Klaus Rüd, Dieter Scholz

Lower Risk Approach for Low Emission Passenger Aircraft – Combined LH2 and Kerosene Propulsion

Purpose – Past decades in passenger aircraft developments have shown that incremental design changes have been successful, whereas ambitious "disruption" and "giant leaps" caused early program cancelations and no results. Examples are battery-electric or hybrid-electric flight (too heavy), full hydrogen combustion aircraft (limited future infrastructure), and hydrogen fuel cell propulsion (addition challenges from heat exchangers, drag, mass). The lesson learned: Also, a change of fuel must be introduced incrementally. The purpose of the preliminary design is to show how civil aviation can move at lower development risk from kerosene-based propulsion to liquid hydrogen (LH2) propulsion by means of a dual-fuel passenger aircraft designed as a replacement of the Airbus A320 (the reference aircraft).

Methodology – Preliminary design is not for a 100% CO2-free aircraft, but rather for an aircraft with a propulsion concept with lower CO2 and non-CO2 emissions. The idea is to use an existing turbo engine concept as the best baseline available and to benefit from proven reliability, operability, and MRO experience, while costs and development risks are kept low. The aircraft configuration shall be conventional, i.e. a proven tube-and-wing, tail-aft arrangement. The new challenge is to develop turbomachinery with a combustion chamber for dual (one at a time or parallel) kerosene and LH2 combustion. The airframe does not need to be new. An existing airframe can be used for a derivative engine and the LH2 tank integration.

Findings – The dual fuel burn capability is the only major new engine technology requirement. It can be based on the double annular combustor (DAC) technology, which was used on some CFM56 engines. An A321 airframe can accommodate the LH2 tank for a dual-fuel A320 or A319 (depending on the fuel ratio). See Figure 1 and 2. Compared to the reference A320, the new aircraft is lighter at take-off, but heavier at landing. On average, in flight it is heavier and needs a little more energy depending on the fuel ratio. It shows reduced CO2 emissions due to partial use of hydrogen. Kerosene versus hydrogen can be used depending on atmospheric conditions to minimize non-CO2 effects. If designed for higher wing loading (e.g. with the same wing for higher mass in cruise), the aircraft has a lower optimum cruise altitude. This can be a benefit for reduced contrail effects.

Social Implications – Inspire walking the walk, not just talking the talk. The argument for achievements only after decades cannot be applied to incremental design changes. Research money (subsidies) should be given only for deliverables. This increases accountability and efficiency for taxpayers' money spent.

Originality – Dual-fuel aircraft have been proposed before. One example is the Green Freighter project. The current contribution argues for dual-fuel passenger aircraft in times of a new industrial paradigm while the climate crisis is ongoing.

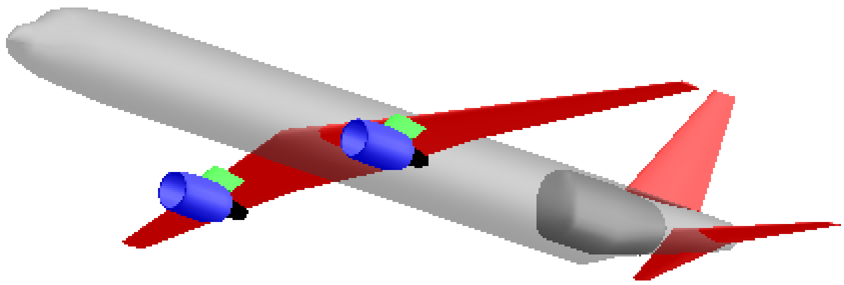

Figure 1: First sketch of a possible tank integration in the aft fuselage. The rear bulkhead (not shown) should be positioned forward of the LH2 tank to separate the tank from the pressure cabin.

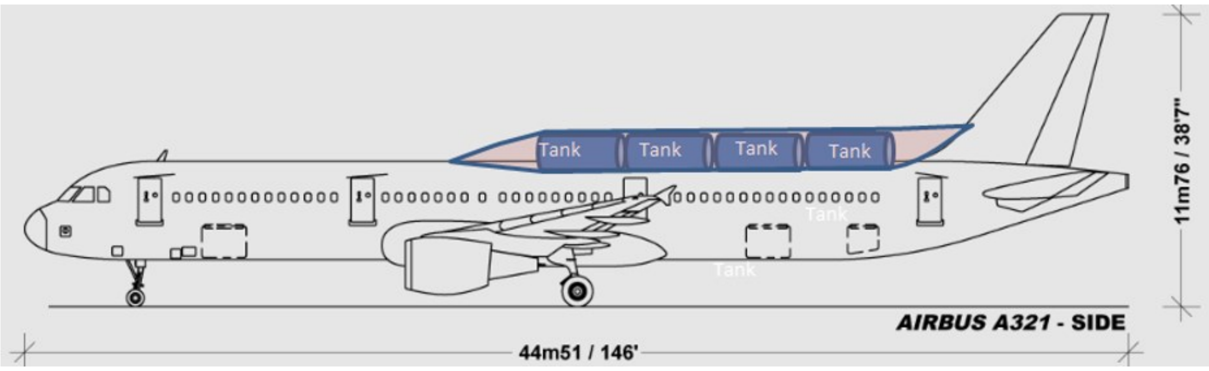

Figure 2: Alternative tank integration on top of the fuselage inspired by the Cryoplane project.

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Prof. Dr.-Ing. Dieter Scholz, MSME
Hamburg University of Applied Sciences
Department of Automotive and Aeronautical Engineering
Aircraft Design and Systems Group (AERO)
http://www.ProfScholz.de
info@ProfScholz.de