TOWARD A GREENER AIRCRAFT ARCHITECTURE

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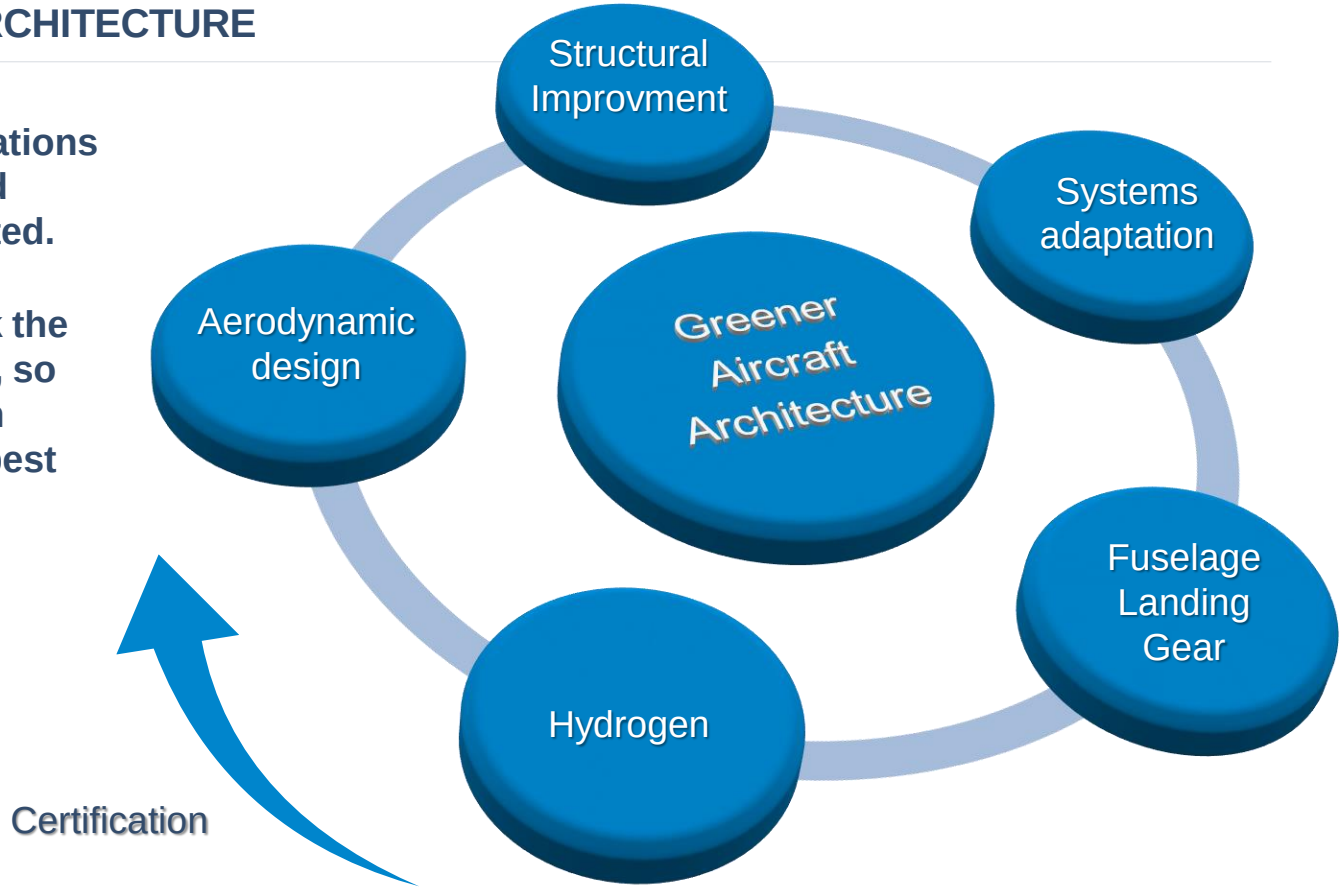
DASSAULT AVIATION

GREENER AIRCRAFT ARCHITECTURE

Multiple elementary innovations have to be developped and multineanously implemented.

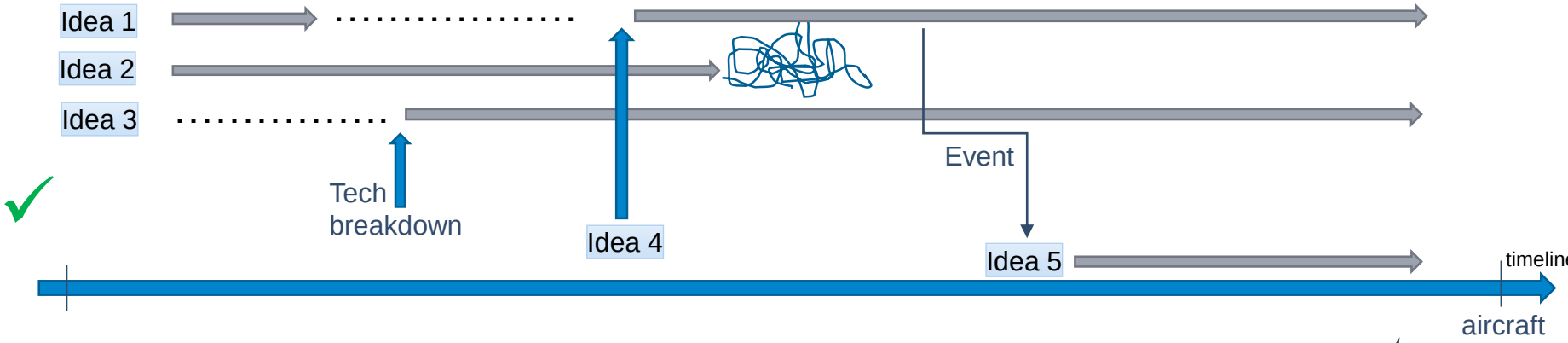
The objective is to re-think the architecture of the aircraft, so that a greener concept can emerge and combine the best ideas.



FROM THE IDEA TO THE CONCRETE AIRCRAFT INTEGRATION

The development of a new architectures does not follow a linear and regular scheme.

It requires short term POCs, european studies to increase maturity & TRL, concept demos, and hopefully can lead to final aircraft integration.

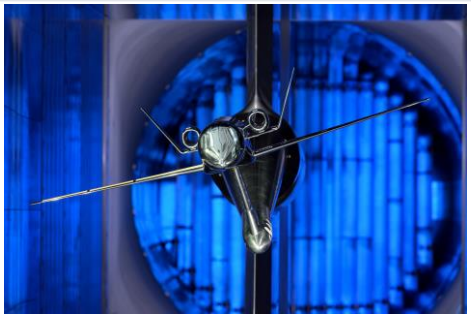


AERODYNAMICS DESIGN

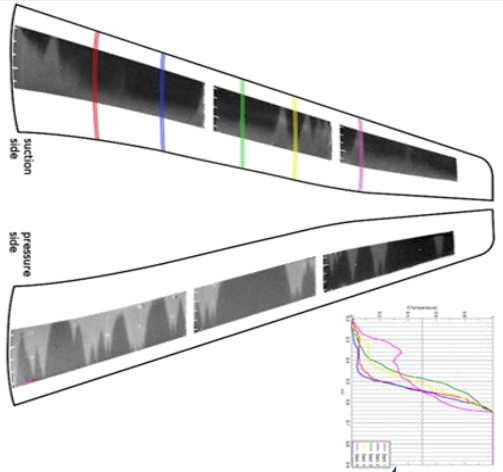
Optimization of aircraft configuration : increase L/D ratio, with:

- **Extended laminarity (50% of wing surface) easier to obtain on bizjets than on airliners because of :**
  - reduced reynold number (~10M) size effect
  - high altitude effect (FL>410).
- **High aspect ratio : more achievable thanks to composite materials and load & flutter alleviation.**

Both are more efficient at reduced wing sweep, which lead to reduced cruise Mach Number.



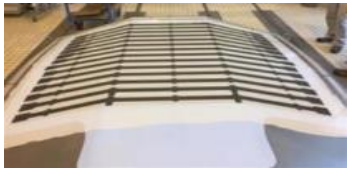
Laminar testing @ETW october 2015



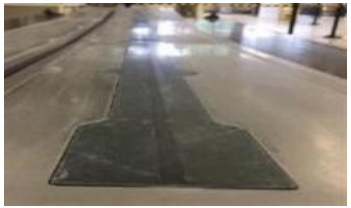
STRUCTURAL DEVELOPMENT (1/2)

High aspect ratio are achievable by weight optimization using composites for complex shapes.

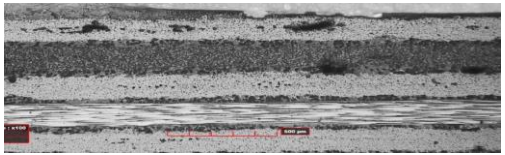
- Composite necessary to meet desirable stiffness from both structure and handling qualities standpoint at the aspect ratio/wing sweep goal
- For example, Central Wing Box Panel Demonstrator (Airframe ITD – CleanSky 2)
  - Highly loaded composite part
  - Manufacturing of big composite parts meeting theoretical geometry (stiffened panels)
  - Innovative materials and innovative manufacturing processes



Stiffeners installed in the curing tool (co-bonding of the skin with the stiffeners)

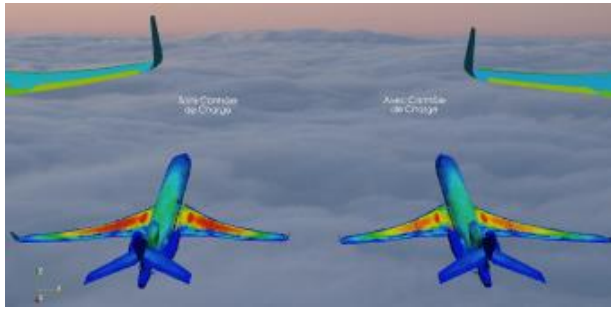


Stiffener installed in the tool aiming at deforming it at the required geometry (kink angles)



Micrographic Analysis (➔ voids)

STRUCTURAL DEVELOPMENT (2/2)

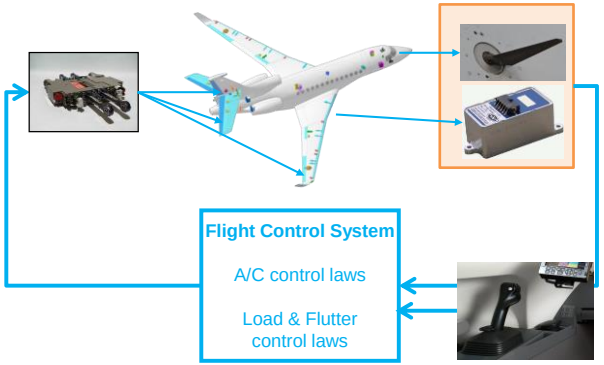


High aspect ratio are achievable by load and flutter alleviation.

The structural design of A/C wings is performed such as to:

- Sustain dynamic loads encountered during maneuvers or turbulence
- Avoid dynamic instabilities that can arise at high speed (flutter)

High aspect ratio wings need heavy structural reinforcement to fulfill these objectives obliterating the aerodynamic gain.



- **Load control**

Load control consists in reducing the loads by using all control surfaces in a smart way to optimize the aerodynamic load distribution during maneuvers or while encountering turbulences.

- **Flutter control**

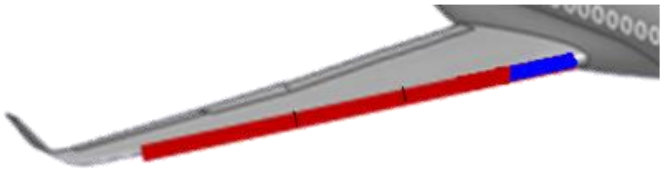
Flutter control consists in damping flutter oscillations by a smart dynamic motion of the control surfaces

SYSTEM ADAPTATION

Ice protection on Falcon takes hot air from engines and warm wing leading edge through a swap.

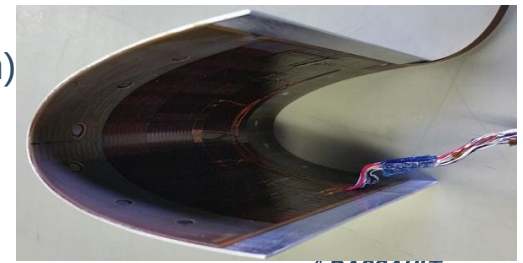
This technology has to be questionned because of :

- Engine core reduction (for performant modern engine with high by pass ratio)
- Certification rules (hot air limit temperature, Super large droplets)
- The increase of surface to protect on high span wings (~+50% vs typical falcon wings).



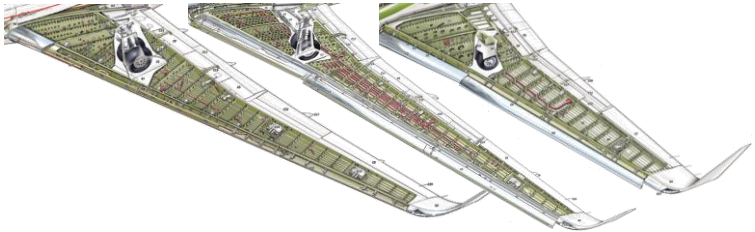
Technologies such as heater mats are quite mature on the shelf, but need to be integrated in the aircraft in terms of:

- Consistency to the power needs (x4 to x6 vs current electrical design)
- Industrial integration process
- Robustness during operations

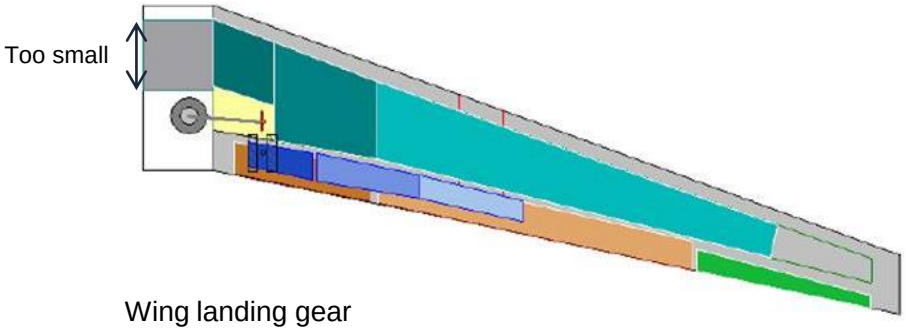


FUSELAGE LANDING GEAR (1/2)

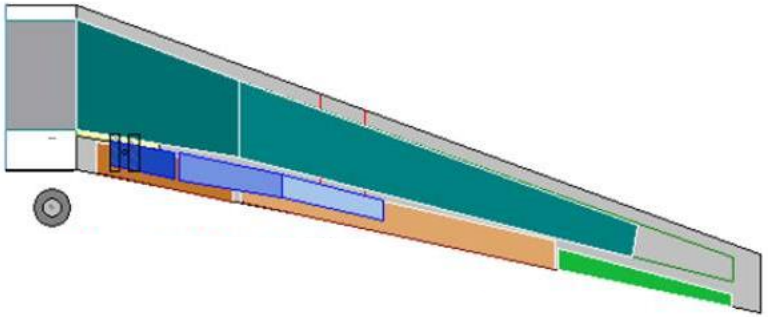
Traditionnal business jet wings have high sweep angles and great root chords, which allows to embed the main landing gears.



With a high aspect ratio, the reduced root chord lead to move the landing gear in the fuselage.



Wing landing gear

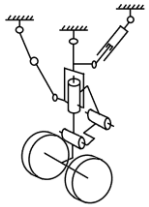


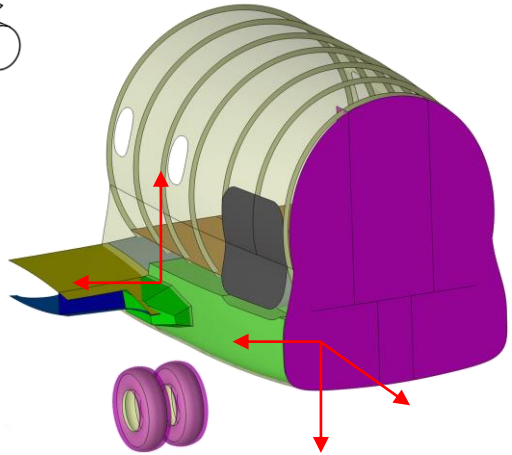
Fuse landing gear

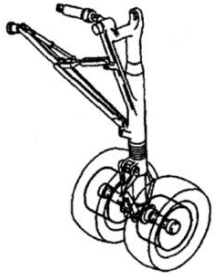
FUSELAGE LANDING GEAR (2/2)

Landing gear in the fuselage is a challenge for business jet : fuselage diameter is smaller than airliners.

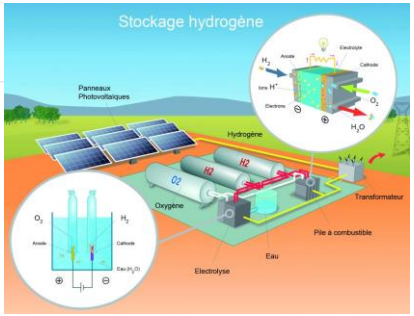
- Complex cinematics necessary to fit small bay
- New kind of efforts to be supported by fuselage frame structure
- Noise aspects to take into account
- Reduced wheel track





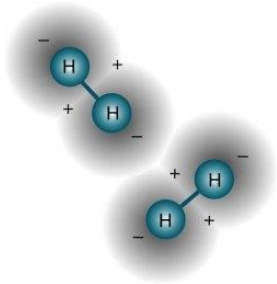


HYDROGEN (1/2)



The Hydrogen alternative :

- CO2 free fuel.
- Contrail impact needs to be quantified, expected to be limited compared to current situation.
- Safety will be a key issue and drives completely the propulsion and fuel system integration
- Bizjet operate a majority of short range missions which could be compatible with gaseous hydrogen, much simpler in terms of operations
- Progress in Airframe and Engine efficiciency will be enablers of carbon free/low density fuels, as they will increase the range accessible with the volume and weight limited fuel quantities on board

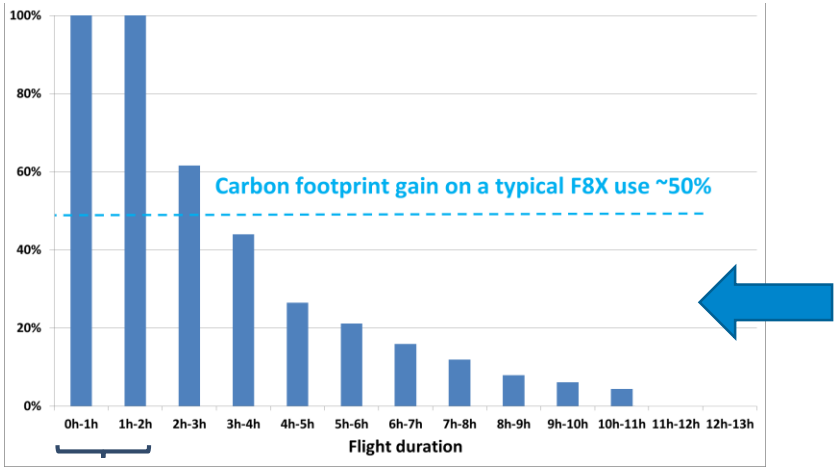


HYDROGEN(2/2)

Hybrid Kerosene/gaseous H2 can allow zero emission flight under 2 Hrs (2/3 of Falcon operations) while still enabling long range flights.

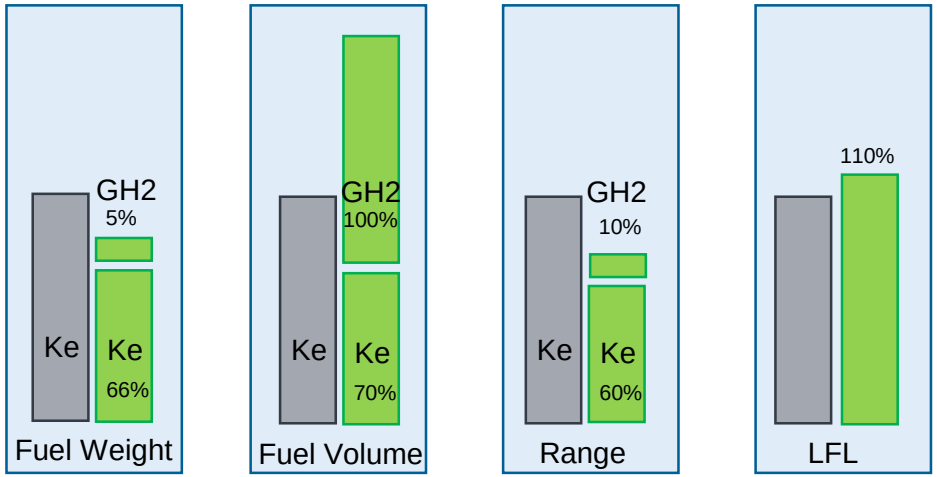
Key performance enablers will be low weight GH2 tanks (15%) for which an ambitious techno road map is necessary.

Aircraft carbon footprint



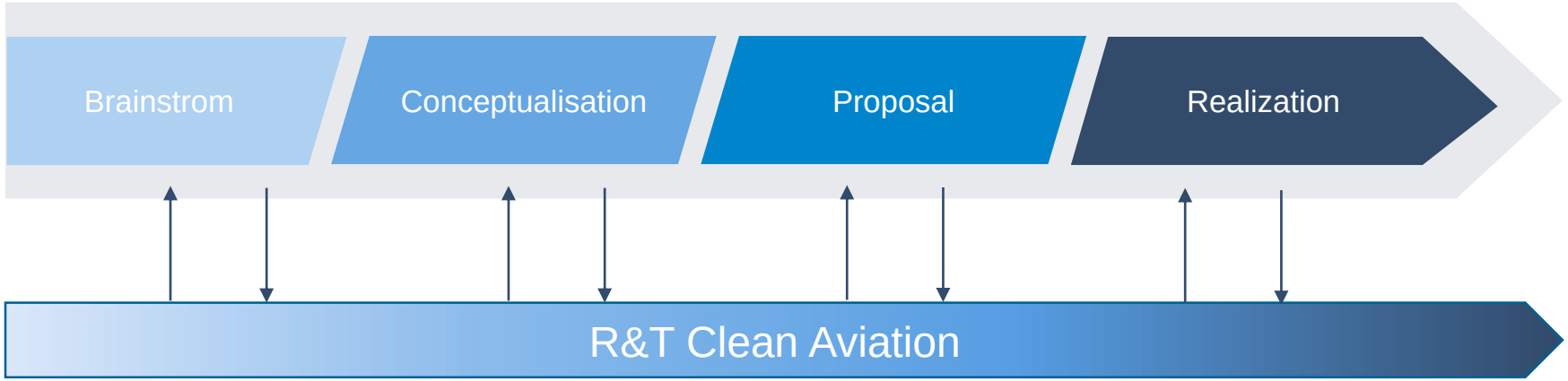
2/3 of the flights =1/3 of carbon footprint

Example of performances consequences at Fixed MTOW



CERTIFICATION

To achieve the final objective of an aircraft integrating all thoses major innovations, it requires that certification is prepared in parallel to technology deployement.



OUTLOOK FOR THE FUTURE

Business Aviation enables flight from, or to, secondary airport not reached by commercial airlines, thus, is very efficient to carry flexibly management / tech teams or specific equipment .

Technology developments already under way, combined with drop-in sustainable aircraft fuel, will be solutions for environmental progress. Options are prepared towards decarbonization in the following range:

Short term:

- Compatibility with 100% Sustainable Aircraft Fuel

Mid / long term:

- L/D increase: maximal aspect ratio achievable thanks to composite material and active load alleviation to be defined on a conventional configuration, interest of Truss Braced Wing to be indepth studied .

- Systems adaptation such as electric ice protection and fuselage landing gear.