2nd AIAA Drag Prediction Workshop

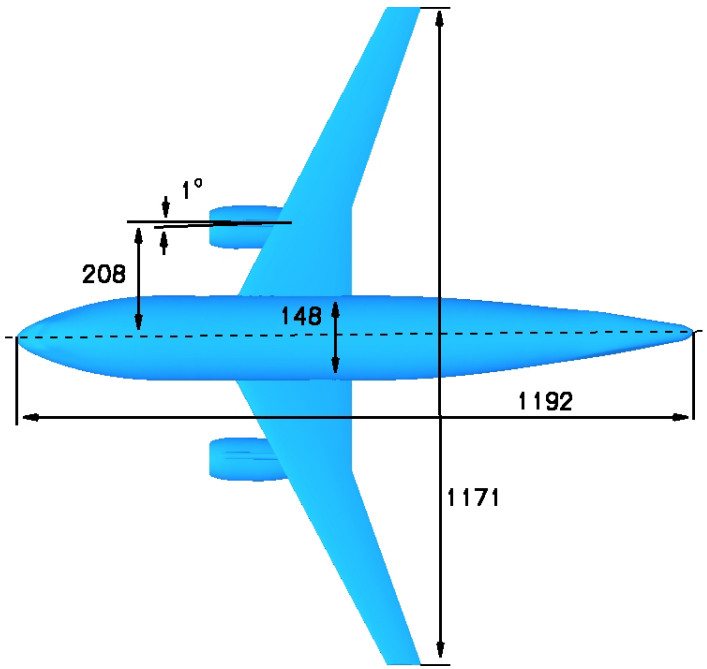
DLR-F6 Geometry & Issues

M. Rakowitz

DLR, Institute of Aerodynamics and Flow Technology, Braunschweig, Germany

DLR-F6

- Airbus-like wind tunnel model, 2 through flow nacelles
- design point: Ma = 0.75 , C_A = 0.5 , Re = $3 \cdot 10^6$
- wind tunnel campaigns in cooperation with ONERA (1990-1998)



F6 History

- F6 is a modification of F4 with the aim to have a more elliptic lift distribution and less boundary layer separation at the rear upper wing surface
- High speed tests with several through flow nacelles in ONERA-S2MA
- Design about 25 years ago

Geometric Details

F6 differences to F4:

- **DEF 2- DEF 4 R4/4 airfoil instead of R4**
- **translation of airfoil at kink → smoother surface**
- **different twist distribution**
- **DEF 3 at eta= 0.84 instead of eta = 0.7 (more elliptic lift distribution)**

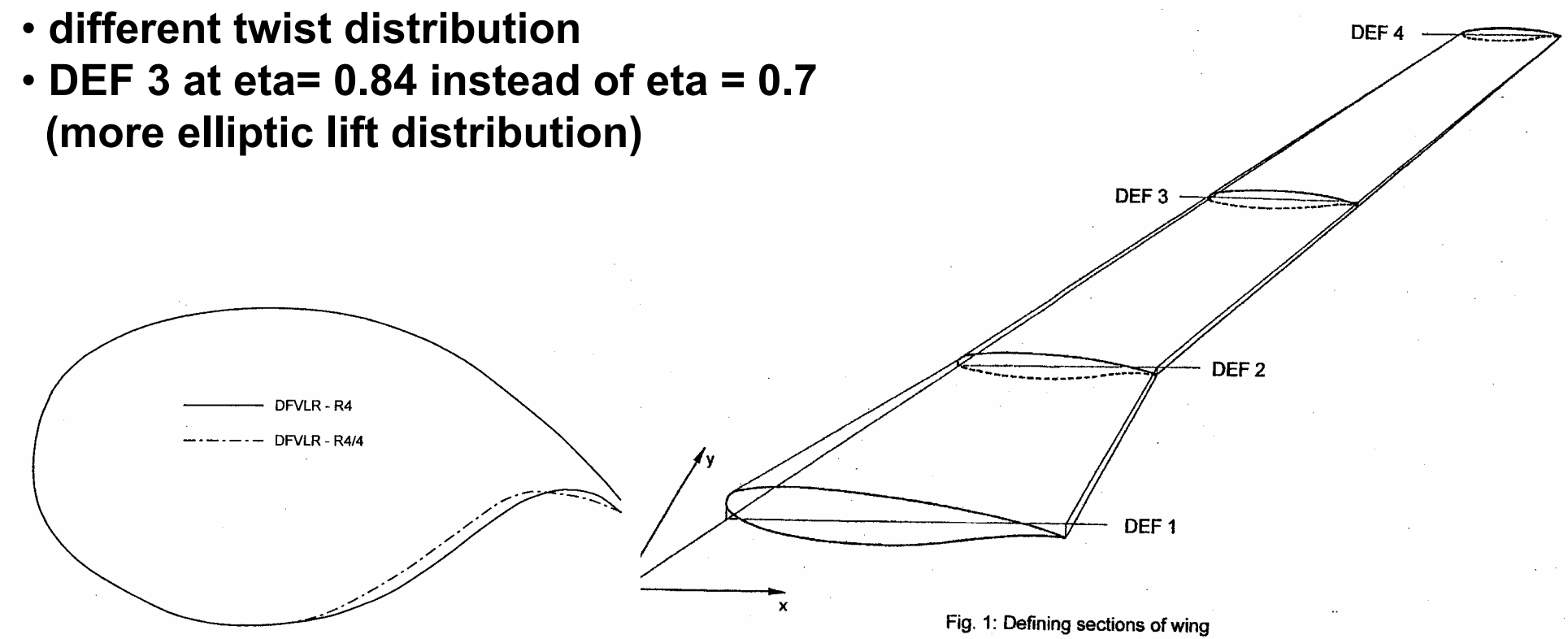
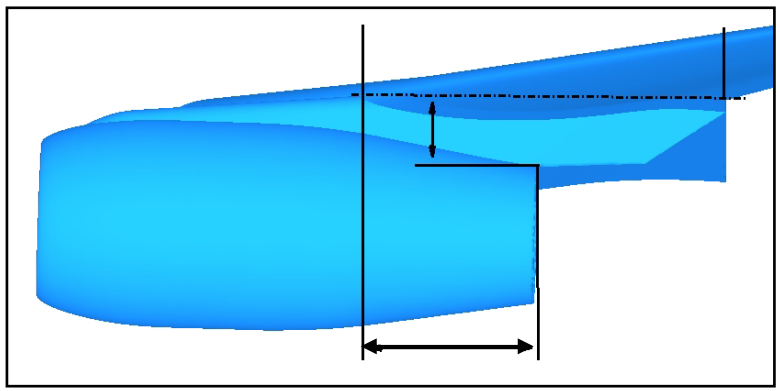


Fig. 1: Defining sections of wing

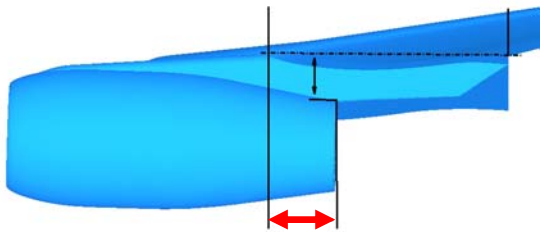
DLR-F6 Nacelle

long nacelle: CFM-56-L

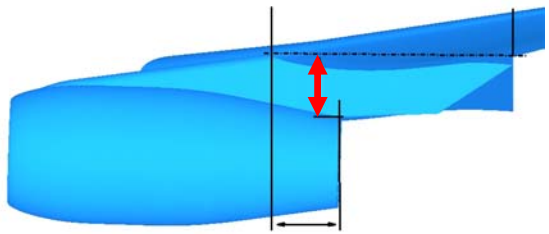
CFM-L-1



CFM-L-2



CFM-L-3



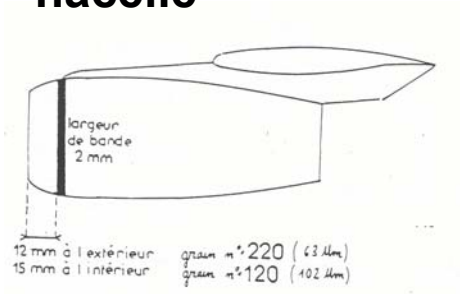
choice for DPWII:

CFM-L-1: closest position relative to wing → highest interference drag

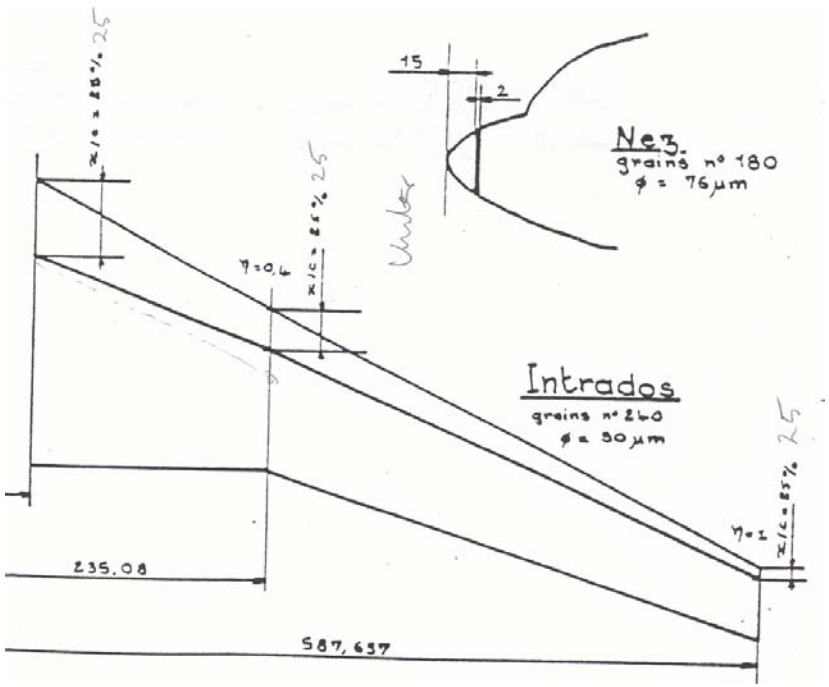
Wind Tunnel Trip Locations

Simplification for DPWII: for CFD only trips on wing

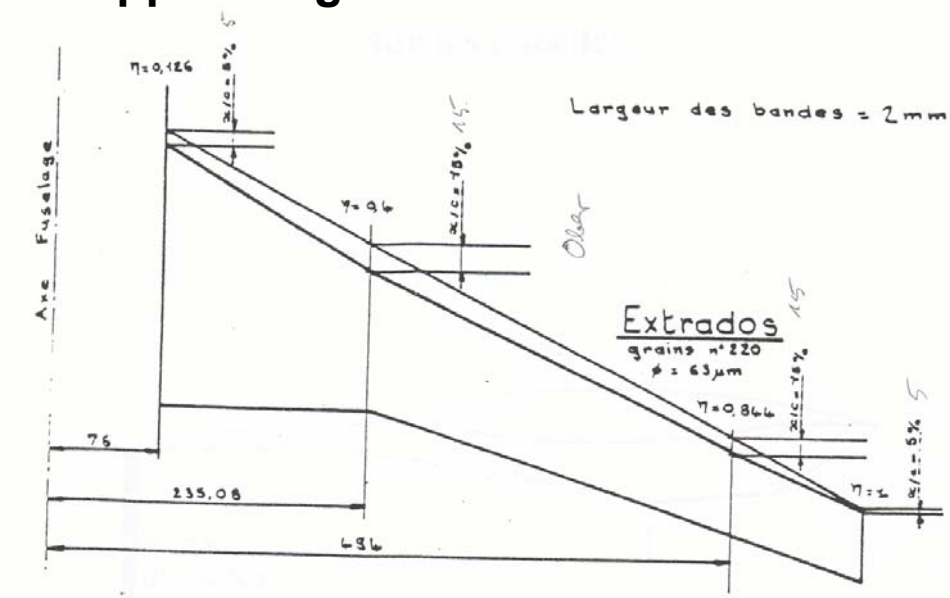
nacelle



lower wing and fuselage



upper wing



Geometric Measurement

- Measurement with FARO Goldarm (tol.: 5/100 mm) at DLR shop Cologne
- Measured coordinates compared to original NC-production coordinates

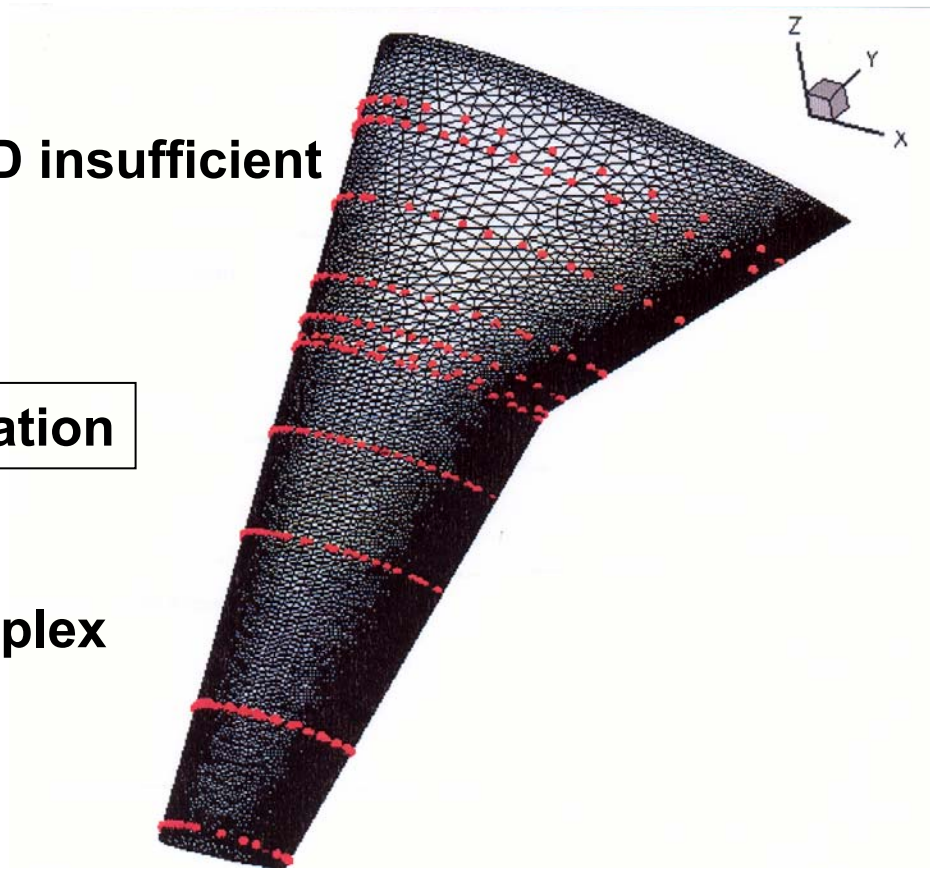
- CAD modelling for measurement
- Mechanical alignment of wing with CAD insufficient

therefore

Realignment using numerical optimization

- Centaur™ surface grid
- transformation matrix/least-squares/suplex (Stefan Melber, DLR)

→ wing shape ok



FEM - Aeroelastic Wing Deformation

- **Subcontract to Dynatec GmbH Braunschweig**
- **Modelling of wing attachment and cavity**

FEM model
10-nodes-tetras

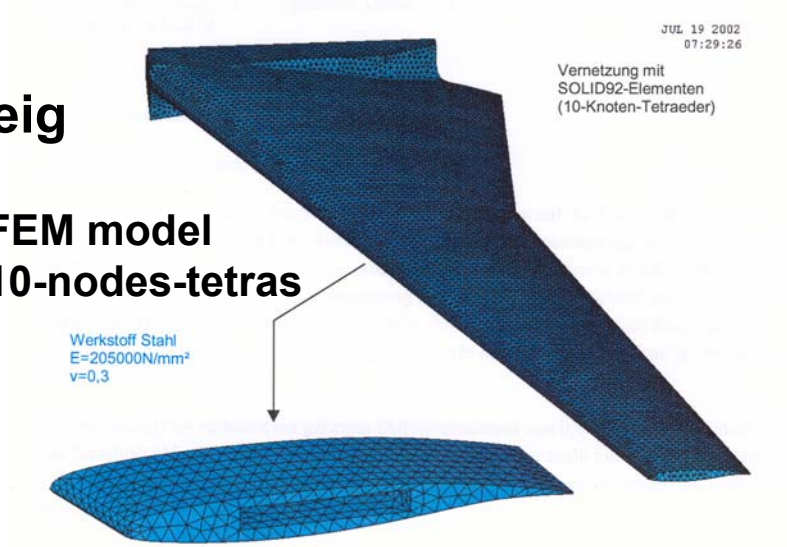
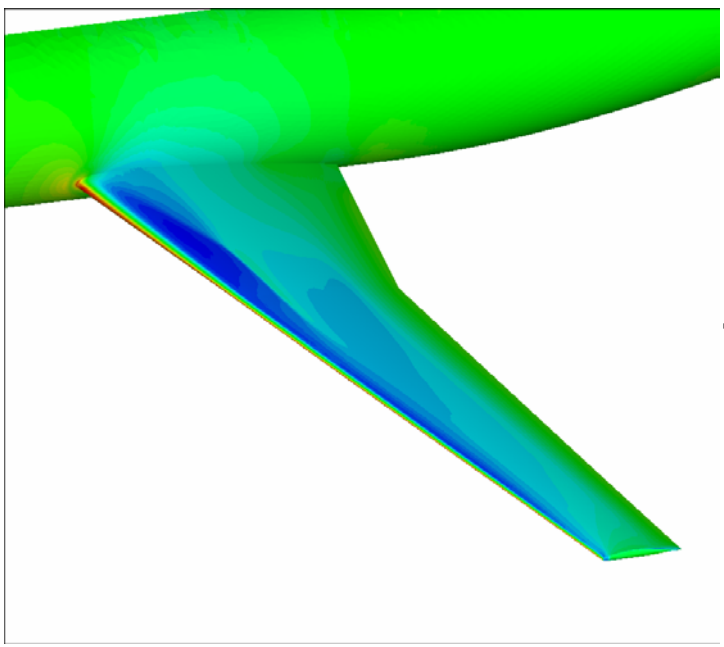
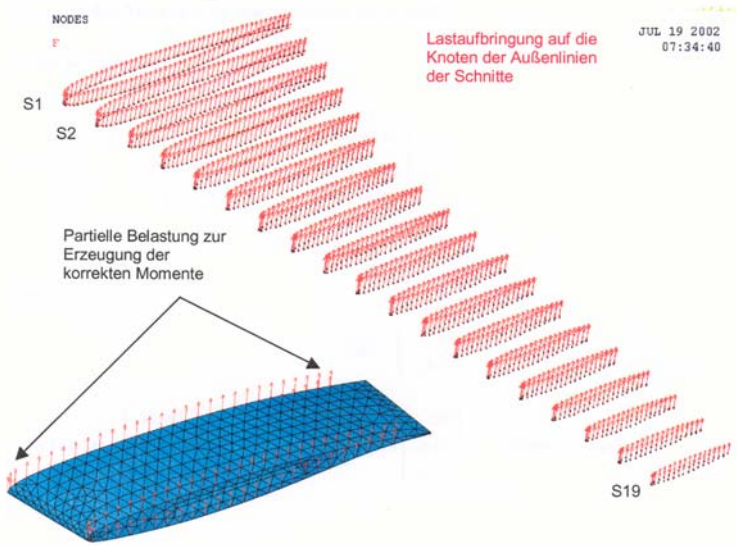


Bild 2: Vernetztes Modell.

TAU solution on old geometry
F6 wb Ma: 0.75, Re: 3e6, C_L: 0.5

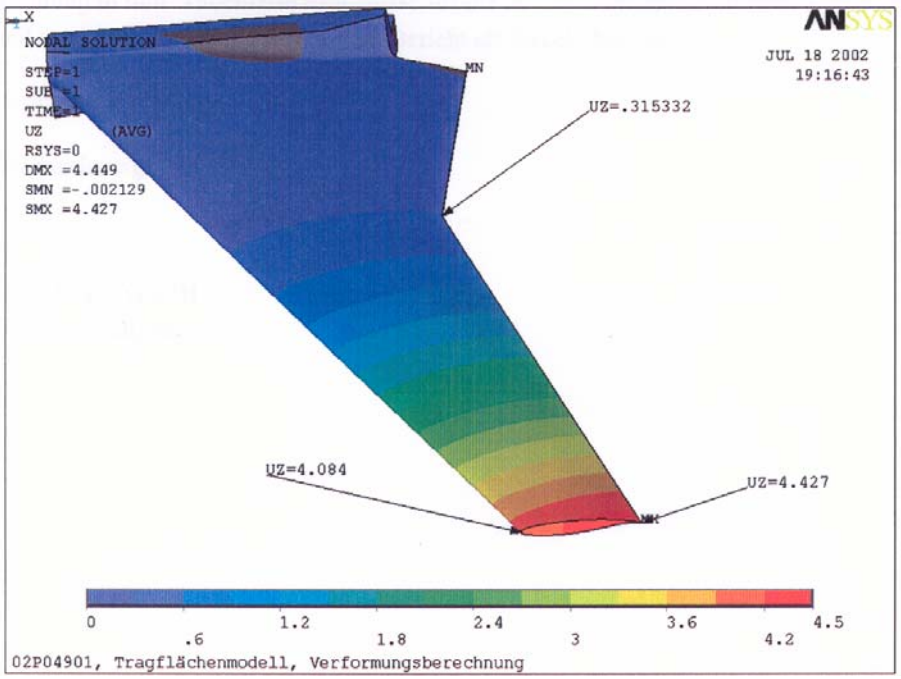


loads

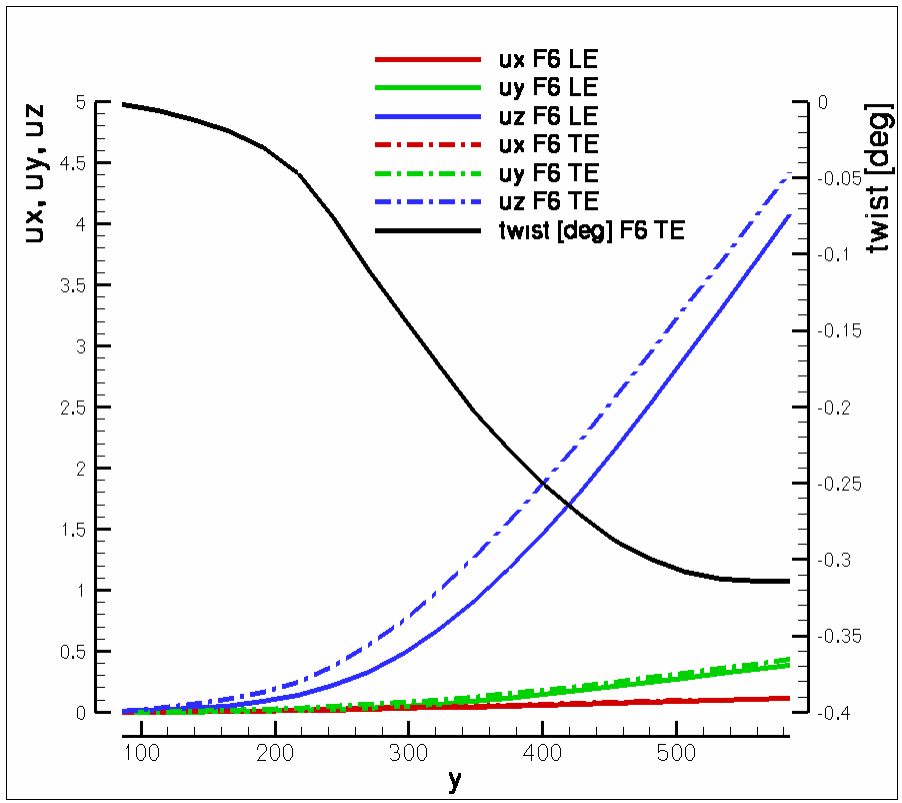


FEM - Aeroelastic Wing Deformation

Ansys simulation

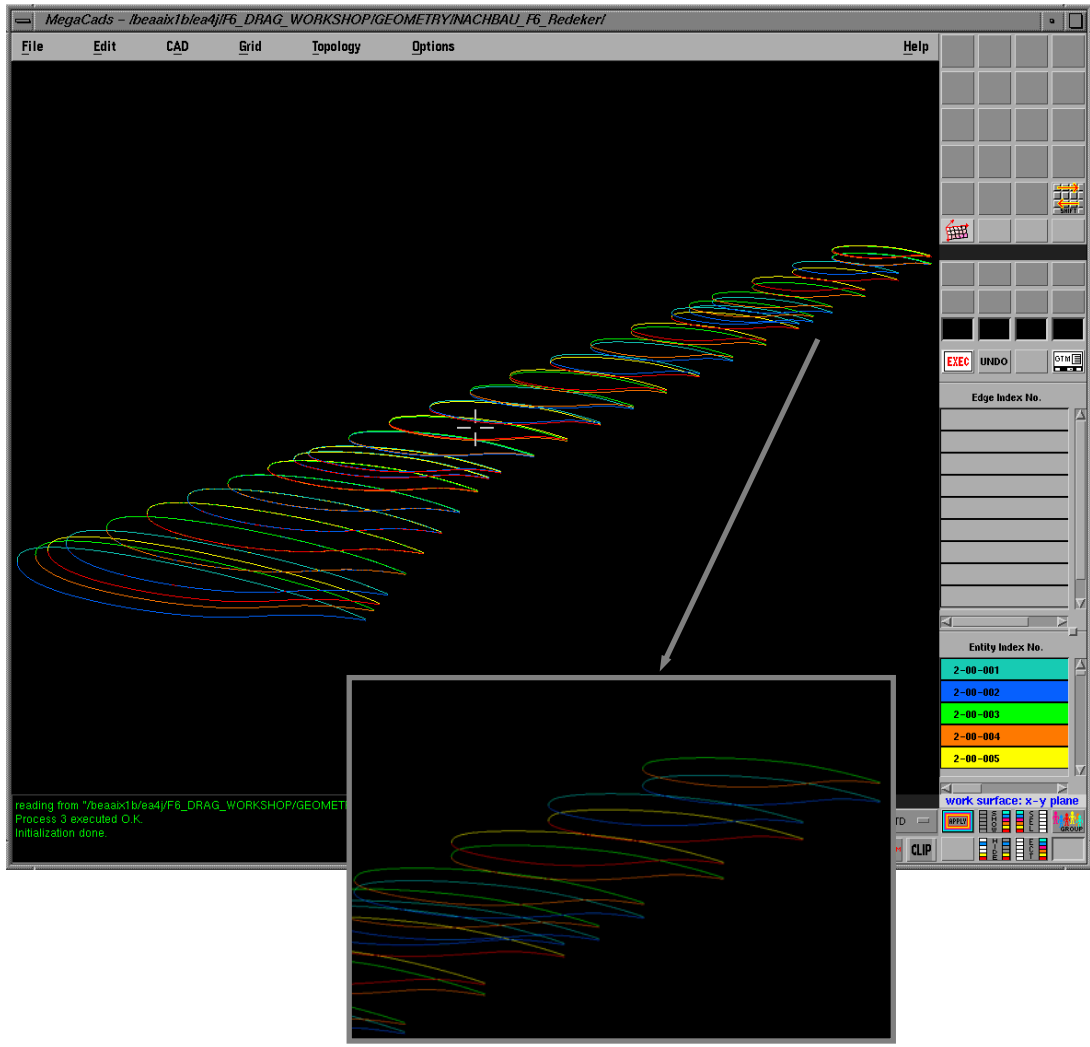


Moderate deflections and twist



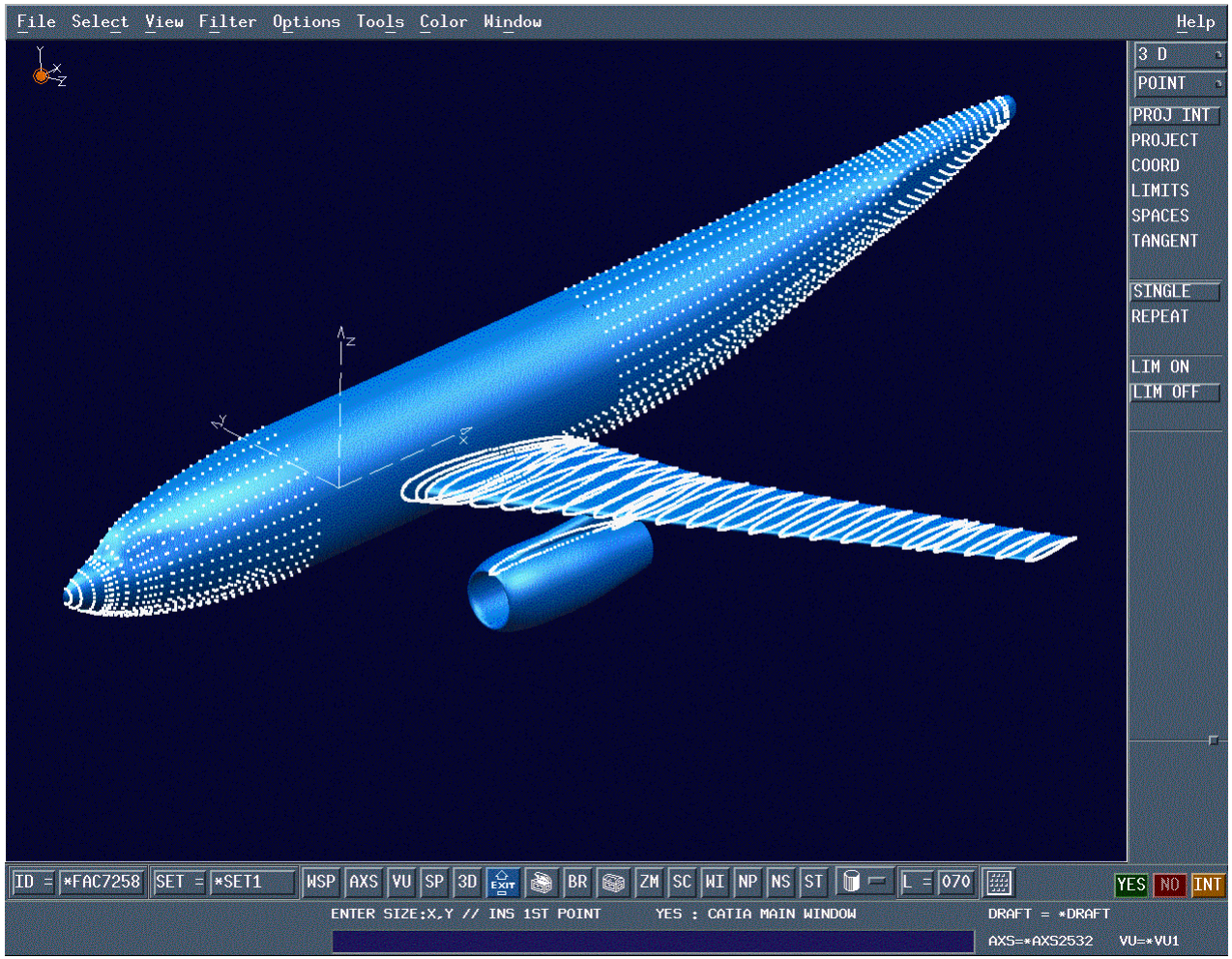
CAD - MegaCads

- Use of basic CAD functions of MegaCads
- Interpolation between the 4 defining sections
- Addition of deflections and twist to original sections
- Output to CATIA



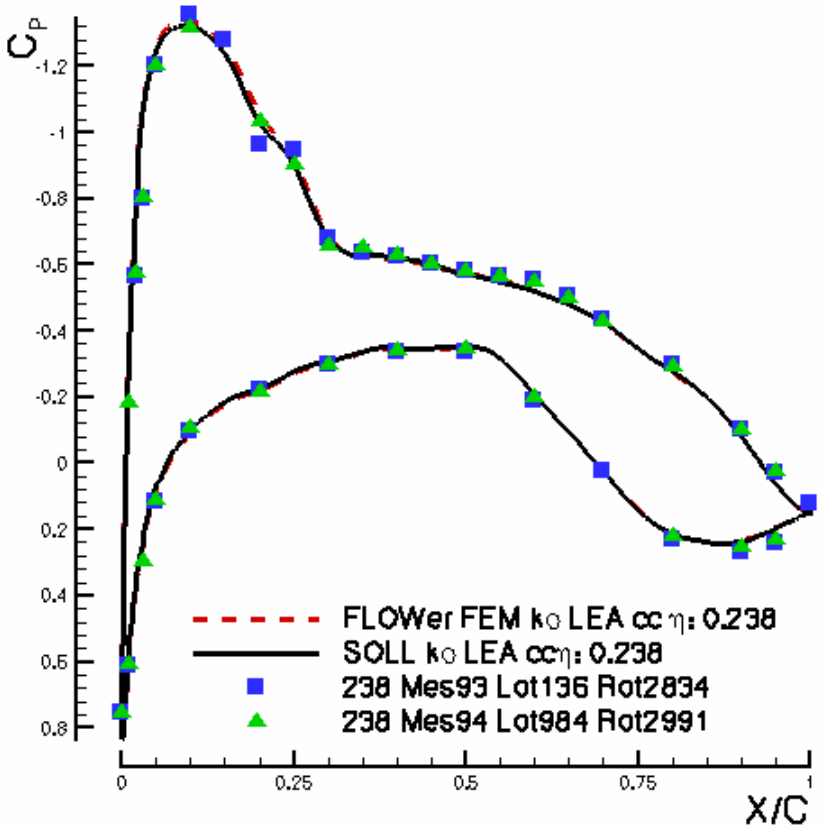
CAD - CATIA

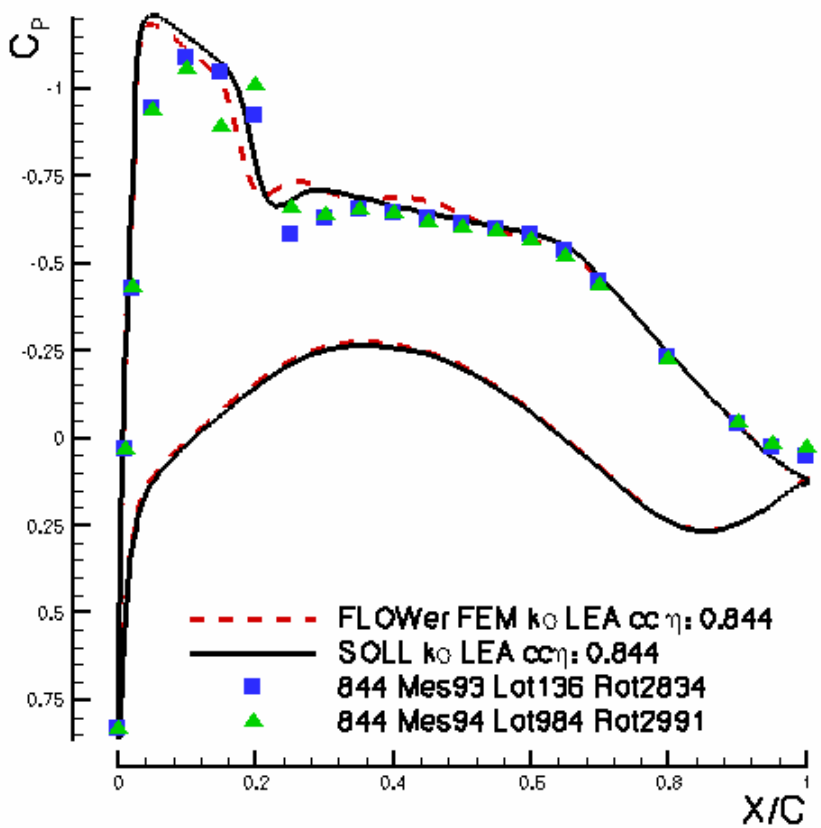
- Complete geometry revised (fuselage, pylon, nacelle)
- new wing: original nc- coor-dinates + aeroelastic defl.
- Geometry-check by other committee members
  → several iterations
- CAD by Arno Ronzheimer and Lars Lekemark, DLR



CFD Check - FLOWer

- Use of MegaCads script of DPWI F4 to generate structured multiblock F6 grid
- FLOWer run using kω-LEA
- Comparison of geometries with (FEM) and without (SOLL) aeroel. deflection





Summary

- Underestimated the effort to check an old wind tunnel model and produce a new CAD model

Ideal:

- Wind tunnel and CFD geometry are based on same CAD
- Geometry check before/after each wind tunnel campaign
- Deformation measurement during wind tunnel test