ULTRA-LOW EMISSION INNOVATIONS FOR MID-CENTURY AIRCRAFT ENGINES

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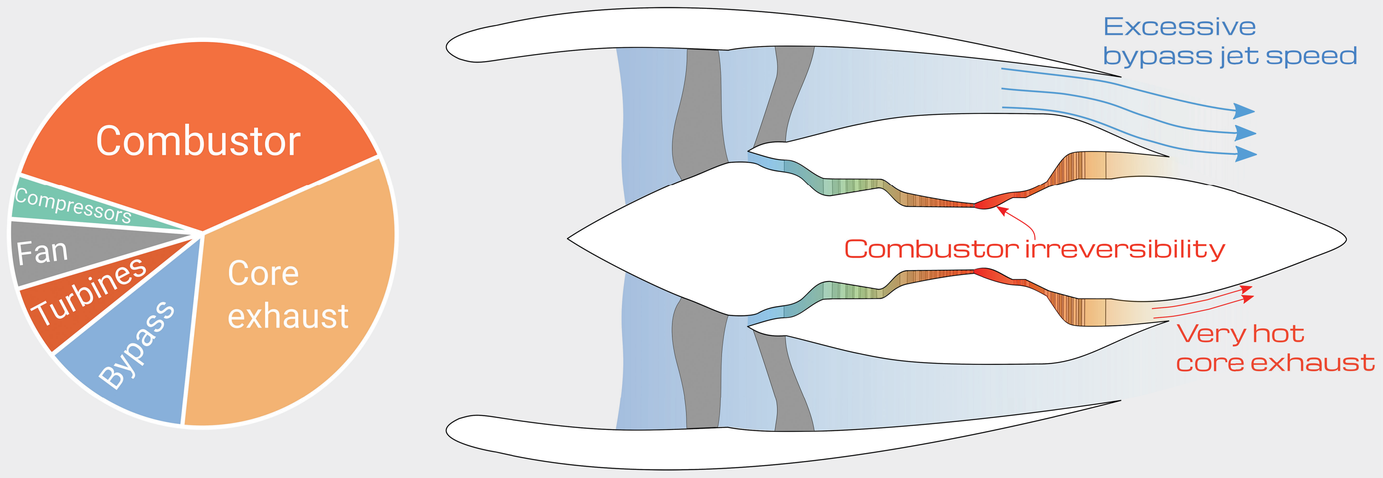
Are major efficiency gains for the turbofan still in reach?

The revolution in fuel efficiency that commercial air transport has undergone over the last 60 years is astonishing and has helped keep airlines keen to buy new aircraft. Development efforts are now however showing diminishing returns, increasing interest in more radical concepts. Large turbofan engines generate thrust with an overall efficiency of around 40%. Significant improvements should still be possible if the remaining major losses could be attacked by more radical design concepts.

The major loss sources in state-of-the art turbofans are combustor irreversibility, core exhaust heat loss and bypass exhaust kinetic energy. Together these account for more than 80% of the overall losses, as shown in Fig.1.

Fig 1: Major losses in state-of-the-art gas turbine engines.



Radical Technology

Industry is already reducing kinetic energy loss by introducing ultra-high bypass ratio geared fan engines, and open-rotor concepts are also being considered to give further improvements. EU Horizon 2020 research and innovation ULTIMATE project supports such activities by providing key enabling integration and low-noise enabler technologies.

To attack the other two loss sources, the ULTIMATE project has identified five breakthrough technologies: topping cycles (or constant volume combustion systems), intercooling, recuperation, secondary combustion, and bottoming cycles. These technologies are complemented by novel propulsor and nacelle designs.

To quantify the benefits from radical technologies, the project started by establishing likely efficiency improvements up to year-2050, assuming continued incremental development of existing technologies. Two new year-2050 reference engine concepts were proposed, the ultra-high bypass ratio geared turbofan (similar in configuration to the Rolls-Royce UltraFan® in Fig. 2) and the counter-rotating open-rotor (Fig. 3). Two aircraft concept designs were also established at TRL1, see Fig. 4. For a short-range aircraft mission, the project estimated a 55% reduction in CO_2 whereas for the long-range aircraft a 46% reduction was achieved, both relative to year-2000 in-service baseline aircraft.

The ULTIMATE technologies were then added to the year-2050 aircraft and engines, and assessed for further performance improvements.

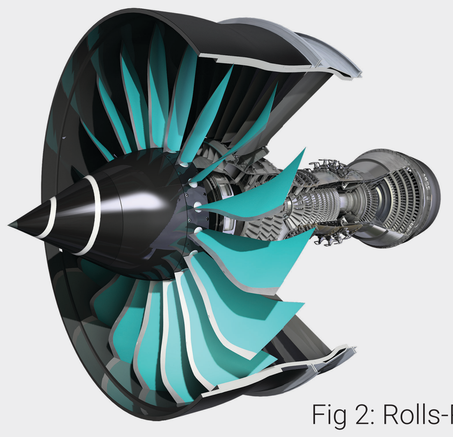


Fig 2: Rolls-Royce UltraFan®

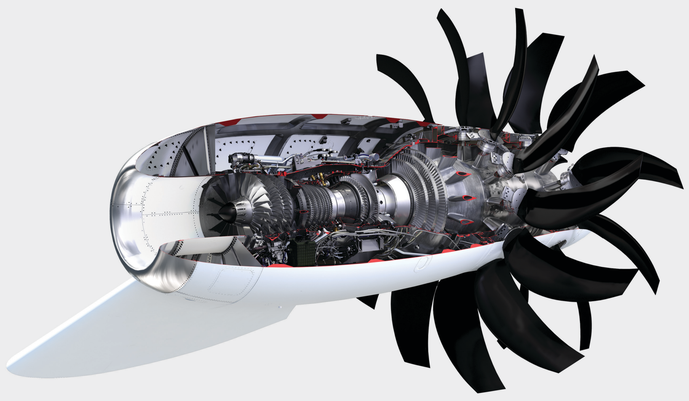


Fig 3: Reference 2050 geared open-rotor.

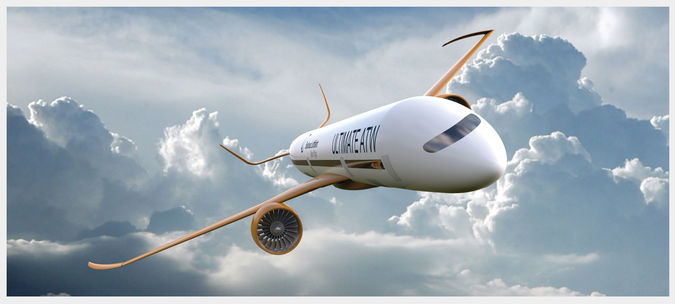


Fig 4: Reference 2050 advanced tube and wing aircraft.

ULTIMATE Consortium

The project is led by Chalmers University of Technology in Sweden, and the project consortium includes Cranfield University, Bauhaus Luftfahrt, ISAE Supaero, Aristotle University of Thessaloniki, GKN Aerospace Sweden, MTU Aero Engines, Rolls-Royce plc, Safran Aircraft Engines and ARTTIC.

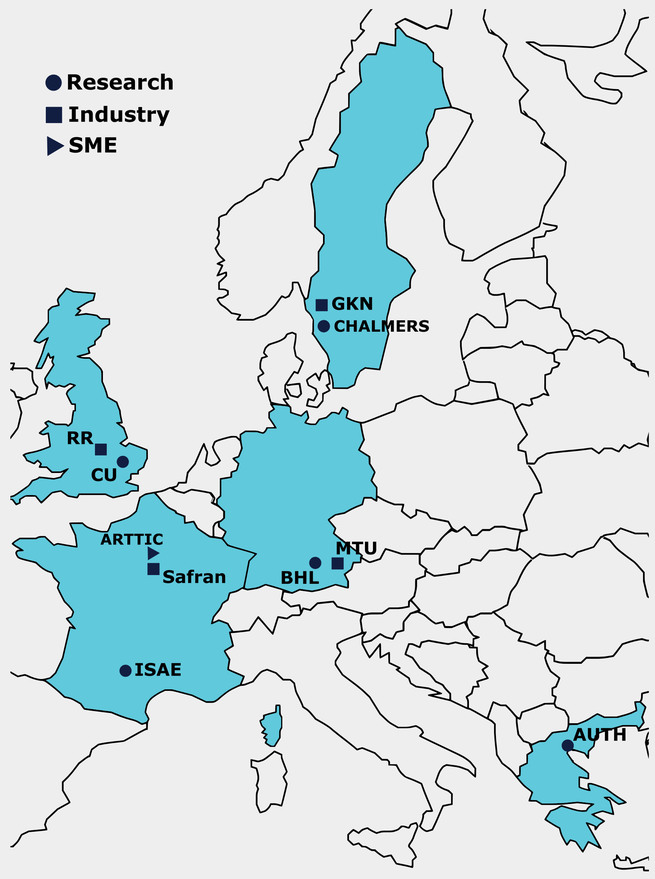


Fig 5: ULTIMATE partners in Europe.

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