OpenVSP with AVL

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OpenVSP Workshop v3
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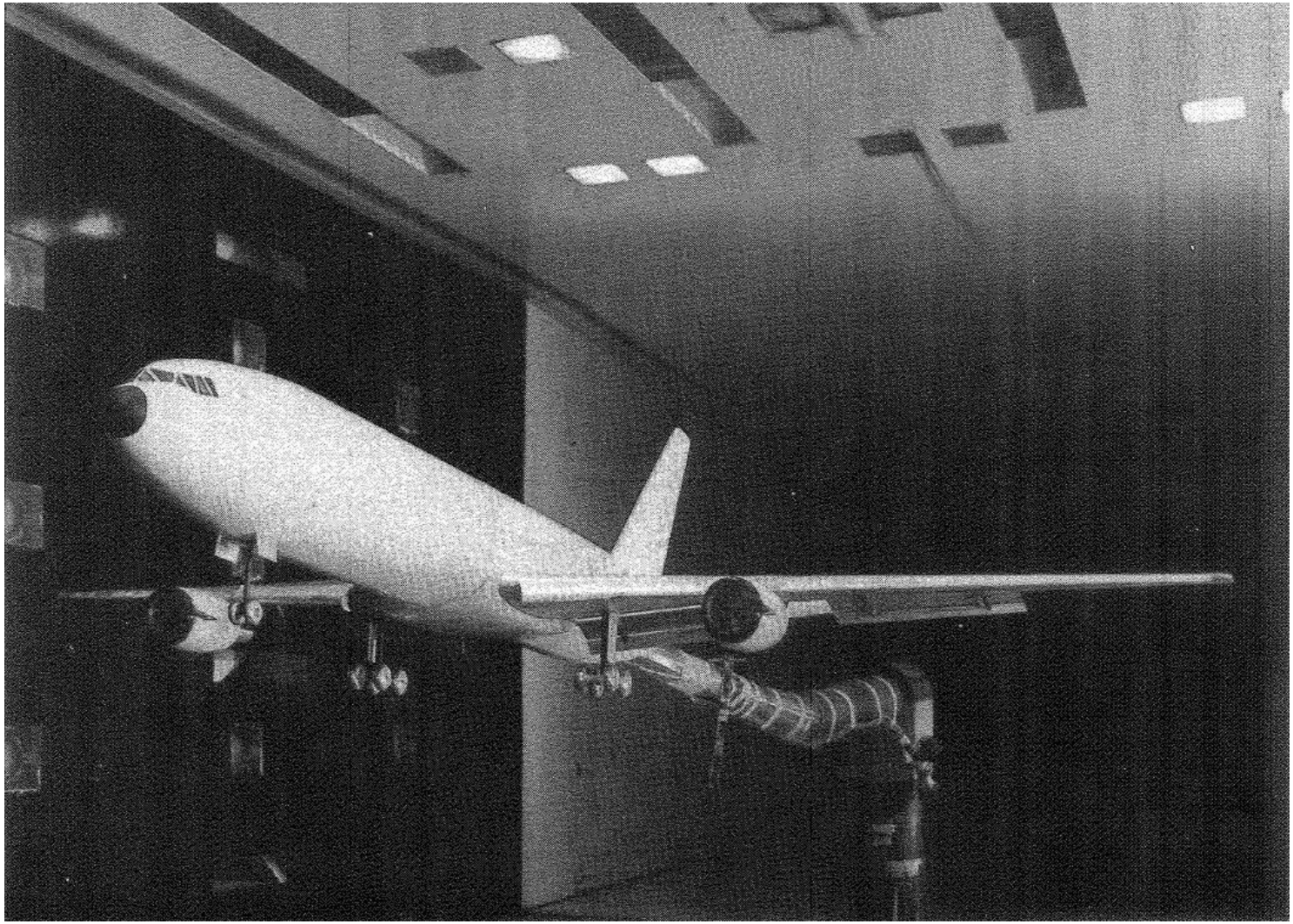
Outline

- NASA EET AR12 Model
- Flap Modeling
- OpenVSP to AVL Conversion
- Validation Results
- Degenerate Geometry

NASA EET AR12 Model

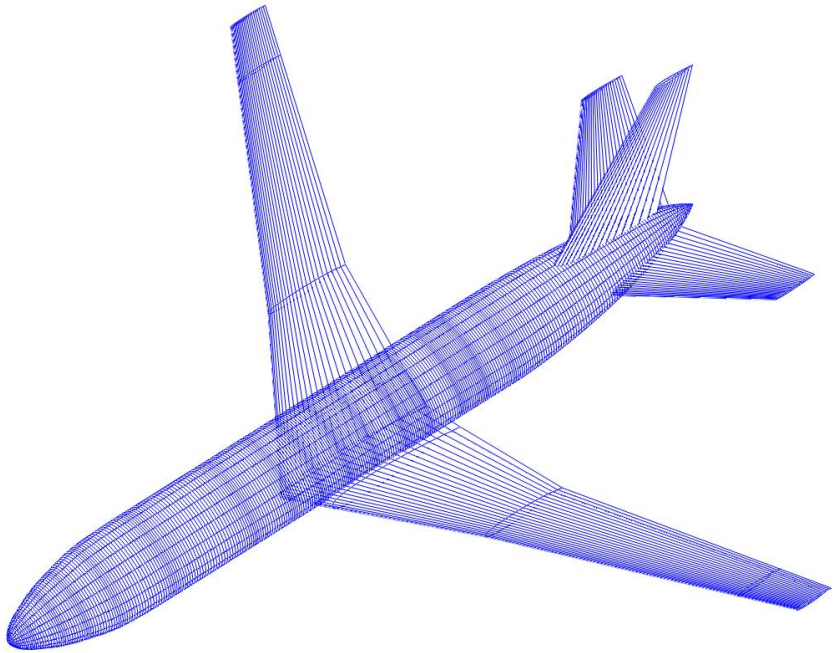


Morgan, H.L. and Paulson, J.W.: NASA TP-1580 (1979) L-78-1654

NASA EET AR12 Model

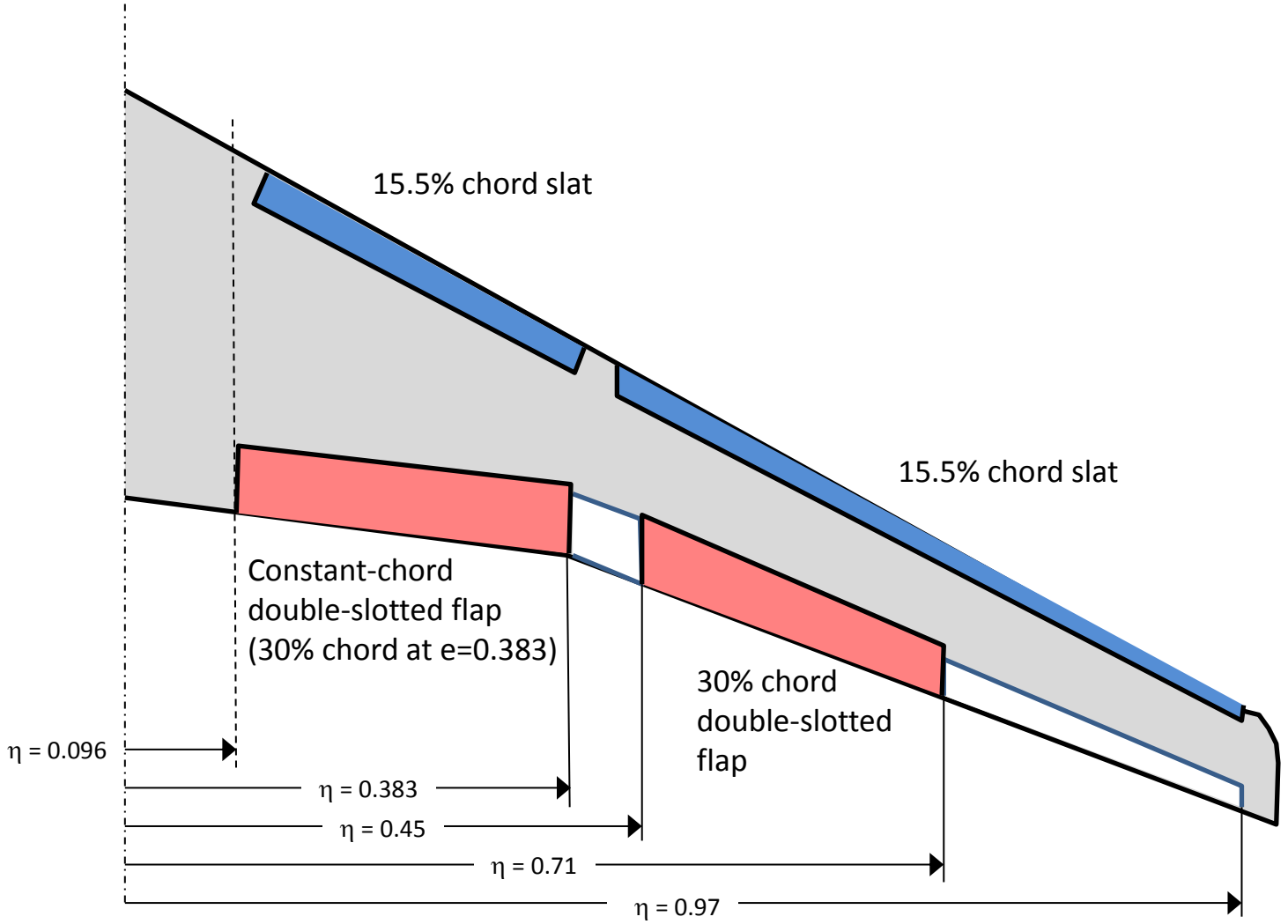
- Langley 14x22 Wind Tunnel ca. 1978
- 12-foot span supercritical wing
- Full-span slats
- Part-span double-slotted flaps with cutout
- Moveable horizontal tail
- Flow-through nacelles, landing gear
- Morgan, H. L.: NASA TM-80048 (1979) and Morgan, H.L. and Paulson, J.W.: NASA TP-1580 (1979)

EET AR12 OpenVSP Model



- Planform shape from configuration description
- Wing airfoils from tabulated coordinates
- Fuselage sections digitized from plotted cross sections
- No nacelles, gear or gear pod
- Wing twist added to Hermite export file using external utility

Flap and Control Surface Layout

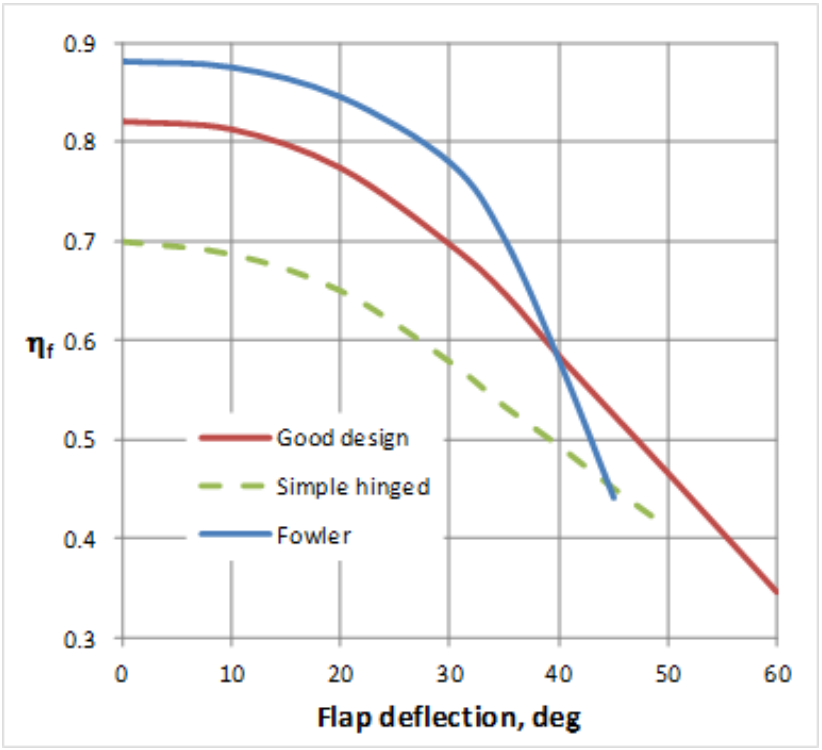


Modeling of Flap Effects

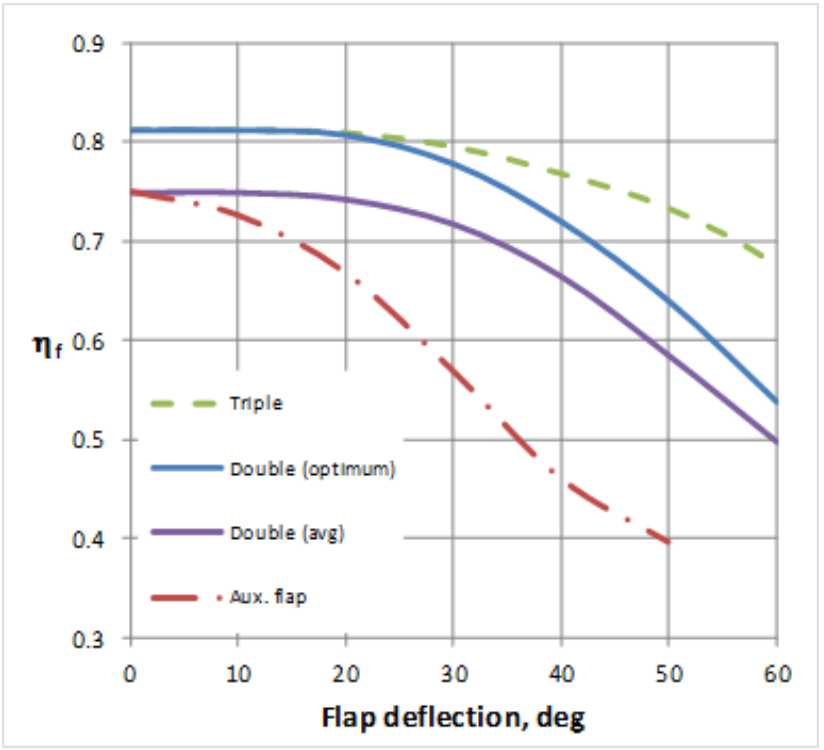
- In practice, the theoretical lift increment from linear theory cannot be realized
  - inadequacy of linear theory at large flap angles
  - viscous effects
  - flow separation at large flap angles
- Apply a flap effectiveness factor, η_δ
- Account for slotted flap chord extension

Slotted Flap Effectiveness

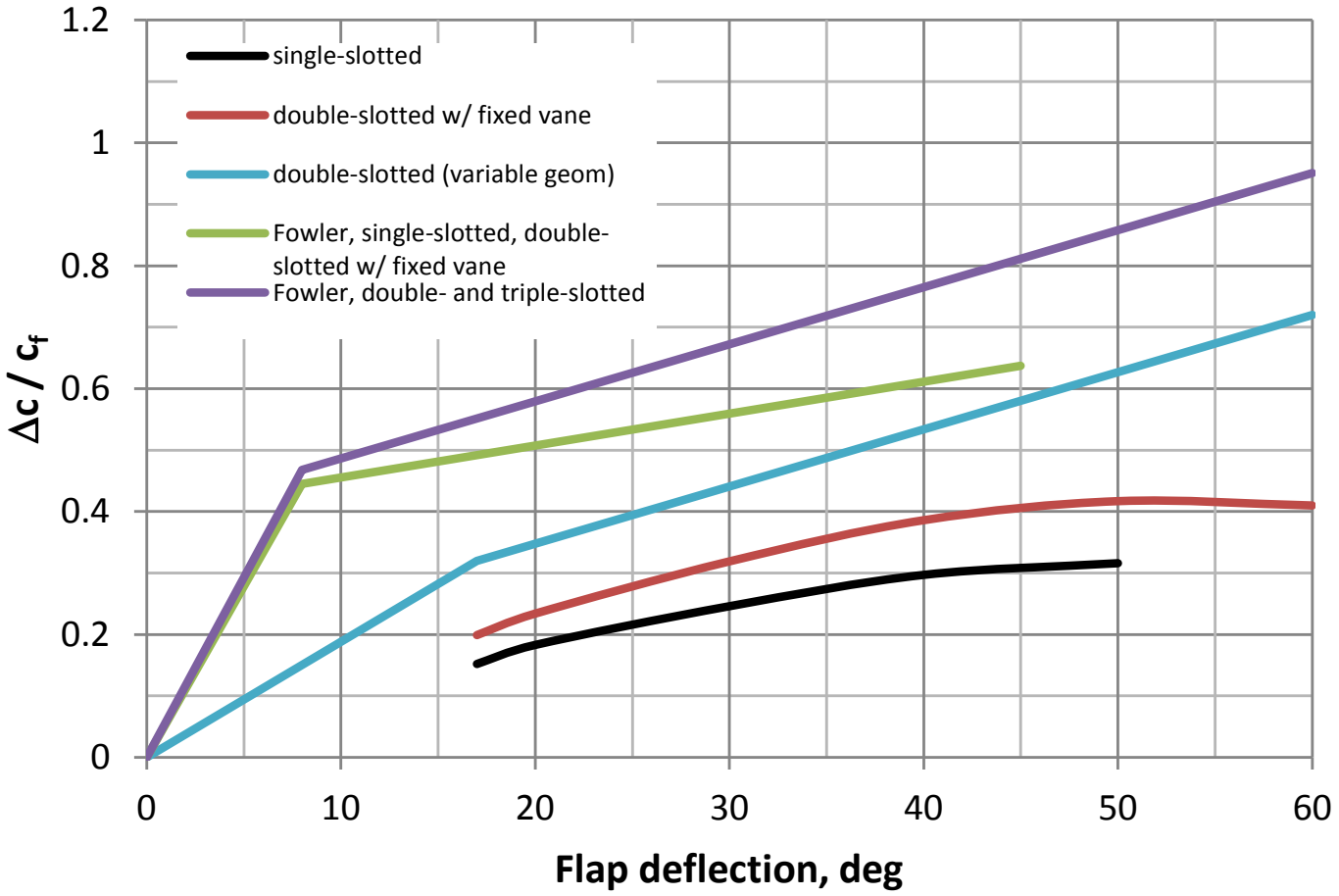
Single-slotted



Double- and triple-slotted



Empirical Chord Extension Ratios



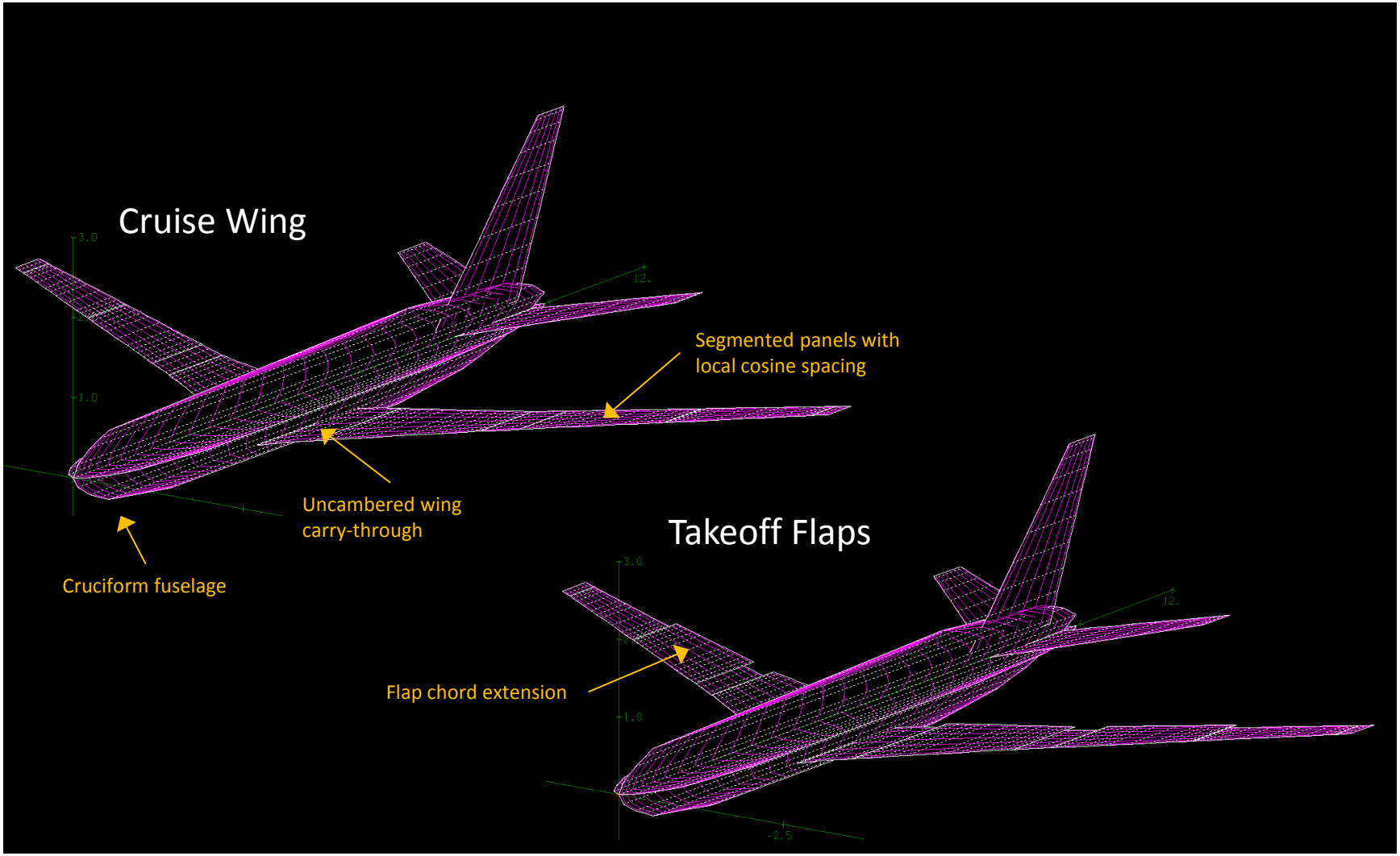
Athena Vortex Lattice (AVL)

- Open-source (GPL) code developed at MIT (Drela & Youngren)
- Forces and moments, trim, steady rotation
- Stability derivatives w.r.t. angles, rotation, control surfaces
- Rigib-body, quasi-steady eigenmode analysis
- Incidence, camber, and control-surface or flap deflections modeled as normal-vector tilt only

OpenVSP to AVL Conversion

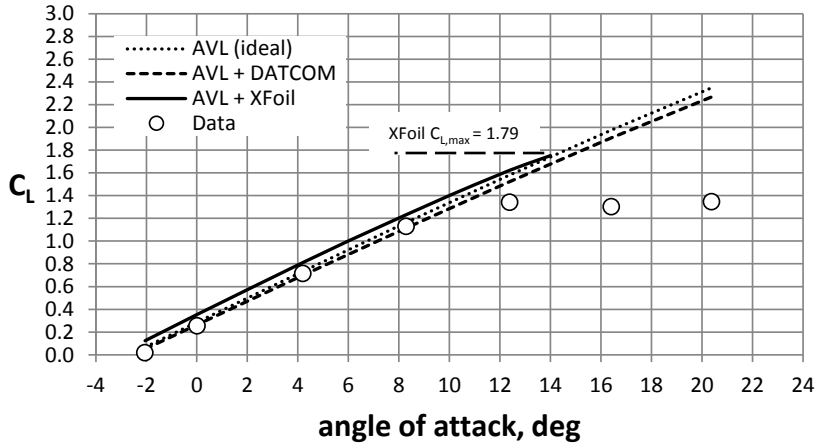
- Uses OpenVSP Hermite (Xsec) file export with external HRM2AVL utility
- AVL lifting surface sections (leading-edge coordinate, chord, incidence) calculated from Hermite cross sections
- Lifting-surface sections converted to normalized airfoils → camberline determined by AVL
- Cruciform fuselage interpolated from Hermite cross sections
- Flap chord extension built into model

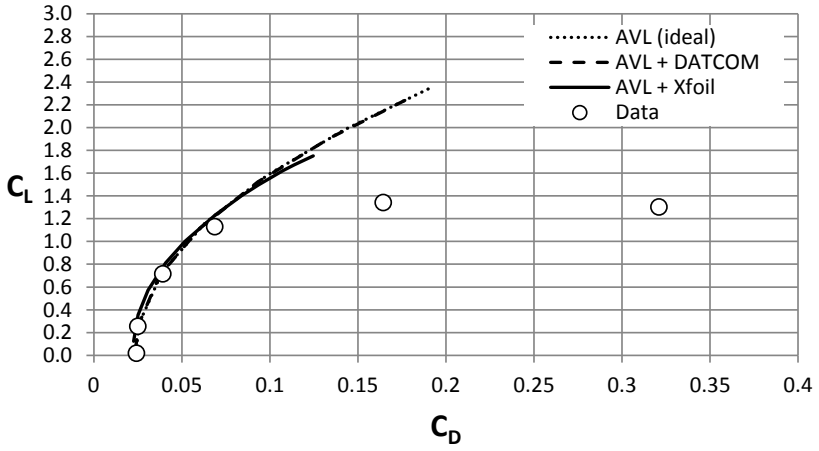
EET AR12 AVL Model

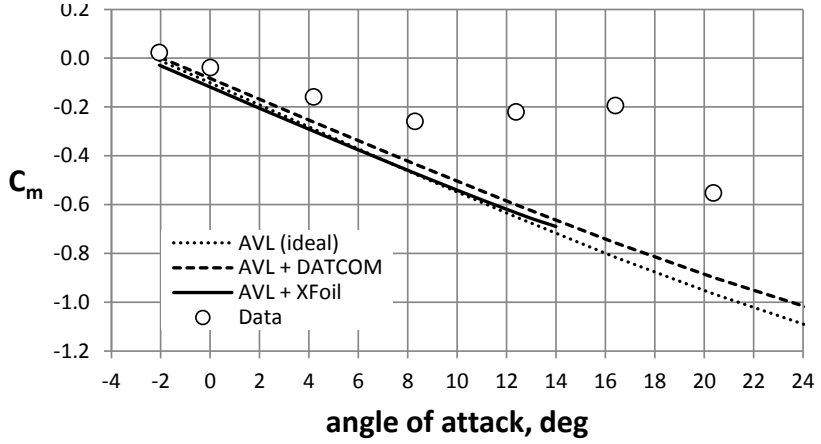


Cruise Wing Validation Results

Mach 0.168, $Re_c = 1.37 \times 10^6$



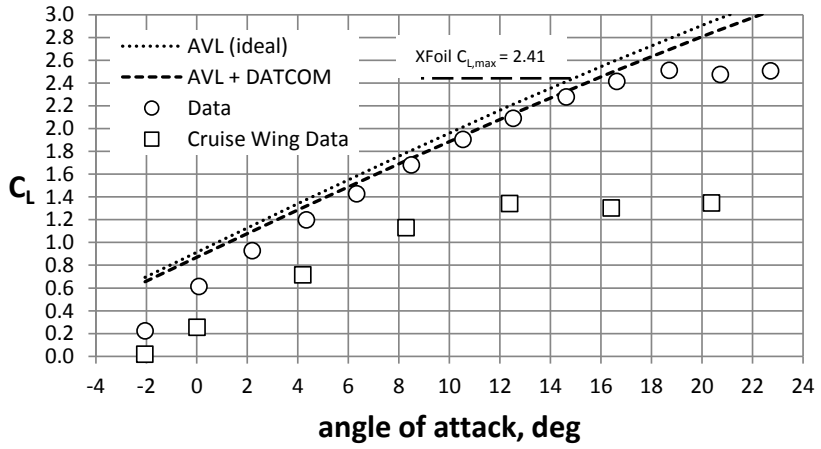


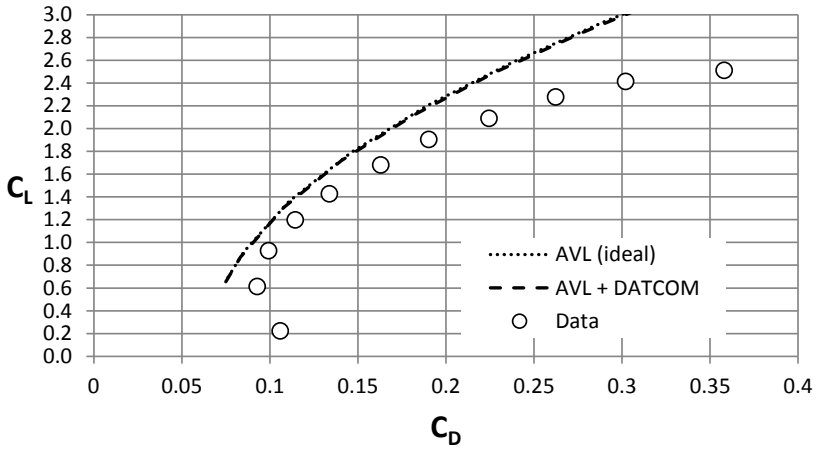


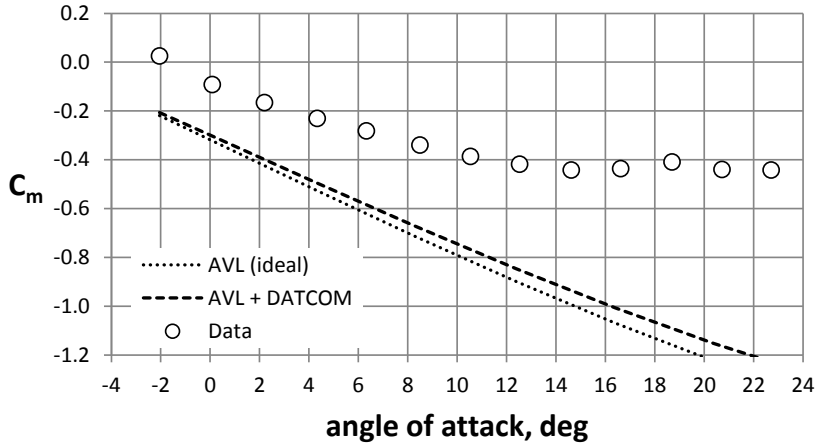
- Actual $C_{L,\max}$ = 1.34
- Predicted $C_{L,\max}$ (XFoil) = 1.79 (+33%)

Takeoff Wing Validation Results

Mach 0.168, $Re_c = 1.37 \times 10^6$



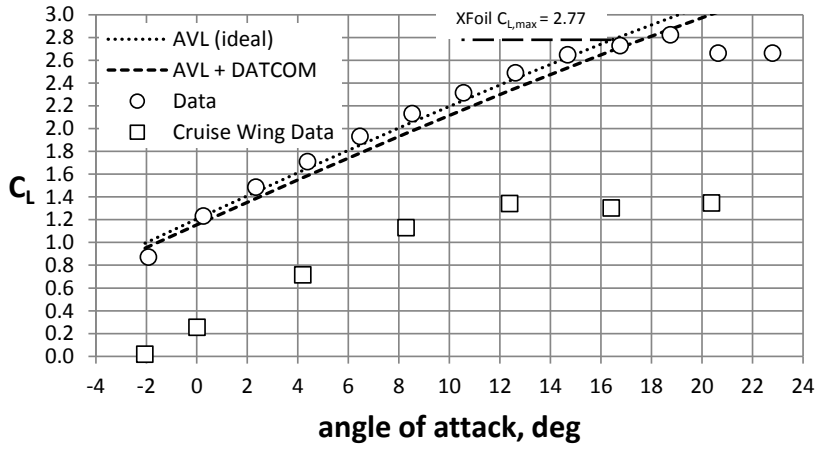


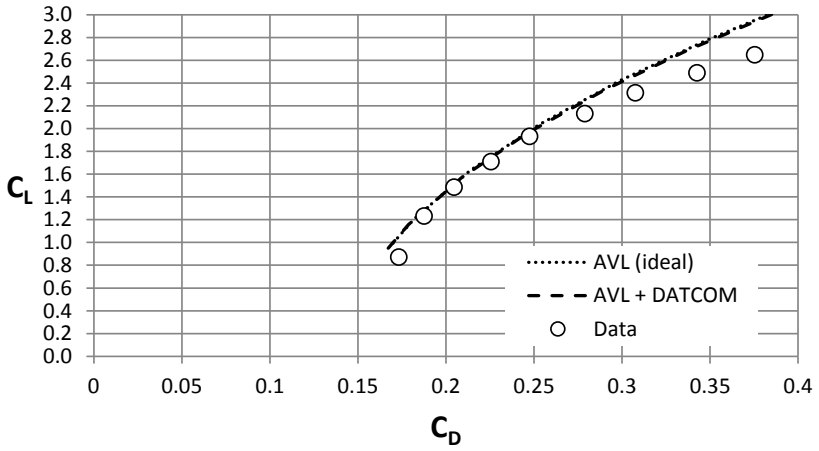


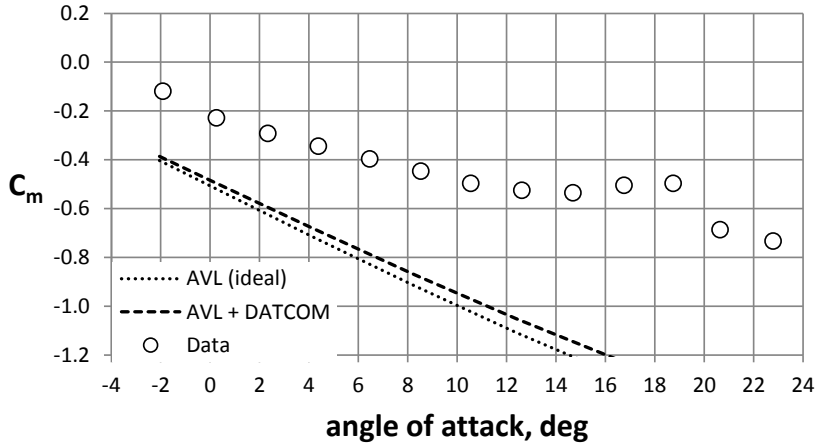
- Actual $C_{L,\max}$ = 2.51
- Predicted $C_{L,\max}$ (Xfoil + empirical $\Delta c_{\ell,\max}$) = 2.41 (-4.0%)

Landing Wing Validation Results

Mach 0.168, $Re_c = 1.37 \times 10^6$







- Actual $C_{L,\max}$ = 2.82
- Predicted $C_{L,\max}$ (Xfoil + empirical $\Delta c_{\ell,\max}$) = 2.77 (-1.8%)

OpenVSP v3.0 Degenerate Geometry

OpenVSP Model

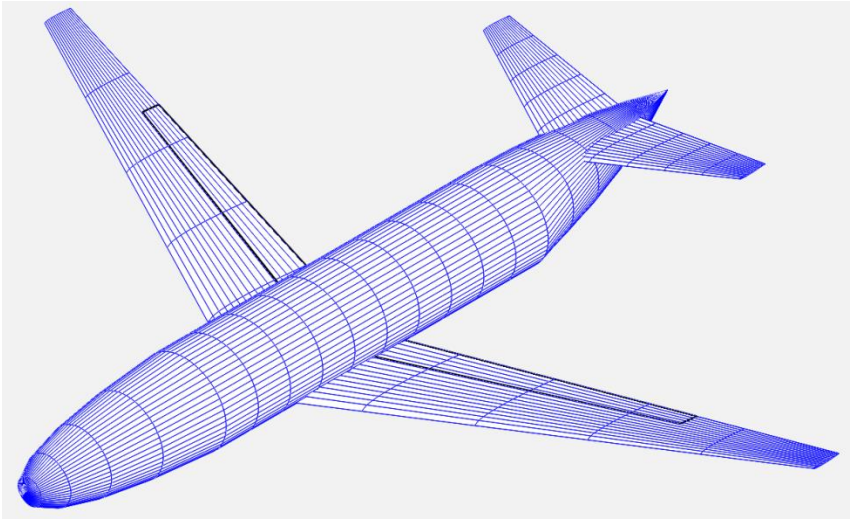
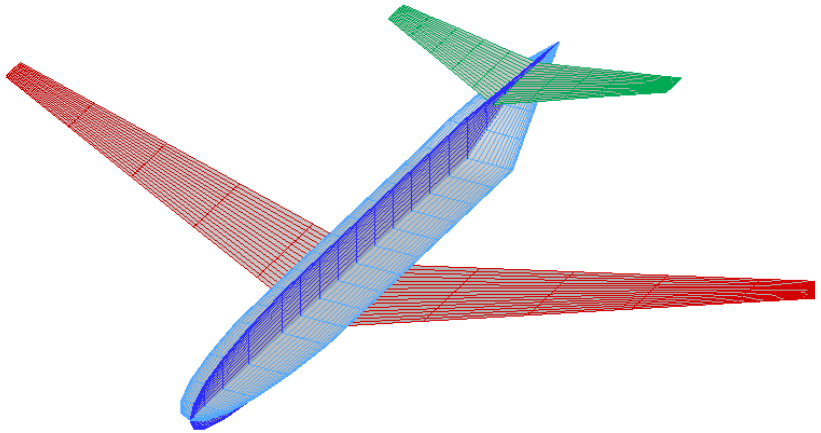


Plate Export

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