Short Medium Range Turboprop Powered Aircraft as an Enabler for Low Climate Impact

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The volume of government funded research on green aviation technologies has been continuously increasing over the years in an effort of finding means for bringing the global environmental impact of aviation down to the levels set by the Paris agreement. As a result, the main focus of the aviation research community has been shifting towards more sustainable solutions of air transport with topics like electric propulsion systems and hydrogen powered aircraft. The internal German Aerospace Center (DLR) project EXACT (Exploration of Electric Aircraft Concepts and Technologies) is one such effort to improve the know how and capabilities on the topic of sustainable aviation. It also aims to provide an outline of the potential of different energy storage means and propulsion system technologies in terms of environmental impact. The resulting aircraft concepts are to be assessed using models for global environmental impact coupled with prediction models of the future regional and short-range passenger transport market.

EXACT is currently in its initial phase, where a broad landscape of aircraft concepts is analyzed at global-aircraft-fleet level using low level of fidelity modelling. The main objective is to outline the most promising energy storage and propulsion architecture solutions and to establish the modelling basis for the later phases with an increased level of fidelity. To improve the reliability of these initial results, all current tools have been calibrated on existing reference aircraft and applied to produce conventional baseline aircraft models with assumed entry into service (EIS) of 2040. These baseline aircraft aim to serve as a benchmark for any other concept aircraft featuring non-conventional technologies. Above all, they can provide an answer to the important question of what can be achieved with the well-known and currently widely used propulsion, airframe, and systems technologies under the boundary conditions of the future market.

The current study aims to partially answer the last question by providing the environmental impact and cost comparison between a turbofan and a turboprop baseline aircraft designed for the short-range market of 2040 for the TLARS shown in Table 1.

Table 1: Top-Level Aircraft Requirements (TLARs).

PARAMETER	UNITS	Turboprop Baseline	Turbofan Baseline
Year of Entry Into Service (EIS)	-	2040	2040
Design Range	nm	1500	1500
Design Cruise Mach Number	-	0.62	0.78
Initial Cruise Altitude	ft	27000	33000
Service Ceiling	ft	33000	39000
Takeoff Balanced Field Length (SL, ISA conditions)	m	1850	1850
Maximal Approach Speed (Calibrated Airspeed)	kts	140	140
Number of Passengers Stretch Version (High-Density Layout)	-	250	250
Design Mission Payload Stretch Version	kg	23750	23750
Max Payload Stretch Version	kg	25000	25000
Number of Passengers Base Version (High-Density Layout)	-	200	200

Both baseline aircraft were sized as family concepts with a base version and a stretch version. As a typical state-of-the-art representative of the current short-range market, the A320neo and A321neo were used as reference aircraft for the modelling calibration and validation.

The current results show that the turbofan baseline aircraft (EIS 2040) is around 13% more fuel efficient than the reference aircraft (EIS 2012) due to evolutionary technological improvements of airframe masses and engine efficiency and partly due to reduced design range. The turboprop baseline (EIS 2040), however, is around 29% more fuel efficient than the turbofan baseline for the same EIS, see Figure 1. Therefore, a turboprop short to medium range aircraft with EIS of 2040 would be approximately 40% more efficient than current turbofan aircraft, which could be a significant step for reducing the CO_2 emissions of aviation.

The non-CO_2 impact of air transport, such as contrail formation and NO_x emissions, are also positively affected by a turboprop design, due to the naturally lower best cruising altitude, which results from the lower speed of the aircraft. The current EXACT results provide an estimate that the turboprop aircraft would allow for around 55% climate impact reduction compared to the current levels even without using synthetic fuels.

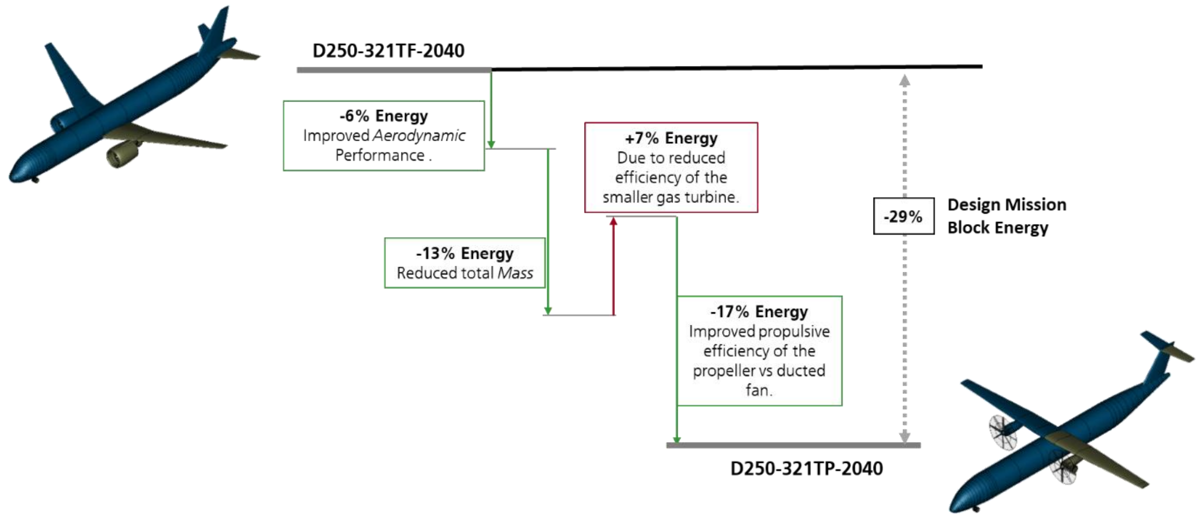

Figure 1: Block energy comparison between the stretch versions of the baseline aircraft, both with EIS 2040.

Another important outcome of the study is that the fuel efficiency of the turboprop aircraft is a sufficient compensation for the slower cruise speed in terms of operating cost. According to the latest results, assuming future fuel price projections, the turboprop baseline is around 5% more cost efficient than the turbofan baseline. This implies that open rotor aircraft could play an increasingly significant role for the future world fleet.

In this study, both aircraft will be further compared assuming synthetic kerosene as fuel. A design altitude trade off study with regard to climate impact will be shown as well.