DLR Ehemaligentreffen Braunschweig 17-Jun-05

Presented by

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Aero Design & Data Dept.

Bremen / Germany

Aerodynamic Design of Airbus High-Lift Wings

AIRBUS

Overview

- Zur Person

- Process & tools for high-lift design at Airbus
  - The high-lift wing design process
  - CFD
  - Windtunnel testing

- Examples from High-lift Wing Design Tasks
  - Integrated High-Speed / Low-Speed Design
  - Aero optimisation & Systems constraints
  - Multidisciplinary optimisation
  - Configuration issues

Zur Person

Daniel Reckzeh

34 Jahre

Stationen im DLR:

1998-2000 Wissenschaftlicher Mitarbeiter im DLR Braunschweig (SM-EA) im Rahmen der DLR-DASA „Nachwuchsinitiative", abgeordnet zu Airbus Bremen, Segment Produktaerodynamik, Fachgebiet: Aerodynamischer Entwurf von Hochauftriebssystemen

Stationen außerhalb des DLR:

1997-98 Selbständige Tätigkeit (eigenes Ingenieurbüro) im Unterauftrag von Airbus Bremen im Tragflügelentwurf

2000-03 Airbus Bremen - Entwurfsingenieur im aerodynamischen Entwurf in der Abteilung „High-Lift devices"

Meine jetzige Tätigkeit:

- Airbus Bremen – Engineering / Flight-Physics
- Aerodynamic Design & Data Domain (EGA)

Seit 2003 Leitung der transnationalen Abteilung „High-lift devices" (Bremen & Filton)

Seit 2005 Leitung des Segments „Configuration design" (Bremen)

Was ich aus dem DLR mitgenommen habe:

- Einstieg in die Luftfahrtbranche
- Erfahrungen in der „akademischen" & „industriellen" Aerodynamik
- Netzwerkbildung im Rahmen der NWI (Nachwuchsinitiative)

Zur Person

Welche Tätigkeitsbereiche habe ich durchlaufen ?

- Build up of a process chain for Geometry tools and CFD-Methods for high-lift wing design
- CFD-Tool development: Modelling of 3D separated flows on complete aircraft configurations
- Windtunnel model specification for high-lift wing development
- High-lift windtunnel testing and analysis for R&T and A380
- In charge of A380 high-lift wing aerodynamic design
- Coordination of A400M Airbus high-lift wing aerodynamic design
- Transnational Lead of High-Lift Devices Group, responsible for all Airbus High-Lift Wing Design activities
- Capability Manager Configuration Design

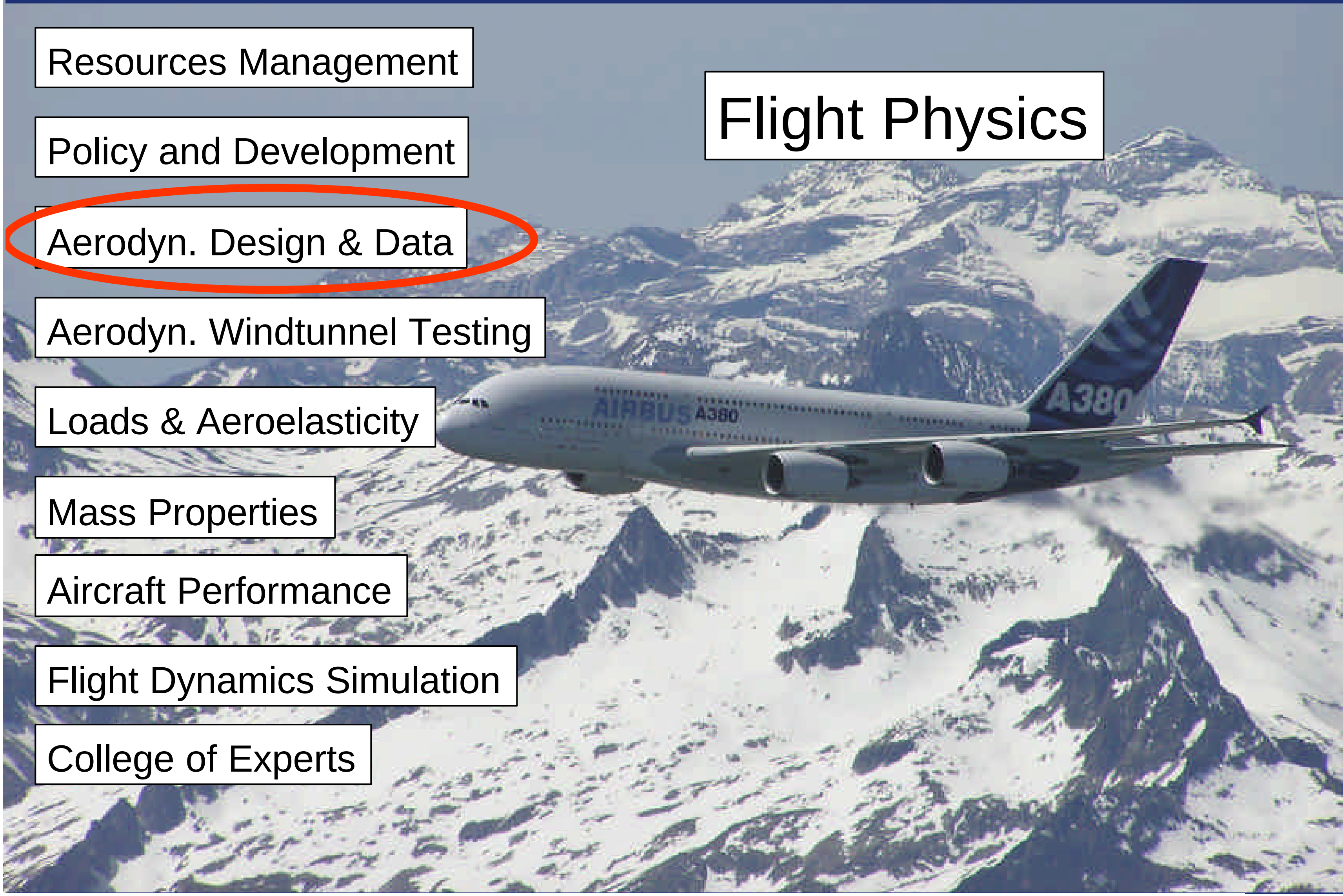
Organisation Airbus Engineering

Airbus engineering

WHERE IDEAS TAKE OFF

- Research / Technology
- Architecture & Integration
- Flight Physics
- Systems and Integration Tests
- Powerplant Systems
- Structure
- Flight Safety Enhancement
- Product Integrity
- Flight Operations

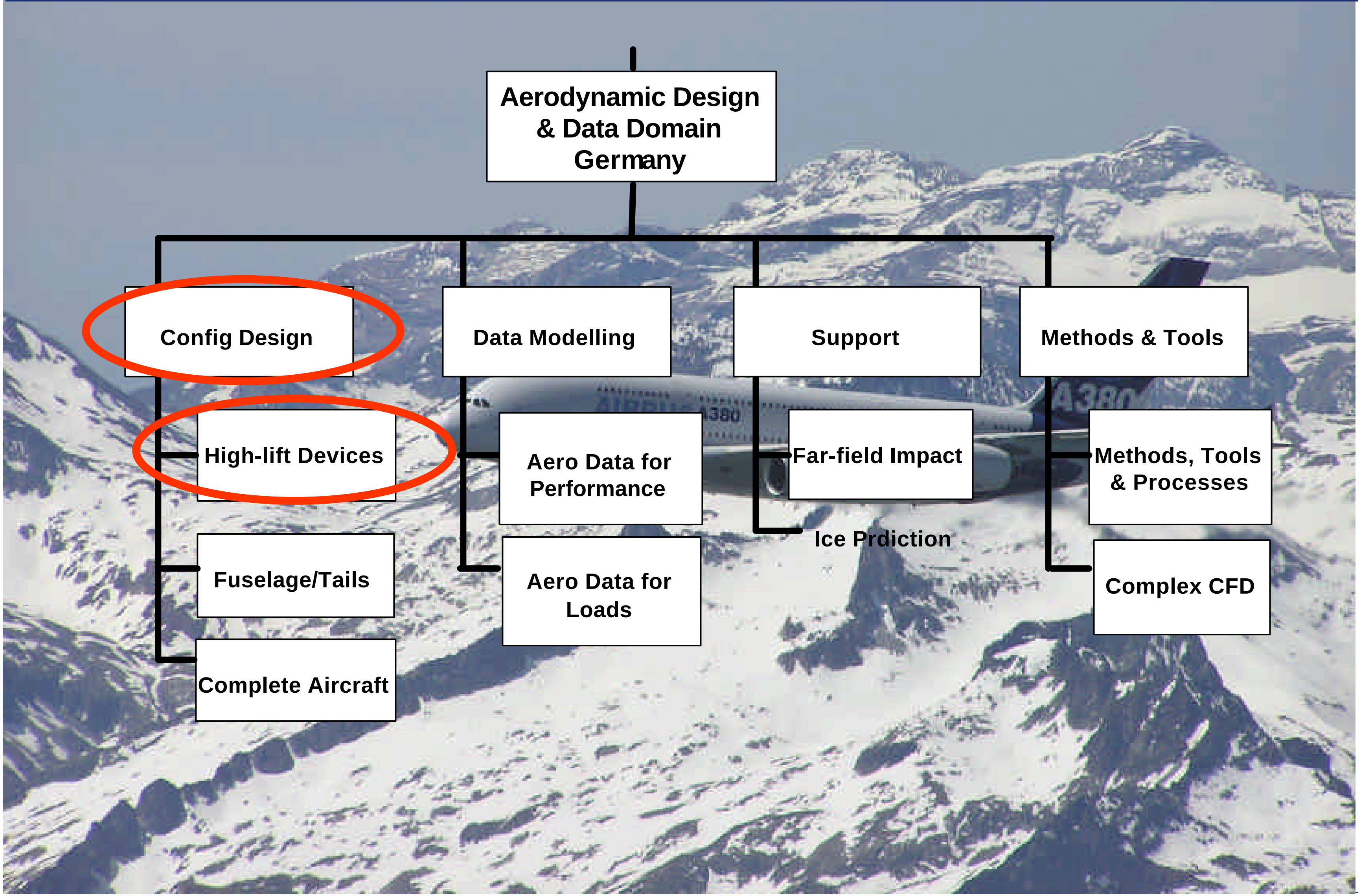
Organisation Airbus Flight Physics



Flight Physics

- Resources Management
- Policy and Development
- Aerodyn. Design & Data
- Aerodyn. Windtunnel Testing
- Loads & Aeroelasticity
- Mass Properties
- Aircraft Performance
- Flight Dynamics Simulation
- College of Experts

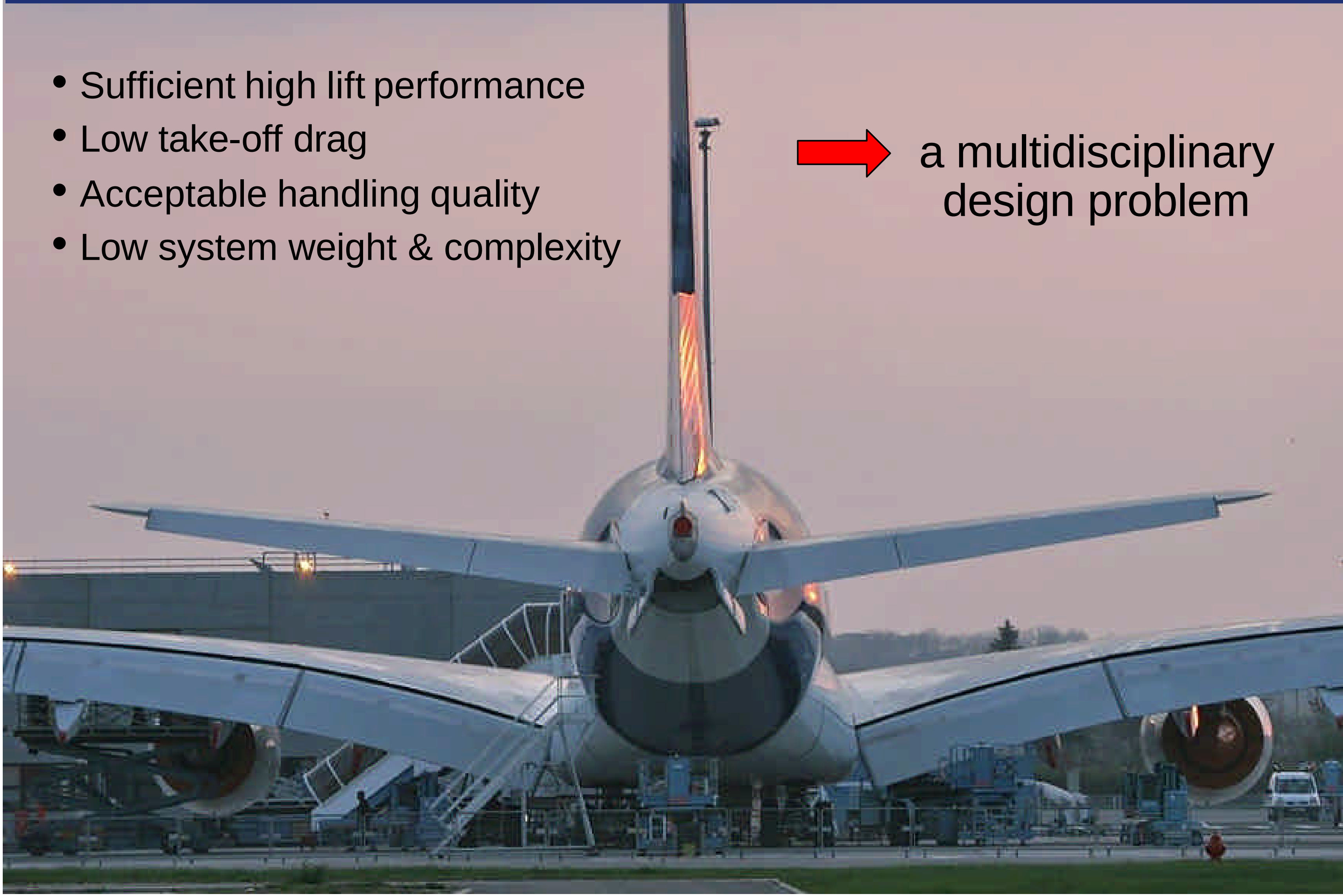
Organisation
Aero Design & Data Domain Germany



Requirements to the High-Lift Configuration

- Sufficient high lift performance
- Low take-off drag
- Acceptable handling quality
- Low system weight & complexity

→ a multidisciplinary design problem



The High-Lift Wing Aero Design Process

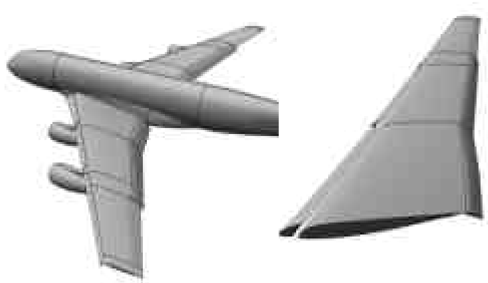
Inputs

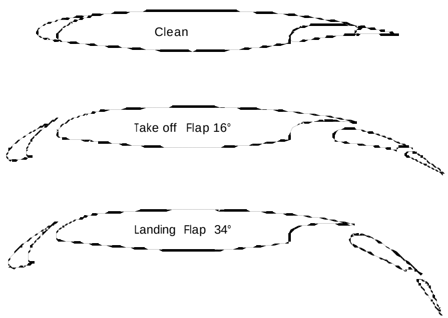
- TLAR (requirements, performance & noise targets)
- General A/C layout
- Wing planform
- Cruise Wing surface

High Lift Devices **Aero design & Master Geometry**

Outputs

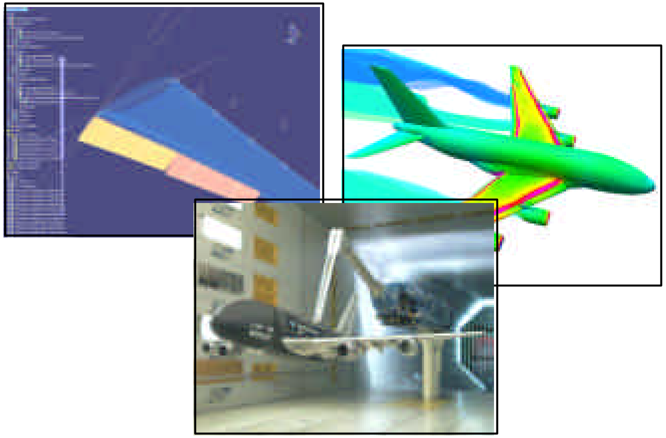
- High-lift configuration layout
- High-lift devices shapes
- Requirements for system design (Target kinematics, Settings, etc)



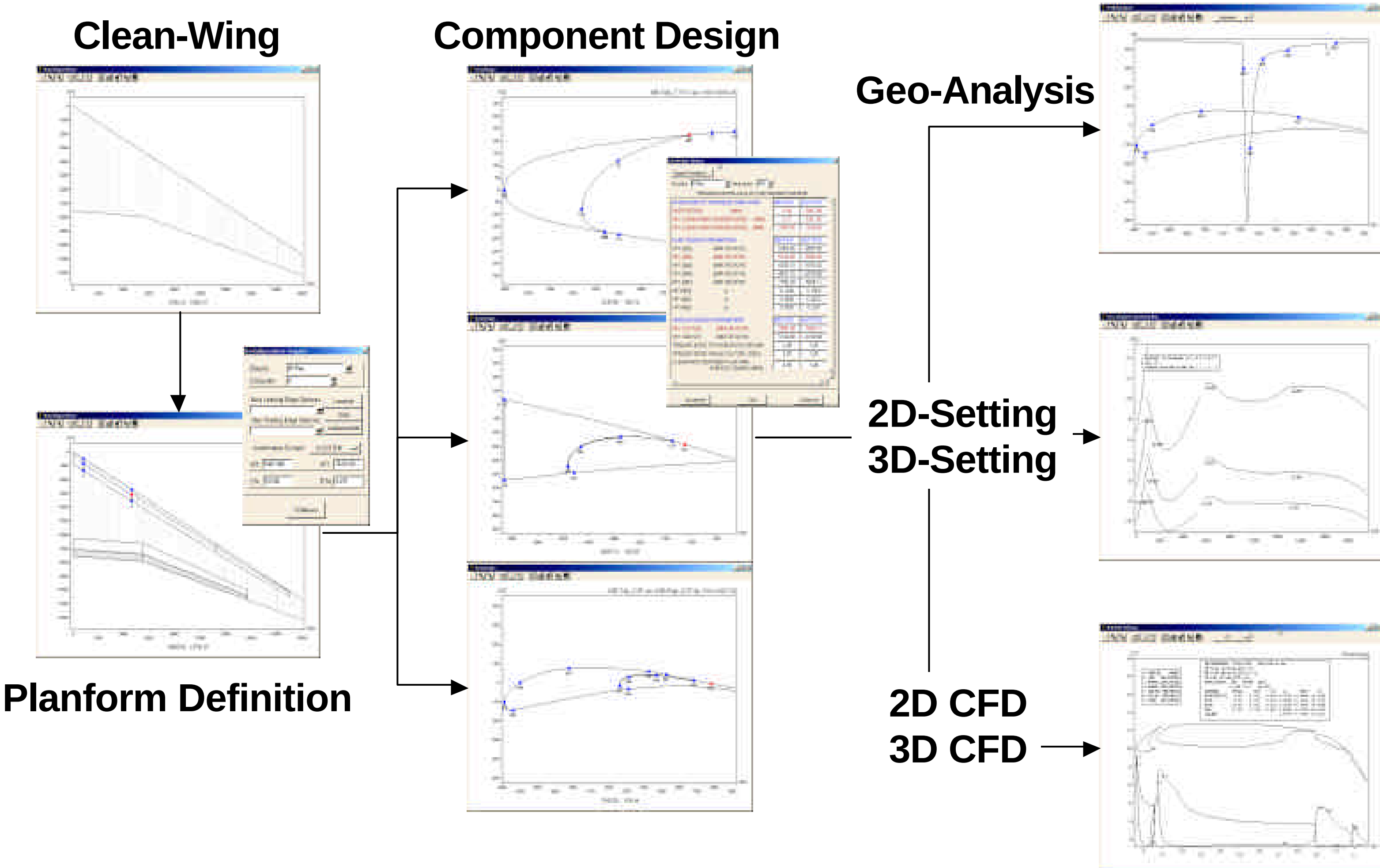


Tools

- CAD
- KBE aero design tools
- CFD Flow Analysis
- Windtunnel testing
- Aeroacoustic analysis



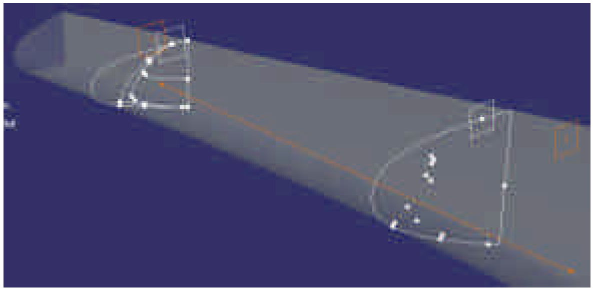
Parametric Shape Design & Analysis Tools



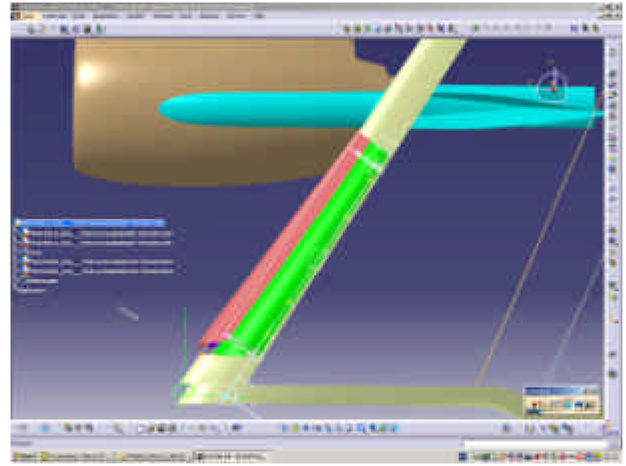
AIRBUS

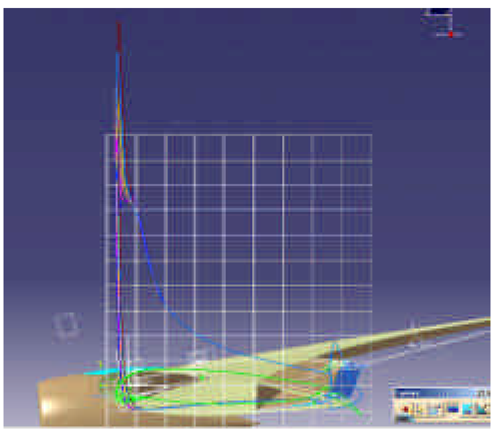
Parametric Shape Design & Analysis Tools

- Examples from Droop Nose Device Design

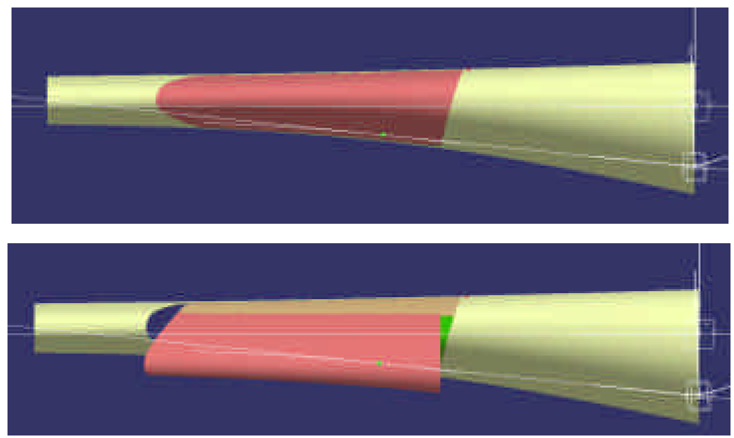


Shape design incl kinematic constraints



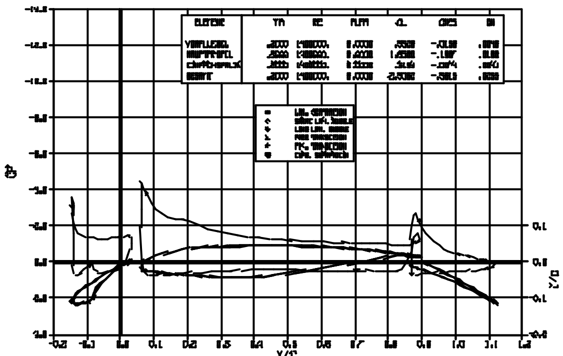


Aerodynamic analysis

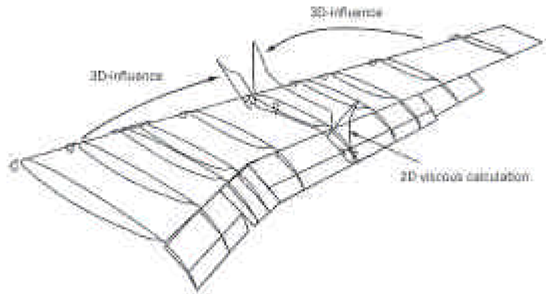


Target kinematics

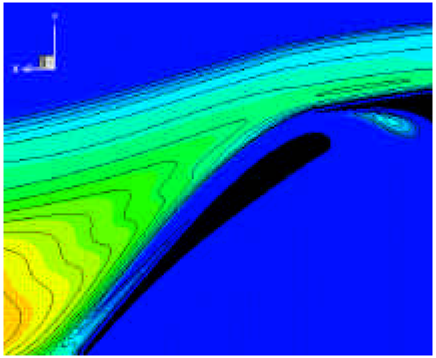
CFD-based High-Lift Wing Design



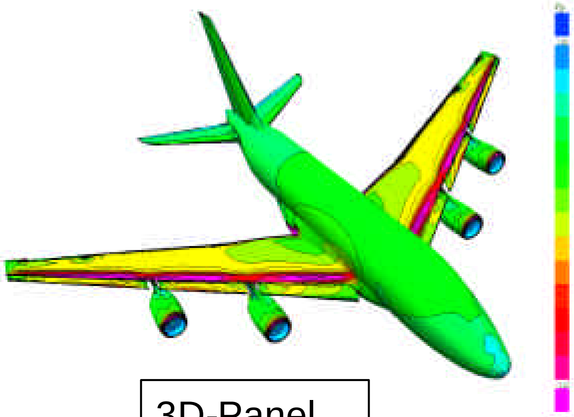
2D-Panel



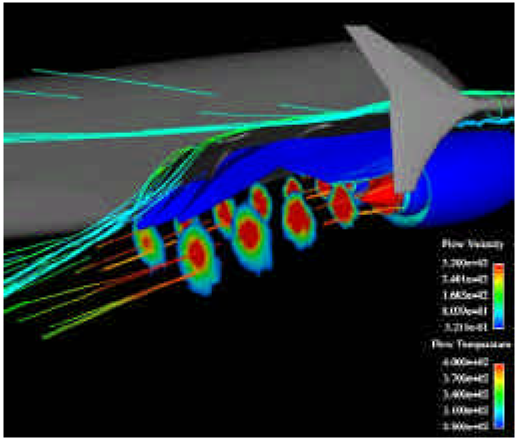
Quasi-3D



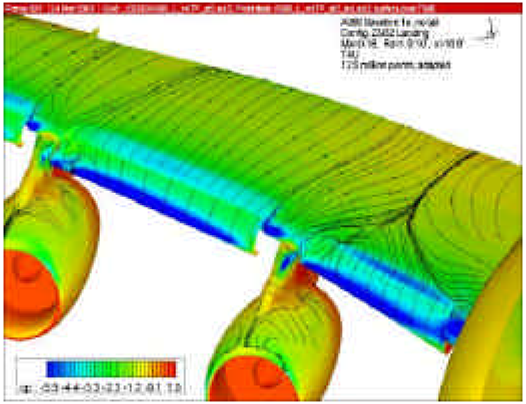
2D-Navier-Stokes



3D-Panel



3D-Euler

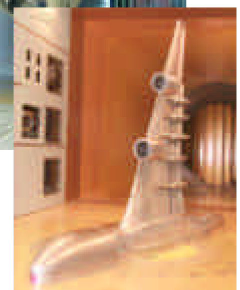


3D-Navier-Stokes

Windtunnels for Airbus High-Lift Development

A380 „Model chain“ (1)
Small Halfmodel X03
(Scale 1:32)

- LSWT Bremen (Re=1.5 Mio)
- KKK Cologne (Re=7 Mio)
- ETW Cologne (Re=25 Mio)



A380 „Model chain“ (3)
Complete model X06

- LSWT Filton (Re=1.5 Mio)
- F1 Toulose (Re=8 Mio)
- Q5m Farnborough (Re=6 Mio)

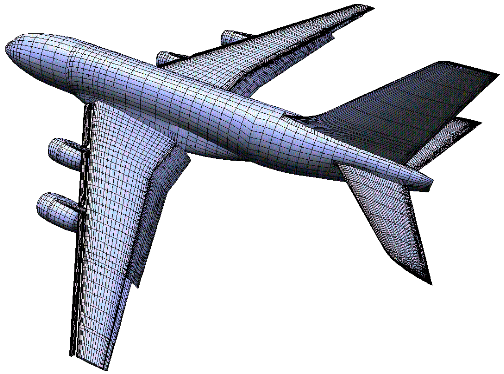
A380 „Model chain“ (2)
Large complete model X08
(Scale 1:17)

- DNW Emmeloord (Re=3.5 Mio)

Large halfmodel X08H

- LSWT Filton (Re=3.5 Mio)
- F1 Toulouse (Re=12 Mio)
- Q5m Farnborough (Re=10 Mio)

Tools for design verification: CFD vs Windtunnel ?

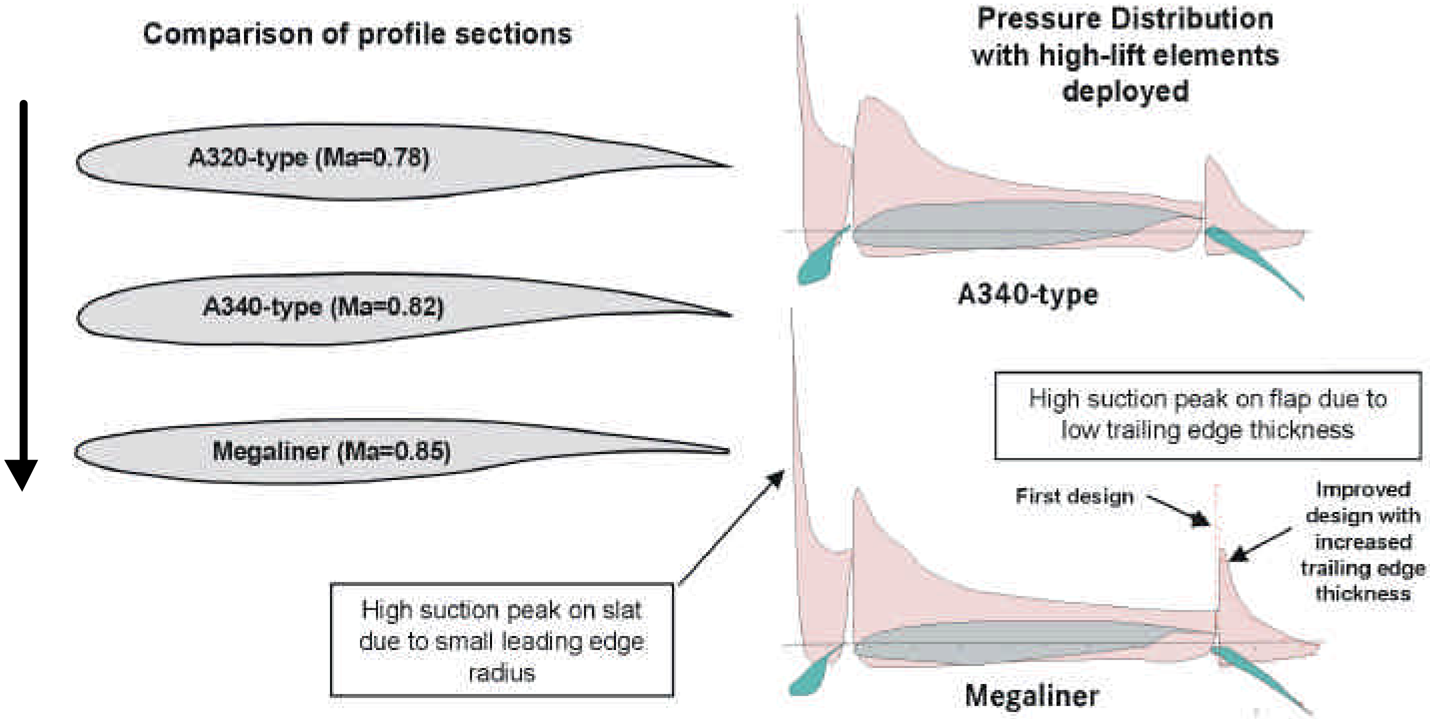


?

Designers' view (provocative) :

- CFD and Wintunnel are tools for design analysis.
  - *"CFD delivers fast pretty pictures but with partly questionable results"*
  - *"Windtunnel testing is extremely expensive and requires too much time"*
- Way out ?
  - *"Despite their discrepancies we can not live without the one or the other, the combination of both advantages makes it."*
  - CFD to be used in far more intensive combination with Windtunnel testing
  - The major step ahead for design will be the close-coupled use of reliable (i.e. validated) complex CFD

Integrated High-Speed / Low-Speed Design



- *Thin outer wing profiles with small leading edge radius:* high Slat-angle necessary, therefore long Slat-tracks with high weight and intregration problems
- *Thin rear profile thickness (high rear-loading in cruise):* low flap-thickness with high boundary layer loading, high flap structure weight, flexible structure gives difficulties in maintaining target flap gap

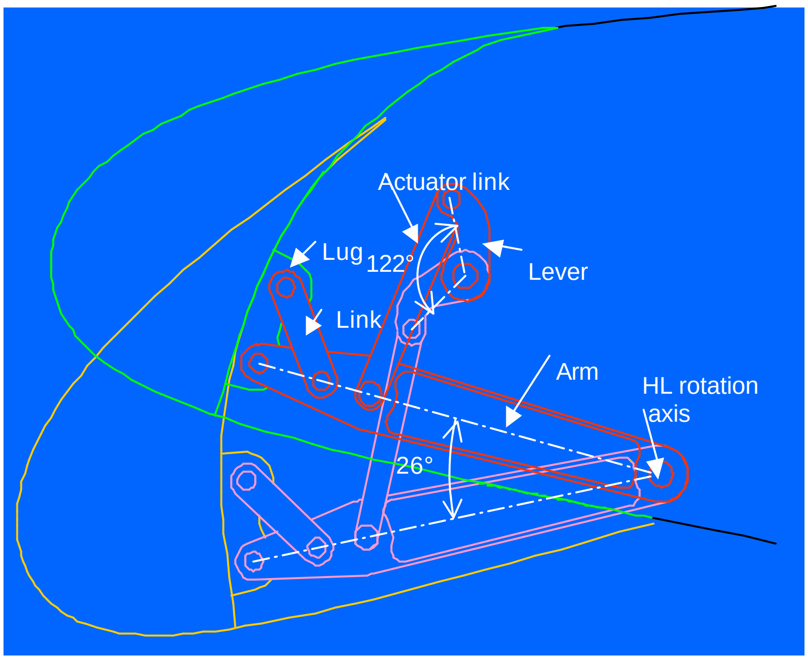
The droop-nose device

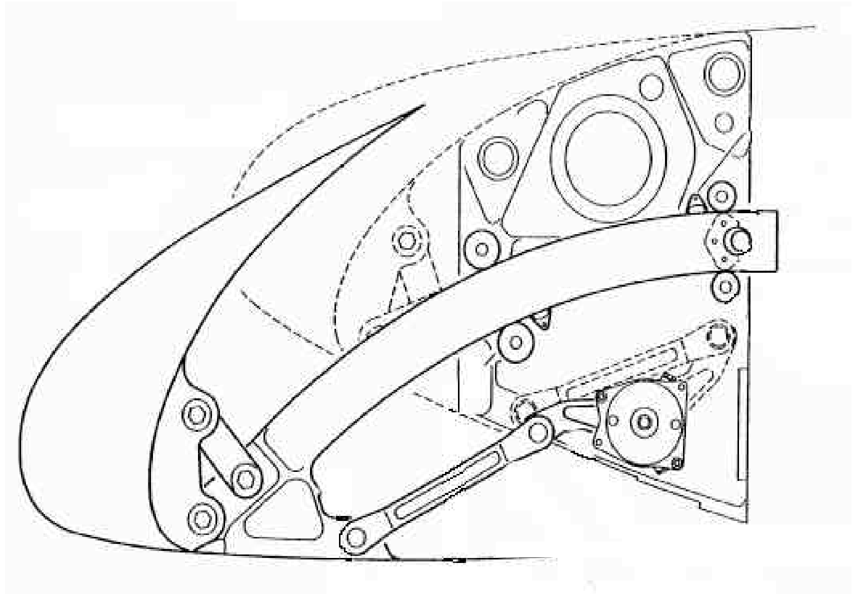
Droop Nose Device

lower drag
reduced maximum lift

Slat

higher maximum lift
increased drag



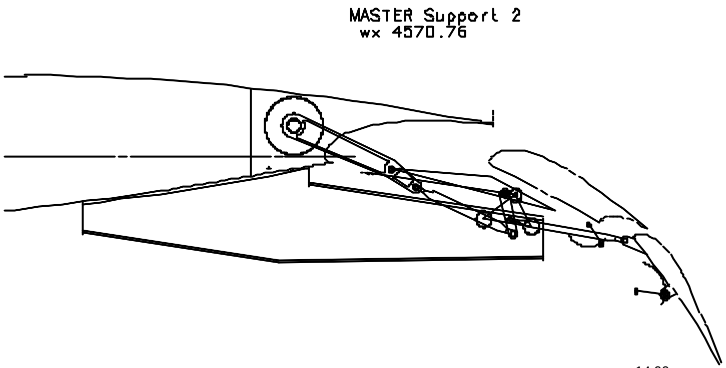


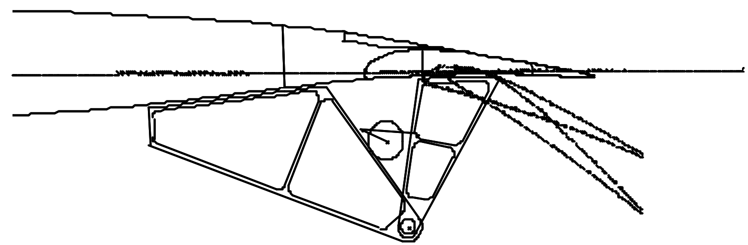
Selected for inboard wing of A380

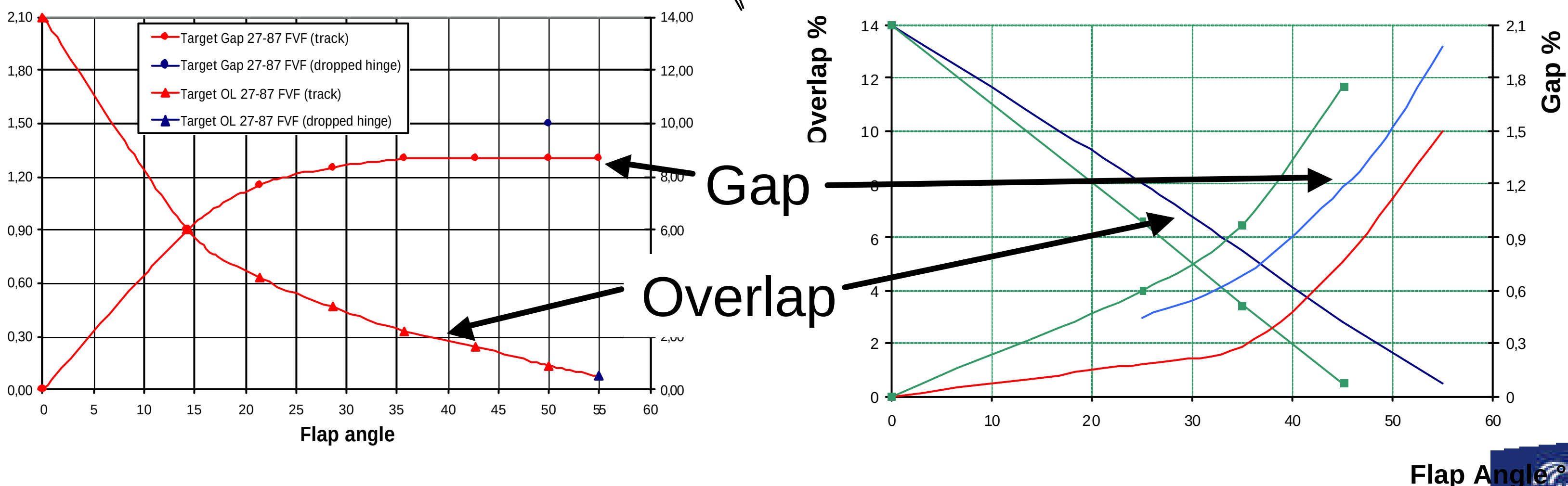
Kinematics system versus Aero target

Track mechanism fulfills Aero Target, but complex and heavy

Dropped Hinge mechanism insuffiecient to Aero Target, but less complex and lighter

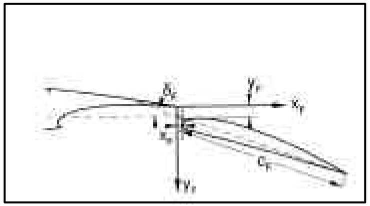


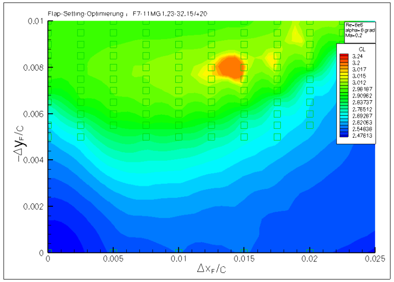


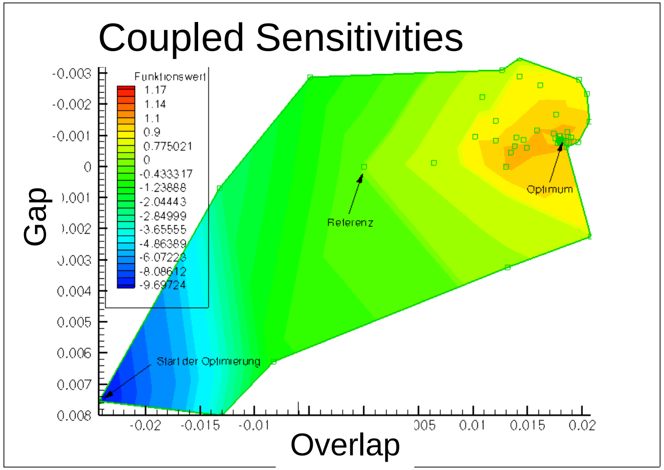


Multidisciplinary design optimisation

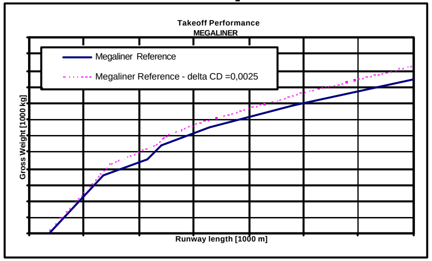
- Aero dependancies



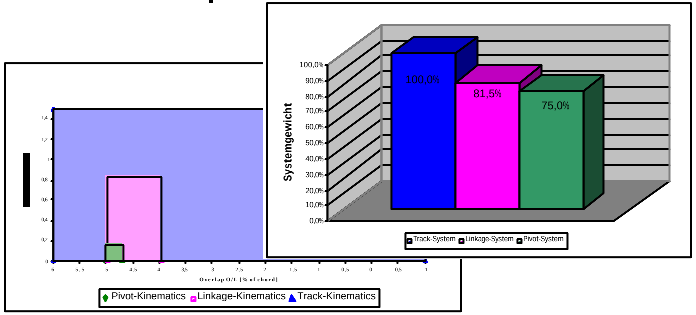


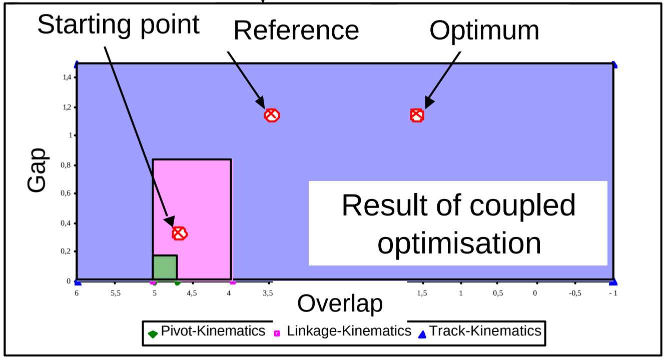


- Performance dependancies

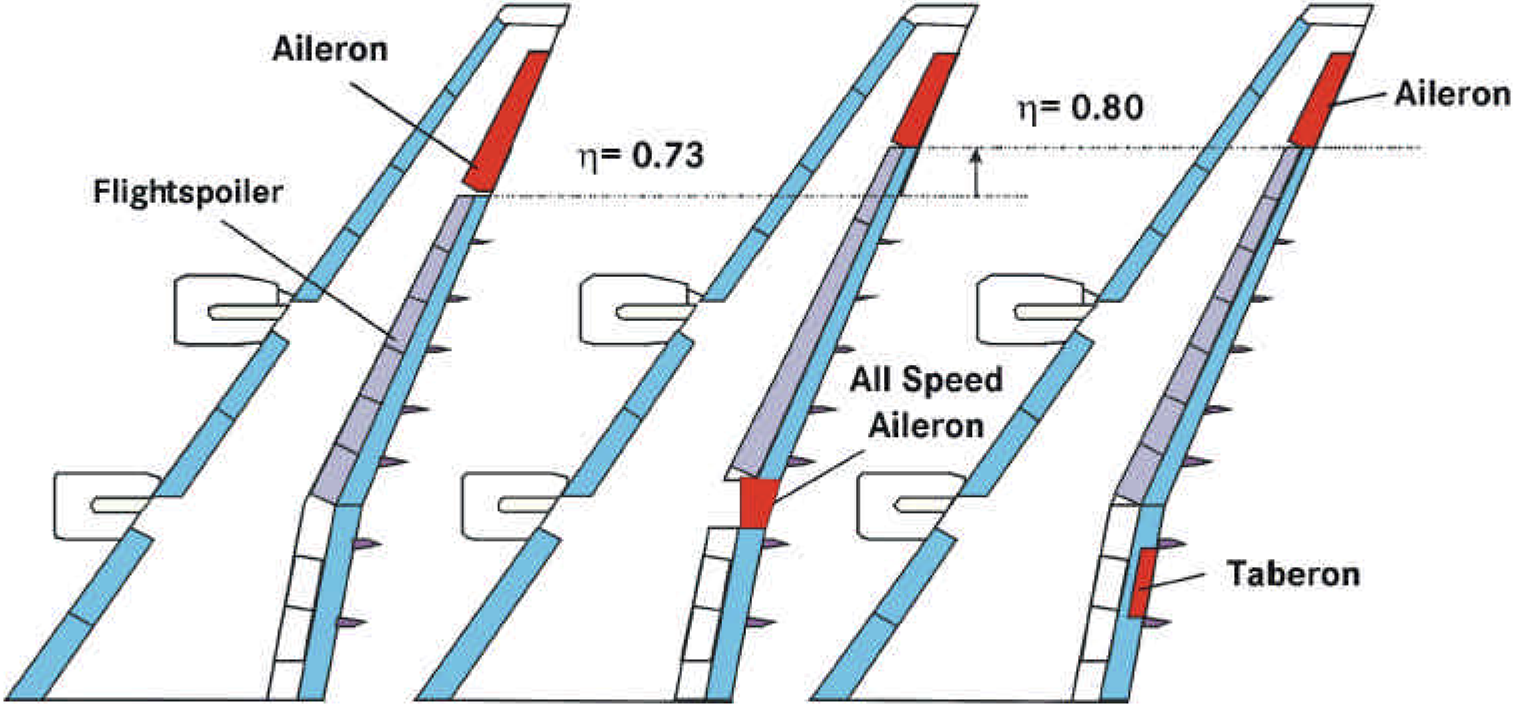


- Systems dependancies



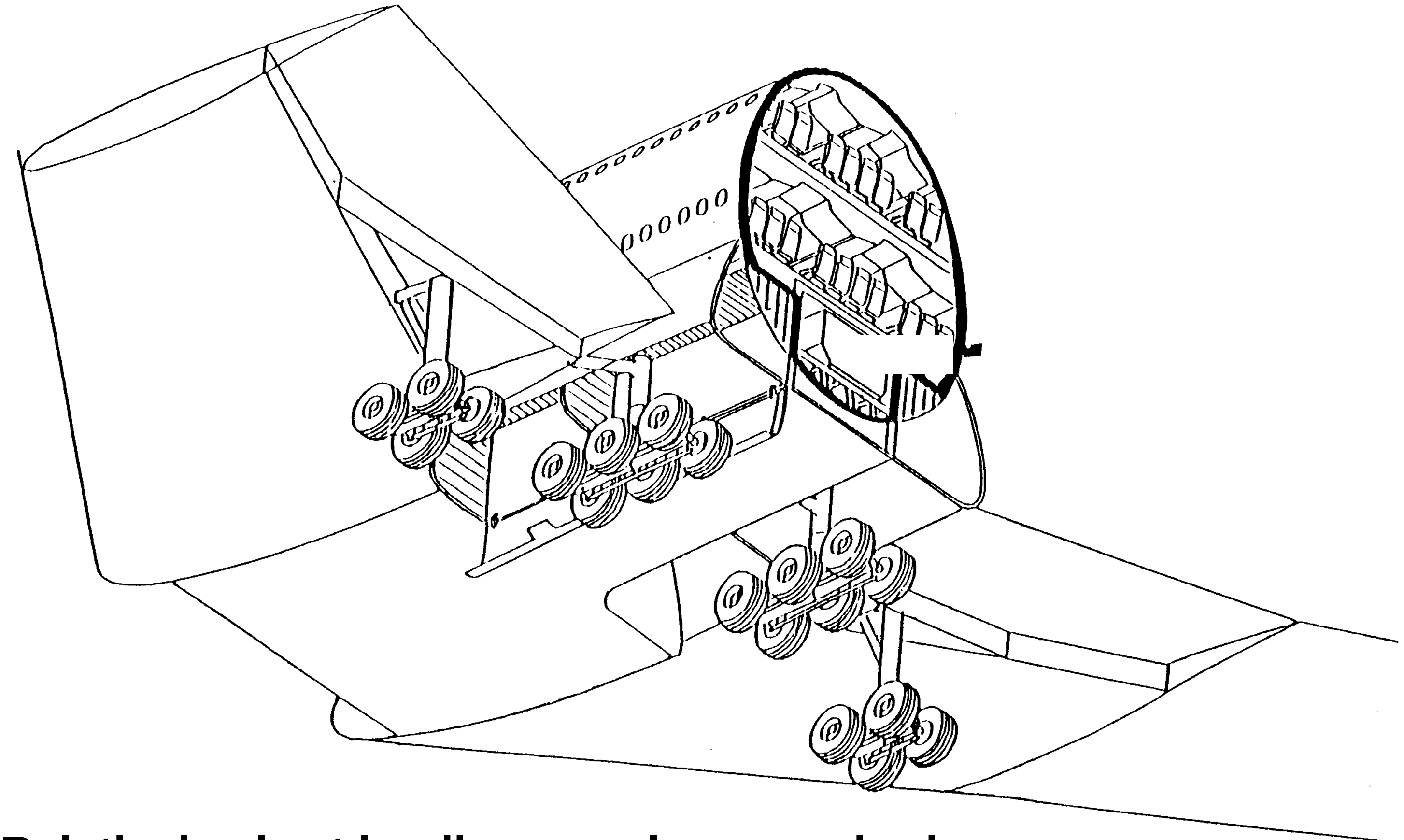


Wing Layout Studies



- *Flexible wing structure with aileron reversal tendency:* Application of an inboard „All-Speed-Aileron“ with increased outer flap span, resp. application of an inboard „Taberon“

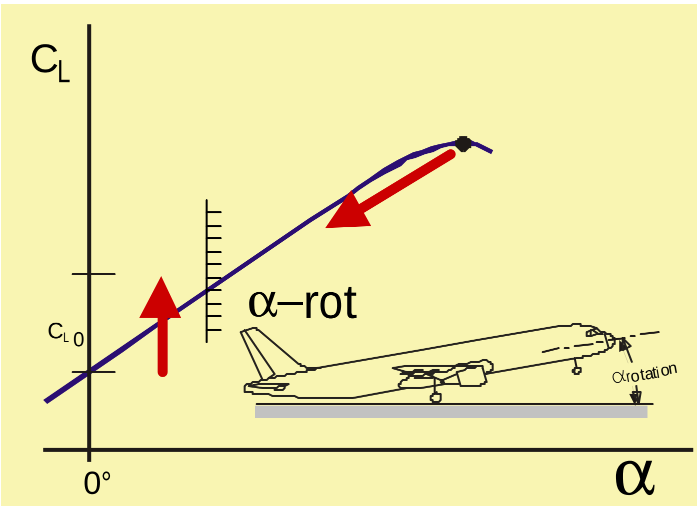
Impact of the landing gear height



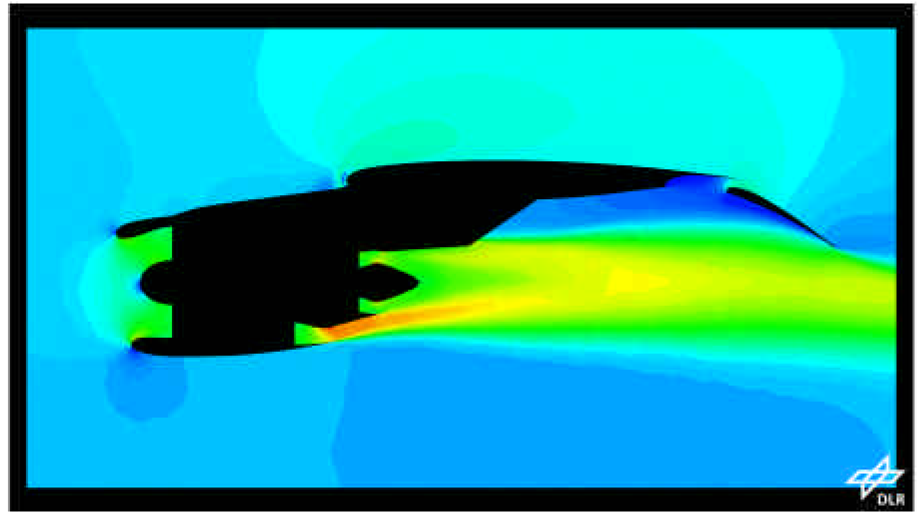
Relatively short landing gear legs required
- **to control aircraft weight**
- **to improve space allocation for I/B flap**

Impact of the landing gear height

fuselage close to ground
➔ rotation limit



engine close to wing
➔ engine exhaust jet blowing on flaps



challenge :
sufficient lift at α = 8°...10°
but maximum lift can be somewhat compromised (without negative effect on T/O performance)

challenges :
- prediction of aerodynamic ínterference
- vibrations by turbulent engine exhaust
- temperatures on high lift elements – material ?

Conclusions

- **High-Lift Design is a major driver for overall wing design**
- **Continuing adaptation of the high-lift wing layout to the current aircraft requirements:**
  aerodynamic design not better than necessary
- **Optimisation under multidisciplinary constraints:**
  small penalty for aerodynamics can cause large benefit for other disciplines
- **Consequent design verification with high Reynolds-number testing and CFD predictions is necessary to reduce (unwanted) margins for the aircraft as far as possible**
- **Design decisions more and more based on CFD alone**
- **A closed multidisciplinary design loop is not possible due to the complexity of the task**


Vielen Dank für die Aufmerksamkeit !
Fragen ?
Jetzt, gleich, oder: Daniel.Reckzeh@airbus.com
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A380

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