Promising Configurations for Future Passenger Aircraft

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Abstract A promising aircraft configuration for typical short to medium range would be a turboprop aircraft with large propeller diameter. The concept can benefit further from a strut braced wing and natural laminar flow. Most important for an efficient aircraft design is a high aspect ratio. For a given span (limits at airports need to be observed) the effective aspect ratio can be increased with winglets or folding wings. Much better would be to offer wing tip extensions to standard aircraft, accepting the next larger ICAO wing span category for some aircraft in the fleet. Electric flight on batteries is not the answer due to severe range limitations. Regenerative energy could be converted to hydrogen with electrolysis and stored as liquid hydrogen (LH2) in a stretched fuselage with hydrogen tanks installed in front and aft of the cabin. Research is on the way to directly convert (regenerative electrical) energy to hydrocarbons. Such synthetic fuel could be used even in older aircraft offering a fast improvement for the environment.

Keywords Aircraft · Passenger · Turboprop · Braced wing · Natural laminar flow · High aspect ratio · Span · Battery · Hydrogen · Stretch · Synthetic fuel

Passenger aircraft carry passenger with their baggage and often additional cargo over a certain distance or range. Passenger, baggage, and cargo are called payload because they generate revenue for the airline operating the aircraft for profit. An aircraft consists of major components. For a conventional aircraft these components are one fuselage, one wing, a horizontal tail, and a vertical tail. Horizontal tail and vertical tail are together called empennage and are located aft. An unconventional configuration deviates in one or more aspects from the definition of the conventional configuration.

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Aircraft burn fuel to CO_2 and dump CO_2 and other pollutants into the atmosphere. Fossil energy resources are final and the atmosphere has limits to the amount of pollutants it can take. Hence a reduction in fuel consumption is paramount to the life cycle balance of aircraft. All aeronautical disciplines (aerodynamics, structures, propulsion, etc) have their share in researching ways to reduce fuel consumption of aircraft. Aircraft design is responsible for the aircraft configuration and for integrating fuel saving technologies from other aeronautical disciplines into the aircraft.

A promising configuration for future passenger aircraft is a conventional or unconventional combination of major aircraft components also integrating the effects of new technologies from other aeronautical disciplines such that operating costs are reduced by also reducing fuel burn considerably. Today the dominant configuration for passenger aircraft is the conventional configuration with a low wing and engines in nacelles mounted with pylons to the lower side of the wing. This configuration has evolved during decades of aircraft design, production, and operation with the objective to reduce operating cost.

There is not just one promising aircraft configuration for future passenger aircraft with reduced fuel consumption. Depending on payload and range requirements, different configurations can be proposed.

For very large aircraft with more than 1000 passengers, the wing becomes the dominating major component and the Blended Wing Body (BWB) configuration should be chosen. The Blended Wing Body consists of a wide lift generating fuselage blending into conventional outer wings. Similar to a flying wing the BWB has no horizontal tail. One or two vertical tails should be included. The BWB has a low wetted area compared to its wing area. It has a higher L/D compared to conventional aircraft due to lower zero lift drag. Problem for the BWB is its structural layout as a passenger aircraft needs a pressure cabin. Not solved is the integration of supercritical airfoils and the requirement for static longitudinal stability for civil certification. Difficulties come from evacuation after ditching and from landing gear integration.

For the typical short to medium range aircraft with up to 200 passengers (in mixed class cabin layout with one aisle) a turboprop aircraft with large propeller diameter should be chosen. Innovative is here the choice of a propeller for bigger aircraft which are so far only available as jets. The propeller has a higher propulsive efficiency than a jet. In contrast to the unducted fan, the path to certification of a propeller aircraft is known. Cabin noise should be kept low with additional sound insulating material. Starting from a reduced fuel mass, aircraft mass goes

down further from snow ball effects including increased aspect ratio within the span limited wing to 36 m of ICAO class C. The concept can benefit further from a strut-braced wing with natural laminar flow. This configuration is further detailed in the conference proceedings.

Most important for an efficient aircraft design is a high aspect ratio. For a given span (at the airport), the effective aspect ratio can be increased with winglets, folding wings, or with a box wing. The Box Wing Aircraft (BWA)consists of two wings of half chord (compared to the conventional reference aircraft) in a biplane layout with winglets connecting the wingtips. All these solutions have disadvantages and it is proposed to offer instead the option of (horizontal) wing tip extensions to standard layouts (conforming to ICAO span limits) just violating the span limit and as such accepting the next larger ICAO category for the aircraft.

With the ideas above, we have assumed that fossil fuel will still be available in the future. If this is not the case, fuel has to come from some regenerative process. Biofuel production is not a regenerative process (as has been shown by other authors). Regenerative electrical energy (e.g., from wind, water, or sun) needs to be used instead. If this energy is stored in batteries on board of the aircraft, range is limited to only about 700 km due to the weight of the batteries. When electrical energy is converted to hydrogen (electrolysis), it can be used in gas turbine engines (turbofan, turboprop), and medium range flight is easily possible. However, the aircraft configuration needs to be adapted due to the larger volume of the liquid hydrogen (LH2) with its low density compared to jet fuel. It is recommended to stretch the fuselage and to install the hydrogen tanks in front and aft of the cabin. Research is on the way to directly convert energy to hydrocarbons. Fuel which can be used as a full substitute or in a mixture with today's jet fuel is called drop-in fuel. Synthetic fuel is a drop-in fuel. It could be used even in older aircraft without the need for any modification of the aircraft.