2024-2025 Graduate Team Aircraft Design Competition

Ultra Premium, Long Range Business Jet

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Background

The high end business jet market is characterized by aircraft such as the Gulfstream G650 and Global 7500 that have premium interiors, long range, and high cruise Machs. Additionally, there are converted passenger models such as the Boeing Business Jet or Airbus Corporate Jet which are modified 737s and A320s respectively. These also have long range and premium interiors, with cabins initially sized for 100+ passengers and now outfitted for much fewer.

Customers in the high-end business jet market are willing to pay a premium for luxurious interiors, aircraft performance such as range and takeoff field length, and unlike commercial airline customers, for the general appearance of the aircraft. This request for proposals (RFP) is to design the next generation of high-end business jets, with a focus on challenging performance requirements, creative and luxurious interiors, and a leeway to the aircraft designer to trade aircraft performance (such as fuel burn) and/or production cost for aircraft appeal.

Many requirements are outlined at a high level, especially the interior requirements, and left to the designer to determine optimal geometry to balance luxury and aircraft capability. Explanations of these trades are expected in the RFP response.

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

- **General Requirements**
  - (M) Capable of taking off and landing from standard airport runways
  - (M) Minimum cruise Mach of M0.85
    - (T) Target cruise Mach: M0.92
  - (M) Capable of VFR and IFR flight
  - (M) Capable of flight in known icing conditions
  - (M) Meets applicable certification rules in FAA 14 CFR Part 25
    - All missions below assume reserves and equipment required to meet applicable FARs
  - (M) Engine/propulsion system assumptions documented and the use of an engine that will be in service by 2035
    - Document assumptions on, at a minimum, specific energy consumption/efficiency, thrust/power and weight should be specified
- **Interior Requirements**
  - (M) Seating for 8 passengers with 60 inch pitch and 22 inches wide
    - (T) Lay flat reclinable
  - (M) Seating for 1 flight attendant in the passenger compartment
  - (M) One queen size bed (60 inches by 80 inches) in a private room
  - (M) Two lavatories
    - (M) One standard lavatory accessible to passengers and flight crew
    - (M) One handicap accessible lavatory
      - (M) One hot water shower in handicap accessible lavatory
      - (M) Provisions for 30 minutes of shower total water capability
  - (M) One galley, accessible by flight attendant and sized for the design range mission length
  - (M) Modern flight deck for two pilots, with one jump-seat accessible by passengers while aircraft is in flight
  - (M) Provisions for Wifi and satellite TV
  - (T) Crew rest area, sized by crew requirements for design range mission
  - (M) Provisions for business productivity, such as but not limited to:
    - Conference table, permanent or storable
    - Televisions that be used to display laptop content
  - (M) Pressurization capability for 6,000 feet equivalent cabin altitude at maximum service ceiling (Maximum service ceiling set by aircraft design team, stated for clarity)
  - (M) Air condition capability to keep at least 30% of the baggage area at 45 degrees Fahrenheit on a 100 degree Fahrenheit day on the ground, sea level
- **Design Passenger Mission**
  - (M) Crew: 3 flight crew
    - 2 pilots
    - 1 flight attendant
  - (M) Passenger capacity: 8 passengers

    - (M) Passenger and baggage weight assumptions
        - Passenger weight of 215 lbs
        - Baggage weight per passenger of 50 lbs, with 8 cubic feet of baggage space per passenger
    - (M) 8,000 nautical mile range
    - (M) Takeoff from a 6,000 foot runway
        - Sea level standard day temperature and pressure
        - Grooved concrete, dry runway
    - (M) Landing on a 6,000 foot runway
        - Sea level standard day temperature and pressure
        - Grooved concrete, dry runway
- **Aspen Economic Mission – Representative of a mission from KVNY to KASE in winter**
    - (M) 4 passengers
        - 215 lbs per passenger
        - 100 lbs per passenger of baggage weight
        - 20 cubic feet of baggage per passenger
    - (M) Takeoff from KVNY
        - Optimal runway
        - 59 degrees Fahrenheit
        - Standard pressure
    - (M) Range from KVNY to KASE
        - Great circle distance + 5% for wind and airways
    - (M) Landing at KASE
        - Optimal runway
        - 20 degrees Fahrenheit
        - Standard pressure
        - Wheel braking coefficient of 0.16, representative of Medium braking action
- **Napa Economic Mission – Representative of a mission from Napa to Mexico City in summer**
    - (M) 8 passengers
        - 215 lbs per passenger
        - 40 lbs per passenger of baggage weight
        - 5 cubic feet of baggage per passenger
    - (M) Storage of 12 cases of wine
        - 40 lbs per case of wine
        - 1 cubic foot of space per wine case
        - 4 of the cases stored in climate-controlled space at 45 degrees Fahrenheit
    - (M) Takeoff from KAPC
        - Optimal runway
        - 75 degrees Fahrenheit
        - Standard Pressure
        - Dry runway
    - (M) Range from KAPC to MEX
        - Great circle distance + 5% for wind and airways
    - (M) Landing at MEX
        - Optimal runway
        - 85 degrees Fahrenheit
        - Standard Pressure
        - Dry runway

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.

Design Objectives

- While meeting all mandatory aircraft requirements, design an aircraft with the minimum production cost, with assumptions on market size documented by the team
- The aircraft designer may sacrifice production cost for a differentiating or enhancing feature, either in the aircraft interior or exterior that adds to aircraft appeal. This qualitative trade must be documented and justified in the

report.

Notes and assumptions:

- Assume an EIS of 2031 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.
    a. Required gust loads are specified in Federal Aviation Regulations (FAR) Part 25.
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.
    a. Scaled three-views (dimensioned) and 3-D model imagery of appropriate quality are expected. The three-view must include at least:
        i. Fully dimensioned front, left, and top views
        ii. Location of aircraft aerodynamic center (from nose)
        iii. Location of average CG location (relative to nose)
        iv. Tail moment arms
    b. 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.
        i. Cross-section showing passenger
        ii. Layout Of Passenger Accommodations (LOPA)
        iii. Layout of baggage compartment and baggage doors
        iv. Fuselage centerline diagram
    c. 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 energy weight allocation. Establish a forward and aft center of gravity (CG) limits for safe flight in the normal categories.
    a. Weight assessment summary shall be shown at least at the following level of detail:
        i. Propulsion
        ii. Airframe Structure
            1. Wing
            2. Empennage
            3. Landing Gear
            4. Fuselage
        iii. Control systems
        iv. Payloads
        v. Systems
            1. Instruments and Avionics
            2. Fuel/oil (battery if needed)
            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.
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.
    a. Estimate the non-recurring development costs of the airplane including engineering, FAA/EASA

certification, production tooling, facilities, and labor
    b. Estimate the fly away cost of each member of the family
    c. Estimate of direct operating cost per airplane flight hour
12. Lifecycle emissions analysis, which includes:
    a. Emissions associated with aircraft production
    b. In-service emissions
        i. Analysis should include key greenhouse gases such as Carbon Dioxide and Nitrous Oxide

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.

A) The student is 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 is 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.
B) 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:
1. Mission performance and sizing for the definition of a mission profiles.
2. 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.

Reference Material
- 14 CFR Part 25
  https://www.ecfr.gov/current/title-14/chapter-I/subchapter-C/part-25?toc=1

Airport Descriptions:

- **KVNY -- https://www.airnav.com/airport/KVNY**
- **MEX -- https://acukwik.com/Airport-Info/MMMX**
- **KAPC -- https://www.airnav.com/airport/KAPC**

Representative Aircraft Design

- **Gulfstream G650/G700/G800 -- https://en.wikipedia.org/wiki/Gulfstream_G650/G700/G800#Variants**
- **Bombardier Global 7500 – https://en.wikipedia.org/wiki/Bombardier_Global_7500**
- **Boeing Business Jet -- https://en.wikipedia.org/wiki/Boeing_Business_Jet**
- **Airbus Corporate Jet -- https://en.wikipedia.org/wiki/Airbus_Corporate_Jets**
- **Embraer Lineage 1000 - https://en.wikipedia.org/wiki/Embraer_Lineage_1000**