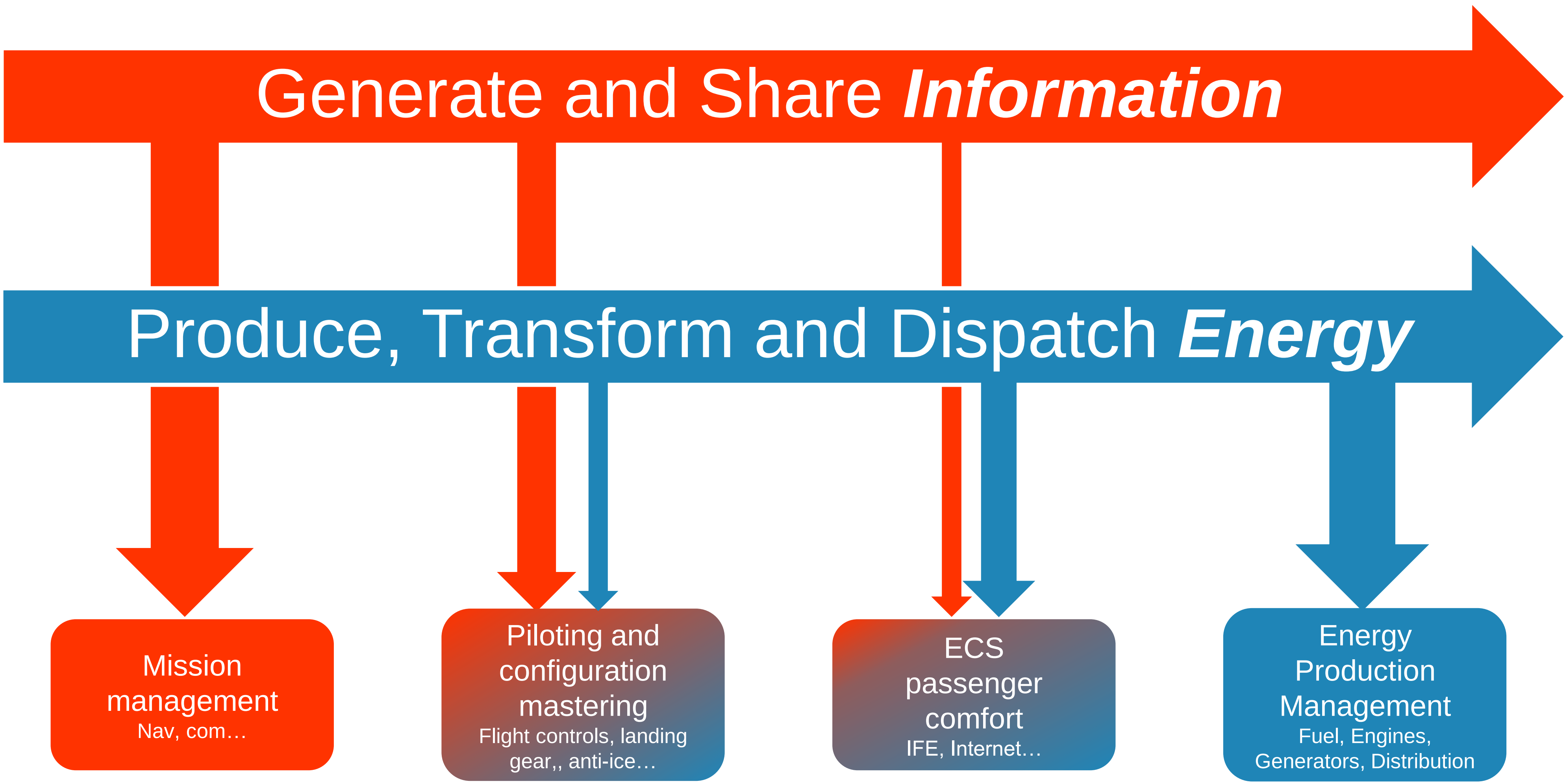
Future Trends in Aircraft Energy and Propulsion Systems

ICAS

September 2014

ENERGY AND PROPULSION : THE DRIVERS

TWO MAIN FUNCTIONAL CHAINS ON AN AIRCRAFT

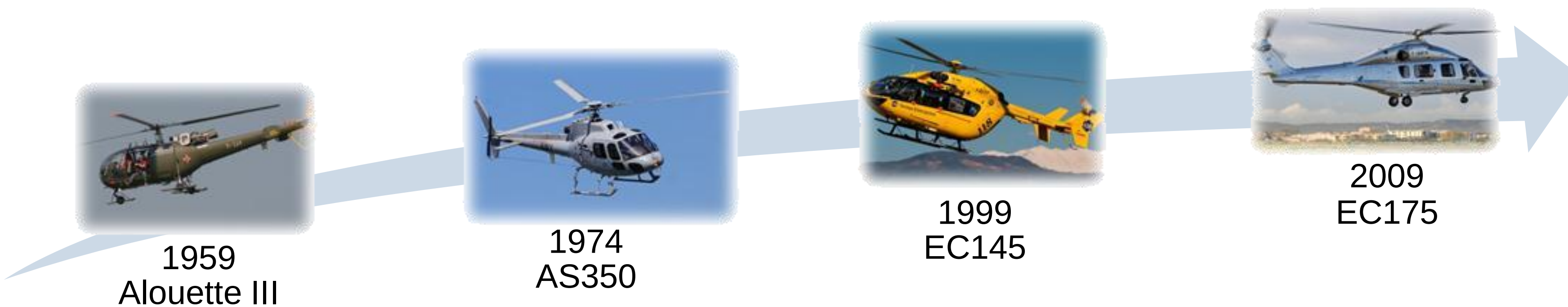


THE DOMINANT DESIGN

→ **We have been optimizing the same architectures for 50 years**

- **Airliners** : Tube + wing + 2 or 4 turbofans below wing

- **Helicopters** : turboshaft + mechanical transmissions



→ **The associated systems have solidified within ATA**

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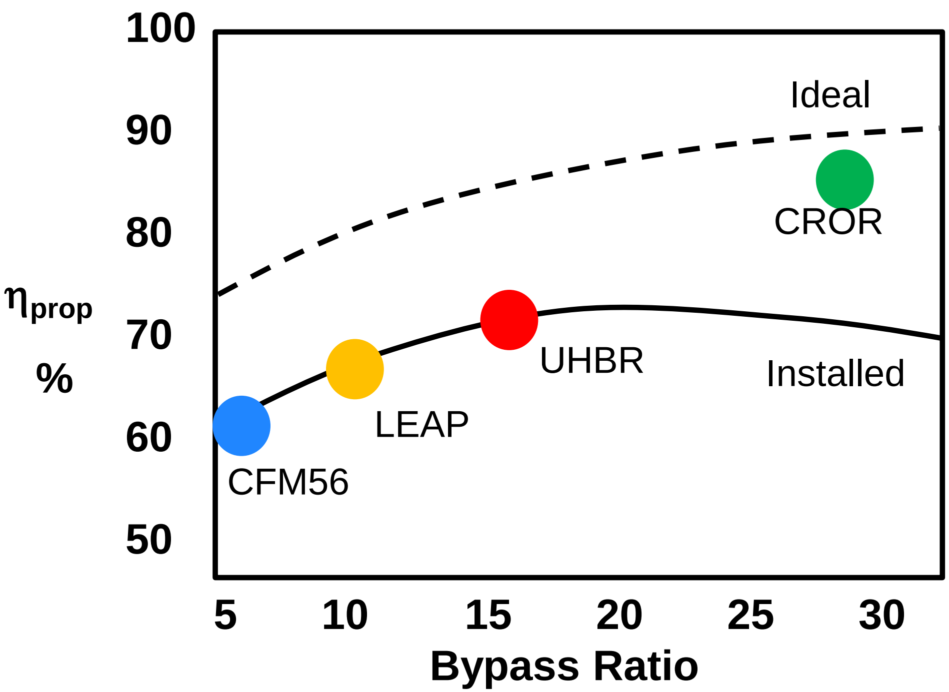
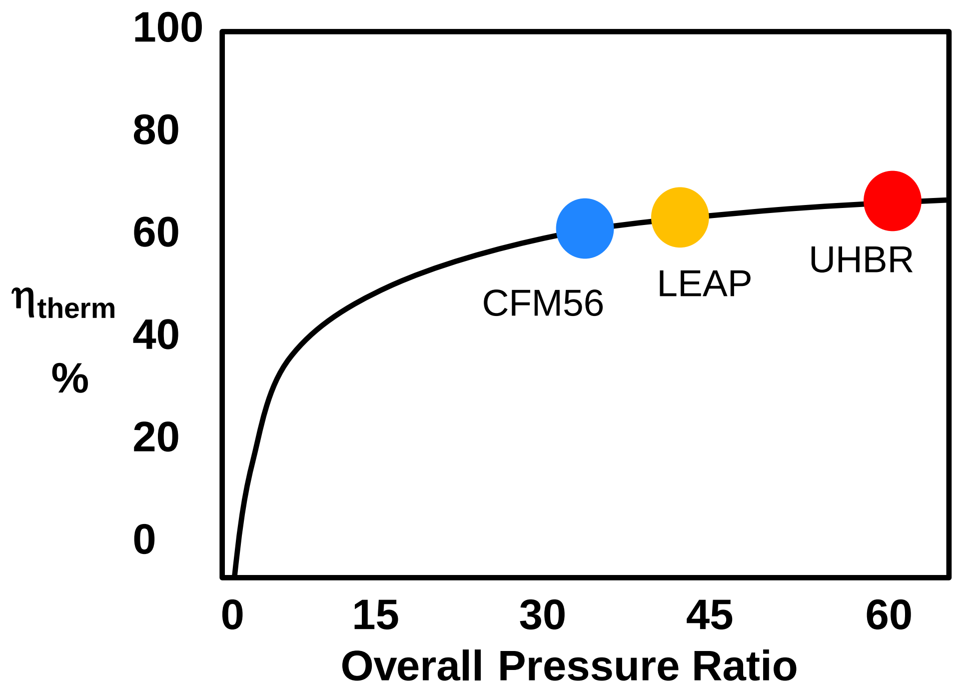
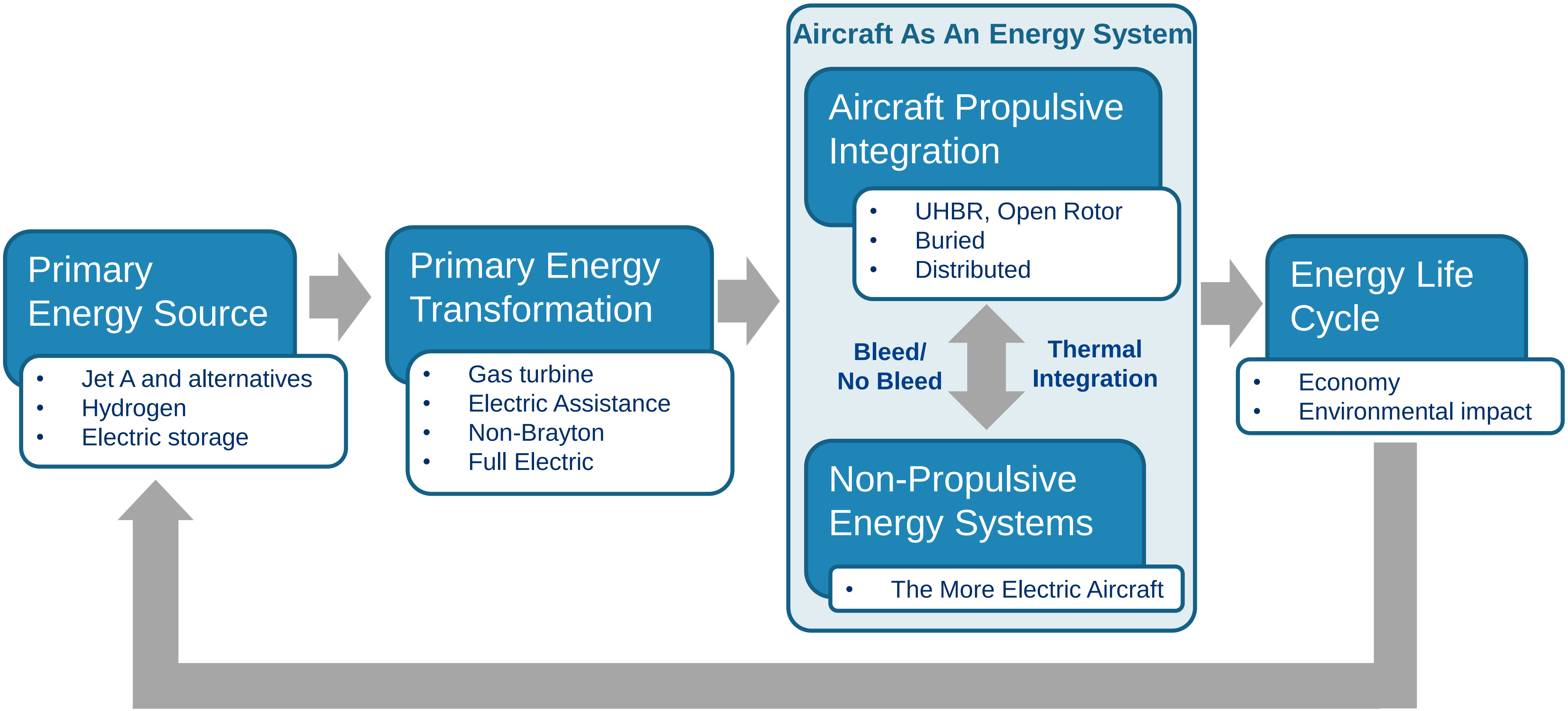
WE ARE REACHING THE LIMITS



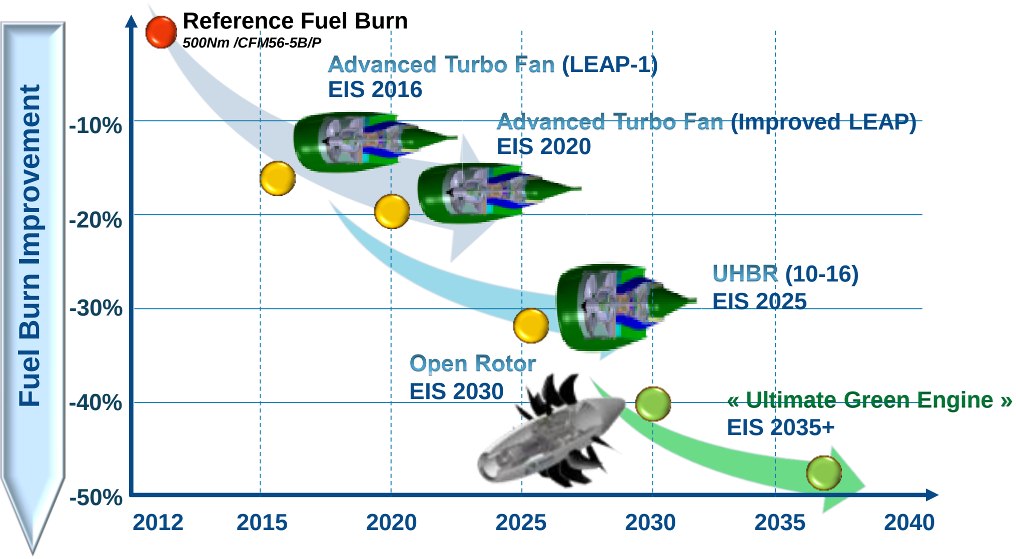


ADDRESSING THE WHOLE ENERGY CHAIN

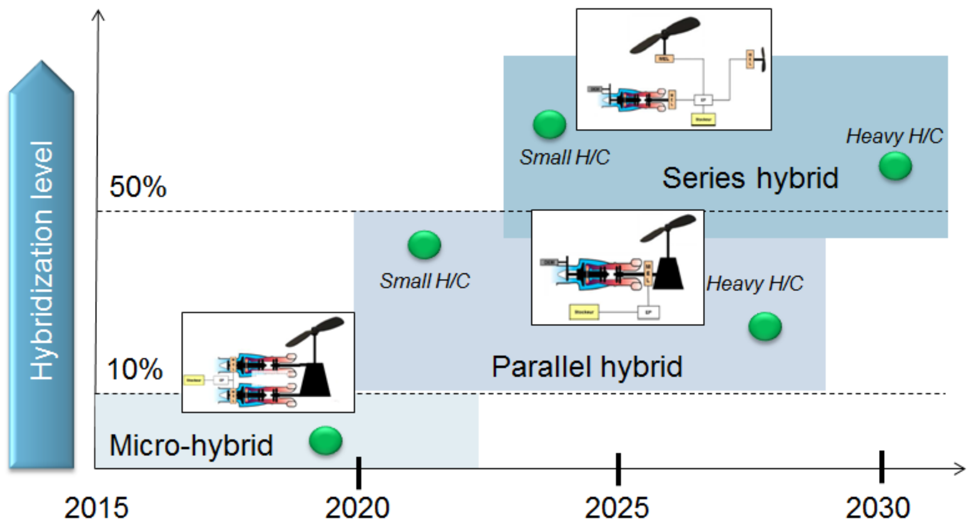


PROPULSION TRENDS

Aircraft engines



Helicopter Propulsion



KEY PROPULSION ISSUES

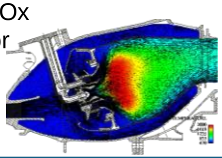
➔ Turbofans, Open Rotor

- Materials : High temperatures, low density for large engines
- CFD
- Turbomachinery efficiency and emissions limits
- Integration : Size, drag, thin nacelle, thermal management, equipments relocation in core zone


Advanced Metallic HPT Blade


Composite Fan Blade

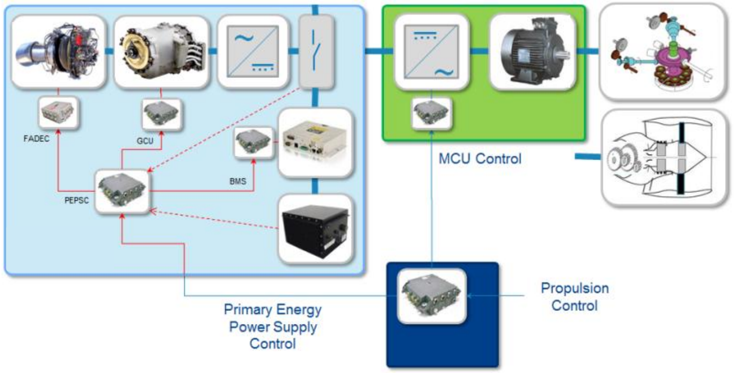

CMC LPT Blade


Ultra-Low NOx Combustor


3D Optimized Compressor

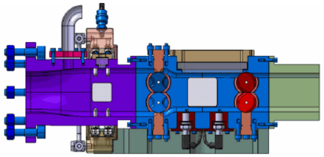
➔ Hybrid propulsion

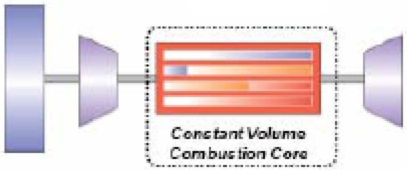
- Maturity of Electrical Technlogies : battery energy density, power electronics cooling…
- Power Sharing and Management
- Airframer vs. Propulsion System Supplier perimeters



➔ Non-Brayton cycles

- Injection & combustion chamber technologies
- Integration into an engine that produces thrust


Experimental CVC chamber



Engine Integration

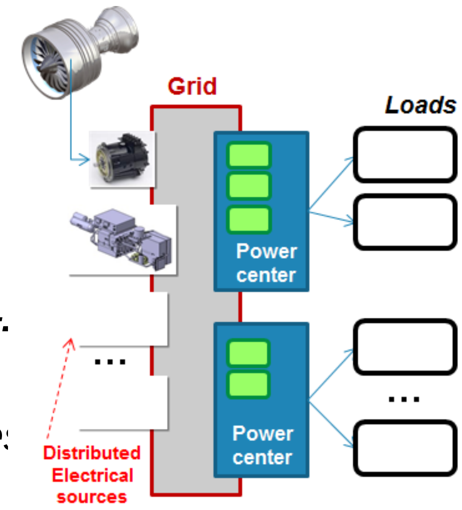
AIRCRAFT AS AN ENERGY SYSTEM

➔ The Bleed / Non-Bleed Issue

- ECS : constant energy load, second most important energy need
- Bleed air is a burden on propulsive optimization
- Clean cabin air issues

➔ Need to assess the benefit of bleedless architectures on short-medium range

➔ *Open the door to innovative non-propulsive generation architectures involving turbo APUs, piston engines, fuel cells*

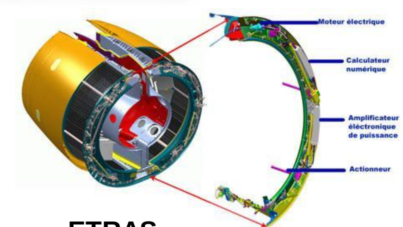


➔ More Electrical Aircraft

- Safran has created Labinal Power Systems
- Range of Electrical Applications & Equipments
- Mass of wiring = mass of all other electrical components

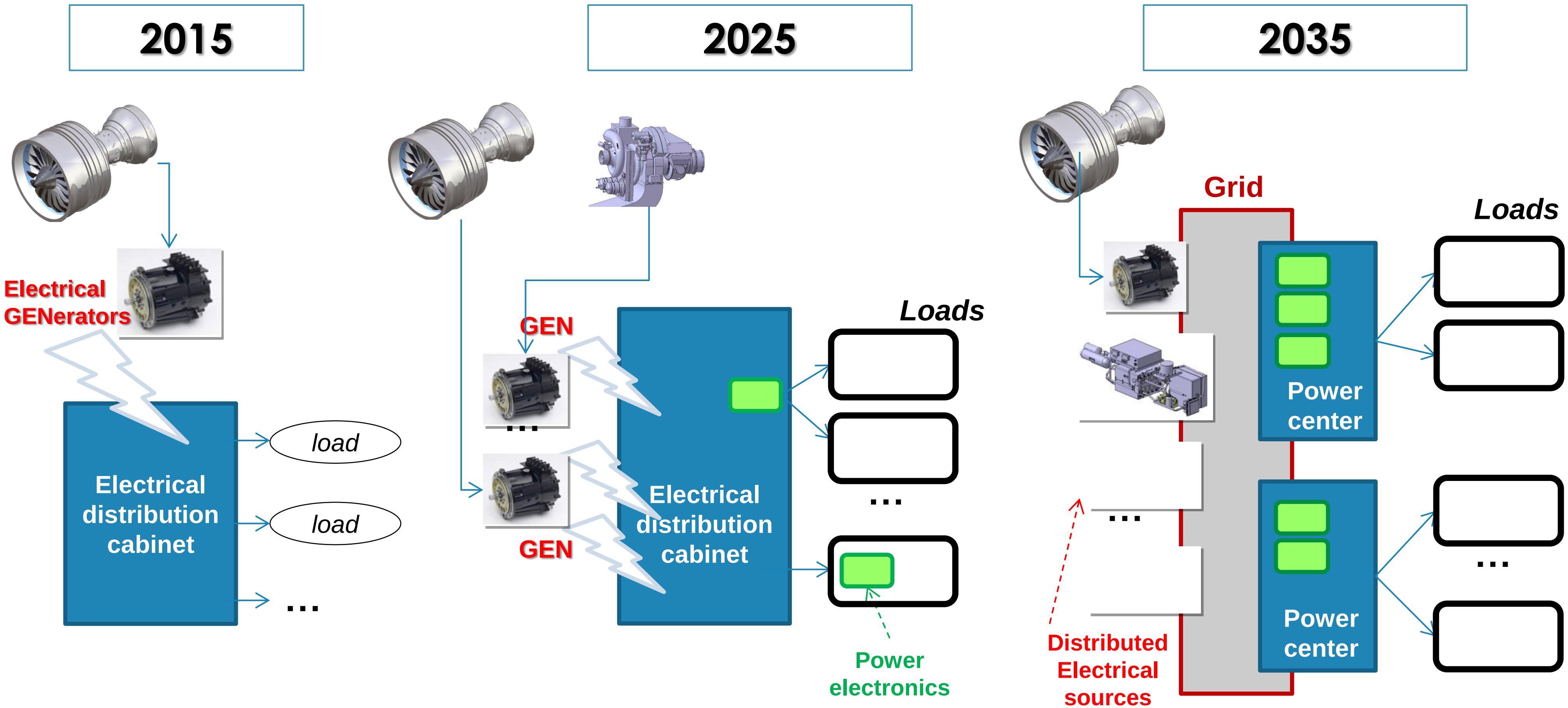
➔ Need for global electrical optimization

EBAC



ETRAS

EVOLUTION OF SYSTEMS CONFIGURATION

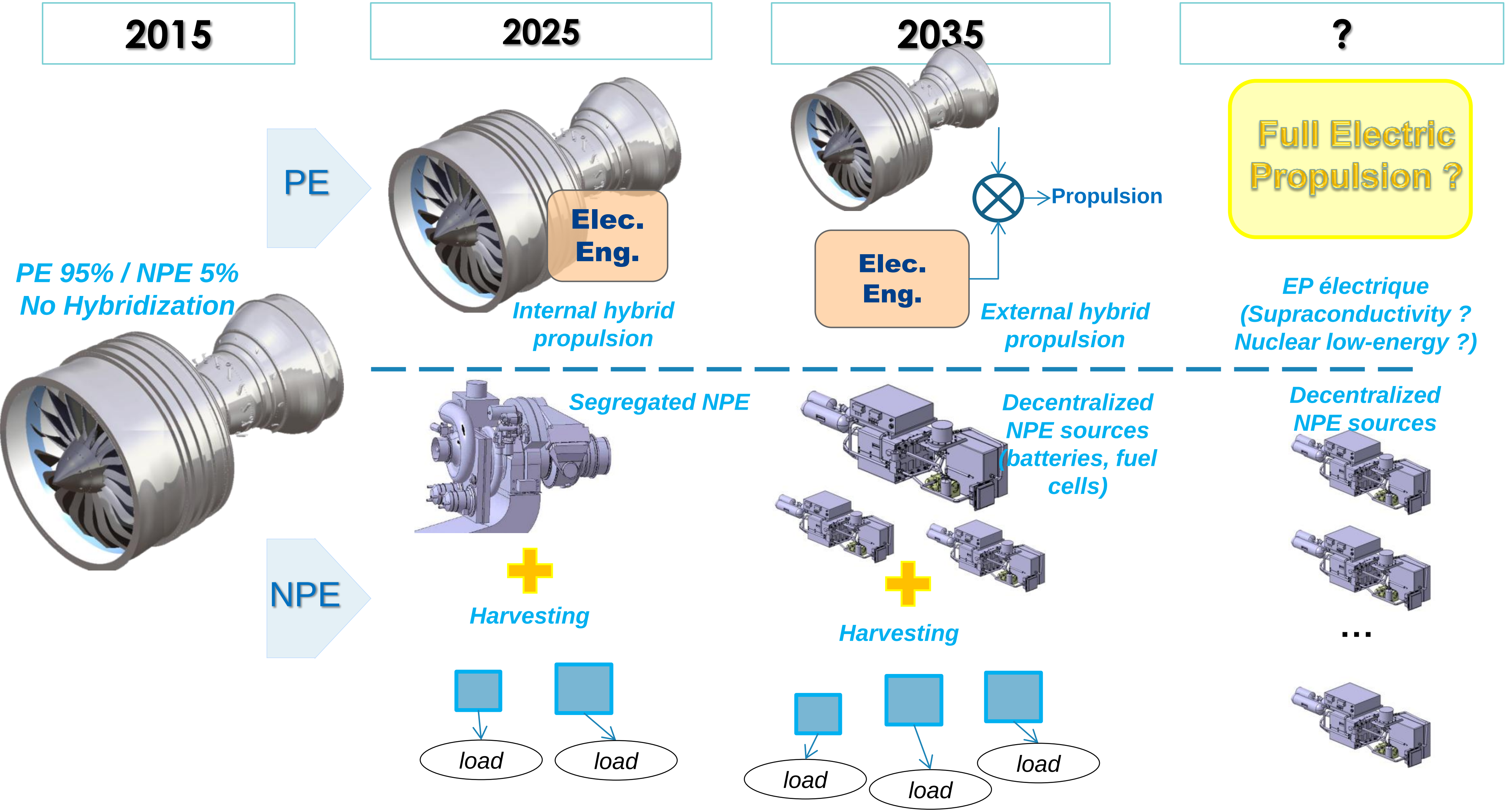


Multiple Electrical Generators
Load-dedicated Power Electronics
or limited mutualization

Distributed Electrical Sources
Multifunction Power Centers
Reconfigurable distribution grid
Standard « sliced » Power electronics

EVOLUTION OF HYBRID PROPULSION VISION

PROPULSIVE (PE) AND NON PROPULSIVE (NPE) ENERGIES



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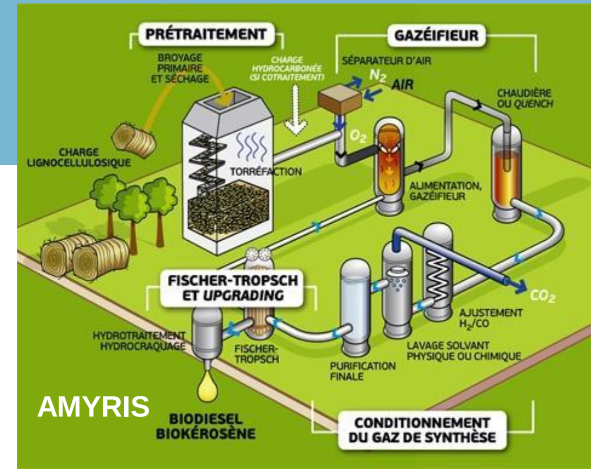
ENERGY LIFE CYCLE

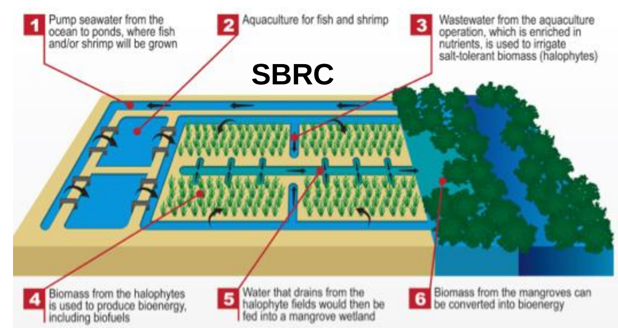


➔ Renewable Hydrocarbons

- Key for the coming decades
  - Truly Sustainable – Low environmental impact
  - Low energy processing

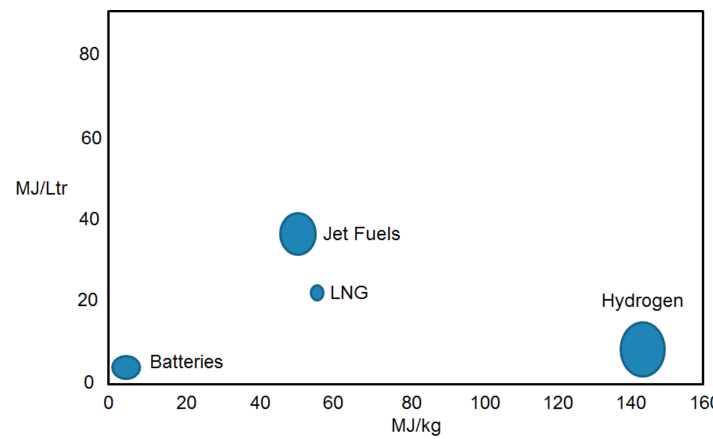
➔ ***Total – Amyris*** : bio-transformation

➔ ***SBRC*** : Sea water irrigation of Halophytes (salt-compatible plants like Salicornia)

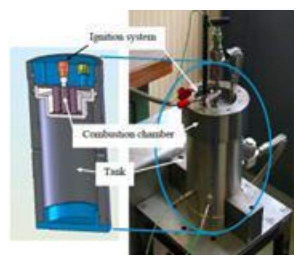


➔ Hydrogen

- Probably not an engine issue (see space applications)
- **LH2** :
  - Energy Volume Density is an issue for massive use (LH2 density similar to table tennis balls)
  - Logistics for massive aviation supply not easy
- **High pressure gas** or **solid storage** may be envisioned for limited energy needs (galleys, emergency functions)



Herakles Solid H2 Generator



➔ *Need to model the full cycle*

CONCLUSION

- **Gas turbines will remain at the heart of propulsive energy for the decades to come**
  - Integration issues more and more critical
  - Electric assistance (hybridization) will play a significant role

- **Aircraft will be more and more optimized as a global energy system**
  - Bleed/Non Bleed continues to be investigated
  - Electrical Technologies will generalize on non-propulsive functions
  - Electrical network (generation, distribution incl. wiring) offers optimization opportunities

- **Renewable Hydrocarbons will play a significant role, complemented by targeted hydrogen primary source usage**

> ➔ *The dialogue between the Airframer and Equipment Supplier is more crucial than ever*
>
> ➔ *More advances needed in applied physics and systems research*

KEY MISSIONS, KEY TECHNOLOGIES, KEY TALENTS