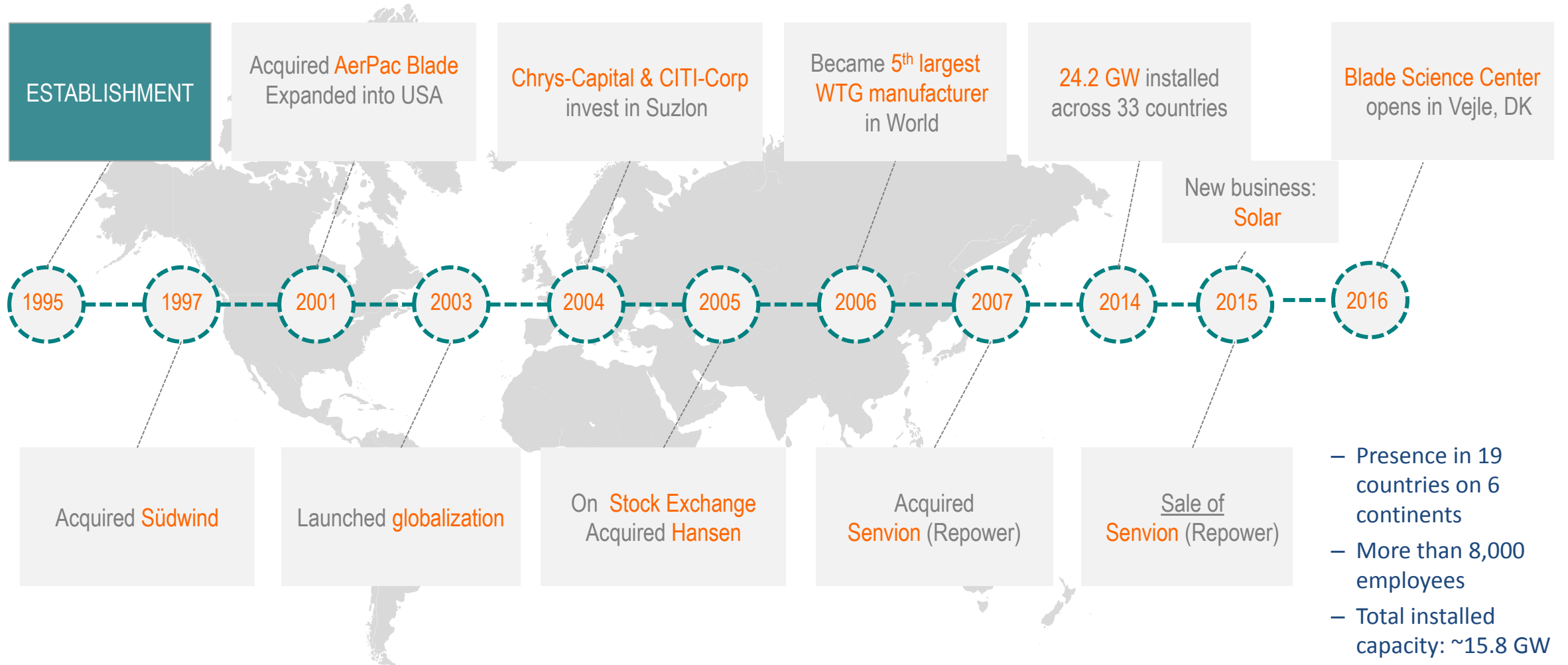


Design and optimization
of wind turbine
aerodynamic add-ons

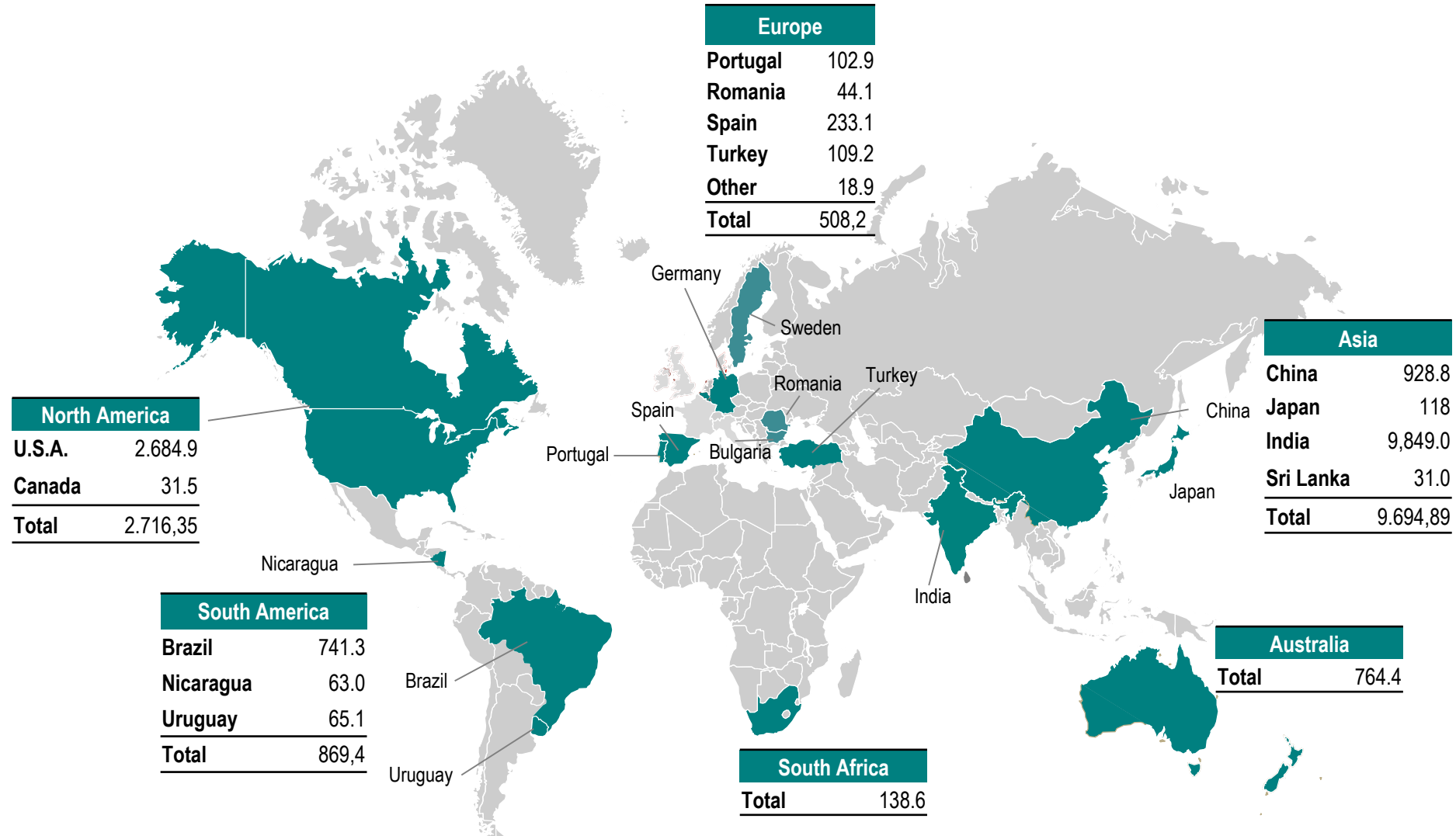
Stig Staghøj Knudsen
Senior CFD Engineer
Suzlon Blade Science Center

Suzlon Energy – Brief History



- Presence in 19 countries on 6 continents
- More than 8,000 employees
- Total installed capacity: ~15.8 GW (Sep-2016).
- More than 10,000 turbines at 325 sites

Installed capacity



Technology Hubs

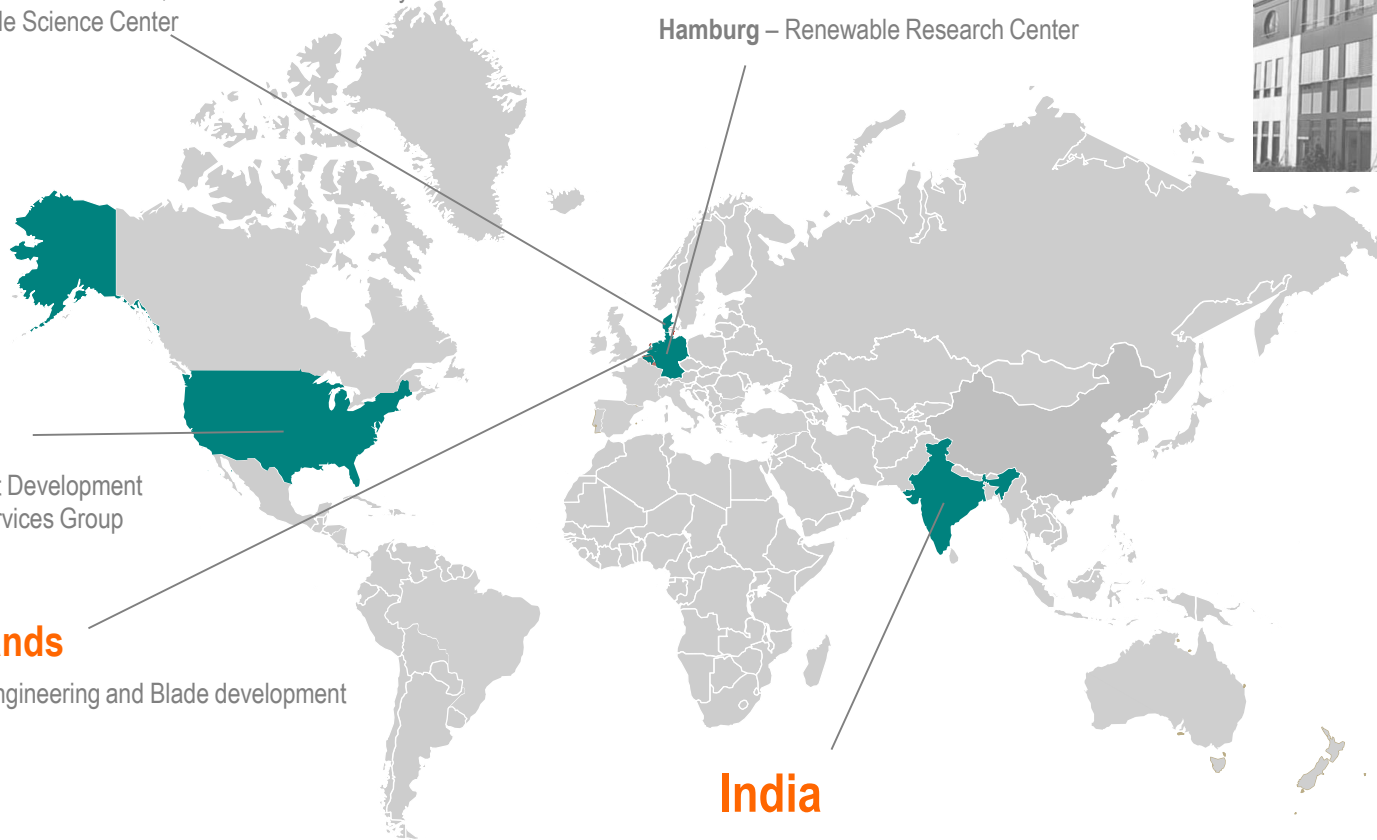


Denmark

Aarhus – Global Wind&Site, SCADA and Control Systems
Vejele - Blade Science Center

Germany

Hamburg and Rostock – WTG Product Development
Hamburg – Renewable Research Center



U.S.A.

WTG Product Development
Technical Services Group

Netherlands

Hengelo – Engineering and Blade development

India

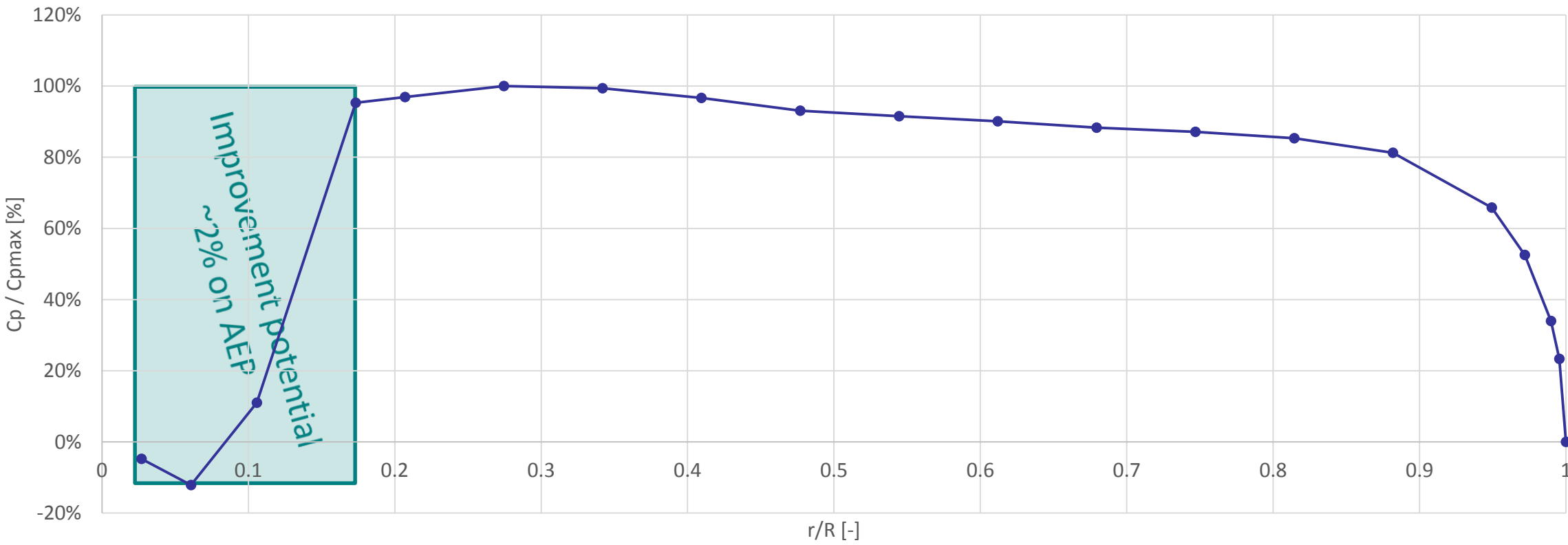
Vadodara – Blade Testing Center
Pune and Chennai – Engineering Center
Bhuj – Materials Testing Lab



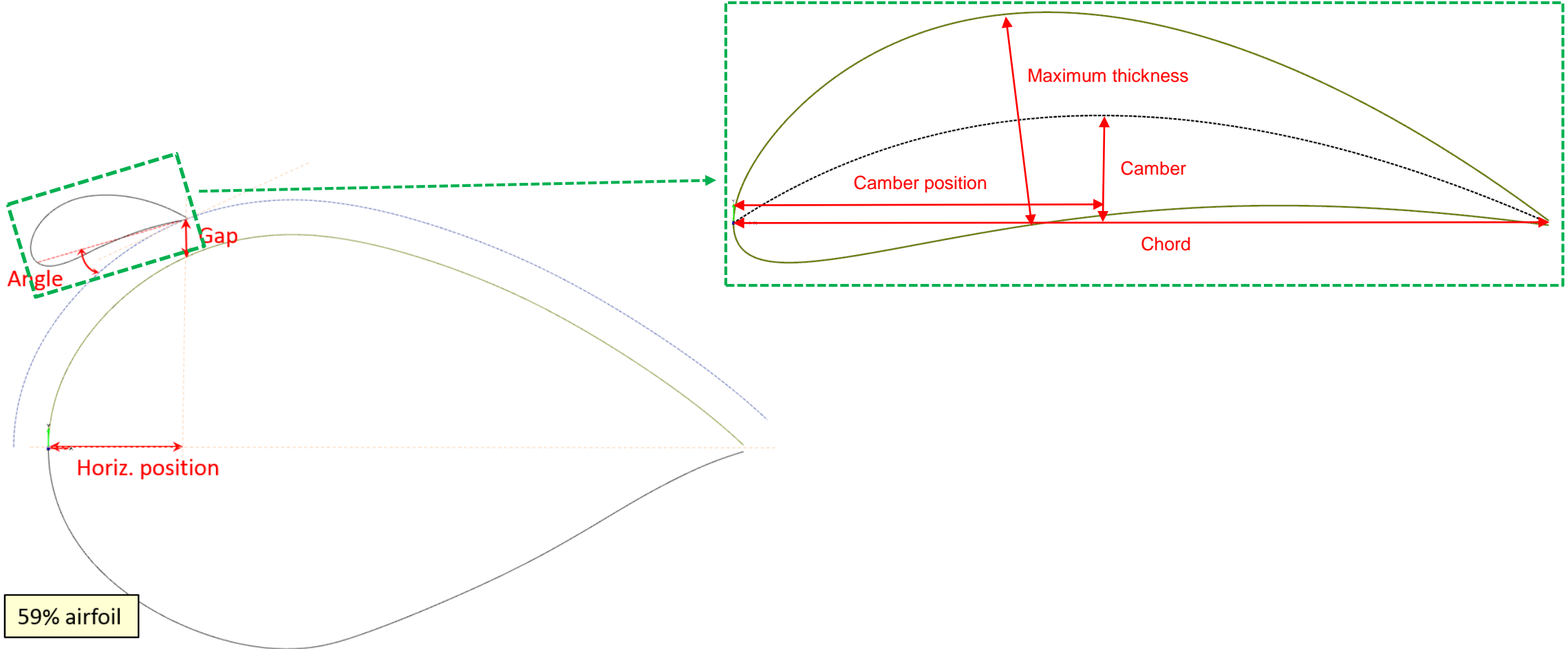
Aerodynamic add-on Leading edge slat (vorflügel)



S111 – Slat – Aerodynamic potential



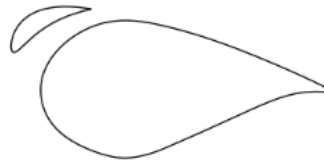
2D design optimization



MSES for performance evaluation

MSES: Fully coupled viscous-inviscid formulation, like XFOIL, but able to handle multi-element configurations

Fast execution:
1 min for full polar



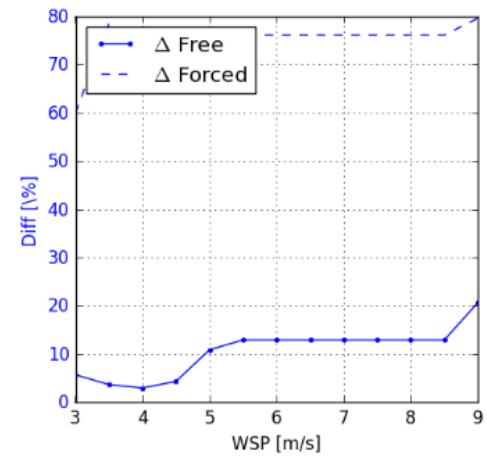
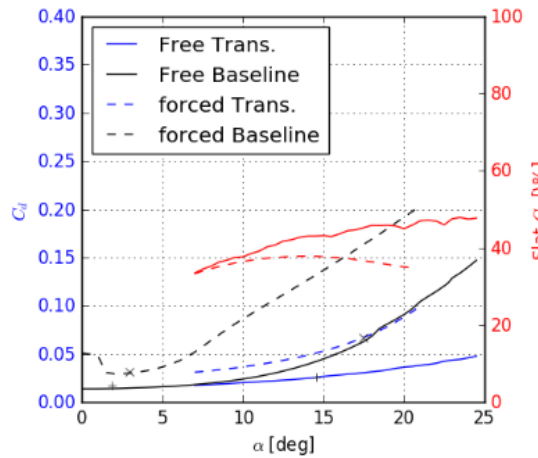
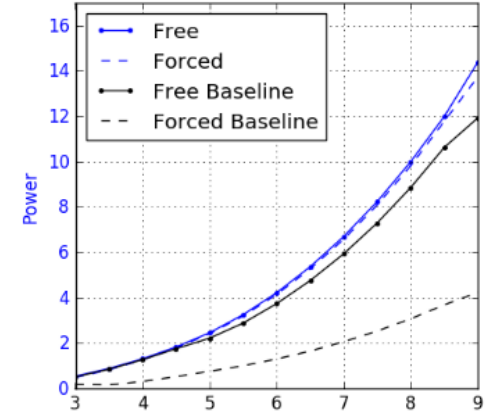
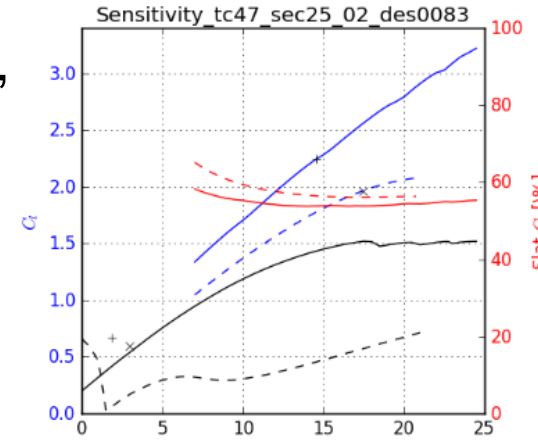
```

dx=17.305, Gap=5.938, beta=-9.219
cs=30.938, ca=31.602, th=21.953

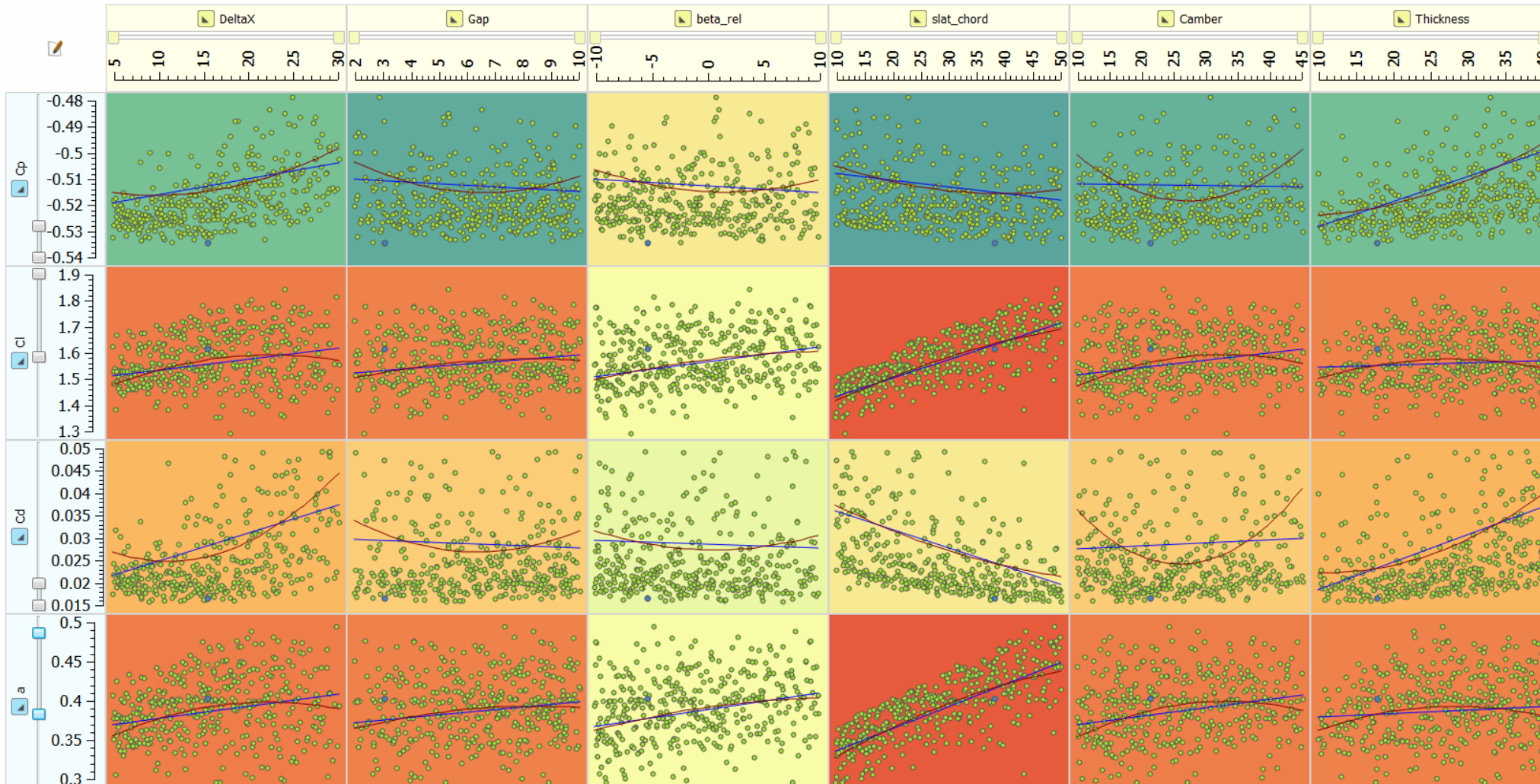
AEP=3.09e+06
(AEP_free=3.12e+06 AEP_forced=3.05e+06)

dAEP=118.332
(dAEP_free=12.947 dAEP_forced=223.717)
    
```

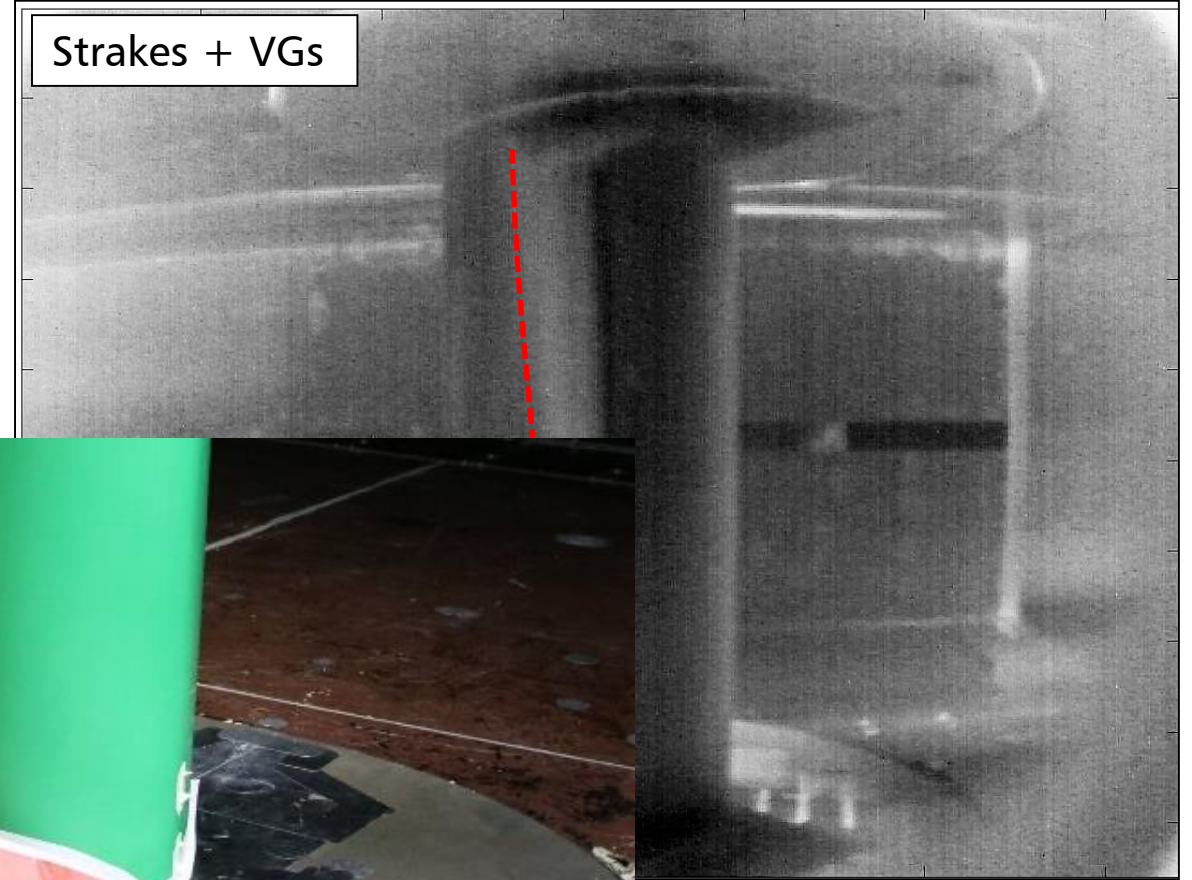
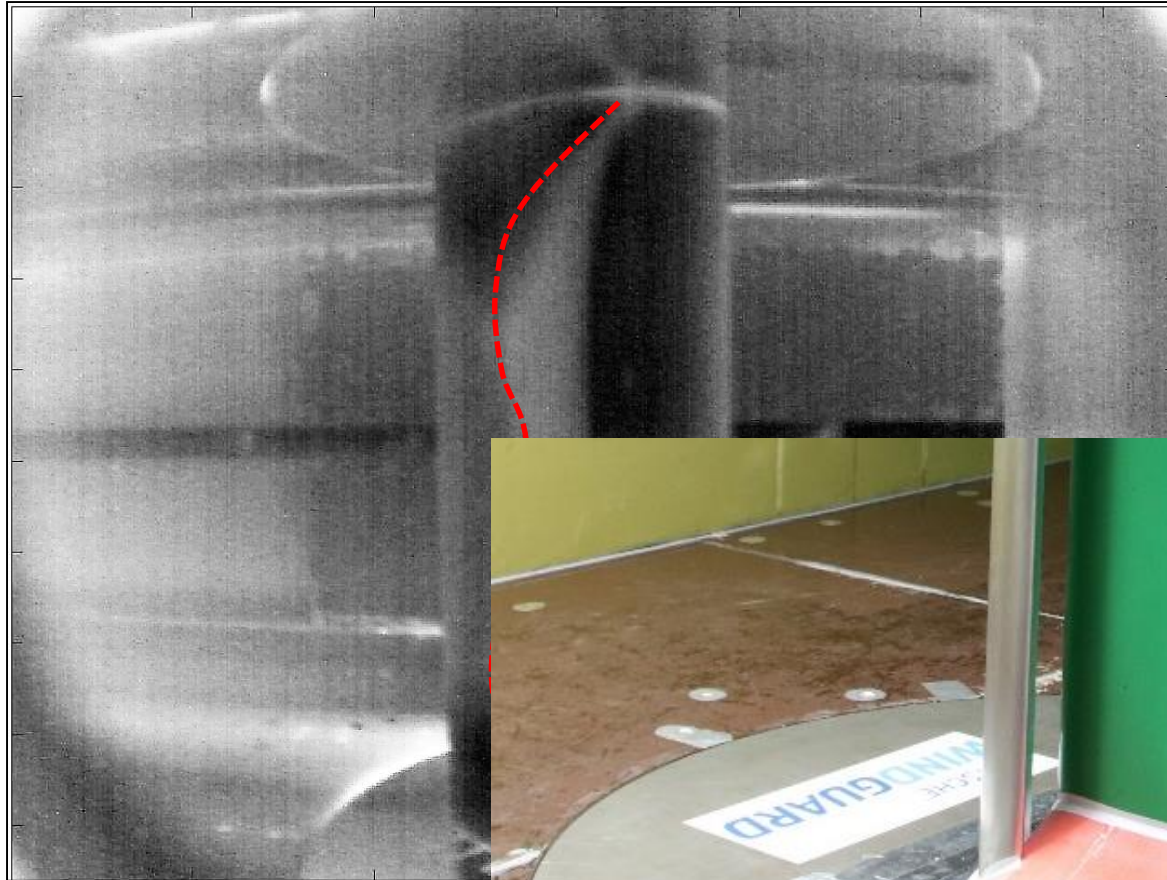
Coupled with small BEM code to find local C_p



2D design optimization outcome

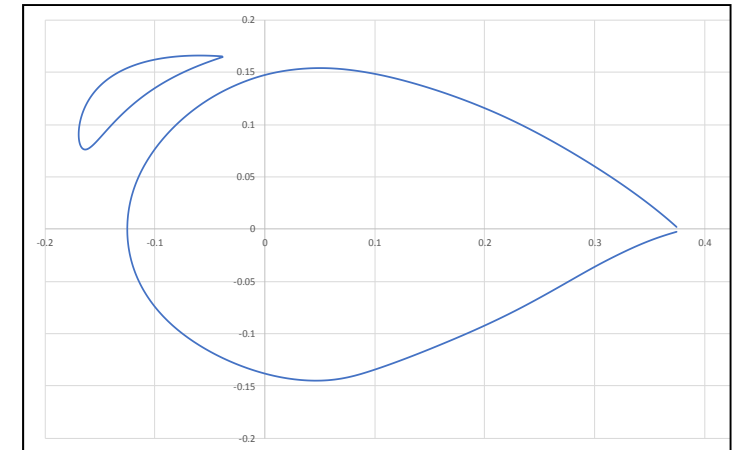
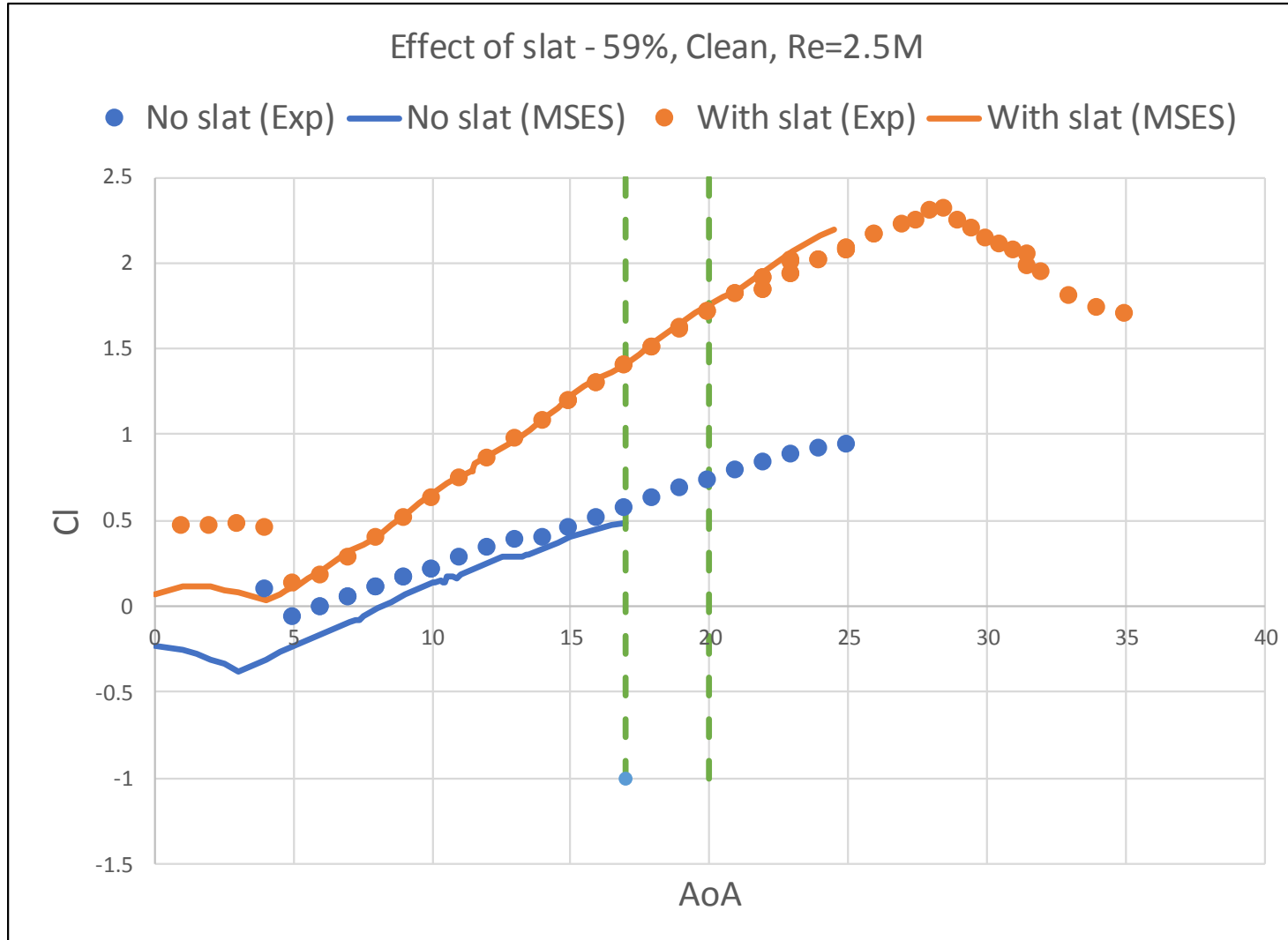


Wind Tunnel Test Campaign – 3D Effects



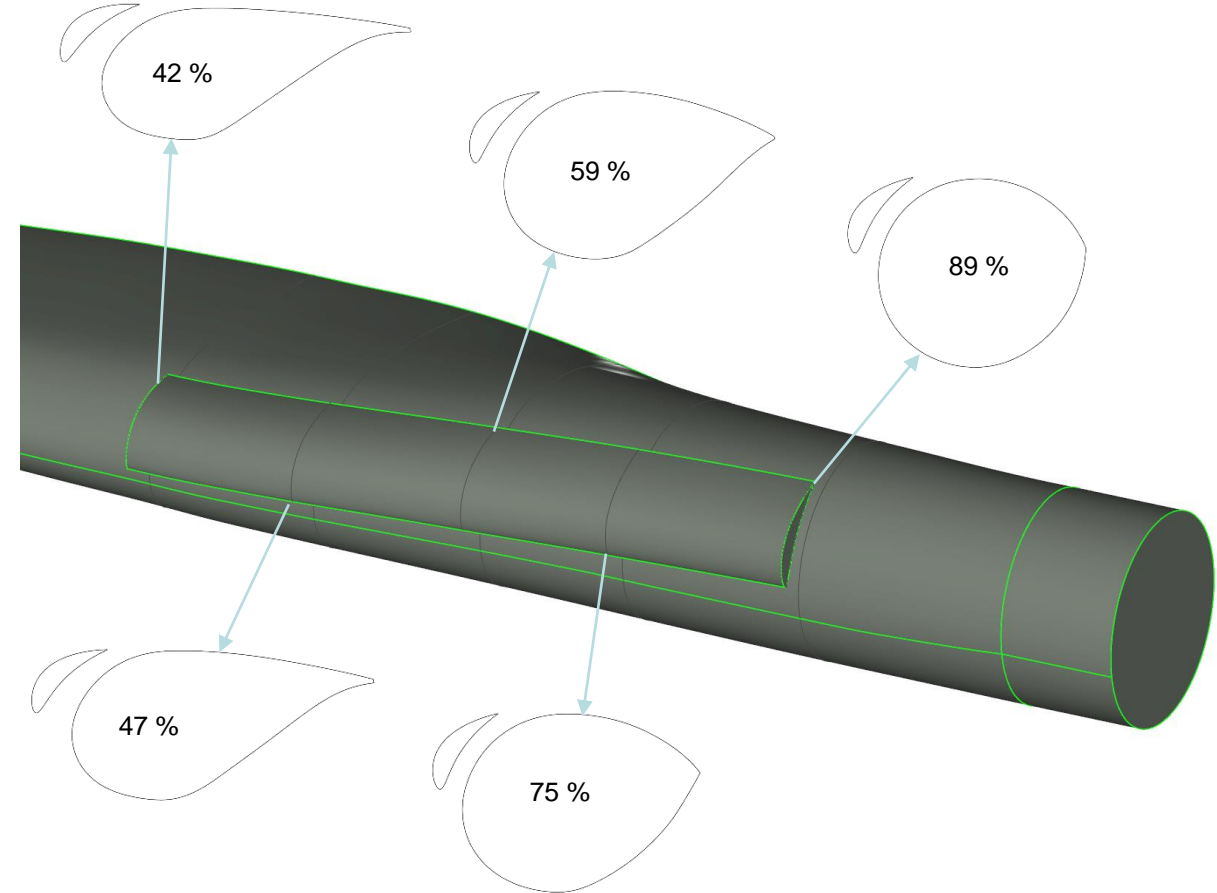
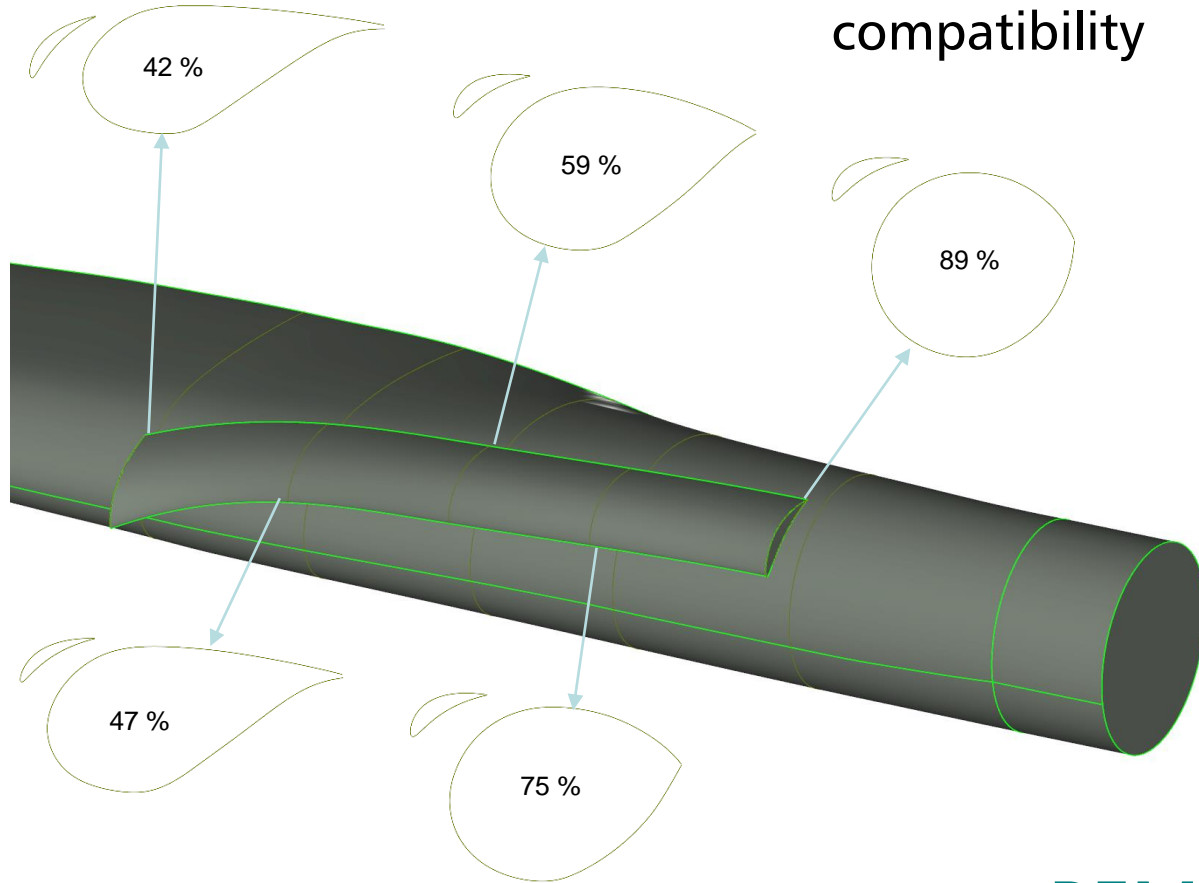
Wind Tunnel Test Campaigns

Effect of slat



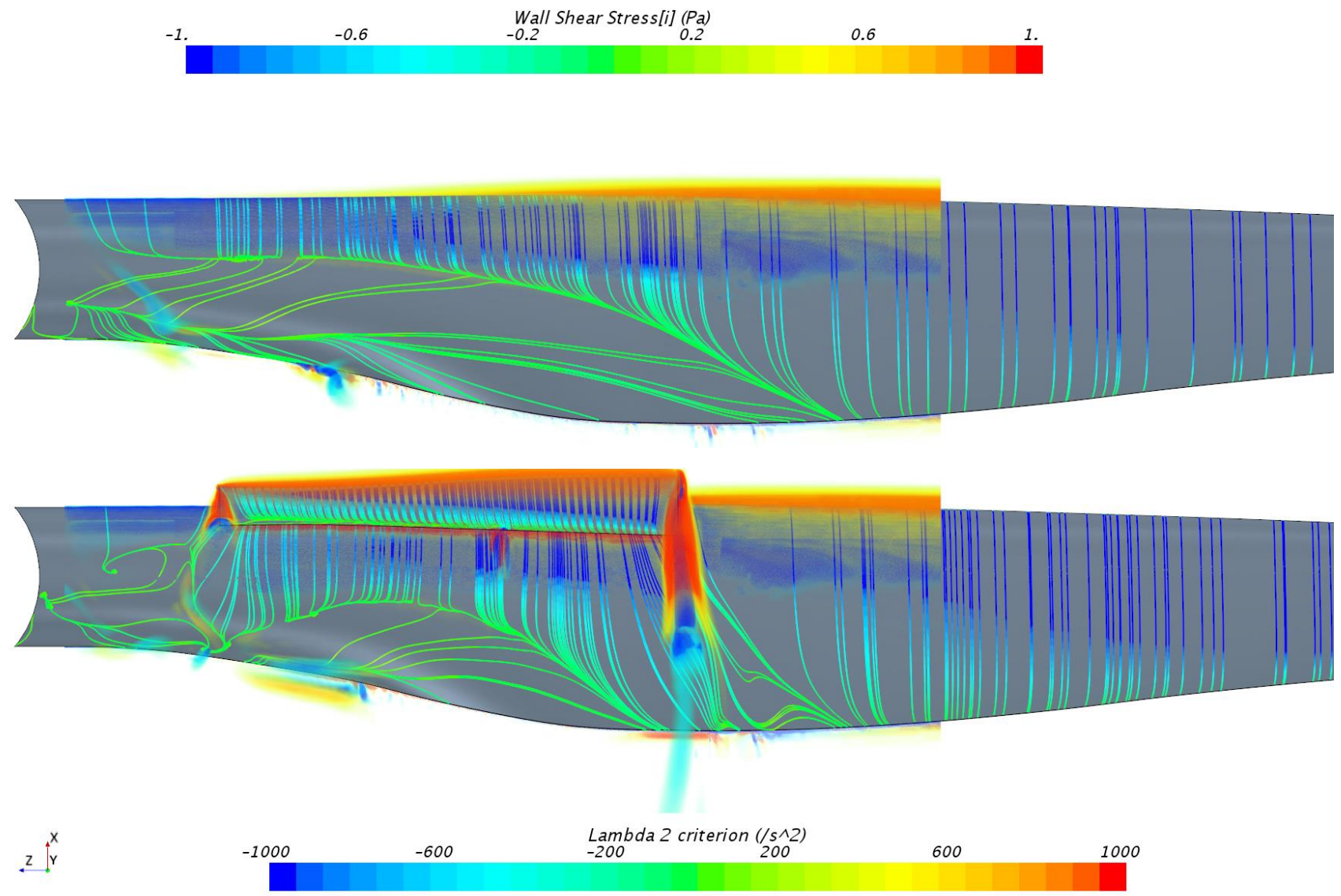
2D to 3D

Increase geometric compatibility



BEM:
150 % of AEP
target

3D CFD



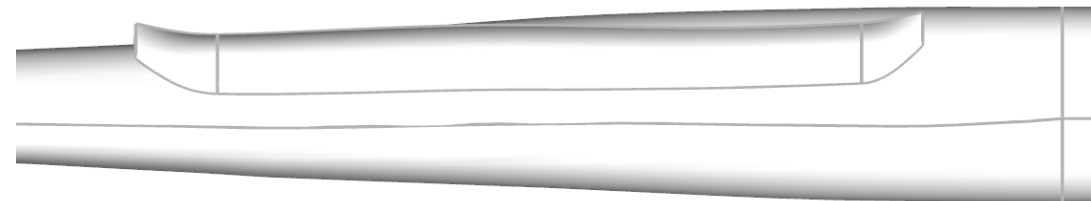
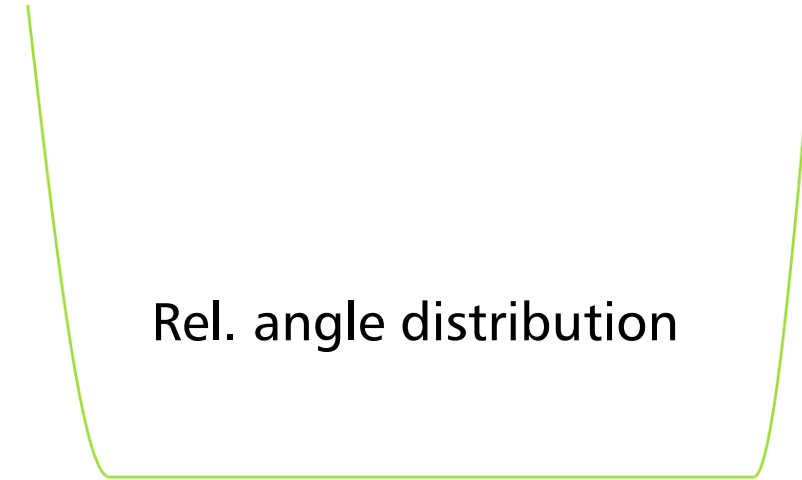
No slat

First iteration
AEP ↓

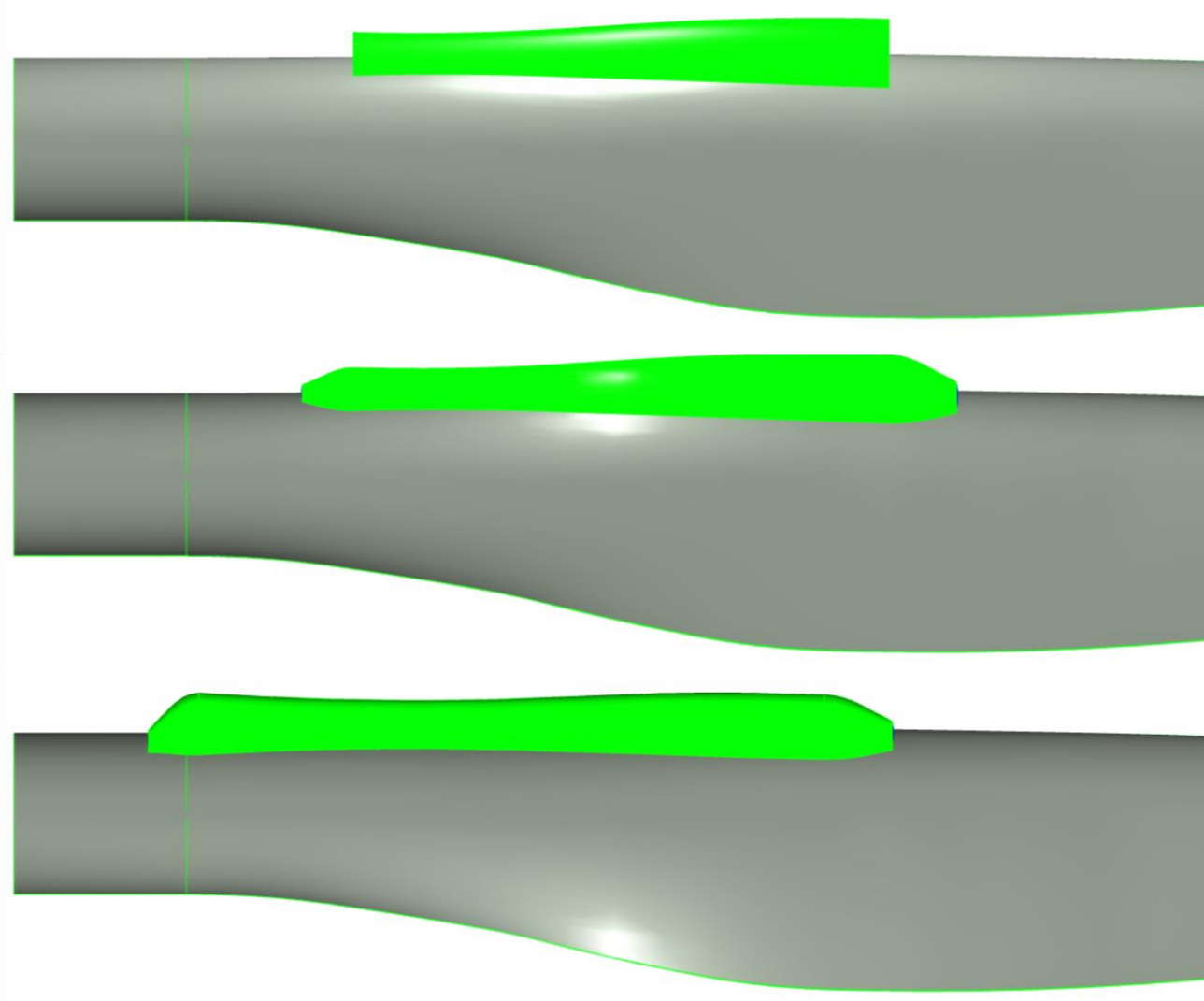
3D CAD model for optimization

New CAD model

- Distribution for parameters to allow for 3D optimization
- Smooth surface generation by meta-surfaces
- Extensions to unload and reduce tip vortices



Slat geometry change

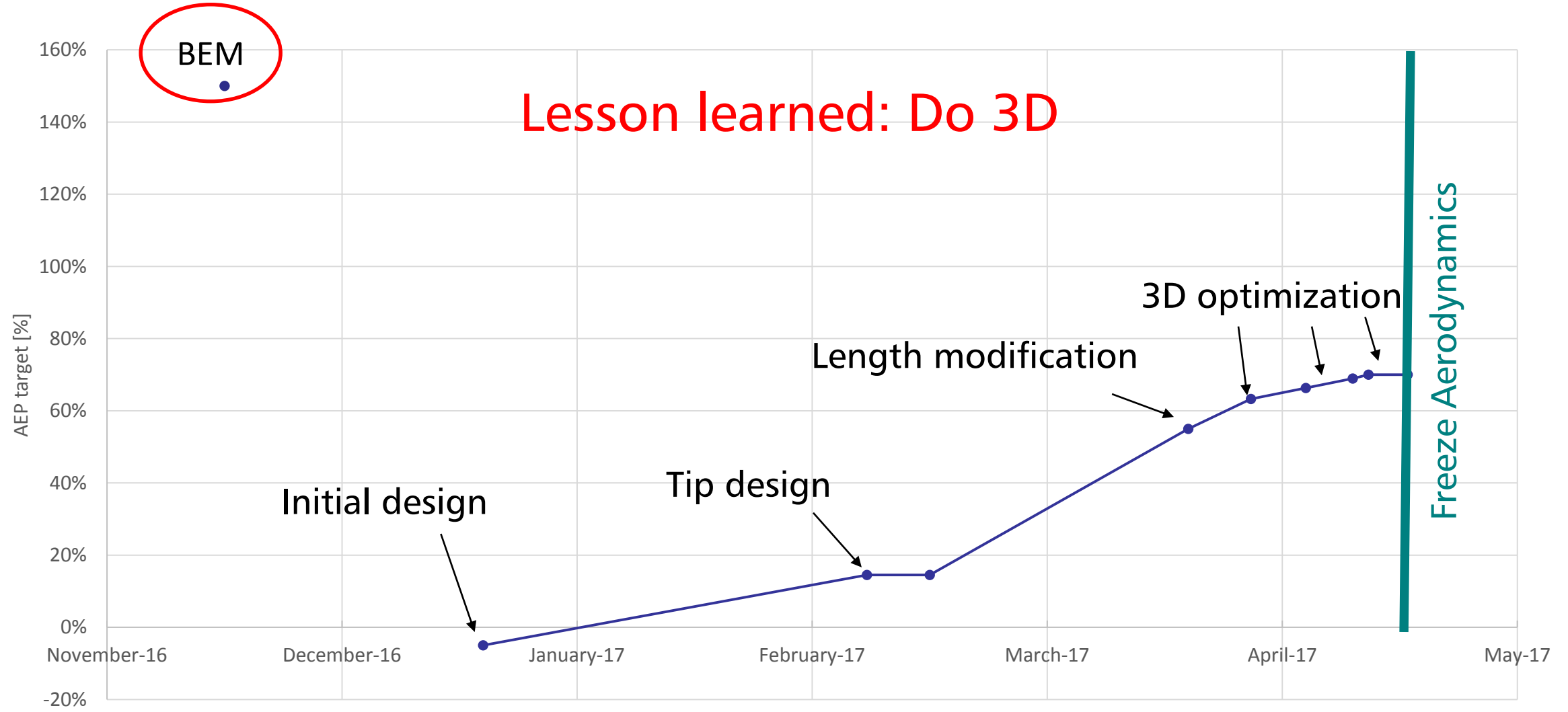


Initial design

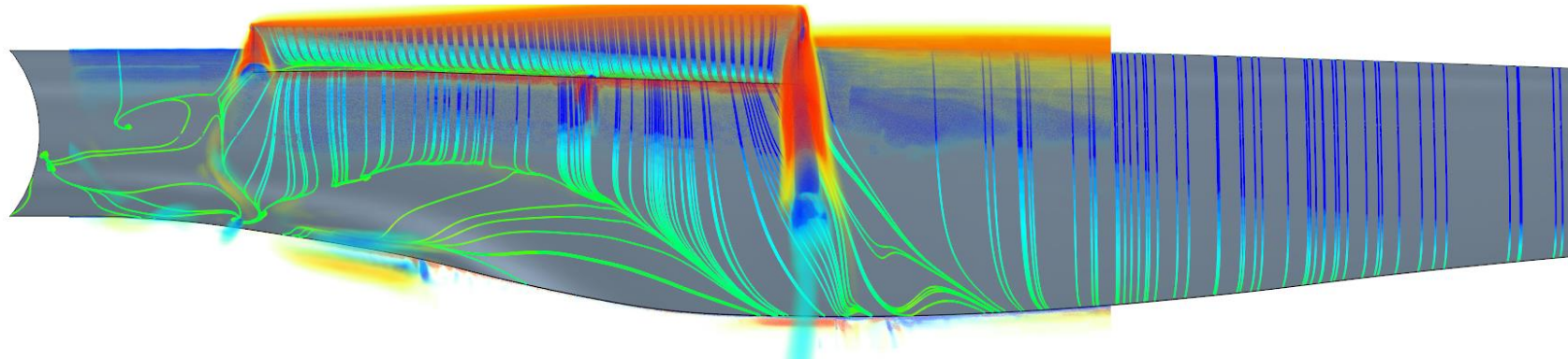
Tip extensions

Final design

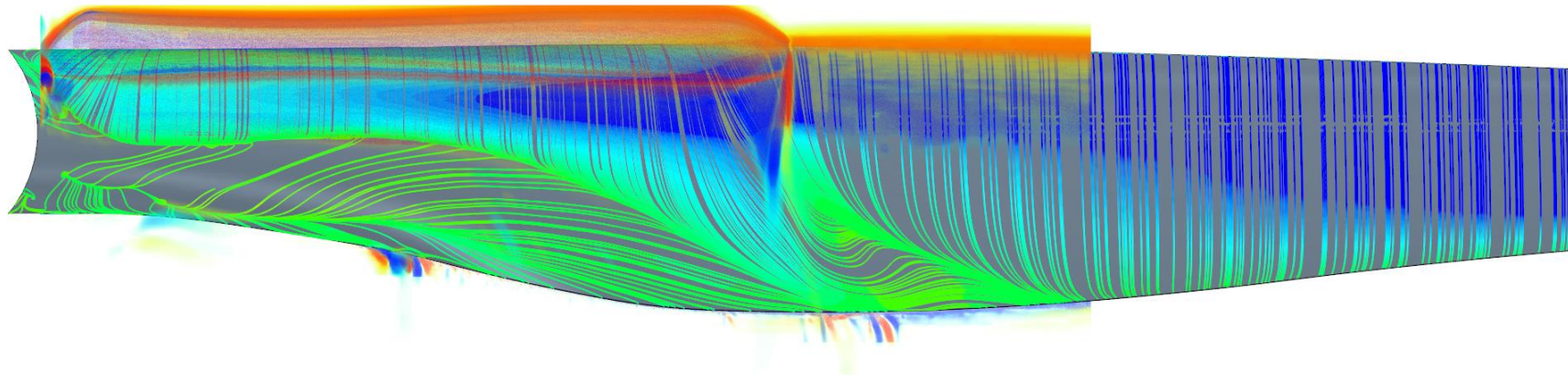
3D optimization



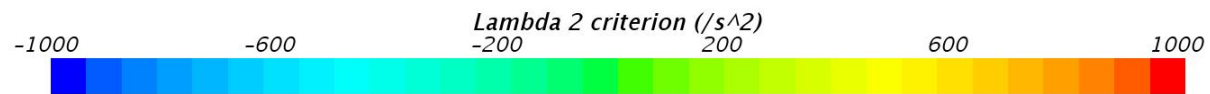
3D optimized design



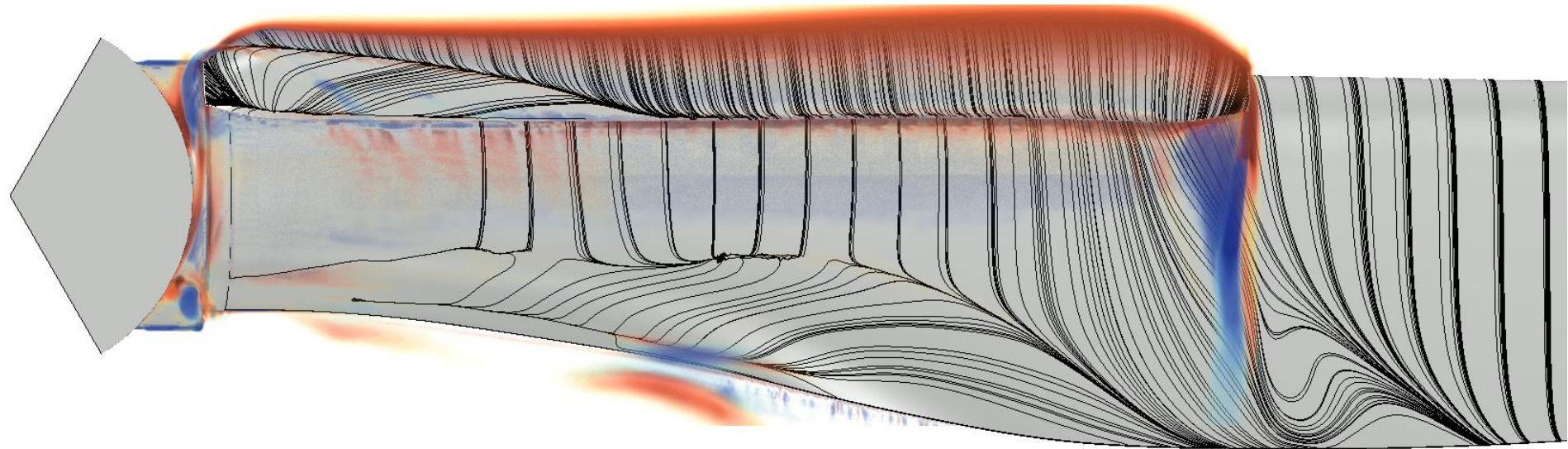
Initial Design
from 2D



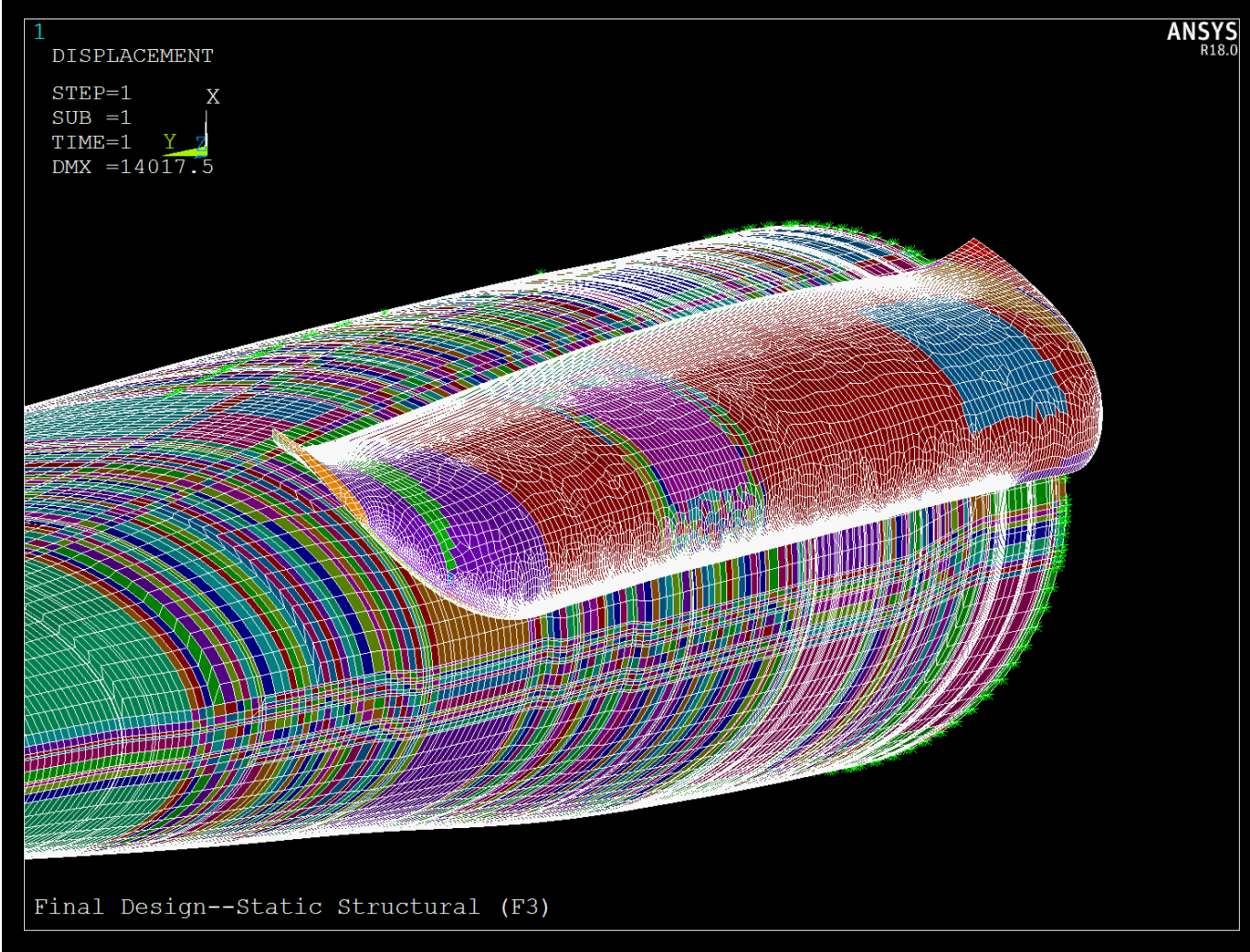
Final 3D
design



Effect of spinner and Cone



Structural design





1
2
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17

DUZLON
A GREENER TOMORROW

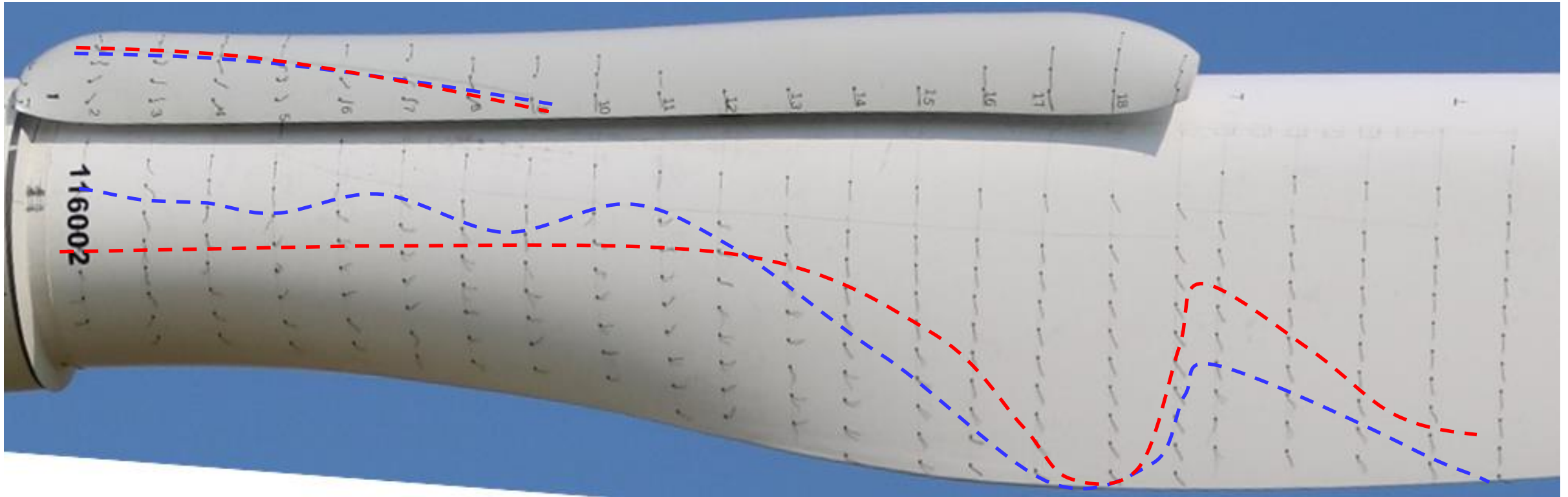
Group of approximately ten workers in safety gear standing at the base of the tower.



Hoisting the slat



Comparison with tuft visualization



Separation line (CFD)

70 % of AEP target

Separation line (Tufts)

150 % of AEP target (+VG)



SUZLON

POWERING A GREENER TOMORROW