Unlimited Class Air Racer

Request for Proposal

2025-2026 Undergraduate Individual Aircraft Design Competition
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Background

Each year, the National Championship Air Races are held in September. Over approximately a week, several classes of aircraft are raced, culminating in the popular Unlimited Class. This class has been dominated for decades by modified examples of classic piston-engine, propeller-driven fighters. The few truly competitive aircraft have been extensively modified and appear to have reached the zenith of what may be achievable using this approach. There have been a few examples of specially-designed Unlimited Class air racers, but they have not proven competitive. In order to reinvigorate this sport, new clean-sheet designs are needed that are competitive with the best current racers.

Project Objective

This RFP asks for an original aircraft design capable of beating the best race times ever posted by Unlimited Class Air Racers at the National Championship.

This design must both meet all the explicit Unlimited Class rules as well as not violate the spirit of the race. For example, turbocharging would be allowed, but turbo-compounding would not be because the addition of a power turbine would mean that the aircraft is not solely piston-engine. Similarly, a motor jet would not be allowed. While there is no explicit requirement for the pilot to be on board, a UAV would undoubtedly be disqualified on safety grounds. Similarly, even if cutting pylons deliberately while taking the time penalty or some other exceptional maneuvers are technically winning strategies, extreme cases would be disqualified on safety grounds. Be creative, but do not violate the spirit of the race.

In order to prove that your design meets the Project Objective, you must develop a performance analysis capability that simulates your aircraft on the racecourse, under typical race conditions, with an output of the lap times of the race.

Also, while there are many aircraft design/analysis methods available, none have been developed with this class of aircraft in mind. Luckily, there are several unmodified fighters that are raced, and some should have sufficient publicly available data for this purpose. Once the methods are shown to be realistic, then the new design can be performed with greater confidence.

General Design Requirements:

Class Rules:

- Piston-driven aircraft
- Empty weight greater than 4,500 lb
- Capable of pulling a minimum of +6g while maintaining level flight

Race Day Operating Design Conditions:

- Roswell Air Center (KROW) near Roswell, New Mexico during 10-14 September
- Design for +/- 2 standard deviations of temperature based on the past 10 years of weather data
- Account for wind conditions (speed and direction) typical of the time of year at the venue
- The pilot's force required to attain the maximum +6g load must be accounted for. For center stick controls, this force must be between 15 and 35 lb
- Assume 2 warm up/line up laps prior to the race laps
- Account for Gold, Silver, and Bronze races (# of laps)
- Minimum fuel reserves must account for 10 minutes at 5,000 ft

Ferry Mission Capability:

- Takeoff and Landing performance appropriate for a sea level dry 4,000 ft runway, with consideration of Engine-Out emergency operation
- Minimum range ≥ 500 nmi (removable supplemental fuel tanks may be considered with a trade study)
- Minimum 2,000 ft altitude
- Minimum ceiling ≥ 10,000 ft
- Reserves consistent with part 91 IFR operations

Miscellaneous requirements to be covered in the report:

- FAA Experimental certification basis
- Pilot visibility should be appropriate for safe race operations i.e., minimum 270-degree field of vision without canopy supports

Notes:

- All race performance to be computed at representative race day atmospheric conditions
- Ferry flight to be computed at standard atmospheric conditions
- All atmospheric conditions should be noted

Report Requirements

The technical proposal must convincingly demonstrate that the analysis methodology is realistic and that the design that results from it satisfies the requirements. The proposal should satisfy the following tasks to show how the design would be developed.

1. Present the validation dataset collected, show how it was used, and explain any method calibration performed.
2. Justify the final design and describe the technologies and technical approach used to meet the mission requirements.
3. Provide sizing plots used to guide the design selection. Describe sensitivity studies used.

4. Include a dimensioned 3-view general arrangement drawing.
5. Include figures and drawings showing the internal arrangement.
6. Show a weight breakdown of the major components and systems. Show weight and CG envelope to cover the following loadings:
    a. Race
        i. Takeoff
        ii. Race
        iii. Landing
    b. Ferry
        i. Takeoff
        ii. Cruise
        iii. Landing
7. Define the aircraft's speeds: stall, ferry (best range), race speeds (including anticipated course time)
8. Show estimated component drag build-ups (parasite) and drag polars (+ lift dependent profile, induced, and trim) for all conditions. Remember to account for compressibility and cooling drag.
9. Show estimated propulsion performance including engine power, fuel flow, and propulsive efficiency for all conditions. Remember to account for compressibility.
10. Include performance flight envelope, payload-range, and V-n diagrams.
11. Performance data at a minimum should include
    a. Design requirements
    b. Takeoff and landing performance estimated for Roswell Air Center, with consideration of Engine-Out emergency operation
    c. Estimated lap times
    d. Maximum speed
12. Show estimated stability for all flight and loading conditions.
13. Include a text description and illustrations of the primary load bearing airframe structure, and state rational for material selection.
14. Include descriptions of the major aircraft systems.
15. Describe any advanced technologies or design approaches and their relative benefits as used to obtain performance improvements. Address risk mitigation if these technologies fail to materialize, including cost increase and performance decrements.
16. Provide flyaway cost estimate for production run of 1 and 10 units. Provide fixed and variable (hourly) operating cost estimates.

Reference Material

Roswell Air Center Unlimited Class Racecourse Map
https://airrace.org/wp-content/uploads/2025/05/NCAR_MAP_UNLIMITED.pdf