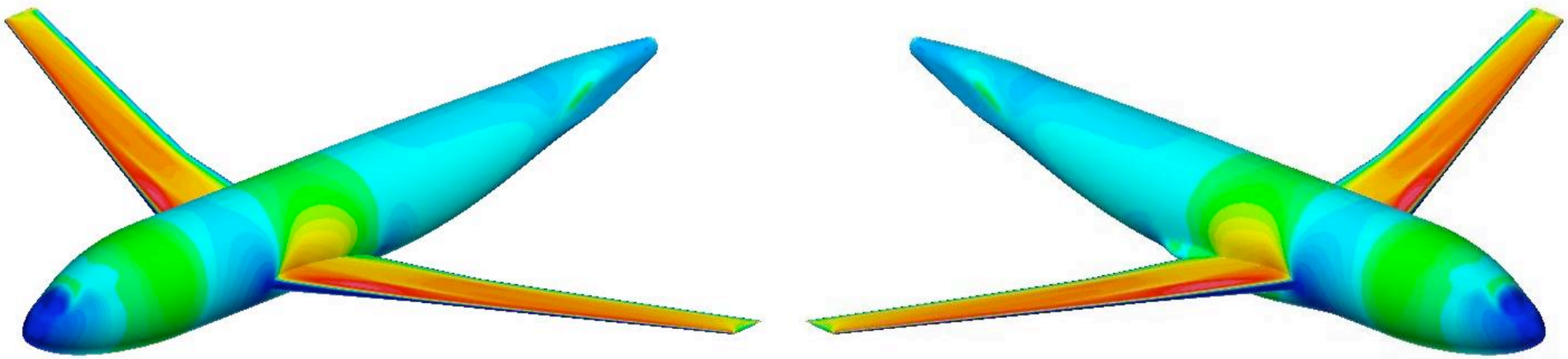

QinetiQ



Presentation of Results for DPW3

Matt Milne

3rd AIAA CFD Drag Prediction Workshop

3rd-4th June 2006, San Francisco, California, USA

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Contents

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Section 1

Background

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Background

- QinetiQ participated successfully in DPW1 & 2
  - previous entries led by Andy Shires
  - work carried out using SAUNA block-structured mesh with
    - SAUNA flow solver (DPW1)
    - RANSMB flow solver (DPW2)
- More recently QinetiQ have been evaluating commercial CFD codes as an alternative to in-house bespoke methods
  - see AIAA-2006-2988
  - QinetiQ working closely with CD-Adapco evaluating STAR-CCM+ since it's release in early 2004
  - QinetiQ work for DPW3 was conducted using STAR-CCM+ flow solver on SAUNA block-structured meshes

Section 2

Mesh Generation

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SAUNA Mesh Generation

- GEMS geometry pre-processor used to configure IGES CAD model into definition suitable for CFD
- Block-structured mesh generated using SAUNA
- Initial mesh on DLR-F6 took approximately 5 days to generate
  - same topology and grid edits were used with FX2B fairing in place, and for mesh refinement study, hence each additional mesh was generated in approximately 30 minutes
- O-grid generated around body and also around wing
  - O-grid on wing is much more efficient than more conventional C-H topology
    - 4.6×10^6 cells with O-grid (cf. 12.1×10^6 cells with C-H wing topology)
    - avoids adding unnecessary mesh refinement in the field

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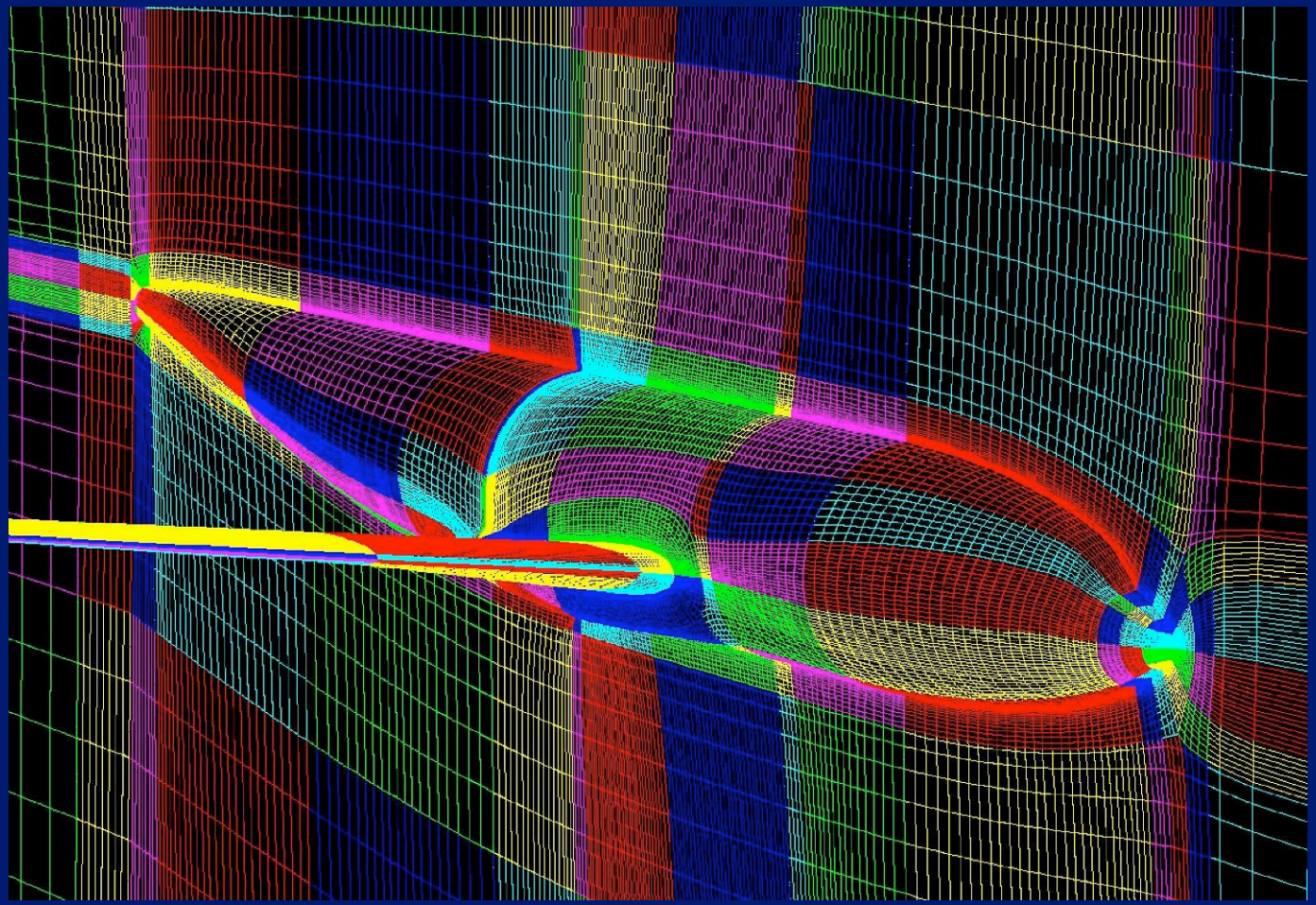
SAUNA Mesh Generation



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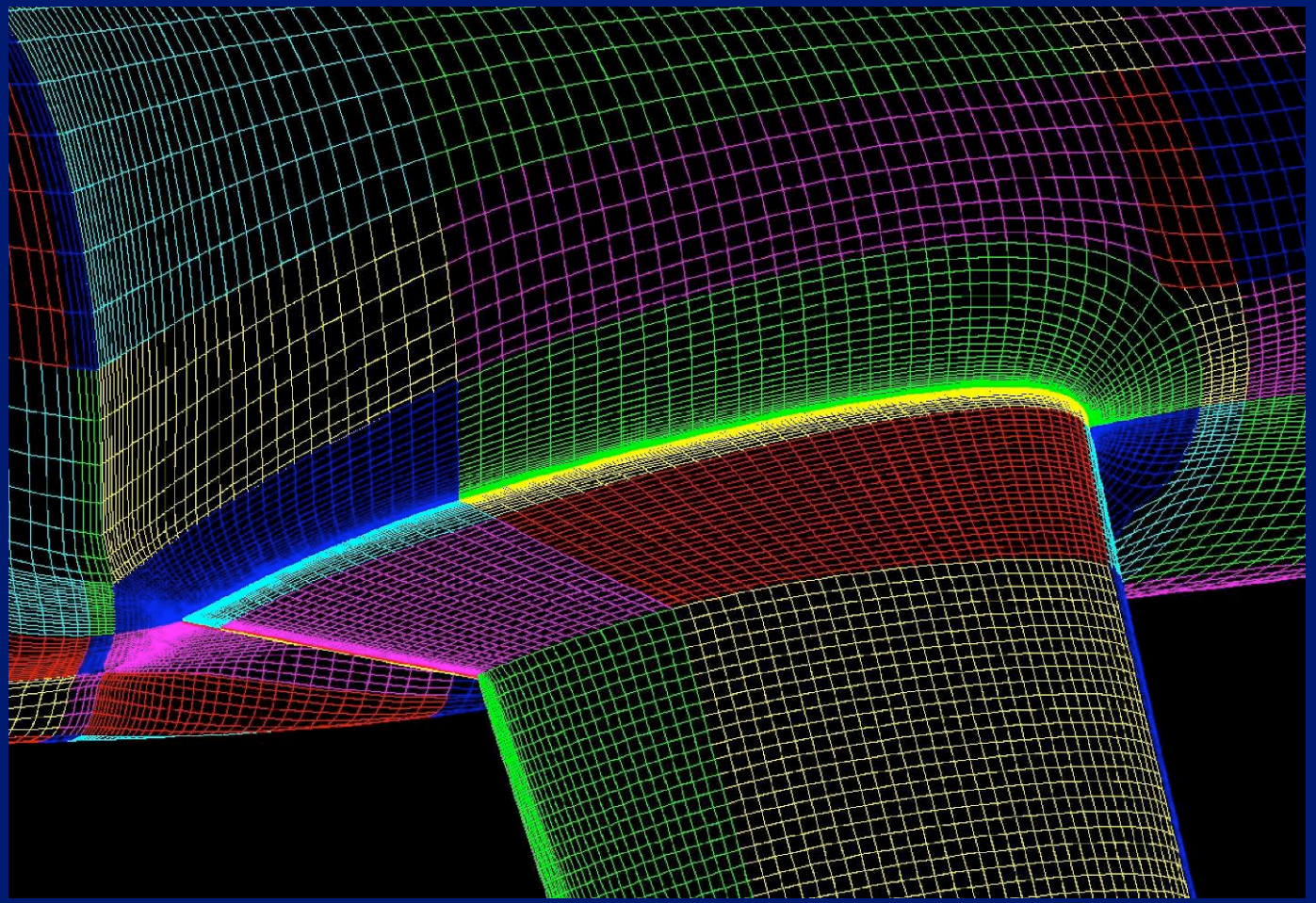
SAUNA Mesh Generation



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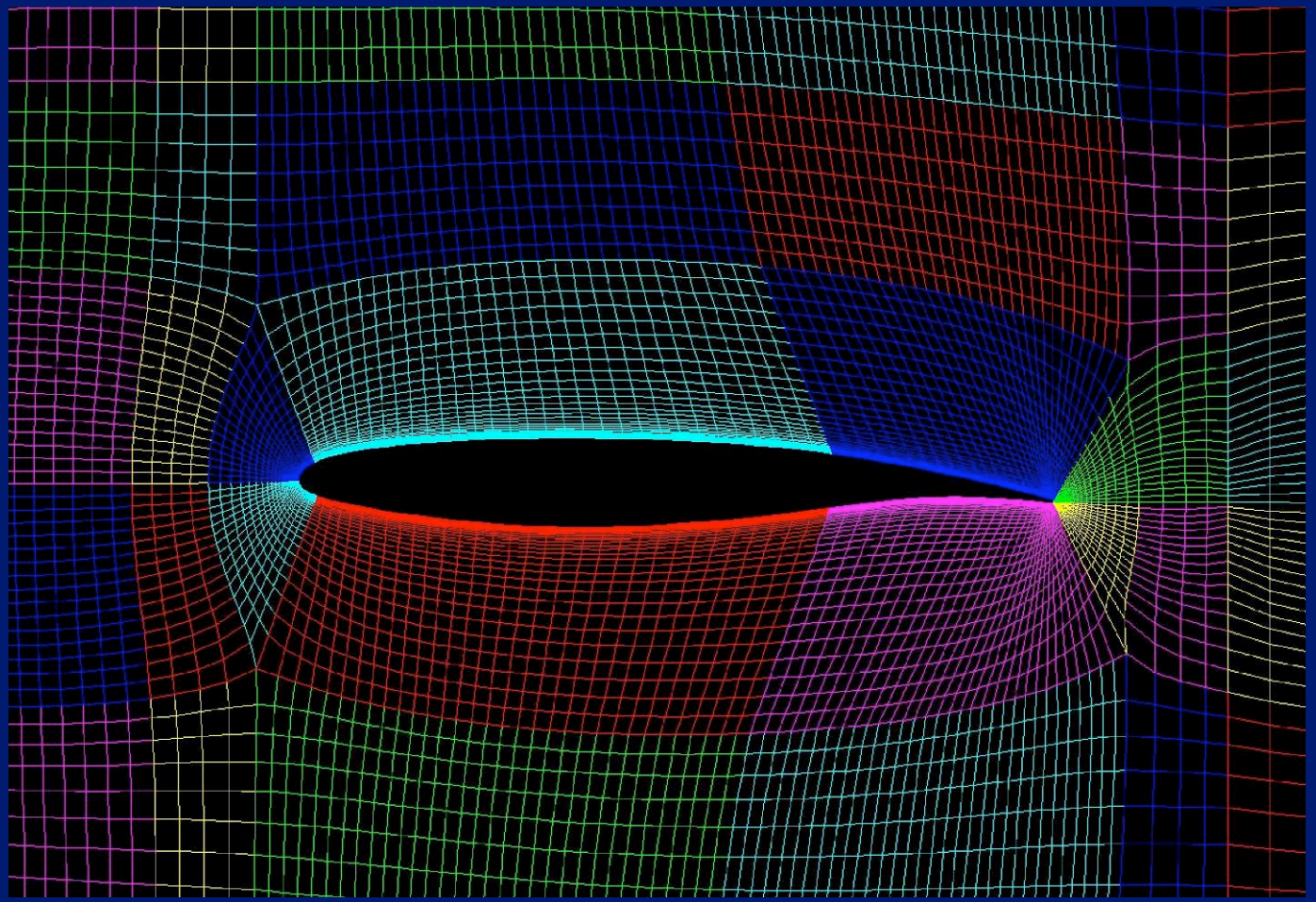
SAUNA Mesh Generation



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SAUNA Mesh Generation

- 3 levels of grid were generated for each configuration
- Same block structure used for each grid level
- Same topology and grid edits were used for both DLR-F6 and model with FX2B fairing
  - different grid levels required minor changes to grid edits

Mesh	No. Cells
coarse	2.5×10^6
medium	4.6×10^6
fine	9.6×10^6

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Section 3

Results

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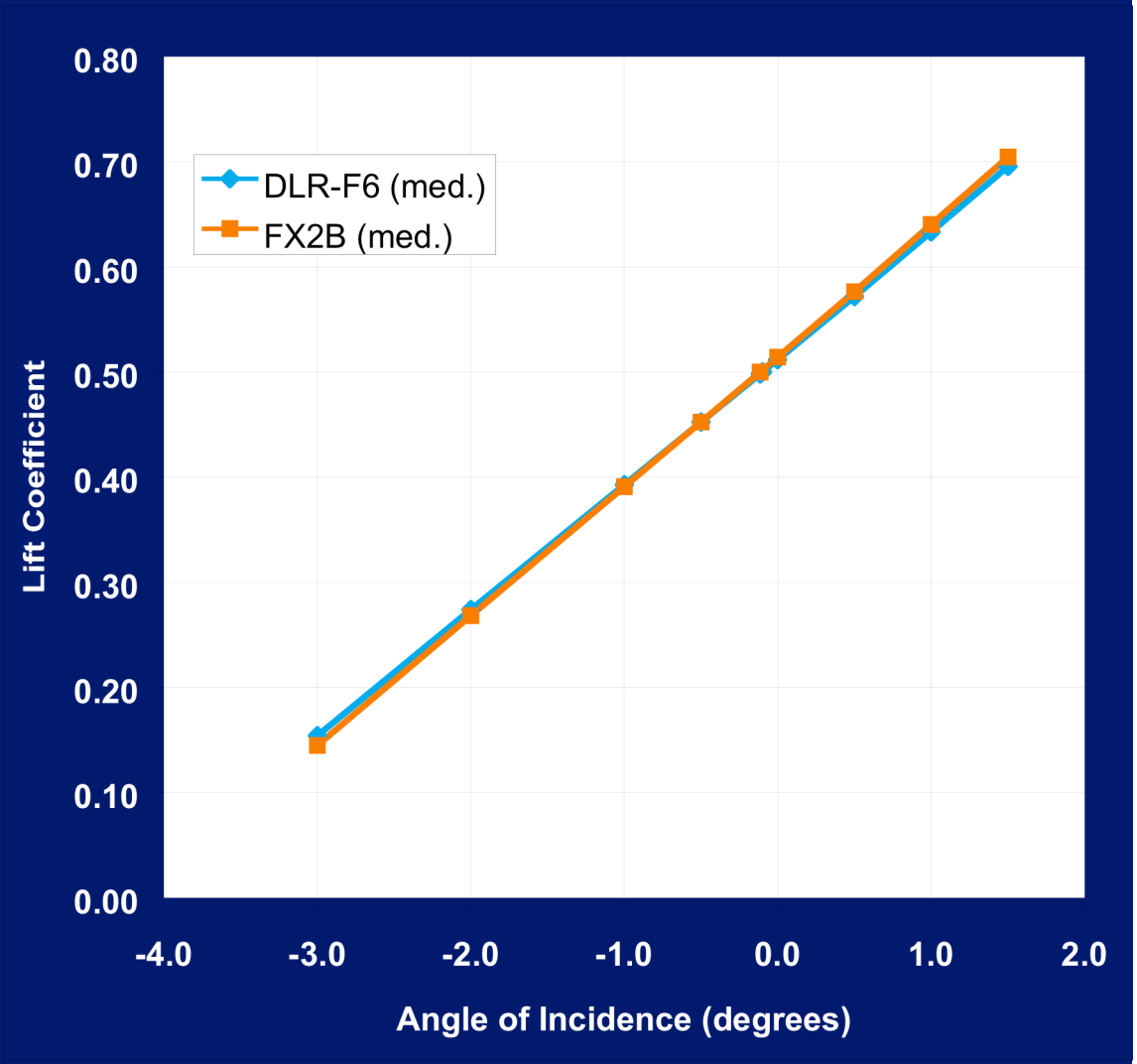
Results

- Difficult to judge quality of results with no point of reference
- Addition of FX2B fairing has little impact on lift-curve slope



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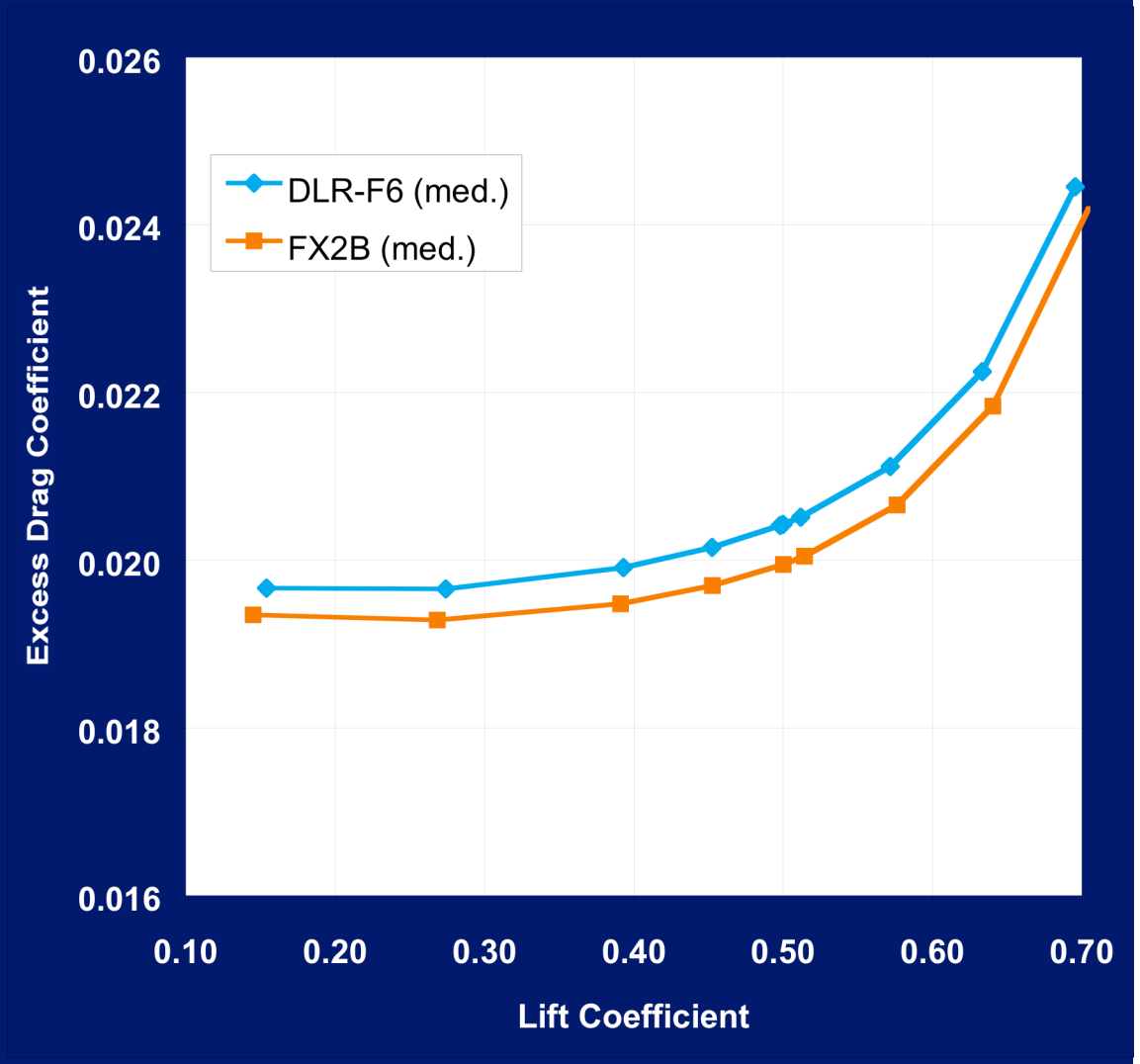
Results

- Excess drag coefficient plotted
  - $C_D' = C_D - C_L^2/\pi AR$
- Lift dependent drag appears to be unchanged
  - but fairing reduces parasitic drag by 3-4 drag counts



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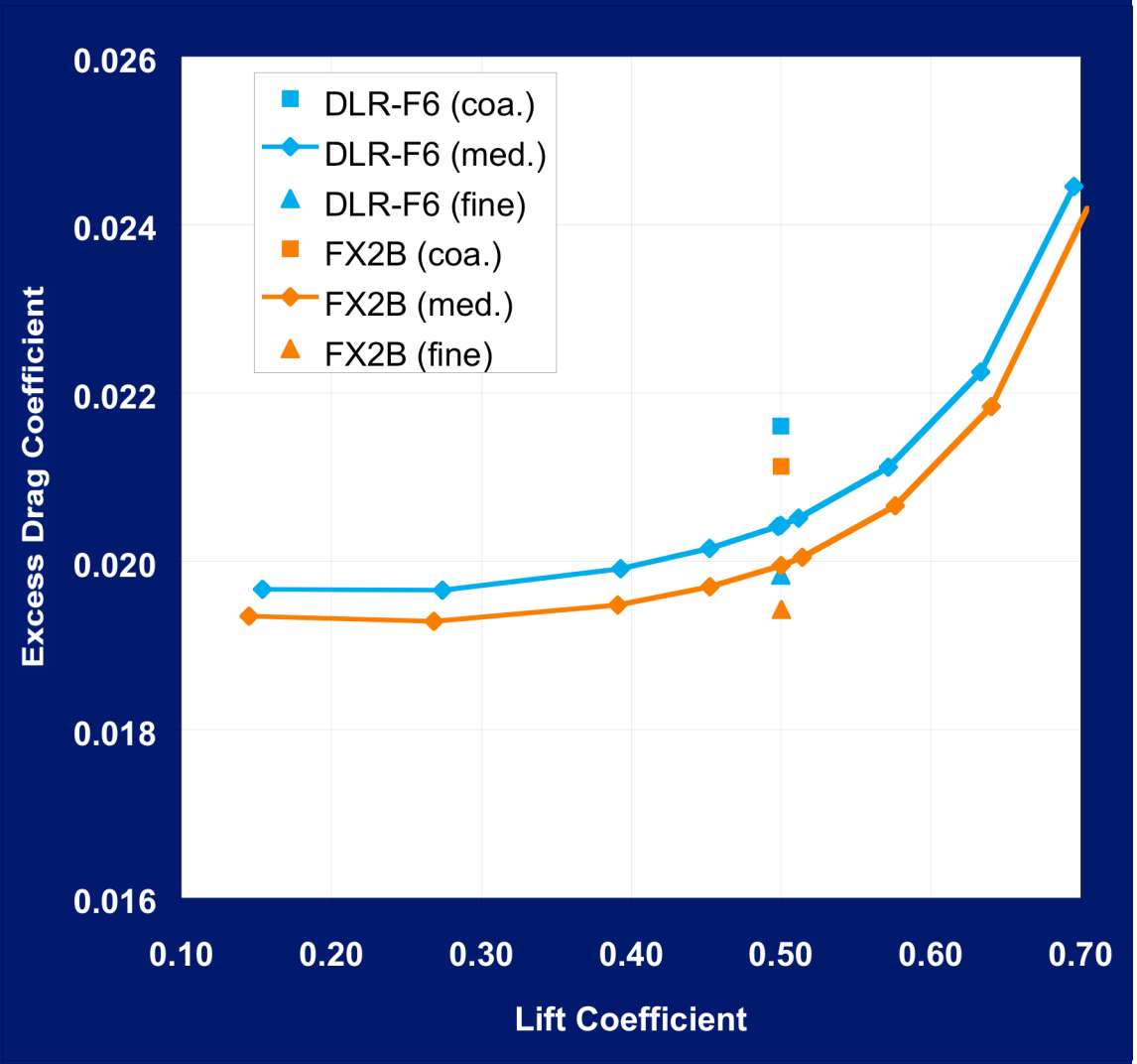
Results

- Excess drag coefficient plotted
  - $C_D' = C_D - C_L^2/\pi AR$
- Lift dependent drag appears to be unchanged
  - but fairing reduces parasitic drag by 3-4 drag counts
- Mesh refinement study shows drag is sensitive to mesh density
- Compared to medium mesh:
  - coarse mesh is 12 drag counts higher
  - fine mesh is 6 drag counts lower
- More work is required to determine whether sensitivity is to lift dependent or parasitic drag



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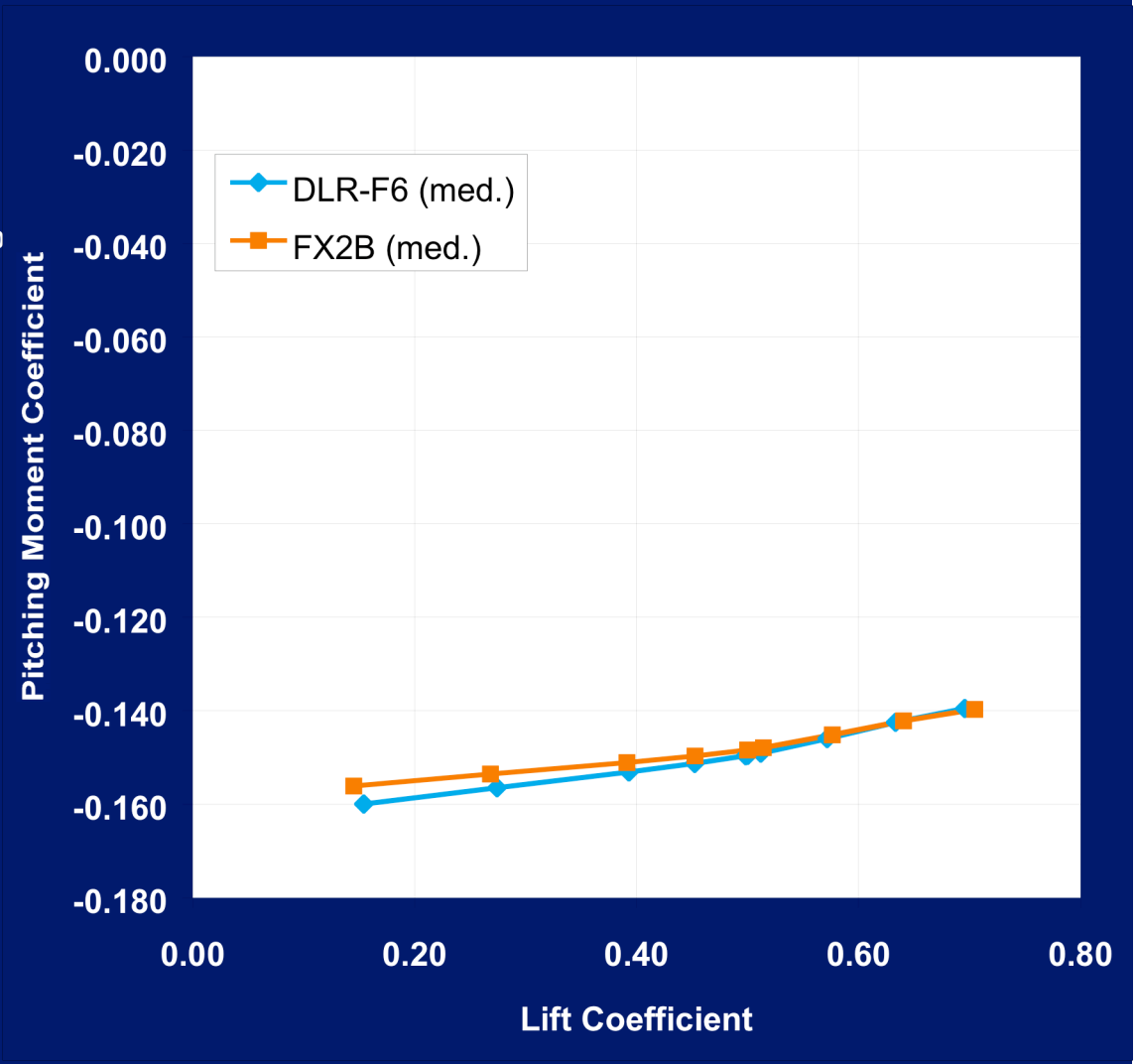
Results

- Calculated pitching moment results show that DLR-F6 is 3.7% unstable without a tail
  - addition of FX2B fairing reduces instability by 0.8% and increases C_{m0} slightly



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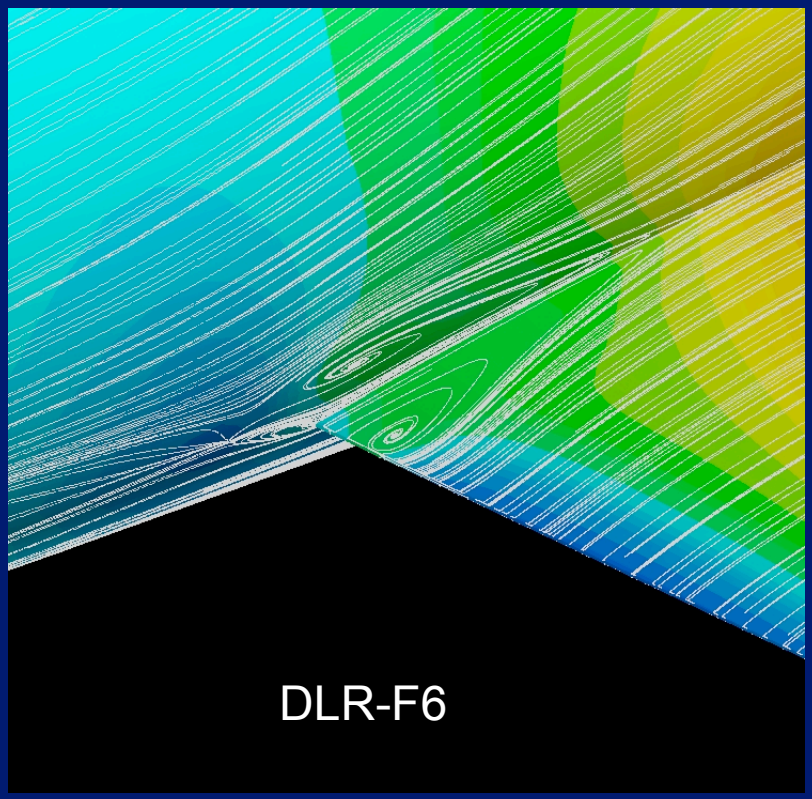
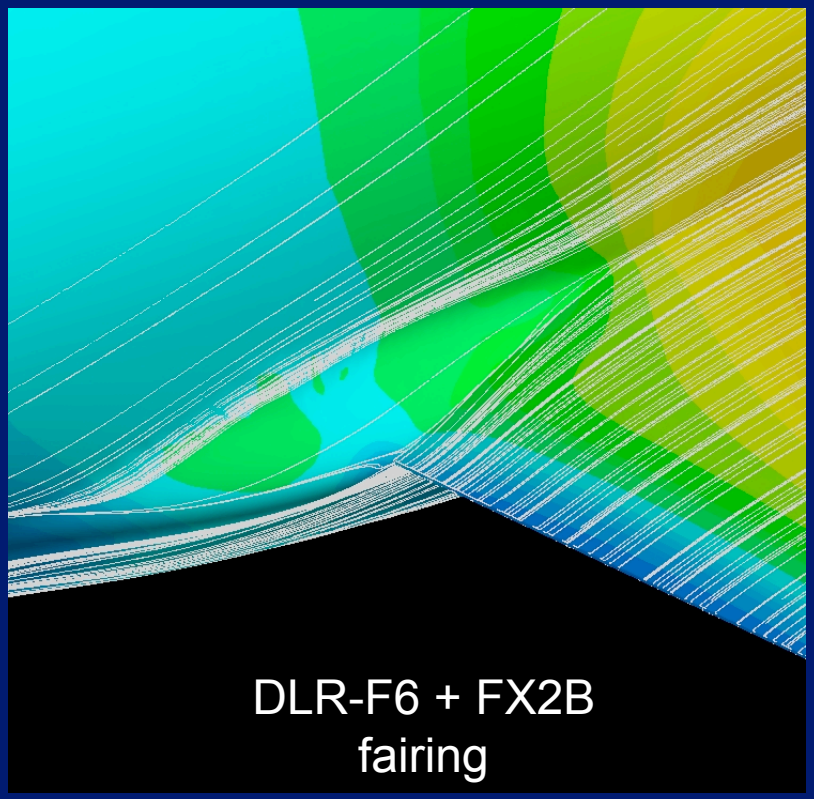
Results

- Analysis of calculated surface streamline plots show that the addition of the FX2B fairing has removed the trailing-edge wing-root separation bubble



DLR-F6



DLR-F6 + FX2B fairing

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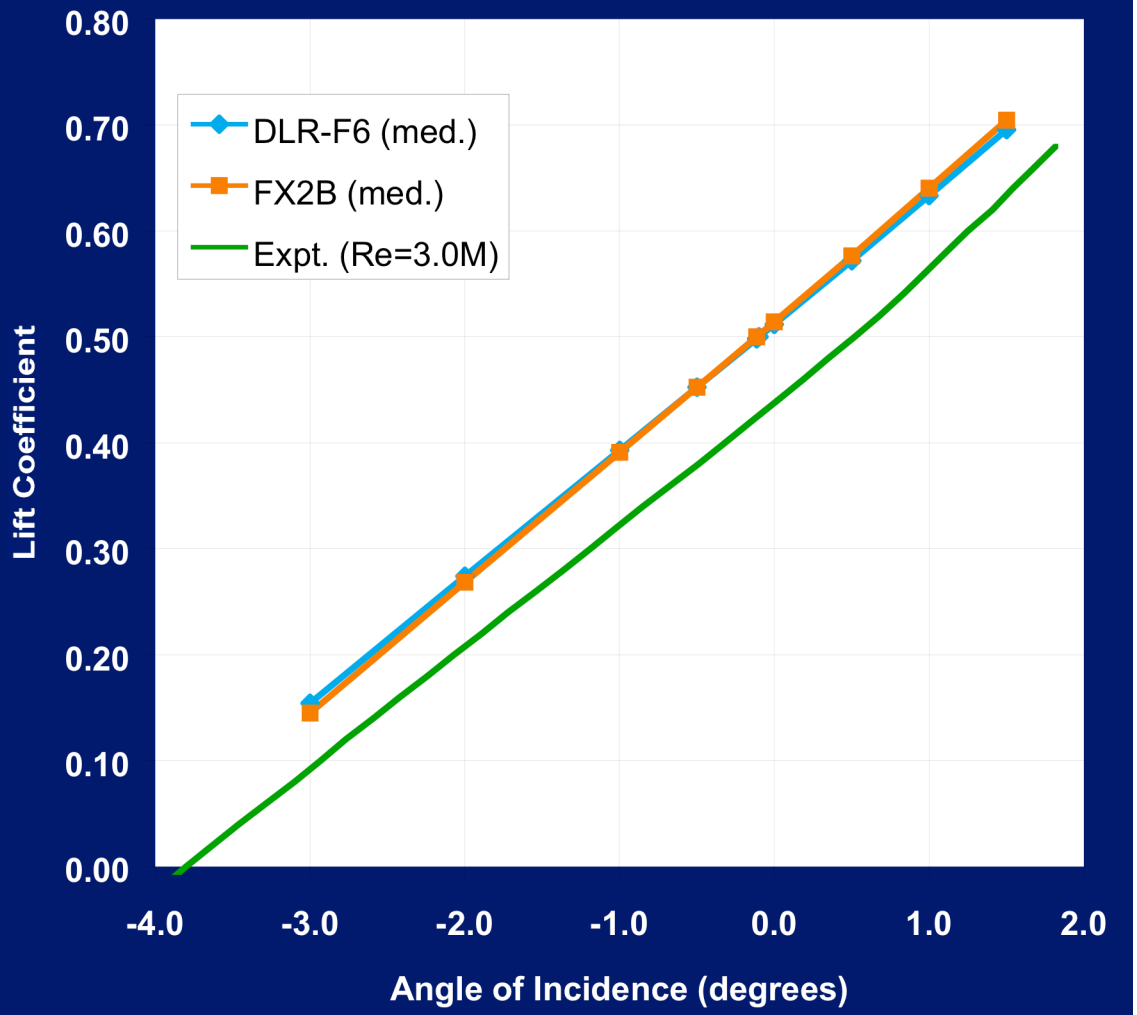
Results

- Difficult to judge quality of results with no point of reference
- Reconsider results in context of experimental measurements for DLR-F6 used for DPW2
  - caution is needed here as wind-tunnel results are for a lower Re (3 million) than DPW3
- Suspect the difference in lift between experiment and CFD is too big to be a Reynolds number effect
  - suspect CFD is genuinely over-predicting lift, which will also affect lift dependent drag



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Results

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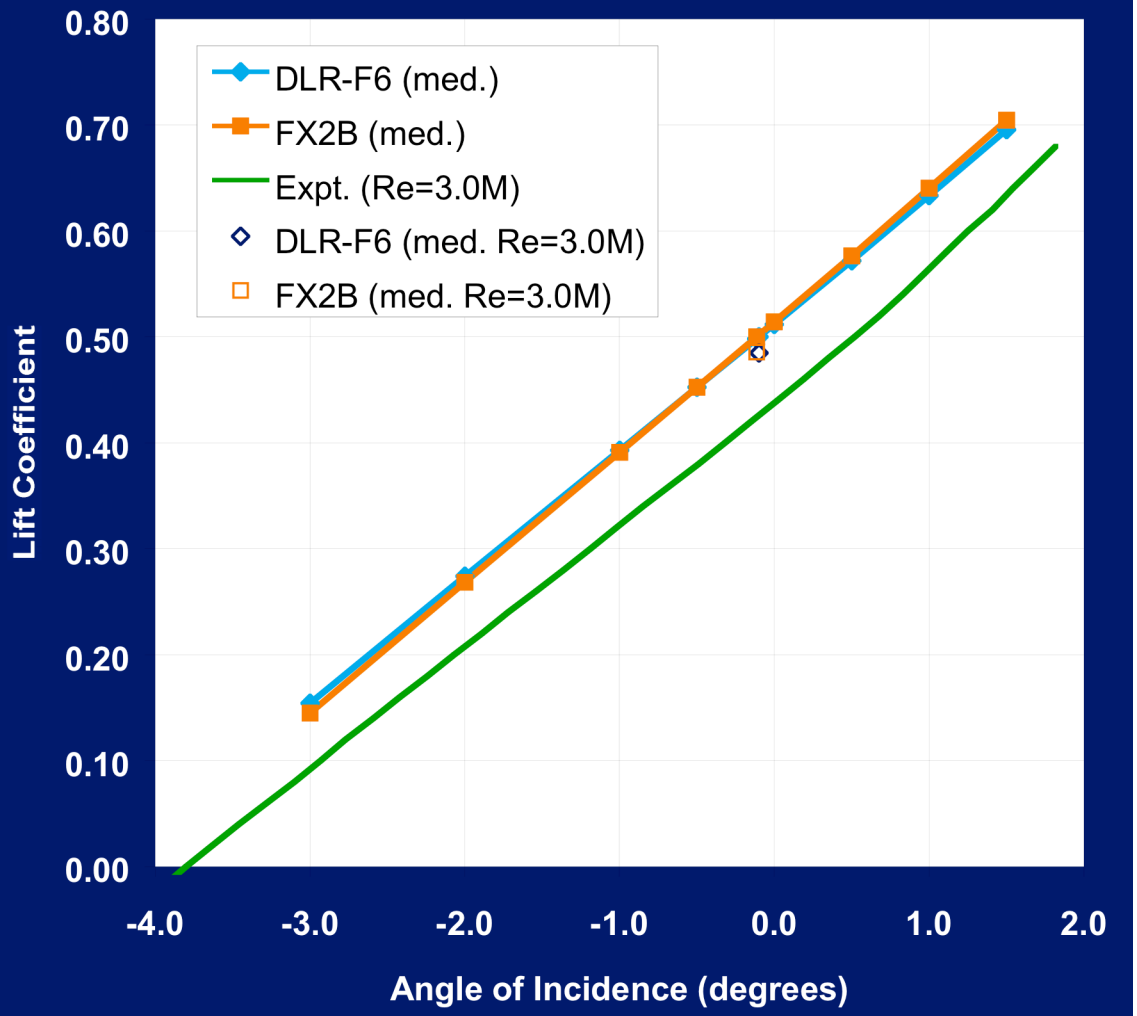
  - suspect CFD is genuinely over-predicting lift, which will also affect lift dependent drag
  - additional CFD calculations appear to confirm this



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Section 4

Discussion

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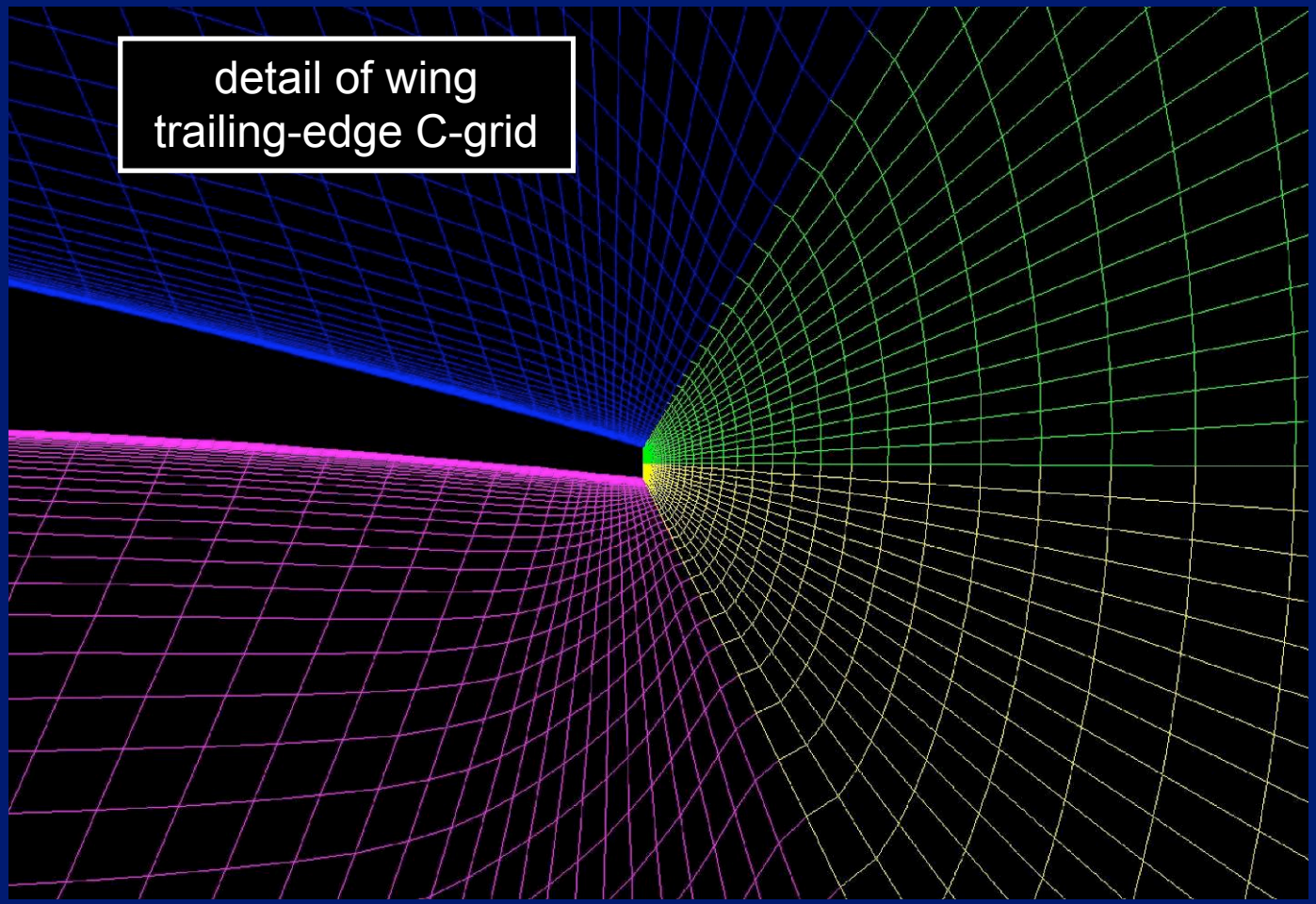
Discussion

- Why does lift appear to be over-predicted?
- Possible reasons:
  - C-grid at wing trailing-edge
    - poor mesh quality?
    - insufficient resolution of the trailing-edge and wake?
      - how does this affect the way circulation, and hence lift, is modelled?
      - how does QinetiQ's mesh quality and resolution compare to other meshes *i.e.* structured, unstructured, overset etc.

SAUNA Mesh Generation



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Discussion

- Why does lift appear to be over-predicted?
- Possible reasons:
  - trailing-edge modelling
    - we have modelled the thick trailing edge
    - this is now the preferred method for QinetiQ
      - although some solvers have a special BC for thick trailing-edges
    - but Shires obtained excellent results for DPW1 using a sharp trailing-edge

Section 5

Conclusions

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Conclusions

- Addition of FX2B fairing to DLR-F6 model removes the trailing-edge wing-root separation bubble
  - predicted effect on lift is small but fairing yields a useful reduction in drag (3-4 drag counts)
- Predicted trends look reasonable compared to experimental results for DLR-F6
  - but comparisons are made with caution because of difference in Reynolds number
- Suspect CFD is over-predicting lift, with subsequent effect on lift dependent drag and pitching moment
  - this may be due to method used here to model wing trailing-edge
    - trailing-edge C-grid?
    - thick vs. sharp trailing-edge?
  - further work is required to investigate the effect of trailing-edge modelling on the results and establish best practice for future work

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