstration area with site specific details. Each team's local test site SFOC should refer to the Competition Alma SFOC. Each team's individual SFOC will be required to be allowed to fly at the competition and will have to be presented to the judges. It may require up to **6 months** to obtain an SFOC. It is consequently highly recommended that teams submit their SFOC application to Transport Canada **early in the fall** and do follow up with their local inspector (refer to Table 1) to ensure they received the application and are processing it.

Transport Canada UAS information website:Tc.gc.ca/safetyfirst

Table 1 - Transport Canada Regional Contacts

Atlantic Region - New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland & Labrador
PO Box 42
Moncton, New Brunswick, E1C 8K6
Telephone: 1-800-305-2059
E-mail: casa-saca@tc.gc.ca

Quebec Region
700 Leigh Capreol, Zone 4E, NA Dept.
Dorval, Quebec, H4Y 1G7
Telephone: 1-800-305-2059
Fax: 1-855-633-3697
E-mail: csva-vsca@tc.gc.ca

Ontario Region
4900 Yonge Street, 4th Floor
North York, Ontario, M2N 6A5
Telephone: 1-800-305-2059
Fax: (416) 952-0196 / 1-877-822-2129
Fee Payment: (416) 952-0400 / 1-800-305-2059
E-mail: CASO-SACO@tc.gc.ca

Prairie and Northern Region - Alberta, Saskatchewan, Manitoba, Yukon, Northwest Territories and Nunavut
344 Edmonton Street
Winnipeg, Manitoba, R3C OP6
Telephone: 1-800-305-2059
Fax: (204) 984-8125
E-mail: CASPNR-SACRPN@tc.gc.ca

Pacific Region (British Columbia)
Transport Canada
820 - 800 Burrard Street
Vancouver, British Columbia, V6Z 2J8
Telephone: 1-800-305-2059
Fax: 1 855 618-6288

E-mail: CAOPac-OACPac@tc.gc.ca

Annex B - USC Student Competition 2016 – Design Paper Evaluation Guide

Table 2 - Design Paper Evaluation Guide

Section or Topic	Topic Scores (all out of 10)	Section Weight
Overall Report Presentation		
Grammar and spelling, page limit adhered to (penalty for papers exceeding page limit)		15
The report is well structured and clearly organized		
Effective use of figures, charts and tables		
References provided for all cited content		
The paper is objective and free from commercialism		
Technical Description of the Unmanned Vehicle System		
Clear and concise summary of the critical design requirements in the students' own words		50
Alternate solutions presented and rationale for chosen solution presented		
Detailed description of the major features of the vehicle segment of the system including propulsion, power, autonomous control (if included), weight and balance (UAV) and mission payload.		
Detailed description of the major systems of the communication segment of the system including radio frequencies and transmitter powers.		
Detailed description of the major systems of the control station segment of the system including vehicle control methods, vehicle health and status monitoring and payload operations.		
Description of the major functions and features of the integrated unmanned vehicle system.		
Description of system level testing completed and/or planned to demonstrate that the UVS meets the stated design requirements.		
Technical Innovation and Novelty		
The described UAV system represents a novel approach to the mission requirements.		10
Adequately emphasizes the novel elements of the proposed system.		
Safety and Risk Management		
Complete description of system level safety issues		15
Identification of potential single point failure modes		
Completed draft SFOC application attached to the technical report as an appendix		
Technical Risk Mitigation plan described (ie what technical problems are possible during the construction and testing phase and how will they be dealt with)		
Project Management		
Clear, concise and complete list of milestones presented		10
Schedule provided for detailed design, construction and testing phases prior to competition.		
Overall project budget provided (including estimate of labour, cash and donations required)		
Total Mark out of 100		

Annex C - USC Student Competition 2016 – Judging Guide

Introduction

The competition is set up around a mission scenario. The goal of each team is to achieve as many of the stated mission objectives as possible and be rewarded accordingly. This guide outlines how points are awarded for each mission objective.

Mission Elements

There are seven mission elements:

1. present the team and its capabilities to convince client that the team is able to do the job,
2. determine the number of each goose species in the area,
3. determine the number and location of nesting pairs (hence nests),
4. perform a Ripley's K factor analysis for the nest distribution,
5. locate a nest with eggs,
6. retrieve one or more eggs from the selected nest
7. prepare a report that summarizes the team's findings.

Object characteristics

Targets

Multiple goose-like targets representing each species will be present in the *non-forested* regions of the Flight Area (see Figure 3). Teams must detect and count the geese, count the numbers for each species as well as determine the number of nesting pairs and the location of the nests by species. The targets will be stationary and at ambient temperature. The targets consist of:

- Goose-like targets (Possibly: Lesser Snow goose, Blue Snow goose and Canada goose) randomly located throughout the *non-forested* region of the flight area;

- Nesting pairs will be in close proximity to each other (< 3 metres);

- Groups of three or more geese but not necessarily nesting pairs;

- Solitary individuals;

- In the Egg Retrieval Area some nests will have eggs, others will not. Eggs weight from 60-100 grams and are light brown or white.

Figure 3: Typical goose targets (Sillosock)

Documentation Characteristics

Presentation

Each team will make a 10 minute presentation to reassure the clients that they are able to do the work. The presentation shall ideally contain the following elements:

1. who your team is,
2. what is the expertise of each team member,
3. what equipment you propose to use for the work,
4. how you propose to conduct the required tasks,
5. why the clients should put their confidence in your team.

Reporting

Each team is required to produce a report detailing their findings. The geo-coordinates of the nests shall be provided as an Excel table. The analysis report should be provided to the judges in pdf format. Both reports will be on the USB key supplied by the competition committee. The report shall ideally contain the following elements:

1. title page
2. problem statement
3. description of flight plan strategy for data gathering
4. results for goose census
    a. number of nesting pairs and hence nests with a picture.
    b. geo-location of each nest (Lat/Long in degrees, decimal degrees)
    c. Statistical analysis of the nest distribution (Ripley's K factor)

5. In the egg retrieval area:
    a. retrieval of an egg for chemical analysis
6. concluding comments

Note that photos may be tagged with lat-long coordinates offline during the production of the report.

An Excel file template will be provided to each team to record results for nest location. This results file shall be provided to the judges along with the team report.

Each team shall submit only one report and one set of results to the judges 60 minutes after the end of their last flight. The report and results set can be based on the data collected during the two allocated flight windows.

Scoring

Presentation

The team presentation will be evaluated according to Table 3.

Table 3 - Presentation evaluation criteria

Criteria	Score
well organized, contains all elements, convincing client opinion – has great confidence in selected team	1.0
adequately organized, has most elements, mostly convincing client opinion – has confidence in selected team	0.7
somewhat disorganized, missing elements, partially convincing client opinion – some doubt in selected team	0.5
unorganized, missing many elements, not convincing client opinion – looking for replacement team	0

Nest Location Accuracy

The lat-long coordinates of the nest centroids will be evaluated for accuracy. The error distance between the true geo-location and the team estimated geo-location will be calculated for each observed nest. Nests that are not observed will impose a penalty in that they will not add to the team's score. The reciprocal of the error distance for each observed nest will be used to evaluate the results. For Example, for an error distance of 1 meter, the points awarded will be 1. For an error distance of less than 1 meter, 1 point will be awarded. For an error distance of say 10 meters, 0.1 points will be awarded etc. The maximum allowed error will be 25 meters.

Census Count

The census count will be evaluated according to Table 4.

Table 4 – Census count criteria

Criteria	Score$_{photo}$
>98% correct number of total counts for all species	1.0
90-98% correct number of counts	0.6
80-90% correct number of counts	0.3
<80% correct counts	0

Species

Correct species numbers will be evaluated according to Table 5.

Table 5 - Species identification criteria

Criteria	Score$_{obj}$
Correct number of species	1.0
Incorrect number of species	0

Egg retrieval ability

The retrieval ability will be evaluated according to Table 6.

Table 6 – Egg retrieval criteria

Criteria	Score
Able to retrieve at least one egg	1.00
Unable to retrieve at least one egg	0.0

Report

The results report will be subjectively evaluated according to Table7. Note that the report is scored according to how well it is written and how clearly results are presented. No consideration is made here on the accuracy of the results. The accuracy of results is evaluated elsewhere.

Table 7 - Report evaluation criteria

Criteria	Score
well written, contains all required elements, nicely presented client opinion – greatly satisfied, report worthy for sharing with key outside organizations	1.00
well written, contains most required elements, adequate presentation client opinion – satisfied, report worthy for wide distribution within internal organization	0.75
adequately written, contains most required elements, adequate presentation client opinion – moderately satisfied, report will have limited distribution within internal organization	0.50
poorly written, missing many required elements, poorly presented client opinion – not satisfied, use report for internal discussions only	0.25
only results are provided in an arbitrary format client opinion – not satisfied, file document and read when time is available	0

UAS Suitability Evaluation

The conduct of the actual tasks in this competition has been addressed in the evaluation criteria above. Equally critical in a design competition is the suitability of the UAS in ways that are not directly measured by its ability to execute the tasks. The following criteria will also be assessed during each team's flight and pre-flight periods:

1. System Ease of Use: evaluated according to Table 8.

Criteria	Score
System is easily carried by two people, is easy to set up and ready to fly within 30 minutes, requires no more than two people to operate, and is easily packed up within 30 minutes	1.00
System does not meet one of the above criteria	0.75
System does not meet two or more of the above criteria, but team conduct of setup, operation, and packup are well organized and efficient	0.50
Team is haphazard, in crisis, setup and packup are disorganized and/or difficult, above criteria are not met	0

2. System Capabilities: evaluated according to Table 9.

Criteria	Score

System is stable and easy to fly, has no apparent control limitations in winds, provides status of UAV during flight (location, battery, etc), lands safely in appropriate location.	1.00
System does not meet one of the above criteria	0.75
Control or capability in conditions is marginal	0.50
UAV crashes or is difficult to control	0

Score calculation

The team score will be calculated according to Table 10.

Table 10 - Score tabulation

Item	Weight	Calculation	Sub-total
Presentation	$W_{pres} = 5$		T_{pres} (ref. Sec. 5.1)
Nest Location	$W_{NL} = 15$		T_{NL} (ref. Sec. 5.2)
Census Count	$W_{CC} = 20$		T_{CC} (ref. Sec. 5.3)
Species	$W_{SP} = 5$		T_{SP} (ref. Sec. 5.4)
Egg Retrieval	$W_{ER} = 20$		T_{ER} (ref. Sec. 5.5)
System Ease of Use	5		
System Capabilities	10		
Report	$W_{rep} = 20$		T_{rep} (ref. Sec. 5.6)
		Total (T_{pres}+T_{NL}+T_{CC}+T_{SP}+T_{ER}+ +T_{rep})	T_{tot}

Annex D - Nest location and egg retrieval

Nest Definition

A nest will be defined by a nesting pair of geese. For the competition, a nesting pair of geese is defined as two geese of the same species located within 3 meters of each other. Geese separated by more than 3 meters will not be considered nesting pairs. There may or may not be an actual nest and not all nests will contain eggs. The nest location (centroid between the two geese) will be reported. A statistical analysis of the total nest geographic distribution is also required. This will help the biologists determine the effect one species has on another as well as the nesting behaviours of each species. Typically, a Ripley's K factor analysis is performed for this type of data. This competition requires an analysis of this type.

Q&A

1) How many eggs are there in a nest?

Answer: Typically there will be 3-5 eggs per nest. However, some nests may have no eggs and others may have more than 5.

2) How is the nest defined?

Answer: The nest is defined as the centroid between a nesting pair of geese of the same species. The distance between the birds will be 3 meters or less for the nesting pair.

3) How much do the eggs weigh?

Answer: All eggs will be between 60 and 100 grams.

4) What are the limitations on the egg retrieval device?

Answer: We are looking to stimulate innovation. There are no limits on the egg retrieval device other than it must be carried by an air vehicle and it must remain attached to the air vehicle. The egg must be retrieved unbroken. A land vehicle is not acceptable. The egg must be retrieved by an air vehicle.

5) Can more than one air vehicle be used?

Answer: Yes. Both fixed-wing and rotary-wing aircraft may be used. Both may fly at the same time if there is a separate operator for each aircraft.

6) How do we report the location of the nests?

Answer: The latitude and longitude of the nest will be determined from aerial measurements, imagery. An Excel table of the results will be produced for scoring. Latitude and longitude will be reported in degrees and decimal degrees.

7) What type of statistical analysis is required?

Answer: Ripley's K factor as a function of distances from a nest is typically what is used for this type of work. This is useful in determining clustering as a function of distance.

8) What is the general location of the nests with eggs for retrieval?

Answer: The nests with eggs are located within the egg retrieval flight area as shown in Figure 1. Competitors must search this area to find a nest with eggs and retrieve at least one egg. The distance from the GCS to the egg retrieval flight area has been reduced to allow direct real time RF communications with the air vehicle. A spotter to help guide the air vehicle will not be allowed. All control must come from the GCS area. Each egg will have a unique number written on it.

Annex E - FAQ How to turn in a competitive round in the student UAV competition

Winning a competition is like doing well in an exam; the results reflect the effort that was spent preparing for the event. By the time 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 their system design. Teams must apply proven project management techniques and procedures that will allow them to manage both time and resources effectively.

There were several crashes at previous competitions. These incidents suggest that teams did not identify and prepare themselves to respond to the many variables that could lead to an on-site system failure. These teams did not manage risks effectively as part of their conceive/design/develop/test/fly process. To succeed, teams must implement a robust risk management process designed to identify potential risk events in order to reduce the impact of realized risks on the team's performance in the competition. Obviously, risk management is only one part of an overall project management approach, but many of the failures observed at the competition could have been avoided had the team used a more disciplined project management approach during their system development process.

To improve their chance of success, teams must do as much as possible to get major issues identified and resolved long before they show up for the competition. For example:

There is a year before the next competition. Now might be a good time to develop a schedule with clearly identified milestones that will serve as go/no-go points. This will allow the team to change direction before additional time and effort is expended working on a sub-optimal solution.

Use a life cycle approach. The CONOPS details the challenges that the competition will present. Analyze this document with the intent of identifying the most significant challenges and plan your system design and search strategy accordingly.

Review the schedule and adjust the time lines to reflect the effort required to develop and test potential solutions. The schedule review process is iterative. This will allow the team to assess its progress throughout the design/test process so that the effort will not be concentrated at the end of the academic year when there are greater demands on the students' time.

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. Revisit the risk analysis at each team meeting to reassess risk items and to identify new or emerging risks. Assess risks based on probability and impact and decide early whether to accept, avoid, mitigate, or transfer identified risks.

As the competition date approaches, conduct a risk management process specific to the venue. 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.

Develop a pre-event test plan based on the competition criteria. There is no substitute for training and experience. By the time the aircraft is flown in competition, it reflects the team's readiness to provide a proven solution to a client's problem. The client wants results; it is up to the team to convince the client that their solution is able to provide quality results. Do not forget that quality can be defined as conformance to specification. Designs that attempt to "gold plate" their system inevitably generate additional risks.

Prepare the competition search plan by optimizing for the UAV’s unique combination of performance characteristics and sensor resolution. This will generate the best opportunity for mission success.

Environmental conditions can vary greatly over the course of the competition. Be prepared to adjust the search parameters in response to the prevailing conditions.

This is critical: conduct a post-competition analysis and evaluation that will document and record successes, failures, and lessons learned. Do not forget that lessons learned can also be derived from a competitor’s performance/strategy!

Finally, keep in mind that “Flying is so many parts skill, so many parts planning, so many parts maintenance, and so many parts luck. The trick is to reduce the luck by increasing the others.” – David L. Baker

This competition is all about being able to demonstrate what your system can do without being sidelined by gotchas or mishaps.

Practice. You need to understand your system and your team mates.

Reliability is key. Predictability is almost as good.

Get through your checklist as far as possible before the clock starts.

External umbilical cables are your friends. Do not start uploading firmware or assembling the aircraft after the clock starts – have it ready to take to the runway!

Your only pre-clock constraint is radio silence. Think about how far you can prepare before radios come on. Minutes count.

Checklists are key to a predictable outcome. Ideally checklists after the clock starts are short.

Team radio calls should be practiced when doing your flights before the competition. Having standard messages will prevent confusing conversations.

Boring is good. Boring wins. Flashy often stays on the ground.

Corollary1: you can win with a well-understood, low-tech approach. You won’t likely win with a complex system that you haven’t learned to manage.

Corollary2: it isn’t all about winning. Get your system out and exercise it in the competition environment. That’s how you win next year!

RF and data link technology can be the biggest issue in the system, especially if a system uses more than one frequency.

Keep it simple.

Test data links extensively before the competition.

When testing, understand that ground-to-ground range is short compared with ground-to- air.

Corollary 1: get your GCS antennas up on high.

Corollary 2: don't stand in front of your teams' antenna.

Frequencies interfere. Nearby antennas can conflict even on different frequencies.

Look up "RF interference". Think of it as a bad thing. Don’t forget your GPS has an antenna too.

Watch the other teams operate.

Bring a spare. Keep software backups.

Be gentle with your wires - on board and in the ground. Harness failures are a leading cause of not being able to fly that day.

Practice more.

Read the CONOPS and rules! Understand the scoring system! Deliver the data or data product that is asked for!

It does not matter how well your system works if you do not deliver the stuff that scores points!

Evolve your system incrementally year-by-year. If you think you are on the right path, then do not change up everything and start over from scratch. This includes your team roles and training.

The winning teams are very selective in the changes they make to their system architecture and team architecture.