APU on More Electrical Aircraft : a vision for the future

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Abstract
The recent evolution of aircraft architecture tends to make electricity the main energy driver On-Board. The trade-off associated with, intent to show a sensible increase of the electrical power required by the different system on-board. This has a direct impact on the power off take from the main generators during the flight, on the main engine operability and also on the APU generator for ground operation.
In this frame, the Auxiliary Power Unit System architecture needs to evolve. Extention to new functions has to be adressed as some technological limitations show off on the main engine for existing but also future architectures. MICROTURBO has started to adapt to MEA and AEA by certifying its Bleedless APU, the e_APU60 in May 2013 and will continue its move by proposing a new answer to Energy On-Board need. This solution named Power On Demand system intents to propose "a la carte" power generation solutions that will be customized to match the proper Energy requirement of any type of aircraft architecture. The triple objectives of such system is : optimisation of the balance between the Propulsive and non Propulsive Energy On-Board, optimisation of the energetical efficiency of the aircraft and reduction of the environmental foot print of present and future aircraft program.

Introduction
The present functions of an APU are to provide pneumatic and electric power for ground operation to start the main engines and supply energy to the ECS, and during flight in case of main engine failures.

Fig.1 : APU Location on Aircraft

It is an essential link of the energy chain on board an aircraft as it contributes to the overall aircraft Fuel Burn performance and on the noise and pollution level.
The APU carries its own specific Type Certificate « CS APU » (US « TSO-C77b) with two categories:
- Cat 2 : Ground Use
- Cat 1 : Flight Use (Icing, Ingestion, Starting system, Automatic shutdown)
This gives the APU a specific role on-board as there are limited number of system carrying their own Type Certificate (Aircraft CS – 23/25, Engine CS – E, APU CS – APU, Propeller CS – P, Helicopters CS – 27/29).

With the recent evolution of the aircraft architecture leading to consider More Electrical System on board, the functions attached to the APU have started to change to match the new functional requirements.

and Business Jets
Anticipating this More Electrical Architecture evolution on Helicopter and Business Jet, MICROTURBO has launched Mid 2007 a demonstration program around a Bleedless APU, named e_APU.
The specificity of the bleedless architecture lies in the compactness of the core engine, since no load compressor is required. This enables either to increase the Overall Pressure Ratio up to 8 for small gas turbine or to avoid adding a load compressor on the shaft for bigger APU’s.
The impact is a direct decrease of more than 30% for the Specific Fuel Consumption and more than 10% on the Power to weight Ratio (comparison between competitors and e_APU60).

Fig. 2 : Comparison between bleed / bleedless Architectures

In the reduced time of 15months, the e_APU Team has put a brand new engine on a test bench for its first run, based on a bleedless architecture that had never been designed or manufactured before at MICROTURBO.
On the 31th December 2008, the e_APU60 performed its first run. The result of this first run has been the launch of a development contract with the first eAPU60 Customer on the 23rd April 2009.
26 months have been necessary, performing successfully:
- Performance
- Endurance
- Overspeed protection
- Engine control
- Containment module

The certification process has started 1st January 2012 with the Award of the type certificate received in the 31st May 2013 based on:
- CS-APU + CRI (overload conditions and hardware/software related)
- Category 1 “essential”
- Continuous icing capability validated by test at APU level
- DAL A (catastrophic event from airframe SSA)
- Full rotor containment
- High level of EMC/EMI
- FAA certification TSO C77b - May 2014

From APU provider to System Provider

With the appearance of More Electrical Provider, the classical ATA Chapter frontiers have been shaken. Optimisation across ATA chapter appears to be the way to find differentiation at Aircraft Level.

To capture those changes, MICRO TURBO has decided to move from an APU Provider to a System Provider position. This has required the acquisition of competencies outside of the classical Turbine scope:
- Inlet/Exhaust aerodynamic
- Noise reduction
- Piloted Air Inlet Door
- Mounts/Struts

But it has also required to deploy widely the Aerospace Recommended Practice 4754 in MICRO TURBO.

Results of this movement has been the development of the installation kit of the APSS00D for Falcon 5X and APS2[800] for the Global 7000/8000, two major programs in the business jet market, with a strong achievement of -6dBA vs ICAO (20m perimeter) in terms of noise reduction on an installation APU.

PODS : The next step

Ready as a system Provider, MICRO TURBO is looking at the next step of APU’s that will align with the evolution of functional perimeter:
- At Product Level (Inside ATA49), the future aim to a diversification of the thermal source with the appearance of Fuel Cell or Piston Engine in complement or replacement of Gas Turbine
- At Functional Level (cross ATA 21/24/36/49), the future aim to an over-extended integration, additional functionality such as Main engine Load-Shading, Additional Power Unit, Autonomous Power Unit or Emergency Power Unit such as the IPS on JSF
Moving from an APU World …………

……………to a Power On Demand System

Fig. 7 : MICROTURBO Vision on PODS

This solution foreseen by MICROTURBO is the Power On Demand system that intents to propose "a la carte" power generation solution to the Customer for the next generation of Aircraft. It will be customized to match the proper Energy requirement of any type of aircraft architecture.

The concept of Power On Demand System looks for solution to the Aircraft Manufacturer and the Airline or final User in the frame of :

- Creating Value through :
  - Understanding Energetic Efficiency at Aircraft Level
  - Cross ATA Multi system Optimization
- Proposing adaptive Solutions for :
  - Diversified Aircraft Fleet
  - Multiple Operating Profile
- Setting up an « à la carte » approach matching the Airframer Strategy on :
  - Global Integration
  - Individual WP
- Guarantying a Certificability of Energy Solution

The global Trade-Off will be driven by :

- The optimisation of the balance between the Propulsive and non Propulsive Energy On-Board,
- The optimisation of the energetical efficiency of the aircraft
- The reduction of the environmental foot print of present and future aircraft program.

To achieve its objective, MICROTURBO has identified Technological Gaps that will need to be covered to have this solution ready for the next decade :

- Multi System Compatibility and Optimization (ATA21/24/49)
- Highly Reliable System with the target of reaching IFSD 10^9 and MTBF 10.000OH equivalent to Main Engine
- Increase of Power to Weight Ratio with the target of reaching -40% in 2030 at System Level
- Enhanced Integration to match ACARE 2050 Requirement
- Multi-Source energy Management to address Smart Grid solution at Aircraft Level

A step-by-step approach based on classical TRL scale has been put forward using Demonstration Program led by SAFRAN Innovation to accelerate the process

The first intermediate step is expected to reach TRL6 end of 2015.

Conclusions

In line with the MEA Architecture and the system trade-off studies, MICROTURBO has started in early 2008 the move to address more electrical architecture requirement by successfully developing the e_APU60 and becoming a Tier 1 System Provider.

In the coming future, MICROTURBO will continue its transformation by proposing an evolution of the APU System in a Power On Demand System to its customer with the aim to address further optimization of the Energy Production and Management On Board the Aircraft.