# FY20 RWDC National Unmanned Aircraft System Challenge: Pilot Package Delivery

## Background

Small Unmanned Aircraft Systems (sUAS) have near-term potential for numerous civil and commercial applications. The FY20 RWDC National challenge will continue the focus on Unmanned Aircraft Systems and implementation of a UAS. This year’s mission is to support package delivery in an urban environment. The teams will use concepts from Engineering Technology (i.e., application of science and engineering to support product improvement, industrial processes, and operational functions) to identify, compare, analyze, demonstrate, and defend the most appropriate component combinations, system/subsystem design, operational methods, and business case to support the challenge scenario. Through use of an inquiry-based learning approach with mentoring and coaching, the students will have an opportunity to learn (and apply) the skills and general principles associated with the challenge in a highly interactive and experiential setting. For example, the students will need to consider and understand the various Unmanned Aircraft System elemental (subsystem) interactions, dependencies, and limitations (e.g., power available, duration, range of communications, functional achievement) as they relate to the operation, maintenance, and development to best support their proposed business case.

To support the inquiry-based learning approach, each team will perform and document the following in an engineering design notebook:

1. ***Task Analysis*** - analyze the mission/task to be performed
2. ***Strategy and Design*** - determine engineering design process, roles, theory of operation, design requirements, system design, crew resources, integration testing, and design updates
3. ***Costs*** - calculate costs and anticipated capabilities associated with design and operation, including modification of the design to further support a competitive and viable business case

You will need to work together as a team with coaches and mentors to identify what you need to learn while pursuing the completion of this challenge. By connecting your own experience and interest, you will have an opportunity to gain further insight into the application of design concepts, better understand application of Unmanned Aircraft System technology, and work collaboratively towards completion of a common goal.

## Challenge

This year’s challenge is to design Unmanned Aircraft Systems (UAS), create a theory of operation, and develop a business plan for the commercial operations of the system based on the following scenario.

***Scenario:*** *Based on the success of your initial contract, the package delivery company wants to extend its agreement with your company. Through negotiations, a few changes have been made to the details of the contract. Most changes focus on the business plan, but there are a few clarifications on the unmanned aircraft performance based on city concerns.*

*Your Company has been contracted by a package delivery company to do a pilot program for aerial deliveries. The contracting company requires that your team carry packages that weigh up to 5 kg and have maximum dimensions of 0.5 m X 0.5 m X 0.25 m. Your team must deliver the packages from a Central Hub to locations in the city (see map at end of document and in the Detailed Background). Your team will decide what delivery locations will be serviced with your Unmanned Aerial Vehicle(s) (UAV). Assume all of the packages are the maximum size and maximum weight listed above. Also, assume that you will be delivering to the same locations each day. For this challenge, assume that the city has received the necessary waivers from the FAA to operate UAS in the city. In order to obtain the waivers, any UAS design must meet a set of safety requirements (outlined below) to operate within the city. The contracting delivery company will pay your team based on the number of delivered packages per day* (*a day is defined as a 12-hour period of daylight) over a 30-day period.*

***The Urban Environment:*** *The pilot delivery program will be conducted over an 8 km by 8 km environment. A map of the urban environment is provided at the end of this document and in the Detailed Background. The map includes neighborhoods of different population densities that include maximum package deliveries per day for each neighborhood. As part of agreement with the contracting company and city, your team must design flight corridors for your delivery UAVs (additional information in the detailed background document). All refueling/recharging and package pick up must occur at the Central Hub (details included in the Detailed Background document).*

***Delivery System:*** *Teams must design an efficient and safe delivery system. All packages must be delivered to a designated 3 m by 3 m space at the delivery location. Teams may assume that the required 3 m by 3 m space will be available at the delivery location (part of the delivery agreement between the costumer and delivery company). Packages may be lowered from a hovering aircraft (minimum hovering altitude of 0.5 m); or aircraft may land, release the package, and takeoff. Aircraft that land and takeoff must fit within the 3 m by 3 m space and all landing and takeoffs must be vertical.*

***Safety:*** *You should include ways of addressing any possible safety issues that might arise. At a minimum, you must address safety issues outlined under Requirements below.*

***Business case:*** *Teams will be doing this year’s project as if they were contracted by a company to fly packages using an Unmanned Aircraft System (UAS). What that means is that your company will be paid based on the number of packages you deliver in the service area in a day (a day is defined as a 12-hour period of daylight). You will need to show that you are making money over a 30-day period from the fees you receive from deliveries (assume you are delivering the same number of packages each day). You need to show that you are making enough money to cover more than your operating costs (the cost of fuel and personnel). You should also show that you are able to cover your fixed costs over time (the cost of things like your UAV and other parts of your UAS) even if that occurs over a longer period than 30-days. For this new contract, the base rate for each package has been lowered from $150/package to $50/package. However, more opportunities to earn bonuses have been added. Additional details on business case (e.g. information on the bonuses) are listed in the Detailed Background.*

## Requirements

The requirements for the UAS are focused on the ability to fly safely in an urban environment around people. Your aircraft must meet all of the following requirements in order to be allowed to fly within the city. Other than these requirements, you are to assume that you are given any additional permission to flight outside of current regulations regarding unmanned systems.

* **Guidance without GPS:** Aircraft flying in an urban environment cannot rely on GPS for accurate position or guidance information. “Urban Canyon” is a common phenomenon in cities. Aircraft must be able to accurately navigate the city when GPS signal is lost or if there is signal interference.
* **Obstacle avoidance:** The aircraft must be able to avoid all stationary and moving obstacles. Geofencing should be used for known fixed objects such as buildings. The aircraft must be able to detect and avoid moving objects or any other stationary objects not included in the geofencing. The aircraft must be able to stay at least 1 m from any obstacles.
* **Beyond line of sight:** The aircraft must be able to operate beyond line of sight. The aircraft must be monitored during the entire flight, and the aircraft must have a system for a pilot to take control of the aircraft when needed.
* **Fuel/charge reserve:** The aircraft must have a fuel/charge reserve that allows for an additional 15 min of flight beyond the required time to complete its mission. This additional reserve is to account for non-design conditions such as non-ideal atmospheric conditions and congestion at the Central Hub.
* **One engine out condition:** The aircraft must be able to continue safe and controllable flight if an engine fails. During aircraft design, assume that engine failure occurs while the aircraft is carrying the package. The aircraft must be able to use the remaining engines to either return to the Central Hub, deliver the package, or make a safe landing depending on your company’s protocols and aircraft location.
* **Emergency landings:** The aircraft must have a procedure to make an emergency landing in case of a failure on the aircraft or it encounters a scenario in which it does not know how to respond. The aircraft must try to find a location to land that minimizes damage to property and injury to people. The aircraft must provide visual and auditory cues to warn people during the landing. To protect property and people, propellers on fixed-wing aircraft must be foldable and not be spinning during landing. Rotors on rotorcraft must be enclosed so that the blade tip cannot strike any object.
* **Use of multiple UAVs:** If you decide to use multiple UAVs simultaneously, you must explain how you plan to safely manage the flight paths of all flying UAVs to insure there are no accidents. Detailed explanation will be needed on how you keep them from crashing into each other and how you will keep them far enough apart especially at the Central Hub.

## Objectives

Your designs will be judged on how well they satisfy the objectives while meeting the requirements above. You are also allowed to use more than one design in your system as long as you can justify how the additional UAVs will improve your profitability. It will be up to your team to decide the number of deliveries you will make and provide sound engineering arguments to justify your design decisions.

* Minimize your costs
* Maximize profit for your company
* Maximize the number of packages delivered in a day (additional information about these areas is provided in the Detailed Background).
* Maximize efficiency at the Central Hub
  + Packages must be picked up from the Central Hub
  + Assume all packages weigh 5 kg with the dimensions 0.5 m X 0.5 m X 0.25 m
  + All refueling/recharging or battery swaps must be done at the Central Hub
  + Consider accessibility/usability of design (e.g. fuel/battery location and securing package to aircraft)

## Constraints

* Antennas on-board the vehicle(s) must be separated by a minimum of 18 in. to avoid destructive interference
* Your aircraft must contain a transponder so it can identify itself to other aircraft (manned and unmanned) and help with detection and avoidance. There could be other unmanned aircraft flying in the vicinity of your aircraft that also use transponders. However, your aircraft must still be able to detect and avoid other unmanned aircraft without using the transponder in case the transponder is broken or it does not have one (i.e. hobby aircraft flying illegally).
* Your choice of system control hardware, sensor selection, remote vehicle element(s), Command Control Communications (C3), support equipment, and other subsystem components is not solely limited to cataloged items; substitutions are permissible and encouraged with justification and analysis provided in the design decisions in the Engineering Design Notebook.

## Assumptions

* You may assume that your company has received permission to operate within the requirements the city has given.
* Communications must be maintained with ALL remote vehicle elements (redundant secondary system required)
* A human operator will be required to take control of an unmanned system in an emergency (i.e., redundant secondary control)
* Assume standard sea level conditions with no wind.

## Other Resources

* RWDC National Unmanned Aircraft System Challenge: Detailed Background
* Challenge Statements and Detailed Backgrounds from previous RWDC competitions
* Winning Engineering Design Notebooks from previous years
* RWDC Content Webinars (schedule to be determined)
  + Overview of Unmanned Aircraft Systems (UAS)
  + Systems Engineering and Vehicle Performance Factors
  + Business Case and Cost Considerations
* The RWDC Support Site with FAQs, tutorials, material allowables, library of available propulsion systems and fuselages, and other supporting materials: Getting Started section of the RWDC website (<http://www.realworlddesignchallenge.org>).
* The following represent the recommended baseline remote air vehicle element (i.e., UAV) platforms for this challenge:
  + Fixed-wing (tractor propeller) UAS Design
  + Fixed-wing (pusher propeller) UAS Design
  + Hybrid Design (fixed-wing/quadrotor)
  + Rotary-wing Design
  + Multirotor Design
* Baseline CAD models for each baseline remote vehicle element to be provided
* Mentors from the aerospace and defense industry, government agencies, and higher education

## Tools

* PTC Creo Computer Aided Design (CAD) software for 3D geometry design (if you have other CAD tools you may use them).
* Excel sizing, performance, and cost worksheets

## Team Submissions

The Engineering Design Notebook submission including the business plan and appendices must be 80 pages or less. Detailed information regarding what must be documented can be found in the RWDC FY20 National Challenge Scoring Rubric. Teams must submit the following:

1. Engineering Design Notebook (refer to RWDC FY20 National Challenge Scoring Rubric)
2. CAD drawings in Engineering Design Notebook (refer to RWDC FY20 National Challenge Scoring Rubric)
3. Presentation at the National/International competition. Additional information on presentation requirements will be provided separately.

## Scoring

* Teams’ submissions will be evaluated based on criteria outlined in the RWDC FY20 National Challenge Scoring Rubric and in reference to the example mission scenario
* Technical scoring will be based on deliverables to be incorporated in the Engineering Design Notebook
* Engineering Design Notebooks must follow the paragraph order of the RWDC FY20 National Challenge Scoring Rubric
* Judges will be looking for the ability to express comprehension and linkage between the design solutions with what students have learned. Specific recognition will be given for design viability, manufacturability, innovation, business plan development, and additional application beyond the package delivery mission
* The Engineering Design Notebook will count as 70% of the final team score at the National/International competition.
* In the event of teams having close scores at any level of the competition, the Executive Summary for the Engineering Design Notebook will be used as a “tiebreaker.”

## Merit Awards

Special RWDC Merit Awards will be given at the National/International Challenge Championship in Washington, DC. Merit awards will be granted at judges’ discretion to teams that do not place in the top three, but are top performers overall. Only one merit award will be granted per team. Awards will be based on the team presentation and Engineering Design Notebooks.

* Innovation
* Design Viability
* Team Work and Collaboration
* Effective Mentor Collaboration
* STEM Interest Impact
* Most Creative
* Against All Odds
* Best Business Case
* Best First Year Team
* Judges Award

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