DPW8 Workshop, AIAA Aviation Conference, June 2026

Working Group – Source of Scatter

UWE Bristol contributions/observations

1. DPW 8 Test case 1a · ONERA OAT15A Aerofoil

2. DPW-8 Test case 1d & 1e · Wing-Only Configuration

3. Lessons learned from an educational perspective

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CFD Analysis & Observations – ONERA OAT15A

1. Effect of fluid solver, grid type and turbulence model
2. Statistical Analysis

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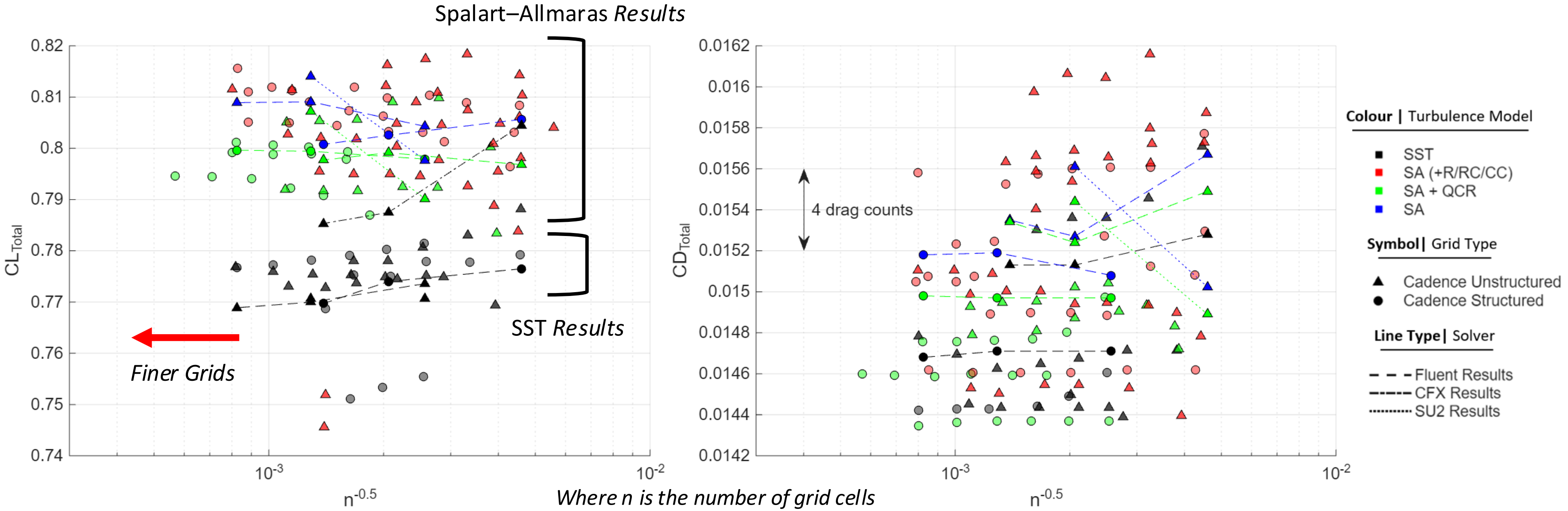
RESULTS

$M_\infty = 0.73, \theta = 1.5°$

- Cadence grid levels **1**, **4** and **6** investigated for structured and unstructured cases at angles-of-attack of **1.5°** and **3.1°** using a sample of 116 solutions for the 1.5° case and 154 data points for the 3.1° case.

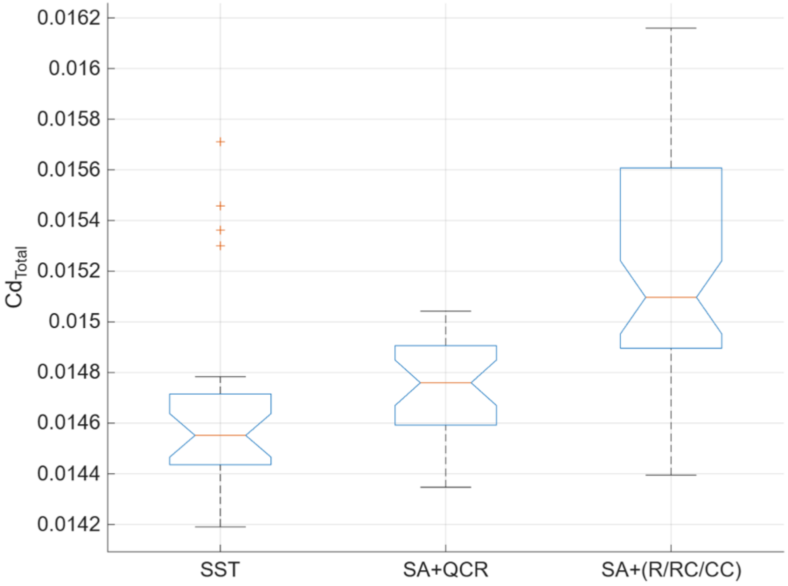


- Fluent SST results tend to converge with increasing grid density for both structured and unstructured cases.
- Baseline SA model results tend to disperse with increasing grid resolution.

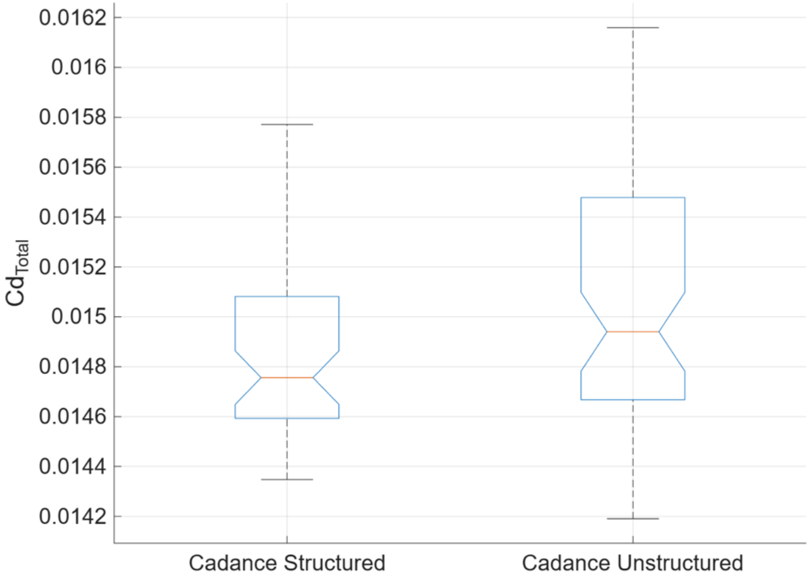
RESULTS

$M_\infty = 0.73, \theta = 1.5°$

Turbulence Model Study



Grid Structure Study



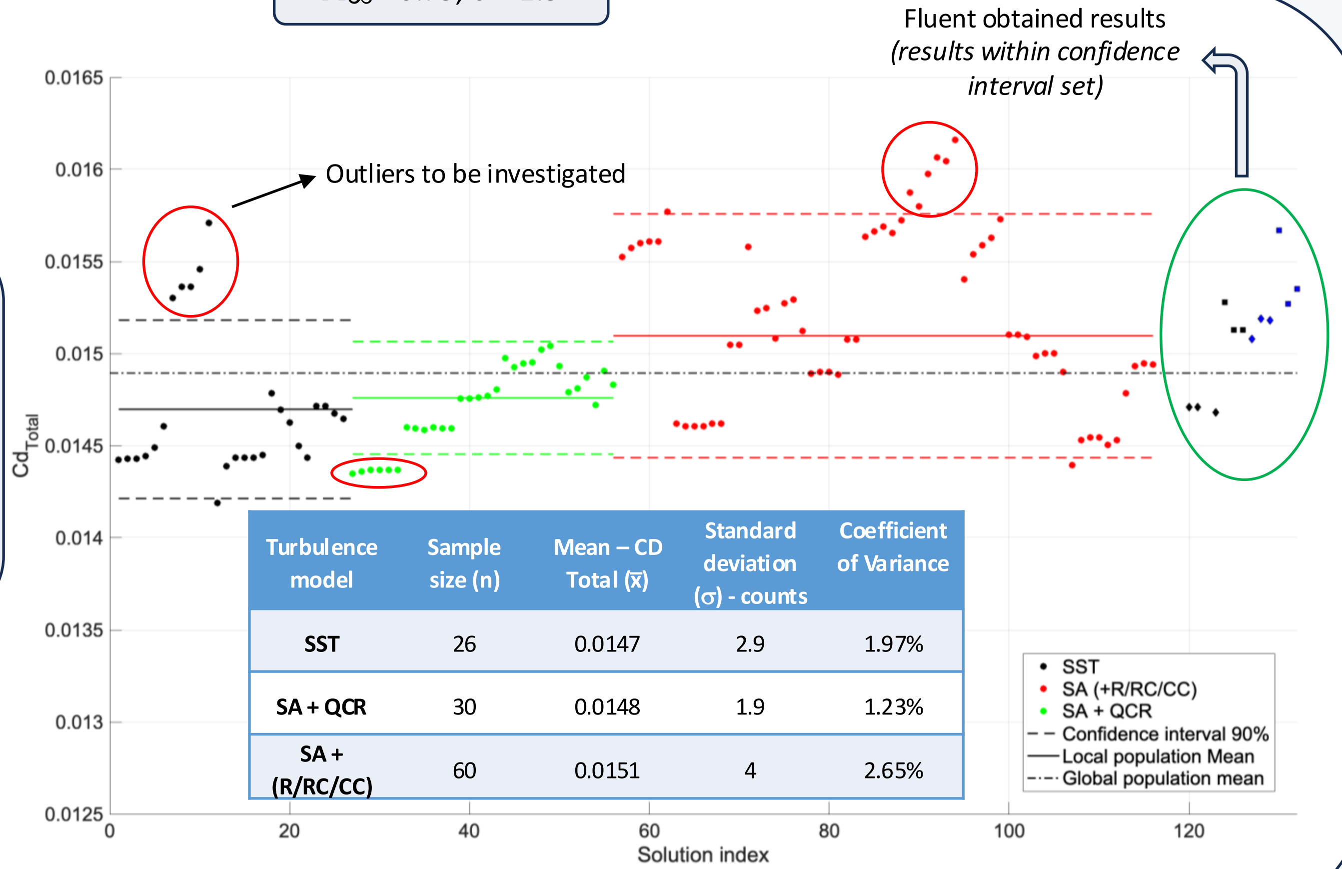
- Unstructured grids was found to provide a larger range in drag solutions (20 drag count range from 14 counts).
- SA+(R/RC/CC) model was found to have the largest variation of drag results compared to QCR corrections and SST.

Statistical Analysis

$M_{\infty} = 0.73$, $\theta = 1.5°$

Overall +- 7.5 drag counts from global population mean

- **SA + (R/RC/CC)** model has the largest variance between the scatter and the population mean.
- **SA + QCR** model provided a more ‘robust’ solutions which sits close to the global mean.
- **Menter SST** had the lowest overall mean

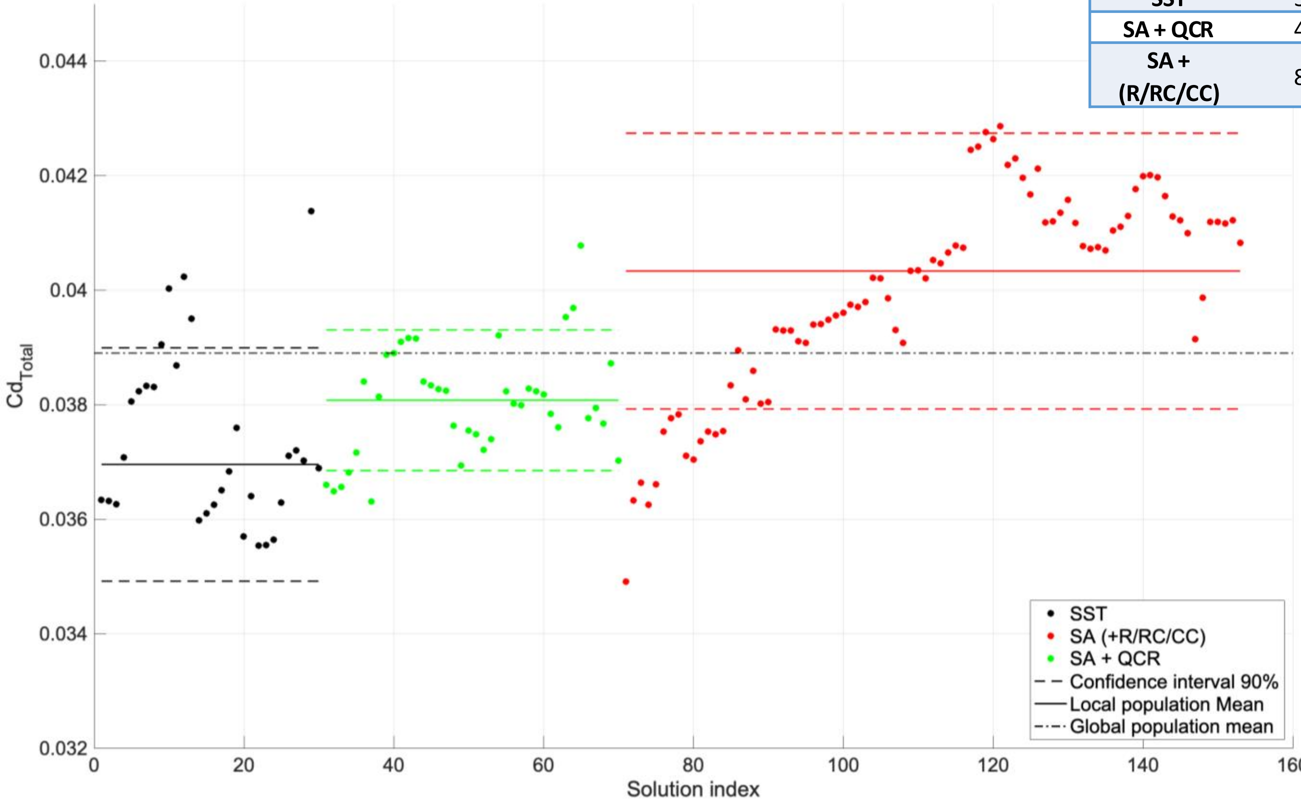


Turbulence model	Sample size (n)	Mean – CD Total ($\bar{x}$)	Standard deviation (σ) - counts	Coefficient of Variance
SST	26	0.0147	2.9	1.97%
SA + QCR	30	0.0148	1.9	1.23%
SA + (R/RC/CC)	60	0.0151	4	2.65%

Statistical Analysis

$M_\infty = 0.73$, $\theta = 3.1°$

Turbulence model	Sample size (n)	Mean – CD Total ($\bar{x}$)	Standard deviation (σ) - counts	Coefficient of Variance
SST	30	0.0370	12.4	3.4%
SA + QCR	40	0.0381	7.5	2.0%
SA + (R/RC/CC)	83	0.0403	14.6	3.6%



- All models' variance increased with higher AoA
- **SA + QCR** model proved less *sensitive* to more challenging conditions

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CFD Analysis of Transonic Drag Prediction

RANS CFD

DPW-8 Test Case 1d & 1e · Wing-Only Configuration

Ma 0.76	Re 5×10^6	4 Meshes	~98M
Mach Number	Reynolds Number	Grid Levels	Max Elements

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CHALLENGES FACED

01

Computational Resource Constraints

Only 4 of 6 mesh levels completed. Tiny & Coarse ran on UWE desktop PCs; Medium (48 cores) & Fine (144 cores) required Rescale cloud HPC. Extra-fine & Ultra-fine were outside budget ($100 allocation).

02

Solver Instability on Dense Meshes

Fine & Medium grids caused solver divergence at default settings.
Temperature limits in ANSYS Fluent had to be raised to prevent failure — a recognised numerical limitation introduced into the solution.

03

Data Post-Processing Across Two Environments

Tiny/Coarse residuals monitored in Fluent GUI.
Medium/Fine output files exported from Rescale (cloud computing) and post-processed in MATLAB — requiring custom scripts to parse history files and plot CL, CD, CM convergence.

WHY DID THESE DIFFICULTIES OCCUR?

Transonic physics is inherently demanding

Shock–boundary-layer interaction, local supersonic pockets, and pressure recovery all require fine near-wall resolution. RANS grids grow as N^3 — going from Coarse (~22M) to Fine (~98M) elements is a ×4.5 jump in memory and compute time.

DPW-8 grids are research-grade, not student-grade

Benchmark CGNS files were defined in inches, requiring manual rescaling. The 6-level sequence spans 7M → 700M+ elements; university hardware tops out around 22M cells for interactive RANS work.

Spalart–Allmaras near-wall sensitivity

The SA one-equation model resolves viscous sublayer gradients at y^+~1. Increased density means finer y^+ targets and stiffer equation sets — raising the risk of temperature-limiter activation in Fluent's density-based solver.

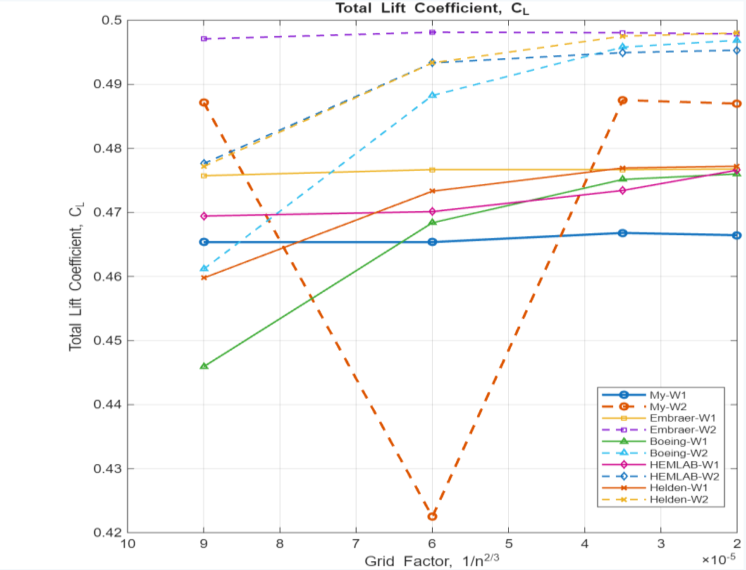
Distributed workflow complexity

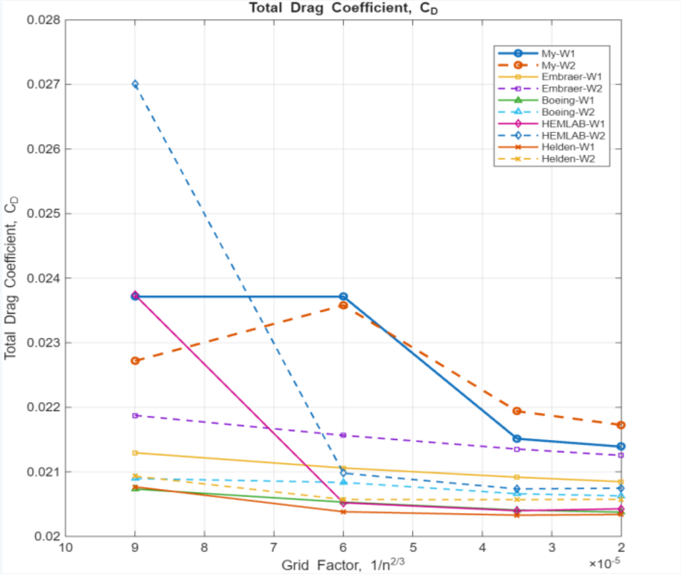
Running jobs across two environments (local GUI + Rescale cloud) introduced a data handoff problem: history files were not natively formatted for MATLAB, requiring a bespoke parsing pipeline not covered in standard coursework.

Key insight: difficulties were not errors — they were predictable consequences of applying industry-scale CFD within a student resource envelope.

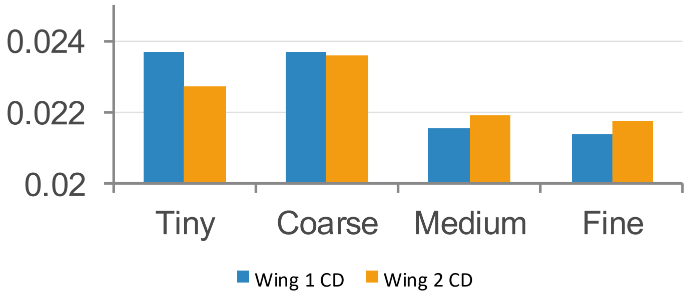
RESULTS

CL vs Participants





My Results: CD Convergence



✓ Fine mesh within DPW-8 scatter band

WHAT I LEARNED & STUDENT IMPACT

LESSONS LEARNED

Mesh resolution governs drag accuracy

ΔCD 18× smaller from Coarse→Medium vs Medium→Fine. Near-wall gradients converge slowly; lift converges faster than drag.

Cloud HPC is essential for research-grade CFD

Rescale enabled 48- and 144-core runs impossible locally. Journal automation prevented costly failed cloud submissions.

Validation requires benchmark comparison

Plotting against DPW-8 scatter is the only way to separate solver variability from genuine error. Both wings landed within the band.

Constraints mirror real engineering

Budget, time, and hardware limits are real in industry too. Documenting every workaround and its numerical impact is professional practice.

STUDENT IMPACT

- First independent use of industry-scale RANS CFD (ANSYS Fluent) on a live AIAA benchmark case
- Hands-on HPC experience: job scheduling, journal automation, core-count scaling, cloud resource management
- Independently reproduced results within published DPW-8 scatter — a standard met by professional participants
- Built multi-environment data pipeline (Fluent → Rescale → MATLAB) with no prior template
- Linked numerical decisions (y^+, turbulence model, convergence) directly to output credibility

DPW8 – lessons learned

From a university perspective…

Negatives:

1. The family of whole aircraft cases are still too expensive mesh element-wise to run – we could only run 4 meshes (due to being permitted to run 2 cases on cloud computing).

2. The required treatment of the meshes to bring them into the software we use is challenging for the students.

3. We use CFD-Post (Synopsys/Ansys) as the software that all students use, but some project students use ParaView. Tecplot is only used for DPW due to its expense.

4. Only one standard version of Spalart-Allmaras available to us in Ansys Fluent, no variants.

DPW8 – lessons learned

From a university perspective…

Positives (technical)

1. Substantially increases their CFD knowledge and standard.

2. Expands their use of software beyond what they are taught in their degrees

3. Aids their experience and confidence in problem solving.

4. Enables them to understand that CFD cases are not perfect and do go wrong
   but importantly the point is to persist, find the sources of error
   and understand that error will never be annihilated.

5. To take part in a real research project of importance to industry and academia.

6. Helps to identify the state of the art in CFD

DPW8 – lessons learned

From a university perspective…

Positives (career)

1. Working in a professional context with others is an opportunity that many students are looking for in their project but it is stressful and scary for them.

2. Enhanced CFD skills should make the students more employable.

3. Enforces the idea of the importance of networking.

4. Gives them a publication for their C.V. if they persist to the end.

5. Thank-you from an academic's perspective of encouraging our students to be a part of DPW research

Thank You

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