Aero Challenge 01
A Reference-Withheld NACA 0012 Prediction Experiment

Alex Blythe / Aero engineering record

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Abstract

A nominal two-dimensional steady-RANS prediction was preregistered, executed on three grids at each of 18 angles, and frozen before the experimental reference was revealed. The numerical disposition is FAIL; experimental coefficient comparison is FAIL; overall status is FAIL. This result is preserved without post-reveal tuning.

1 Decision and scope

Complete nominal steady-RANS prediction retained. Numerical acceptance failed; no design-ready or validated prediction is claimed, irrespective of later coefficient agreement. Setup supervisor was source-exposed; solver execution was reference-withheld. No physical-time average, exact grit equivalence, or universal validation is claimed.

2 What was actually tested

NASA TM-4074 Table XIII, first subtable: NACA0012, Mach0.15, Reynolds number5.95 million, fixed transition strips at5 percent chord. The complete18-point CL/CD polar is retained. This is not a Cp-field comparison, an as-built reconstruction or a certified design calculation.

3 Independence limitation

The solver containers had no reference or decryption key. However, the source-exposed supervisor authored the numerical setup. This is runtime reference withholding, not double-blind source selection or independently blinded supervisory design. A fresh input-only model review does not remove that limitation.

4 Top-level results

0 of 54 cases passed their applicable individual numerical gates; 2 of 18 medium/fine comparisons passed. 54 meshes retained failed checkMesh checks under the declared thin-grid policy, not clean mesh-quality passes. Frozen experimental bounds: CL RMSE <=0.10 and maximum absolute error <=0.20; CD RMSE <=0.005 and maximum absolute error <=0.010. These are declared utility bounds, not experimental confidence intervals.

Quantity	RMSE	Maximum absolute error	Gate
CD	0.079659	0.232675	FAIL
CL	0.635532	1.420456	FAIL

5 Source reconstruction and chronology

C. L. Ladson, NASA TM-4074 (1988), NTRS 19880019495. Table XIII, first subtable: M=0.15, R=5.95e6, transition fixed with No. 180 grit. Only the source-defined inputs and all operating-point locations are disclosed here. The permitted package records the geometry description, every operating point, facility conditions and unknowns. Measured coefficients were transcribed and sealed by a source-exposed custodian. Per-point uncertainty is not supplied; no invented confidence interval or post-hoc tolerance widening is used.

Event	UTC timestamp
INPUT_FROZEN	2026-09-13T18:58:19.947242+00:00
CRITERIA_FROZEN	2026-09-13T21:18:15.527028+00:00
CRITERIA_FROZEN_ANCHORED	2026-09-13T21:19:26.103190+00:00
SOLVE	2026-09-13T21:19:26.298933+00:00
PREDICTION_FROZEN	2026-09-14T14:00:53.514967+00:00
PREDICTION_FROZEN_ANCHORED	2026-09-14T14:02:24.436781+00:00
REFERENCE_UNSEALED	2026-09-14T14:02:25.517366+00:00
COMPARED	2026-09-14T14:02:26.109491+00:00
COMPARED_ANCHORED	2026-09-14T14:02:36.194802+00:00

5.1 Custody and execution separation

The original source PDF and plaintext reference were held outside the website repository. AES-256-GCM ciphertext and input hashes were public before prediction. Each solver container was non-root, network-disabled and capability-dropped, with a read-only generator and a fresh output bind. No RAG or model inference occurred during solving.

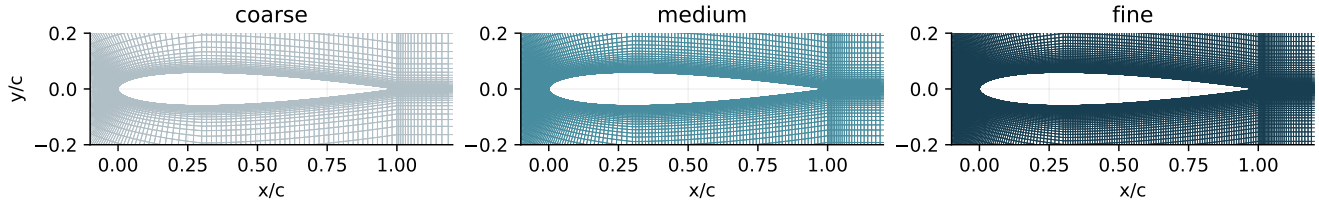
5.2 No retroactive tuning

Model choices, mesh counts, averaging windows and acceptance thresholds were fixed in the preregistration commit. All run attempts were retained. Reproduction and report-generation code performs declared arithmetic; it does not choose a more favorable angle subset.

6 Numerical model and geometry

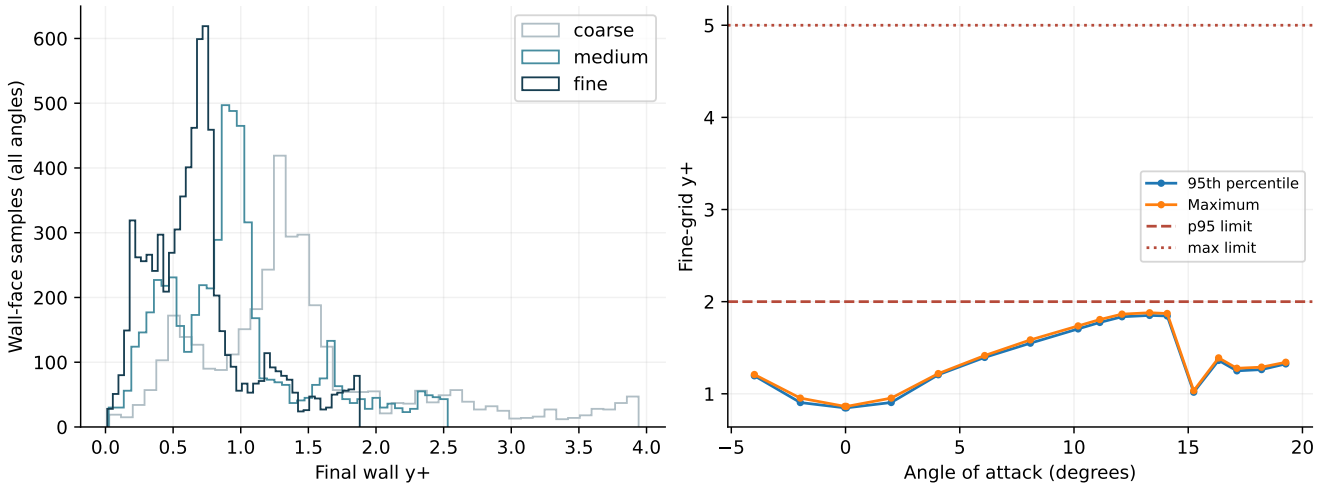
Two-dimensional incompressible steady Reynolds-averaged Navier-Stokes. Low-Mach approximation at M=0.15; compressibility is not resolved or corrected post hoc. A bounded steady-model test, not a claim that the complete angle series is physically steady. Oscillating/nonstationary cases fail numerical acceptance. gammaInt fixed to 0 for x/c<0.05 and 1 for x/c>=0.05 in a geometric near-surface band of thickness 0.02c. Cells selected against nominal thickness; constraints audited. This approximates prescribed transition, not physical roughness or strip-width drag. Inlet turbulence intensity0.1 percent and length scale0.01c are assumptions, not tunnel measurements. The nominal chord is0.601m. Velocity is0.15 sqrt(1.4 R T) at an assumed288.15K; kinematic viscosity is Uc/Re, preserving chord Reynolds number. Coefficients use kinematic pressure normalization; no atmospheric-density claim is made.

$$C_L = \frac{L}{\frac{1}{2}\rho U_\infty^2 cb}, \qquad C_D = \frac{D}{\frac{1}{2}\rho U_\infty^2 cb}, \qquad \nu = \frac{U_\infty c}{Re_c}. \tag{1}$$



Actual retained mesh edges from the three p01 cases. The nominal surface comes from the pinned Foundation10 geometry asset. Template and geometry provenance are retained with GPL licensing. Thin-cell/aspect-ratio warnings are not erased; checkMesh logs accompany every case.

7 Wall treatment and numerical gates

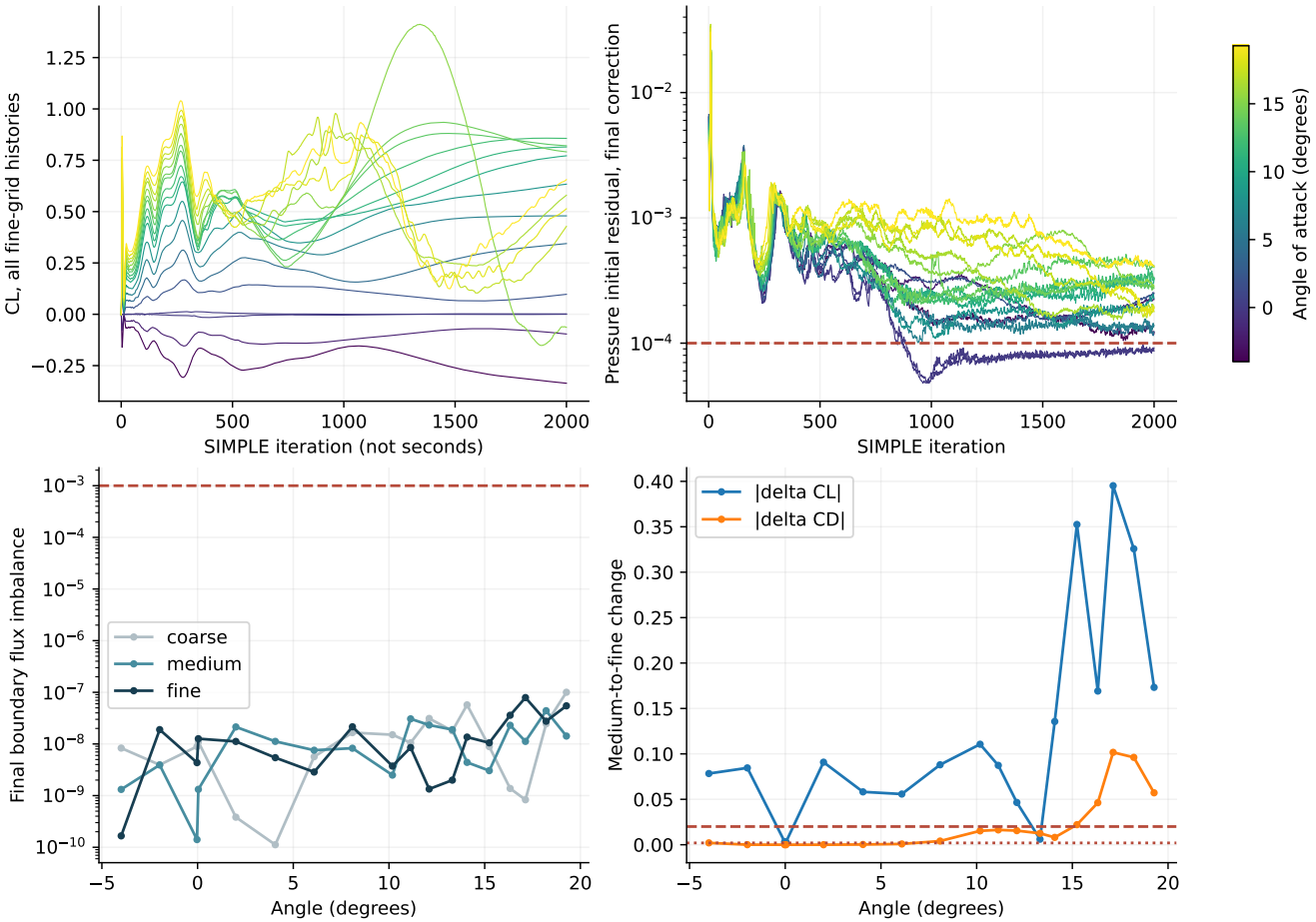


The fine-grid95th-percentile y+ limit is2 and its maximum limit is5. A passing y+ check alone does not establish transition equivalence, turbulence-model adequacy or physical validation. The imposed intermittency band is not a geometrically resolved grit strip.

7.1 Acceptance policy

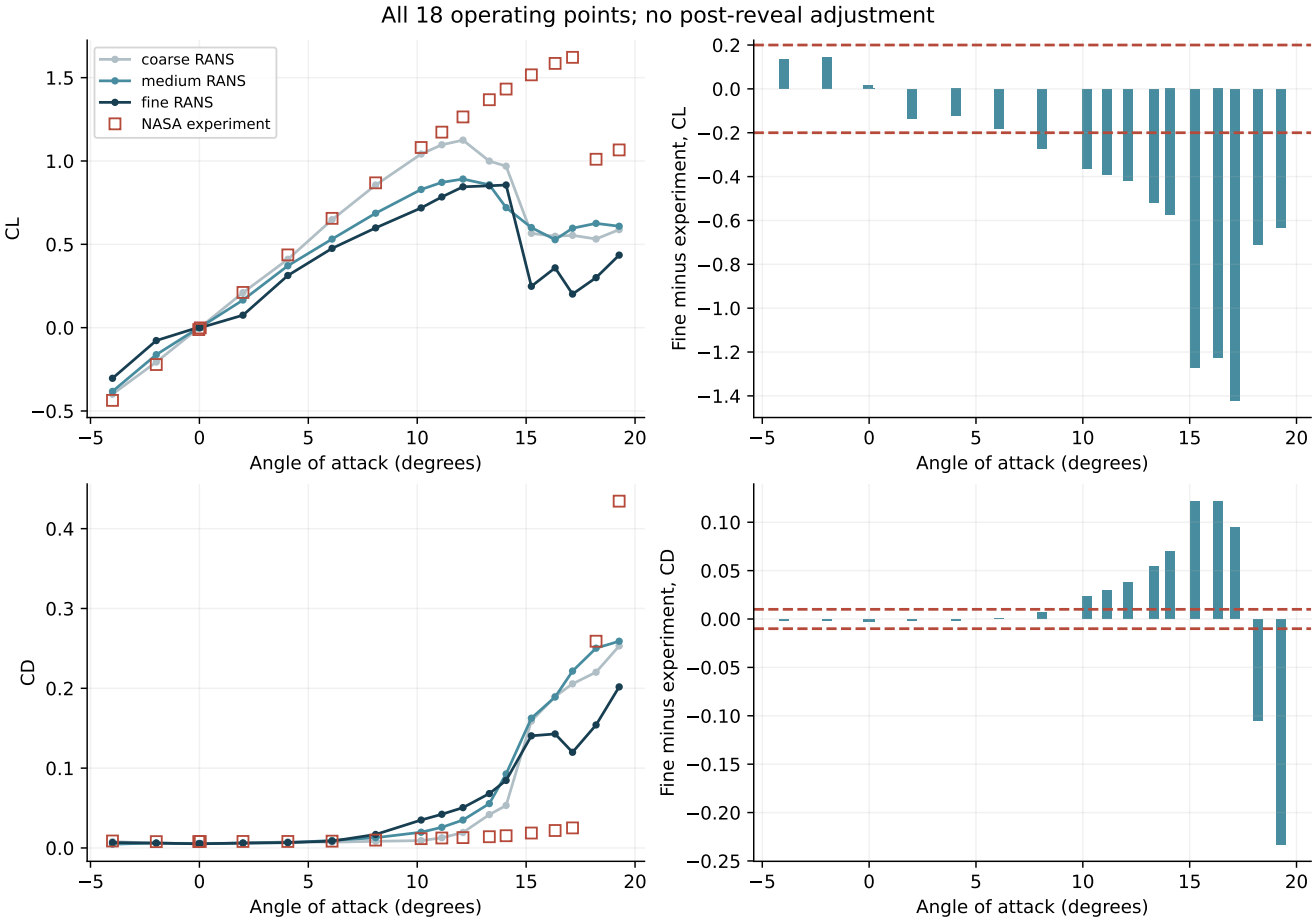
Each case must finish2000 SIMPLE iterations with finite fields and verified trip constraints. Initial residuals at the final iteration must be at most1e-4 and final linear residuals at most1e-6 for the declared fields. Boundary-flux imbalance must be at most0.001; the separate solver-continuity limits remain in preregistration. Means over iterations1000–1500 and1500–2000 must differ by at most0.01 CL and0.001 CD. Last500-iteration ranges must be at most0.02 CL and0.002 CD. Medium-to-fine differences must be at most0.02 CL and0.002 CD. Iteration means are not physical-time averages.

8 Convergence, conservation and grid sensitivity



Every fine-grid force and pressure-residual history is shown. Boundary flux is independently summed over retained patch fluxes and normalized by total absolute boundary flux; it is not a residual relabeled as conservation. Numerical warnings and failed gates are retained even if the coefficient comparison happens to agree.

9 Frozen prediction versus experiment



All points are shown on their registered angles. Dashed error bounds are the preregistered maximum-absolute-error limits. Experimental uncertainty bars are absent because pointwise uncertainty is not supplied. The fine grid supplies the frozen prediction; no grid extrapolation is substituted after reveal.

10 Complete coefficient errors

α	C_L pred.	C_L exp.	Error	C_D pred.	C_D exp.	Error
-3.99000	-0.30394	-0.43630	0.13236	0.00680	0.00871	-0.00191
-1.98000	-0.07748	-0.22130	0.14382	0.00609	0.00792	-0.00183
-0.03000	0.00229	-0.01150	0.01379	0.00521	0.00803	-0.00282
0.04000	-0.00048	-0.00130	0.00082	0.00521	0.00811	-0.00290
2.00000	0.07477	0.21130	-0.13653	0.00617	0.00814	-0.00197
4.06000	0.31296	0.43650	-0.12354	0.00680	0.00814	-0.00134
6.09000	0.47563	0.65580	-0.18017	0.00857	0.00851	0.00006
8.09000	0.59855	0.86890	-0.27035	0.01690	0.00985	0.00705
10.18000	0.71838	1.08090	-0.36252	0.03499	0.01165	0.02334
11.13000	0.78427	1.17310	-0.38883	0.04221	0.01247	0.02974
12.10000	0.84511	1.26440	-0.41929	0.05051	0.01299	0.03752
13.31000	0.85120	1.36760	-0.51640	0.06813	0.01408	0.05405
14.08000	0.85596	1.43160	-0.57564	0.08461	0.01533	0.06928
15.24000	0.24802	1.51690	-1.26888	0.14048	0.01870	0.12178
16.33000	0.35868	1.58550	-1.22682	0.14284	0.02186	0.12098
17.13000	0.20144	1.62190	-1.42046	0.11987	0.02513	0.09474
18.21000	0.29992	1.01040	-0.71048	0.15410	0.25899	-0.10489
19.27000	0.43528	1.06640	-0.63112	0.20179	0.43446	-0.23267

10.1 Experimental and numerical outcomes are separate

Numerical status: FAIL. Experimental comparison: FAIL. Overall status: FAIL. A failed numerical gate prevents an overall PASS regardless of coefficient agreement. This report does not infer a unique physical cause of error from coefficient mismatch alone.

11 Limitations and reproduction

The study assumes a nominal two-dimensional geometry, low-Mach incompressibility, an assumed inlet turbulence state and a prescribed-transition surrogate. The source does not establish exact as-built coordinates, grit height, series temperature or pointwise coefficient uncertainty. A steady RANS fixed point cannot establish physical steadiness near stall. No transient averaging, spanwise instability resolution or physical grit drag is claimed. During pre-registration development, rejected O-grid and C-grid attempts exposed mesh-quality and runtime issues. A case-insensitive Phi/phi filename collision was repaired by not exporting the uppercase potential field. The unmodified transition model uses limiting expressions with zero-vorticity denominators: floating-point trapping was disabled, but stored fields and coefficients were required to be finite. These decisions are recorded before production, not hidden post-reveal repairs.

11.1 Reproduce a case

```
python code/execute_case.py NEW_OUTPUT --level fine
  --angle -3.99 --duration 2000 --timeout 7200
```

Use the pinned public OpenFOAM10 image recorded in preregistration. Every case archive includes generated geometry, mesh, initial/final fields, constraints, decks, logs, coefficient history, extraction results and its own file-hash manifest. Archive hashes are committed with the prediction. Running the code requires Docker and local Python; no model token or private VM access is required.

11.2 References

1. C. L. Ladson. NASA TM-4074 (1988). https://ntrs.nasa.gov/citations/19880019495.
2. OpenFOAM Foundation, Version10 source and user guide. https://doc.cfd.direct/openfoam/user-guide-v10/.
3. R. B. Langtry and F. R. Menter (2009), Correlation-based transition modeling for unstructured parallelized CFD codes, AIAA Journal47(12),2894–2906. Model implementation: Foundation10 kOmegaSSTLM.

12 Commitments and artifact identity

input.json 827bb840cce7068cd09c0a292aea4efcd73a8d046c18c7e7eb1751fbefce3c73

reference.enc bc70021062c16133cef3816ddea98a6e9fe54a60c1908ccdf7d03f60bada0184

preregistration.json d82c98b1f835a52b88c7f355e738253741cb2aa0ae3216913cdad1993c985c6c

blind_prediction.json 7b5e04d12e2e0be0aaefdec2eb29c1a9728f6f0ddbb90f2d6a72160742638e31

comparison.json f165ced785f6a23604e579a5b64b71261d80b78fd3c29b51c04befd45f069b46

CRITERIA_FROZEN_ANCHORED 0fb460ae948d0a11ce39ed565d619d5eb1d78622

PREDICTION_FROZEN_ANCHORED b98e123b11a37bf0f0e0dfae916bfe2d5b4e1507

COMPARED_ANCHORED ada06530369cbdd9393cf9432241c0954d916b93

Hashes establish identity, not scientific validity or an immutable timestamp against repository administrators. The original frozen prediction and its failures remain preserved. Any later tuning must be published as a separately versioned follow-up.