FY19 RWDC National Unmanned Aerial System Challenge: Pilot Urban Survey Mission

Background

Small Unmanned Aircraft Systems (sUAS) have near-term potential for numerous civil and commercial applications. The FY19 RWDC State challenge will continue the focus on unmanned systems and implementation of a UAS but this year to support an urban survey mission. 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 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 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 system technology, and work collaboratively towards completion of a common goal.

Challenge

This year's challenge is to design unmanned aircraft systems, 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 your initial proposal, your company has made it through the first round of reviews. For the final review, the city (in the United States of America) has made a few changes to the request for proposal (RFP).*

The city is requesting bids for a pilot program to test the feasibility of safe UAS operation within the city to perform the surveying tasks. For this challenge, you will 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. In addition to the requirements, the contract is requesting for the system to perform certain survey tasks effectively. Winning the contract will be based on the most competitive bid (most reasonably priced for the performance).

The city has been increasing the vegetation within the city to help curb the effects of pollution. The purpose of the UAS is to survey the vegetation for its general health and report what plants need additional care.

The Urban Environment: *The city is looking for a test of concept over a 1.6 km by 1.6 km environment. You will need to create a system and operational plan that fulfills the mission while minimizing risk to people and property. A map of the urban environment is provided in the National Detailed Background.*

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.*

Concept of Operations: *During the first round of reviewing bids, city officials decided that they need more information on how the UAS operates within the city. A detailed Concept of Operations (CONOPS) must be included in all bids and include details about the tasks that happen pre-mission, during the mission, and post-mission. These tasks must include communication with all stakeholders.*

Business case: *Teams will be doing this year's project as if they were responding to a Request for a Proposal (RFP) from a city. What that means is that the city will give a contract to do the whole project and will be giving budget requirements. This scenario will have the proposal set up as if it is getting bids from multiple people to see which one has the best price, meets all of the requirements, and performs the objectives most effectively. Inside of your budget, you will be required to perform the survey objectives eight times during the year (two times during the Spring, Summer, Fall, and Winter). Additional budget details 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 considered for the contract with the city. Other than these requirements, you are to assume that your company has been given any additional permission to flight outside of current regulations regarding unmanned systems as long as adequate explanation of additional safety features is provided.

- **Launch and recovery:** All launch and recovery procedures must take place within 3 m by 3 m space. Aircraft capable of vertical takeoff and/or landing must takeoff/land within this space. Any equipment necessary to launch and/or recover other types of aircraft must fit within this space.
- **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.
- **Emergency landings:** The aircraft must have a procedure to make an emergency landing in case of a failure on the aircraft, it encounters a scenario in which it does not know how to respond, or an emergency scenario requires the aircraft to land immediately. 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 aircraft must be enclosed so that the blade tip cannot strike any object.

Objectives

Your designs will be judged on how well they satisfy the objectives while meeting the requirements above. You must be able to fly in **all** of the plant areas listed below. You are also allowed to use more than one design in your system as long as you are able to stay within the proposed budgetary restrictions for the Request for Proposal listed in the detailed background. You should note that maximizing one objective might be at the detriment of another objective. It will be up to your team to decide the importance of each objective and provide sound engineering arguments to justify your design decisions.

- Minimize the contract bid
- Maximize profit for your company
- Monitor plant health in the following areas (additional information about these areas is provided in the Detailed Background)
    - A vacant lot and park
    - On top of a building that is 120 m tall
    - On a wall on the side of a building
    - On a wall on the side of a road with no shoulder
    - On the median and sides of a street with sidewalks on both sides.

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), 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 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)
- U.S. Standard Atmosphere and Standard Day conditions are assumed

Other Resources

- RWDC National Unmanned Challenge: Detailed Background
- Challenge statements and Detailed Backgrounds from previous RWDC Precision Agriculture years
- Winning Engineering Design Notebooks from previous years
- RWDC Content Webinars
    - Overview of Unmanned Systems
    - Systems Engineering and Vehicle Performance Factors
    - Precision Agriculture and Application of Unmanned Systems
    - 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

PTC Tools

- PTC Creo
- 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 FY19 National Challenge Scoring Rubric. Teams must submit the following:

1. Engineering Design Notebook (refer to RWDC FY19 State Challenge Scoring Rubric)
2. CAD drawings in engineering design notebook (refer to RWDC FY19 National Challenge Scoring Rubric)
3. Presentation for 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 FY19 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 FY19 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, and business plan development.
- The Engineering Design Notebook will count as 70% of the final team score at the National/International competition.

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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