Presented by

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Far-field drag breakdown applied to the DLR-F6 configuration

In the framework of the 2nd CFD Drag Prediction Workshop

Context of the topic

- <u>To tackle the issue of aircraft performance</u>
  - 4 Optimal shape design □

    need for reliable drag breakdown
  - 4 Cruise performance assessment □

    need for accurate overall drag level

- <u>Prevailing role of CFD</u>
  - 4 Generation of well adapted grids
  - 4 Need for <u>a breakthrough</u> in drag assessment
    - – information provided by near-field integration <u>insufficient</u>
    - – <u>far-field abilities</u> very attractive in terms of
      - improvement of the accuracy
      - physical drag breakdown
      - spatial distribution of drag sources

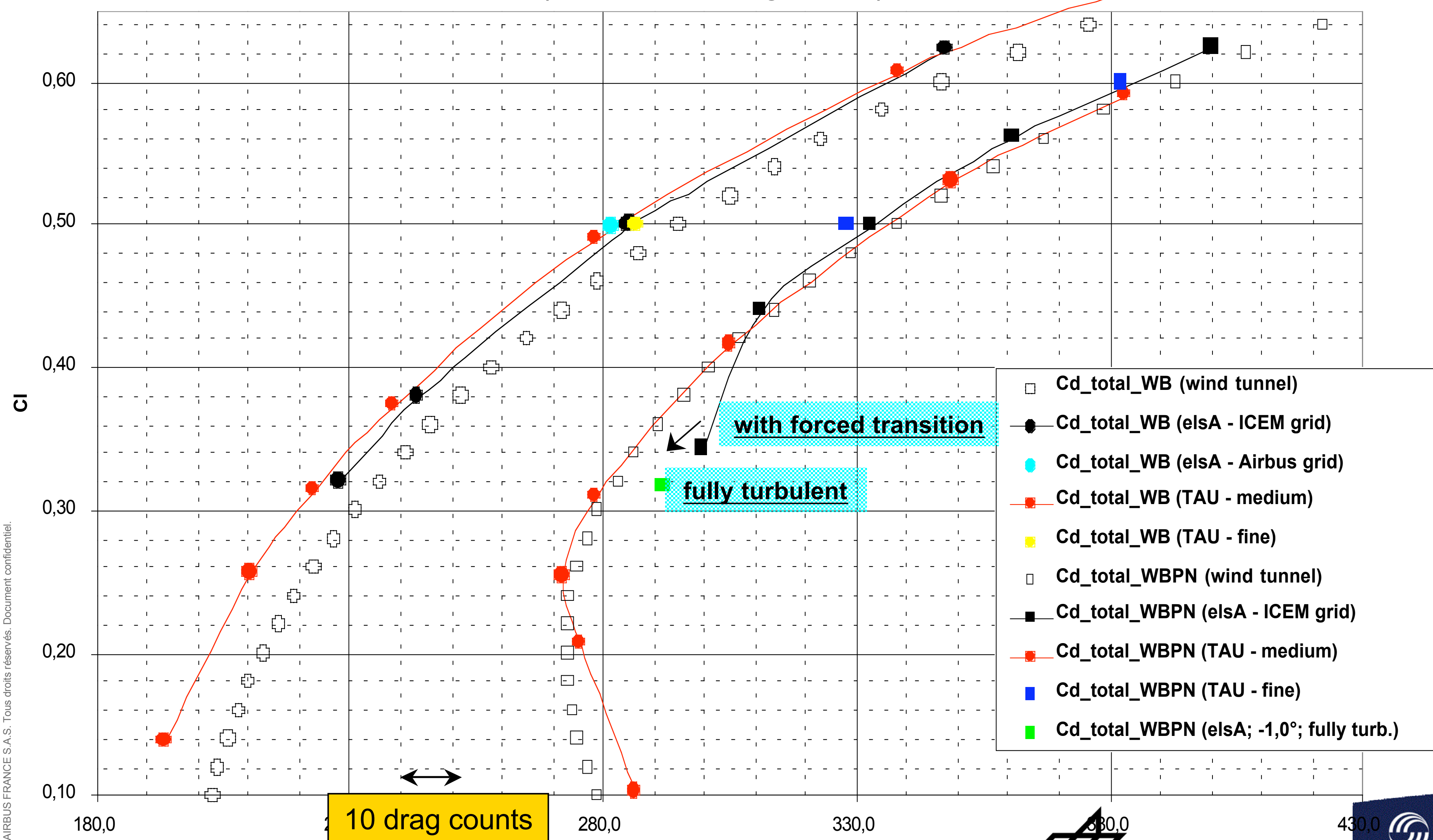
Tools used by Airbus for the 2nd DPW

- Structured multiblock solver : elsA
  - Developed by ONERA
  - Oriented-object structure (C++)
  - Turbulence model : k- (Wilcox)
  - 4 Centred scheme
  - Dissipation : Jameson type scalar scheme
  - Implicit time integration : LU-SSOR method

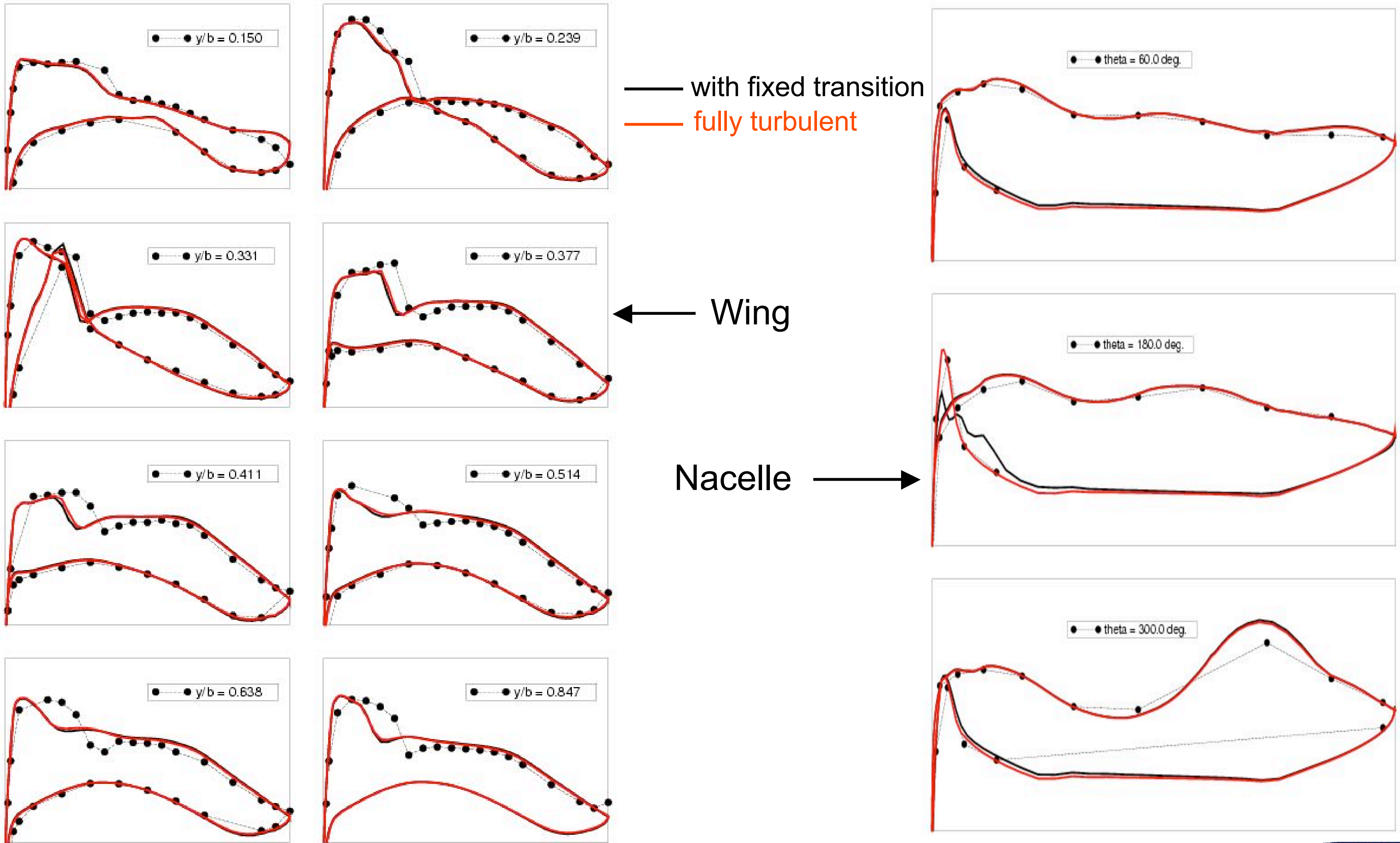
- Far-field drag analysis tool : FFD41
  - developed by ONERA / Airbus France
    (van der Vooren / Destarac's theory)
  - industrialized by Airbus France
  - daily used by shape designers and aerodynamic data engineers
  - capability for dealing with patched grids (soon AMR grids)

Drag polar (near-field integration)

Comparison elsA / TAU of the drag polars
(WB & WBPN configurations)



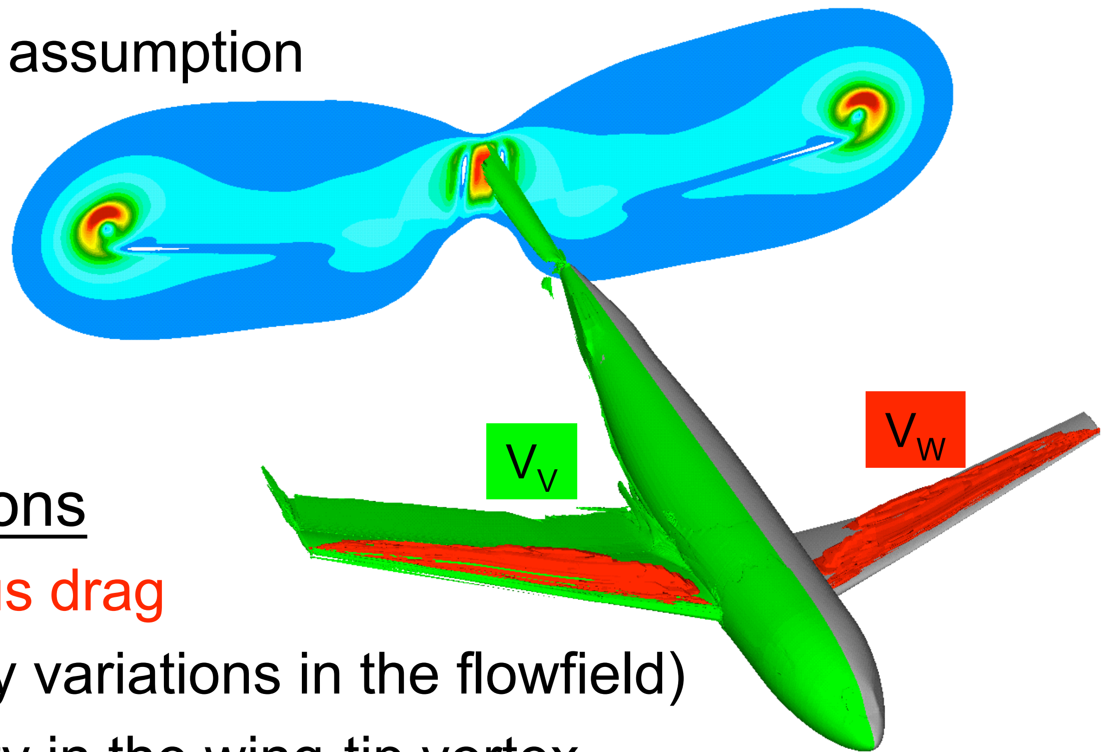
Cp distributions
(elsA, medium ICEM grid, WBPN, CL=0.50)



Physical and numerical drag breakdown

- <u>Exact near-field/far-field balance</u>
  - no small disturbances assumption

$$\left(D_p + D_f\right)_A = D_v + D_w + D_i$$



- <u>Numerical considerations</u>
  - production of spurious drag (connected to entropy variations in the flowfield)
  - decay of axial vorticity in the wing-tip vortex
     transformation of induced drag into spurious drag

$$\left(D_p + D_f\right)_A = D_v + D_w + \underbrace{D_i^{app} + D_i^{sp}}_{D_i} + D_{sp}$$

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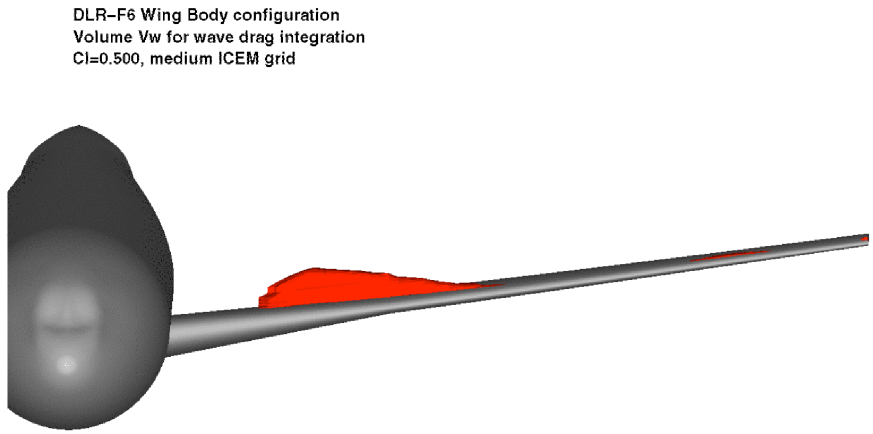
Far-field analysis

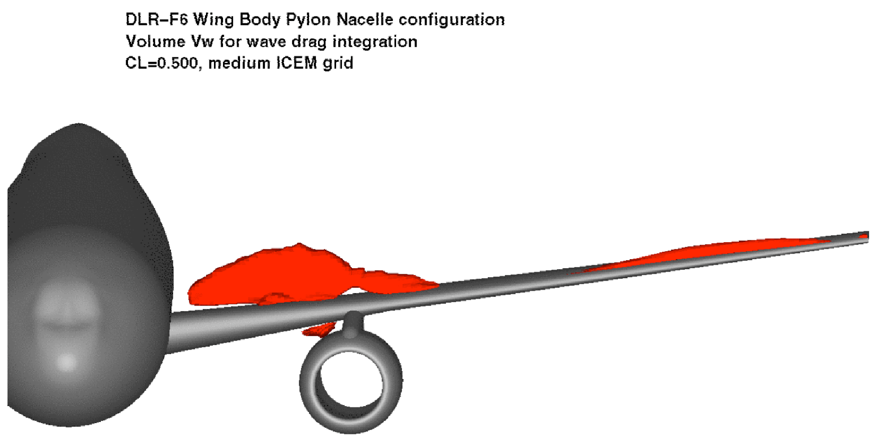
GridCDfCDvpCDwCDi			TAU		125.363.31.389.6279.5WB		

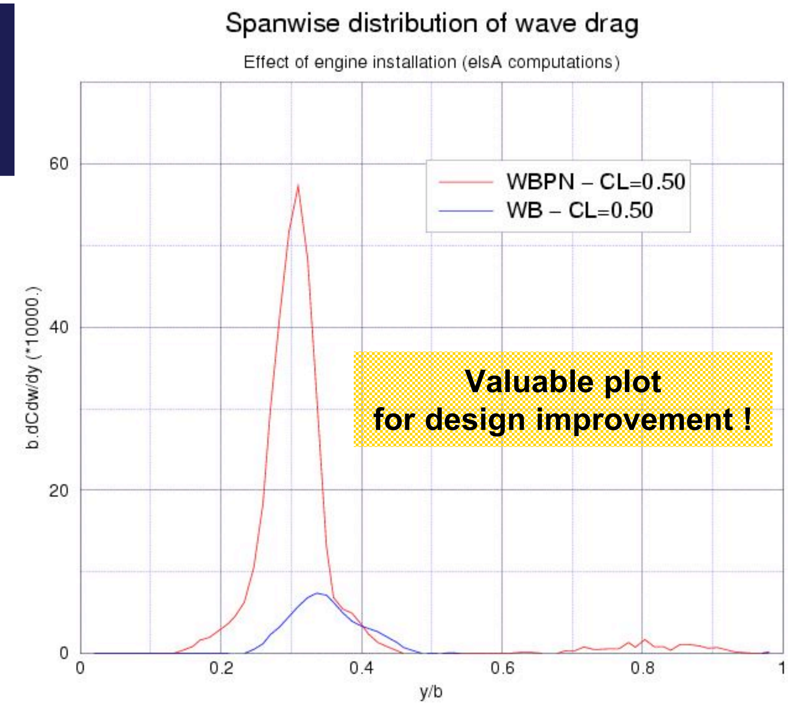
- Comments
  - lower overall far-field drag □ removal of the spurious drag
  - quite high discrepancy on the viscous terms □

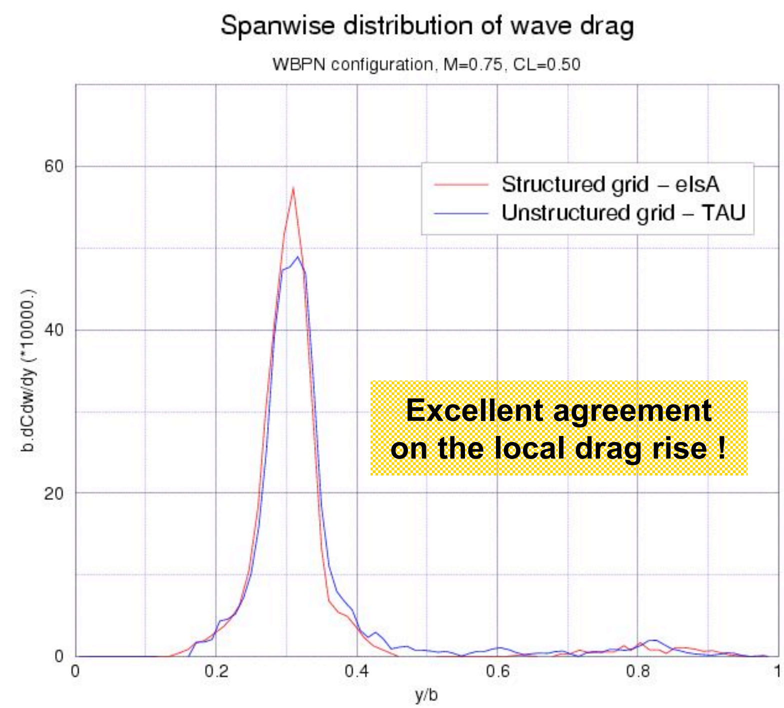
    turbulence model ? role of the grid size ?
  - 4 good agreement on the wave drag magnitude
  - uncertainty on the induced drag : correction of the vortex decay ?
  - incremental drag better predicted than the near-field for elsA
    - TAU : □CD = 41,2.10^{-4}
    - elsA : □CD = 45,9.10^{-4}

Wave drag distribution

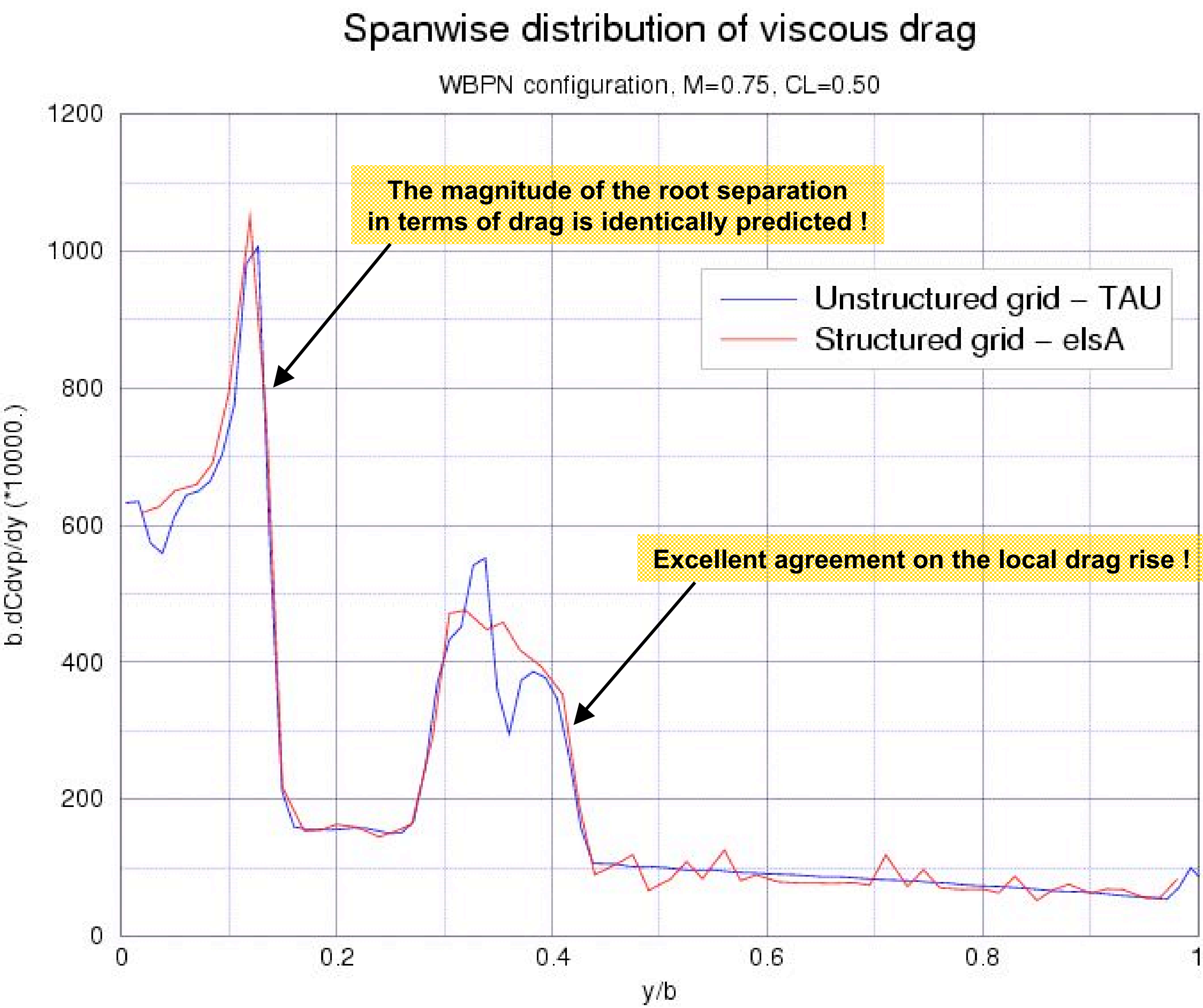








Viscous drag distribution



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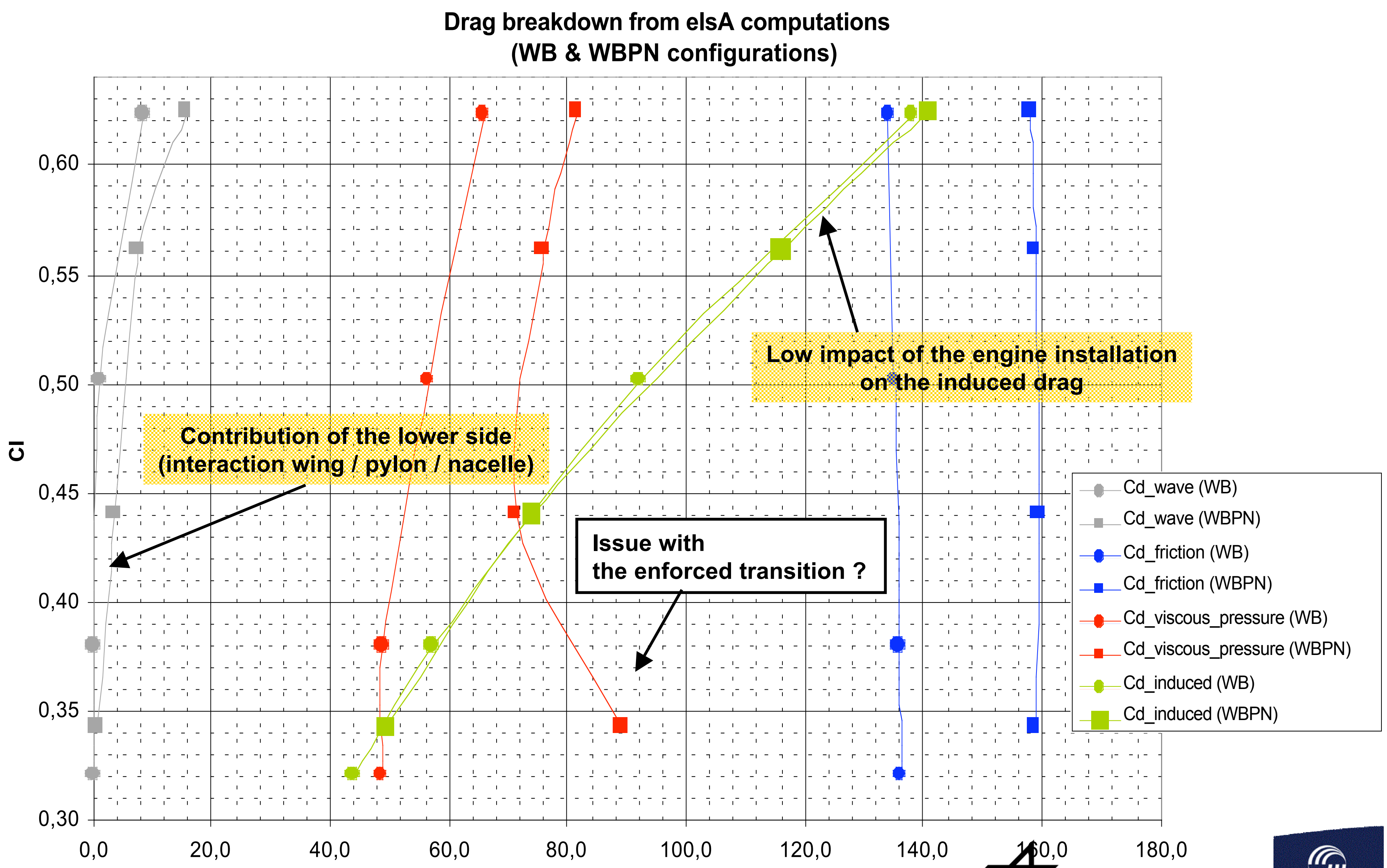
Drag polar breakdown (elsA computations)



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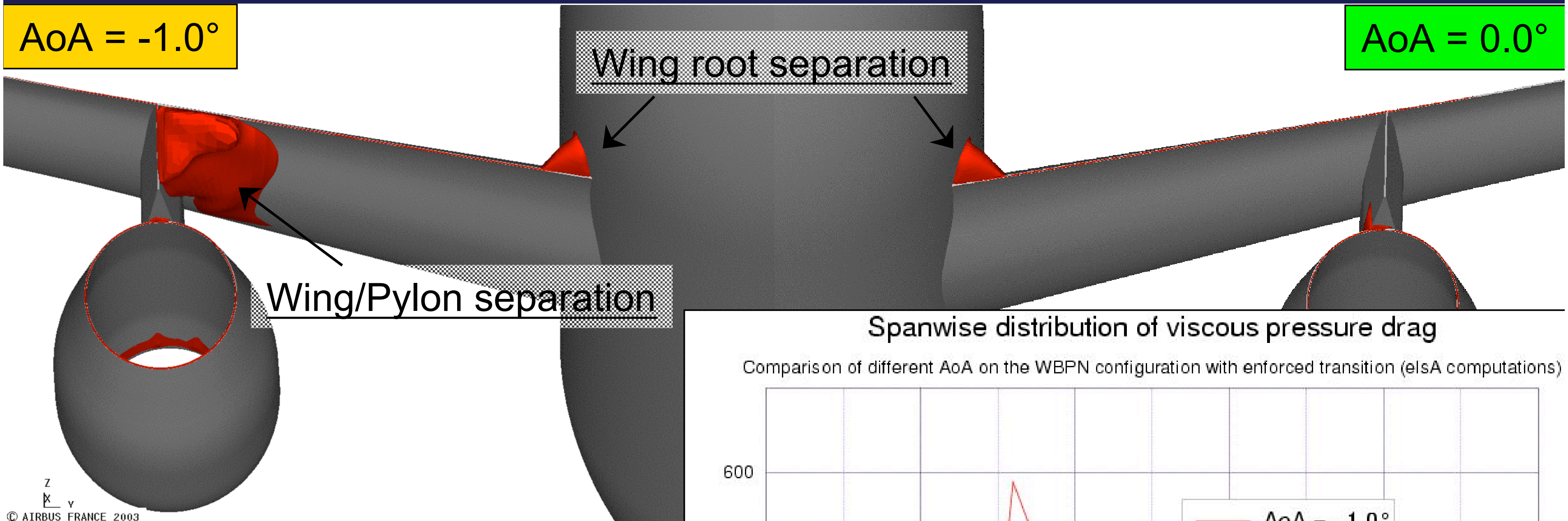
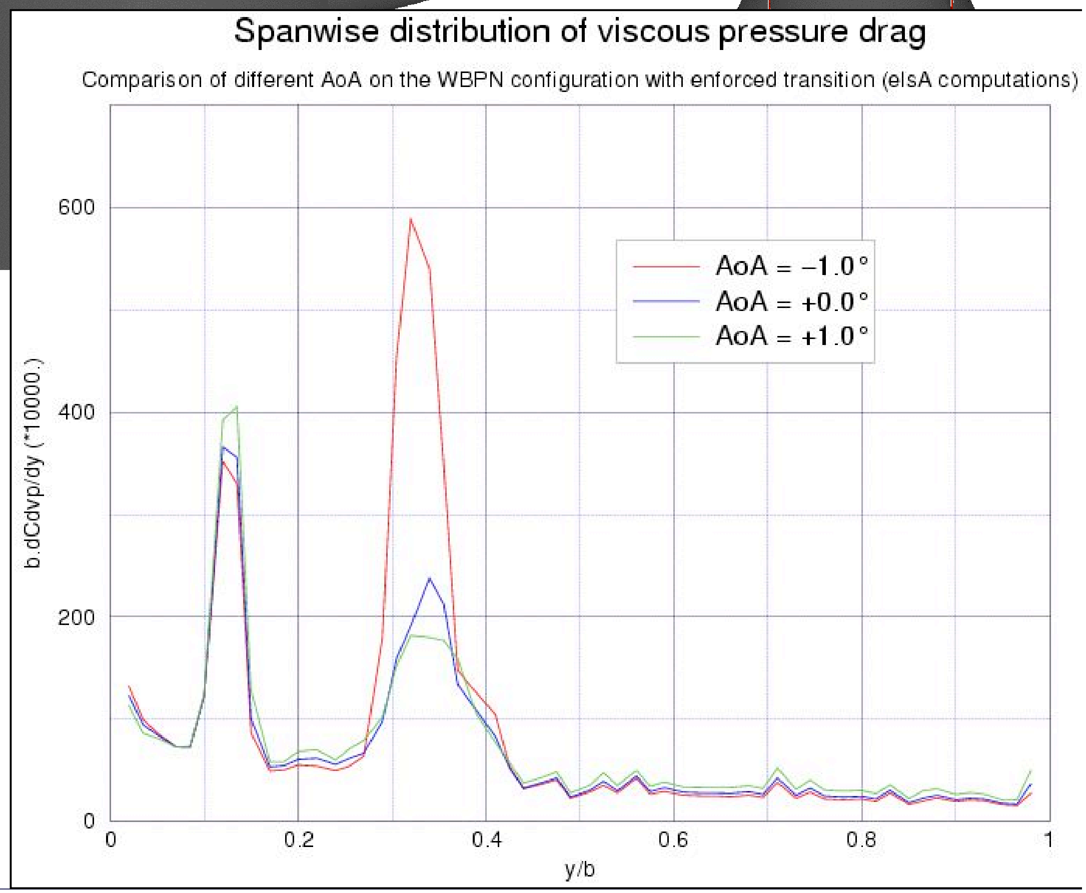
WBPN@-1.0° : an example of analysis





Physical intuition confirmed by the far-field analysis

→ very valuable information provided by FFD41

Conclusions

- Far-field drag analysis tools = an intelligent means of making the most of CFD
  - shape design improvement (including optimisation)
  - identification of CFD issues (grids, solvers, etc.)
  - New sensors for automatic refinement
- Physical drag breakdown is available **for both Airbus solvers** (elsA & TAU)
  - discrepancies remain to be addressed
  - some obvious satisfactory trends
- The one-drag count accuracy : a utopia
  - solver able to capture the flow features
  - well-built grid
  - far-field drag assessment tool

→ **the 1 d.c. variation is at hand**