BAE SYSTEMS

ASPECTS OF USE OF CFD FOR UAV CONFIGURATION DESIGN

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Tim Pemberton,

Senior Specialist, BAE SYSTEMS

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See also ADM001685, CSP 02-5078, Proceedings for Aerodynamic Issues of Unmanned Air Vehicles (UAV)., The original document contains color images.

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UCAV DESIGN PROBLEM

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- Problem (for Aerodynamics) is as much due to novel planforms as Unmanned
- Novel planforms negate traditional Aerodynamic ground rules (sweep, span, AR etc)
- S&C is a significant challenge
- Requirement for rapid proto-typing for planform/basic layout studies and control surface optimisation
- Fast-response WT - small scale, stereo-lithography, PSP
- Fast-response CFD -Euler, High RE turb models RANS

TYPICAL EXAMPLE

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Investigation of Fin Position on a typical Novel Planform

- Establish credibility of CFD for prediction of general flow trends at low speed, high incidence for novel planforms
- Assist in interpretation of 'small-scale' wind tunnel testing

TYPICAL EXAMPLE

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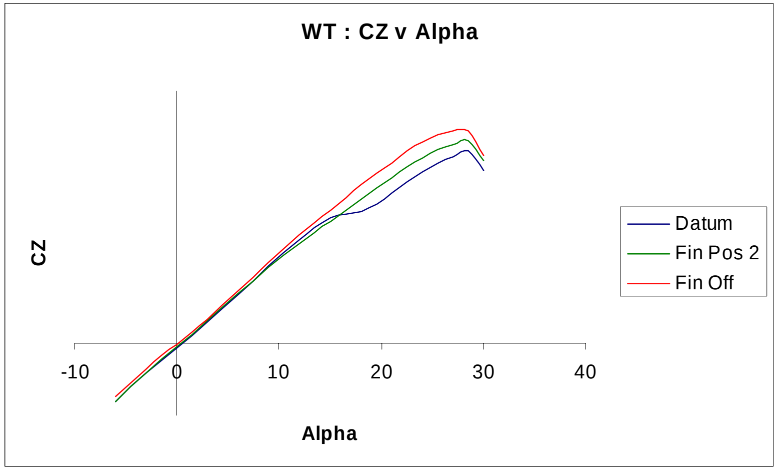
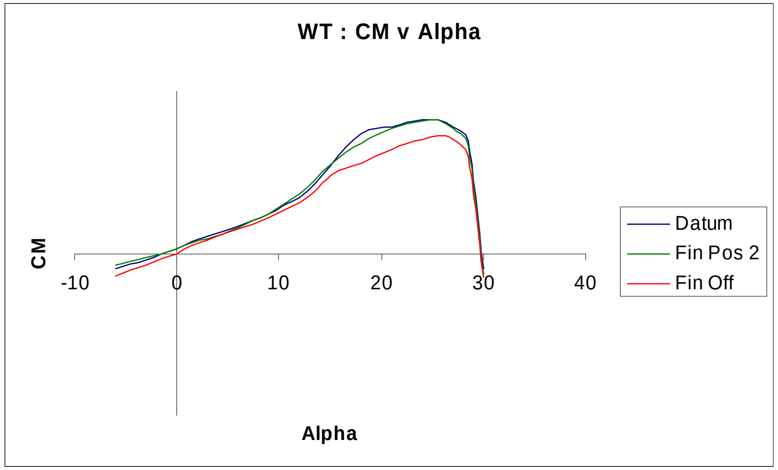
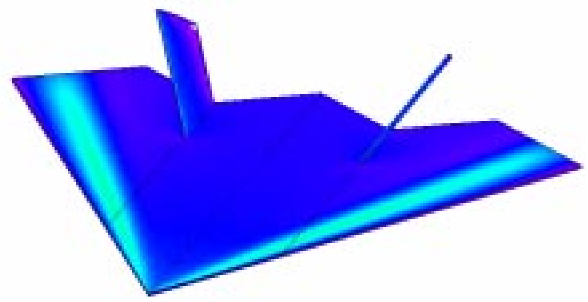




Small Scale WT testing - Effect of fin position



Datum (flat-plate) model

NOTES ON CFD CALCULATIONS

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- 6-8million unstructured grid cells required for credible vortex capture from Euler, with particular emphasis on field resolution
- 2-3million 'BAE Systems Autogrid' cells required for equivalent capture from RANS
- kεRNG turbulence model (wall function) suitable
- Euler solution turnround 4hrs on 8 Origin processors, RANS 2 days

EFFECT OF FIN POSITION

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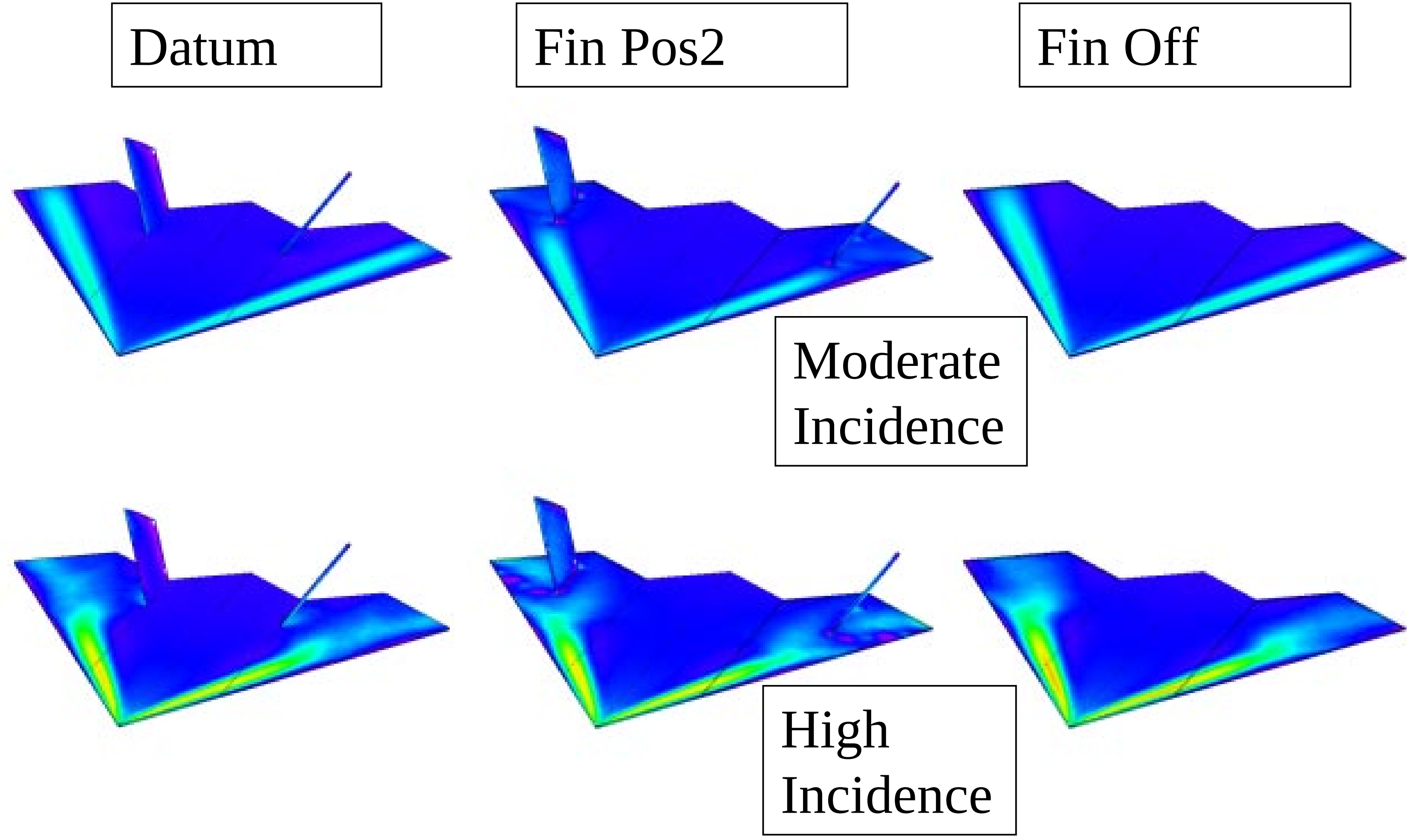

Flat Plate CFD Euler, local velocity contours

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EFFECT OF FIN ON FORCES

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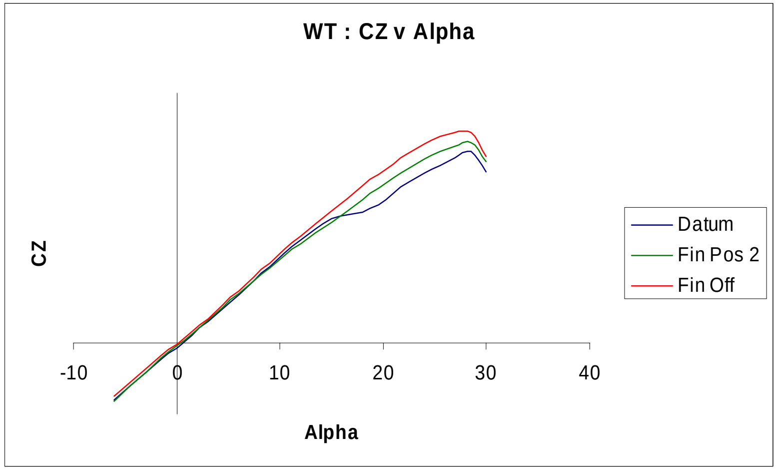
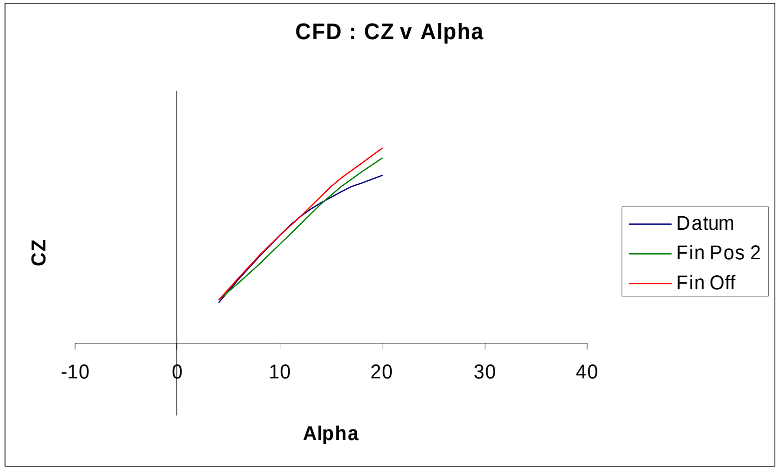
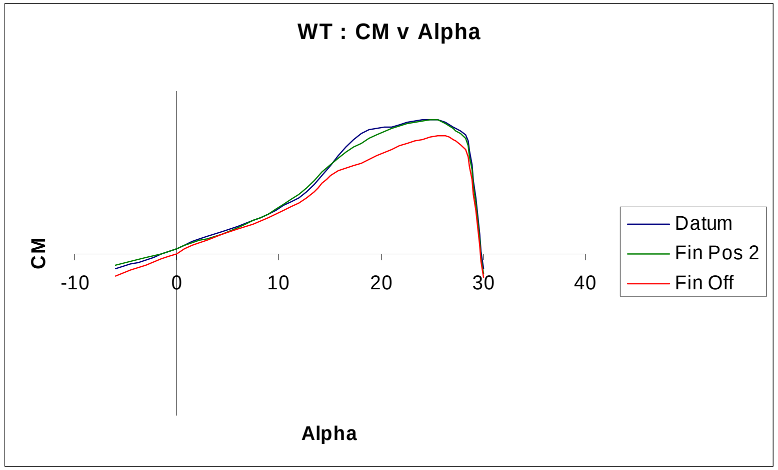
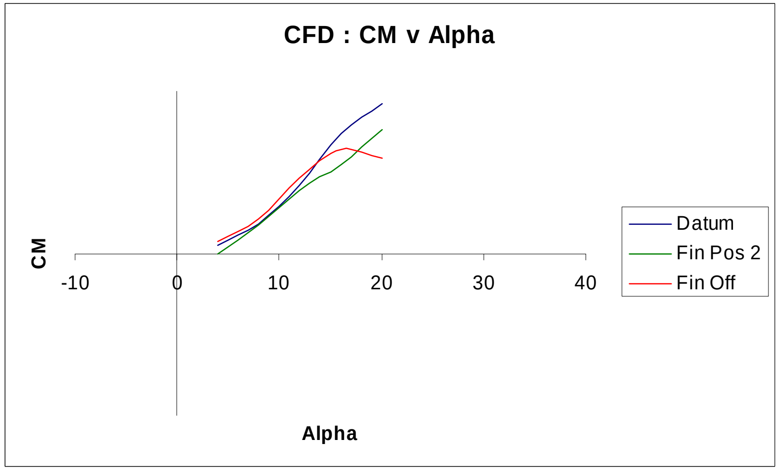




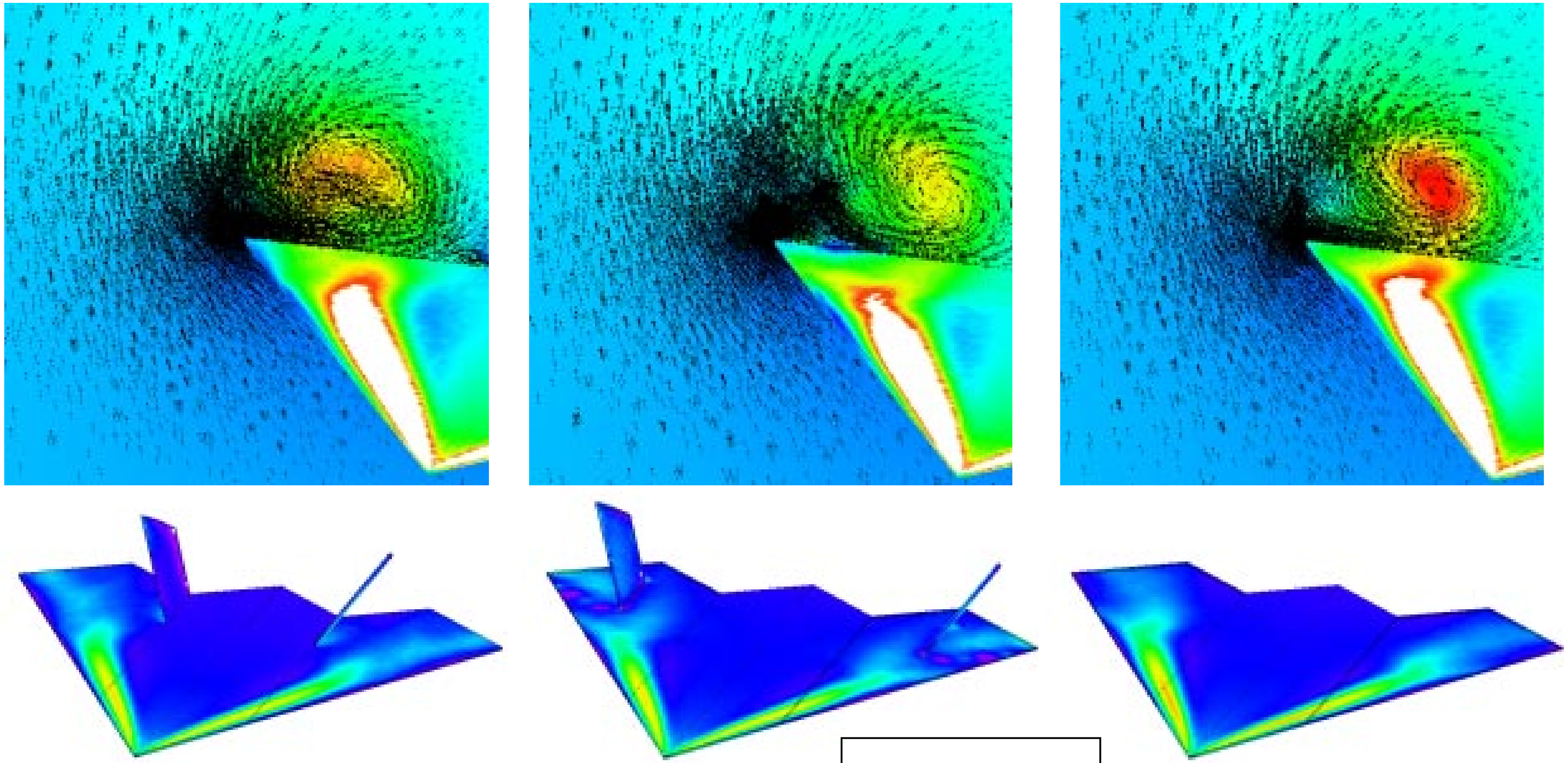




Flat Plate Wind Tunnel v CFD (Euler)

EFFECT OF FIN ON FLOWFIELD

BAE SYSTEMS



High Inc

Datum

Fin Pos2

Fin Off

Flat Plate CFD Euler, velocity vectors, local vel contours

INVISCID v VISCOUS

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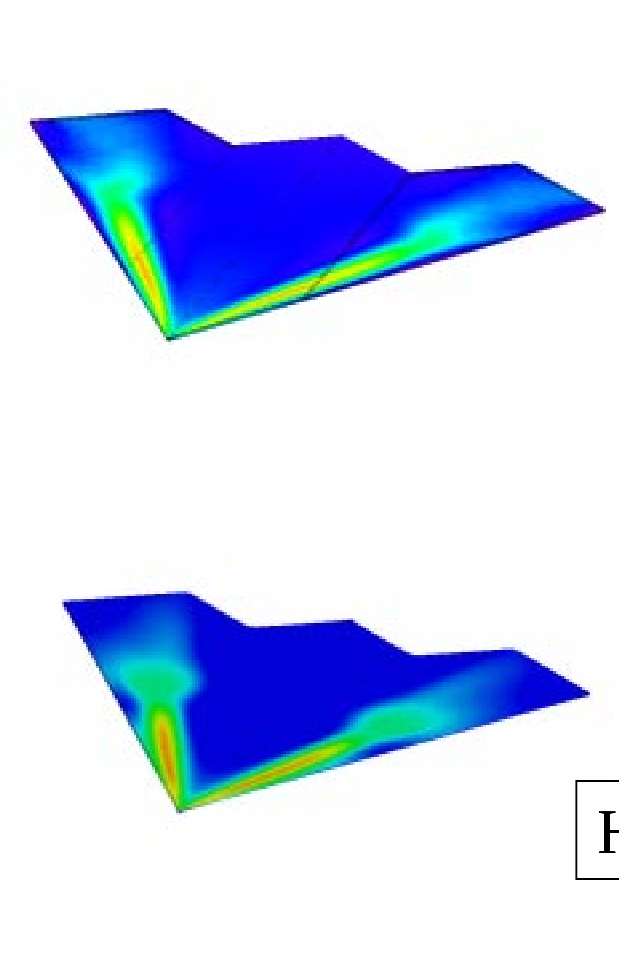


EULER

RANS

High Inc

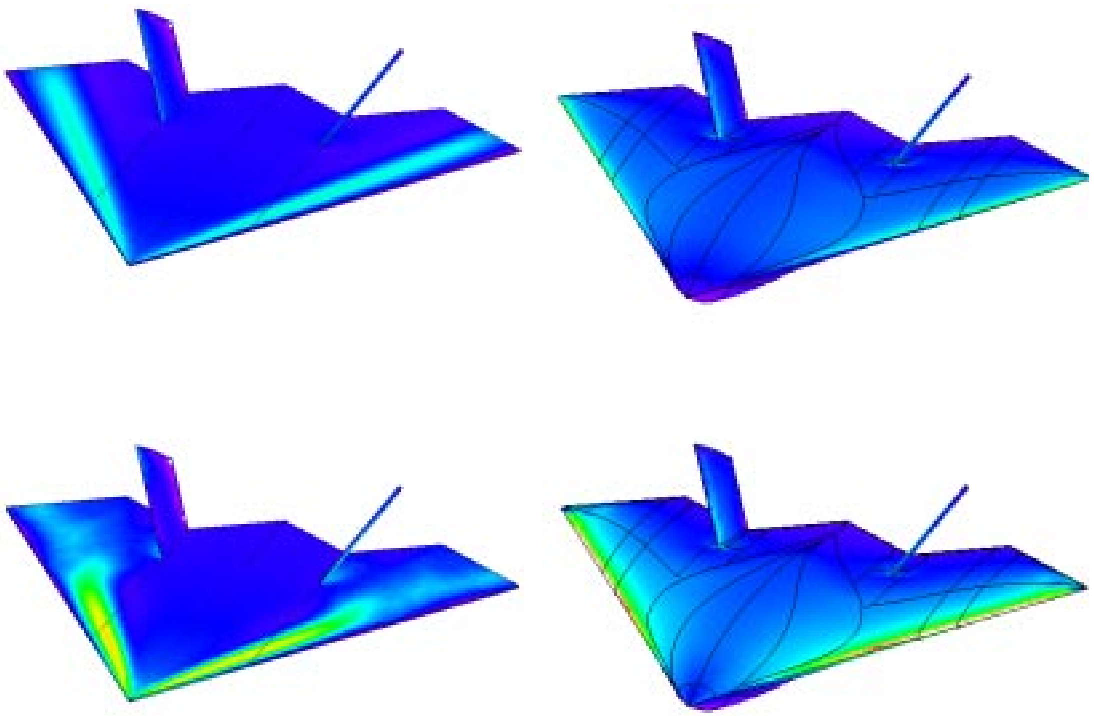
Flat Plate CFD Euler v RANS

EFFECT OF THICKNESS

BAE SYSTEMS

Flat Plate

10% t/c



Moderate Incidence

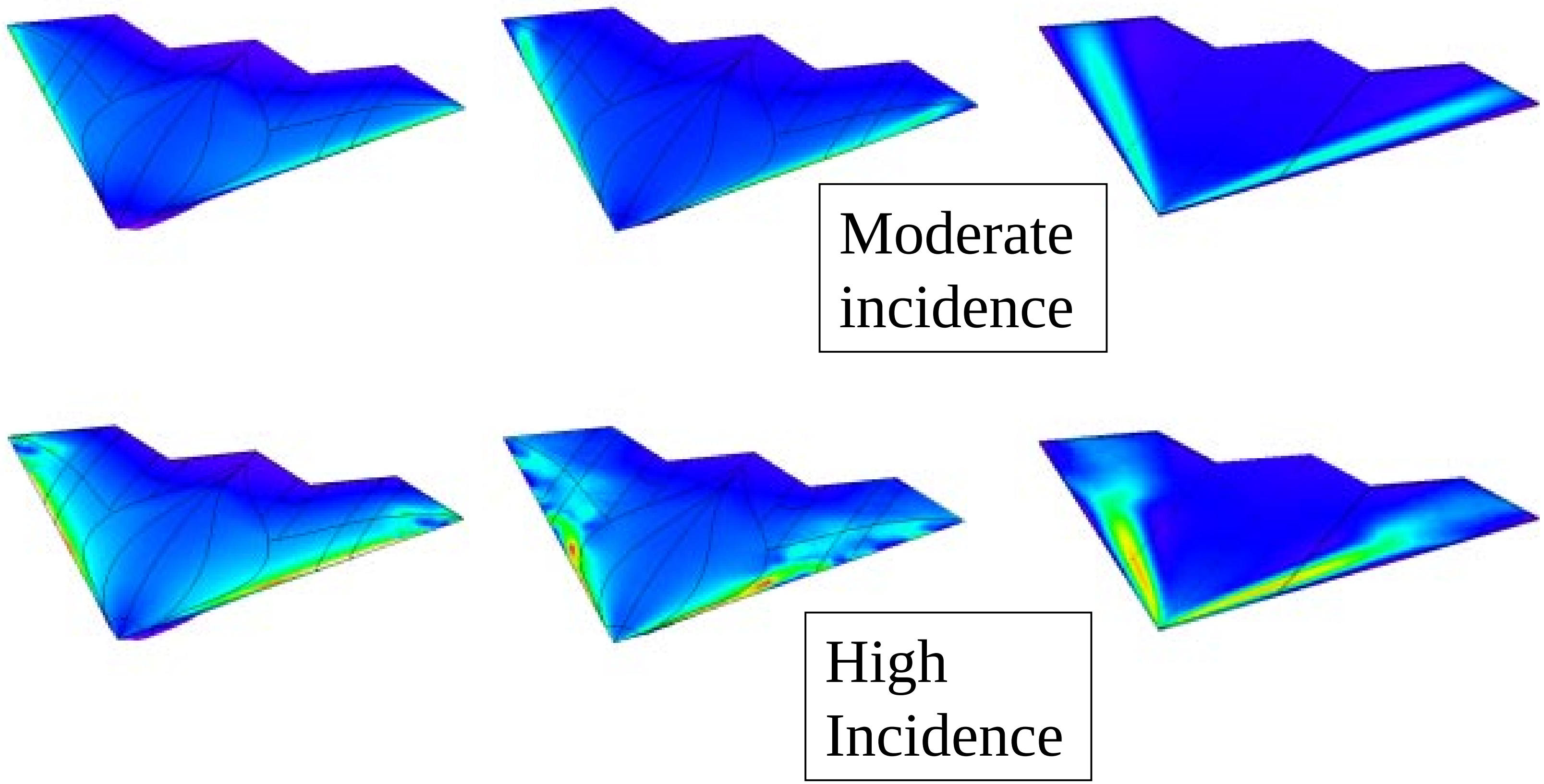
High Incidence

Flat Plate v Symmetric airfoil, CFD Euler, local vel contours

EFFECT OF THICKNESS (FIN OFF)

BAE SYSTEMS

10% t/c	5% t/c	Flat Plate



Flat Plate v Symmetric airfoil, CFD Euler, local vel contours

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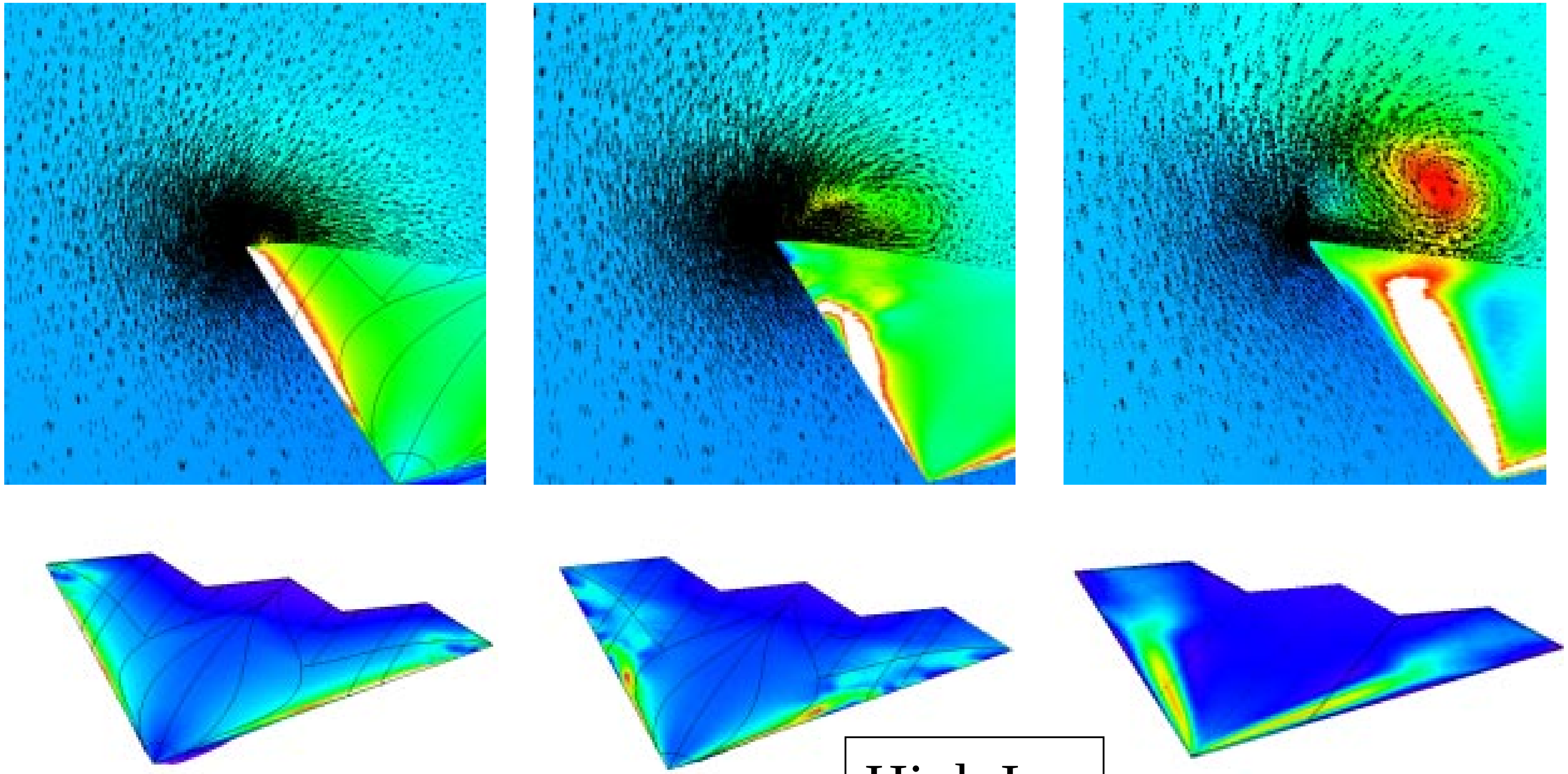
EFFECT OF T/C ON FLOWFIELD

BAE SYSTEMS



High Inc

10% t/c

5% t/c

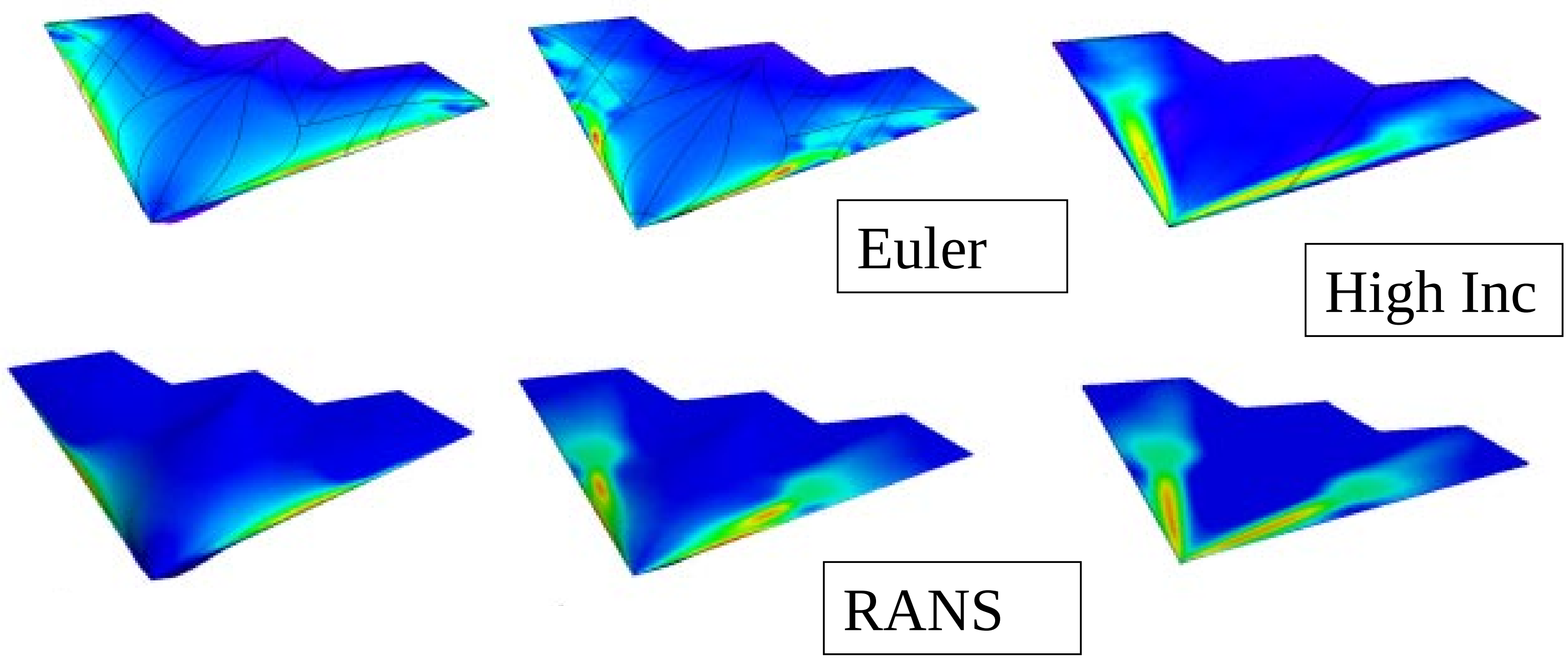
Flat plate

CFD Euler, velocity vectors and local vel contours

EFFECT OF T/C, EULER v RANS

BAE SYSTEMS

10% t/c | 5% t/c | Flat Plate



Flat Plate v Symmetric airfoil, Euler v RANS

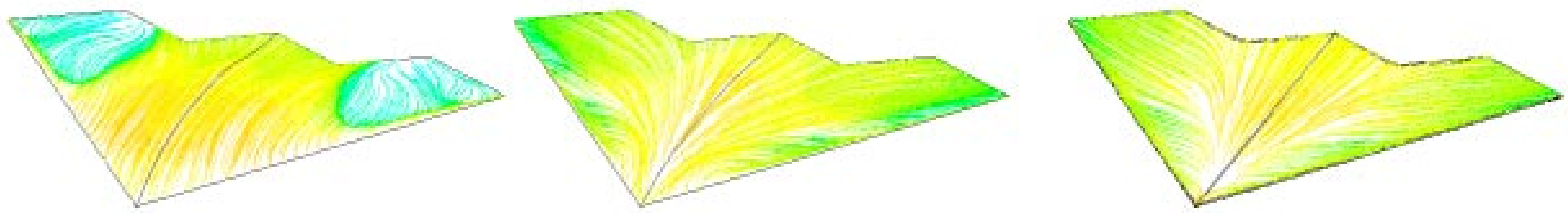
EFFECT OF THICKNESS

BAE SYSTEMS

10% t/c

5% t/c

Flat Plate



High Inc

RANS

CFD RANS, surface flow patterns

SUMMARY

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- Euler showing good prediction of flat plate
- Absolute values of pitching moment poor at high incidence, though engineering decisions can be made by interpretation
- RANS improves absolute predictions, though at too great an overhead in CPU time to be practical for design optimisation
- Difference in flow behaviour between thin and thick airfoils defines limit of applicability of flat plate wind tunnel models

FURTHER ASSESSMENT OF CFD

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- RANS assessed on BAE Systems Autogrid meshes for a vortical flow case and a mixed attached/separated flow case
- kg results poor for both cases in terms of comparison with limited WT data, RANS (kε RNG) and engineering judgement
- kε RNG results good for both cases

VORTICAL FLOW CASE

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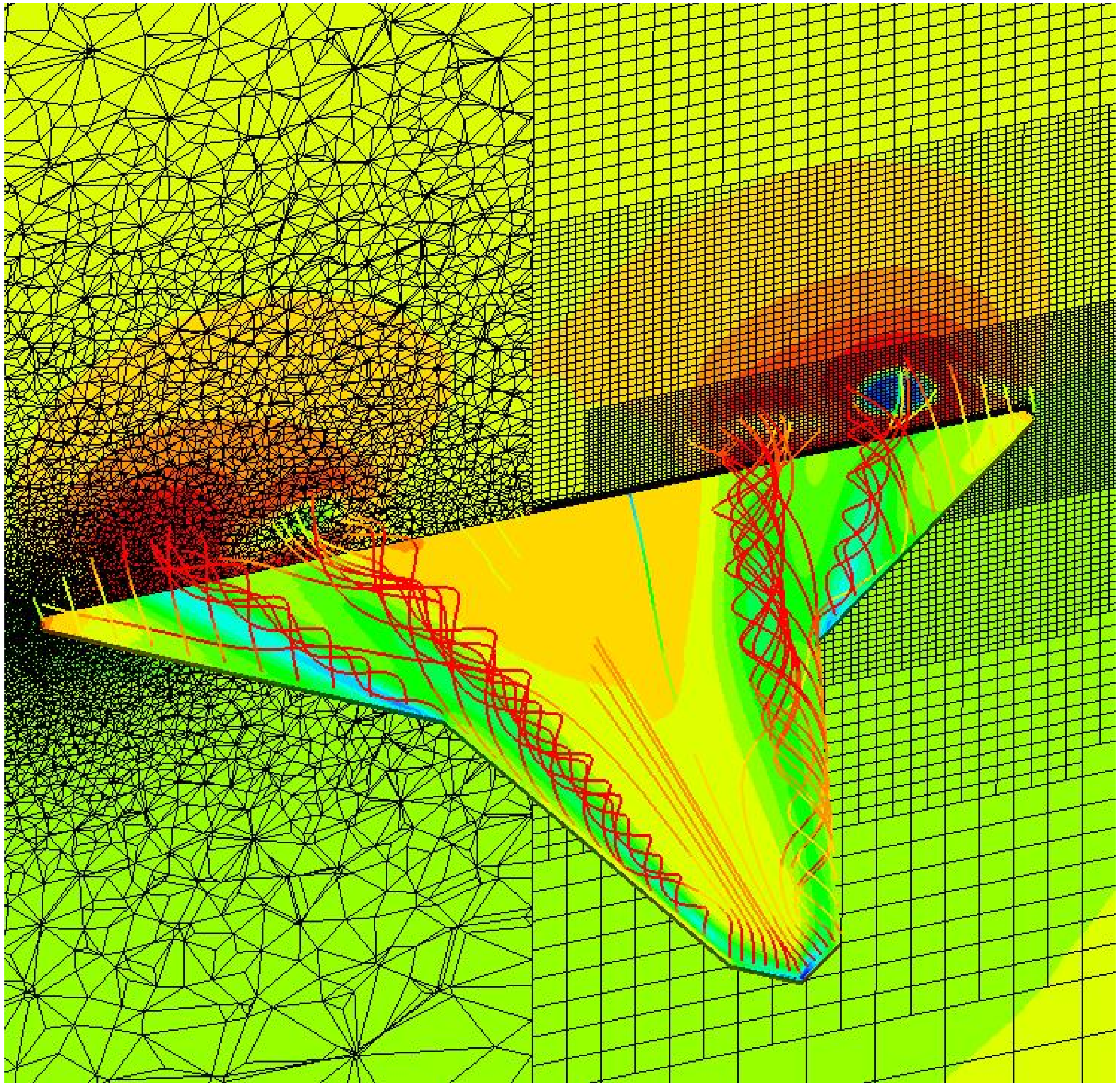
EULER



RANS

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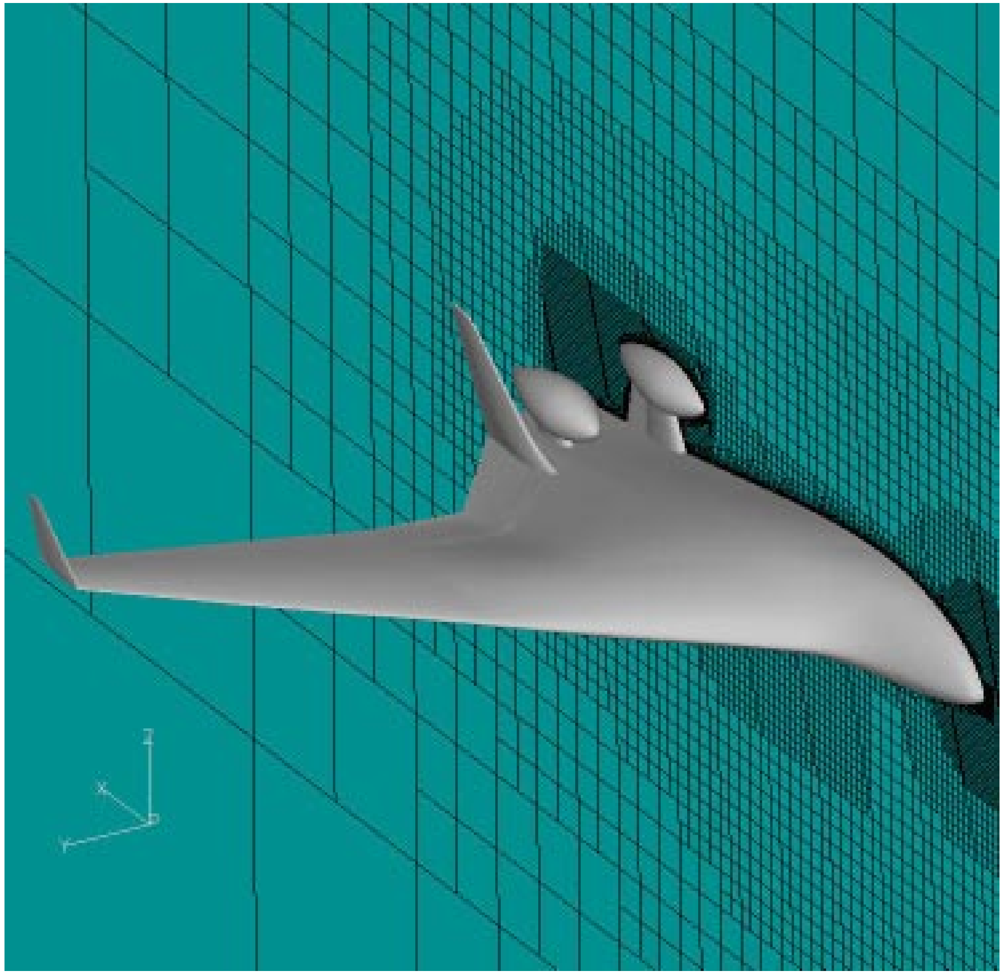
MIXED ATTACHED/SEPARATED FLOW CASE

BAE SYSTEMS

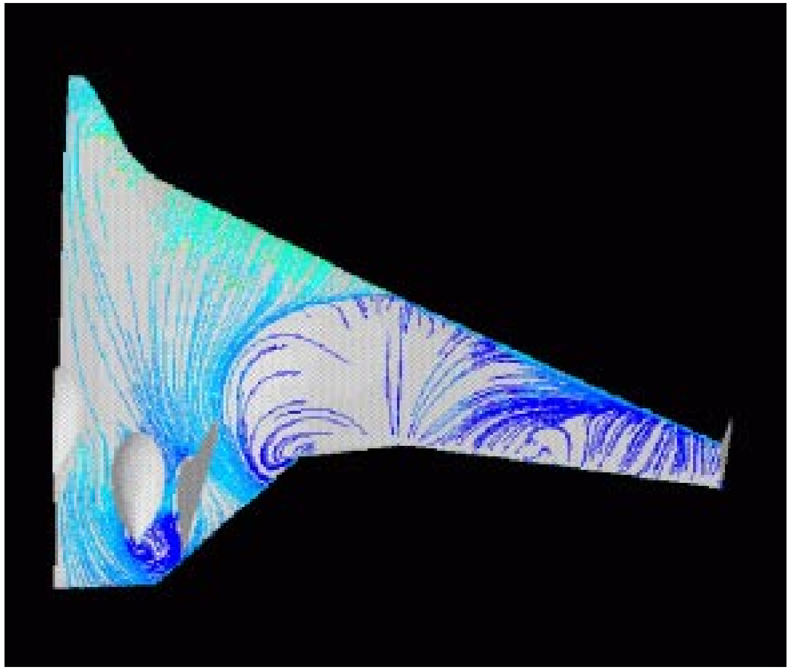
BWB

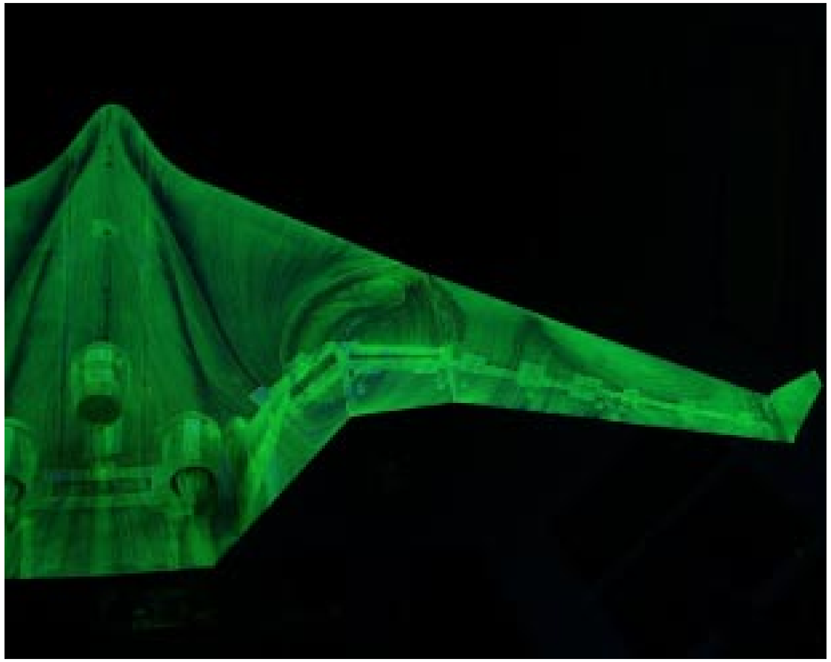


MIXED ATTACHED/SEPARATED FLOW CASE

BAE SYSTEMS

BWB High Incidence





RANS KERNG

WIND TUNNEL

CONCLUSIONS

BAE SYSTEMS

- Novel Planforms mean S+C Issues must be addressed early in the UCAV design cycle
- CFD and WT must work together here
- Requirement for rapid assessment
- Flat-plate and stereo-lith small-scale WT models, in conjunction with Euler and ‘reduced-accuracy’ RANS CFD can be applied here
- This approach requires engineering judgement and expertise to be fully effective