FY18 RWDC State Unmanned Aerial System Challenge: Practical Solutions to Precision Agriculture

Background

By 2050, there will be an estimated additional two billion people on Earth, which will significantly impact the availability of food. It has been estimated that there will be a need to produce 70% more food to address such a population growth. Throughout history, advances in technology have allowed farmers to produce more food. One piece of current technology that has the potential to greatly help the modern farmer is the unmanned aircraft system (UAS). By using a UAS, the farmer can more precisely monitor a field of crops and be able to apply water, fertilizer, or pesticides in a manner that saves time, saves money, saves resources, and increases crop yield.

The FY18 RWDC State challenge will continue the focus on unmanned systems and precision agriculture through the design and implementation of a UAS to support precision agriculture in the production of corn. 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:

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
4) ***Alternative Uses*** - identify alternative uses of system to improve marketability and use cases

As you progress through the challenge, your team will incrementally be presented with background relating to the composition and operation of unmanned system designs, engineering design principles, unmanned system application to precision agriculture, business management, and development tools. 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: *Your Company has been tasked with making a case whether or not the part 107 regulations are restricting the ability to improve crop yield while minimizing profits. You will be comparing your aircraft to two aircraft that do precision agriculture in the United States. Your UAS design should perform spraying and/or surveying better than the one or both of the aircrafts given. While you may choose to have capabilities of both UAS designs given in your design, you must do better than the DJI Agras MG-1 at spraying, do better than the eBee SQ at surveying, or do better at both. To demonstrate the abilities of your aircraft, you will be using the test field owned by your company. The field is 2 miles by 2 miles in size (2560 acres) and the crop is corn. It will also be assumed that you must provide your surveying and spraying as a service to the farmer, you may NOT say your business case is to sell the aircraft.*

If you decide that your UAV will only take care of one of the 2 features done by the DJI Agras MG-1(spraying) or the eBee SQ (surveying), you will need to come up with a way of completing those tasks through traditional methods. For example, if you make a surveying UAV that is unable to do any spraying, you will need to research another method of getting the pesticide to the affected areas. The cost of performing the additional tasks that your UAV design does not complete must be accounted for in your costs for servicing the field. You must however have at least one UAV that completes the survey and/or spraying tasks of the DJI Agras MG-1(spraying) or the eBee SQ (surveying). You should be comparing your system to the given performances of the two given designs. The performance of the DJI Agras MG-1(spraying) and the eBee SQ (surveying) are listed in the detailed background.

Both designs may use unmanned ground vehicles or other robotic systems if desired. In addition, multiple aircraft may be used at the same time.

Field: *As mentioned earlier, the size of the test field is 2 miles by 2 miles (2560 acres). Dirt access roads surround the field. Aircraft with a width of 9 ft or less may use the access roads for takeoff and landing. Larger aircraft must use the grass landing strip owned by the company that is located 1 mile north of the northern border of the test field.*

Although this field size is the testing site for your UAS, you should try to find at what range of field sizes does your UAS best perform.

Safety: *For each area that your team decides to go outside of part 107 with your UAS, you should include ways of addressing any possible safety issues that might arise. Besides any safety concerns from being outside of part 107, your aircraft should also, at a minimum, have the following safety features:*

- *Procedures for loss of signal from the pilot and GPS*
- *Procedures for obstacle detection and avoidance*

Specific part 107 regulations can be found at

http://realworlddesignchallenge.org/resources/021515_sUAS_Summary-1.pdf

Business case *Teams will be looking to see if they can make a case that their designs outside of part 107 regulations will lead to an increased opportunity for profit. The increased profit should be made from a reduction of costs or an improvement in revenue (through increased crop yield). Teams should look at how changes to the field size changes the cost per acre. The changes in the cost per acre should be used to find a range of optimal field sizes to reduce your costs. Teams should NOT just raise the price of their system to improve its profitability. Any increase in price should be within a reasonable price for a farmer to spend and still make money himself.*

Comparison: *The outcome from your team will be an unmanned system capable of surveying a field and spraying pesticides. You will be comparing your systems performance with the ones given to you in the detailed background. You will try to make a case that if you go outside of the part 107 regulations then you will have the opportunity to significantly improve the profitability of your system.*

Objectives

Unlike previous challenges, there will not be an objective function. Instead, your designs will be judged on how well they satisfy the objectives. 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.

- Maximize crop yield
- Minimize resources used (man-hours, cost, energy, etc.)
- Maximize profit for the farmer and your company
- Aircraft has safety protocols and procedures to account for loss of signal and obstacle detection
- Aircraft can safety operate outside of part 107 regulations if needed

Constraints

- Antennas on-board the vehicle(s) must be separated by a minimum of 18 inches to avoid destructive interference
- 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.
- Your design must comply with any other FAA guidelines and regulations

Assumptions

- You may assume that your company has received permission to disperse pesticides using your UAV.
- Communications must be maintained with ALL remote vehicle elements (redundant secondary system required)
- The control system:
    - Include global positioning system (GPS) navigation and telemetry for operating the vehicle and payload.
    - Include ability to relay mission payload commands (release dispersant, change pressure, etc.) from control station, and ability to implement repetitive mission payload command routines (e.g., release dispersant over specific targeted areas logged in GPS).
    - ***NOTE:*** *Autonomous controls can include capabilities to follow a pre-programmed path (waypoint following) as well as the ability for the "operator" to update movement (flight or driving) patterns in real-time during the mission*
- 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, with no winds aloft

Other Resources

- RWDC State 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 (schedule to be determined)
    - 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 FY18 State Challenge Scoring Rubric. Teams must submit the following:

1. Engineering Design Notebook (refer to RWDC FY18 State Challenge Scoring Rubric)
2. CAD drawings (refer to RWDC FY18 State Challenge Scoring Rubric)

Scoring

- Teams' submissions will be evaluated based on criteria outlined in the RWDC FY18 State 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 FY18 State 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 precision agriculture

Merit Awards

Special RWDC Merit Awards will be given at the National 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

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