AIRCRAFT ENGINES

CHALLENGES OF UHBR POWERPLANTS (ULTRA HIGH BYPASS RATIO)

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Context

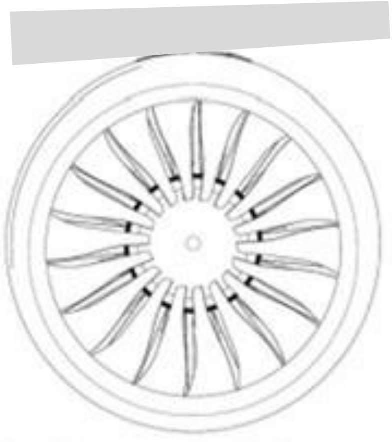
Longstanding objectives of fuel burn and emission reductions assigned to aeronautical industry IPPS mounted under wing

⇒ For example, the B737 story :

1970 : JT8D
Fan diameter : 49,2 ''
Bypass ratio : 1,7

1998 : CFM56-7B
Fan diameter : 61''
Bypass ratio : 5,5

2017 : LEAP-1B
Fan diameter : 69''
Bypass ratio : 9



Next A/C generation
> 2025 : UHBR
Fan diameter : > 80''
Bypass ratio : > 12
smallest nacelle

How to improve the engine performance?

- **Increase bypass ratio is possible via either larger fan (more drag) or smaller HP core (lower performance)**

  ➡ Engine efficiency increases to the detriment of IPPS weight and drag

- **More overall pressure ratio (OPR) ➔ Hotter engine**

  ➡ Need to have a thermal management without negative impacts to SFC, weight and pressure losses

- **Add more actuators to optimize the engine performances during all flight phases**

  ➡ Engine more complex in terms of control and installation

How to improve the IPPS (*) performance?

- **A larger fan without more drag**
  - ➔ More compact nacelle
- **Engine efficiency increases ➔ More engine thermal dissipations**
  - ➔ Need to add more heat exchangers around the engine
- **Minimize systems (EBU: Engine Built Up) weight between engine and A/C**
  - ➔ Optimize the EBU routing and size

➔ Need to have a compact nacelle around the equipped engine
Minimize IPPS weight and drag impact

Answer is : having a better integration around the engine

(*) IPPS = Integrated PowerPlant System

UHBR constraints vs aircraft

- **Interaction between IPPS and wing due to the ground clearance or collapsed nose gear**

  ➡ Impact on the main landing gear length
  Thrust reverser efficiency could decreased due to ram drag increases
  Impossibility to replace current engine with UHBR w/o aircraft modifications

- **Reduce the max nacelle diameter**

  ➡ Minimize the equipment number and volume in the fan compartment
  Reduce the IPPS drag

- **IPPS weight impact on A/C structures**

  ➡ Increase the A/C weight

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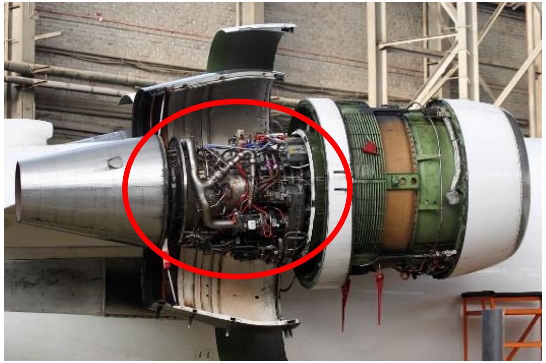
Systems optimization


CF34-3B

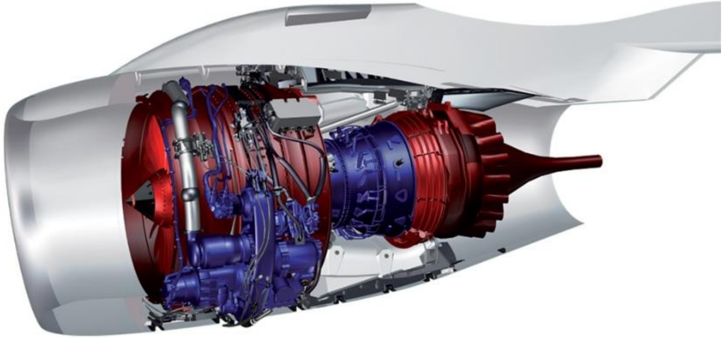
UHBR architecture = challenge for IPPS equipment

- less space for the engine systems installation
  - ➔ almost no space available in fan area ➔ AGB in the core compartment
- less space for ventilation solutions
  - ➔ higher temperature in the engine compartments

Use of existing IPPS equipment technologies would:

- Drastically reduce UHBR performances (bigger aerolines)
- Drastically increase development time (additional iterations needed to find the best solution for equipment integration)

Systems optimization



UHBR architecture = challenge for IPPS equipment

- More compact IPPS systems
  - ➔ Define common systems
  - ➔ Use composite for brackets and pipes ➔ Weight reduction
- Merge IPPS functions
  - ➔ One control system for engine and nacelle

For example, common actuator for booster anti-ice and starter bleed valve

- Equipment modules
  - ➔ Optimize the equipment packaging ➔ reduce connections between systems ➔ trade between maintenance time/cost and weight

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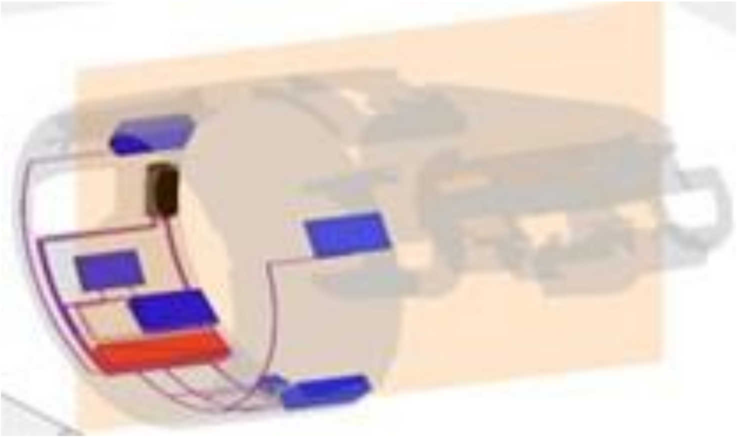
Systems optimization



UHBR architecture = challenge for IPPS equipment

- Clear view of IPPS systems installation around the engine
  - ➡ Integrate all systems with minimum time.
  - ➡ Modify quickly the equipment location with all interfaces
  - ➡ Harnesses and pipes routing to minimize the bracket quantity and weight
- Define the keep in zone for each system and optimize installation constraints
  - ➡ Equipment interface optimization
- Maintenance
  - ➡ Maintenance simulation for access and tools

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Thermal management

IPPS new generation requests thermal management optimization

- More thermal power dissipation (Engine and A/C electrical generators)

  ➡ Need to install additional heat exchangers without IPPS performance impacts

Some current solutions

- Brick heat exchanger

  ➡ Occupies significant volume in the fan

or core compartments

- Surface heat exchanger

  ➡ Need space in the flow and minimize the pressure losses

➔ Interaction with the nacelle and maintenance access

Reduce development schedule

IPPS and A/C are defined in the same time in parallel

➔ Need to optimize the development time for each component

➡ Schedule reduction

Other architecture for UHBR

Open Rotor

- The Open Rotor features a breakthrough architecture, with two counter-rotating, unshrouded fans, allowing to reduce fuel consumption and CO_2 emissions by 30% compared to current CFM56 engines

All technologies studied during NIPSE program will be used for next architecture generation

Questions?

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