



Nyt profil i LM's vindtunnel Høj effektivitet og ruhedsfølsomhed

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New Airfoil in LM's Wind Tunnel: High Efficiency and Roughness Insensitivity

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Peter B. Andersen, Mads Døssing – Risø DTU**

Peter Fuglsang, Stefano Bove – LM Glasfiber

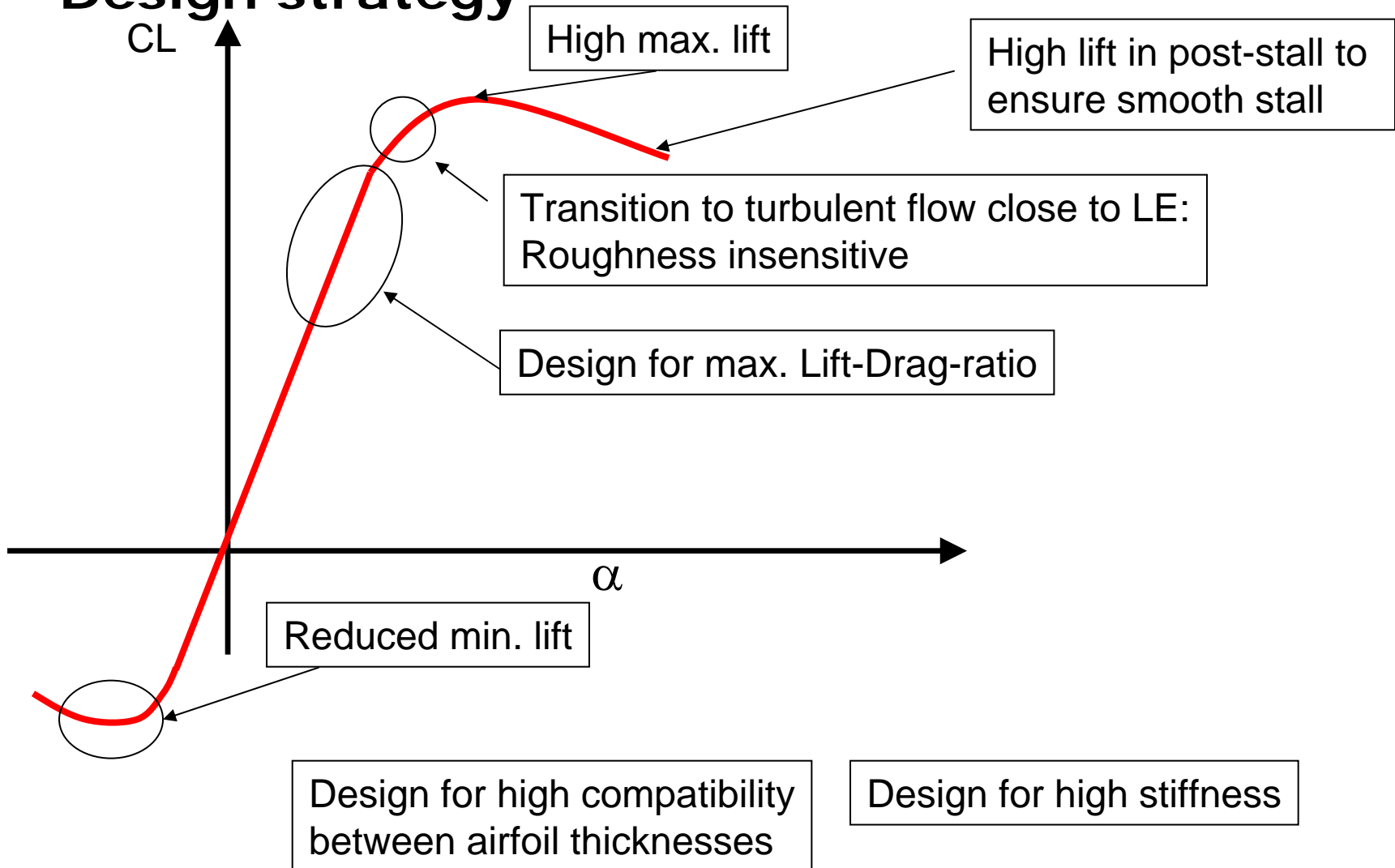
Outline

- Motivation
- Design
- Measurement setup
- Results
- Conclusions

Motivation

- A new airfoil series have been designed at Risø DTU because we have learned several lessons from three airfoil series designed from 1998 to 2002 (Risø-A1, Risø-P and Risø-B1) :
 1. Roughness insensitivity is very important
 2. High aerodynamic efficiency is very important
 3. A relatively high stiffness of the airfoil sections is important
 4. A high compatibility between different airfoil sections is important
- Additionally, some important questions have arised:
 1. What happens to the airfoil performance for different turbulence intensities?
 2. How does the small scale turbulence behave?
 3. Are the models for predicting transition from laminar to turbulent flow trustworthy?

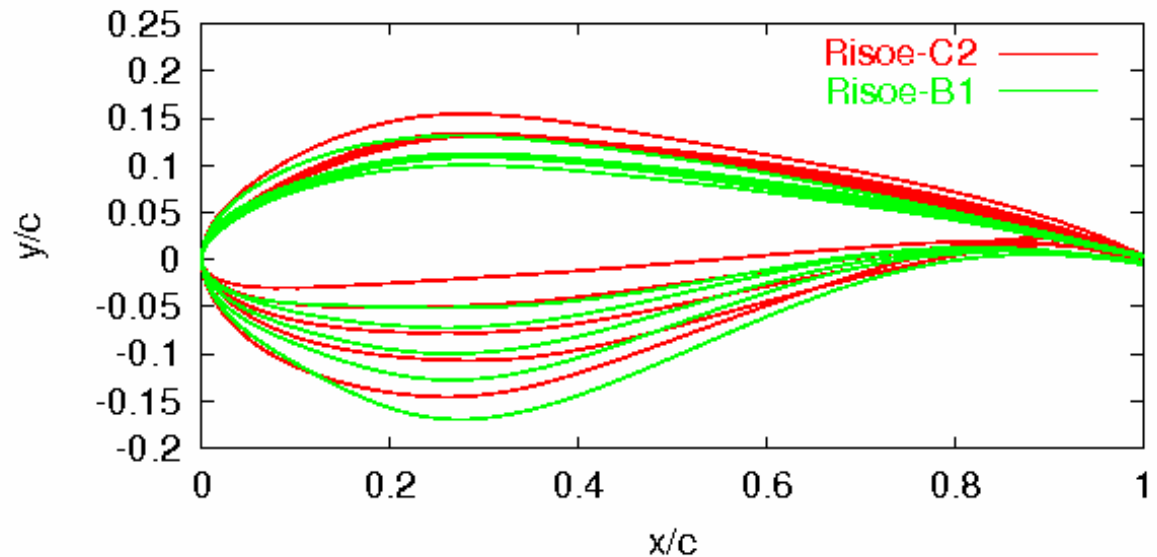
Design strategy



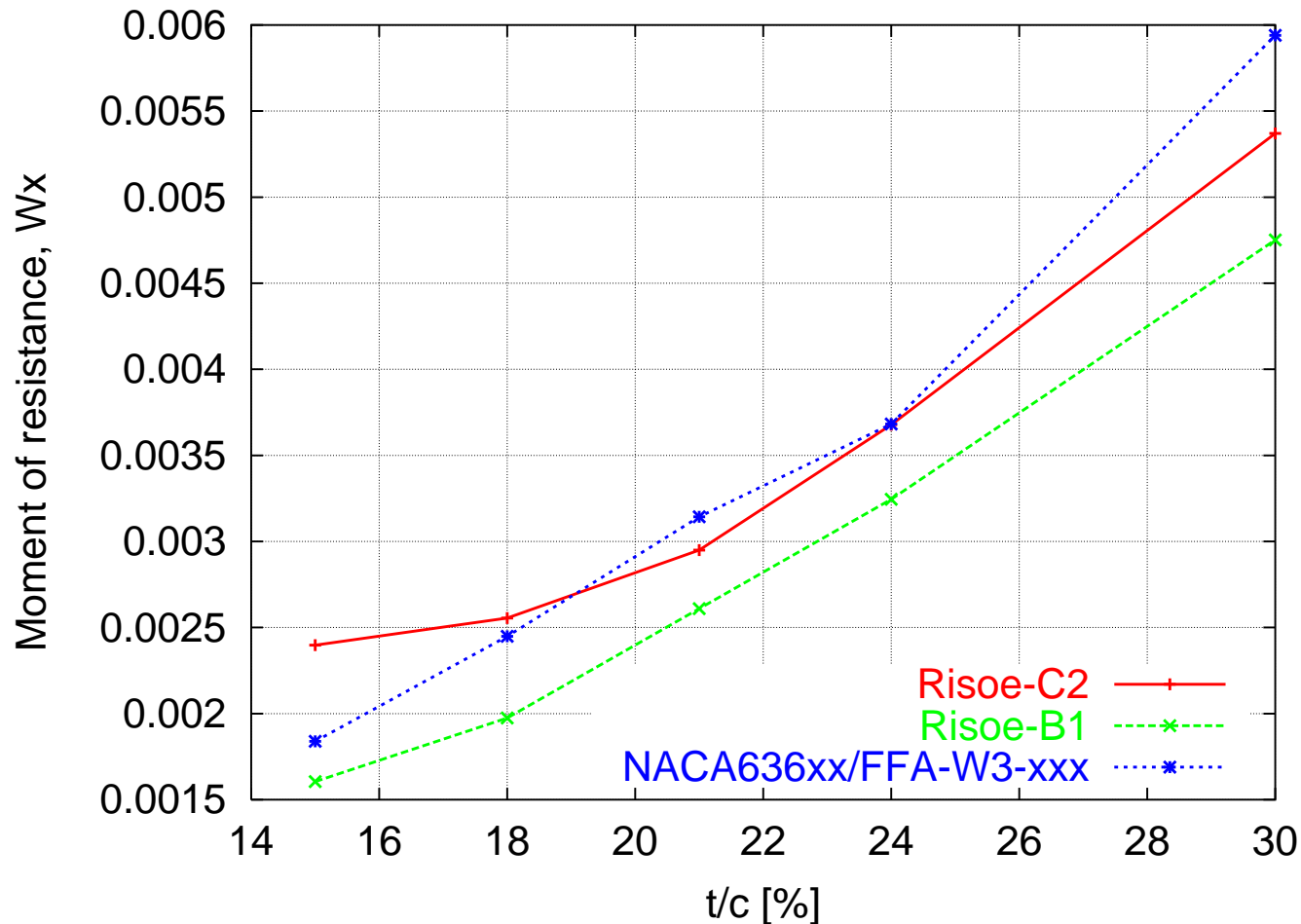
Design result

- Design objectives of new airfoils similar to Risø-B1
 - High maximum lift
 - Insensitivity to roughness
 - High compatibility

- Design objectives of new airfoils differing from Risø-B1
 - Increased stiffness
 - Slightly higher compatibility
 - High aerodynamic efficiency
 - Reduced minimum CL



Design result: Moment of resistance

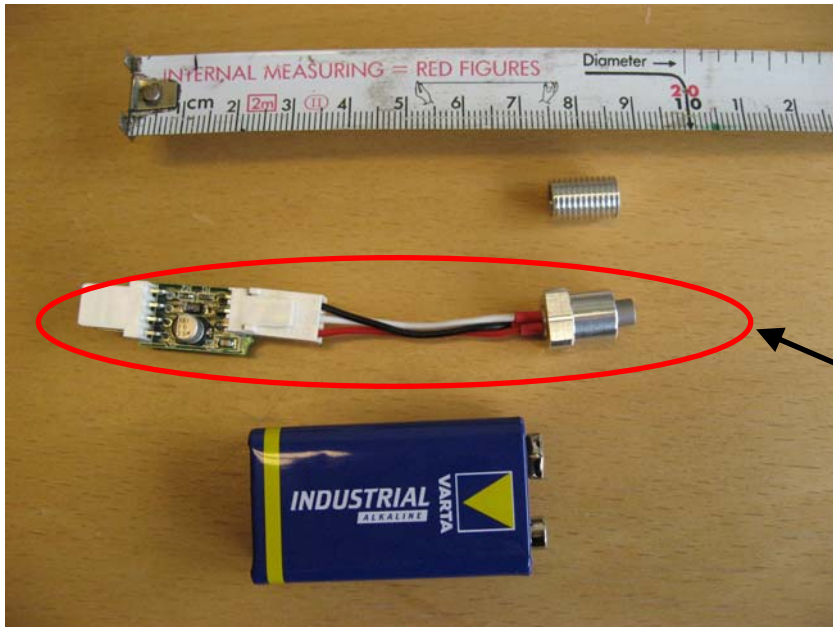
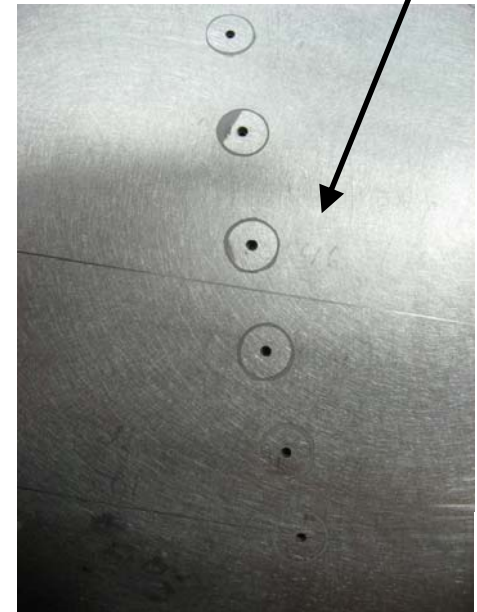


Measurement setup



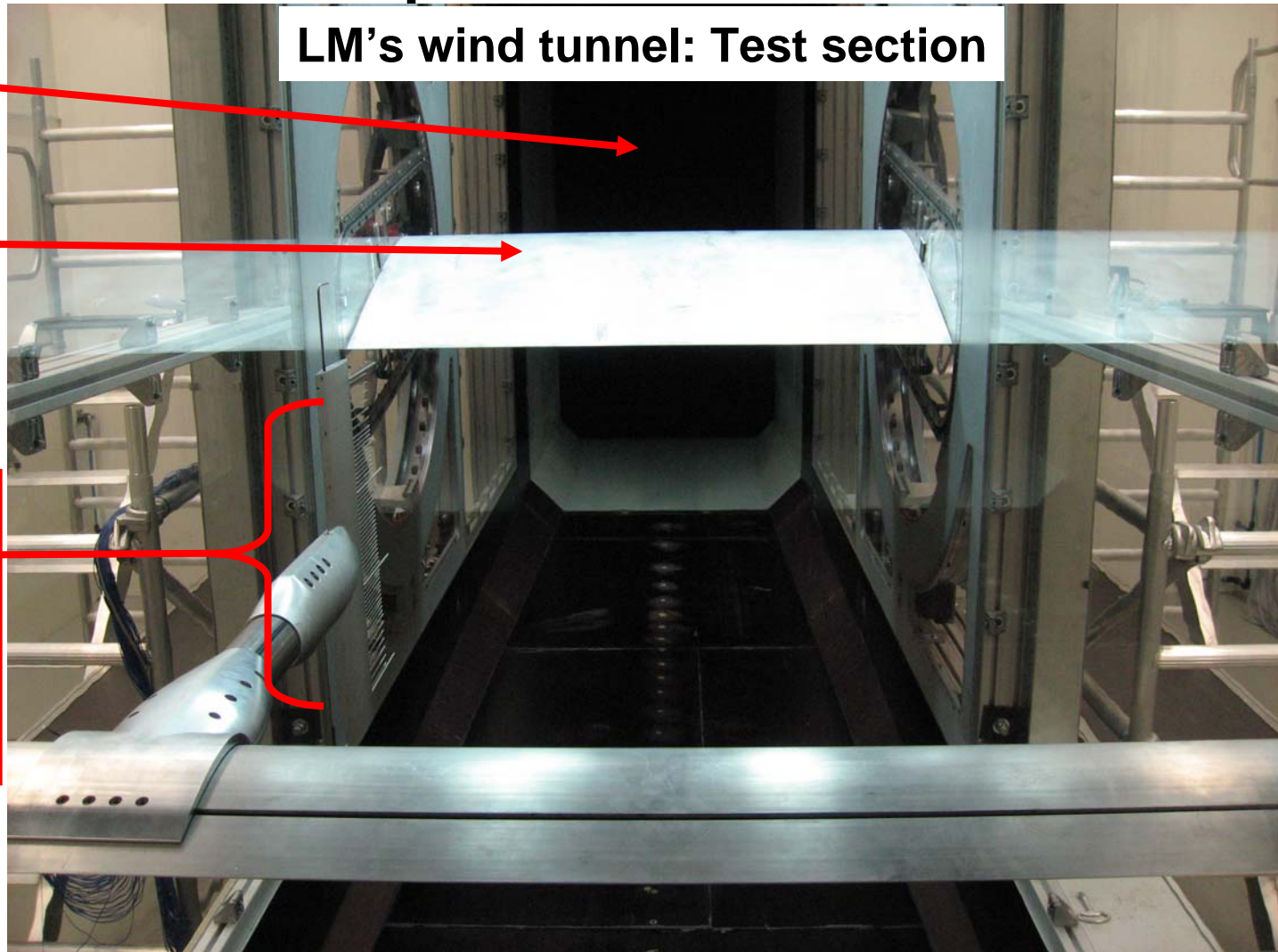
The microphone

The microphones mounted at airfoil leading edge



The microphone in the housing (right) and amplifiers (left)

Measurement setup



LM's wind tunnel: Test section

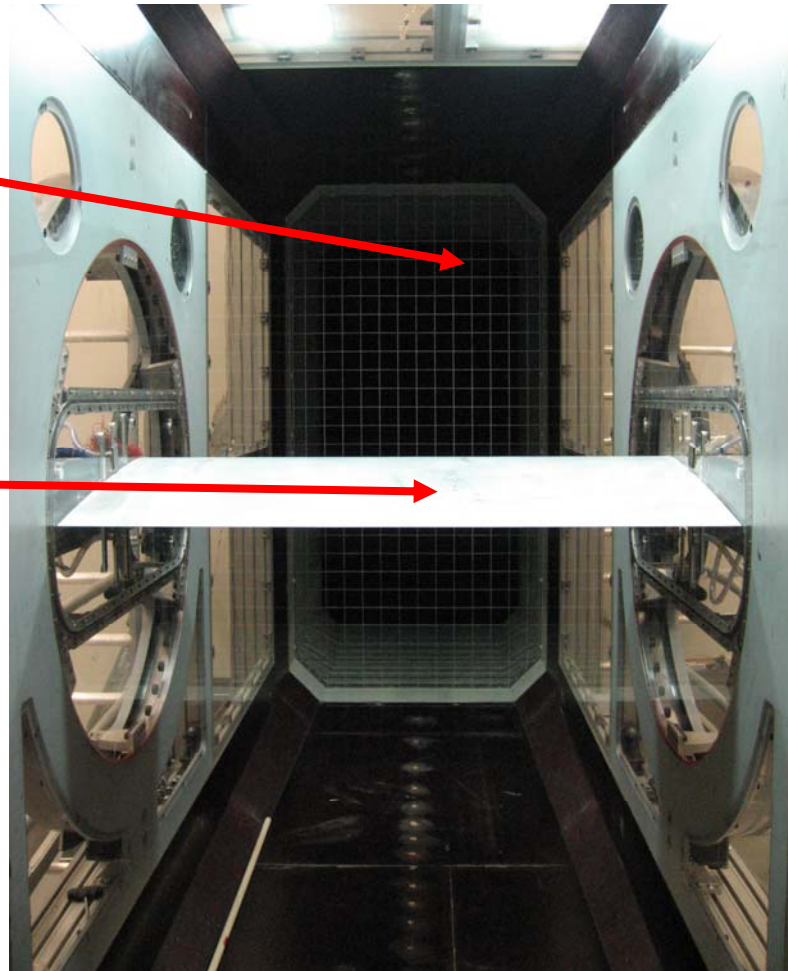
Inlet

Airfoil

Wake rake:
Measurement of
drag using
traversing

Measurement setup

LM's wind tunnel: Test section

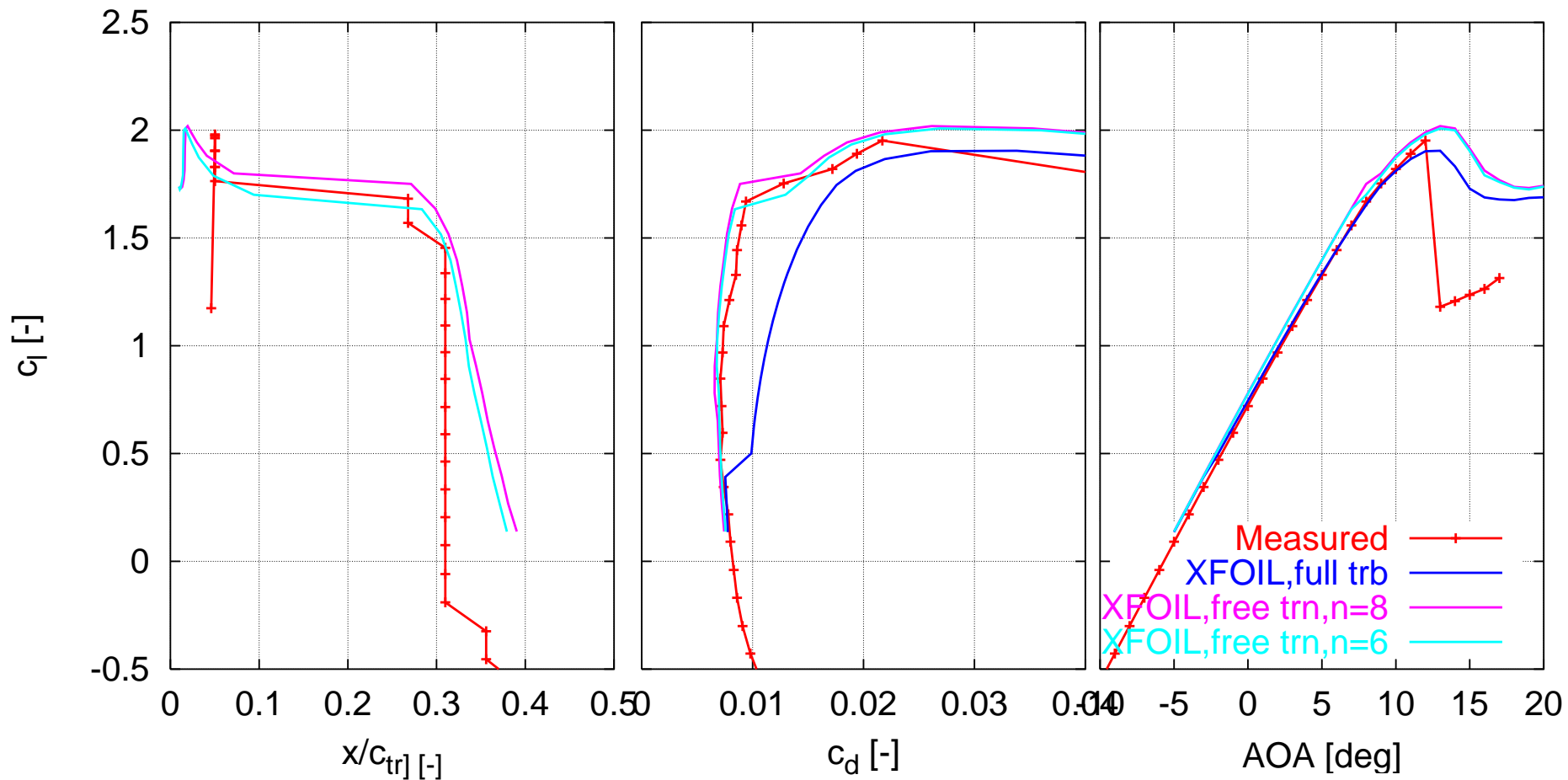


Inlet with turbulence grid

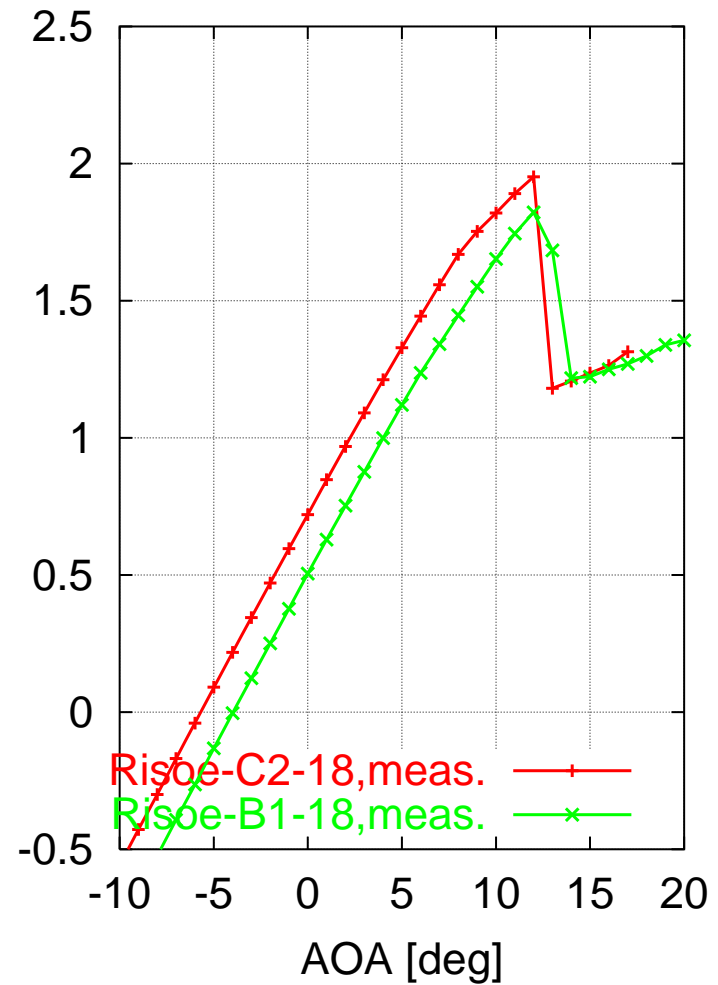
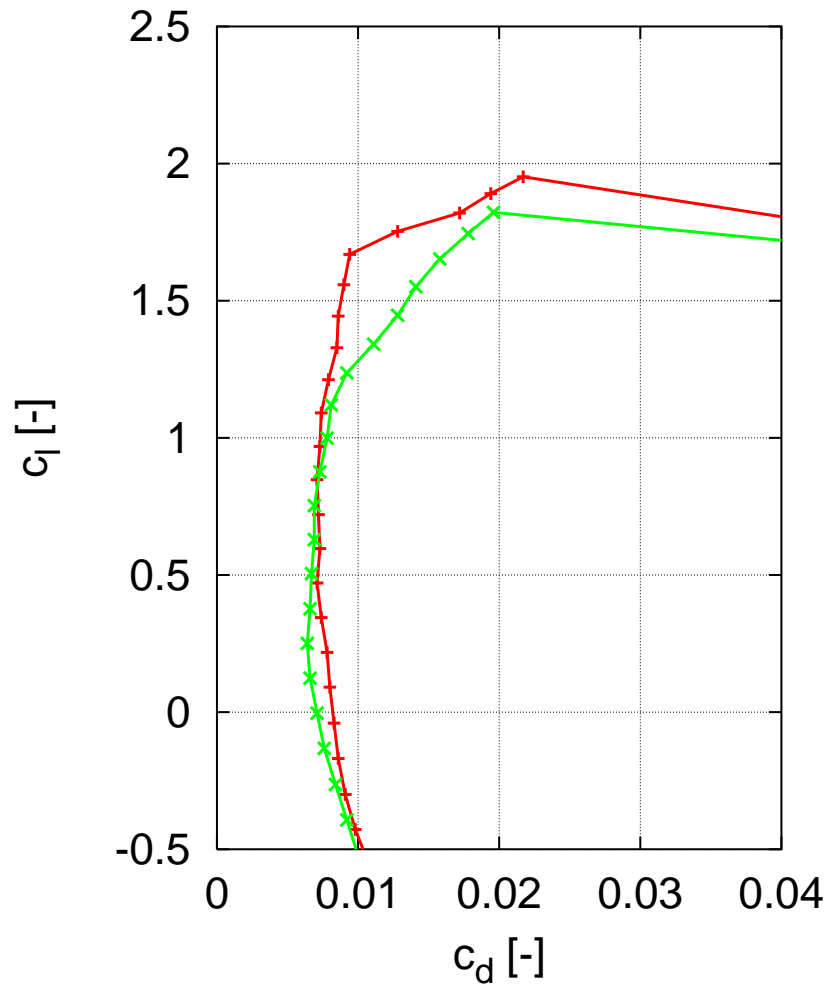
**Turbulence grids:
Grid1: 20x20cm
Grid2: 10x10cm**

Airfoil

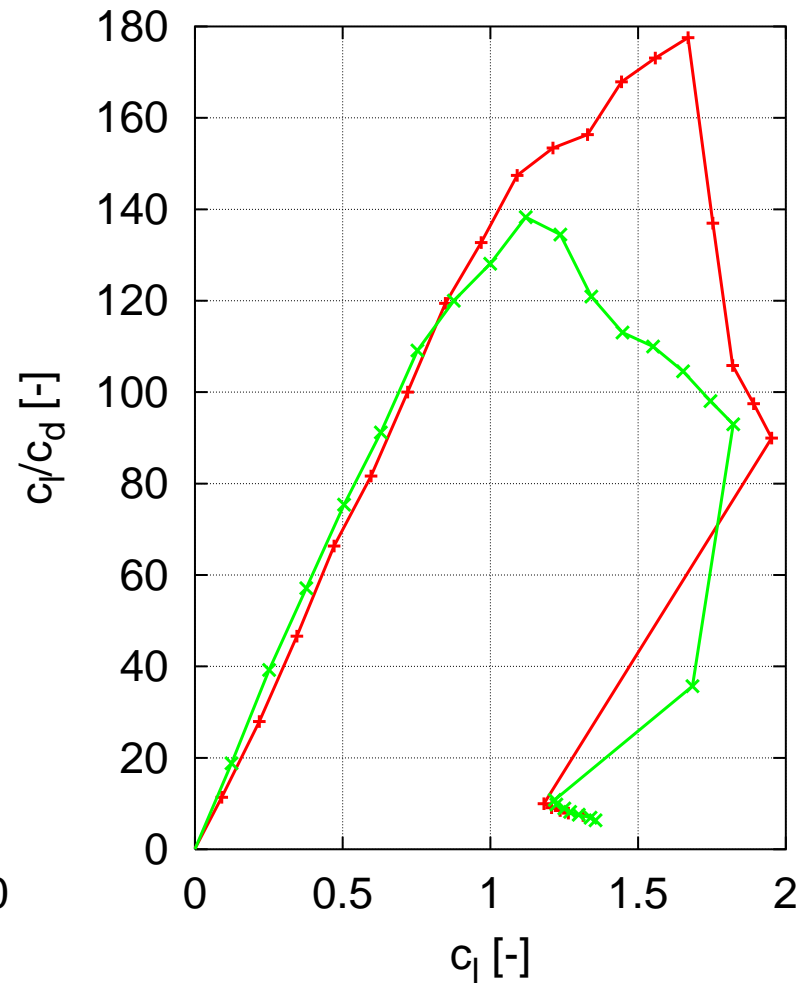
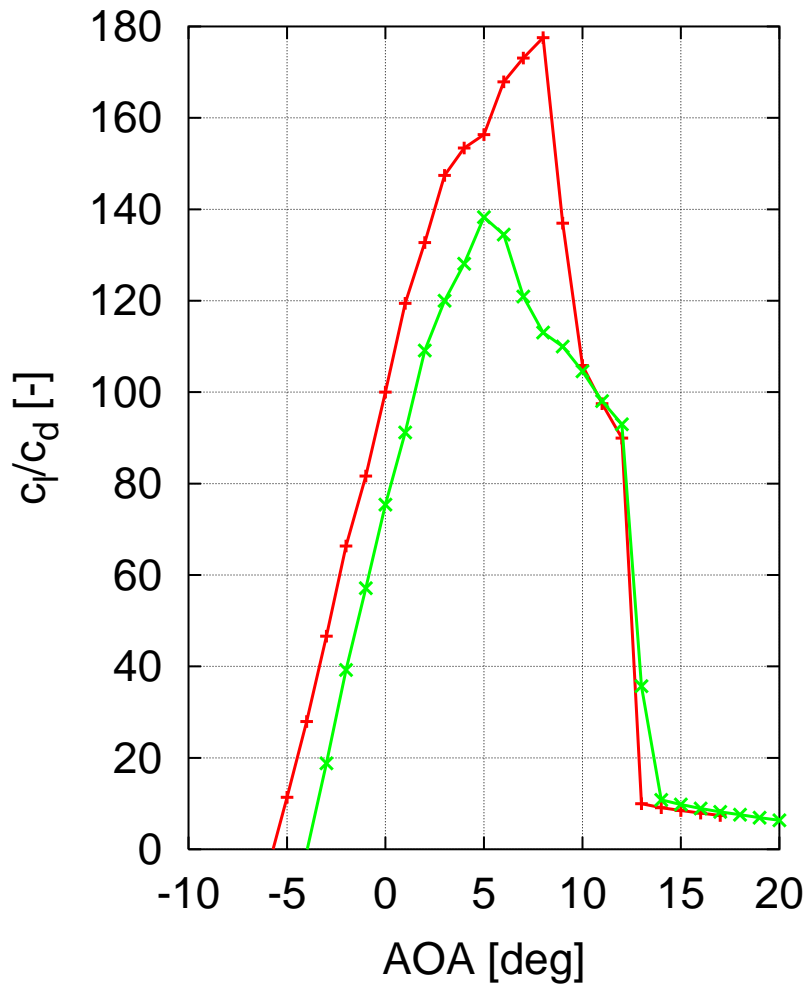
Results: Risø-C2-18, Clean, Transition



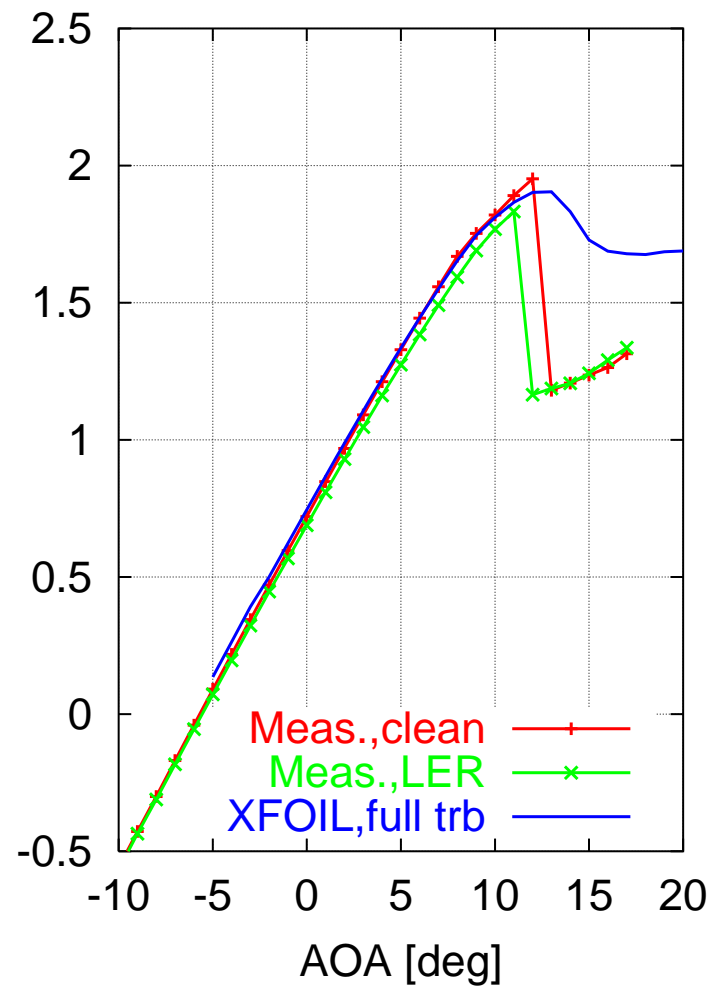
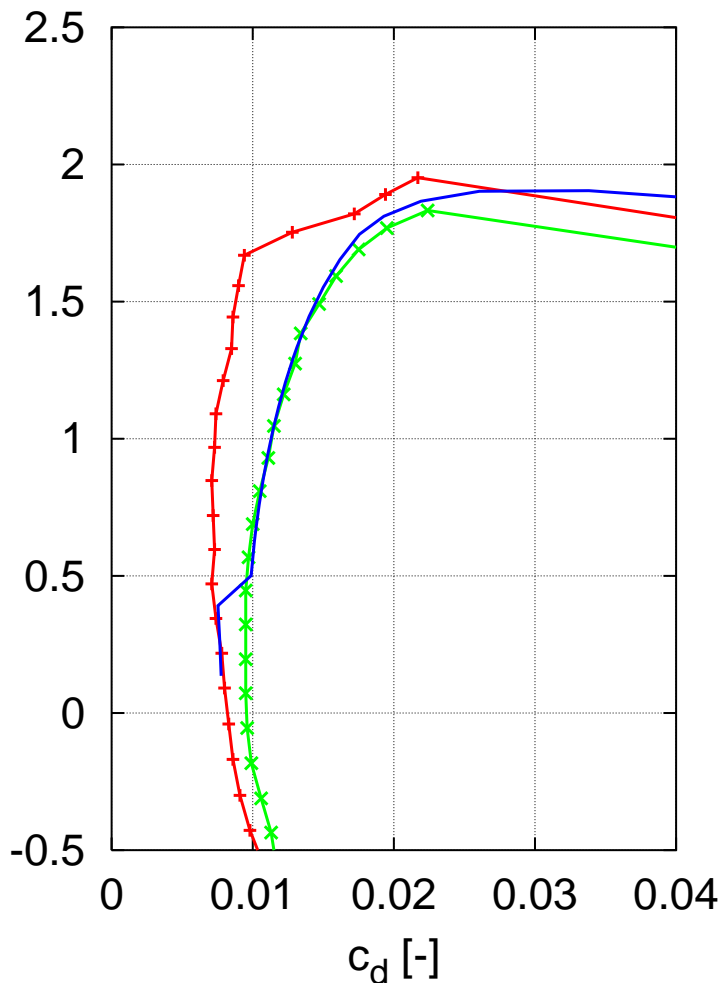
Results: Risø-C2-18 / Risø-B1-18, Clean



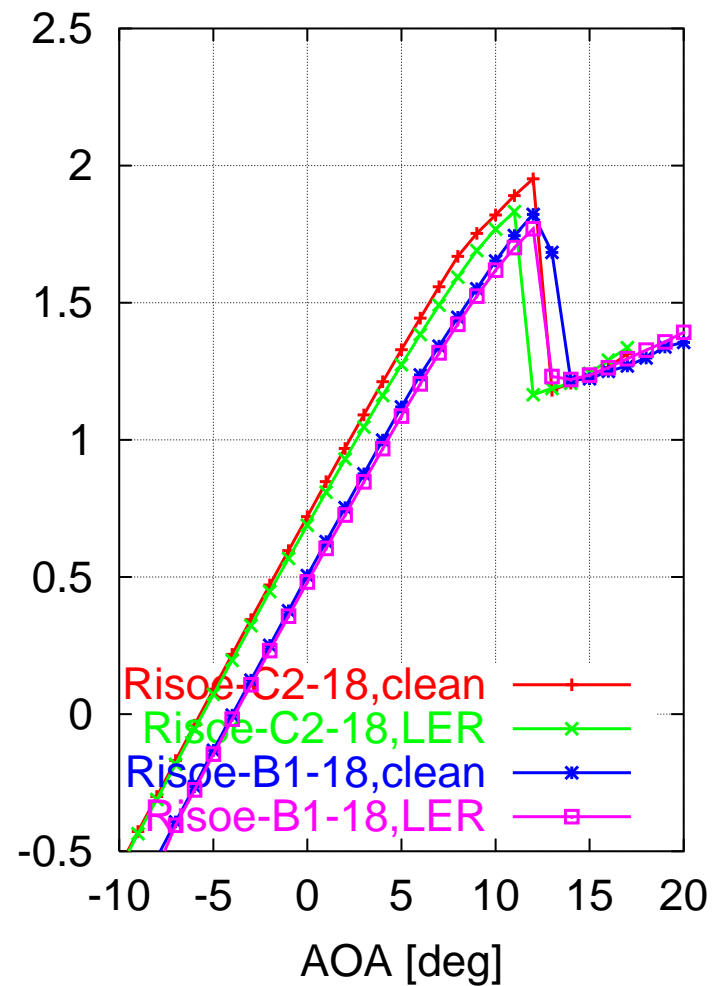
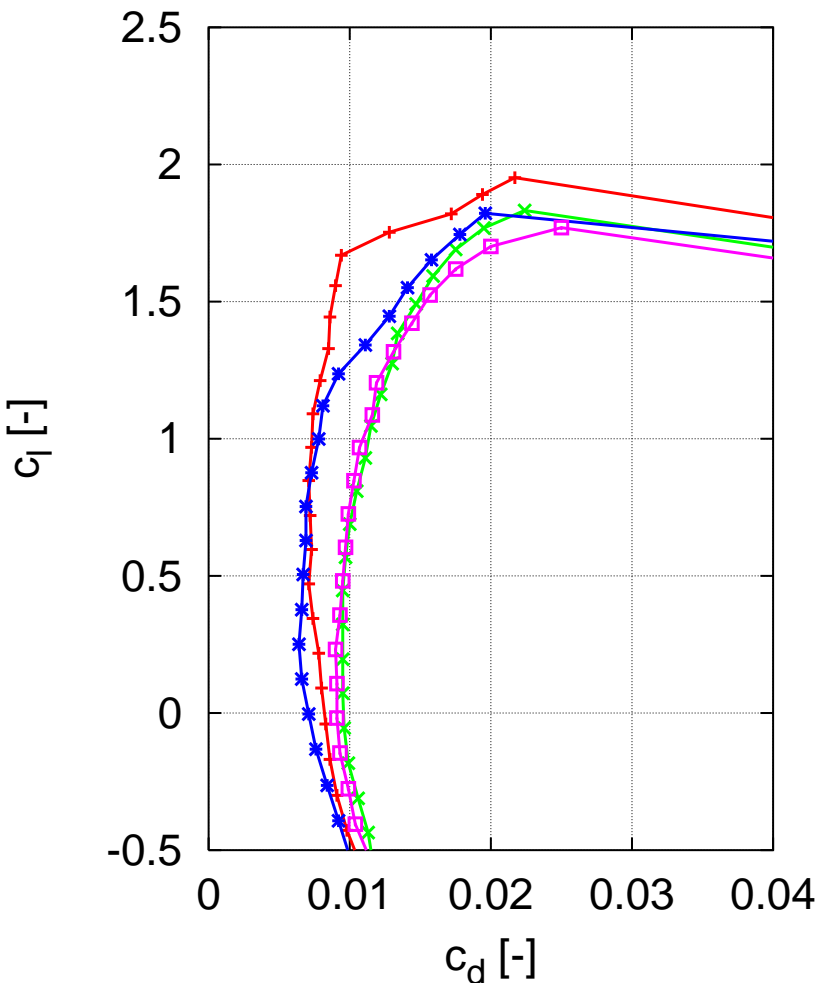
Results: Risø-C2-18 / Risø-B1-18, Clean



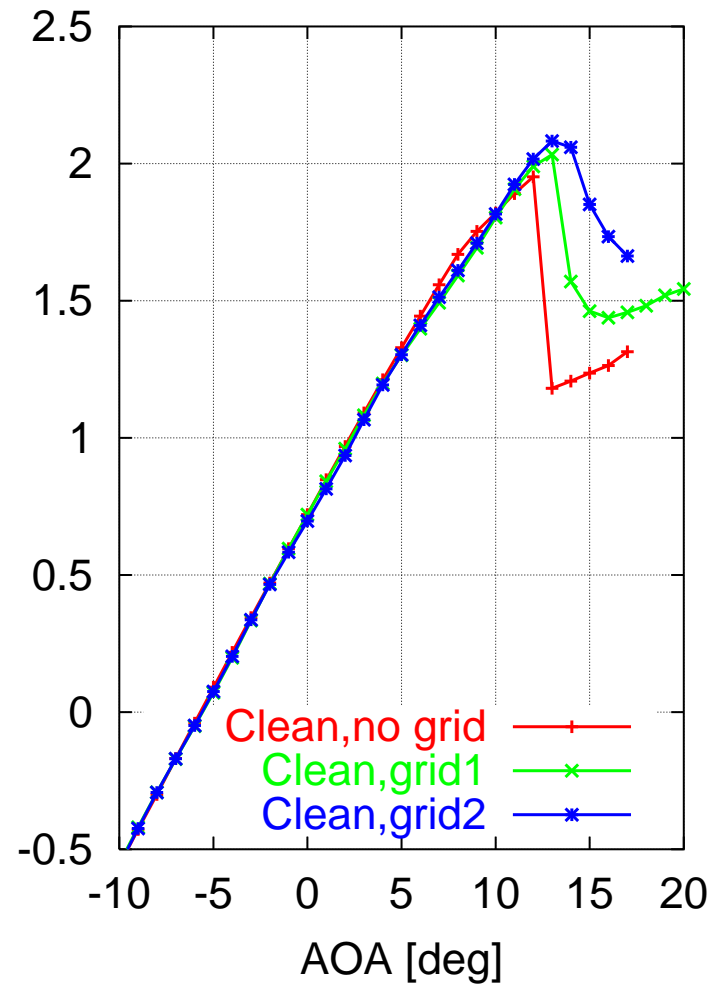
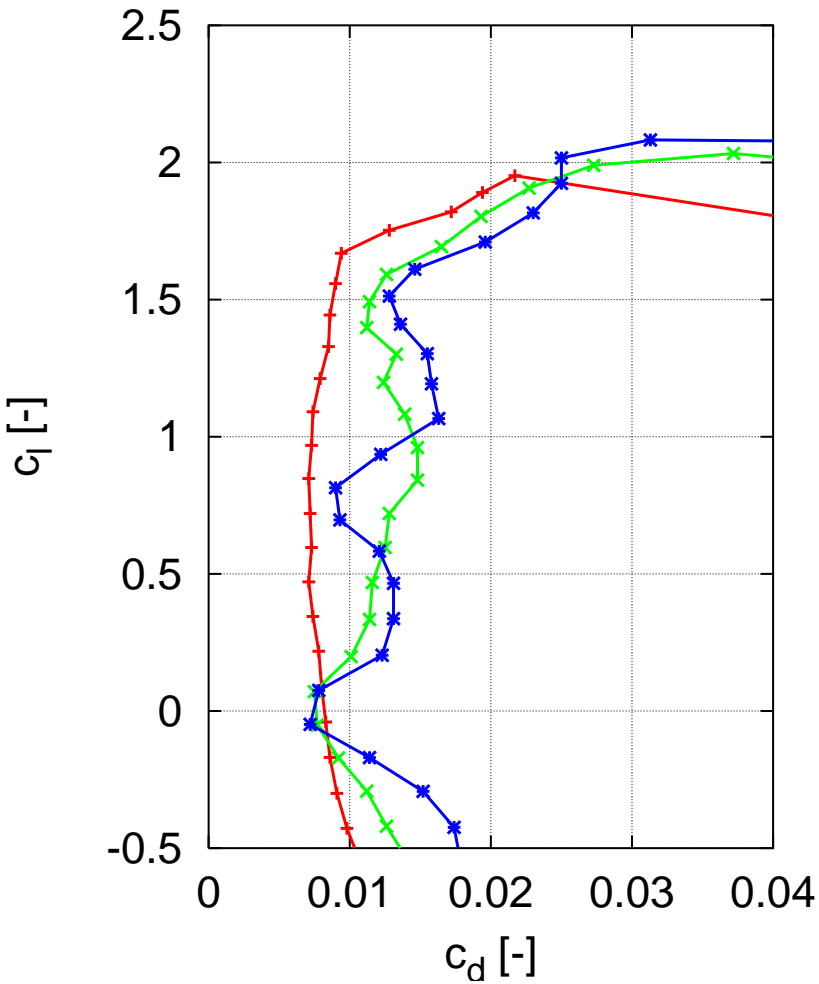
Results: Risø-C2-18, LER (ZZ90@5%/10%)



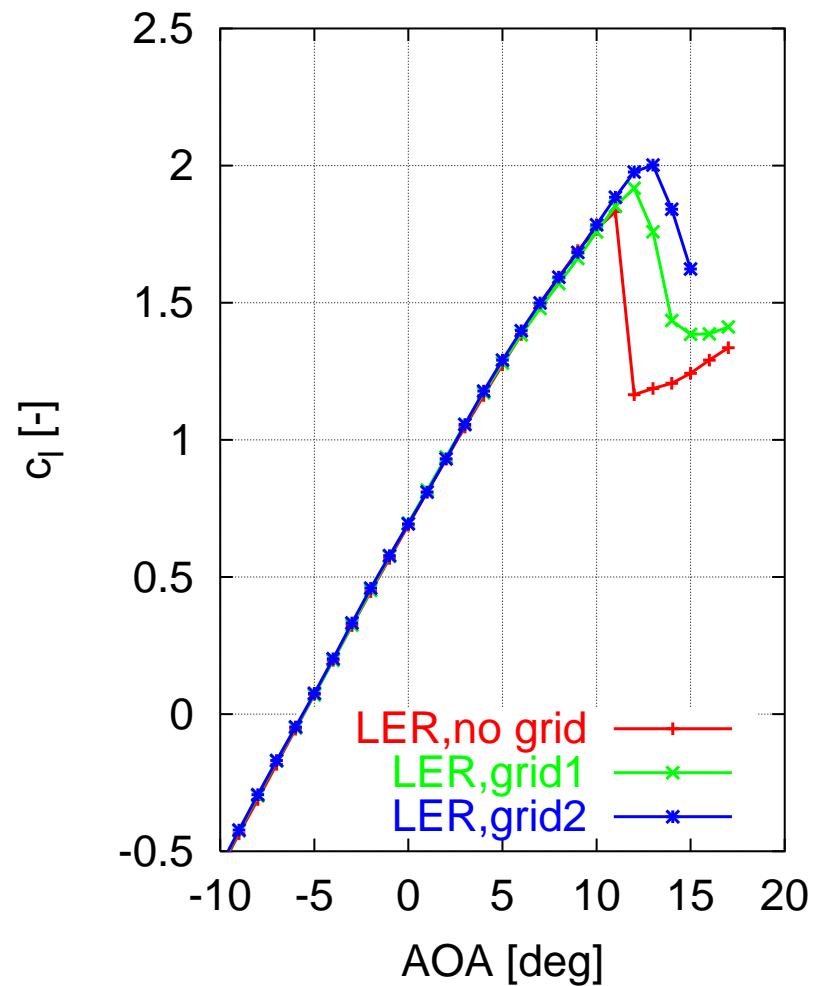
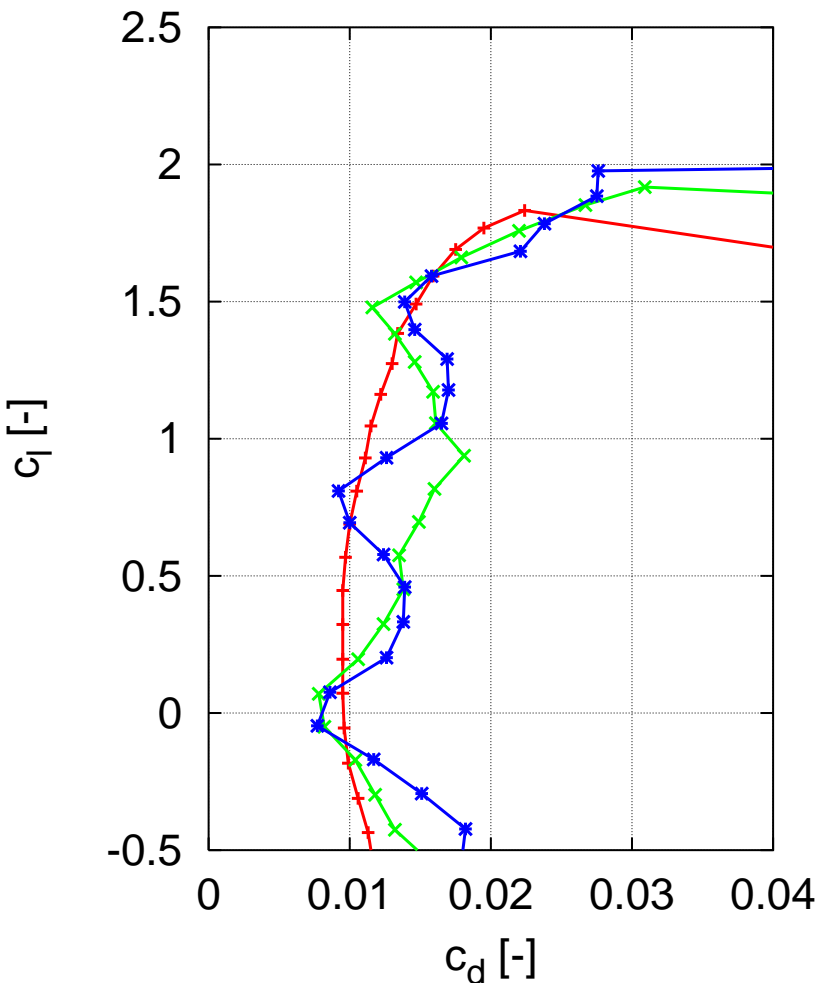
Results: Risø-C2-18 / Risø-B1-18, LER



Results: Risø-C2-18, Clean, Turbulence



Results: Risø-C2-18, LER, Turbulence



Conclusions

- Design objectives of new airfoils similar to Risø-B1
 - High maximum lift - **OK**
 - Insensitivity to roughness - **OK**
 - High compatibility - **OK**
- Design objectives of new airfoils differing from Risø-B1
 - Increased stiffness - **OK**
 - Slightly higher compatibility - **OK**
 - High aerodynamic efficiency - **OK**
 - Reduced minimum CL – **not entirely OK** (probably caused by transition modelling for negative angles of attack)
- It is possible to design roughness insensitive airfoils which
 - without leading edge roughness - show high lift-drag ratio
- XFOIL and the e^n transition model seems to predict the transition point well on the Risø airfoils for positive angles of attack
- Investigation of the influence of turbulence will be carried on....

Acknowledgements

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