Request for Proposal

Modern Regional Jet Family

Background

The smaller regional jet market currently has products that are based upon older designs that have their origins in the late 1980s and early 1990s. The 50 seat Canadian Regional Jet (CRJ) and Embraer 145 first flew in the early 1990s and make up most of the domestic regional jet fleet.

The industry analyses forecast as many as 2,000 new regional aircraft being needed in the next 20 years. This presents an opportunity to develop new regional aircraft to satisfy the 50-seat portion of the market that meets the US domestic "Scope Clause" that has significantly better fuel burn and economics than existing options. The overall goal is to be at least 20% better than existing 50-seat regional jets in 500 n mi block fuel per seat with a cost to build that is comparable to the existing aircraft.

An approximate 76-seat stretch derivative of the 50-seat airplane also needs to be designed as part of this regional jet airplane family. The 76-seat aircraft must meet the design weight limits within the US domestic airline "Scope Clause" agreements. This airplane should be designed to be competitive with the Embraer E170 and the Mitsubishi SpaceJet M100.

Requirements: [R] = Mandatory Requirement [O] = Objective or Goal, Tradeable

General Requirements

The requirements and objectives below are applicable to both aircraft within the family unless otherwise specified.

- Entry Into Service (EIS)
  - [R] 2030 for first airplane model introduced and 2031 for second model
  - [R] Use existing engine(s) or one that is in development will be in service by 2029, at least a year prior to the airplane EIS.
    - Assumptions on at least specific fuel consumption/efficiency, thrust/power and weight must be documented.
- Passenger Capacity
  - [R] 50 +0/-4 passengers in a single class seating arrangement at a 30" seat pitch
  - [R] 76 +0/-4 passengers in a single class seating arrangement at a 30" seat pitch
- Design Range with full passengers
  - [R] 2,000 n mi 50-seat version
  - [R] At least 1,500 n mi 76-seat version
- Cruise Mach Number
  - [R] Minimum Mach 0.78
  - [O] Target Mach 0.80
- Seat Width

        - [R] Minimum seat width of 17.2”
        - [O] Target seat width of 18”
    - Cross-Section
        - [R] Stand up height in the aisle similar to competitive aircraft
        - [R] Baggage compartment is tall enough to be serviced ergonomically
        - [R] Aisle width: 18” minimum
    - Wing Span
        - [O] Maximum of ICAO Code B (< 24 m)
        - [R] Maximum of ICAO Code C (< 36 m)
    - Performance
        - [R] Approach speed category C (<141 knots)
        - [R] Design range mission performance 50 seat airplane
            - Maximum takeoff field length of 4,000’ over a 50’ obstacle to a runway with dry pavement (sea level ISA + 18°F day).
            - Maximum landing field length of 4,000’ over a 50’ obstacle to a runway with dry pavement (sea level ISA + 18°F day) at maximum landing weight
            - Takeoff, and landing performance should also be shown at 5,000’ above mean sea level (ISA + 18°F)
            - Distance to climb up to initial cruising altitude less than 200 n mi
            - Initial cruising altitude of at least FL320
        - [R] Design Range mission performance 76 seat airplane
            - Maximum takeoff field length of 6,000’ over a 50’ obstacle to a runway with dry pavement (sea level ISA + 18°F day).
            - Maximum landing field length of 6,000’ over a 50’ obstacle to a runway with dry pavement (sea level ISA + 18°F day) at maximum landing weight
            - Takeoff, and landing performance should also be shown at 5,000’ above mean sea level (ISA + 18°F)
        - Economic Missions
            - [R] Show fuel burn performance per trip and per seat and compare with the appropriate competitive aircraft at 500 and 1,000 n mi
    - [R] Meet 14 CFR 25.121 Climb Gradient Requirements
    - Certifications
        - [R] Capable of VFR and IFR flight with an autopilot
        - [R] Capable of flight in known icing conditions
        - [R] Meets applicable certification rules in FAA 14 CFR Part 25
            - All missions below assume reserves and equipment required to meet applicable FARs
        - [O] Provide systems and avionics architecture that will enable autonomous operations
            - Provide a market justification for choosing to either provide or omit this capability
            - Determine how the design would change
- **Payload Requirements**
    - [R] Crew: 2 pilots and at least 1 cabin crew member for every 50 passengers
    - Pilot and baggage design weights:
        - Pilot/Crew weight of 190 lb
        - Baggage weight per pilot of 30 lb and volume of at least 4 cubic feet per person

- Passenger and baggage weights
  - 200 lb per passenger
  - 40 lb (5 cubic feet) of baggage per passenger

Design Objectives

- Maximize the structural and systems commonality between the 50- and 76-seat aircraft to minimize the development cost. Show what components, structures, etc. will be common between the models in the presentation and report.

- 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 (failure rate, time-to-repair, etc.) equal or better than that of comparable aircraft.

Other Features and Considerations

- Flying qualities should meet CFR Part 25.

- 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.

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 or graphical representation of the sized aircraft based on the requirements and design objectives given. This should describe or represent the quantitative justification for the sized wing area and selected power or thrust of the aircraft designs.

2. An analysis of the performance of the aircraft against the design and long-range ferry missions.

3. Aircraft performance summaries shall be documented and the aircraft flight envelopes shall be shown graphically.

4. A V-n diagram for the aircraft with identification of necessary aircraft velocities and design load factors.

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 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) limit for safe flight.

   - Weight assessment summary shall be shown at least at the following level of detail:

     1. Propulsion (engine, propeller, gearbox, nacelle, strut, fan, 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. Crew
5. Passengers and Payloads
6. Systems
    1. Instruments and Avionics
    2. Fuel/oil
    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 estimates and a business case analysis. This assessment should identify the cost groups and drivers, assumptions, and design choices aimed at the minimization of operation costs.
    - Estimate the non-recurring development costs of the airplane including engineering, FAA/EASA certification, production tooling, facilities and labor
    - Estimate the acquisition (or "fly away") cost
    - 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 operating cost for the aircraft assuming 1,200 flight hours per year in a mixture of training, ferry, and operational flights.
        - Fuel, oil, tires, brakes, and other consumable quantities
        - Estimate of maintenance cost per flight
        - Flight crew costs
        - Including other costs will strengthen the proposal

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 Matthew Orr 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

General Information

https://www.embraermarketoutlook2019.com/

https://www.airbus.com/aircraft/market/global-market-forecast.html

https://www.boeing.com/commercial/market/commercial-market-outlook

Existing Regional Aircraft and Reference Information

https://en.wikipedia.org/wiki/Scope_clause

https://en.wikipedia.org/wiki/Bombardier_CRJ100/200

https://en.wikipedia.org/wiki/Bombardier_CRJ700_series#CRJ550

https://en.wikipedia.org/wiki/Embraer_E-Jet_family

https://en.wikipedia.org/wiki/Mitsubishi_SpaceJet

https://www.skybrary.aero/index.php/ICAO_Aerodrome_Reference_Code

FAA 14 CFR Part 25

https://www.ecfr.gov/cgi-bin/text-idx?SID=ffa15036a5063e0af45f080a365945dc&mc=true&tpl=/ecfrbrowse/Title14/14cfr25_main_02.tpl