International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03410
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Design Project of Eight Seater Short Range Business Jet Aircraft (Cessna Citation CJ3+)

Siva Jothi S[1], Thatchayini K[2], Kulasekaran@Chinna Samy K[3], Siranjeevi S[4]

[1] Assistant Professor of Mechanical Engineering, Anna University / Satyam College of Engineering and Technology, Kanyakumari Dist.

[2, 3, 4] Students of Aeronautical Engineering, Anna University / Satyam College of Engineering and Technology, Kanyakumari Dist.

Abstract - This project explores the design and development of an eight-seat short-range business jet, aiming to optimize performance, passenger comfort, and operational efficiency for regional travel. With a targeted range of 2,500 nautical miles, the proposed aircraft is intended to facilitate quick and convenient transportation between major urban centers. The design features a modern seating arrangement that ensures passenger comfort and privacy, along with advanced amenities that enhance the in-flight experience. The aircraft will be powered by twin turbofan engines, allowing it to cruise at speeds of approximately Mach 0.8. In this paper a business jet aircraft is designed to carry 8 passengers and with service ceiling of 45,000 ft Preliminary analyses confirm that this configuration strikes an effective balance between performance and fuel efficiency. The airframe will utilize advanced composite materials to reduce weight while enhancing structural integrity and aerodynamic properties, thereby improving overall efficiency.

Key Words: Cruise Speed, Service Ceiling, Strikes, Turbo fan Engine, Aircraft.

1. INTRODUCTION

Eight-seater short-range business jets, also known as very light jets (VLJs), are a category of small business jets typically designed for 4-8 passengers and single-pilot operation, offering a cost-effective entry point into private aviation. Passenger Capacity: Designed to accommodate 4-8 passengers, making them suitable for small groups or families. Range: While "short-range" is a relative term, these jets typically have a range of around 1953 nautical miles, suitable for shorter to medium-distance flights.

Single-Pilot Operation Many VLJs are approved for single-pilot operation, simplifying crew requirements and reducing operational costs. Entry-Level Jets: VLJs are considered the lightest business jets, offering a cost-effective entry point into private aviation.

Examples: Some examples of eight-seater short-range business jets include the Cessna Citation CJ3, Embraer Phenom 300, and Honda Jet.

Performance: These jets offer a good balance of speed, fuel efficiency, and maneuverability for their size. Cabin Features: While small, these jets often feature comfortable seating, entertainment systems, and Wi-Fi connectivity.

Short Field Performance: Some models, like the Dassault Falcon 8X, are known for their outstanding short-field performance, allowing them to access smaller airports. Modern aircraft are a complex combination of aerodynamic performance, lightweight durable structures and advanced systems engineering. Air passengers demand more comfort and more environmentally friendly aircraft. Hence many technical challenges need to be balanced for an aircraft to economically achieve its design specification. The design process begins from scratch and involves a number of calculations, logistic planning, design and real world considerations, and a level head to meet any hurdle head on. Every airplane goes through many changes in design before it is finally built in a factory.

These steps between the first ideas for an airplane and the time when it is actually flown make up the design process. Along the way, engineers think about four main areas of aeronautics: Aerodynamics, Propulsion, Structures and Materials, and Stability and Control. Aerodynamics is the study of how air flows around an airplane. In order for an airplane to fly at all, air must flow over and under its wings. The more aerodynamic, or streamlined the airplane is, the less resistance it has against the air. If air can move around the airplane easier, the airplane's engines have less work to do.

This means the engines do not have to be as big or eat up as much fuel which makes the airplane more lightweight and easier to fly. Engineers have to think about what type of airplane they are designing because

International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03410
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

certain airplanes need to be aerodynamic in certain ways. For example, fighter jets maneuver and turn quickly and fly faster than sound (supersonic flight) over short distances. Most passenger airplanes, on the other hand, fly below the speed of sound (subsonic flight) for long periods of time. Business jets have a much more luxurious interior, with a number of amenities and services that a normal airliner would not have. Airliners are designed to carry large numbers of people, most of who are looking for the lowest cost possible. Business jets on the other hand are designed to carry people in a much higher level of comfort. The people who travel by business jet are almost always quite well off and expect this level of comfort when they travel.

2. COMPARACTIVE STUDY

Parameter/ Aircraft	Cessna Citation CJ 3+	Embraer Phenom 300E	Nextant 400XTi	Hawker 800XP
Role	Light business jet	Light business jet	Light business jet	Mid-size business jet
Status	Active service	In service	In service	In service
Crew	1	1	2	2
Range (miles)	2040	2010	2160	2920
Cruise Speed	417knots	414knots	447knots	447knots
No of Passengers	8	9	10	9
Wing Position	High	Low	Mid-Wing	Low
Engine Position	Rear of cabin	Rear of cabin	Rear of cabin	Rear of cabin
Altitude	45000 feet	45000 feet	45000 feet	41000 feet

3. CONCEPTUAL DESIGN

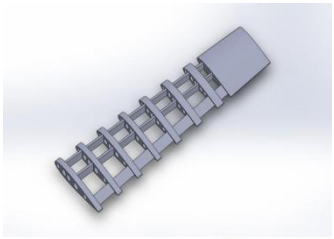
Design Concept

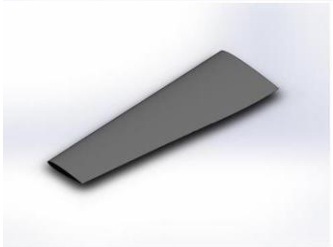
This project is to expand my personal knowledge of the design process which goes into the design process of an airplane. To enhance my knowledge, a business jet was chosen to be the main subject. A business jet was chosen as it is similar to a passenger airliner, yet a smaller scale. The design of business jet aircraft is a critical factor that influences their performance, efficiency, comfort, and overall operational capabilities. Unlike commercial airliners, which prioritize high passenger capacity and cost-effectiveness, business jets are tailored to meet the specific needs of corporate clients and high-net-worth individuals.

- The Wing
- Landing gear design
- Aircraft subsystems
- Weight estimation
- V-n diagram
- Weight and balance analysis
- Drag Polar

The Wing Selection

The Cessna Citation CJ3+ features a 16.26-meter wingspan with a high-tech, computer-sculpted airfoil design. This wing design enhances lift and reduces drag, offering a combination of performance and efficiency. The wings also include a small "aileron fence" and are equipped with leading edge heating for anti-icing. a natural laminar flow wing design that improves fuel efficiency and performance, along with a wider span for increased lift and reduced drag. The wings also contribute to the CJ3+'s ability to achieve a maximum cruise speed of 416 ktas (770 km/h) and a range of 2,040 nm (3,778 km).





International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03410
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Wing design and performance

Natural Laminar Flow

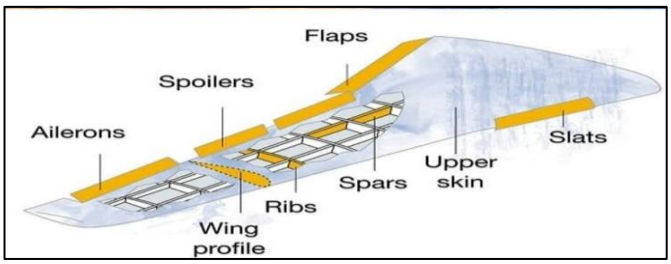
The CJ3+ employs a natural laminar flow wing, which minimizes turbulence and drag, leading to improved fuel efficiency and enhanced climb performance.

Wider Span

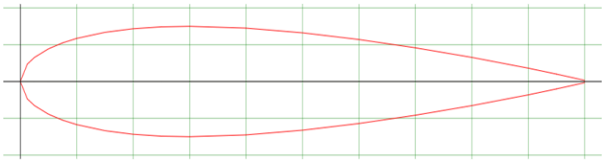
The CJ3+'s wider wing span provides a larger surface area for lift, contributing to its ability to carry a heavier payload and achieve higher maximum takeoff weights.

Performance

The CJ3+'s wing design, combined with its powerful engines, allows it to reach high altitudes (45,000 ft) and climb rapidly (4,478 fpm).



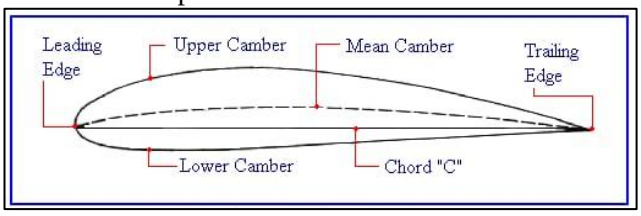
4. AEROFOIL SELECTION



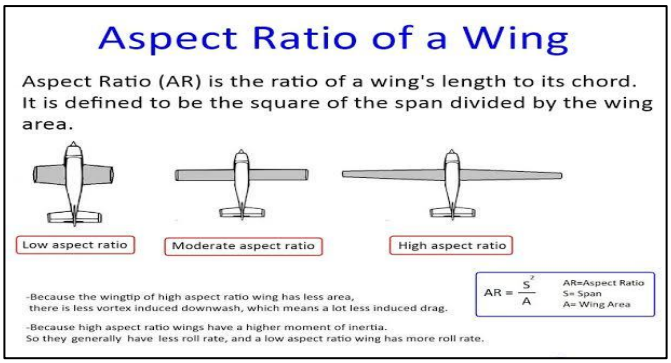
Chord line: Straight line connecting leading edge and trailing edge.

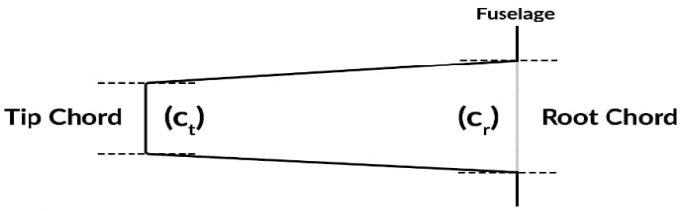
Thickness: Measured perpendicular to chord line as a % of it.

Camber: Curvature of section – perpendicular distance of section mid-points from chord line as a % of it.



Airfoil is a cross-section of a wing or blade; thus, it is a two-dimensional shape. A typical airfoil and its main terminology .When an airfoil is located in a fluid flow its first point that hits the wind is called the leading edge (assuming that wind blows from left to right). Similarly, the last point of the airfoil on which the wind leaves the airfoil is called the trailing edge. The straight line that connects these two points is called the chord. The dashed line shown on the figure is called the camber line which is a line such that the thickness of the airfoil is equal on its both sides. Note that the thickness is measured perpendicular to the camber line. The 15 indicates that the airfoil has a 15% thickness to chord length ratio: it is 15% as thick as it is long.





5. POWER PLANT SELECTION

An aircraft power plant depends heavily on the intended mission, aircraft type, and speed/altitude requirements. For low-speed, low-altitude applications, reciprocating engines are common due to their cost and efficiency. As speeds and altitudes increase, various types of jet engines (turbojet, turbofan, and turboprop) become more suitable.

Types of Aircraft Power plants:

- Reciprocating engine
- Turbojet engine
- Turbofan engine
- Turboprop engine
- Ramjet engine
- Scramjet engine
- Pulsejet engine

Business jet power plant selection typically involves choosing from various turbofans engine models, with Pratt & Whitney and Honeywell being prominent manufacturers. Engine selection depends on

International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03410
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

factors like thrust requirements, fuel efficiency, and operational needs, such as airport performance at high altitudes.

Factors Influencing Power plant Selection:

Thrust Requirements: The engine must provide sufficient thrust to take off, accelerate, and maintain speed at cruising altitude.

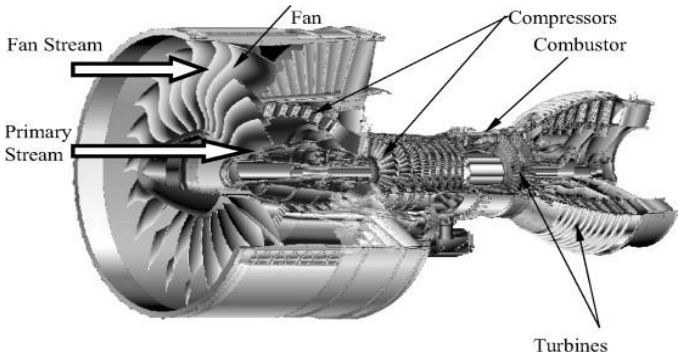
Fuel Efficiency: Fuel consumption is a critical factor for long-range flights and overall operating costs.

Operational Needs: Considerations like airport altitude, runway length, and operating temperature can influence engine selection.

Performance: Engine performance, including climb rate and speed, impacts the aircraft's ability to reach its destination efficiently.

Maintenance and Reliability: Factors like engine lifespan, availability of maintenance services, and component reliability play a role.

Turbofans: Feature a turbine engine with a fan, providing good efficiency for a wide range of speeds and altitudes, commonly used in commercial aircraft.



Common Turbofan Engine Manufacturers:

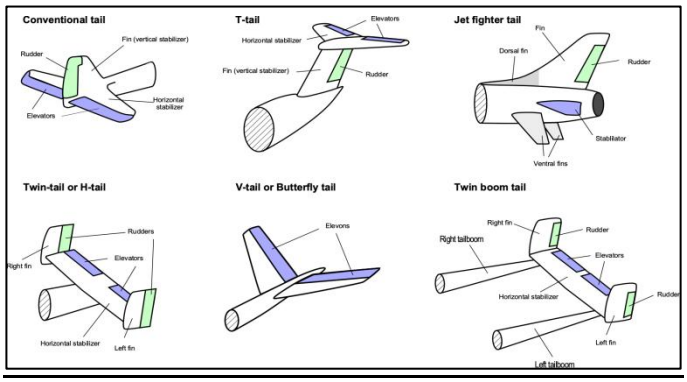
- **Pratt & Whitney:** Offers a wide range of engines for various business jet types, including the PW800 and PW600 families, known for their fuel efficiency and advanced technology.
- **Honeywell:** Provides engines like the TFE731, known for their reliability and use in many business jets.

6. TAIL SELECTION

Aircraft tail selection involves choosing the right design and size of the tail surfaces (horizontal and vertical stabilizers, rudder, and elevator) to achieve desired flight characteristics like stability, control, and performance. This selection process considers factors such as aircraft type, flight envelope, and design constraints, with the goal of optimizing the tail's contribution to overall flight safety and efficiency.

T-Tail: Features a horizontal stabilizer mounted high on the vertical stabilizer, reducing wake interference from the wing and improving stability.

Tail Design Options:



Horizontal Stabilizer

The horizontal stabilizer is a fixed wing structure on an aircraft's tail, working with the vertical stabilizer to ensure stability and control. It helps maintain longitudinal balance, preventing the nose from pitching up or down and enabling pilots to control the aircraft's pitch. The elevator, a movable part attached to the stabilizer, provides the control for adjusting the aircraft's attitude.

Vertical stabilizer

Vertical stabilizer or tail fin is the static part of the vertical tail of an aircraft. The term is commonly applied to the assembly of both this fixed surface and one or more movable rudders hinged to it. Their role is to provide control, stability and trim in yaw (also

International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03410
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

known as directional or weathercock stability). It is part of the aircraft empennage, specifically of its stabilizers.

Horizontal tail (stabilizer) volume ratio:

VH = (SH * LH) / (SW * MAC)

Vertical tail (stabilizer) volume ratio:

VV = SV * LV / (SW * b)

7. AIRCRAFT PERFORMANCE:

Speed: The ability to reach high speeds, crucial for various flight operations.

Climb Rate: The ability to gain altitude quickly, important for safety and efficient flight.

Ceiling: The maximum altitude an aircraft can reach influenced by engine power and altitude restrictions.

Range: The distance an aircraft can travel on a single tank of fuel, crucial for long-haul flights.

Fuel Efficiency: The amount of fuel consumed per unit of distance traveled, a key factor for economic and environmental considerations.

Takeoff and Landing Distance: The distance required for takeoff and landing, influenced by aircraft weight, runway conditions, and other factors.

Maneuverability: The ability to change direction and altitude quickly and effectively, important for various flight maneuvers.

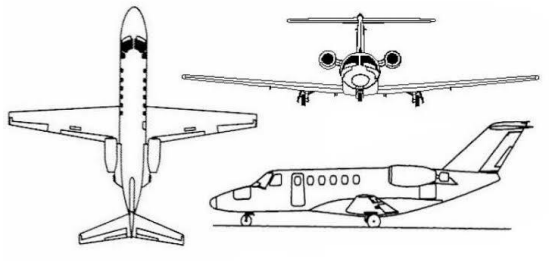
Factors Affecting Aircraft Performance:

- **Aircraft Weight:** Higher weight reduces performance in all aspects, including climb rate, ceiling, and range.
- **Atmospheric Conditions:** Temperature, pressure, and humidity affect the performance of the engines and the aerodynamic forces acting on the aircraft.
- **Runway Conditions:** Runway length, surface type, and crosswind conditions affect takeoff and landing performance.
- **Aircraft Design:** Wing shape, engine type, and other design features significantly influence performance characteristics.

8. FINAL DESIGN PARAMETERS

PARAMETERS	VALUE
LENGTH	51 feet 2 inches (15.60 meters)
SERVICE CEILING	45,000 ft
ASPECT RATIO	9.52
WING AREA	294 square feet
EMPTY WEIGHT	10,510 Lb
RANGE	1,194 nm
TAKE OFF WEIGHT	13870Ibl (6291 kg)
CRUISE VELOCITY	416 knots (478 mph)
RATE OF CLIMB	4,478 feet per minute (fpm)
ALTITUDE	45000 feet

8. THREE VIEW DAIGRAM



9. CONCLUTION

The Cessna Citation CJ3+ is a highly regarded light jet known for its balance of performance, efficiency, and luxury. It's a versatile aircraft suitable for both business and personal travel, offering a comfortable and efficient flying experience. The CJ3+ is particularly well-suited for single-pilot operations and is a popular choice for charter services, thanks to its reliability and impressive range. The CJ3+ boasts a range of up to 2,040 nautical miles, making it capable of covering significant distances. Its maximum cruise speed is 416 knots, and it can reach an altitude of 45,000 feet. The aircraft is equipped with advanced avionics, including the Garmin G3000 system, offering an intuitive and efficient flight deck experience. Cessna provides comprehensive maintenance and support for CJ3+ aircraft, ensuring optimal performance and safety.

In conclusion, the Citation CJ3+ is a well-rounded light jet that offers a compelling combination of performance, efficiency, and comfort, making it a popular choice for various aviation needs.

10. REFERENCES

[1] Govindaraju, P., & Crossley, W. A. (2013). Profit motivated airline fleet allocation and concurrent aircraft design for multiple airlines. Paper presented at the *2013 AIAA Aviation Technology, Integration, and Operations Conference (ATIO 2013)*, 19 pp

[2] Airpartner.com. (2017). *Aircraft Guides |Private Jets | Airliners | Cargo aircraft | AirPartner USA*. [online] Available at: http://www.airpartner.com/enUS/aircraft guide/#privatejet [Accessed 4 Sep. 2017].

[3] Airfoiltools.com. (2017). NACA 64-008A AIRFOIL (n64008a-il). [online] Available at:

http://airfoiltools.com/airfoil/details?airfoil=n64008a-il [Accessed 14 Sep. 2017].

[4] https://cessna.txtav.com/en/citation/cj3-gen2

[5] https://www.guardianjet.com/jet-aircraft-online-tools/aircraft-brochure.cfm?m=Cessna/Textron-CJ3+-186

[6] https://www.flyexclusive.com/citation-cj3-plus

[7]https://www.globalair.com/aircraft-for-sale/specifications?specid=1565

[8] https://en.wikipedia.org/wiki/Business_jet

https://aeroaffaires.com/private-jet-hire/midsize-jets/