National Wind Tunnel Facility

Instrumentation Sub-Group

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Remit: Explore academia-industry synergies

- Three possible areas of collaboration/explorations

1. Variations of force/moment or pressure sensors (low-cost and configurable for applications)
2. Flowfield measurements (PIV, PSP etc) - Use low-cost cameras, LEDs and other non-conventional measurement techniques.
3. Data assimilation techniques to access previously inaccessible information using a combination of experiments and numerics
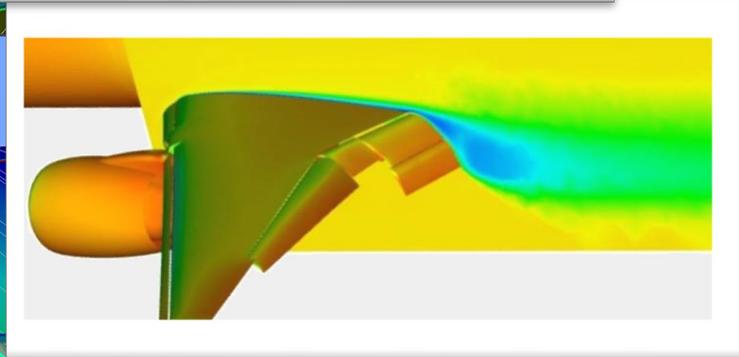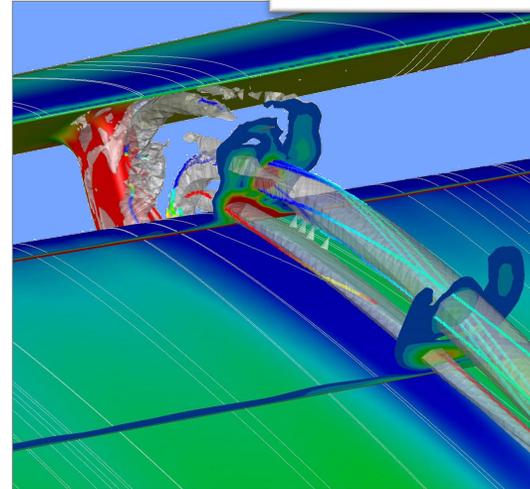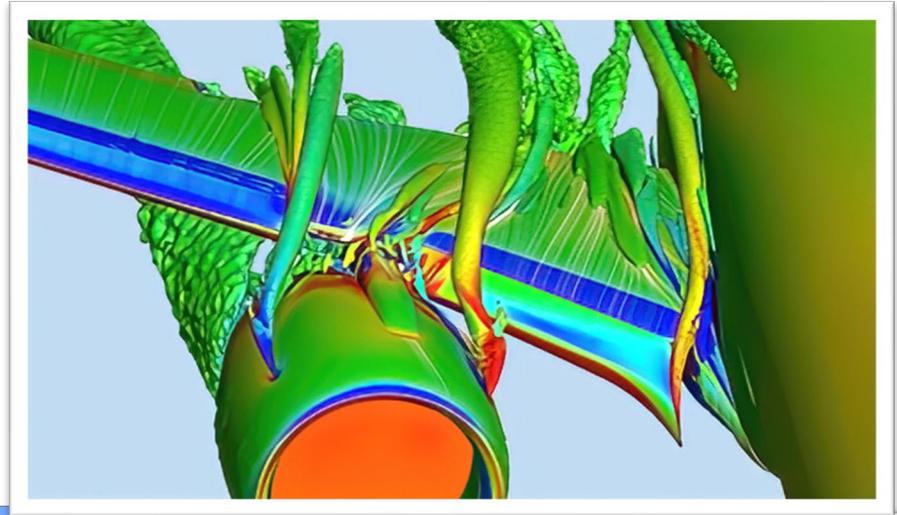
Opportunities to Address Key Flow Phenomena with Novel Instrumentation

1st NWTF Conference, Birmingham

Ashley Evans

26 May 2023

Challenges in High-Lift Aerodynamic Modeling

Airbus

- Lots of different **fluid dynamic phenomena, and their interactions**, (e.g. in the presence of strong pressure gradients)
  - Slat bracket effects
  - $C_{L,max}$ characterization
  - Unsteady flow characterization
  - Nacelle chine vortex flow and interactions
  - Trailing edge flow features and increments
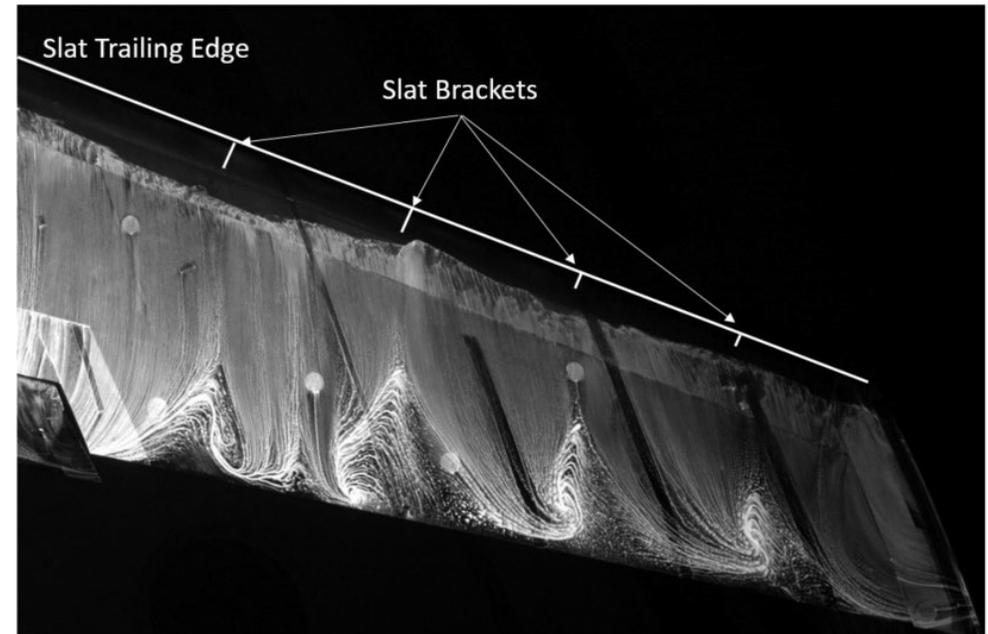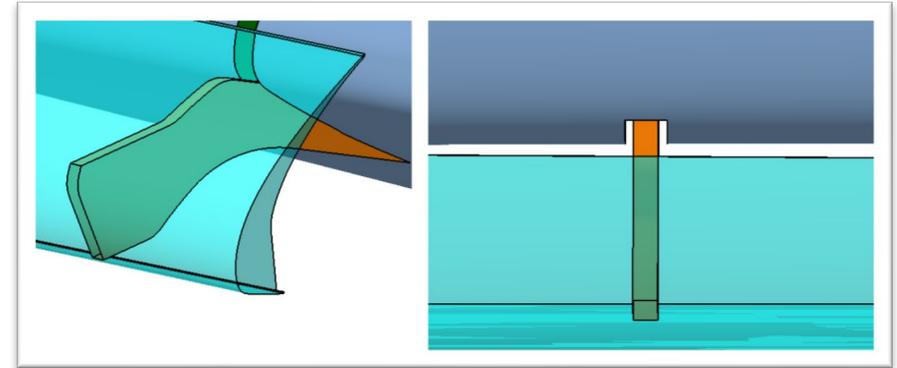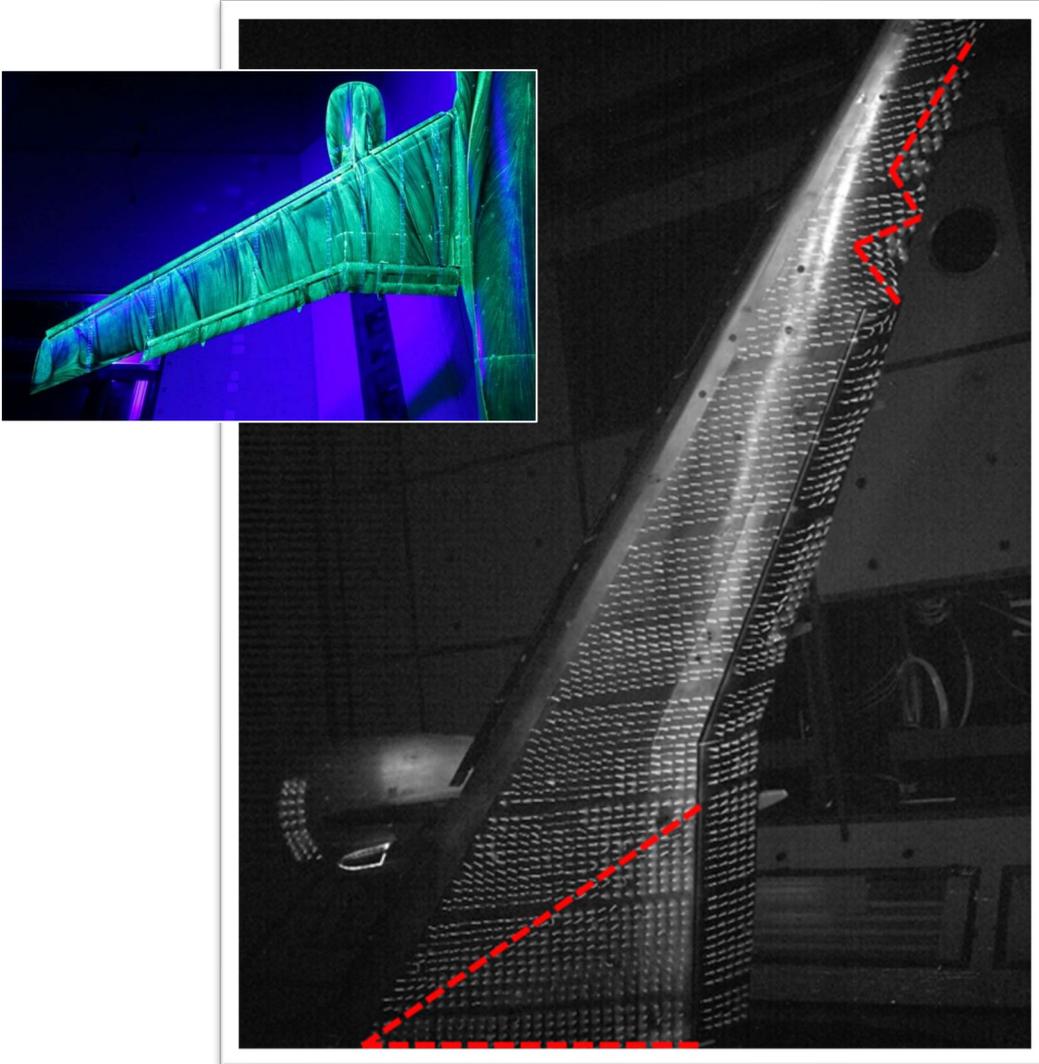

Boeing, 2012
Airbus

Clark, A., Slotnick J., Taylor, N., and Rumsey, C., "Requirements and Challenges for CFD Validation within the High-Lift Common Research Model Ecosystem" AIAA-2020-2772, https://doi.org/10.2514/6.2020-2772

Slat Bracket Effects

- Relatively **small geometric detail** leads to **large aerodynamic impact.**

- Very **complex flow phenomena**, but current data sets only provide limited surface flow visualization

- **Off body flow measurements** will provide critical validation data for method development and assessment, and may lead to improvements in turbulence models.

Clark, A., Slotnick J., Taylor, N., and Rumsey, C., "Requirements and Challenges for CFD Validation within the High-Lift Common Research Model Ecosystem" AIAA-2020-2772, https://doi.org/10.2514/6.2020-2772

$C_{L,max}$ Characterization

- Additional focus is required beyond just predicting $C_{L,max}$ magnitude with CFD – **Want to get the "right answer" for the "right reasons"**
  - Pitching moment
  - Surface visualization

- Usually requires dedicated efforts to obtain surface visualization data (e.g., oil flow, mini tufts), not just at maximum lift, but as flow separation regions develop

- **Off body data** will help characterize and explain flow interactions that lead to lift loss

Clark, A., Slotnick J., Taylor, N., and Rumsey, C., "Requirements and Challenges for CFD Validation within the High-Lift Common Research Model Ecosystem" AIAA-2020-2772, https://doi.org/10.2514/6.2020-2772

Nacelle Chine Vortex Flow and Interactions

- A **vortex generated from the nacelle chine** strongly influences aerodynamic performance on the inboard wing, particularly at stall.

- CFD gridding and solver parameters can strongly influence the strength of the vortex and the path of propagation.

- **Off body flow data** will be invaluable to validate vortex behavior, and help determine CFD modeling best practices.

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Trailing Edge Flow Features and Increments

- Trailing edge flap increments are driven by turbulent flow separation, but **different set of considerations** compared to maximum lift:
  - **Maximum loading** typically occurs at **operational (lower) angles of attack**
  - **Trailing edge unloads** as maximum lift is approached
  - Different modeling considerations must be addressed to obtain an adequate solution for this class of problems
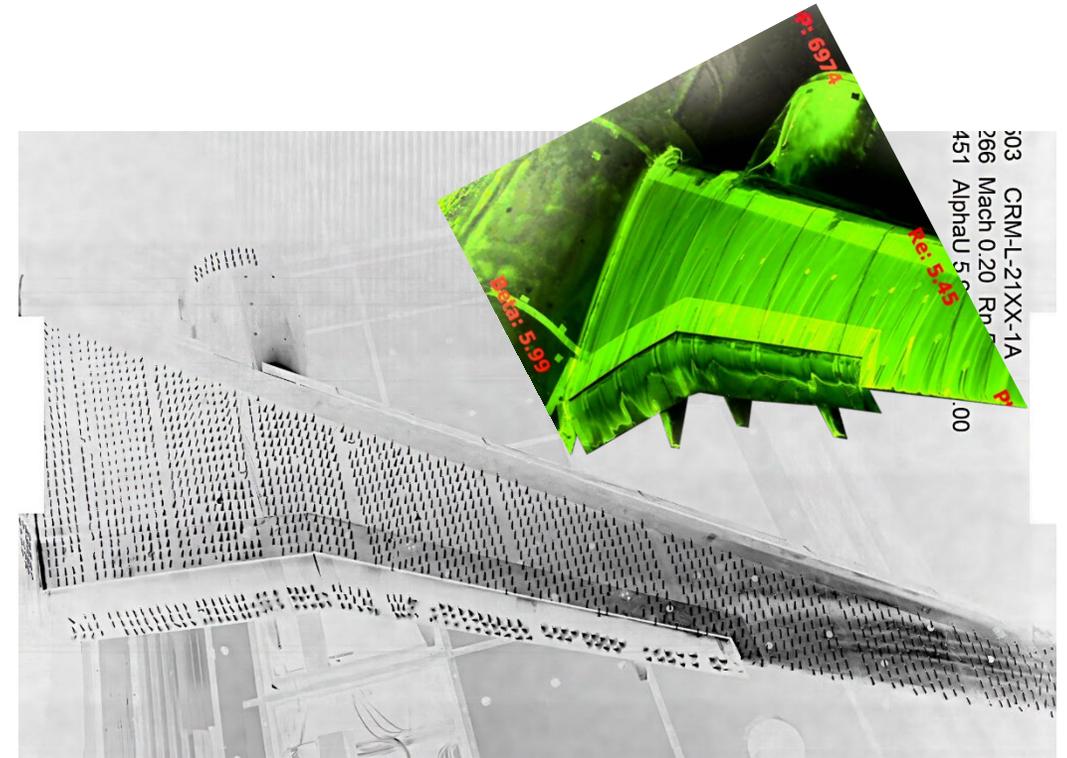
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Action: Deep-Dive Discussions

- **Online meeting in mid June (Details to be announced soon)**

- 6-8 talks – 10 mins each from researchers across the UK to talk about their latest developments
- It can be one type of sensor or a variety of them

- Opening lecture (10 mins) from Ashley Evans (measurement challenges in Industrial wind tunnels)

Get in touch

Interested in giving a talk (contact: Bharathram Ganapathisubramani: g.bharath@soton.ac.uk)
Interested in attending (contact: Claire Mcnamara: c.mc-namara@imperial.ac.uk)