DACAPO® – The energy-autonomous cabin

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MEA 2015 More Electric Aircraft

Abstract

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Abstract The path towards More Electric Aircraft (MEA) requires innovative ideas and solutions for future energy supply concepts in civil aviation. Energy-efficient, quiet and emission-free fuel cells, powered by renewably produced hydrogen are favorites for this approach. However, the introduction of a fuel cell based energy supply requires the skilful integration into the aircraft infrastructure. The analysis of the electrical consumers in terms of performance and energy shows that consumers, especially the loads in the passenger cabin, burden the on-board power supply. Therefore in this article a decentrally powered, energy-independent, so-called DACAPO® cabin is presented. An approach and a first, feasible step for an alternative energy supply on board could be energy-autonomous galleys, since the largest consumers in the cabin are the galleys. MAGIC® galleys are self-supporting, and may relief the electrical on-board system significantly.

Introduction DACAPO® is Diehl's vision for greener cabins in future, but also (retrofittable) in today's Aircraft. DACAPO® means Distributed Autonomous CABin POwer, and the vision follows the idea to separate the A/C into cabin systems and aircraft systems with independent power networks (Fig. 1). All cabin systems are supplied by MAGIC® (Modular Autonomous Galley with Integrated power Cell) galleys. Fig. 1: The DACAPO® cabin is energy autonomous and supplied by MAGIC® galleys. The electrical power is generated by an energy trolley inside a MAGIC® galley. Each energy trolley is designed to cope with the standard full size Atlas trolley dimensions. The introduction of MAGIC® galleys needs only minor changes in the aircraft and is independent of any infrastructure of the aircraft. For refueling and maintenance the energy trolley will be exchanged using the well-known supply chain like catering services. [1] Why focus on galleys? Energetically today's aircrafts are supplied by the engine generators and the Auxiliary Power Unit (APU). Galleys and the ECS (environmental conditioning system) are the two main energy consumers on board. Galleys make up 1/3 and more of the total consumption of electrical energy. And they need the appropriate electrical performance; in an Airbus A380 for instance it amounts to more than 500 kW of electrical performance for six galleys. This leads to conclusion 1: Galleys represent one of the main consumers of electrical energy. [2] Fig. 2: The MAGIC® galley is energy autonomous and supplied by one energy trolley. A fuel cell produces not only electrical...
energy but also by-products like heat and water (water steam) and inert gas. These by-products could be used synergistically in a galley and in the galley area and improve the overall system efficiency. This leads to conclusion 2: Fuel cell systems can be well integrated into a galley under use of all their products. In each known cabin layout there are at least two galleys (for single aisle), or more galleys (for long range wide body airplanes). This leads to conclusion 3: There is always the possibility to establish a power grid by interconnecting galleys. Why energy inside trolleys? Trolleys have an established well-known supply-chain on each airport. Their size is standardized (ATLAS standard) for full or half-size trolleys (Fig. 3). Fig. 3: The energy trolleys can use the well-established supply chain during ground services. The energy (fuel) and the energy generation system for producing electrical green energy will be integrated into one trolley. On-ground the energy trolley will be exchanged together with the standard trolleys. Therefore any refueling or maintenance activities will not influence turn-around times. The energy trolley will have a dedicated slot/position inside the galley. For activation or deactivation the trolley simply has to be pushed-in or pulled-out at this slot/position (“plug & power”). Fig. 4: The energy trolleys (called “Power Cell”) contain a complete energy generation system by simple interfaces and standard dimensions the technology inside the trolley can be evolved completely independent of the aircraft. This allows continuous optimization and reflection of newest technologies, e.g. the best fitting technologies for fuel cells or batteries. What are the benefits? There are benefits for airliners, airframers and airports as well as for passengers: More Flexible Cabin Layout - Sufficient energy due to a scalable concept provides capabilities of seamless interior expansion e.g. adding additional inserts in the galleys. Changes remain local to that galley and installation of additional power feeders is history. Seeing the galleys as energy source of the cabin the flexibility will be applicable and local to the cabin. In existing aircrafts a MAGIC® galley will add the same flexibility. Simplified Manufacturing - The MAGIC® galleys as part of the DACAPO® cabin contribute to cost savings due to clear encapsulated system design and seamless interfaces during final assembly, since the electrical installation of galleys in the Final Assembly Line (FAL) is simplified. Driven by the DACAPO® architecture the on-board power supply will be necessarily more decentralized, which allows for shorter cable lengths (Feeder Lines). This in turn has a favorable effect on the FAL (easier) and the overall cable weight (less). Less Noise - Noise reduction trends lead to restricted use of the APU during ground operation. Airport offer chargeable noiseless ground power. Alternative DACAPO® aircrafts produce noiseless electrical power (green energy) independent of any flight phase and therefore avoid ground power fees. Fig. 5: The fuel cell is supplied with a harmless, green producible and biodegradable fuel containing H2 Green Energy – The Airliner/Airframer may be recognized by passengers as more environmental friendly, using green energy technology on their airplanes. The DACAPO® cabin is envisaged to enable introduction of green energy to an aircraft (Fig. 5). Even on the first step of introducing the MAGIC® galley the green energy and the weight savings of the DACAPO® cabin (less cables and replacement of some systems) contributes to reduce fossil fuel burn and therefore CO2 and NOx reduction. Especially on ground the DACAPO® cabin contributes as an enabler to greener airport operation by supplying green energy to cabin systems. [3] How it looks with certifyability? Diehl Aerospace is one of Germanys largest aviation supplier and has an extensive experience in certification. As an active member of EUROCAE and SAE working groups dealing with hydrogen and fuel cell technology Diehl is well aware about certification and safety related topics regarding fuel cells on-board of the aircraft. Based on this experience certification aspects and safety has been the driver for the described DACAPO® and MAGIC® concepts. Diehl has from the beginning developed and defined the DACAPO® concept in a manner that safety and feasibility were uppermost premise. The used fuel and battery technologies are safe, and the interfaces to the airplane are clear and simple. Is there a market? The further development of the classical on-board architectures leads to an unavoidable dilemma: New requirements regarding efficiency and environmental compatibility of new types of aircraft call for more efficient engines. But the further implementation of the MEA philosophy is leading to an increased demand of electrical energy. The installation of larger integrated engine generators presents, however, technical limitations, and reduces the efficiency of the engine propulsion. The relief of the on-board system by removing the commercial loads, together with the use of fuel cells as additional energy generators on board can present a solution: An energy-autonomous cabin according to the DACAPO® principle creates energy reserves for new electrical consumers resulting from the MEA implementation. Additionally demanded energy is produced by fuel cells. Their operation is clean, of low-noise, efficient, provides direct current, and can be operated by regeneratively produced fuel. Switch to sustainable energy sources and the introduction of green energy in civil aviation, is seen as a future market opportunity. Conclusions The DACAPO® concept, based on MAGIC® galleys and energy trolleys, is an enabler to introduce electrical green energy to the A/C. In a DACAPO® cabin these MAGIC® galleys are building-up a high redundant and reliable power grid supplying cabin and potentially further aircraft systems including emergency power systems also (Fig. 6). Fig. 6: A a highly redundant and reliable power grid can be build-up by MAGIC® galleys, A big advantage is the possible step-by-step introduction starting with retrofittable MAGIC® galleys. An energy trolley for such a galley is just under development at Diehl Aerospace in the framework of the national-funded German Aeronautics Program (LuFo IV-4), and the very first prototype of an energy trolley will be available end of 2015. References [1] KNEPPLE, R. 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