Flying today to prepare tomorrow

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Abstract

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Small Aircraft Competition Landscape Pipistrel Pipistrel has a clear product strategy for electric/hybrid aircraft AC Taurus Alpha Electro Panthera Persons 2 2 4 Propulsion System Electric Motorgilder Electric Trainer Internal Combustion Engine (ICE) Hybrid planned Electric planned Category Ultralight Motorgilder Ultralight Trainer CS23 Status In production In production since 2015 Electric version first flight in 2017 February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Solar 1 Introduction ... and the Future of Electric Flight ?? What are the limits of electric propulsion? Liton/LiPo commercially available Volta Volare GT4 Contemplating both high power and high voltage applications Explore hybrid propulsion as first step to electric propulsion General Aviation Regional aircraft Note 1 KW = 1.34 hp February 2017More Electrical Aircraft 2017 « heavier-than-air flying machines are impossible » Physicist, Lord Kelvin, President, Royal society, England 1885 Hybrid Regional Hybrid SR © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Hybrid/electrical propulsion, why not full electrical? • For a A319 on a 800Nm mission, each pax consumes around 30kg of Kerosene. For the same aircraft with full electrical propulsion, what would be the needed battery weight per pax? February 2017More Electrical Aircraft 2017 Like in the car industry, electricity is there to boost the overall system efficiency but only hybrid/electrical architecture is affordable? Assumptions • Jet Fuel energy density 12kWh/kg • Battery state of the art (with conditioning penalty) 120Wh/kg • Electric motors 3 times more efficient • Same geometry, no resizing • Answer: each pax would need 1 ton of battery, 140t for a A319 => not feasible • Even with battery technology evolution outlook, full electrical flight looks out of reach for civil transport applications in the near future 1 kg 150 kg 1 t © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Power and Energy comparisons February 2017More Electrical Aircraft 2017 Aircraft vs. Car • 1000 more power • 1000-10000 more energy Aircraft are closer to Space Shuttle than to Cars It means that if we had batteries for Full Electric Flight, we could drive a car for more than 40000km with one electrical charge © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. What does that means Hybrid Aircraft for Airbus? • Hybrid in energy sources • Primary sources: fuel, batteries, fuel cells ... • Aircraft energies: electricity, hydraulic (central or local), air • Hybrid on energy users including MEA (More Electrical Airplane) and less bleed aircraft • Hybrid in engine propulsion architectures • Serial architecture (electrical power generated from fuel and thrust coming from electrical motors) for regional Aircraft and below • Parallel architecture (thrust coming from electrical motors and turbofan) for aircraft above 100 seats. This stream includes a lot of potential engine features e.g. fan electrically assisted As a result, Hybrid Aircraft is for Airbus a FULL INTEGRATED AIRCRAFT with a lot of configuration repercussions February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. A380 major systems innovations •Doors with electrical assistance Open Integrated Modular Avionics •AFDX network Variable frequency electrical generators Distribution with Solid State Power Control technology and Distributed power centers Large Ram Air Turbine 8 Identical Interactive cockpit displays 2 Displays for OIS 5000psi hydraulic system pressure Dual/dual air conditioning packs 2 hydraulic + 2 electrical circuits Electro-hydraulic flight Control Actuators On-board Oxygen generating system (not selected by customers) On-board information system (OIS) On-board maintenance system (OMS) A380 Setting a new standard First First First First First First First A380 First Landing gear First • Wing and HTF fuel management First • Brake to Vacate First • Aluminum wires First • Electrical Thrust Reverser First • Runway Over Run protection First February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Next innovations to get a more competitive solution February 2017More Electrical Aircraft 2017 787 MEA MEA2025 230VAC HVDC (+/-270VDC) Simplify wiring installation «Quasi-isolated» HVDC network • • 115VAC deletion • Fast protection • EMC requirement challenge Electrical platform • Critical load management • IMA architecture synergy • SSPC and Power electronics standardisations Techno challenges • High speed generator • Air cooled power electronics • High density electrical power centre • EMA and associated jam tolerant architecture • Electrical pack, thermal management, Vapor Cycle Low consumption deicing WIPS Engine interfaces • Solutions for high mechanical off take risk release • More integrated generator sharing oil with engine 115VAC for technical and commercial loads 115VAC for commercial Liquid power electronics cooling in a centralized bay Shared liquid cooled power electronics Conventional protection Conventional protection HVDC protection Conventional centre Conventional centre Bledless pack Bledless VCS packs Electrical anti-ice WIPS Electrical de-ice WIPS Hydraulic Flight control EMA Flight control Conventional VFSG on gear box Conventional HVDC VFSG on gear box © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Generation technology challenges February 2017More Electrical Aircraft 2017 Main starter-generation • Highly loaded generator • High torque in cold condition during engine starting • High voltage DC generator • High speed – Optimise network quality Electrical APU • Size only by the mechanical off-take with an advanced control • High HVDC speed generator directly on the turbine shaft Fuel cell • Fuel cell is a competitive emergency power technology • Fuel cell is an independent power source from engine Emergency power • Large battery pack • New source types The efficiency of the whole chain (i.e. Fuel electrical power) has to be taken into account for an aircraft assessment bearing in mind that the ground and flight main engine idle may overcome a potential fuel benefit during climb. The engine interface is key © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. End function technology challenges August 2017More Electrical Aircraft 2017 Wing ice protection System Electrical anti-icing power (160kW) vs electro-mechanical de-icing one (10kW) • Certification: New regulation (App. O - SLD) may increase power up to 200kW • Certification: De-icing system requires tests and adequate methods
and tools • Wing ice protection is only necessary 10% of the flight time Electrical Air Conditioning system • Cabin pressure requires high speed electrical compressor motor technologies • Cabin cooling and humidity requires vapour cycle technologies • Thermal management is limited by the technologies to transfer this energy • Air conditioning and electrical network failure cases have to be tackled together Actuators • Flight control architectures have to be jamming tolerant • Electrical mechanical actuator is a key technology • "Lego" structure concept is developed in European Actuation 2015 project All those technologies have been developed through various research projects. A further technology step is still needed to consolidate the expected performances. The selected technologies have to get the right maturity level versus the current solutions © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Integrated MEA • physical integration February 2017 More Electrical Aircraft 2017 Aircraft integration and design • The system integration into an aircraft has been validated • The alt cargo volume is reduced. The pylon area can be optimised • All hydraulic pipe or bleed duct drawings are deleted Aircraft in production • The power network wirings will be installed with other systems. • The actuators can be tested during section assembly. • The 50 hours cycle to test the electrical systems can be challenged Aircraft in service • Fault tolerant architectures permit to increase the Operational Reliability • Health monitoring permit to anticipate failure • Equipment cost reduction can be achieved through standardization and modularity • Electrical ground card cost is lower than the air conditioning ground card The virtues of more electrical technologies has to be further explored © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Potential Efficiency Benefit There is a potential for hybrid electric propulsion Initially for regional aircraft applications Block Energy: • used on a block mission • stored both in fuel and in batteries Block Energy Saving < Block Fuel Saving 2030 technology assumptions Assumptions: • 90 px regional aircraft • Serial hybrid/electric propulsion (gas turbine used in cruise to generate electricity to run electric motors). Batteries used to boost other flight phases. February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Product targets: HRA (Hybrid Regional Aircraft) • Regional Aircraft • 90-100 px • Cruise Mach Number 0.5 • 300 Nm typical mission • Options for step by step introduction depending on level of hybridisation & battery ground handling operations. Batteries 760 kWh Main Gas Turbine E-Motors 6x 1MW Power distrib. & thermal blowout & differential thrust Flat V-Tail from diff. thrust February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Architecture & Integration challenges February 2017More Electrical Aircraft 2017 1 – Battery Module Battery casing and thermal management 2 – Propulsive Module Integrated propulsive module (cooling, power, aero) 3 – Distribution Partial Discharge addressing constraints on electrical feeder installation rules. (around 3kV for weight cable efficiency) 0 100 200 300 400 500 600 700 800 900 1900 2900 Feeders Masses in (Kg) uHVDC Tension in (V) AL and CU feeders masses versus the uHVDC tension CU Mass AL Mass Battery casing with Phase Change Materials could be an option for cooling © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Targets Setting February 2017More Electrical Aircraft 2017 Significant improvement on components expected, even in the mid-term The Hybrid Regional Aircraft studies are in line with intermediate targets Long-Term target for electric machines: 10kWh/kg at system level Long-Term target for batteries: 500Wh/kg at system level x4 x6 Total installed propulsion power for Regional is around 6MW © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Hybrid Ground Demonstrator 1.0 (around 1 MW) Hybrid Ground Demonstrator 2.0 (2 to 6 MW, >1500V) Hybrid and Full Electric G/A Route to hybrid/electric commercial aircraft Hybrid H/C Hybrid UAV Hybrid NRA Way forward Demonstrator means and potential applications Proof of Concept There is a need for both ground and flight demonstrators to prove the concept, mature/drive technology and integrate into aircraft configurations Go/No-Go TRL3/4 TRL 6 February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Aircraft Integration February 2017 More Electrical Aircraft 2017 A/C integration Benches Partial benches Aircraft requirements - Mission definition Targets settings Definition of aircraft & systems architectures Overall energy management Overall aircraft integration Aircraft evaluation Aircraft certification rules making Overall energy management Batteries Power electronics Electrical distribution & Cables Electric motors Overall systems integration Control laws Gas turbine optimisation Safety analysis, thermal architecture From technology bricks developments to aircraft integration Iron Bird Power generation Electrical distribution © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. Conclusions • Hybrid/electric aircraft shows a potential for the future. It opens new design space for aircraft configurations to improve efficiency • In Airbus, a roadmap has been developed with a step by step approach from small technological demonstrator flying today up to the preparation of test benches for higher power and system architecture trade • Target settings and trades at aircraft & propulsive architecture and integration levels have been launched in Airbus to understand the potential benefits at aircraft level and develop targets for technologies • But the route to commercial hybrid aircraft application is still long with many challenges from developing components up to certification and operation • Airbus involvement into launching tests is an invitation to all partners to work with us, from aeronautical or other industries February 2017More Electrical Aircraft 2017 © AIRBUS S.A.S. All rights reserved. Confidential and proprietary document. February 2017More Electrical Aircraft 2017 Thank you © AIRBUS S.A.S. All rights reserved. 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