FIRST WORKSHOP

Integrated HLFC design for the leading edge of a wing:

AFLoNext

2ND GENERATION ACTIVE WING

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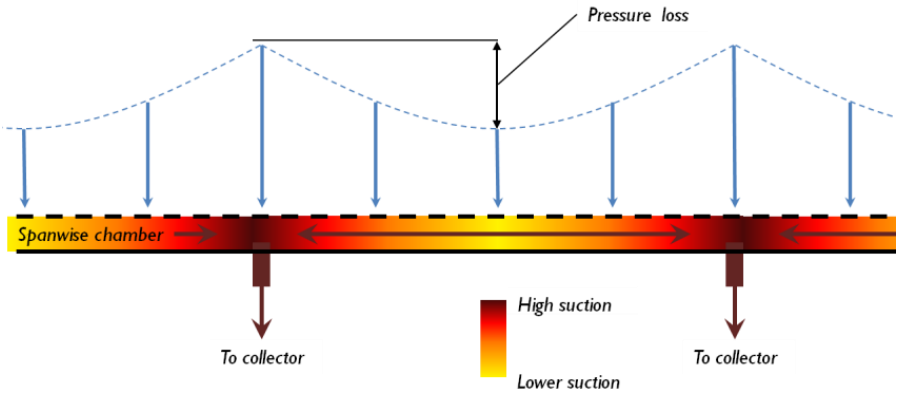
Introduction

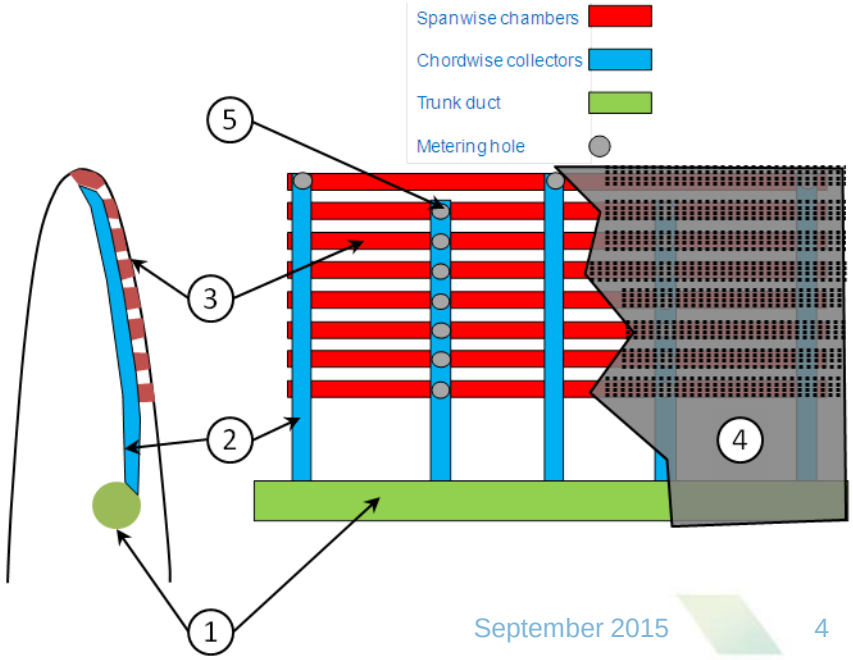
- Integrated wing solution for HLFC with all necessary systems within the leading edge
- Build on and re-learn lessons learnt from previous EU HLFC projects HYLTEC
- Investigate outer wing pressure distribution philosophies best suited to HLFC
- Develop multi-point optimisation framework
- Develop models for evaluation of pressure losses within suction system ducting
- Develop suction distribution and HLFC ducting system for best overall performance including WIPS requirements.
- Ensure suction distributions are self adapting *(constant geometry metering holes)*
- This presentation is concerned only with the aerodynamic analysis (up to November 2014)

Suction system architecture

- Suction system architecture investigated within AFLoNext 1.2

1. Trunk duct *(connected to suction pump in this case but could be passively driven)*
2. Collector ducts *(distributes suction to spanwise chambers)*
3. Spanwise chambers *(distributes suction along porous skin)*
4. Porous suction skin
5. Metering holes

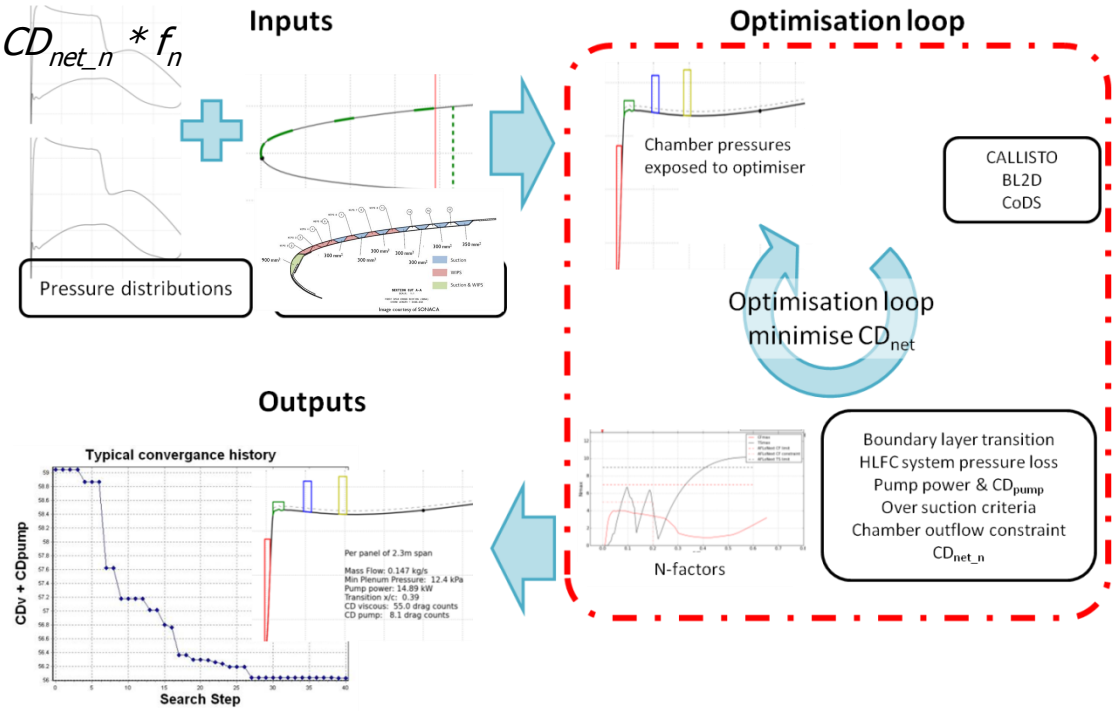




Suction optimisation framework (make things less bad!)

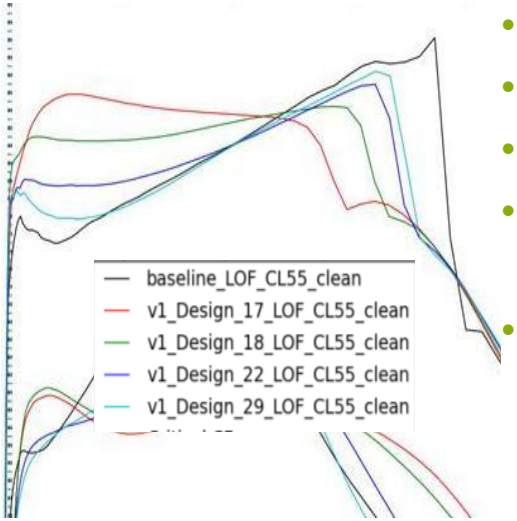
$$CD_{cost} = CD_{net\_1} * f_1 + CD_{net\_2} * f_2 + ... + CD_{net\_n} * f_n$$

$$CD_{net\_n} = CD_v + CD_{pump} + CD_{mass}$$

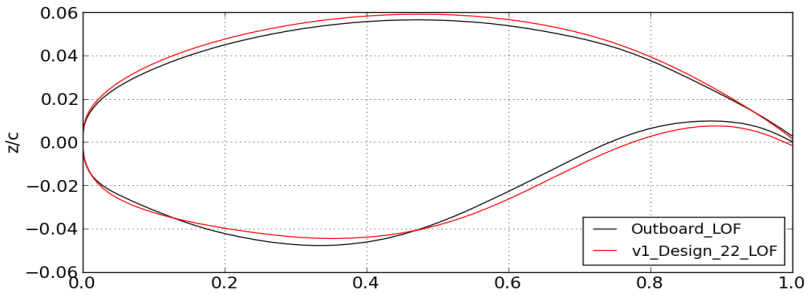


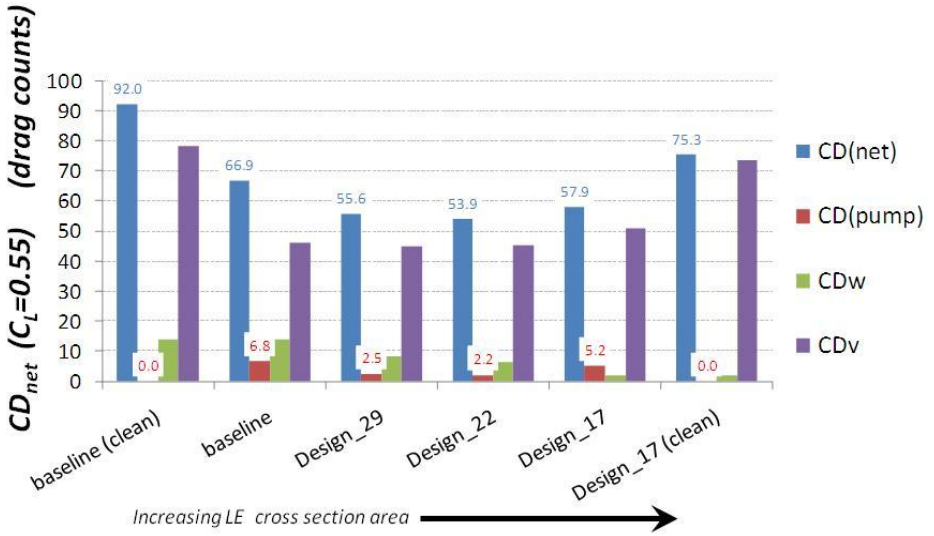
- Optimisation of suction distributions for multiple flow conditions for given HLFC system
- Pressure losses, mass and pump power requirements calculated and included in cost function.
- Allows self adapting suction systems to be optimised.
- Stability analysis limited to linear e^N analysis.

Pressure distribution philosophy for HLFC



- Aerofoils with variation in roof top gradient designed
- Suction distribution “optimised” with preliminary chamber layout
- Suction peak of baseline aerofoil unhelpful at C_l=0.63
- Reducing favourable roof top gradient causes:
  - Reduced wave drag & Increased pump drag
- Design_22 taken forward within project
  - 3.6% increased volume ahead of front spar
  - Increased LE radius improves high-lift performance





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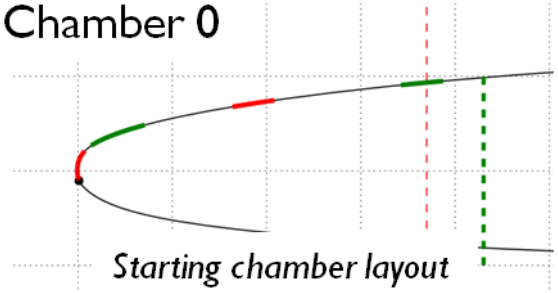
Evolution of chamber layout

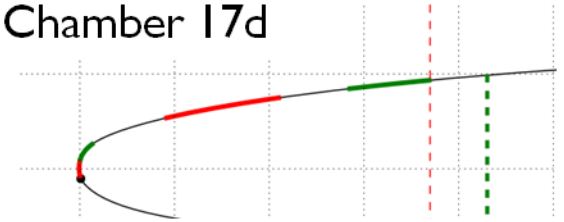
- Chamber layouts have evolved during project (and continue to evolve) in response to:
- Manufacturing constraints, WIPS requirements, performance improvements etc...

Chamber 0



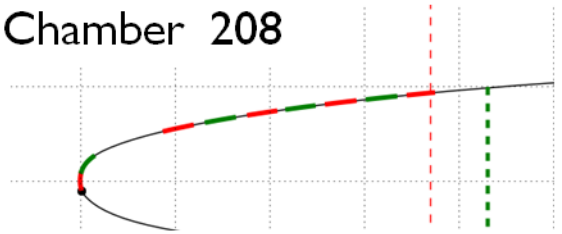
Starting chamber layout

Chamber 17d



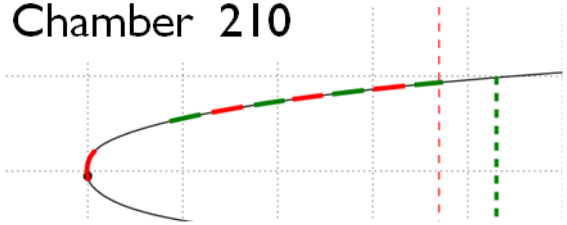
Result of City University London study to incorporate WIPS constraints into chamber layout

Chamber 208



Result of City University London / SONACA study to ensure chamber discretisation complies with the SONACA skin concept.

Chamber 210



SONACA request for a single nose chamber was assessed for viability by City University London.

Self adapting suction system

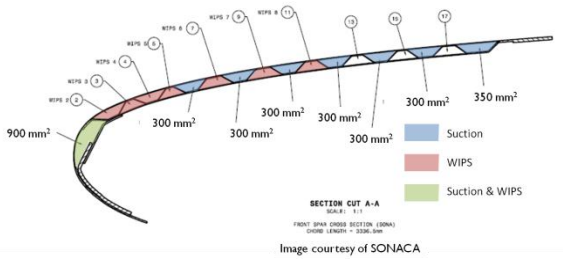
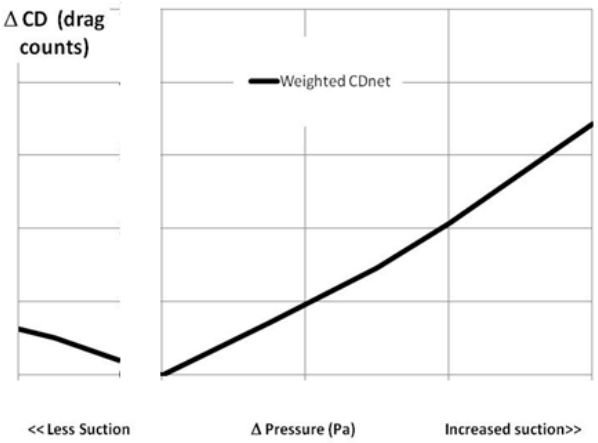
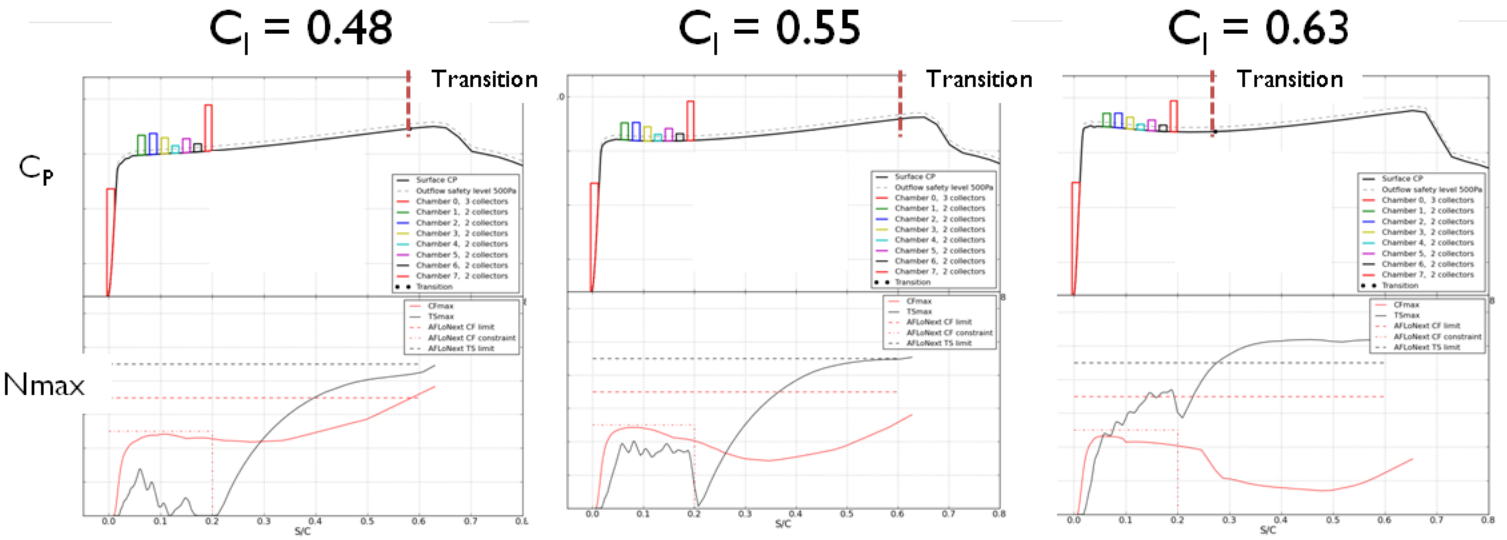


Image courtesy of SONACA

- Suction distributions for self adapting suction distributions
- Cl = 0.63 showed limited laminarity with pump drag outweighing viscous drag reductions
- Suction system robust to changes in suction*(losses along spanwise chambers)*





Summary and outlook

- Good working relationship achieved between partners
- Tools and methodologies developed to make assessments of HLFC performance including effects of HLFC architecture
- Tools and assumptions matured throughout project. Design_22 wing pressure distribution philosophy probably not optimum solution
- Self adapting suction distributions for multiple design points successfully demonstrated
- Suction distributions robust to chamber spanwise pressure losses
- Including WIPS & manufacturability constraints seen as crucial in understanding performance benefit potential of HLFC
- Suction distribution and HLFC architecture continue to be iterated between partners *(now nearing completion!)*

- Understand how spanwise interruptions of suction can be mitigated. *(higher order stability analysis methods)*
- Assessment of alternative suction skin concepts *(awaiting pressure loss characteristics)*

Thank you !

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