

Innovations, technology and efficiency shaping the aerospace environment

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Abstract: *A major goal for the aviation community is reducing fuel consumption. Nowadays we can see so much effort to design a modern aircrafts that offer weight and low fuel burn savings. This study could help to understand the long way during the production of the next generation aircraft such as Airbus A350 which shows us many advantages in fuel economy. In the first part of this study the author describes the history of fuel efficiency from its beginning. The wing design and aircraft's engines are introduced in the second part of the thesis. The importance of ways to reduce aircraft's weights and fuel economy is the main goal for Airbus and this issue is the irreplaceable part of the last chapter of this study. It shows a great visions and practical experience in improving aircraft performance and reducing maintenance expenses. The composites materials and new technologies help to achieve significant weight and fuel reduction and experiments are taking place today to show that this is the right step ahead. It is too early to say which of many researching ways will lead to viable solutions, but the air transport industry is committed to support advanced technological innovations. Anyway, technologies are constantly being deployed and researched by the aviation industry to continuously increase performance.*

Key Words: *advanced technology, fuel efficiency, weight savings, composite materials, aviation industry, aircraft engines*

1. INTRODUCTION

In fact, from the moment the aircraft is designed, engineers work to find the modality of making it more efficient. Unlike ground vehicles, which don't need to be optimised for efficiency to the same extent as aircraft because they can refuel often, long-distance aircraft must carry all their necessary fuel. Fuel is expensive, heavy and its weight can limit the range of an aircraft and also it needs to be stored in tanks which affect the wing size and the payload that can be carried. Safety is the foundation of everything we could do. It is what drives us and also is our mission to provide the safest, more efficient aerospace system in the world. Aviation has come a long way. We have seen some amazing advances, perhaps than the improvement in fuel efficiency. But we cannot forget that our effort to achieve an increased efficiency in terms of fuel consumption is pushing the industry further still.

2. HISTORY OF FUEL EFFICIENCY

Historic trends in improving efficiency levels show that aircraft entering today's fleet are around 80 % more fuel efficient than they were in the 1960s. In the mid-1970s, fuel conservation was further enhanced with the development of flight management systems which automatically set the most efficient cruise speed and engine power setting based on fuel and other operational costs involved, as it can be seen in Fig. 1.

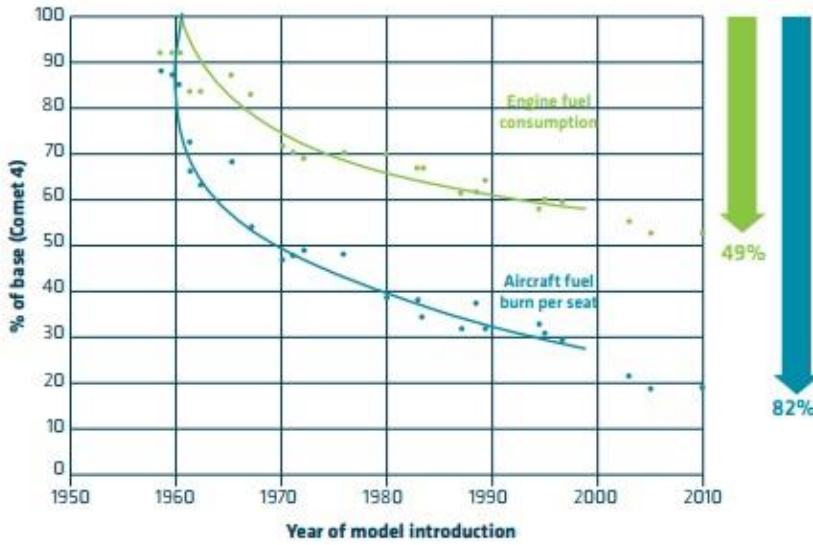
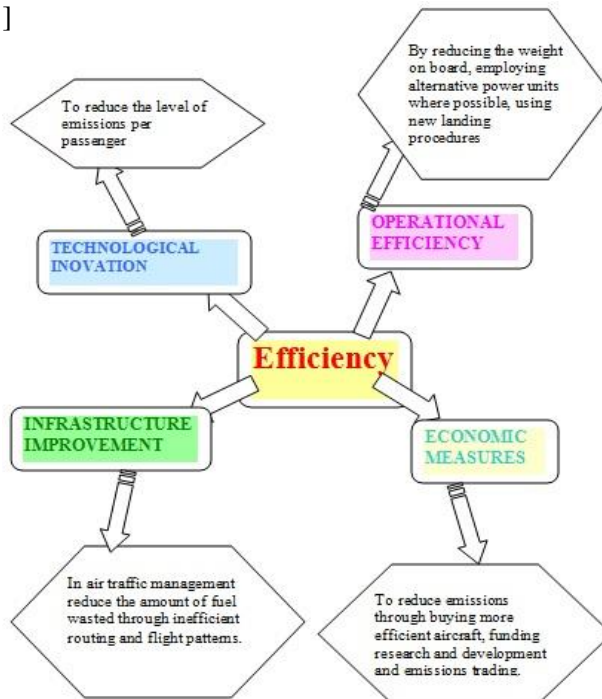


Fig. 1 Fuel efficiency gains since the early jet age

2.1 The importance of fuel efficiency

Fuel is one of the highest cost items of an airline operation and oil prices are changeable. Therefore, when an airline decides to buy new equipment, fuel consumption is one of the first things it looks at. Being able to operate efficiently is critical to the future of the aviation industry, not just for environmental reasons but also for financial ones, especially since fuel is one of the industry’s most costly expenses. Aircraft operations are already over 20% more efficient than 10 years ago, but the industry is aware that much more needs to be done. Consequently, the quest for further efficiency continues on a number of fronts, as it is shown in the next figure. [1]



2.2 NASA and goals for Green Efficient Aviation

NASA has a set of research aims which relate to mitigate environmental impacts of aviation.

NASA aims to reduce aircraft fuel consumption, emissions and noise simultaneously, which is a much more difficult challenge than working to reduce them individually.

Solving problems related to fuel consumption is a matter that NASA is considering. Some ideas have to do with improvements in technology; others have to do with using new technology in new ways.

The challenge:

In 2008, major U.S. commercial air carriers burned 19.7 billion gallons of jet fuel, while aircraft owned and operated by the Department of Defence consumed another 4.6 billion gallons of jet fuel. At an average price of \$3 per gallon, the total cost of fuel was \$73 billion.

The goal:

Develop aircraft technology capable of reducing fuel burn significantly. This technology should enable the design of new aircraft that burn 33 % less fuel than today's airplanes by 2015, 50% less by 2020 and at least 70% less by 2025.



Fig. 2 Future aircraft design could look like this hybrid wing body

NASA's goals are to expand aviation system capacity, enable fuel-efficient flight planning, and reduce the overall environmental footprint of airplanes today and in the future, reduce delays on the ground and in the sky, and improve the ability to operate in all weather conditions. [2]

3. SELECTED FACTORS THAT HAVE THE GREATEST IMPACT ON FUEL ECONOMY

For commercial jetliners, the most important factors are aerodynamics and engine performance.

More effective innovation on current aerodynamic designs could only improve fuel economy by just 3-5%.

The next stage of this chapter takes a look at selected factors that influence the fuel efficiency.

3.1 The wing design and fuel efficiency

The major area of aerodynamic improvements in recent years is the design of the wing. Another area of innovation refers to the wingtips.

Adding winglets tilted upward at the tips, either to new aircraft or as retrofits to existing models, has delivered 3-5% reduction in fuel burn, depending on the length of the flight and type of aircraft – Fig. 3.

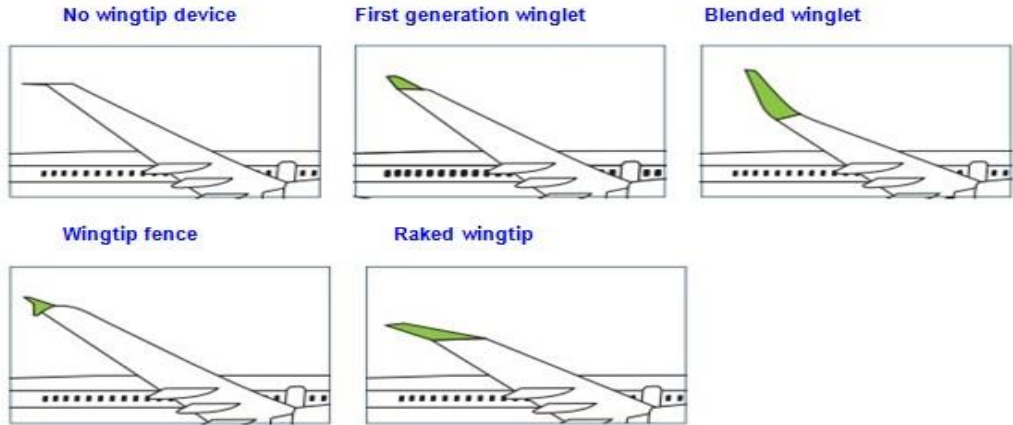


Fig. 3 Different types of wingtip device

When fast moving air along the top of the wing meets the slow air moving underneath at the wing’s tip, it creates a swirling vortex of air – known as a <wake>.

The next figure shows how this wake vortex can be significantly reduced by the use of wingtip devices.

Reducing the disturbance caused by the vortex makes the passage of the aircraft smoother and therefore more efficient, (see Fig. 4). [3]

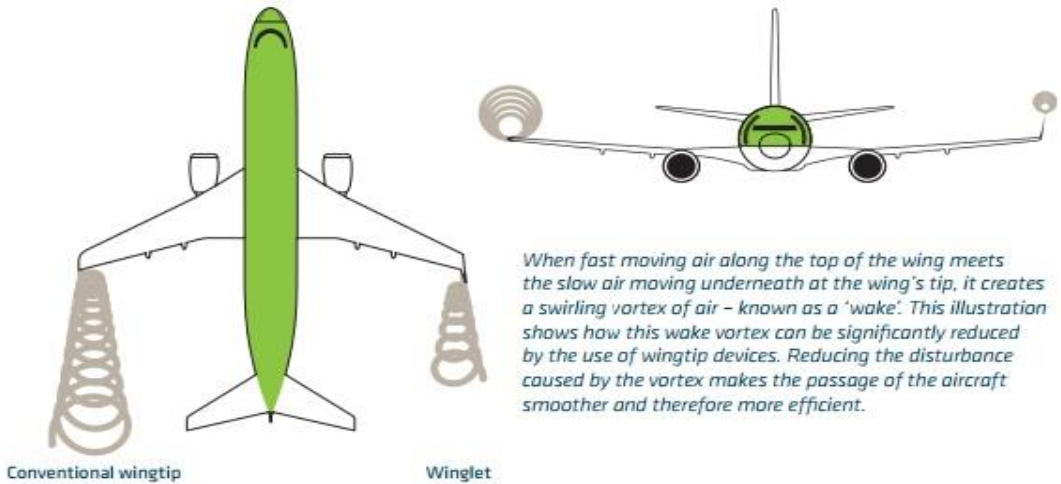


Fig. 4 The efficiency impact of winglets

3.2 Aircraft engines and fuel consumption

Nowadays, aircraft engines play the most important role in determining an aircraft’s fuel efficiency. There have been a number of significant advances in engine design that have led to such efficiency.

TURBOPROP ENGINES and their arrival in the early 1940s was a step-change in power, reliability and efficiency. In recent years there has been a resurgence of interest in the turboprop technology.

A modern turboprop can consume 25-40% less fuel than an equivalent turbofan engine on short haul routes.

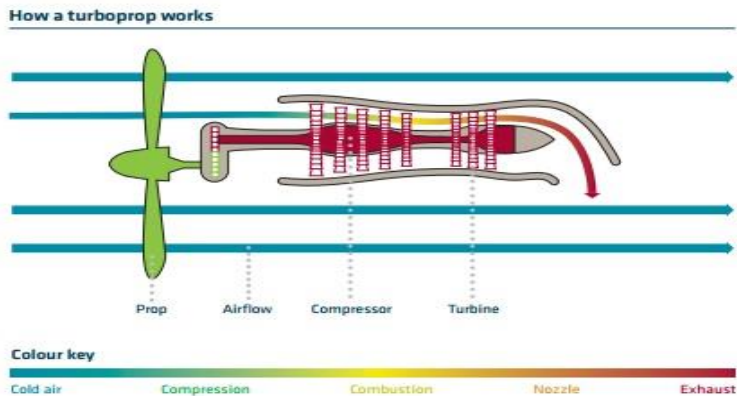
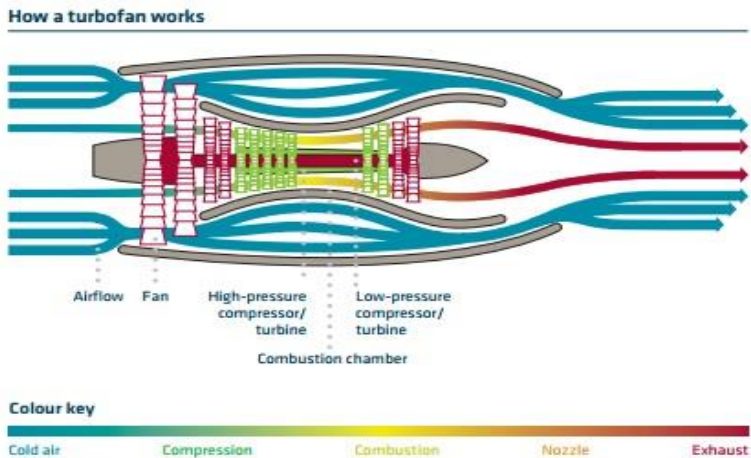


Fig. 5 Turboprop engine

The appearance of the high bypass ratio TURBOFAN ENGINE in the late 1960s changed the civil aviation industry. This engine design was more than twice as powerful but much quieter and cheaper to operate than the turbojets it replaced. It opened the door to a new generation of wide-body aircraft and to a step change in engine efficiency which would see a gradual diminishing of aircraft noise ‘footprints’ over the next 40 years.



A steady investment in advanced technology has enabled jet engine efficiency to improve at an average of 1% a year – which means engines available in 2020 are likely to be at least 10% more efficient than engines designed today. [4]

3.3 The ways of reducing aircraft’s weight and the fuel economy

Another factor that influences fuel economy is the aircraft’s weight. Though many innovations have already been implemented to make the **fuselage lighter** using composite materials, current aviation advancement are focused on lightening the weight of the engines, too. In recent years, aircraft operators as well as manufacturers have been focused on new ways to reduce the weight of the aircraft they operate.

New aircraft paints will soon be available that will weight 10-20% less than current paints. New coatings are under development which will be more resistant to chipping and cracking than current coatings and will be lighter, too. [5]

Washing an aircraft regularly cuts the amount of fuel used as dirt adds to the aircraft's weight and drag. Engine-washing in particular has also been particularly effective at improving the aircraft efficiency.

One engine-wash service is reported to reduce engine fuel burn by as much as 1.2% and decrease the exhaust gas temperature by as much as 15°C, improving performance and increasing the amount of time between engine maintenance operations.

4. THE FUTURE BY AIRBUS FOCUSING ON SOME KEY INNOVATIVE FEATURES

In the last 40 years, the aviation industry has cut fuel burn and CO₂ emissions by 70%, NO_x emissions by 90% and noise by 75%. Working with suppliers to reduce engine emissions is a priority for Airbus. In addition to optimised propulsion systems and overall aerodynamic efficiency, the continuous and progressive introduction of advanced materials and new processes reduce an aircraft's basic weight to minimise fuel consumption. [5]

4.1 Airbus and advanced composite materials

Since the company's inception, Airbus has established itself as a pioneer in aircraft design, with a track record of innovation that includes its introduction of fly-by-wire technology in civil airliners, the development of composite aero structures and the use of advanced materials and aerodynamics.

Composite materials maximise weight reduction – as they typically are 20% lighter than aluminium – and the weight reductions from composite also result in lower fuel consumption during an aircraft's operational lifetime.

4.1.1 Carbon Fibre Reinforced Polymer

The new composite materials, made up of carbon fibres and toughened epoxy resins, are lighter/stiffer/stronger and increase fuel efficiency in aeroplanes, compared with the aluminium currently used. In the 21st century carbon fibre reinforced plastics (CFRP) can and will contribute more than 50% to the structural mass of an aircraft.

Composite materials offer a variety of advantages, however, affordability is the key to survival in aerospace manufacturing, whether civil or military (A400M, UAV/X-45). [7]



Fig. 8 Composite structure in Airbus family

4.1.2 Composites of the A380 and weight saving

The A380 is the first commercial aircraft to incorporate as much as 25% composites, with its carbon-fibre reinforced plastic composite centre wing box saving up to 1.5 tonnes of weight.

As a result, the double-deck jetliner has a very low fuel burn of less than 3 litres per passenger per 100 kilometres.

In-service experience has shown a fuel consumption of 20% less than its nearest competitor.

4.1.3 Composites of the A350XWB and weight saving

Airbus brings together the very latest in aerodynamics, design and advanced technologies in the A350 XWB to provide a 25% step-change in fuel efficiency by *Rolls-Royce Trent XWB engines*.

Over 70% of the A350 XWB's weight-efficient airframe is made from advanced materials, combining 53% of composite structures with titanium and advanced aluminium alloys.

The aircraft's innovative all-new carbon fibre reinforced plastic fuselage results in lower fuel consumption, as well as easier maintenance. [6]

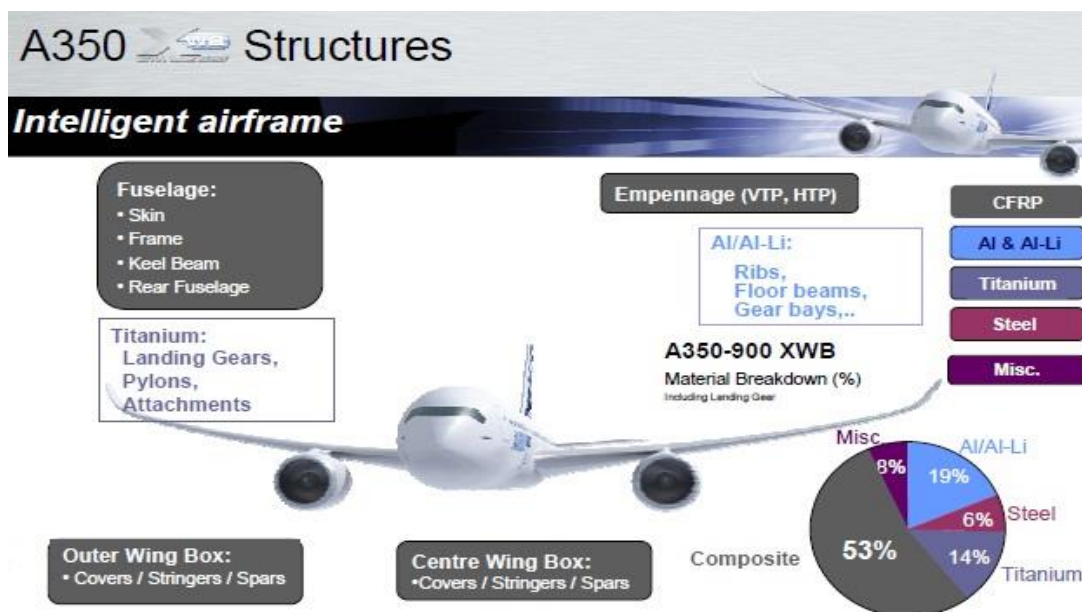


Fig. 9 A350 XWB material breakdown

4.1.4 Wing innovation of the A320neo / A350XWB and fuel efficiency

Airbus has pioneered the use of wingtip devices in aviation for decades. The SHARKLETS wingtip devices represent the latest element in an ongoing continuous improvement programme for its best-selling A320 family.

Sharklets are able to cut fuel burn and emissions by up to 4% and they can offer up to an additional 100 nautical miles or up to an extra payload capability of 1,000 pounds. [8]

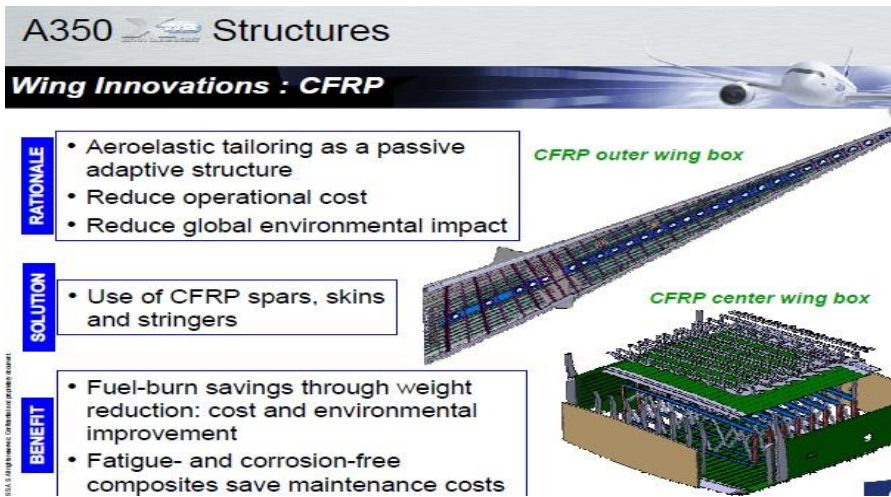


Fig. 10 A350 wing profile

The use of composites for 53% of the aircraft, titanium and advanced alloys has enabled significant structural weight savings. Combined with the next-generation Rolls-Royce Trent XWB engines, there is a 25% step reduction in fuel consumption and operating costs compared to current aircraft of its category.

The A320neo offers a 15% fuel burn saving as compared to current single-aisle aircraft operations, with 12.5% provided by its new engine options (CFM International’s LEAP and the PW1100G PurePower from Pratt & Whitney) and 2.5% from the use of Airbus’ Sharklet wingtip devices.



Fig. 11 PurePower PW1100G Engine P&W

The PurePower PW1000G engine improves fuel burn – gate to gate – by 16% versus today’s best engines. With its benefits of a new, advanced airplane the fuel burn benefit can be even greater – over 20% versus today’s best aircraft. [8]

5. CONCLUSION

A lot of innovations may seem far fetched – aircraft with open fan engines made of ceramic components, located above the fuselage instead of being located below the wings – these advancements are currently being developed by many manufactures.

However, one thing is abundantly clear – these innovations are aimed at not only improving aircraft by making them more fuel efficient and more comfortable for passengers, but also improving our planet by consuming less of our natural resources. No wonder the future seems so fascinating in aviation industry.

REFERENCES

- [1] <http://www.transportenvironment.org/sites/default/files//docs/Publications/2005pubs/2005-12_nlr_aviation_fuel_efficiency.pdf>
- [2] <<http://www.aeronautics.nasa.gov>>
- [3] <http://en.wikipedia.org/wiki/Wingtip_device>
- [4] <http://en.wikipedia.org/wiki/Aircraft_engine>
- [5] <<http://blog.airbaltic.com/2011/06/20/the-future-of-aviation-improving-fuel-efficiency/>>
- [6] <<http://www.airbus.com>>
- [7] <<http://www.shef.ac.uk/aerospace/research/groups/acms>>
- [8] <<http://www.businessinsider.com/jetblue-unveils-airbus-with-sharklets-2013-2>>
- [9] <<http://www.purepowerengine.com/>>