A Breath of Fresh Air in Light Aircraft Propulsion – Requirements and Challenges for the Next Generation of Light Fixed-Wing Aircraft Propulsion Systems

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Unlike modern airliners which are almost exclusively powered by turbofan engines, light fixed-wing aircraft apply a variety of different propulsion systems. This market segment has long been dominated by general aviation for private usage and sports for which operational efficiency is a subordinated merit. As recent work in the field of personal air vehicles (PAV) and new approaches on air commuting services arose, also the interest in efficient propulsion systems for engines below the regional jet segment has increased.

The choice of a specific propulsion system is a major design decision, as it predetermines fundamental performance characteristics and therefore future application capabilities of an aircraft concept. Thus, this article develops a systematic approach on propulsion system requirements to describe limitations on current technology engines, but also to derive and identify limitations of future propulsor systems powering light fixed-wing aircraft.

In a first step, this contribution analyzes flight envelops of common light fixed-wing, (primary) civil aircraft and their corresponding engines. From an aircraft perspective, this includes especially private and commuter aircraft as well as light business jets, whereof the large majority is powered by either piston, turboprop or turbofan engines. With regard to the aircraft's service ceiling and cruise speed, the analyzed data showed a strong separation between fan- and prop-powered concepts. While the characteristics of piston- and turboprop-powered aircraft gradually blurred with the application of turbochargers and reduction gearboxes, a clear difference in engine power capacities was identified. Moreover, weight- and power-specific engine characteristics as well as maintenance requirements were derived for the applied propulsor systems.

In a second step, a choice of projected incremental engine improvements is discussed in the context of the derived engine requirements and characteristics. This is of particular interest as novel (large) turbo engine designs are optimized for increased bypass ratios. However, this poses significant challenges on the core air flow of existing small turbo engines. In addition, potential implications of more radical improvements, such as electric propulsion, are discussed with regard to their potential to replace certain small flight propulsion applications, but also in regard to superior operational and economic characteristics.