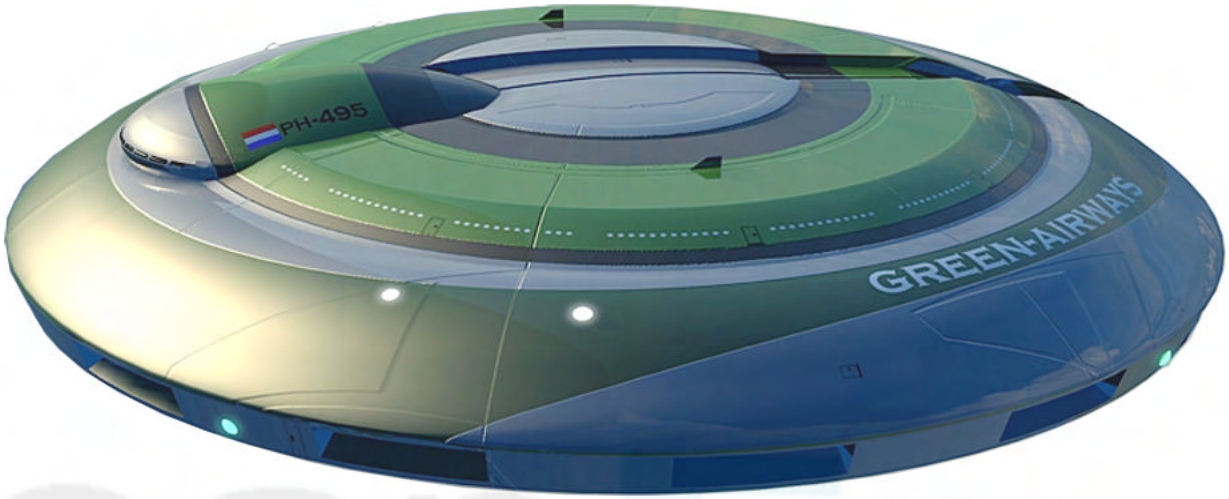
DELcraFT Works: CleanEra Project



Cost-effective Low Emissions and Noise Efficient Revolutionary Aircraft

CleanEra

DELcraFT Works: CleanEra Project

- **Multi disciplined international design team consisting of:**
  - Ca. 10 PhD/Post-doc researchers, each in a different disciplines
  - Several MSc students
- **Combine all knowledge available in Faculty of Aerospace Engineering in a showcase for industry**

Cost-effective Low Emissions and Noise Efficient Revolutionary Aircraft

CleanEra Team

Team members

- **Wasim Arshad**
- **Dipanjay Dewanji**
- **François Geuskens**
- **Chara Lada**
- **Marios Kotsonis**
- **Arvind Rao**
- **Marcel Schroijen**
- **Durk Steenhuizen**
- **Michiel Straathof**
- **Hui Yu**

Partners

KLM Royal Dutch Airlines

STORK

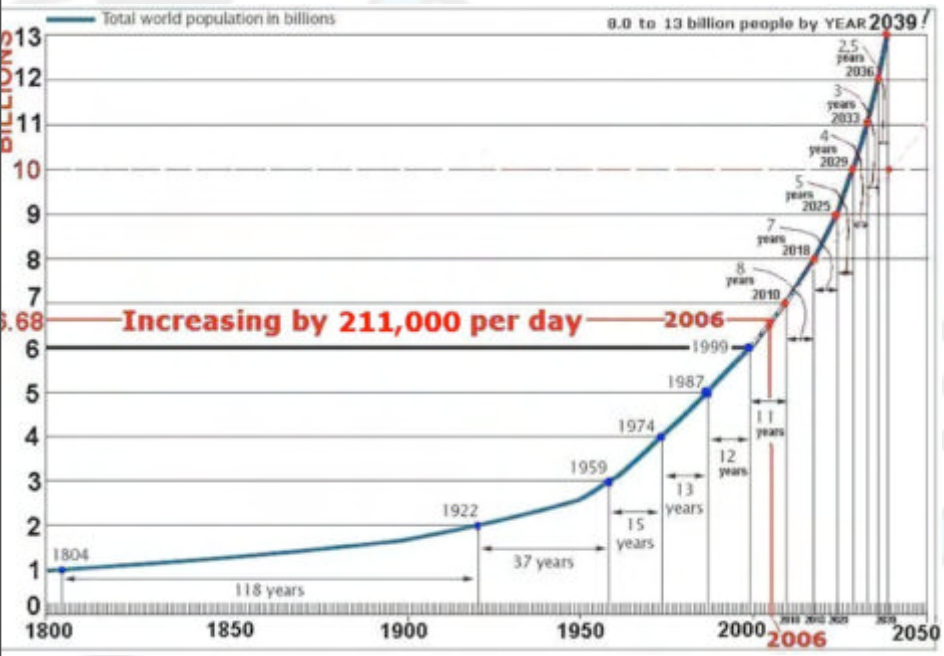
ADSE
CONSULTING AND ENGINEERING

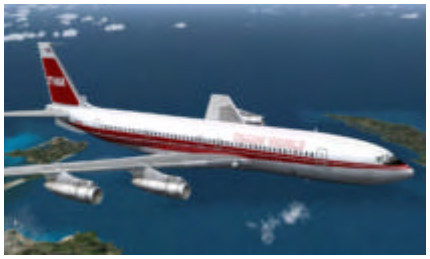
- **Master students**
  - **Ingmar van Dijk**
  - **Jochem Kuiper**
  - **Zeger van der Voet**
  - **...**

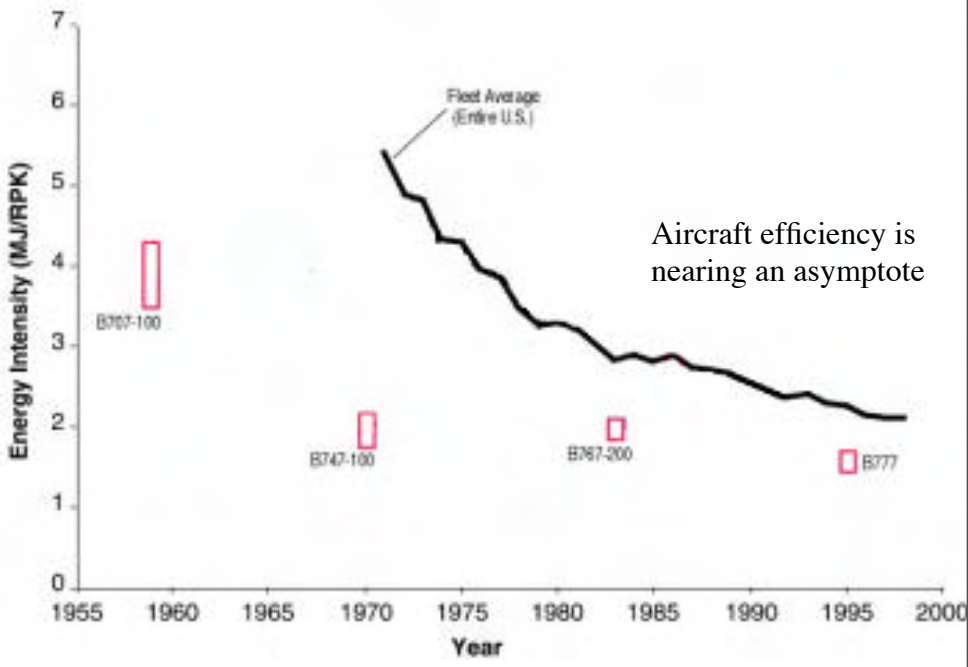
CleanEra

Trends

Aircraft demand will grow
at an ever increasing rate



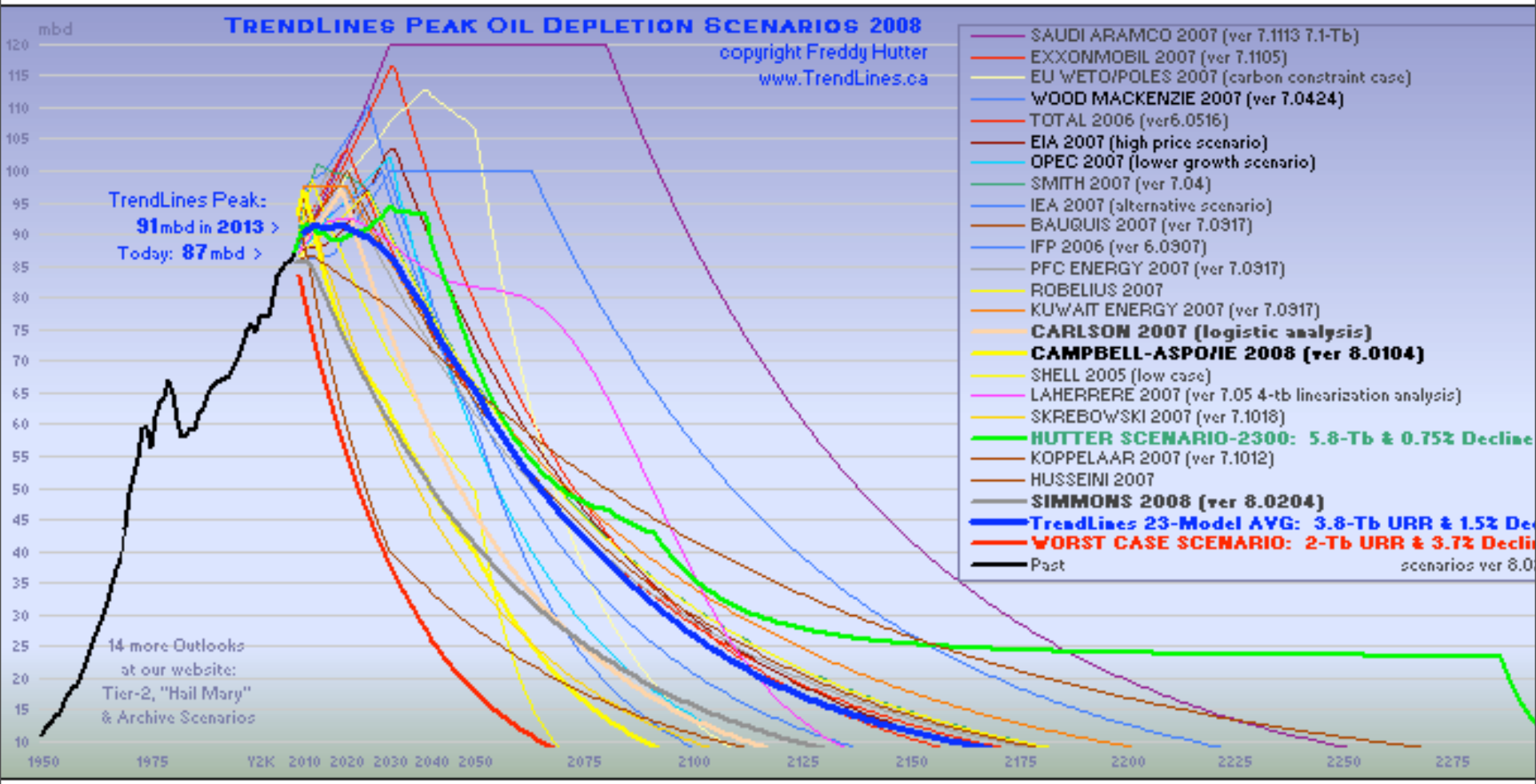




Aircraft efficiency is
nearing an asymptote

CleanEra

Trends



CleanEra

Trends

A revolutionary approach is therefore needed

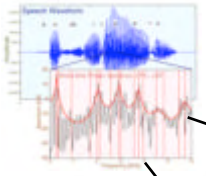
Revolutionary designs are possible

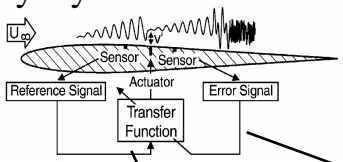
- Military aircraft industry has explored more revolutionary designs such as:

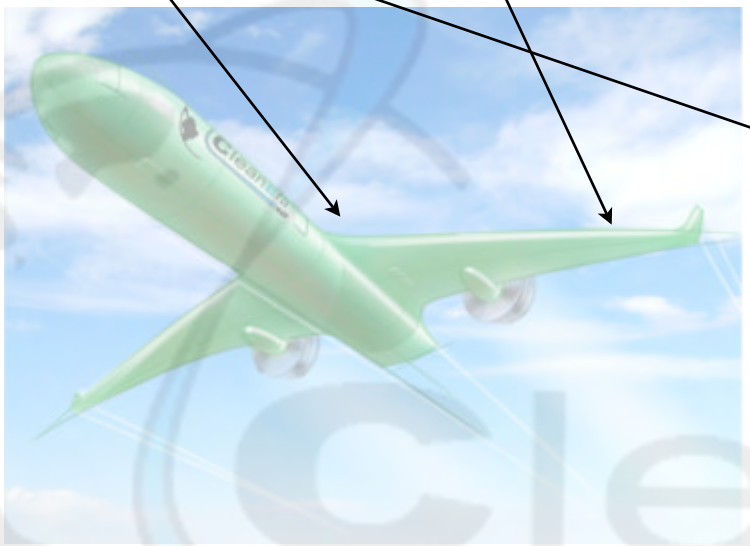
  - Blended Wing Bodies: B-2
  - Dynamically unstable aircraft: F-16
  - High altitude: SR-71 Blackbird
  - Etc.

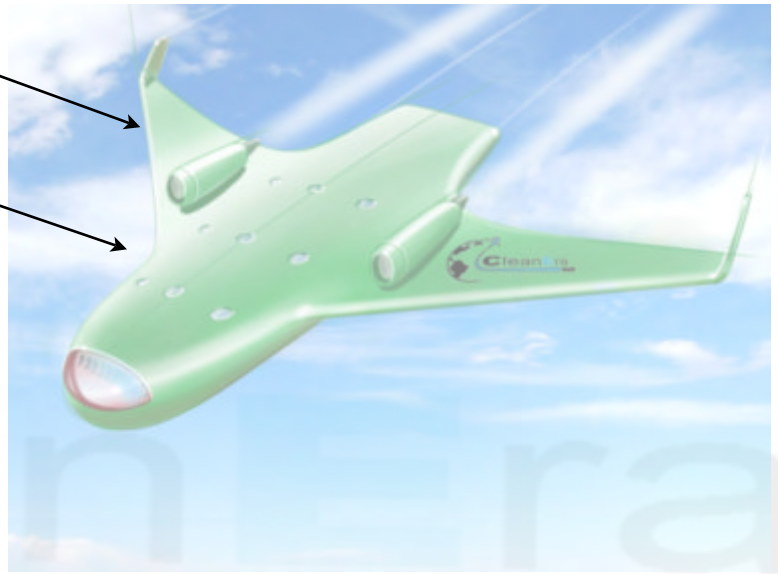
Acoustics

Boundary layer

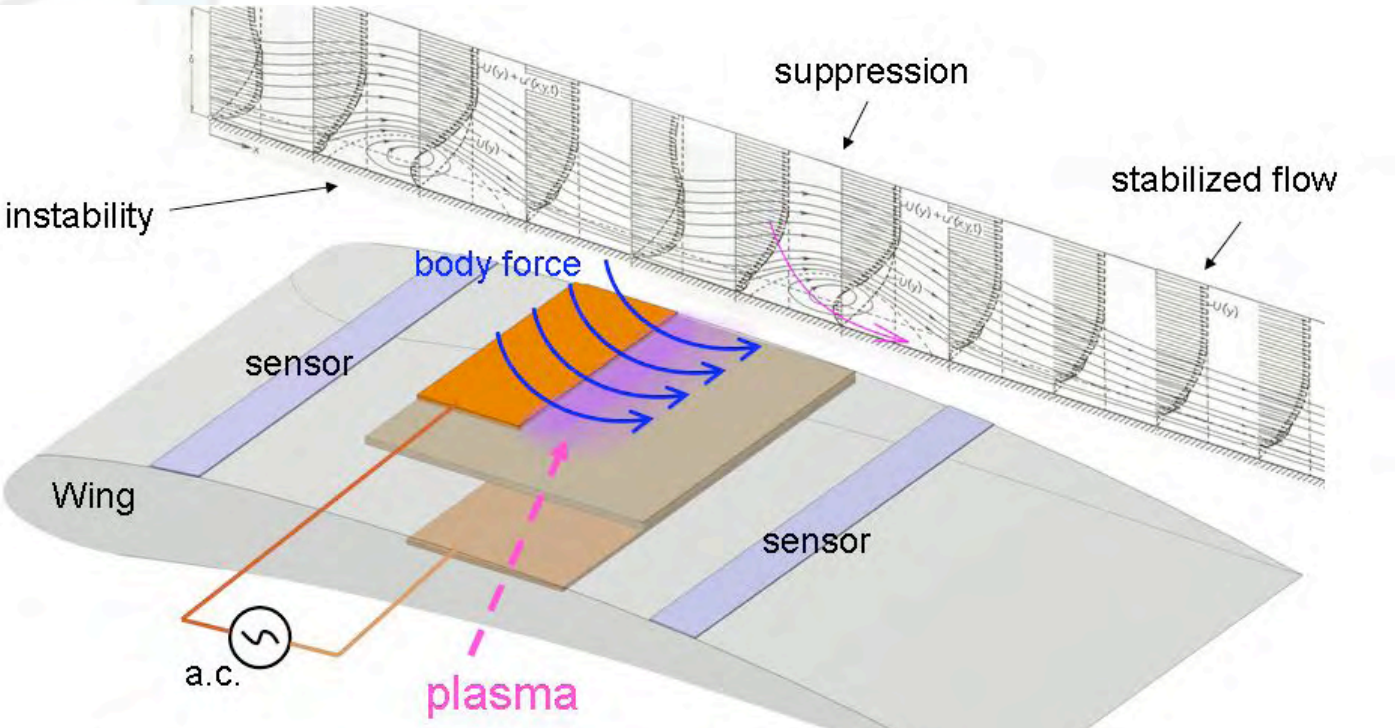


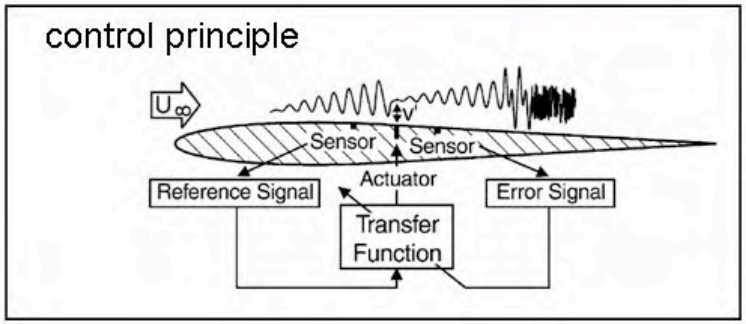






Drag Reduction



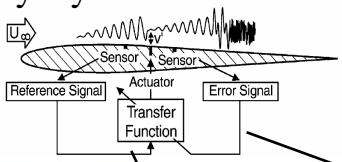


Plasma actuator and control system for suppressing Tollmien-Schlichting instabilities and delaying transition

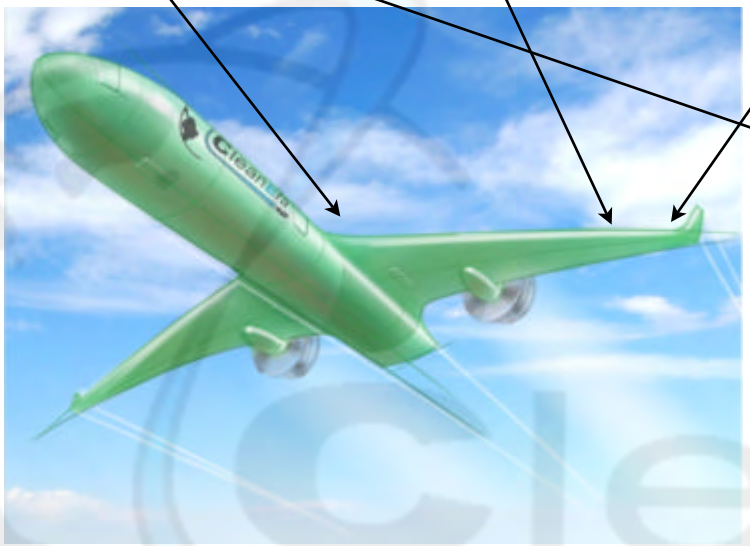
CleanEra

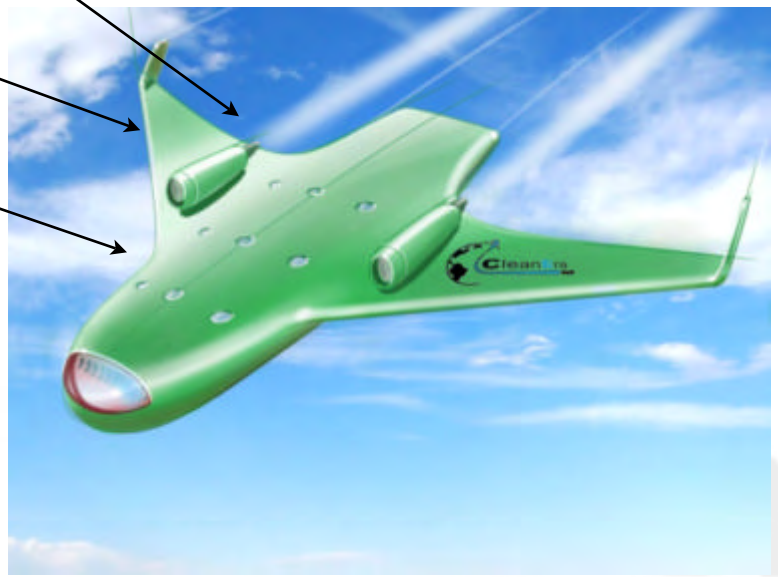
Acoustics

Boundary layer



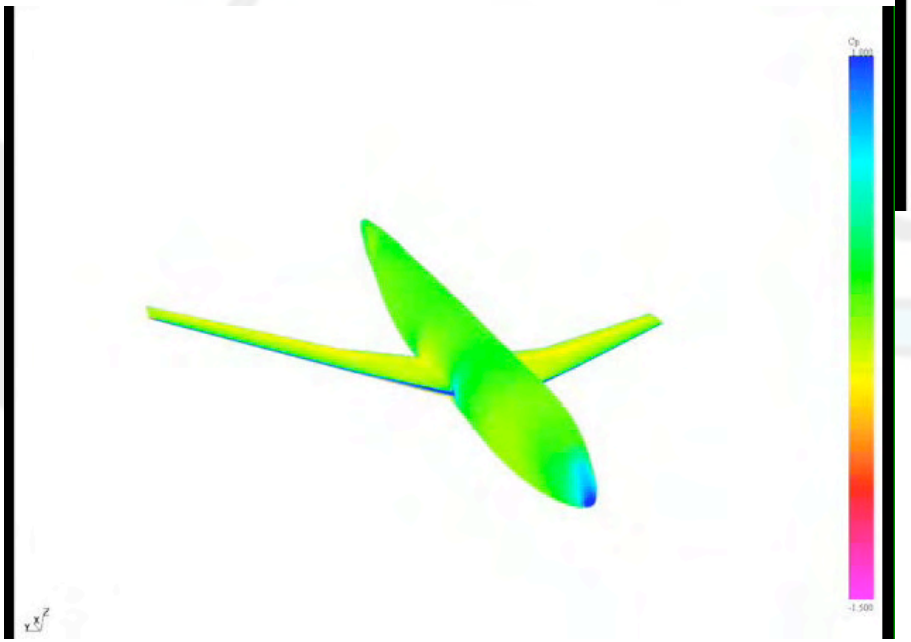
Aero Performance





Aerodynamic Shape Optimization

- Optimal aerodynamic shape by means of Comput. Fluid Dynamics



Possible aerodynamic models:

Potential flow, Euler, Navier-Stokes

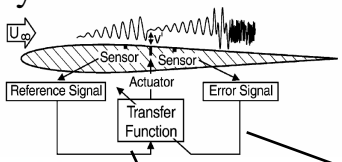
Possible optimization methods:

Adjoint equation method, genetic algorithms, particle swarm optimization

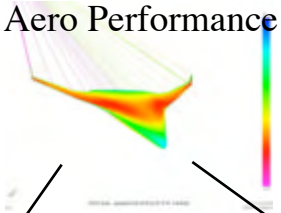
CleanEra

Acoustics

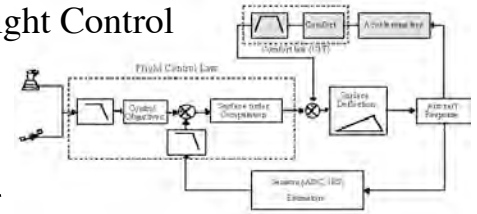
Boundary

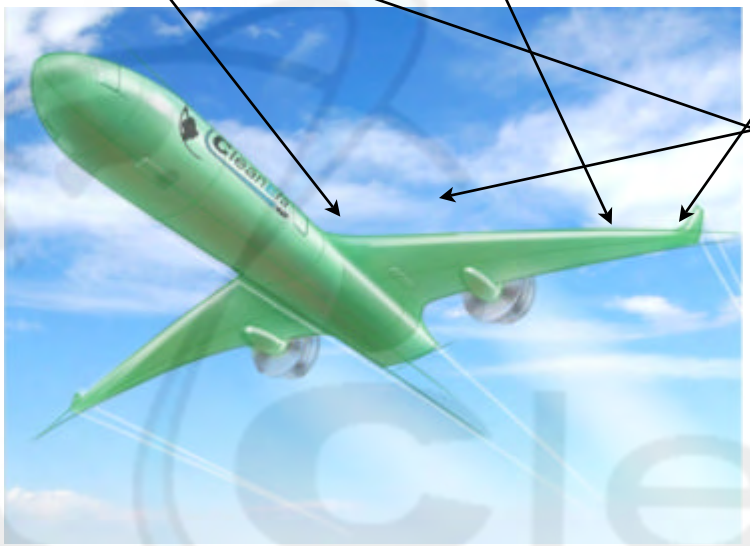


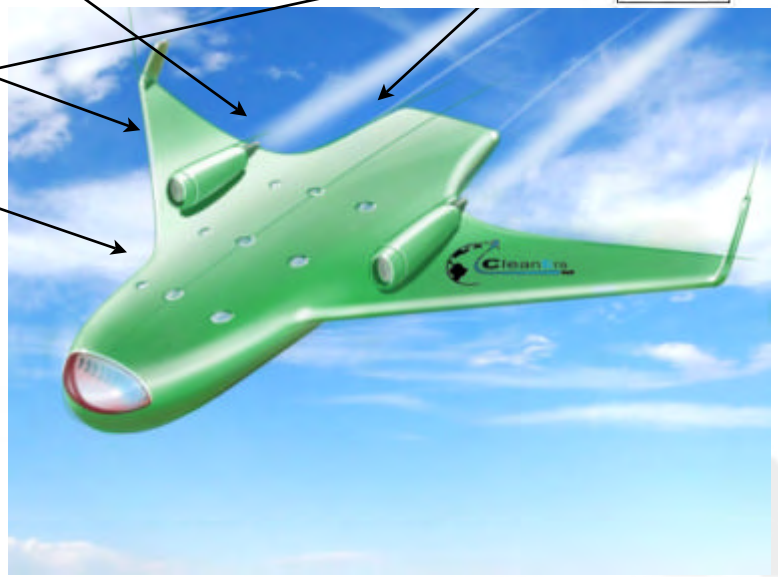
Aero Performance



Flight Control

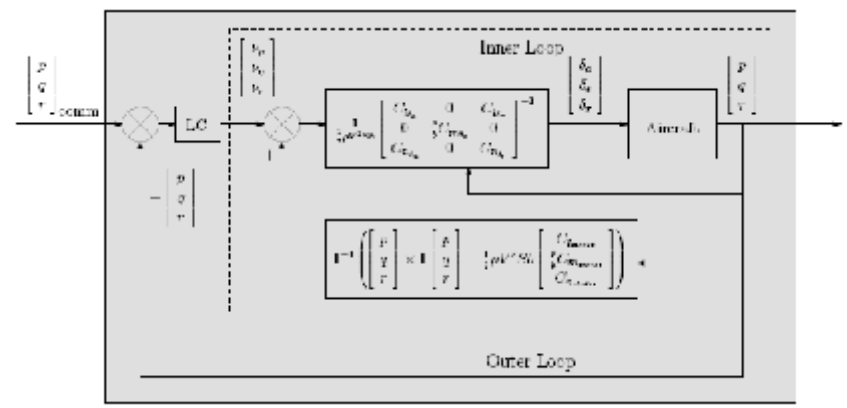


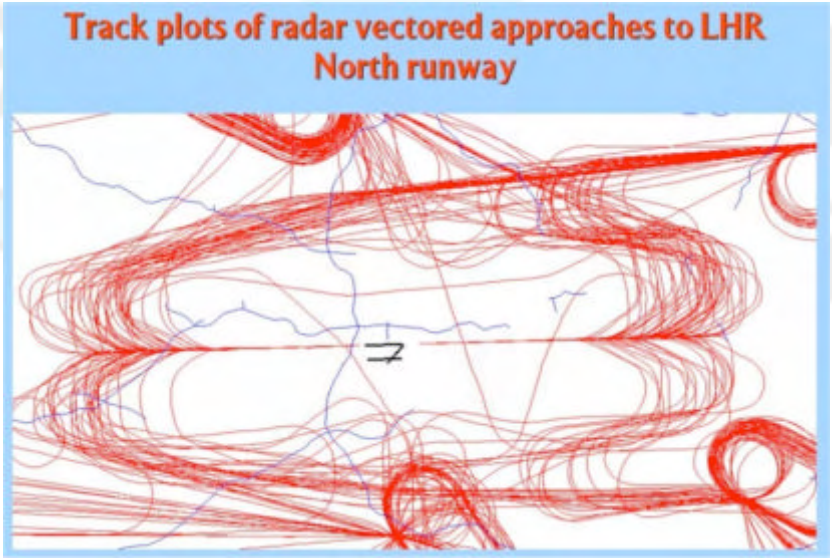




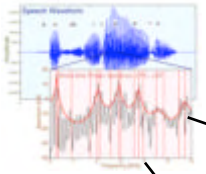
More efficiënt flying

- Advanced procedures
  - Approach &Landing without thrust
    - But with enough flexibility for ATC
    - And safe margins to start enigines
  - Optimal routing





Acoustics



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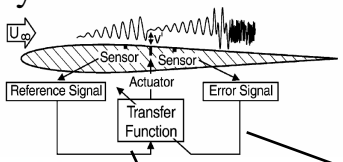
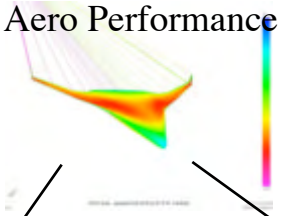
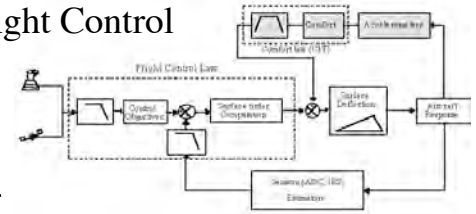
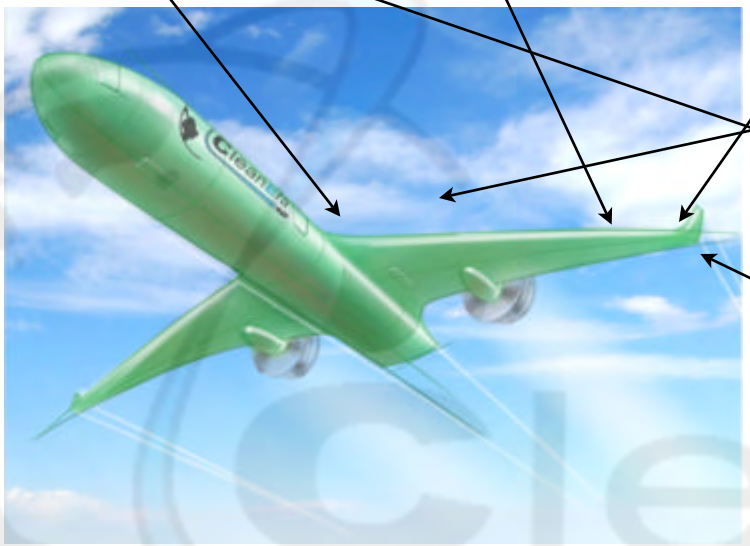


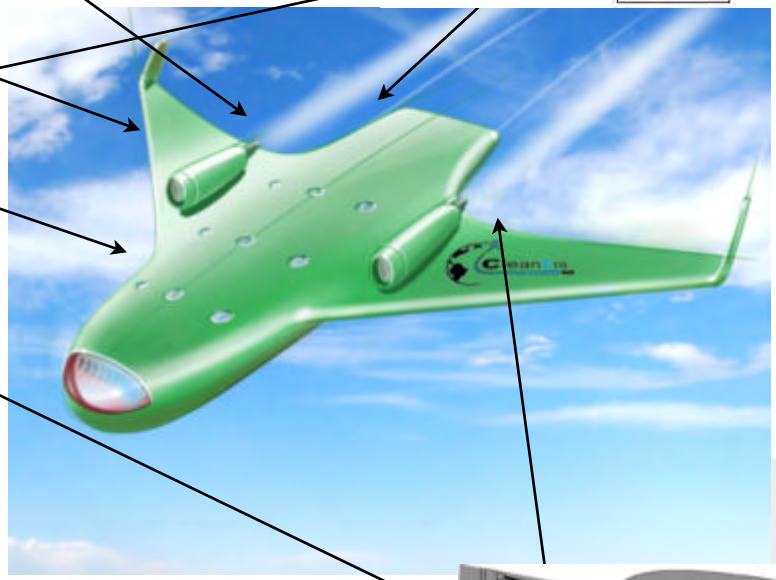
Aero Performance

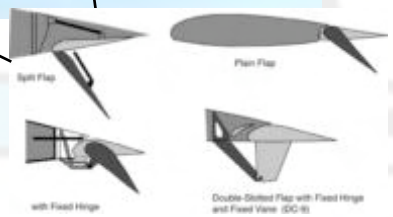


Flight Control









High Lift

Focus on technologies

High-Lift Devices

Sade's goals

- Develop a high-lift configuration that will allow Natural Laminar Flow (NLF) in its retracted state
- Nose section is to be slotless -> impact on $C_{L\ max}$
- Flap at TE is to be single slotted
- Smart structures are to be applied

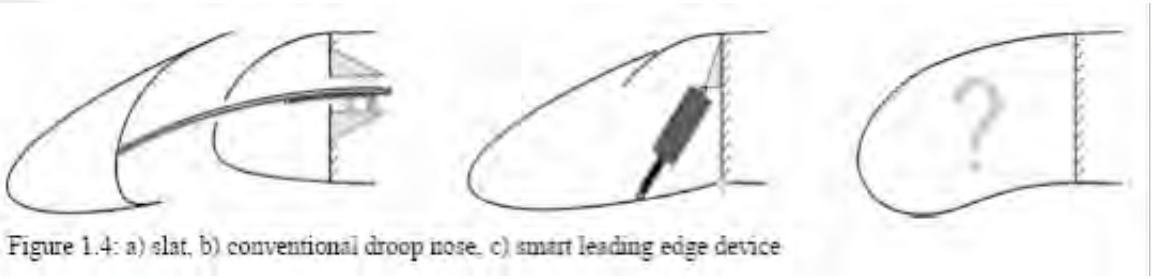
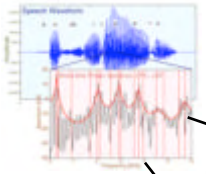
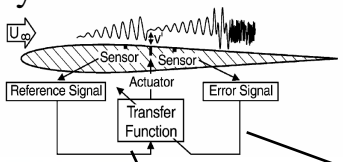


Figure 1.4: a) slat, b) conventional droop nose, c) smart leading edge device

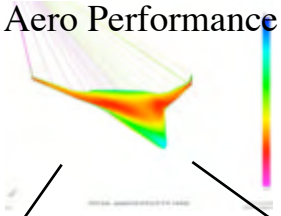
Acoustics



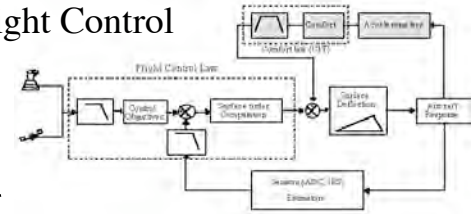
Boundary

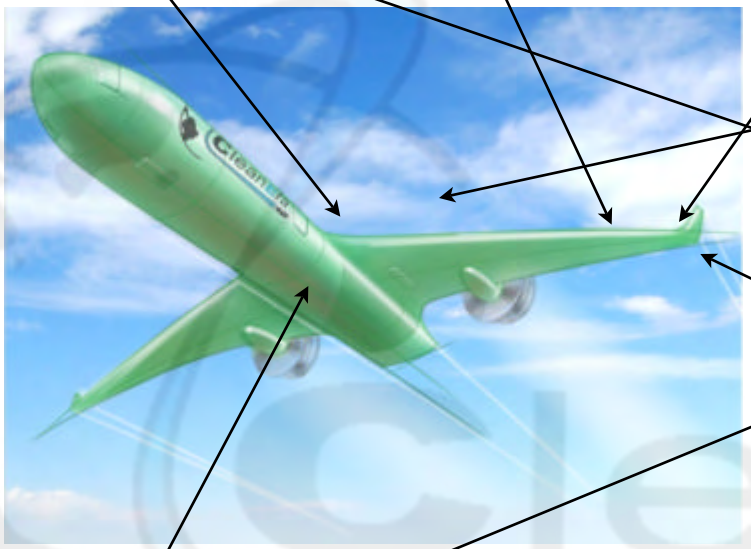


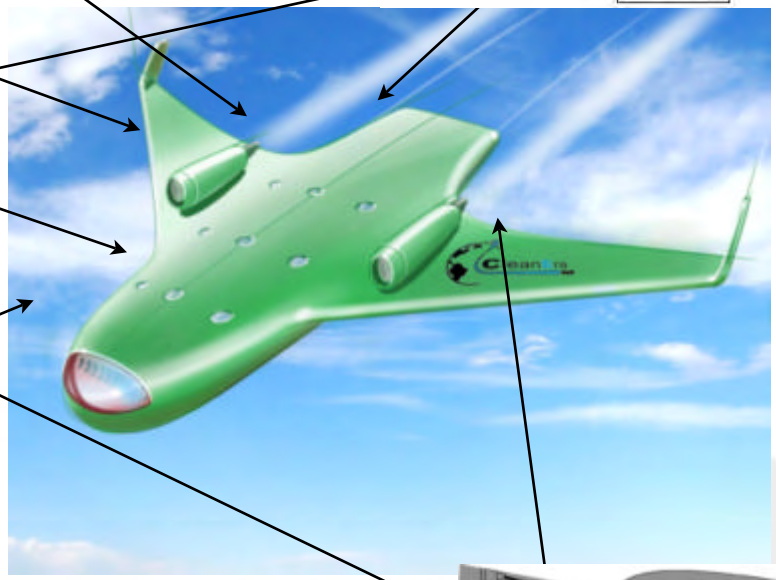
Aero Performance

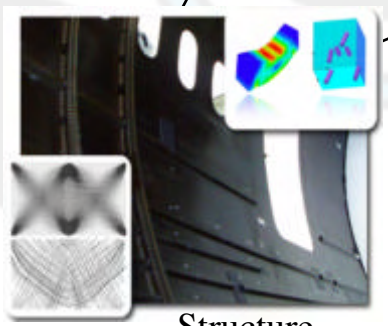


Flight Control

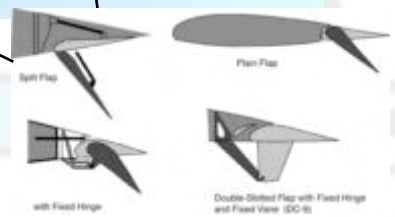








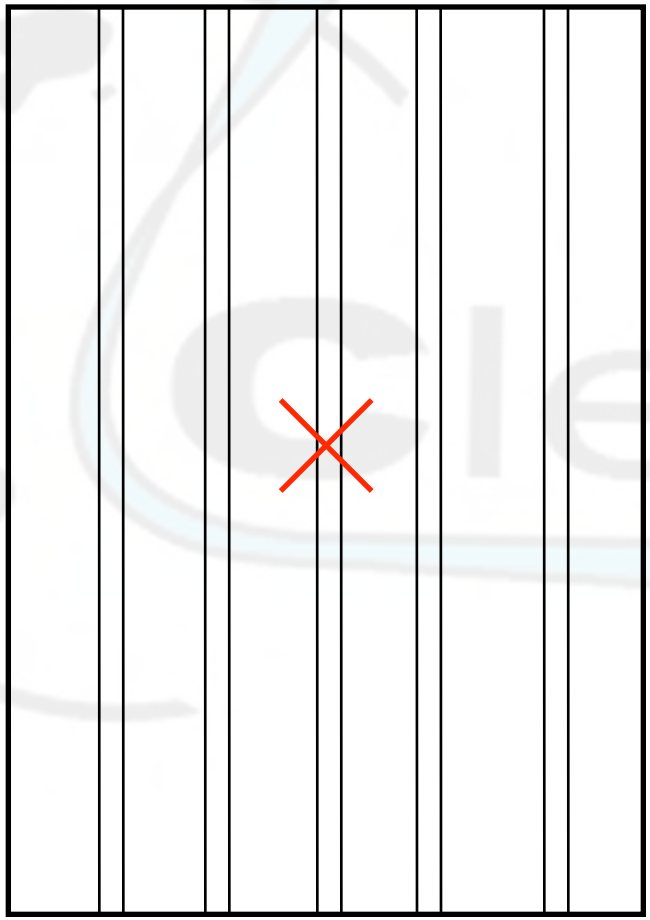
Structure

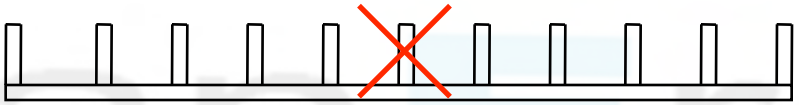


High Lift

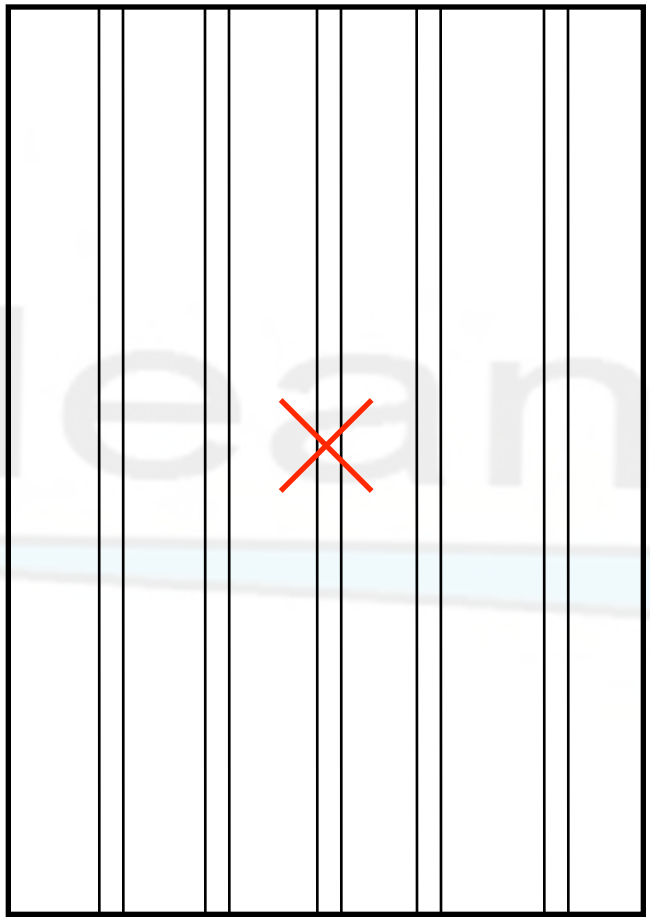
Focus on technologies

Structure - Traditional

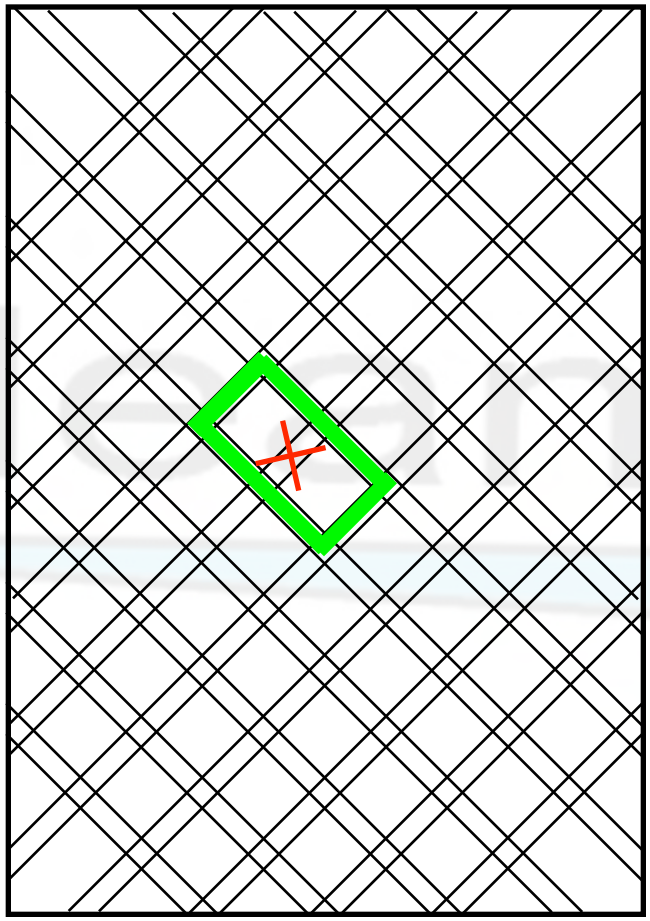




Structure - Traditional

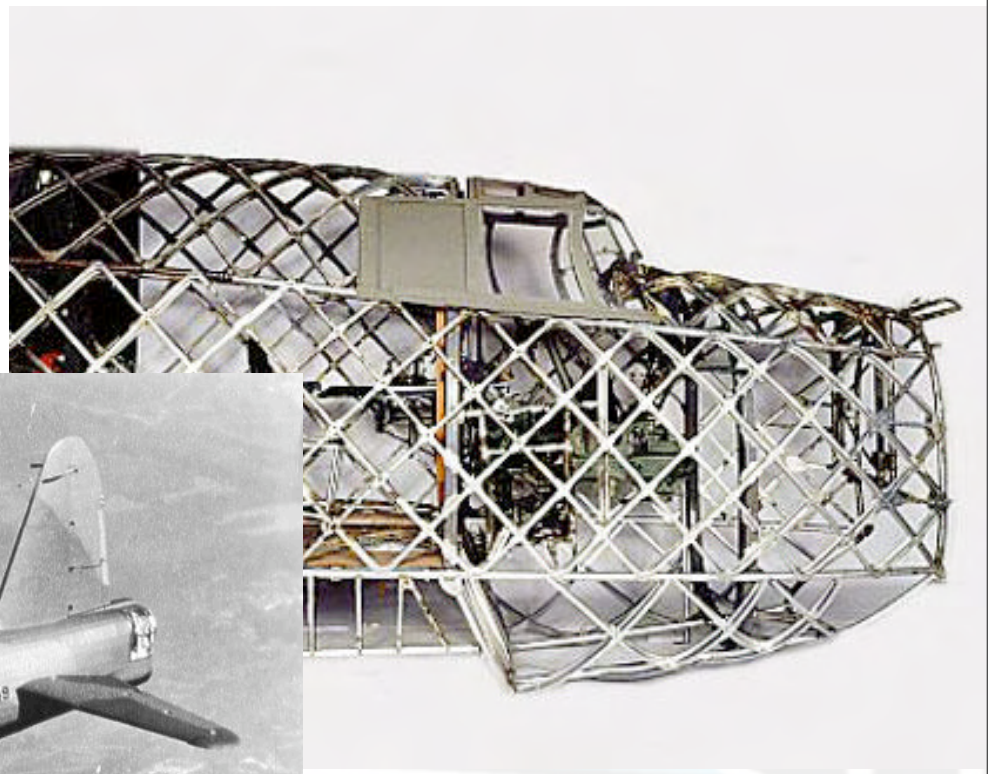


Structure - Traditional



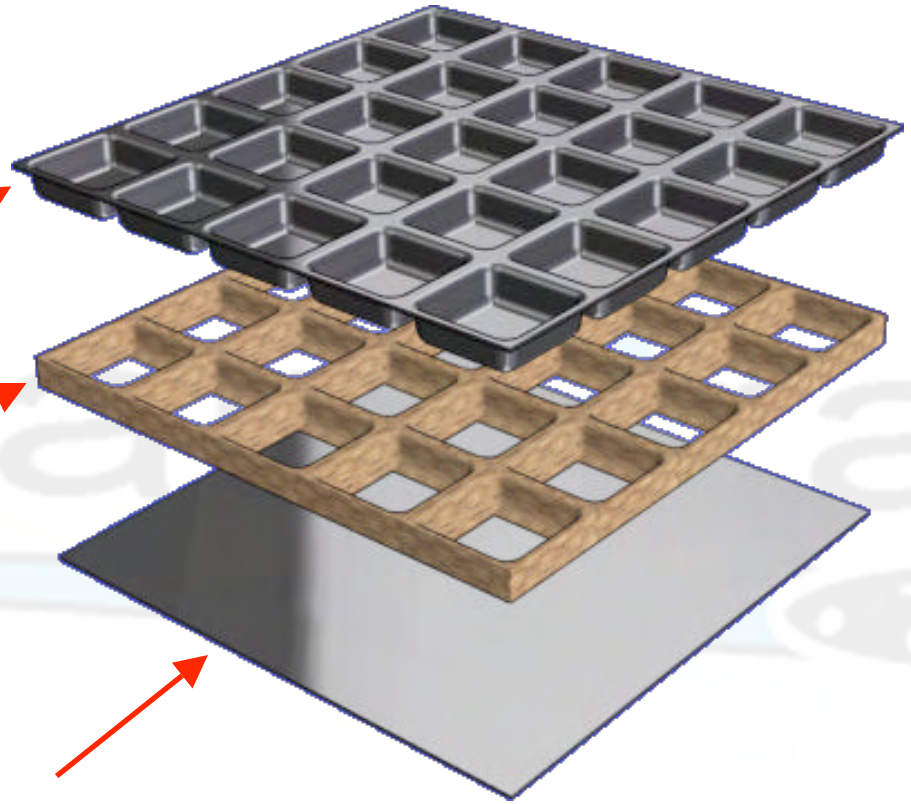
Back to the Future...

Vickers Wellington used a geodesic construction method, which had been devised by Barnes Wallis (1936)



CleanEra

Structure - New



Metallic/Thermoplastic
Pressure Resistant
Inner Skin

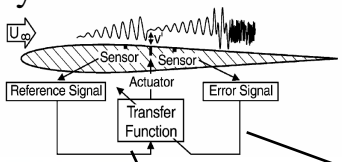
Carbon Fiber Grid

Metallic/Thermoplastic
Non-load carrying
Outer Skin

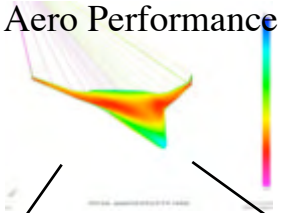
CleanEra

Acoustics

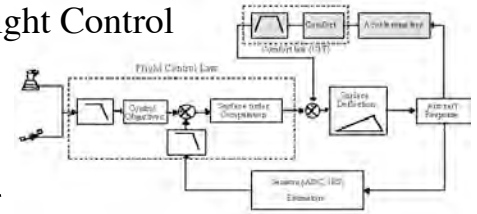
Boundary

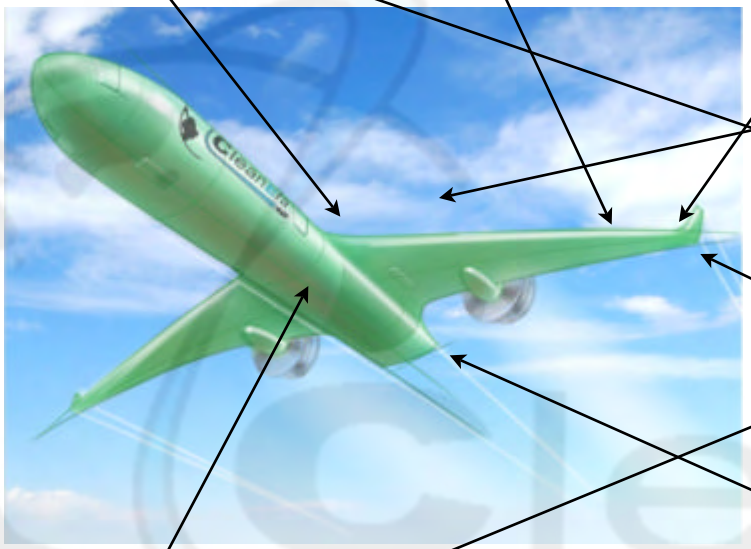


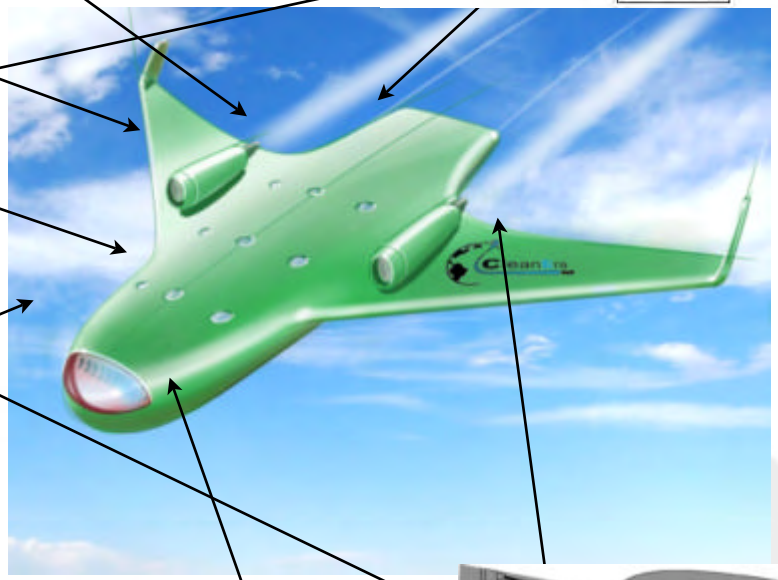
Aero Performance

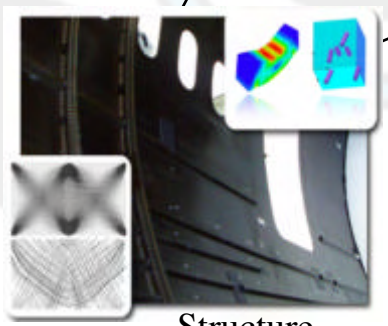


Flight Control

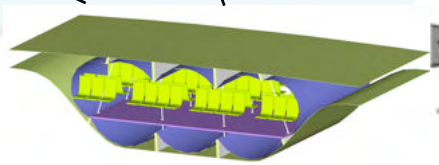




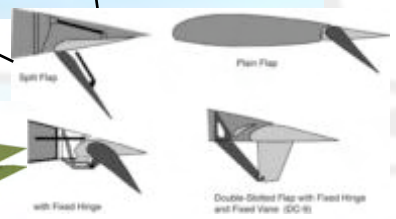




Structure



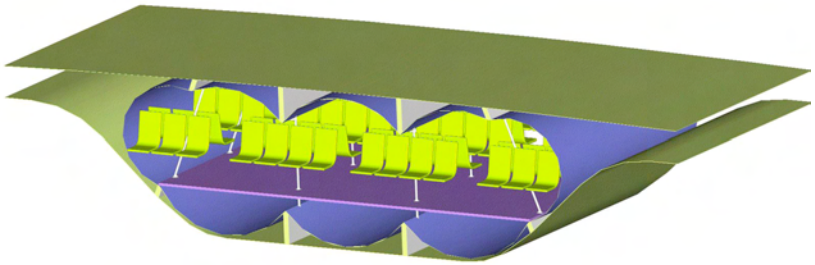
Pressure hull

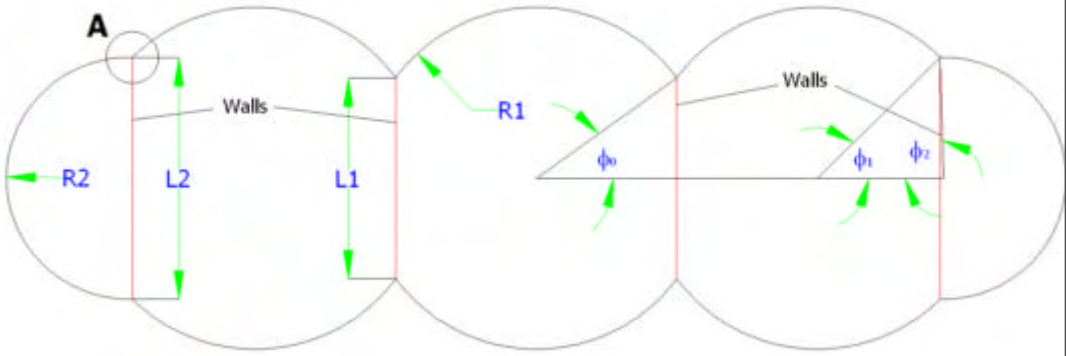


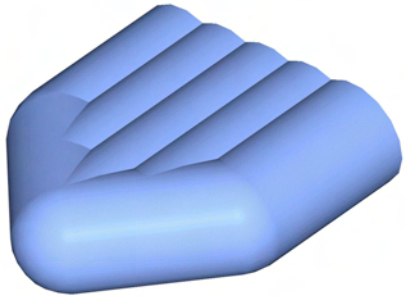
High Lift

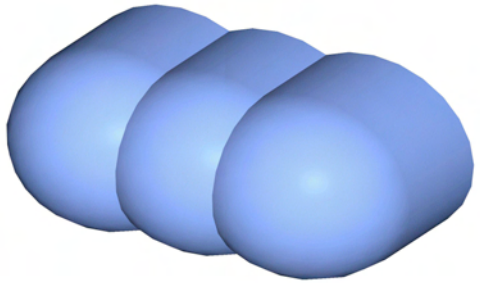
Focus on technologies

Pressure fuselages





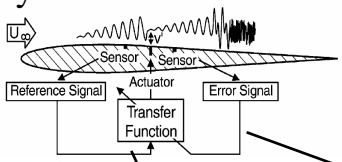




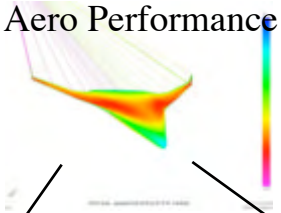
- Fiber reinforced membrane
- Beams are integrated as longitudinal beams in aerodynamic shell (improve structural integrity of aerodynamic shell)

Acoustics

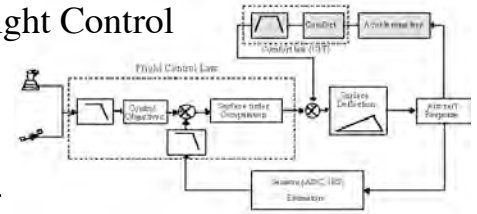
Boundary

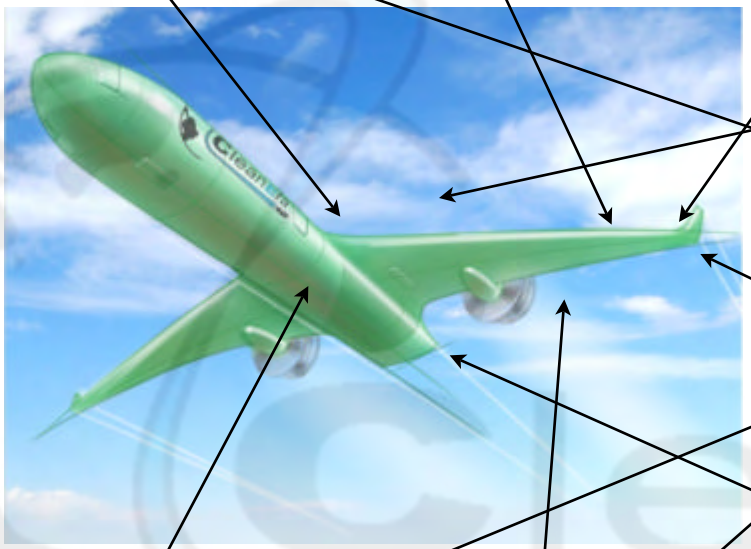


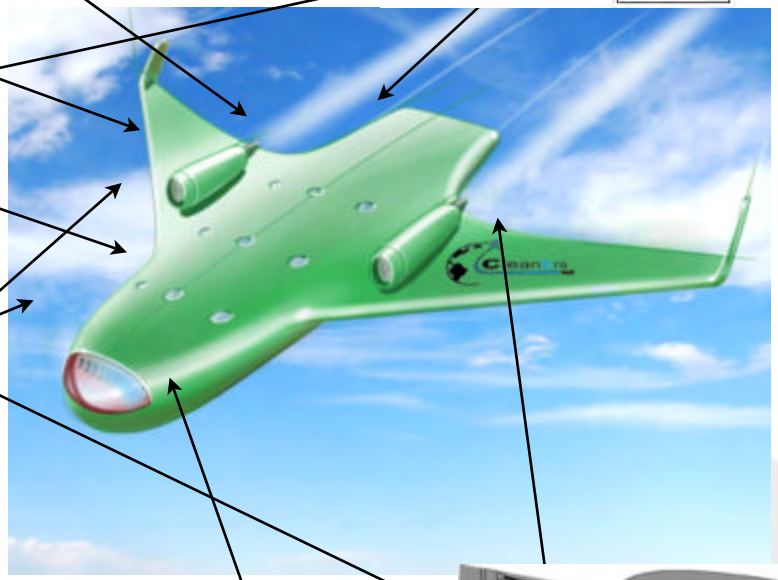
Aero Performance

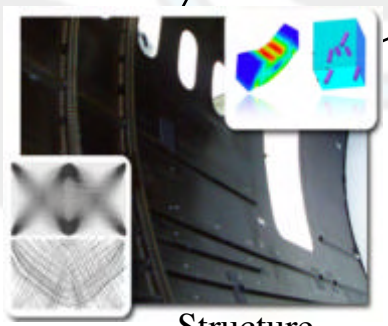


Flight Control



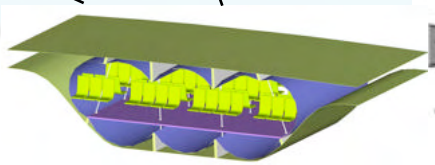




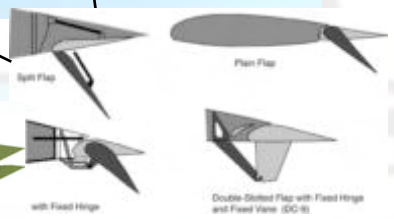


Structure

Engines



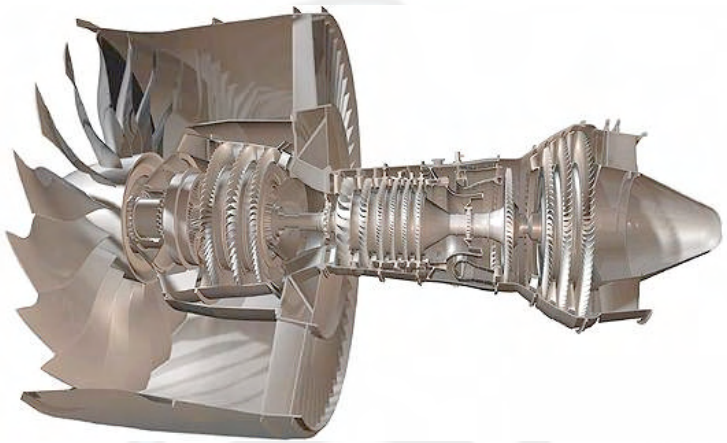
Pressure hull



High Lift

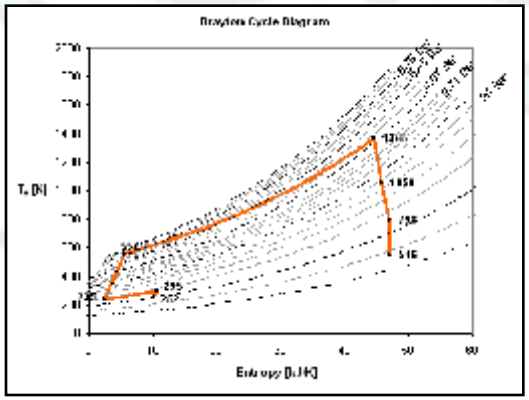
Focus on technologies

Engines

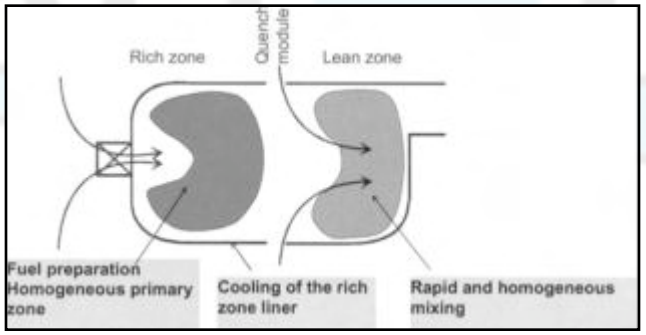


Geared Turbo fan

Improved turbine mat.



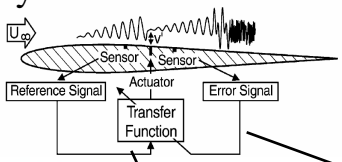
Inter cycle cooling



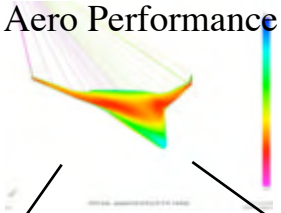
Advanced combustion

Acoustics

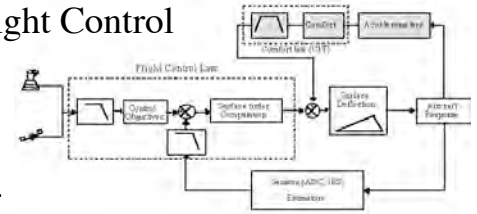
Boundary

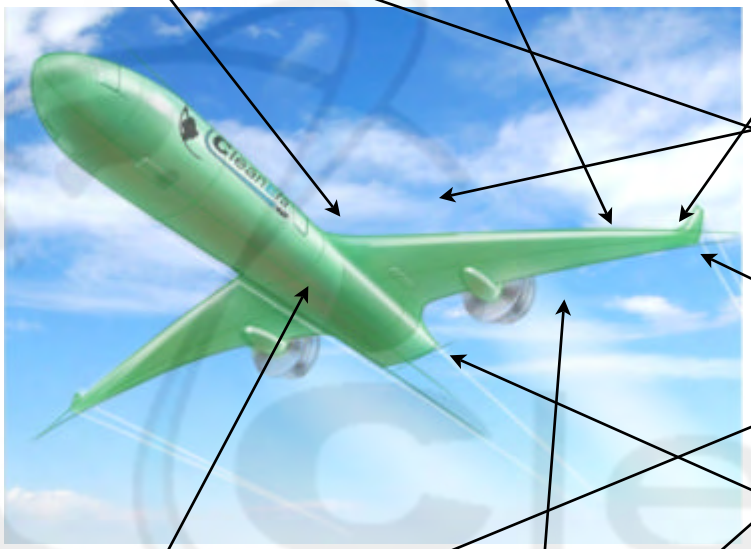


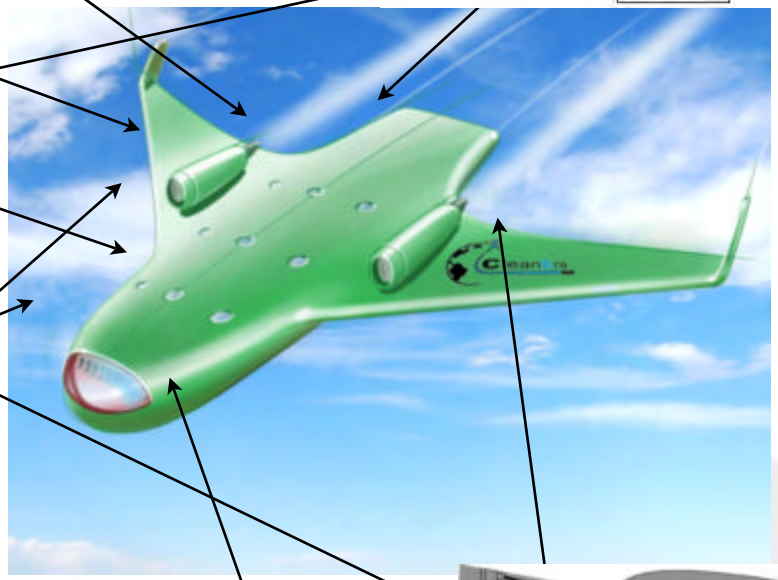
Aero Performance

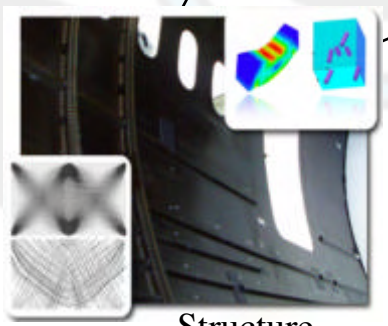


Flight Control



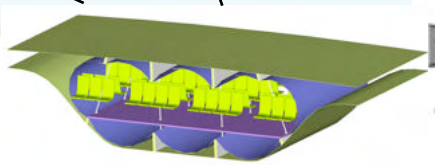




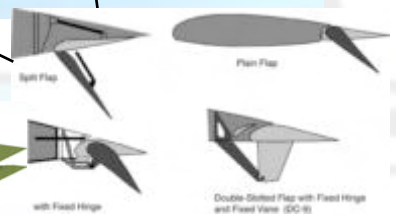


Structure

Engines



Pressure hull

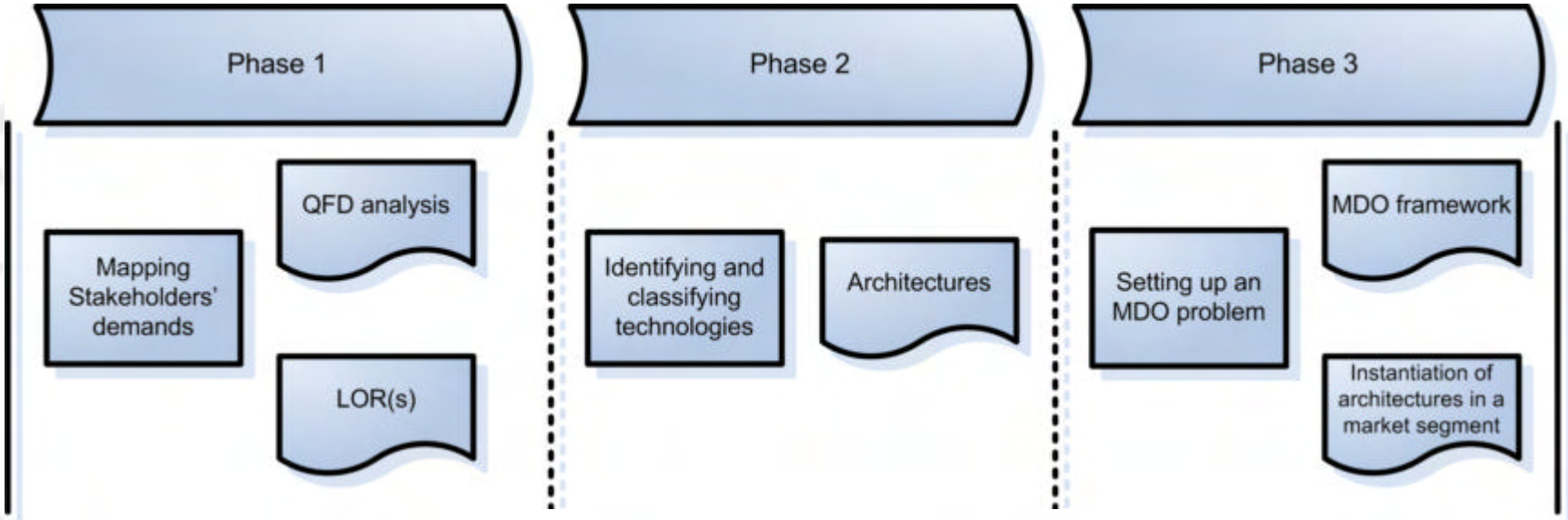


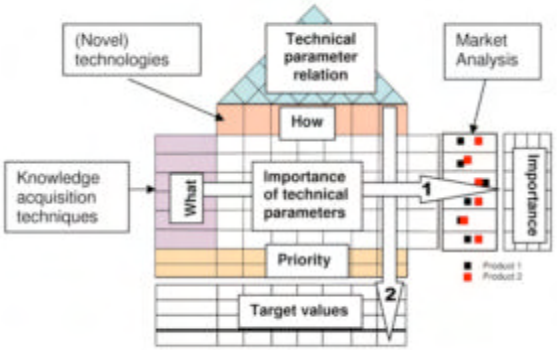
High Lift

Integration of technologies

CleanEra

Integration of Technologies





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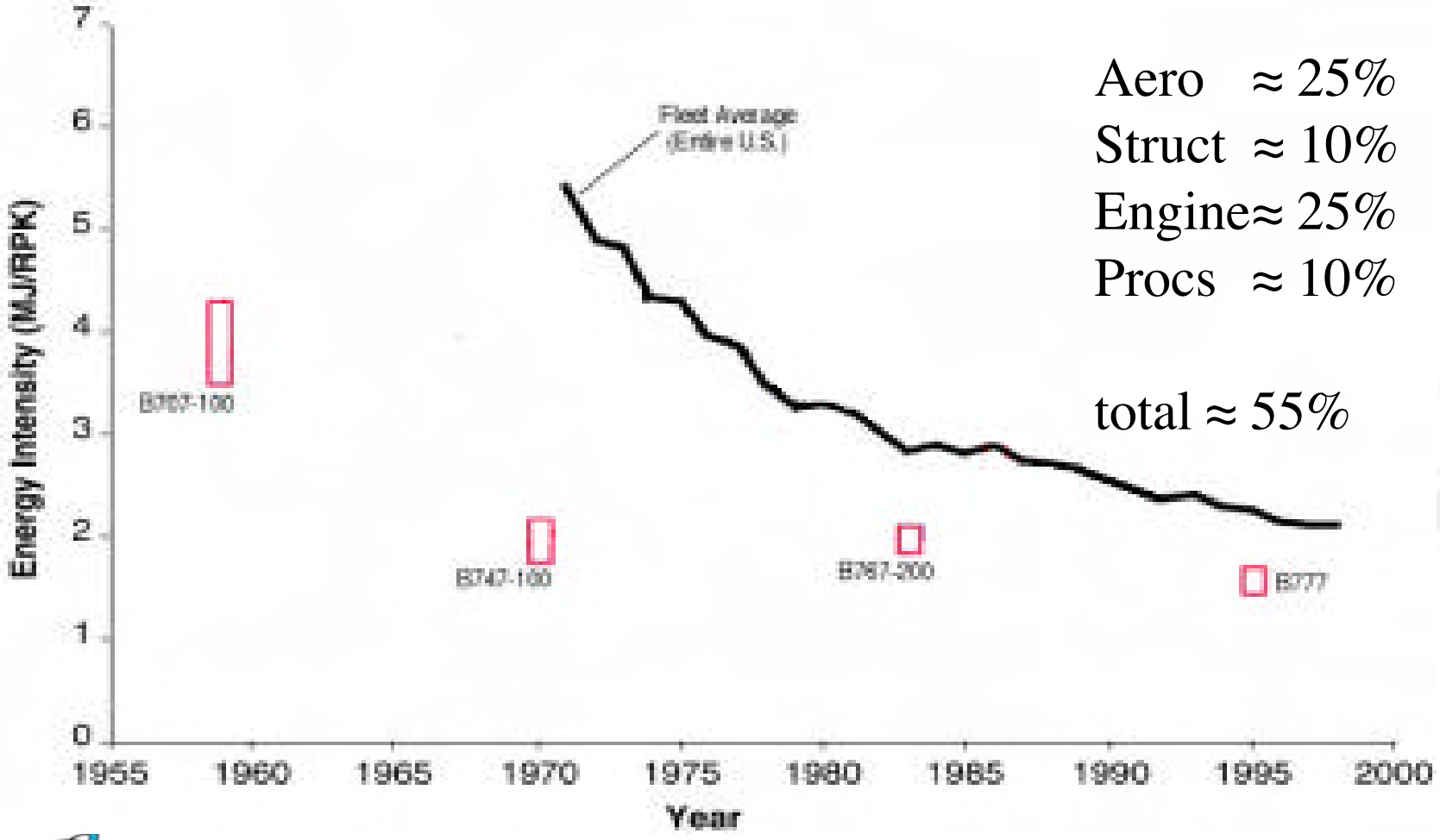
With these technologies a step change is possible



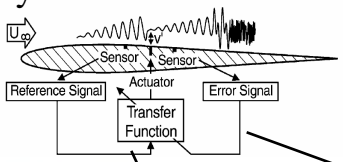
Aero ≈ 25%
Struct ≈ 10%
Engine ≈ 25%
Procs ≈ 10%

total ≈ 55%

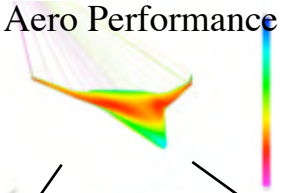
CleanEra

Acoustics

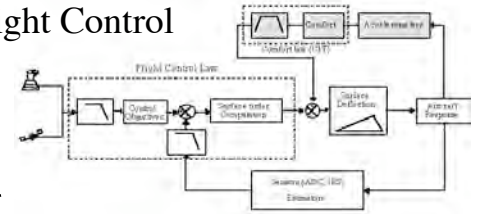
Boundary

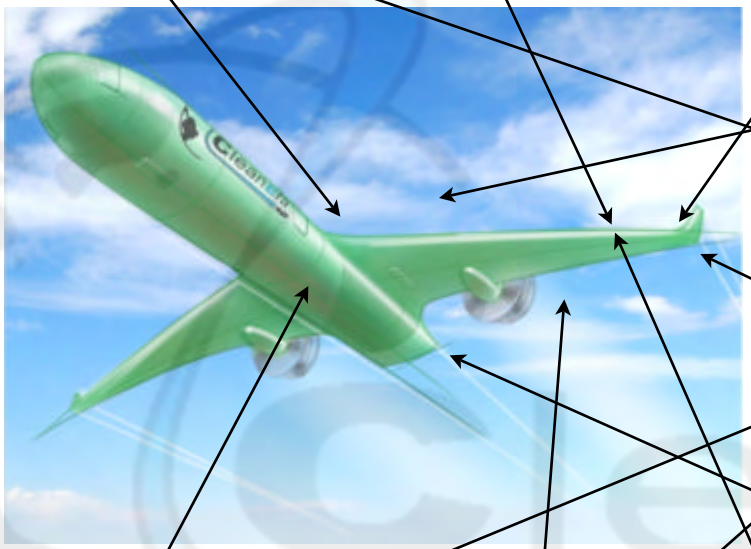


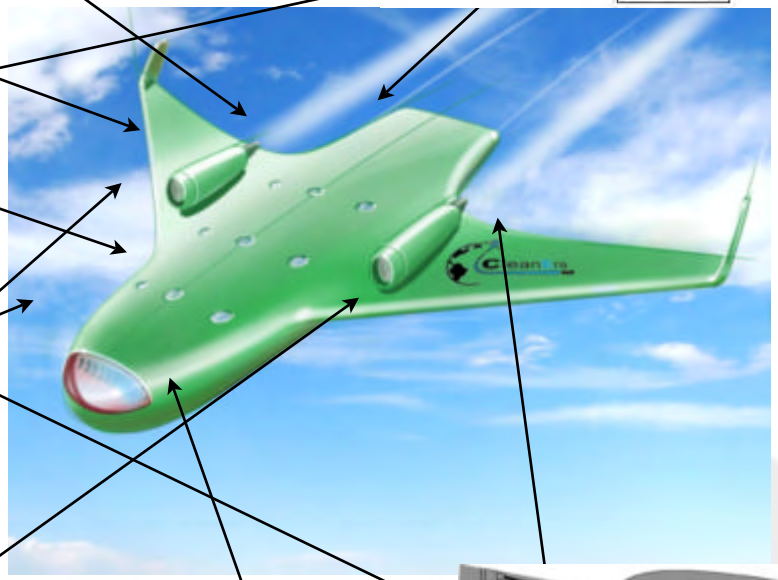
Aero Performance

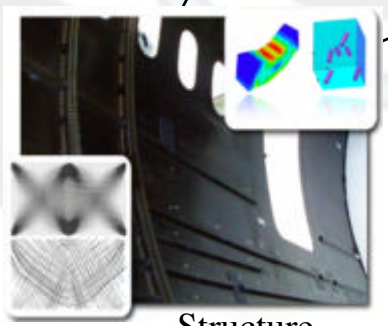


Flight Control





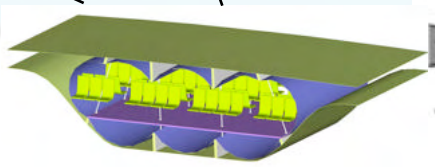




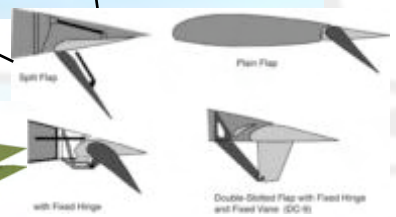
Structure

Engines

Energy systems



Pressure hall



High Lift

Focus on technologies

Effect of Alternative fuels?

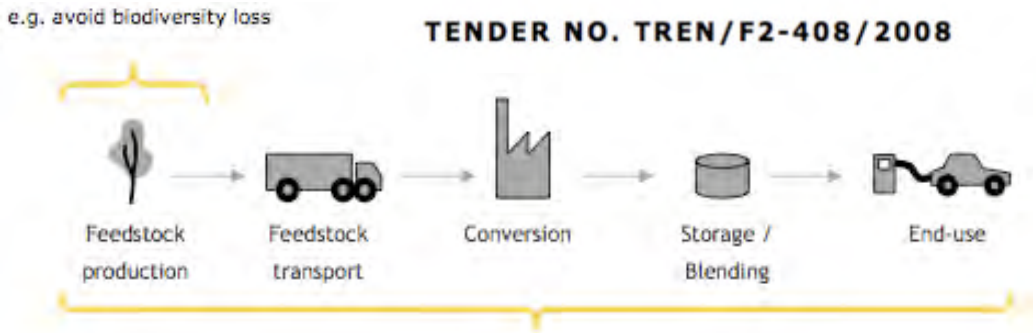
Biofuels

FLAMINGO

FEASIBILITY STUDY AND IMPACT ASSESSMENT ON THE USE OF ALTERNATIVE FUELS, INCLUDING BIOFUELS, FOR AVIATION

ECOFYS TU Delft NLR ABENGOA BIOENERGY Entec KEMA BioMCN ATR KLM

LH2



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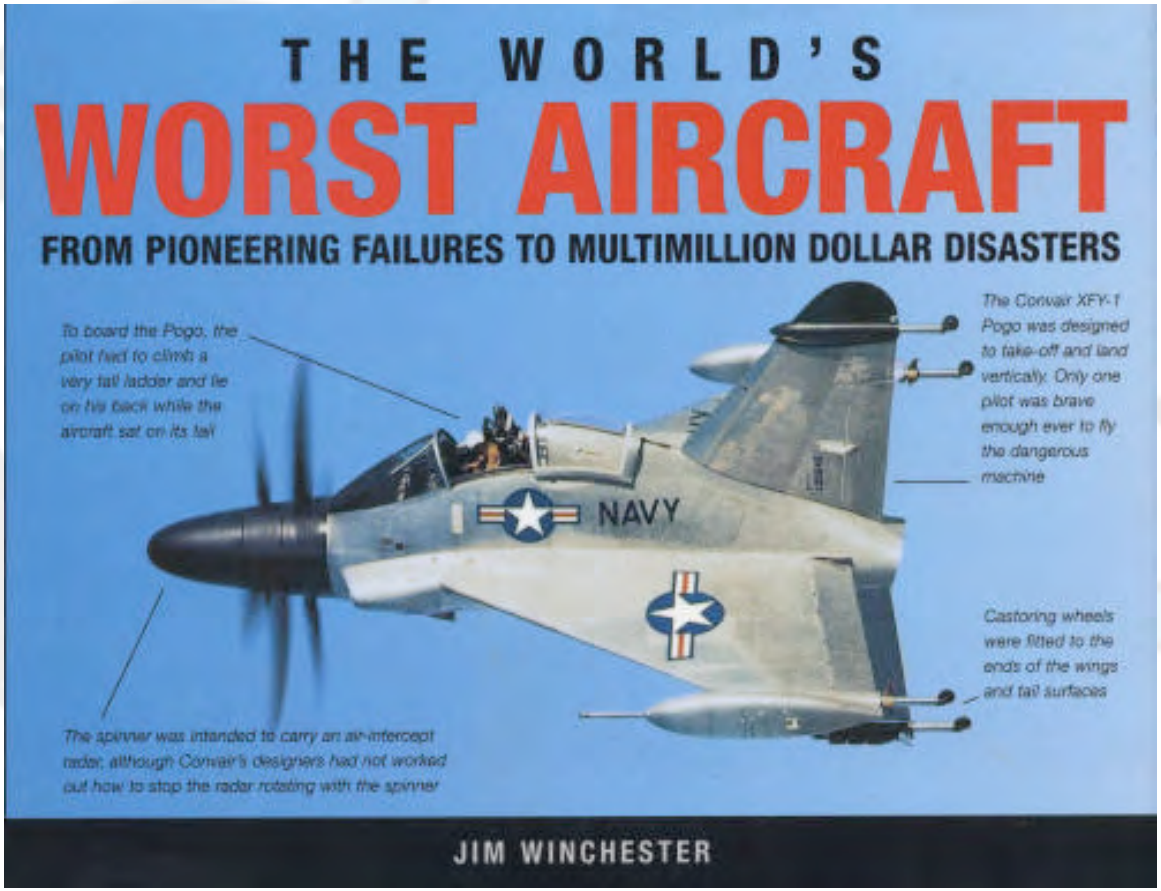
Many possibilities, but..



Enormous change that the first will go bankrupt:

- Excessive cost
- Long development times
- Long certification times
- Uncertainties and risks
- Etc.

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