Request for Proposal

Hybrid-Electric General Aviation Aircraft (HEGAA)

Background

Recent developments in electric motors, controllers, power generation and most importantly batteries have led to the development of hybrid gas-electric cars such as the Toyota Prius and Chevrolet Volt. These vehicles use a combination of energy storage in fossil fuels and chemical batteries to achieve their fuel efficiency, range, and performance goals. There are also fully electric cars such as the Chevrolet Bolt, Tesla Model S, and Nissan Leaf. The technology for batteries in the next decade will be challenged to store enough energy for longer range general aviation travel of 800-1000 nautical miles (nmi) alone.

This Request for Proposal (RFP) is for the design of two-member Hybrid-Electric General Aviation Aircraft family. The entry into service (EIS) is 2028 for a 4-seat model with 1000 nmi of range and 2030 for the 6-seat model with 750 nmi of range. The intent is to have energy storage for takeoff, climb, go-around and emergencies via batteries and electric motors with an engine providing additional power and/or direct propulsion.

Most aircraft manufacturers create a product that can cover the largest number of missions and markets with a minimum of non-recurring development costs and changes to a design. This results in the modification of an existing airframe to perform additional missions. The airframe and propulsion system commonality, by weight, between the 4-seat and 6-seat variant should be 75% or greater of the 4-seater's empty weight.

Engine = internal combustion or jet engine

Motor = electric motor powered by batteries or generated power

Requirements (M) = Mandatory Requirement (T) = Tradable requirement

General Requirements

- Capable of taking off and landing from runways (dirt, grass, metal mat, gravel, asphalt, and concrete)
- Minimum cruise speed of 174 knots
- Target cruise speed: 200 knots or greater
- Capable of VFR and IFR flight with an autopilot
- Capable of flight in known icing conditions
- Meets applicable certification rules in FAA 14 CFR Part 23

  - All missions below assume reserves and equipment required to meet applicable FARs

- Engine/propulsion system assumptions documented
  - Use of engine(s) that will be in service by 2028.
    - Assumptions on at least specific fuel consumption/efficiency, thrust/power and weight should be specified.
    - Ensure that the power used by alternators, generators or other devices are accounted for.
  - Use of electric motor(s) that will be in service by 2028 and document battery energy and power density assumptions based on reasonable technology trends.
    - Document system efficiency including at least the efficiency of the batteries, wires, controllers, thermal management system, connectors, motors and propellers to calculate a total propulsive efficiency.
    - Document electric propulsion system weight
- Show airframe and propulsion system commonality of at least 75% between the 4-seater and 6-seater by weight.
- Show the emergency range to get to an alternate airport at the maximum feasible weight from an engine failure at 5000 ft AGL (ISA + 18 deg F) with electric power from batteries alone for both the 4- and 6-seat variants.
- Provide systems and avionics architecture that could enable autonomous flight
  - Provide a market justification for choosing to either provide or omit this capability

Four-Seat Variant Mission Requirements

- Crew: 1 pilot
- 3 passengers
- Passenger/pilot and baggage weight assumptions
  - Passenger/pilot weight of 190 lb
  - Baggage weight per passenger/passenger of 30 lb and volume of at least 4 cubic feet per passenger
- 1000 nmi design range mission with IFR reserves
  - Maximum takeoff and landing field lengths of 1,500’ over a 50’ obstacle to a runway with dry pavement (sea level ISA + 18oF day).

  - Takeoff, and landing performance should also be shown at 5,000' above mean sea level (ISA + 18oF) as well as for grass & concrete fields at sea level (ISA+18oF)

- Initial climb rate at sea level (ISA+ 18oF) at least 1500 fpm with both electric and fossil fuel propulsion operating
- Meet 14 CFR 23.67 Climb: One engine inoperative requirements with either propulsion type inoperative if it will be treated as a twin-engine airplane

Six-Seat Variant Mission Requirements

- Crew: 1 pilot
- 5 passengers
- Passenger/pilot and baggage weight assumptions
  - Passenger/pilot weight of 190 lb
  - Baggage weight per passenger/pilot of 30 lb and volume of at least 4 cubic feet per passenger
- 750 nmi design range mission with IFR reserves
  - Maximum takeoff and landing field lengths of 1,800 ft over a 50 ft obstacle to a runway with dry pavement (sea level ISA + 18oF day).
  - Takeoff, and landing performance should also be shown at 5,000 ft above mean sea level (ISA + 18 deg F) as well as for grass & concrete fields at sea level (ISA + 18 deg F)
- Initial climb rate at sea level (ISA + 18 deg F) at least 1300 fpm with both electric and fossil fuel propulsion operating
- Meet 14 CFR 23.67 Climb: One engine inoperative requirements with either propulsion type inoperative if it will be treated as a twin-engine airplane

Design Objectives

- Minimize production cost by choosing materials and manufacturing methods appropriate for the annual production rate that is supported by the team's assessment of the potential market size.
- Make the aircraft visually appealing so it will be marketable and identify what features are important to the operators for different missions.
- Make the aircraft reliability equal or better than that of comparable aircraft.
- Make the aircraft maintenance equal or better than that of comparable aircraft.

Other Features and Considerations

- Flying qualities should meet CFR Part 23.
- Identify all systems functionality and components that are required for the aircraft to operate in both controlled and uncontrolled airspace.
- List the equipment required.
- Consider what features will be basic and which will be optional to a customer.

Notes and Assumptions

Assume an EIS of 2028 when making technology decisions.

Proposal and Design Data Requirements

The technical proposal shall present the design of this aircraft clearly and concisely; it shall cover all relevant aspects, features, and disciplines. Pertinent analyses and studies supporting design choices shall be documented.

Full descriptions of the aircraft are expected along with performance capabilities and operational limits. These include, at a minimum:

1. A description of the design missions defined for the proposed concepts for use in calculations of mission performance as per design objectives. This includes the selection of cruise altitude(s) and cruise speeds supported by pertinent trade analyses and discussion.
2. Aircraft performance summaries shall be documented and the aircraft flight envelope shall be shown graphically.
3. Payload range chart(s)
4. A V-n diagram for the aircraft with identification of necessary aircraft velocities and design load factors.
   Required gust loads are specified in 14 Code of Federal Regulations (CFR) Part 23.
5. Materials selection for main structural groups and general structural design, including layout of primary airframe structure as well as the strength capability of the structure and how that compares to what is required at the ultimate load limits of the aircraft. The maximum dive speed of the aircraft shall be specified.
6. Complete geometric description, including dimensioned drawings, control surfaces sizes and hinge locations, and internal arrangement of the aircraft illustrating sufficient volume for all necessary components and systems.
   - Scaled three-views (dimensioned) and 3-D model imagery of appropriate quality are expected. The three-view must include at least:
     1. Fully dimensioned front, left, and top views

2. Location of aircraft aerodynamic center (from nose)
3. Location of average CG location (relative to nose)
4. Tail moment arms

- Diagrams and/or estimates showing that internal volume requirements are met, including as a minimum the internal arrangements of the passenger, cargo and maritime surveillance variants.
    1. Cross-section showing passenger seats
    2. Layout of passenger cabin
    3. Layout of cockpit
    4. Layout of cargo and size and location of any unique cargo doors
    5. Fuselage centerline diagram
- Diagrams showing the location and functions for all aircraft systems.

7. Important aerodynamic characteristics and aerodynamic performance for key mission segments and requirements
8. Aircraft weight statement, aircraft center-of-gravity envelope reflecting payloads and fuel allocation. Establish a forward and aft center of gravity (CG) limits for safe flight.
    - Weight assessment summary shall be shown at least at the following level of detail:
        1. Propulsion (engine/motor, batteries, controller, wiring, heat sink, cowl, strut, propeller, spinner etc. as applicable)
        2. Airframe Structure
            1. Wing
            2. Empennage
            3. Landing Gear (including wheels tires and brakes)
            4. Fuselage
        3. Control system (flight controls linkages, hydraulics, wires, actuators bellcranks, engine controls etc.)
        4. Payloads (seats, seatbelts, cushions and other cabin systems)
        5. Systems
            1. Instruments and Avionics
            2. Fuel/oil (battery if electric)

3. Hydraulic/pneumatic/electrical systems (if chosen)

9. Propulsion system description and characterization including performance, dimensions, and weights. The selection of the propulsion system(s), sizing, and airframe integration must be supported by analysis, trade studies, and discussion

10. Summary of basic stability and control characteristics; this should include, but is not limited to static margin, pitch, roll and yaw derivatives.

11. Summary of cost estimate and a business case analysis. This assessment should identify the cost groups and drivers, assumptions, and design choices aimed at the minimization of production costs.

    - Estimate the non-recurring development costs of the airplane including engineering, FAA/EASA certification, production tooling, facilities and labor
    - Estimate the fly away cost of each member of the family
    - Estimate the price that would have to be sold for to generate at least a 15% profit
        - Show how the airplane could be produced profitably at production rates ranging from 4 to 10 airplanes per month or a rate that is supported by a brief market analysis
    - Estimate of direct operating cost per airplane flight hour
        - Fuel, oil, tires, brakes, battery cost and other consumable quantities
        - Estimate of maintenance cost per flight hour
        - Flight and cabin crew costs per hour

The proposal response will include trade documentation on the two major aspects of the design development, a) the concept selection trades, and b), the concept development trade studies.

The students are to develop and present the alternative concepts considered leading to the down-select of their preferred concept. The methods and rationale used for the down-select shall be presented. At a minimum a qualitative assessment of strengths and weaknesses of the alternatives shall be given, discussing merits, leading to a justification as to why the preferred concept was the best proposal response. Quantitative justification of why the selected proposal is the best at meeting the proposal measures of merit(s) will strengthen the proposal.

In addition, the submittal shall include the major trade studies conducted justifying the optimization, sizing, architectural arrangement and integration of the specifically selected proposal concept. Quantitative data shall be presented showing why their concept “works" and is the preferred design compromise that best achieves the RFP.

Specific analysis and trade studies of interest sought in proposals include:

- Mission performance and sizing for the definition of a mission profiles.
- Overall aircraft concept selection (airframe and propulsion system) vs. design requirements objectives

All concept and technology assumptions must be reasonable and justified for the EIS year.

Procured Data

No data is procured as part of this RFP.

Additional Contacts

All technical questions pertaining to this RFP should be directed to Matt Orr via e-mail at: matthew.w.orr@boeing.com

Any updates to this RFP will be posted on the AIAA Design Competitions web site http://www.aiaa.org/DesignCompetitions/

Reference Material

FAA Part 23

http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title14/14cfr23_main_02.tpl

Representative Aircraft Designs

http://cirrusaircraft.com/aircraft/sr22/ (Cirrus SR-22)

http://www.mooney.com/en/AcclaimUltra.html (Mooney Acclaim)

http://beechcraft.txtav.com/en/baron-g58 (Beech Baron)

http://beechcraft.txtav.com/en/bonanza-g36 (Beech Bonanza)

http://www.piper.com/aircraft/trainer-class/seneca-v/ (Piper Seneca)

http://cessna.txtav.com/en/piston/cessna-ttx (Cessna TTX)

http://cessna.txtav.com/en/piston/cessna-turbo-stationair-hd (Cessna 206)

Design Competition Rules

General Rules

- All AIAA Student members are eligible and encouraged to participate. Membership with AIAA must be current to submit a report and to receive any prizes.
- Students must submit their letter of intent and final report via the online submission system before on the posted deadlines to be eligible to participate. No extensions will be granted.
- More than one design may be submitted from students at any one school.
- If a design group withdraws their final report from the competition, the team leader must notify AIAA Headquarters immediately.
- Design projects that are used as part of an organized classroom requirement are eligible and encouraged for competition.

Categories/Submissions

- Team Submissions
    - Team competitions will be groups of not more than ten AIAA Student Members per entry.
- Individual Submissions
    - Individual competitions will consist of only one AIAA Student member per entry.
- Graduate
    - Graduate students may participate in the graduate categories only.
- Undergraduate
    - Undergraduate students may participate in the undergraduate categories only.
- Letter of Intent (LOI)
    - A Letter of Intent indicating interest in participating in the design competitions is required before submitting a final report.
    - All Letters of Intent must be submitted through the online submission system.
    - Letter of Intent must include student's names, emails, AIAA membership numbers, faculty advisor(s) names, emails, and project advisor(s) names and emails. Any LOI that is not completed will be ineligible to submit a final report.
- Final Report
    - An electronic copy of the report in Adobe PDF format must be submitted to AIAA using the online submission site. Total size of the file cannot exceed 20 MB.
    - A "Signature" page must be included in the report and indicate all participants, including faculty and project advisors, along with students' AIAA member numbers and signatures.
    - Each report should be no more than 100 pages, double-spaced (including graphs, drawings, photographs, and appendices) if it were to be printed o 8.5"x11.0" paper, and the font should be no smaller than 10 pt. Times New Roman.
        - Engine Design Competition is limited to 50 pages.

Copyright

All submissions to the competition shall be the original work of the team members.

Any submission that does not contain a copyright notice shall become the property of AIAA. A team desiring to maintain copyright ownership may so indicate on the signature page but nevertheless, by submitting a proposal, grants an irrevocable license to AIAA to copy, display, publish, and distribute the work and to use it for all of AIAA's current and future print and electronic uses (e.g. "Copyright © 20__ by ____. Published by the American Institute of Aeronautics and Astronautics, Inc., with permission.).

Any submission purporting to limit or deny AIAA licensure (or copyright) will not be eligible for prizes.

Conflict of Interest

It should be noted that it shall be considered a conflict of interest for a design professor to write or assist in writing RFPs and/or judging proposals submitted if (s)he will have students participating in, or that can be expected to participate in those competitions. A design professor with such a conflict must refrain from participating in the development of such competition RFPs and/or judging any proposals submitted in such competitions.

Schedule

- Letter of Intent — 10 February 2018 (11:59 pm Eastern Time)
- Proposal delivered to AIAA Headquarters — 10 May 2018 (11:59 pm Eastern Time)
- Announcement of Winners — 31 August 2018 (11:59 pm Eastern Time)
    - Engine Design Competition dates
        - Letter of Intent – 14 February 2018 (11:59 pm Eastern Time)
        - Proposal delivered to AIAA Headquarters – 16 May 2018 (11:59 pm Eastern Time)
        - Round 1 evaluations completed – 30 June 2018 (11:59 pm Eastern Time)
        - Round 2 presentations at AIAA Propulsion and Energy Forum 2018

Awards

The prize money provided for the competitions is funded through the AIAA Foundation. The monetary awards may differ for each competition, with a maximum award of $500. The award amounts are listed below.

The top three design teams will be awarded certificates. One representative from the first place team *may be* invited by the Technical Committee responsible for the RFP to make a presentation of their design at an AIAA forum. A travel stipend *may be* available for some competitions, with a maximum travel stipend of $750 which may be used to help with costs for flight, hotel, or conference registration to attend an AIAA forum.

Aircraft Design Competitions

- Graduate Team Aircraft - Advanced Pilot Training Aircraft
- Undergraduate Team Aircraft – Hybrid-Electric General Aviation Aircraft (HEGAA)
    - 1st Place: $500; 2nd Place: $250; 3rd Place $125
- Undergraduate Individual Aircraft – Close Air Support Aircraft (A-10 Replacement)

Engine Design Competition

- Undergraduate Team Engine –Candidate Engines for a Next Generation Supersonic Transport
    - 1st Place: $500; 2nd Place: $250; 3rd Place $125

Space Transportation Competition

- Undergraduate Team Space Transportation – Pluto Orbiter
    - 1st Place: $500; 2nd Place: $250; 3rd Place $125

Space Design Competition

- Undergraduate Team Space Design – Lunar Prospecting
    - 1st Place: $500; 2nd Place: $250; 3rd Place $125

Structures Design Competition

- Graduate Team Structures – Fuselage Design
- Undergraduate Team Structures – Supersonic Wing
    - 1st Place: $500; 2nd Place: $250; 3rd Place $125

Proposal Requirements

The technical proposal is the most important factor in the award of a contract. It should be specific and complete. While it is realized that all of the technical factors cannot be included in advance, the following should be included and keyed accordingly:

- Demonstrate a thorough understanding of the Request for Proposal (RFP) requirements.
- Describe the proposed technical approaches to comply with each of the requirements specified in the RFP, including phasing of tasks. Legibility, clarity, and completeness of the technical approach are primary factors in evaluation of the proposals.
- Particular emphasis should be directed at identification of critical, technical problem areas. Descriptions, sketches, drawings, systems analysis, method of attack, and discussions of

new techniques should be presented in sufficient detail to permit engineering evaluation of the proposal. Exceptions to proposed technical requirements should be identified and explained.

- Include tradeoff studies performed to arrive at the final design.
- Provide a description of automated design tools used to develop the design.

Basis for Judging

1. Technical Content (35 points)

This concerns the correctness of theory, validity of reasoning used, apparent understanding and grasp of the subject, etc. Are all major factors considered and a reasonably accurate evaluation of these factors presented?

2. Organization and Presentation (20 points)

The description of the design as an instrument of communication is a strong factor on judging. Organization of written design, clarity, and inclusion of pertinent information are major factors.

3. Originality (20 points)

The design proposal should avoid standard textbook information, and should show the independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the method show an adaptation or creation of automated design tools?

4. Practical Application and Feasibility (25 points)

The proposal should present conclusions or recommendations that are feasible and practical, and not merely lead the evaluators into further difficult or insolvable problems.