Appendix B Sources of Experimental Data for Code Validation

Airfoil Data Sources

Some sources of airfoil geometry and experimental data for use in code evaluation are listed here. Note that rigorous validation of codes requires very careful analysis, and an understanding of possible experimental, as well as computational, error. See the junior Aerodynamic Lab notes for my comments on the issues involved in aerodynamic testing in wind tunnels. Hardcopies of the NACA reports are located in the Virginia Tech Library at DOCS Y3.N21/5:9 on the first floor.

Books

Abbott and von Doenhoff, *Theory of Airfoil Sections*. Look in the references for the original NACA airfoil reports. Note that pressure distributions are fairly rare. See also NACA R 824.


NASA Low and Medium Speed Airfoils


**NASA Transonic Airfoils**


**Laminar Flow Airfoils**


**Other Low and Medium Speed Airfoils and Airfoil Data**

Beasley, William D., and McGhee, Robert J., “Experimental and Theoretical Low-Speed Aerodynamic Characteristics of the NACA 65(1)-213, \(a = 0.50\), Airfoil,” NASA TMX-3160, Feb. 1975

Hicks, Raymond M., “A Recontoured Upper Surface Designed to Increase the Maximum Lift Coefficient of a Modified NACA 65(0.82) (9.9) Airfoil Section,” NASA TM 85855, Feb. 1984.


Stivers, “Effects of Subsonic Mach Number on the Forces and Pressure Distributions on Four 64A-Series Airfoil Sections at Angles of Attack as High as 28°,” NACA TN 3162, 1954.

**Multi-element Airfoil Data**


Appendix B: Data Sources


Other data sources:

Bertin and Smith, 1st edition, page 102-102, NACA 4412, pressure distribution, 2nd edition: pg 201-202, 3rd edition: pg 221-222 (from Pinkerton, NACA R 563, 1936, but WATCH OUT! This data is not what you might think. See NACA R-646 for true 2-D data!)


Three-Dimensional Data Sources

Elementary body geometries: There were many tests conducted by the NACA using geometries that are simple to model. Similar tests were also done in the early days of NASA. The NACA reports were classified at the time, but have been declassified. A sample of cases I’ve used are included here:


The standard transonic test case: the ONERA M6 wing has been used in practically every transonic code validation calculation ever published. The data is contained in AGARD AR-138 cited below.

Supercritical Wings:


Hinson, B.L., and Burdges, K.P., “Acquisition and Application of Transonic Wing and Far-Field Test Data for Three-Dimensional Computational Method Evaluation,” AFOSR-TR-80-0421, March 1980, available from DTIC as AD A085 258. These are the Lockheed Wings A, B, and C.

Keener, E.R., “Pressure Distribution Measurements on a Transonic Low-Aspect Ratio Wing,” NASA TM 86683, 1985. (this is the so-called Lockheed Wing C)
Keener, E.R., “Boundary Layer Measurements on a Transonic Low-Aspect Ratio Wing,” NASA TM 88214, 1986. (this is the so-called Lockheed Wing C)

Supersonic Wing Data:


AGARD Test Cases

AGARD has selected test cases for CFD code validation. These cases are important because an attempt has been made to define the test conditions and any corrections required precisely enough for use in code validation work. This is not an easy job. This also means that the airfoil test coordinates and results are available in tabulated form in these reports. The reports include:


Two-dimensional test cases:

(1) NACA 0012, over a range of subsonic Mach and angle of attack, both force and moment and pressure distributions,

(2) NLR QE 0.11-0.75-1.375, a symmetrical airfoil designed to be shock free at a transonic design point, Mach range from 0.30 to 0.85, all at zero angle of attack,

(3) CAST 7, pressure distributions over a range of Mach from 0.40 to 0.80, α from -2° to 5°, also boundary layer measurements. No force and moment data;

(4) NLR7301, thick supercritical airfoil (16.5%), Mach from 0.30 to 0.85, a from -4° to +4°, pressure, and force and moment;

(5) SKF 1.1/with maneuver flap, (French), Mach number from 0.50 to 1.2, force and moment and pressure over a limited range of angle of attack;

(6) RAE 2822, surface pressure distribution, boundary layer and wake rake surveys, over a range of Mach and α (this is one of the most complete sets of data in the report),

(7) NAE 75-036-13:2, Mach range from 0.5 to 0.84, α from 0 to 4° at M = 0.75, 2° for other Machs.

(8 ) MBB-A3 NASA 10% supercritical, M from 0.6 to 0.80, α from 0.5° to 2.5°.

Three dimensional cases:

(1) ONERA M6, pressure distributions,

(2) ONERA AFV D, variable sweep wing,

(3) MBB-AVA Pilot Model with supercritical wing,

(4) RAE Wing A,

(5) NASA Supercritical-Wing Research Airplane Model (actually the F-8, pressure distributions only).
Body alone configurations:

1. 1.5D Ogive Circular Cylinder Body, L/D = 21.5,
2. MBB Body of revolution No. 3,
3. 10° cone-cylinder at α zero, M from 0.91 to 1.22,
4. ONERA calibration body model C5, M from 0.6 to 1.0, α zero.


Five additional three-dimensional data sets were identified and included in the ADDENDUM

(B-6) Lockheed-AFOSR Wing A: Semi-span wing, M 0.62-0.84, α from -2° to 5°, Re on mac: 6 million
(B-7) Lockheed-AFOSR Wing B: Semi-span wing, M: 0.70 to 0.94, α from -2° to +5°, Re on mac: 10 million
(B-8) ARA M100 Wing/body, full model, M: 0.50-0.93, α from -4° to +3°, Re on mac: 3.5 million
(B-9) ARA M86 Wing/body, full model, M: 0.50-0.82, α from 0° to +8°, Re on mac: 2.8-3.7 million
(B-10) FFA Aircraft (SAAB A32A Lansen), M: 0.40-0.89, α from 0° to +10°, Re on mac: 10-30 million


Seven test cases are defined, five airfoils and two wings. The include:

*Airfoils:*

1. NACA 64006 with oscillating flap,
2. NACA 64A010 with oscillatory pitching,
3. NACA 0012 with oscillatory and transient pitching,
4. NLR 7301 airfoil with (i) oscillatory pitching and oscillating flap at NLR and (ii) with oscillating pitching (NASA Ames).

*Wing data*

1. RAE Wing A with an oscillating flap
2. NORA Model with oscillation about the swept axis.

**AGARD AR-211, “Test Cases for Inviscid Flowfield Methods,” May 1985.**

*Two dimensional test cases*

NACA 0012 airfoil at

1. M = 0.80, α = 1.25°,
2. M = 0.85, α = 1°,
3. M = 0.95, α = 0°,
4. M = 1.25, α = 0°,
5. M = 1.25, α = 7°,

RAE 2822 airfoil at

6. M = 0.75, α = 3°,
NLR 7301 airfoil at (7) $M = 0.720957$, $\alpha = .194^\circ$, (theoretical data)
Chiocchia-Nocilla at (8) $M = 0.769$, $\alpha = 0^\circ$. (sharp le)

2-D Cascade test cases:
- HOBSON-1 (9) $M = 0.476$, $a = 43.544^\circ$, Spacing, s/c = 1.0121
- HOBSON-2 (10) $M = 0.575$, $a = 46.123^\circ$, Spacing, s/c = 0.5259

Three-dimensional cases
- ONERA M6 airfoil at (11) $M = 0.84$, $\alpha = 3.06^\circ$,
  (12) $M = 0.92$, $\alpha = 0^\circ$,
- Butler wing at (13) $M = 2.50$, $\alpha = 0^\circ$,
- Dillner wing at (14) $M = 1.50$, $\alpha = 15^\circ$,
  (15) $M = 0.70$, $\alpha = 15^\circ$,
- NASA Ames swept wing at (16) $M = 0.833$, $\alpha = 1.75^\circ$,
- AGARD B at (17) $M = 1.5, \alpha = 0^\circ$,
  (18) $M = 1.5, \alpha = 2^\circ$,
  (19) $M = 2.0$, $\alpha = 0^\circ$,
  (20) $M = 2.0, \alpha = 2^\circ$.


By now the data is much more elaborate, and there are many more cases.
A - Airfoil cases (13)
B - Wing-fuselage (6)
C - Bodies (6)
D - Delta wing class (5)
E - Aero-Propulsion/Pylon/Store (9)

The data is available on floppy disks. The Virginia Tech Library has this data in the media center. According to the report the data is available from the NASA Center for Aerospace Information, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934. Contact: NASA Access Help Desk, (301) 621-0390, fax: (301) 621-0134. However, I’m not sure that this procedure actually worked when we tried it.