Arizona State University
Drone Delivery Challenge Competition (D2C2)

Competition Rules

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1/31/2020
2 Introduction

2.1 Competition Overview
The Arizona State University (ASU) is hosting a Drone Delivery Challenge Competition (D2C2). This Competition is sponsored by ASU Research Enterprise (ASURE) and ASME’s Technical Events and Content (TEC). The Competition is a method to bring together researchers from academia, industry, and government agencies to focus on a particular problem and quickly create an innovative solution. During the challenge teams will develop small drones that can operate autonomously or through tele-operation to pick up and deliver packages safely and efficiently.

2.2 D2C2 Objectives
The challenge has a number of objectives, in particular to:

- Provide an opportunity for students to learn practical skills for industry;
- Provide an opportunity for students to develop and demonstrate team work, leadership and commercial skills as well as technical competence;
- Foster collaboration across the southwest region of the United States in the UAS technology area, and to provide a forum for interdisciplinary research across the country.
- Rapidly innovate and develop solutions that can potentially be used as products.

2.3 Real World Scenario
Imagine yourself as part of a R&D team to develop technologies for a package delivery company. You will have to launch a small unmanned aerial system (sUAS) that can pick up and deliver packages with various sizes and weights. The challenges associated with this task include 1) identify and securely grasp the correct package, 2) maintain stability and avoid obstacles during flight with a package, and 3) precisely hover or land at the desired location to drop the package without any damage. You can choose to operate the drone either remotely with a human pilot, or autonomously based on onboard sensors. A layout of the scene is shown in Figure 1, and details of the layout will be announced later. The objects’ weights will range from 20 grams to 1 kilogram, and sizes will range from a golf ball with 5 mm diameter to 150×110×70 mm. The objects will include various shapes. You don’t need to be able to pick up all the objects in order to participate or win the competition.

Several key requirements for this scenario include: 1) Safety: the drone should be able to maintain stability and avoid collision during operation. It should not pose any risks to infrastructure and people on the flight path. 2) Cost: you should consider not only the cost of building the drone, but also the overall operation cost of the system. Therefore, although tele-operation may be feasible for some complex tasks, autonomy is needed to bring down the overall cost of the system. 3) Efficiency: the drone delivery system is expected to significantly reduce the time it takes to complete one package delivery, compared to conventional delivery methods based on ground vehicles. 4) Endurance: The air vehicle should be capable of flight for a minimum of 15 minutes at one time to allow a reasonable flight distance for package delivery. 5) User friendliness: the drone delivery system should consist of not only the drone, but also a friendly user interface to allow the human operator to monitor the progress of delivery and take over the control of the drone if necessary.

The innovative design your team develops is the key to your success.
3 Competition Overview

3.1 Submissions

Only one submission shall be submitted per team. Submissions must be made using the Initial Submission template. The completed system design should be sent to the organizers of this competition before the deadline (more details are provided in the sections below).

By submitting, participants accept all provisions of the Official Rules and agree to abide by all decisions made by the Organizers.

The Organizers reserve the right to change, postpone or cancel any aspect of the competition for any reason.

Submissions must be received no later than February 7, 2020 at 11:59PM (Arizona Time). Submissions received after this time are not eligible to take part in this competition.

3.2 Eligibility and Team Structure

The competition is open to teams consisting of members 18 years of age and older. There is no size constraint to the team size. For student teams, a faculty mentor is required from the same university.

A team manager is required for each team. The team manager is the team’s official liaison with the Organizers. For the purposes of this competition, the team manager is responsible for scheduling the team’s activities and acting as a central Point Of Contact for the team.

A team safety lead is required for each team. The team safety lead is responsible to ensure the team operates in a safe manner by reinforcing safe practices, leading the appropriate safety briefing and following the safety procedures.
The Drone Delivery Challenge Competition (D2C2), while having a set of defined performance objectives to achieve, is as much about the development and demonstration of team-working skills as it is about the capability development.

3.3 Costs and Funding

There is no entry fee required for participation in the competition.

Teams ultimately selected to move forward with design development will receive funding to support the development and testing. The funding amount will be determined by the evaluation committee based on the number of teams ultimately selected as finalists.

Each team will be required to keep a workbook documenting the use of the funds. The workbook must list the item, quantity, unit cost, and a link to the product and services purchased. Teams are also required to maintain all invoices and or receipts for any funds used for the D2C2 and present these at the conclusion of the competition or when requested.

For selected finalist teams from outside the state of Arizona, limited funding will be available to cover their coach-class airfare and lodging. The teams are responsible for any additional travel costs. More details will be provided to the teams selected as finalists.

3.4 D2C2 Schedule

The following schedule depicts the date for the major program events. Details and final dates will be posted to the D2C2 website that will be announced soon.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 5, 2020</td>
<td>Formal announcement of challenge and open for submissions.</td>
</tr>
<tr>
<td>February 7, 2020</td>
<td>Drone Delivery Challenge Competition (D2C2) is closed for submissions.</td>
</tr>
<tr>
<td>February 11, 2020</td>
<td>Finalists are announced</td>
</tr>
<tr>
<td>February 17, 2020</td>
<td>D2C2 Kick-Off Webinar for all finalist teams (tentative)</td>
</tr>
<tr>
<td>March 13, 2020</td>
<td>Teams submit their final design package for the safety check</td>
</tr>
<tr>
<td>April 2, 2020</td>
<td>D2C2 live demonstration and competition in Mesa, Arizona</td>
</tr>
</tbody>
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4 Points of Contact

Competition Organizers

- Chris Fortunato: Christian.Fortunato.ASURE@asu.edu
- Wenlong Zhang: Wenlong.Zhang@asu.edu

Drone Safety Officer

- Lloyd Brown: Lloyd.Brown@asu.edu
5 **Intellectual Property**

IP generated as a result of participating in the D2C2 will be owned by the participating teams. If they use any university resources for building and testing the drones, they should consult their home universities to clarify the owner of the IP. The competition organizers do not seek any IPs originated from this competition.

6 **Design and Operational Requirements**

The D2C2 has been designed to expose students to a number of disciplines that they will need in their careers. Factors which the evaluation team will be looking for include:

- A methodical systems engineering approach to identify the requirements, selection of concept with a design to meet those requirements, and the 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;
- Innovation in the approach to solving the engineering challenges;
- Appreciate practical design issues and sound design principles essential for a successful, robust and a reliability; e.g. adequate strength and stiffness of key structural components, consideration given to maintenance, ease of repair in the field, modular design for integration of future capacities, intuitive design, interface, and controls.
- 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 fly-off event;
- Attention to environmental impact, including minimizing noise, developing an efficient aircraft design which minimizes energy consumption, and attention to minimizing use of hazardous materials.

6.1 **System Design Requirements**

The D2C2 is to design, build and demonstrate a small drone capable of supporting a mission which is modelled on the real life humanitarian aid scenario. System Design Requirements defines the “shall have” capabilities that represent the minimum system capabilities. The D2C2 seeks to test a number of requirements.

- Safety, demonstrating safe design and flight operations, and integration of a Flight Termination System (FTS).
- Reduced Size Weight and Power (SWaP), Reduced SWaP of the drone and if specifically designed, the controller. The weight of the drone shall not exceed 1,000g (measured in flight configuration). Total system weight (to include all components and any spares) shall not exceed 2,000 grams.
- Grasping, the air vehicle should be equipped with a grasping mechanism to pick up the package from the ground.
- Endurance, the air vehicle shall be capable of flights 15 minutes or longer in duration.
- Controller, the system shall have a dedicated controller (included in the system weight). The controller shall include the flight controls for the air vehicle, receive and store flight information,
and provide the datalink to the between the air vehicle and the human operator through wireless communication.

- Navigation, the air vehicle shall be directed manually by the operator interacting with the controller or automatically by planning its flight paths based on the onboard sensors and controllers;
- Environmental impact, to reduce the impact to rescue operations the air vehicle shall have a minimal audio and visual signature;
- Cost, each team should provide a total cost of the drone hardware and a cost breakdown.

The System Design Requirements are the minimum capabilities that the system shall have. The implementation of the requirements are up to the teams participating in the D2C2.

### 6.2 Enhanced System Capabilities

The inclusion of Enhanced System Capabilities above and beyond System Design Requirement are at the discretion of the team. However, these types of capabilities can create a more technological advanced and innovative solution. Teams must balance cost, capability, and schedule to ensure the enhanced capability can be integrated within the competition constraints. Examples of Enhanced System Capacities include, but not limited to,

- Capabilities to recognize and alert an operator or avoid obstacles which may impact the operation of the air vehicle.
- Capabilities that enable a system to operate autonomously in cluttered environment with static and moving obstacles.
- Capabilities that allows grasping packages with various sizes and shapes.
- Capabilities that provide an indication of system health, sensor performance, pending failures, and required maintenance.
- Capabilities that autonomously identify and pick up the package.

Enhanced System Capabilities should be features above the System Design Requirements that increase the ability of system to support and win the D2C2.

### 6.3 Design Safety Requirements

The system SHALL NOT include these specific, these types, or similar to designs or design elements.

- The system shall not have metal-blade propellers or gaseous boosts.
- The system shall not carry hazardous chemicals, pyrotechnic devices, or materials intended to separate from the air vehicle during flight.

### 6.4 Development Methods

Teams are expected to conduct methodical systems engineering approach to identify the requirements, selection of concept with a design to meet those requirements, and test to confirm that the actual system meets the requirements in practice.

Teams shall have design artifacts that define the, hardware, software, electrical, and signal, design to sufficient detail to support production of the system.

Key Performance Measures (KPM) should be identified by teams based upon their specific design. These include key requirements such as (but not limited to) weight, cost, efficiency, and flight time. KPMs
should estimate requirements to evaluate margins and compliance with requirements. Key Performance Measures shall be tracked over time until actual measurements are taken.

6.5 Safety
The D2C2 Drone Safety Officer (DSO) is Lloyd Brown (Lloyd.Brown@asu.edu, (480) 884-0404). Any questions regarding safety and safe operation of the system should be directed to the DSO.

Unless the drone designed is lighter than 250 grams, each team is required to register their drone(s) with Federal Aviation Administration (FAA). More details of this registration can be found through the following link: https://federaldroneregistration.com/.

All flights will be conducted in the facility designed by the D2C2 organizing committee. At no time will any system be flown in any other facility, space, area, or outside.

NOTE: THE TEAM WILL BE FULLY RESPONSIBLE FOR ANY COSTS OR VIOLATION OF FAA FULES WHEN FLYING THE AIR VEHICLE ANYWHERE OTHER THAN THE DESIGNATED FLYING FACILITY

6.5.1 Flight Termination System
A Flight Termination System (FTS) shall be incorporated as part of the design and is a mandatory requirement to participate in the final competition scheduled on April 2, 2020. The purpose of the FTS is to initiate automatically all relevant actions which halt all flight activities and force the system into low energy landing state. The FTS should be automatically implemented should the data links between the ground control unit and the drone is unintentionally lost or be subject to interference / degradation. The FTS shall also be capable of manual selection should the Flight Safety Officer deem the drone’s behavior a threat to the maintenance of Air Safety.

The actions of the FTS must aim to safely land the drone as soon as possible after initiation. The FTS shall be automatically initiated after 5 seconds of unintentional lost Uplink. The Uplink is defined as the data link which provides control inputs to the drone from the controller, including manual initiation of the FTS. The FTS should be automatically initiated promptly and no longer than 10 seconds after unintentional lost Downlink. The Downlink is defined as the data link which relays the drone’s telemetry / positional information and video feed to the controller.

A ‘Return to Home’ function is not acceptable as an FTS.

6.5.2 Other Design Safety Requirements
The design and construction of the drone shall employ good design practice, with appropriate use of materials and components;

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

Any fuel / battery combination deemed high risk by the Review Committee, DSO, or Organizers may be disqualified.
7 Review Committees

Review Committees are used to provide a multi-disciplined perspective of the D2C2 proposals. Review Committee members are drawn from academia, agencies developing & soliciting UAS and UAV related technology, defense and aerospace industry, UAS enthusiasts, and technology developers.

Committee members apply a rubric and their specific perspective to evaluate designs during the initial submission phase. During design reviews the Review Committee evaluates the design of the system at a particular phase of development and provides teams with insight and guidance to address potential problems and enhance the capability being developed.

Members of the Review Committee that are not ASU or ASURE employees will sign a Non-Disclosure Agreement and Intellectual Property Rights waiver prior to attending the event.

8 Competition Activities

8.1 Initial Submission

The initial submission for the D2C2 is a proposal that identifies the team taking part in the competition to include the Facility Advisor and a description of the system being proposed. The system description includes:

- Why the solution will be a critical asset to package delivery missions.
- Describe the key requirements for the team’s solution and how these requirements will be satisfied.
- What the team intends to design and build and any particular focus areas.

Teams will complete the Initial Submission template and submit the package No Later Than February 7, 2020 at 11:59PM (Arizona Time). Submission received after this time are not eligible to take part in the competition.

Eligible submissions are evaluated by the Review Committee based upon on innovation, technical merit, and ability to produce the solution. Based upon the proposal evaluation an initial down select will occur. Finalists will be announced on February 11, 2020.

8.2 In Progress Information Session and Reviews

Progress is monitored during the conceptualization, development, and production phases through an information session and reviews with Review Committees and the teams. The primary goal of the review is ensure the teams develop their intended solution and resolve any roadblocks to development.

8.2.1 Kick-off Webinar for Finalist Teams

A kick-off webinar is tentatively scheduled on February 17, 2020 to provide selected finalist teams more information about the final competition, including the objects to be delivered, design of the test field, budget for each team, and rubrics for evaluating a team’s performance. It will also include a Q&A session to clarify any questions the finalist teams may have. All finalist teams must participate in this webinar to be qualified for the final field competition.
8.2.2 Flight Safety/Test Readiness Review

The Flight Safety/Test Readiness Review evaluates that the system has demonstrated that it can safely fly, meet the requirements defined by the team, and complete the challenge. The review will focus on the built system and actual system performance. A team is required to send a video to the organizers showing their system’s operations prior to the final competition.

Teams will complete the Flight Safety/Test Readiness Review template for this review and submit the review package before the deadline prior to the review meeting. Flight Safety/Test Readiness Review is anticipated to take approximately 15 minutes followed by static display and briefing of the developed system. Teams may add additional information into the back-up section of the briefing to add context and demonstrate the maturity of the design.

8.3 Onsite Safety Review

Prior to the beginning of the field competition, each team will have to go through an onsite safety review with the DSO. Teams pass the onsite safety review will be issued an Authority To Operate (ATO). Once the ATO has been issued flight operations can be conducted in the designated test field.

8.4 D2C2 Field Competition

The final phase of program is the field competition to evaluate the technical and operational capabilities developed by the various teams. A series of tasks will be used to assess the technical and operational performance of each team’s air vehicle, sensor package, and control station. The winner of the challenge will be selected by the Review Committee based upon the capabilities demonstrated during the field competition with the rubrics provided to the teams in the kick-off webinar. The field competition will take place in an outdoor environment on April 2, 2020 in Mesa, Arizona. All the flight tests will be completed before sunset.

A detailed briefing will be given at the beginning of the field competition covering the logistics and timings of the event, rules and good conduct for safe operations, pre-flight briefings etc.

Teams will also be given an order of events and strict time schedule for flight test. The schedule is necessarily tight and teams who are not ready to fly at their appointed slot time will be disqualified. It is expected that teams will arrive with a fully serviceable drone that is in good working condition.

In addition to the overall winner of the D2C2 competition, there will be a winner in each category for this competition, including safety, efficiency, and endurance. More details of different awards will be given at a later date. The specific tasks and course layout will be announced at a later date. All the information will be released before the kick-off webinar.

The DSO shall have absolute discretion to refuse a team permission to fly, or to order the termination of a flight in progress. Only teams with an ATO will be eligible to enter the field competition.

9 Disclaimer

The competition rules are subject to changes and updates. All teams will be notified when a change is made via an email list and the website of this competition.