Development of Next Generation Civilian Aircraft

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Abstract

Designing a NEXT GENERATION FLYING VEHICLE & its JET ENGINE for commercial air transportation civil aviation Service. Implementation of Innovation in Future Aviation & Aerospace. In the ever-changing dynamics of the world of airspace and technology constant Research and Development is required to adapt to meet the requirement of the passengers. This study aims to develop a subsonic passenger aircraft which is designed in a way to make airline travel economical and affordable to everyone. The design and development of this study aims to i) to reduce the various forces acted on the aircraft thereby reducing the fuel consumption, ii) to utilise proper set of materials and composites to reduce the aircraft weight and iii) proper implementation of Engineering Design techniques. This assessment considers the feasibility of the technology and development efforts, as well as their potential commercial prospects given the anticipated market and current regulatory regime.

Keywords

Aircraft, Drag reduction, Engine, Fuselage, Manufacture, Weight reduction, Wings

Introduction

Subsonic airlines have been the norm now almost reaching speeds of Mach 0.80, with this into consideration all the commercial passenger airlines have adapted to design and implement aircraft to subsonic speeds. Although high speeds are usually desirable in an aircraft, supersonic flight requires much bigger engines, higher fuel consumption and more advanced materials than subsonic flight. A subsonic type therefore costs far less than the equivalent supersonic design, has greater range and causes less harm to the environment. The less harsh subsonic environment also allows a much wider range of aircraft types, such as balloons, airships, and rotorcraft, allowing them to fill a much wider range of roles. The major aspects to be considered in the design of a subsonic passenger planes are fuel efficiency, passenger comfort, cost reduction and environmental impact.

This study analysis the design of Next generation commercial aircraft which aims to build on the existing designs with modifications to make it drag efficient and also efficient thrust to weight ratio. Fuel consumption and maintenance are some of the major factors contributing to the increase in costs, to reduce these costs drag reduction designs such as swept back wing shape and conventional tail design have been considered.

Challenges

Energy is the centre of human life – without it there would be no modern life. Ever since the 19th century, the role of fossil fuels has expanded with every passing year. Much has been made out about the negative impacts on the climate and the resultant effects on health, but the fact remains that it is still impossible to imagine a world without fossil fuels and the energy that they have to offer. The airline industry offers the perfect example of a sector that is almost entirely dependent on fossil fuels and its availability. In fact, about 30% of the costs of the industry goes towards kerosene. This article tries to offer insights into the biggest challenges faced by the airlines today.

Competitiveness

Any change in the GDP is often reflected in airline usage and the fuel also costs almost 50% more in just 5 years. According to Antonio Vázquez, the chairman of IAG and Iberia, competitiveness is one of the most important problems being faced by the airline industry in Europe. Vazquez mentions that this makes alliances vital for the growth and development of airlines – whether with high-speed rail links or with other airlines. He states Iberia's merger with BA as an example where both airlines have managed to gain immense benefits from the merger even though they have not integrated operations.

The Fuel Factor

Fuel price remains to be the biggest concern faced by the airline industry in the modern world. The high costs have led to many airlines imposing fuel surcharges on customers. Industry analysts estimate that with the ever-increasing fuel prices, most airlines are feeling an effect on their bottom lines. An analyst working for the Walter Capital Management states that there is an obvious connection between airline stock and crude oil prices. Singapore Airlines has already termed the cost of fuel as its main challenge. Although its airline doesn't face the challenges faced by the airlines that are privately owned, it still finds it very difficult to tackle fuel prices. Non-government owned airlines like JetBlue and British Airways have many other issues to tackle as well, but fuel costs remain high on their list. Matters simply become worse when economies suffer from economic recessions. In fact, the airline industry suffered an all-time low during economic recessions in the year 2010.

Overcapacity

Several airlines like the TWA have already gone out of business because of issues like overcapacity. Most major airlines in the industry still struggle to get a grip on the constant changes, and many carriers have been seen to be slow to adapt to the changing economic environment. As a result of overcapacity, airlines have had to suffer from rock bottom fares, something that might delight flyers, but not the airlines. These fares directly lead to a major revenue problem, which is already suffering from high fuel costs.

Identification of the factors that contribute to the process of Design selection

1. Selection of number of wings

Wings develop the major portion of the lift of a heavier-than-air aircraft. Wing structures carry some of the heavier loads found in the aircraft structure. The design of a wing depends on many factors, such as the size, weight, speed, rate of climb, and use of the aircraft. The wing must be constructed so that it holds its aerodynamics shape under the extreme stresses of combat manoeuvres or wing loading. Wing construction is similar in most modern aircraft. In its simplest form, the wing is a framework made up of spars and ribs and covered with metal. A Typical fixed wing passenger aircraft have 2 wings with a configuration of 2 engines or 4 engines, the main advantages of these configurations are it reduces the weight of the aircraft significantly and also helpful in drag reduction. The requirement of lift the basic need of an aircraft to takeoff is provided by wings 2 fixed wing is more than sufficient to generate the lift required.

2. Selection of wing shape:

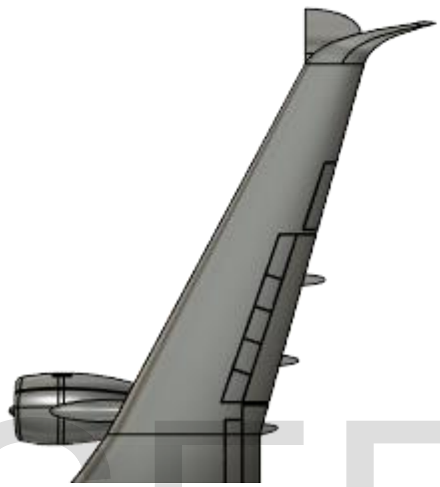
- **Rectangular:** Suitable for smaller aircrafts, not very aerodynamic thereby increasing drag and fuel consumption. Only advantage being easy to build.

- **Elliptical wing:** The elliptical wing is aerodynamically most efficient because elliptical spanwise lift distribution induces the lowest possible drag. However, the manufacturability of this aircraft wing is poor.

- **Delta Wing:** This low aspect ratio wing is used in supersonic aircrafts. The main advantage of a delta wing is that it is efficient in all regimes (supersonic, subsonic, and transonic). Moreover, this type of wing offers a large area for the shape thereby improving manoeuvrability and reducing wing loading. The delta wing doesn't just offer efficient flight experience but is also strong structurally and provides large volume for fuel storage. This wing is also simple to manufacture and maintain. However, like any other type of aircraft wing, delta wing also has some disadvantages. The main disadvantages of this aircraft wing include:
  1. Due to their low aspect ratio, delta wings induce high drag.
  2. At low speed – during landing and takeoff –, these wings have a high angle of attack mainly because, at such low speeds, vortices generate the lift. High stall angles of the delta wings compensate for this.

- **Ogive Wing:** The ogive wing design is used in very high-speed aircrafts. The complex mathematical shape of this aircraft wing is derived to minimize drag at supersonic speeds. Ogive wings offer excellent performance at supersonic speeds with minimal drag. The main disadvantage of these types of aircraft wings is that they are very complex and manufacturing them is difficult. Moreover, their subsonic performance is not satisfactory in comparison.

- **Swept back wings:** The aircraft wings whose leading edges are swept back are called swept back wings. Swept back wings reduce drag when an aircraft is flying at transonic speeds. Most of the high-speed commercial aircrafts use swept back wings. Boeing 787 Dreamliner is one example out of many that uses swept back wings.



- **Forward swept wing:** The aircraft wings whose leading edges are swept forward are called swept forward wings. One disadvantage of this type of configuration is that because of the flow characteristics of the wings, the outboard wings stall before the flaps. This can cause controllability issues. Swept forward wings were therefore only used in very few aircraft, like the Grumman X-29 Switch Blade.The main issue that made this type of wing configuration unsuitable was that it produced wing twisting when it bent under load, putting greater stress on wing roots. The Sukoi Su-47 Berkut is one of the very few aircraft that used this wing.

3. Placement of wing:

High Wing configuration

Advantages: i) Allows placing fuselage closer to ground, thus allowing loading and unloading without special ground handling equipment. ii) Jet engines & propeller have sufficient ground clearance without excessive landing gear length leading to lower landing gear weight. iii) For low speed airplanes, weight saving can be affected by strut braced wing
iv) For short take off and landing (STOL) airplanes, the high wing configuration has the following specific advantages. (a) Large wing flaps can be used. (b) Engines are away from the ground and hence ingestion of debris rising from unprepared runways is avoided. (c) Prevents floating of wing due to ground effect which may occur for low wing configuration.
Disadvantages i) Fuselage generally houses the landing gear in special pods leading to higher weight and drag. ii) Pilot's visibility may be blocked during a turning flight.

Mid wing configuration

Advantages: i) Lower drag. ii) Advantages of ground clearance as in the case of high wing configuration. iii) No blockage of visibility. Hence, used on some military airplanes.
Disadvantages: Wing root structure passing through the fuselage is not possible, which leads to higher weight. However, in HFB Hansa airplane, a swept forward mid-wing is located behind the passenger cabin. This permits wing root structure passing through the fuselage.

Low-wing configuration

Advantages: i) Landing gear can be located in the wing thereby avoiding pods on the fuselage and hence lower drag. However, to provide adequate ground clearance, the fuselage has to be at a higher level as compared to the high wing configuration. ii) Wing structure can be through the fuselage.

Disadvantages: (i) Low ground clearance. (ii) A low-wing configuration has unstable contribution to the longitudinal and lateral static stability. For low-wing airplanes the dihedral angle may be decided by need to avoid wing tip hitting the ground during a bad landing. A wing with high value of dihedral may require higher vertical tail area to prevent tendency to Dutch roll.

4. Number of Engines

The starting point in any airplane design is "How much do you want to carry how far?" There are rules of thumb to translate that into a total airplane weight, comprised of payload, fuel and airplane structure. Once you have ballparked the weight and speed and the planes expected coefficient of drag, you will know how much power you will need in various phases of flight, takeoff being the most demanding.

Since most airplanes now need at least 2 engines (commercial airliners must have at least 2 engines) you take stock of what engines are available that will deliver at the very minimum the needed power. If you need 100,000 pounds of thrust, you need a minimum of 2 X 50,000, or 3 X 34,000 or 4 by 25,000 pounds thrust each.

Flight under extended-range twin-engine operations (ETOPS) rules has proven to be routine, safe, and highly successful around the world. ETOPS allows two-engine-airplane operation for up to 180 min from an en route alternate airport. ETOPS has been used successfully on airplanes built by all major airframe manufacturers, including Boeing (737, 757, 767, 777, and MD-80). The 767 is the most widely used airplane for ETOPS, and the world fleet of 767s has just completed its one millionth ETOPS flight. Though twinjets fly ETOPS routes around the world, they dominate in the North Atlantic market and show potential for the same success in the North Pacific ETOPS market.

The introduction of twinjets reshaped the North Atlantic market, and operators further expanded service to major transportation centres when economically efficient long-range twinjets entered service and ETOPS was approved. Travel between smaller city pairs in Europe and North America also benefited through increased point-to-point services. International air service agreements such as open-skies and the bilateral agreement between Japan, other Asian nations, and the United States are expected to increase flight frequencies in the North Pacific market. These agreements, combined with the availability of economically efficient, long-range airplanes such as the 777, may fuel the growth of ETOPS in the North Pacific to the current level of activity in the North Atlantic. Several airports in the North Pacific are equipped to meet ETOPS planning requirements and so serve as en route alternates for twinjets as well as for three- and four-engine long-range airplanes.

The average total thrust requirement of a mid-range commercial passenger aircraft is 200kN, going by the norm a 2 engine aircraft of 100kN is the most preferred trade off as an increase in number of engines increases the weight and fuel consumption. Boeing 737 one of the most preferred civilian aircraft is also a 2 engine with a thrust requirement 177.8kN delivered by 2 88.9kN engine.

5. Engine location performance-affecting factors:

- **Mounted in the wing root**

  - low asymmetric yaw on engine failure, less rudder required: less drag
  - no engine pods: less parasitic drag
  - engines closer to CG, less downforce needed from the tail: less drag
  - very little reverse thrust available
  - Little space for high-bypass-ratio engines
- **Mounted in pods under the wing**

  - high asymmetric yaw on engine failure requires larger rudder: drag penalties
  - engines provide bending relief on the wing, allowing better wing design (thinner wings): less drag
  - at high incidence angles the pods can prevent spanwise flow: less drag and better stall characteristics
  - full thrust can impose a large, undesirable, pitch up moment (think stall recovery)
  - less freedom in roll on crosswind landings
  - Location ahead of the wing's elastic line helps to dampen flutter
- **Mounted inside the tail or on pods on the rear fuselage**

  - low asymmetric yaw on engine failure, less rudder required: less drag
  - wing design is freed from the need to accommodate engines, allows for more complex wing designs: better performance throughout the flight envelope

  - heavy engines so far aft of the fuselage require wings mounted further aft, and a higher tail to support that: more drag
  - Lower landing gear required, especially in case of short fuselages

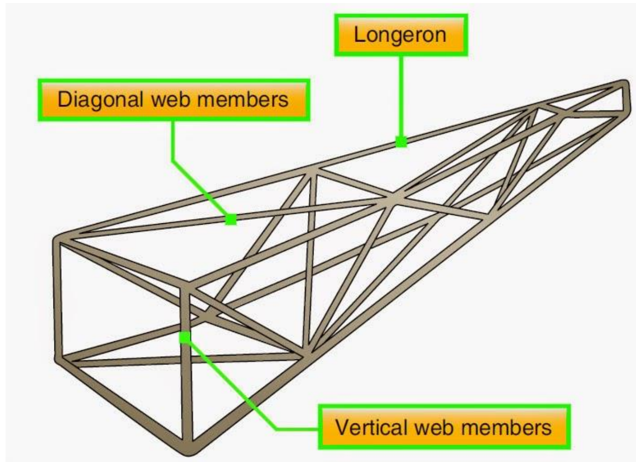
6. Shape of the fuselage

The fuselage is the main structure or body of the fixed-wing aircraft. It provides space for cargo, controls, accessories, passengers, and other equipment. In single-engine aircraft, the fuselage houses the powerplant. In multiengine aircraft, the engines may be either in the fuselage, attached to the fuselage, or suspended from the wing structure. There are two general types of fuselage construction: truss and monocoque.

Truss Type

A truss is a rigid framework made up of members, such as beams, struts, and bars to resist deformation by applied loads. The truss-framed fuselage is generally covered with fabric.

The truss-type fuselage frame is usually constructed of steel tubing welded together in such a manner that all members of the truss can carry both tension and compression loads. [Figure 1] In some aircraft, principally the light, single engine models, truss fuselage frames may be constructed of aluminium alloy and may be riveted or bolted into one piece, with cross-bracing achieved by using solid rods or tubes.



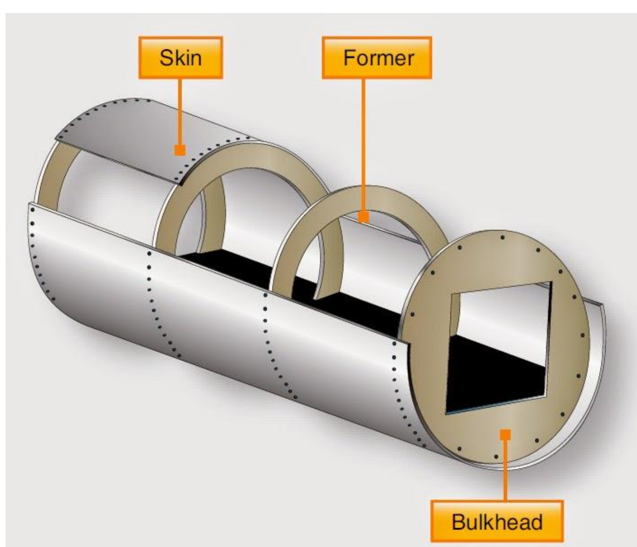
Monocoque Type

The monocoque (single shell) fuselage relies largely on the strength of the skin or covering to carry the primary loads. The design may be divided into two classes:

1. **Monocoque**
2. **Semi monocoque**

Different portions of the same fuselage may belong to either of the two classes, but most modern aircraft are of semi monocoque type construction.

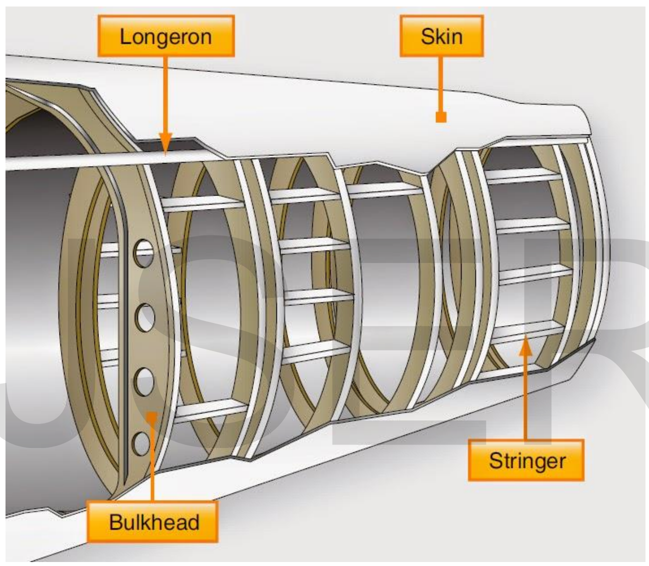
The true monocoque construction uses formers, frame assemblies, and bulkheads to give shape to the fuselage. [Figure 2] The heaviest of these structural members are located at intervals to carry concentrated loads and at points where fittings are used to attach other units such as wings, powerplants, and stabilizers. Since no other bracing members are present, the skin must carry the primary stresses and keep the fuselage rigid. Thus, the biggest problem involved in monocoque construction is maintaining enough strength while keeping the weight within allowable limits.



Semi monocoque Type

To overcome the strength/weight problem of monocoque construction, a modification called semi monocoque construction was developed. It also consists of frame assemblies, bulkheads, and formers as used in the monocoque design but, additionally, the skin is reinforced by longitudinal members called longerons. Longerons usually extend across several frame members and help the skin support primary bending loads. They are typically made of aluminium alloy either of a single piece or a built-up construction.

Stringers are also used in the semi monocoque fuselage. These longitudinal members are typically more numerous and lighter in weight than the longerons. They come in a variety of shapes and are usually made from single piece aluminium alloy extrusions or formed aluminium. Stringers have some rigidity but are chiefly used for giving shape and for attachment of the skin. Stringers and longerons together prevent tension and compression from bending the fuselage.



Other bracing between the longerons and stringers can also be used. Often referred to as web members, these additional support pieces may be installed vertically or diagonally. It must be noted that manufacturers use different nomenclature to describe structural members. For example, there is often little difference between some rings, frames, and formers. One manufacturer may call the same type of brace a ring or a frame. Manufacturer instructions and specifications for a specific aircraft are the best guides. The semi monocoque fuselage is constructed primarily of alloys of aluminium and magnesium, although steel and titanium are sometimes found in areas of high temperatures. Individually, none of the aforementioned components is strong enough to carry the loads imposed during flight and landing. But, when combined, those components form a strong, rigid framework. This is accomplished with gussets, rivets, nuts and bolts, screws, and even friction stir welding. A gusset is a type of connection bracket that adds strength.

7. Design of the tail

The tail of an airplane is designed to provide both stability and control of the airplane in pitch and yaw**.** There are many different forms an aircraft tail can take in meeting these dual requirements of stability and control. Most tail designs have a horizontal wing like structure and one or more vertical or near-vertical structures. Whenever practical, these structures are identified as the horizontal and vertical stabilizers, although some designs do not conveniently fit such a description. **The many types of airplane tail design include,** but are by no means limited to, the conventional, T-tail, cruciform-tail, dual-tail, triple-tail, V-tail, inverted V-tail, inverted Y-tail, twin-tail, boom-tail, high boom-tail, and multiple-plane tail designs.

Conventional Tail Design

The conventional tail design is the most common form**.** It has one vertical stabilizer placed at the tapered tail section of the fuselage and one horizontal stabilizer divided into two parts, one on each side of the vertical stabilizer. For many airplanes, the conventional arrangement provides adequate stability and control with the lowest structural weight. About three-quarters of the airplanes in operation today, including the Airbus A300, the Boeing 777 and 747, and the Beech Bonanza A-36, use this arrangement.

The T-Tail Design

In the T-tail design, a common variation of the conventional tail, the horizontal stabilizer is positioned at the top of the vertical stabilizer. The horizontal stabilizer is then above the propeller flow, or prop wash, and the wing wake. Because the horizontal stabilizer is more efficient, it can therefore be made both smaller and lighter. The placement of the horizontal stabilizer on top of the vertical stabilizer can also make the vertical stabilizer more aerodynamically efficient. By making the vertical stabilizer more effective, its size may be reduced. However, the horizontal stabilizer in the T-tail layout imposes a bending and twisting load on the vertical stabilizer, requiring a stronger, and therefore, a heavier, structure. These loads are avoided in the conventional design. There is also the possibility that at the high pitch angle usually associated with landing the airplane, the horizontal stabilizer of the T tail will be immersed in the slower and more turbulent flow of the wing wake. In some cases, it is possible to compromise severely the control function of the horizontal tail. Nevertheless, the T tail is the second-most common tail design after the conventional.

Both major American transport plane builders, Boeing and McDonnell-Douglas, use the T-tail design. The Boeing 727, with its three fuselage-mounted engines, has a T-tail design, as do the variants of the McDonnell Douglas MD-90, formerly the Douglas DC-9. Other aircraft that employ the T-tail design are the Lockheed C-5A, the Gates Lear-jets 23 and 35A, the Cessna Citation CJ1, the Piper Lance II, and the Beech Skipper 77.

Cruciform-Tail Design

The cruciform tail is an obvious compromise between the conventional and T-tail designs. In the cruciform design, the horizontal stabilizer is moved part of the way up the vertical stabilizer. In this position, the horizontal stabilizer is moved up and away from the jet exhaust and wing wake. The lifting of the horizontal stabilizer also exposes the lower part of the vertical stabilizer, as well as the rudder, to undisturbed airflow. Undisturbed airflow on the rudder is important, particularly in the recovery from spins. A military example of the cruciform tail is the North American RockwellB-1B supersonic bomber. Other aircraft that use the cruciform-tail design are the Dessault Falcon 100 and the Commander.

Dual-Tail Design

The dual-tail design**,** in which the two vertical stabilizers are placed at the ends of the horizontal stabilizers, was at one time fairly common on large flying boats and twin-engine propeller-driven bombers such as the North AmericanB-25. In some cases, this arrangement is attractive, because it places the vertical stabilizers in the prop wash of wing-mounted propellers. The result is the maintenance of good directional control during low-speed operations. The positioning of the two vertical stabilizers at the ends of the horizontal stabilizers allows for a smaller, lighter, and more aerodynamically efficient horizontal stabilizer. However, the overall weight of a plane with a dual-tail design is greater than that of a plane with the single conventional-tail design.

The dual tail is part of the design of the Republic Fairchild A-10 ground-attack airplane, in which the plane's two jet engines are mounted to the rear of the fuselage. When this airplane is viewed from the rear and slightly to either side, the engine exhausts, blocked by the vertical stabilizer, are not easily visible. If a heat-seeking missile is launched at a departing or escaping A-10, the main heat source, the engine exhausts, are at least partially blocked by the vertical stabilizer.

The Ercoupe, a private light airplane developed in the late 1940's and still seen at small airports, uses a dual tail to keep the vertical stabilizer out of the wake from the fuselage and the wing-fuselage junction. The Ercoupe is unique in that it is the only commercial light airplane ever produced with the dual-tail design. Other craft that use the dual-tail design include the Consolidated B-24, the Short Skyvan, and the Martin PBM Mariner flying boat.

Triple-Tail Design

The triple-tail design, with two vertical stabilizers placed at the ends of the horizontal stabilizers and one mounted on the fuselage, is attractive when the height of the vertical stabilizer must meet certain restrictions, such as hangar-door height. Certainly this was the important consideration in the design of the Lockheed Constellation, one of the most significant passenger airplanes of the late 1940's. Another well-known example of the triple-tail design is the Grumman E-2 Hawkeye.

V-Tail Design

The V-Tail, sometimes called the "butterfly" tail, has had limited application in airplane design, the most significant of which has been by the Beech Company in the Beech-craft Bonanza V-35. Clearly, the usual definition of horizontal and vertical stabilizers has no application to the V tail. The intended advantage of the V-tail design is that two surfaces might serve the same function as the three required in the conventional tail and its variants. Removal of one surface then would reduce the drag of the tail surfaces as well as the weight of the tail region. However, wind tunnel studies by the National Advisory Committee on Aeronautics (NACA) have shown that for the V tail to achieve the same degree of stability as a conventional tail, the area of the V tail would have to be about the same size as that of the conventional tail.

Another disadvantage of the V tail has to do with turning the airplane. To turn left, for example, the pilot would press the left rudder pedal and bank the airplane with the left wing down. In V-tail aircraft, the right side of the V (as viewed from the rear) deflects upward, and the left surface deflects downward. This arrangement drives the nose to the left but also causes the airplane to roll away from the turn. Although this tendency to roll is overcome by the wing control provided by the ailerons, it is clear that one control of the airplane produces a secondary effect that opposes the primary effect of another control. This secondary effect of opposing the primary purpose of another control is called adverse coupling. Adverse coupling is one reason that the most recent Bonanza design, the A-36, uses the conventional tail.

The undesirable rolling motion caused by the V tail might be avoided by inverting the butterfly tail. However, except for a few small homemade glider-sail planes, this design has been avoided because of ground clearance problems.

Inverted Y-Tail Design

The inverted Y tail is actually a conventional tail with a noticeable droop to the horizontal stabilizers. In other words, the outer ends of the horizontal stabilizers are lower than the ends attached to the fuselage. The F-4 Phantom, originally a mainstay of the McDonnell Company, used the inverted Y tail to keep the horizontal surfaces out of the wing wake at high angles of attack. It is interesting to note that the tips of the horizontal stabilizers on the first McDonnell Navy fighter, the F-2H Banshee, were bent decidedly upward.

Twin-Tail Design

The twin tail is a feature of various air superiority fighters used by both the U.S. Navy (the F-14 Tomcat) and the U.S. Marine Corps (the F/A-18 Hornet). Although both the F-14 and F/A-18 designs have a superficial resemblance, they also have important differences. The tilt angle of the vertical stabilizer of the F-14 is more pronounced than that of the F-18, so much so that it approaches that of the V tail on the Beech model V-35 Bonanza. With two vertical stabilizers, the twin tail is more effective than the conventional single tail of the same height.

Boom-Tail Design

Boom tails are used when an aircraft's fuselage does not extend entirely back to the horizontal stabilizer. In both the Lockheed P-38 Lightning fighter of World War II and the Fairchild C-119 cargo plane, engines were mounted on the booms. In the case of the C-119, the twin boom allowed easy access to the rear of the fuselage for loading and removing cargo. The twin boom has also been used for an airplane with engines mounted in the fuselage, with one engine, known as the tractor, in the nose of the airplane and one engine, known as the pusher, in the rear of the airplane. Because the thrust of both engines is along the centerline of the airplane, it is much easier in this arrangement to compensate for the loss of one engine than it is in the wing-mounted engine installation. Both the Cessna Skymaster and the new Adam 309 have fuselage-mounted engines. In the case of the Adam 309 the horizontal stabilizer is raised to avoid propeller wake from the pusher, or rear-mounted, engine.

8. Target speed of aircraft

Subsonic aircraft speed is the most preferred for commercial aircraft due to various factors involved in a supersonic aircraft such as structural constraints, high costs, take off noise, sonic boom and environmental impact. These factors contribute a lot to the passenger comfort when flying which leaves us with only subsonic aircrafts as a viable option for commercial aviation. Mach 0.8 is the target speed of the aircraft which is the average of most of the commercially operating subsonic aircrafts.

9. Winglets

Making sense of winglets starts with an understanding of the wing. The wing shape generates lift by exerting downward pressure on the air mass it is traveling through, causing a pressure difference below the wing compared to above; there is less pressure on the upper surface of the wing and more on the lower surface. From this pressure difference, the air below the wings rolls up and wraps around the top of the wing, causing a whirlwind named a wingtip vortex. According to NASA, "The effect of these vortices is increased drag and reduced lift that results in less flight efficiency and higher fuel costs."

Winglets themselves are mini-wings, not unlike a sail. Winglets produce "lift" as well, but because they are tilted upwards, that lift results in forward movement inside the vortex and reduces the strength of that vortex. "Weaker vortices mean less drag at the wingtips and lift is restored," NASA explains.

There is a caveat: Winglets also add weight — some 500 pounds each — and drag. However, the aerodynamic benefits outweigh the additional weight and drag. That's why most jetliners made today come from the factory with winglets. For older aircraft, it's up to the airline to decide whether it makes economic sense to add them, given the cost of installation and the expected fuel savings over the life of the aircraft.

Aviation Partners Boeing, a joint venture between Aviation Partners and Boeing, lists prices of around $1,000,000 for the retrofit of a Boeing 737. That's a lot of money, but in an industry where fuel efficiencies are key, this is a capital expense that will pay off over the medium to long haul. For example, the company says that adding winglets on a Boeing 737-900 can save up to 150,000 gallons of fuel per year. With jet fuel prices currently around $1.90 a gallon, winglets would save $285,000 a year.

The Types of Winglets You Can See

Not all winglets are created equal. Even a casual look at the airplanes at any given airport will tell you that they can look very different from one another, from the small arrow-like wingtips found on some Airbus jets to the huge, upturned winglets of the Boeing 767, resembling the dorsal fin of an orca.

Canted winglets

Canted winglets are short, upward-sloping wedges; they can be found on Airbus A330 and A340 aircraft and on the Boeing 747-400.

Canted Winglets on a Lufthansa A340.

These winglets are likely to disappear from view as the current models of the A330 go out of production and new wing shapes are developed. (The A340 and 747-400 are no longer made.) For example, the A330neo, which entered service last year, has smaller, upturned wingtips.

Blended winglets

You will find blended winglets on many models of the Boeing 737, the best-selling jetliner in the world. Southwest and Ryanair are the biggest operators, and you'll often see them in North America at the tip of 737 wings with WestJet, Delta and American.

They are called blended winglets because they feature a much smoother transition from the wing itself to the winglet, which produces additional efficiencies compared to a canted winglet or wingtip fence

Those are also the winglets found on most Boeing 757s and 767s in service today. They were not installed originally when the planes left the factory, but have been retrofitted by most operators, including American, Delta and United. At 11 feet tall, the 767 winglets are a sight to behold, and the ones on 737s and 757s are just a bit shorter at 8 ft, 2 in.

Sharklets:

The Airbus version of blended winglets

Confusingly for plane spotters, newer Airbus A320-family aircraft also sport blended winglets that look very similar to the winglets on the Boeing 737 — except they're called sharklets. The name is simply a nice piece of marketing. The Airbus design was the subject of a years-long patent dispute between Aviation Partners Boeing and Airbus, with Airbus the loser; the European manufacturer paid out an undisclosed sum to APB.

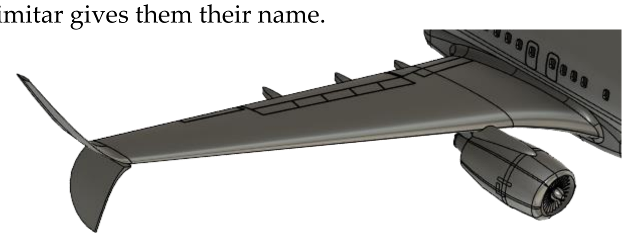
Wingtip fences: An Airbus innovation

The small winglets that you'll see on many Airbus variants are called wingtip fences. This type of winglet was meant to address the wingtip vortices that originate from the bottom of the wing, and therefore have a physical barrier below and above the wing. Spotting them is an easy way to differentiate between a Boeing 737 and an Airbus A320 family aircraft.

The fences are found on A320 family jets, as well as the A380 (not that you'd need to look at the wingtip to recognize the biggest passenger plane in the world!) The fences first appeared on some of the planemaker's 1980s-vintage jets: the A300-600 and the A310, which have almost disappeared from passenger service.

Split-scimitar winglets

Similar to wingtip fences in that they have a physical shape above and below the wing, you'll find so-called split scimitar winglets on many Boeing 737 aircraft. They are either delivered with new airplanes, or retrofit by Aviation Partners Boeing; the former appears on Boeing 737-900ERs flown by Delta, and the latter on many United Airlines 737s. They are a cross between a blended winglet and the wingtip fence, essentially blended winglets with an added airfoil below the wing. Their curvaceous shape resembling a scimitar gives them their name.



Winglets on the Boeing 737 MAX

The Boeing 737 MAX has winglets that look similar to the split-scimitar ones, but they are slightly different and come as standard equipment with every MAX. You can tell them apart because they lack the tapering tips of the split-scimitar winglets.

Boeing designed these winglets specifically for the Boeing 737 MAX. The company says it used "detailed design, surface materials and coatings that enable laminar — or smoother —airflow over the winglet."

Raked Wingtips

A raked wing is not a winglet per se, but the tip of wing itself is swept back compared to the rest of the wing. The functionality is similar. The Boeing 787 Dreamliner, some Boeing 777s and the Boeing 747-8 all have raked wingtips, not winglets.

10. Landing gear

Landing gear is the undercarriage of an aircraft or spacecraft and may be used for either takeoff or landing. For aircraft, the landing gear supports the craft when it is not flying, allowing it to take off, land, and taxi without damage. Wheeled landing gear is the most common with skis or floats needed to operate from snow/ice/water and skids for vertical operation on land. Faster aircraft have retractable undercarriages, which fold away during flight to reduce drag.

Tail Wheel-Type Landing Gear

Tail wheel-type landing gear is also known as conventional gear because many early aircraft use this type of arrangement. The main gears are located forward of the center of gravity, causing the tail to require support from a third wheel assembly. A few early aircraft designs use a skid rather than a tail wheel. This helps slow the aircraft upon landing and provides directional stability. The resulting angle of the aircraft fuselage, when fitted with conventional gear, allows the use of a long propeller that compensates for older, underpowered engine design. The increased clearance of the forward fuselage offered by tail wheel-type landing gear is also advantageous when operating in and out of non-paved runways. Today, aircraft are manufactured with conventional gear for this reason and for the weight savings accompanying the relatively light tail wheel assembly.

The proliferation of hard surface runways has rendered the tail skid obsolete in favour of the tail wheel. Directional control is maintained through differential braking until the speed of the aircraft enables control with the rudder. A steerable tail wheel, connected by cables to the rudder or rudder pedals, is also a common design. Springs are incorporated for dampening.

Tandem Landing Gear

Few aircraft are designed with tandem landing gear. As the name implies, this type of landing gear has the main gear and tail gear aligned on the longitudinal axis of the aircraft. Sailplanes commonly use tandem gear, although many only have one actual gear forward on the fuselage with a skid under the tail. A few military bombers, such as the B-47 and the B-52, have tandem gear, as does the U2 spy plane. The VTOL Harrier has tandem gear but uses small outrigger gear under the wings for support. Generally, placing the gear only under the fuselage facilitates the use of very flexible wings.

Tricycle-Type Landing Gear

The most commonly used landing gear arrangement is the tricycle-type landing gear. It is comprised of main gear and nose gear. Tricycle-type landing gear is used on large and small aircraft with the following benefits:

Allows more forceful application of the brakes without nosing over when braking, which enables higher landing speeds.

Provides better visibility from the flight deck, especially during landing and ground maneuvering.

Prevents ground-looping of the aircraft. Since the aircraft center of gravity is forward of the main gear, forces acting on the center of gravity tend to keep the aircraft moving forward rather than looping, such as with a tail wheel-type landing gear.

The nose gear of a few aircraft with tricycle-type landing gear is not controllable. It simply casters as steering is accomplished with differential braking during taxi. However, nearly all aircraft have steerable nose gear. On light aircraft, the nose gear is directed through mechanical linkage to the rudder pedals. Heavy aircraft typically utilize hydraulic power to steer the nose gear. Control is achieved through an independent tiller in the flight deck.

Multiple wheels spread the weight of the aircraft over a larger area. They also provide a safety margin should one tire fail. Heavy aircraft may use four or more-wheel assemblies on each main gear. When more than two wheels are attached to a landing gear strut, the attaching mechanism is known as a bogie. The number of wheels included in the bogie is a function of the gross design weight of the aircraft and the surface type on which the loaded aircraft is required to land.

11. Composites and materials

Forty years ago, aluminum dominated the aerospace industry. As the new kid on the block, it was considered to be lightweight, inexpensive, and state-of-the-art. In fact, as much as 70% of an aircraft was once made of aluminum. Other new materials such as composites and alloys were also used, including titanium, graphite, and fiberglass, but only in very small quantities – 3% here and 7% there. Readily available, aluminum was used everywhere from the fuselage to main engine components.

Times have changed. A typical jet built today is as little as 20% pure aluminum. Most of the non-critical structural material – paneling and aesthetic interiors – now consist of even lighter-weight carbon fiber reinforced polymers (CFRPs) and honeycomb materials. Meanwhile, for engine parts and critical components, there is a simultaneous push for lower weight and higher temperature resistance for better fuel efficiency, bringing new or previously impractical-to-machine metals into the aerospace material mix.

New material landscape

Standard aerospace aluminums – 6061, 7050, and 7075 – and traditional aerospace metals – nickel 718, titanium 6Al4V, and stainless 15-5PH – still have applications in aerospace. These metals, however, are currently ceding territory to new alloys designed to improve cost and performance. To be clear, these new metals aren't always new, some having been available for decades. Rather, they are new to practical production application, as machine tools, tooling technology, and insert coatings have sufficiently advanced to tackle difficult-to-machine alloys.

Even though the amount of aluminum is declining in aircraft, its use is not completely disappearing. In fact, aluminum is coming back, especially in cases where the move to CFRP has been cost prohibitive or unsuccessful. But the reappearing aluminum is not your father's aluminum. Titanium aluminide (TiAl) and aluminum lithium (Al-Li), for example, which have been around since the 1970s, have only been gaining traction in aerospace since the turn of the century.

Similar to nickel alloy in its heat-resisting properties, TiAl retains strength and corrosion resistance in temperatures up to 1,112°F (600°C). But TiAl is more easily machined, exhibiting similar machinability characteristics to alpha-beta titanium, such as Ti6Al4V. Perhaps more importantly, TiAl has the potential to improve the thrust-to-weight ratio in aircraft engines because it's only half the weight of nickel alloys. Case in point, both low-pressure turbine blades and high-pressure compressor blades, traditionally made of dense Ni-based super alloys are now being machined from TiAl-based alloys. General Electric was a pioneer in this development and uses TiAl low-pressure turbine blades on its GEnx engine, the first large-scale use of this material on a commercial jet engine – in this case in the Boeing 787 Dreamliner.

Another re-introduction of aluminum to aerospace is found in weight-saving Al-Li, specifically designed to improve properties of 7050 and 7075 aluminum. Overall, the addition of lithium strengthens aluminum at a lower density and weight, two catalysts of the aerospace material evolution. Al-Li alloys' high strength, low density, high stiffness, damage tolerance, corrosion resistance, and weld-friendly nature make it a better choice than traditional aluminums in commercial jetliner airframes. Airbus is currently using AA2050. Meanwhile, Alcoa is using AA2090 T83 and 2099 T8E67. The alloy can also be found in the fuel and oxidizer tanks in the SpaceX Falcon 9 launch vehicle and is used extensively in NASA rocket and shuttle projects.

Titanium 5553 (Ti-5553) is another metal that is reasonably new to aerospace, exhibiting high strength, light weight, and good corrosion resistance. Major structural components that need to be stronger and lighter than the previously used stainless steel alloys are perfect application points for this titanium alloy. Nicknamed triple 5-3, this has been a notoriously difficult material to machine – until recently. Extensive research and development have been devoted to making the metal practical to machine, and triple 5-3 has recently proven to be very predictable with machining consistency similar to more traditional titanium alloys like the aforementioned Ti6Al4V. The variances in the two materials require the use of different cutting data to obtain similar tool life. But once an operator has proper parameters set, triple 5-3 machines predictably. The key with triple 5-3 is to run a bit slower and optimize the tool path and coolant system to achieve a good balance of tool life and tool security.

Some structural pieces, like fasteners, landing gear, and actuators, require raw strength, with lightweight properties being less of a priority. In such cases, Carpenter Technology Ferrium S53 steel alloy has provided mechanical properties equal to or better than conventional ultra-high-strength steels, such as 300M and SAE 4340, with the added benefit of general corrosion resistance. This can eliminate the need for cadmium coating and the subsequent related processing.

Composites hit their stride

Composite materials also represent a growing piece of the aerospace material pie. They reduce weight and increase fuel efficiency while being easy to handle, design, shape, and repair. Once only considered for light structural pieces or cabin components, composites' aerospace application range now reaches into true functional components – wing and fuselage skins, engines, and landing gear.

Also, important, composite components can be formed into complex shapes that, for metallic parts, would require machining and create joints. Pre-formed composite components aren't just lightweight and strong, they reduce the number of heavy fasteners and joints – which are potential failure points – within the aircraft. In doing so, composite materials are helping to drive an industry-wide trend of fewer components in overall assemblies, using one-piece designs wherever possible.

While CFRPs represent the lion's share of composite material in both cabin and functional components, and honeycomb materials provide effective and lightweight internal structural components, next-generation materials include ceramic-matrix composites (CMCs), which are emerging in practical use after decades of testing. CMCs are comprised of a ceramic matrix reinforced by a refractory fiber, such as silicon carbide (SiC) fiber. They offer low density/weight, high hardness, and most importantly, superior thermal and chemical resistance. Like CFRPs, they can be molded to certain shapes without any extra machining, making them ideal for internal aerospace engine components, exhaust systems, and other "hot-zone" structures – even replacing the latest in HRSA metals listed earlier.

12. Aircraft Tire

Tire Design

Designing aircraft tires is a very intense undertaking. Once an aircraft manufacturer goes to the tire manufacturer with the size and weight requirements, the tire manufacturer begins the process of designing a tire that meets the needs of the aircraft manufacturer as well as all regulatory requirements — including foreign regulations in many cases.

Engineers are challenged with designing tires with cool running, heat-resistant materials while simultaneously exceeding tire service requirements. Tire prototypes are put through rigorous tests that simulate cycles of landings, take-offs, and taxi operations. It is only after the tires pass all mandatory tests and meet the requirements of the aircraft manufacturer and airworthiness authorities that the tires are put into production.

Two types of tires are used in aircraft applications — bias-ply tires and radial tires. Although both types of tires share some similarities in design, there are differences that need to be noted.

- **Bias-ply tire construction**

A cutaway of a typical bias-ply tire is shown in Figure 1. Bias-ply tires are popular choices for aircraft tires because of their durability and ret readability. The tire construction consists of the following components:

Tread: The tread is made of rubber mixed with other additives to obtain the desired level of toughness, durability, and resistance to wear. The tread pattern is designed to aircraft operational requirements, with the ribbed tread design used widely due to its good traction under varying runway conditions.

Sidewall: The sidewall is a protective layer of rubber that covers the outer casing ply. It extends from the tread edge to the bead area.

Tread Reinforcing Ply: One or more layers of fabric that strengthens and stabilizes the tread area for high-speed operation. It also serves as a reference for the buffing process when tires are retreaded.

Buff Line Cushion: The buff line cushion is made of rubber compound to enhance the adhesion between the tread reinforcing ply and the breakers or casing plies. It is of sufficient thickness to allow for the removal of the old tread when the tire is retreaded.

Breakers: Breakers are reinforcing plies of rubber-coated fabric placed under the buff line cushion to protect casing plies and strengthen and stabilize the tread area. They are considered an integral part of the casing construction.
Casing Plies: Alternate layers of rubber-coated fabric (running at opposite angles to one another) provide the strength of the tire.
Wire Beads: Hoops of high tensile strength steel wire that anchor the casing plies and provide a firm mounting surface on the wheel. The outer edge of the bead that fits against the wheel flange is called the bead heel. The inner bead edge is called the bead toe.
Apex Strip: A wedge of rubber affixed to the top of the bead bundle.
Flippers: Layers of rubberized fabric that help anchor the bead wires to the casing and improve the durability of the tire.
Ply Turnups: The casing plies are anchored by wrapping them around the wire beads, thus forming the ply turnups.
Chafer: A protective layer of rubber and/or fabric located between the casing plies and wheel to minimize chafing.
Liner: In tubeless tires, the liner is a layer of low permeability rubber that acts as a built-in tube and restricts gas from diffusing into the casing plies. In tube-type tires, a thinner liner is used to prevent tube chafing against the inside ply.

- **Radial-ply tire construction**

A typical radial tire is illustrated in Figure 2. With their rigid belt, they provide increased landings and reduced rolling resistance. They have fewer components in their construction and are lighter than similarly sized bias ply tires. Components that differ from bias-ply construction as follows:
Overlay: A layer of reinforcing rubber coated fabric placed on top of the belts to aid in high speed operation.
Belt Plies: A composite structure that stiffens the tread area for increased landings. The belt plies increase the tire strength in the tread area.
Casing Plies: As in bias-ply tires, the casing plies are layers of rubber-coated fabric. However, unlike those in bias plies that run at opposite angles to one another, radial plies run radially from bead to bead.
Chippers: The chippers are layers of rubber-coated fabric applied at diagonal angles that improve the durability of the tire in the bead area.

Tire inflation

Tire inflation is the most critical issue when inspecting installed tires. Although overinflation can damage the tires by causing uneven tread wear, reduced traction, increased susceptibility to cutting, and increased stress on the wheel assemblies, underinflation is by far more damaging. Underinflation produces uneven tread wear and shortens tire life due to excessive flex heating. The bead area of an underinflated tire can be 50 percent hotter than that of a properly inflated one. Heat is damaging to tire rubber compounds and fabrics. It contributes to tread and carcass separations and bead failures.
Ideally, tire pressure should be checked with a calibrated gauge prior to each flight. At a minimum, they should be checked daily. Do not make the mistake of relying on your "calibrated eye" to determine tire inflation. Tire inflation is difficult to determine visually, especially in tandem configurations. Always use a gauge to check inflation. If servicing is required, dry nitrogen should be used due to its inability to sustain combustion. Also, degradation of the casing plies and liner due to oxidation occurs if regular shop air is used. Nitrogen also helps to deter corrosion on the wheel assembly.
It is a good practice to establish a method of recording tire servicing actions. This aids in identifying chronic leakage problems.

Temperature changes

Another thing to remember pertaining to tire inflation is the change in pressure with temperature changes. For every five degrees Fahrenheit change in temperature, there is approximately a one-percent pressure change in the same direction. This should be taken into consideration if the aircraft is going to be subjected to extreme ground temperature changes. In that case, the tires should be inflated to ensure the minimum required pressure is maintained for the cooler climate. Remember to always check tire pressures when they are at ambient temperature. Checking pressures on hot tires could mask an underinflation condition.
One thing that needs to be noted on newly installed tires is that the tire pressure will drop initially due to tire expansion. The tire pressure should be checked closely until it stabilizes — usually after about 12 hours at rated inflation. If it still exhibits a significant pressure drop after that, the tire should be inspected for possible leaks and corrective action taken.

Protecting tires

Tires should be kept clean and free from oil, hydraulic fluids, grease, tar, and solvents. All of these chemicals have a deteriorating effect on the rubber in the tires. Any contaminant should be wiped off with denatured alcohol followed by a soap and water wash.

Aircraft tires are affected by sunlight and weather extremes. Installation of protective covers can help protect tires on aircraft that are tied down outside.

Operational considerations

Whenever taxiing or towing aircraft, the aircraft manufacturer's recommended operational procedures should always be followed. It is always prudent to use large radius turns and low speeds to prevent shoulder damage, tread scrubbing, and overheating. Care should also be taken to avoid running over hazardous areas. Tire damage can result from potholes, cracks in the pavement, or stepoffs from pavement to ground.

The areas where the aircraft will be operated should be kept free from debris. In addition to the damage potential FOD (Foreign Object Debris) poses to engines, it can cause considerable damage to tires if it becomes embedded in the tire tread.

This article has briefly discussed some basics on tire composition as well as some inspection and preventive maintenance techniques. Always refer to the applicable aircraft maintenance manual when working with aircraft tires. In addition, the FAA requires tire manufacturers to provide a care and maintenance manual for their products. This is an additional resource that is available to assist in tire maintenance and inspection procedures. With proper attention during inspection and good preventive maintenance practices, your aircraft tires should provide trouble-free service for many landings.

13. Safety and Precautions

Emergency Backup Systems

We don't want to think about this, but even the best systems need a backup system—or two. Today's aircraft are equipped with backup systems in the event of a catastrophic failure.

- **Ram Air Turbine (RAT)**—Commonly known as RAT in the aviation industry, this small turbine is used as an alternate emergency hydraulic or electrical power source in the event of a catastrophic failure. A propeller-like turbine, which is stowed in a compartment in the fuselage or wing, drops down beneath the plane and generates power from the airstream while being connected to an electrical generator or hydraulic pump. The RAT provides power to vital systems that include flight controls and instrumentation, as well as navigation and communication equipment which aids the pilot to land the plane safely in an emergency.
- **Auxiliary Power Unit (APU)**—Did you ever wonder how the air conditioning and electricity operate on the airplane when the engines aren't running? If so, you can be thankful for the APU should you ever find yourself sitting in an airplane while it's being serviced or prepared for flight. This small turbine is in the rear of the aircraft and supplies electric power, compressed air and hydraulic pressure to the aircraft systems.
- **Floor Proximity Emergence Escape Path Marking System** (FPEEPMS)—Do you recall the flight attendant explaining how arrows will illuminate the floor of the cabin in an emergency, serving as a guide to the exit doors? In case you missed it, this system is in place in the event of a fire in the cabin. Thick smoke can make it impossible to find the way to safety. Since smoke rises, passengers can crawl to avoid smoke as they follow the arrows to the exit doors.
- **Traffic Collision Avoidance System** (TCAS)—These life-saving systems within aircrafts detect, warn and issue instructions to pilots of two aircrafts in the event of an impending collision.
- **Terminal Control Area** (TCA) or Terminal Maneuvering Area (TMA)—In order to reduce the risk of midair collisions, there is a designated area of controlled airspace around major airports where there is a high volume of air traffic. These areas are called terminal control areas (TCA) or terminal maneuvering areas (TMA). Air traffic control ensures aircrafts flying within these areas are safe.
- **Enhanced Ground Proximity Warning** (EGPWS)—This electronic system alerts pilots if their aircraft is in immediate danger of flying into an obstacle, approaching terrain or the ground.

14. Reducing Environmental Impact

- Fly more efficient aircraft.
- Use new technologies to set more efficient flightpaths and reduce delays.
- Use sustainable lower-carbon alternative fuels.
- Invest in emissions offsets within or outside of the aviation sector.

Efficiency improvements

While the efficiency of aircraft—like that of cars—improved greatly in past decades, some analyses indicate that trend has generally stalled since 2012 in the United States. EDF supports strong aviation CO2 standards in the U.S. and through ICAO. As a first step, the U.S. needs to implement the new CO2 standard adopted by ICAO in 2016 – a standard supported by the aviation sector, but which falls short of what is needed to address climate change effectively. The U.S. should work to strengthen that standard and apply it to our domestic flights and to flights all over the world.

In 2016, the Environmental Protection Agency concluded that CO2 from aviation contributes to pollution that endangers public health and welfare. This finding creates a legal requirement for the EPA to establish a CO2 emissions standard for aircraft. In the past, the agency has set aviation emissions standards, which are enforced by the Federal Aviation Administration, at the levels suggested by ICAO. The EPA's aviation endangerment finding has been targeted for attack, but the comprehensive scientific analysis supporting this finding make revisions that weaken or backtrack from this endangerment finding very unlikely to survive judicial review.

Alternative fuels

Airlines are promoting various alternative fuels, including biofuels, as key to the future of carbon-neutral growth in ICAO. Some biofuels do show promise, but without strict standards, including on avoiding double counting, aviation's thirst could destroy forests to make way for jet-fuel plantations. That would make global warming worse and hurt the people whose lives depend on the forests. The quest for a better airline fuel is still not met, the technology for a solar powered aircraft is the future as it holds some promise due to demands in making solar energy cheaper and viable.

Conclusion

The analysis of various aircraft designs evolved over a century gives us a forward direction to designing the future aircrafts, right from Wright brother's till now there has been constant changes in aircraft design. Passengers are a huge part of these changes; aircrafts are becoming more and more viable and economical for travelling inspite of many technical difficulties such as alternative fuel for the conventional fuels used which is expensive and also non eco-friendly. The major aspects considered while making an aircraft economical is reduction of fuel consumption which is a direct result of drag reduction and weight reduction.

The design aspects considered in the making of the aircraft design suitable for commercial purposes are:

Selection of

- 2-winged aircraft to give it sufficient lift required with an addition of horizontal stabilizer at the end of the fuselage. This design helps in weight reduction and also gives stability to the aircraft.
- Swept back wing shape which reduces drag flying at transonic and subsonic speeds.

- Low wing configuration which accommodates landing gear to be located in the wing thereby reducing drag, this configuration also helps in easy refueling and maintenance of the engine and wing thereby decreasing logistical costs.
- 2 ETOPS engines to provide the 200kN thrust requirement gives a major boost to weight reduction as excess engines means more weight and more fuel which increases the expenses.
- Placement of engines nearer to the wing root which means the engines are closer to the CG less downforce needed from the tail therefore less drag.
- Subsonic speeds so that passenger comfort is given due to less noise and also making the design simplistic unlike supersonic aircrafts.
- Semi monocoque round structure which maintains a good cabin pressure giving comfort to the passengers, it also gives good structural stability in terms of spreading loads among the structures.
- Conventional tail design which gives adequate stability and control with the lowest possible weight.
- Split Scimitar winglet enabling laminar or smoother airflow over the winglet.
- Materials and composites usage which are light in weight but also maintains a good strength to weight ratio.

The above design factors help majorly in weight and drag reduction thereby decreasing the thrust requirement and fuel consumptions. The design also aims to make it logistically viable to technicians and mechanics working on the aircraft while taxiing and repairs. With the above said facts and design considerations flying in an aircraft should be economical and beneficial.

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