FY12 RWDC STATE CHALLENGE STATEMENT

Background:

In September of 2004, the FAA approved a new category of aircraft called Light Sport Aircraft (LSA). This category is a new classification of simple-to-operate aircraft with less demanding pilot and aircraft certification requirements. The LSA movement is opening the world of flight to more people through a lower cost of ownership and operation.

In addition, with the political, environmental, and economic consequences of fossil fuel consumption, the transportation industry at large is compelled to “go green” in order to reduce dependency on these increasingly costly energy resources.

The Challenge:

The challenge is to design an efficient, low-carbon-emission and environmentally friendly personal light sport aircraft. The aircraft must accommodate two team members and fly 200 miles in less than two hours at a cruise altitude of 1000 feet above ground level (AGL) minimum.

For the State Challenge, teams will perform aerodynamic, propulsion, sizing, and weight estimation analyses to optimize wing geometry and minimize specific fuel consumption (SFC). Teams are to write a 2000 word essay on what they would see and do given the opportunity to fly their design across the country.

The Final Design Must:

1. Follow FAA design criteria for Light Sport Aircraft: http://www.faa.gov/aircraft/gen_av/light_sport/.

2. Document design details including:
    a. Aerodynamics Analysis ($\boldsymbol{C_L}$, $\boldsymbol{C_D}$, $\boldsymbol{C_M}$ versus angle of attack, AOA)
    b. Power Loading
    c. Wing Loading
    d. Airplane Sizing
    e. Engine Sizing and Selection
    f. Wing Geometry
    g. Airfoil Selection
    h. Tail Geometry
    i. Fuselage Geometry
    j. Weight Estimation
    k. Material Selection for Wing

Objective Function:

Minimize the objective function ($\boldsymbol{Of}$), which is the aircraft cruise efficiency, for the flight mission to fly two team members 200 miles in less than two hours by varying specified design variables without violating constraints:

$$\boldsymbol{Of = 0.57\, K\, (A^3 B)^{-\frac{1}{4}}}$$

Where

$$\boldsymbol{K = \frac{C_D/C_L}{V} \qquad A = \frac{\rho C_D S}{2W} \qquad B = \frac{2W}{\rho b^2 \pi e}}$$

C_L is the aircraft coefficient of lift, C_D is the aircraft coefficient of drag, V is the aircraft cruise velocity, ρ is the density of air, S is the wing planform reference area, W is the aircraft weight, and b is the wing span. e is the Oswald's efficiency factor which can be estimated empirically using $e = 1.78\,(1 - 0.045\,AR^{0.68}) - .64$ for straight wing aircraft with normal aspect ratios, or with computational fluid dynamics (CFD) software. AR is the wing planform aspect ratio. Weight will be estimated with Mathcad and Mechanica methods. See reference on flight efficiency listed below for background on equations.

Design Variables:

- Wing area
- Wing aspect ratio
- Wing taper
- Wing sweep
- Wing twist
- Root and tip airfoil shapes
- Wing placement
- Power plant selection
- Fuselage selection
- Wing material selection

Constraints:

- A maximum takeoff weight of not more than 1,320 pounds.
- A maximum airspeed in level flight with of not more than 120 knots under standard sea level atmospheric conditions.
- A maximum stalling speed (or minimum steady flight speed without the use of lift-enhancing devices) of not more than 45 knots at the aircraft's maximum takeoff weight and most critical center of gravity.
- A maximum seating capacity of no more than two persons, including the pilot.
- A single reciprocating engine or electric motor.
- A fixed or ground-adjustable propeller.
- A non-pressurized cabin.
- Fixed landing gear.
- Not to exceed material allowables for ultimate load condition (6g's) at maximum cruise speed at sea level.
- A minimum skin gage of 0.032 inches.

Assumptions:

- U.S. Standard Atmosphere and Standard Day conditions with no winds aloft.
- Other active design elements (i.e. propeller sizing) will be managed by supporting worksheets and Mathcad methods.

Resources:

- UIUC Airfoil Coordinates Database: http://www.ae.illinois.edu/m-selig/ads/coord_database.html
- CAFÉ Foundation Green Flight Challenge and Resource Library:
  - http://cafefoundation.org/v2/gfc_main.php
  - http://cafefoundation.org/v2/tech_lib.php
- Landmark paper in flight efficiency: http://cafefoundation.org/v2/pdf_tech/MPG.engines/AIAA.1980.1847.B.H.Carson.pdf
- NASA – Green Aviation: http://www.nasa.gov/centers/ames/greenspace/green-aviation.html

- The RWDC Support Site with FAQs, tutorials, Mathcad modules, material allowables, library of available propulsion systems and fuselages, and other supporting materials:
    - www.ptc.com/go/rwdcgettingstarted
    - http://www.ptc.com/appserver/wcms/standards/fileothumbredirect.jsp?&im_dbkey=132074&im_language=en
- Mentors from the aviation industry.

Tools:

- Creo Elements/Pro Student Edition, Creo Elements/Pro Mechanica, Mathcad Prime 1.0 Student Edition, and the Windchill collaboration site provided by PTC.
- FloEFD.Pro aerodynamic analysis software provided by Mentor Graphics.
- Sizing and performance worksheets in Mathcad and Excel provided by NASA and PTC.

Scoring:

- Technical scoring will be based on deliverables to be incorporated in the Design Notebook.
- Design Notebooks should follow the paragraph order of the Scoring Rubric.
- Judges will be looking for ability to express comprehension, and linkage between the design solutions with what students have learned with specific merit given for design viability, innovation, and design considerations that minimize carbon, noise, and infrastructure footprints.