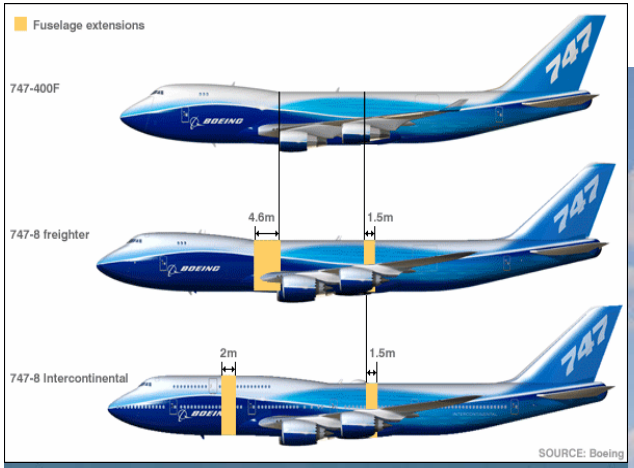
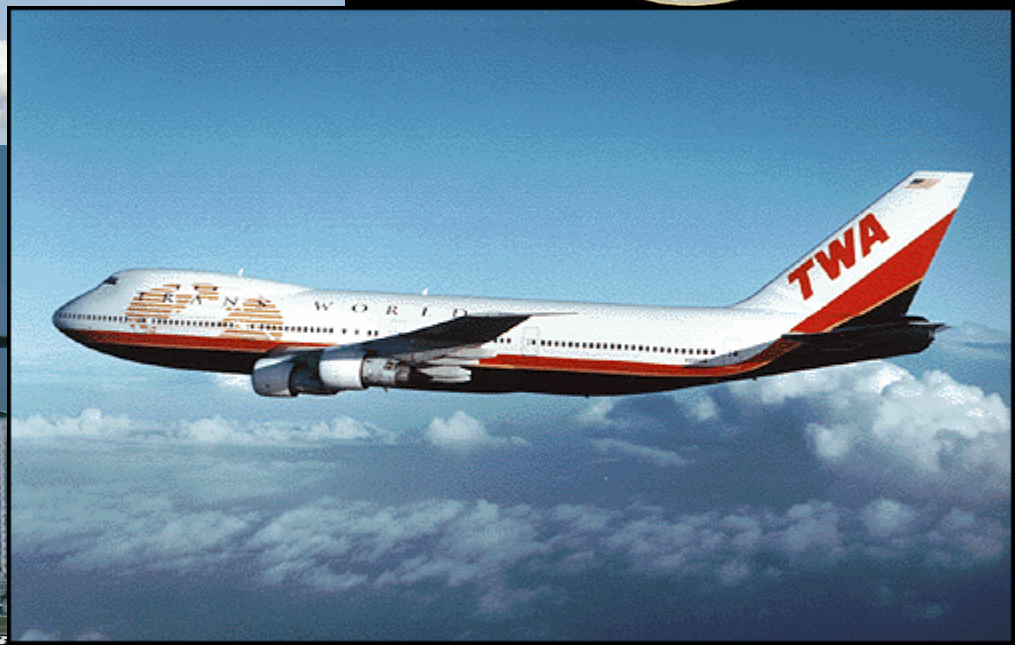
Boeing 747

AOE 4124 Spring 2007

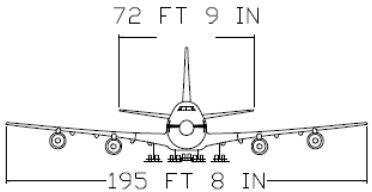
Ken Min, Ryan Plumley, Angela Brooks

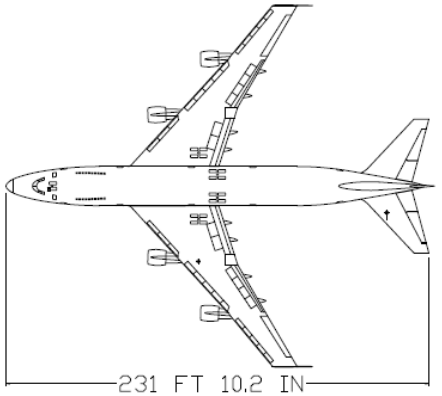


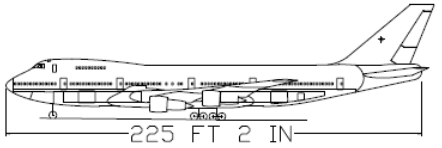


Boeing 747 Specs & Dimensions

Span	195 ft 8 in
Length	231 ft 10.2 in
Height	63 ft 5 in
Cabin Width	20 ft
Cruise	M = 0.84
Cruise Alt.	35,000 ft
TOGW	735,000 lbs
Fuel Cap.	48,445 lbs
Thrust	46,500 lbs P & W JT9D-7A
Range	6,100 miles
Pax	Up to 452







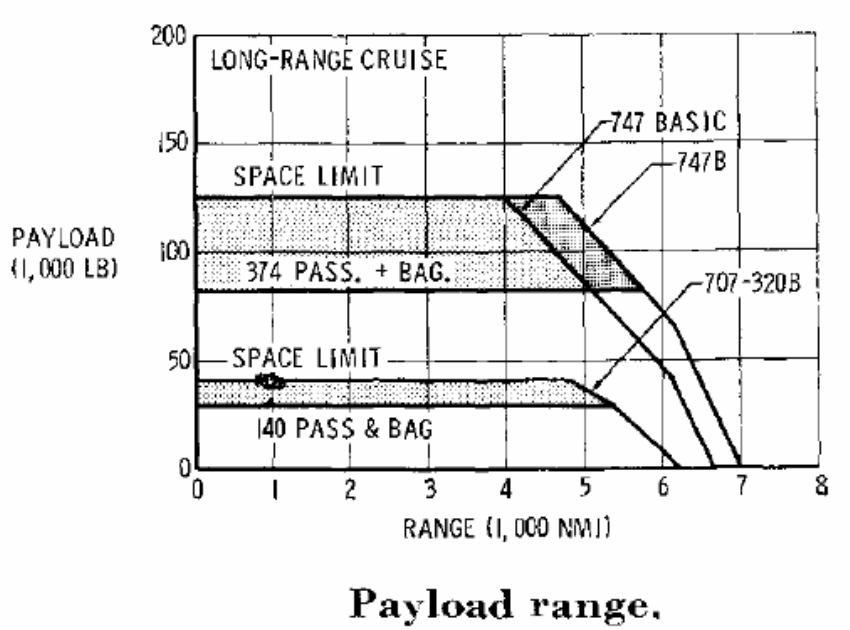
http://www.boeing.com/commercial/747family/pf/pf_classics.html

Engines

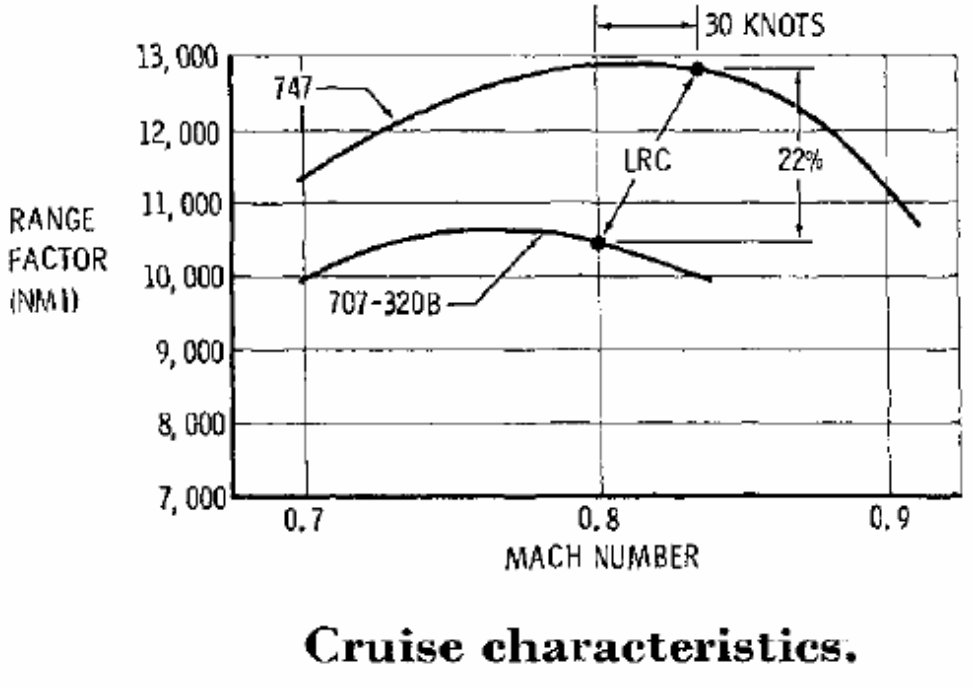
- 4 Pratt & Whitney JT9D
- Turbofan with high bypass ratio (5~8)
- 23% SFC savings at cruise vs. JT3D used on 707-320
- Engines plus better aero allowed for 22% higher range factor and 30 knot faster cruise speed than 707-320

Olason, M.L. *Performance and Economic Design Apsects of the 747 Familiy of Airplanes*. Journal of Aircraft, Vol. 6, No. 6

Engines cont'd



Payload range.



Cruise characteristics.

	Thrust per Engine (lb)
Takeoff	45000
Cruise	10000

JT9D-3 Max Thrust

Olason, M.L. *Performance and Economic Design Apsects of the 747 Familiy of Airplanes*. Journal of Aircraft, Vol. 6, No. 6

Wing Specifications/Geometry for 747-100

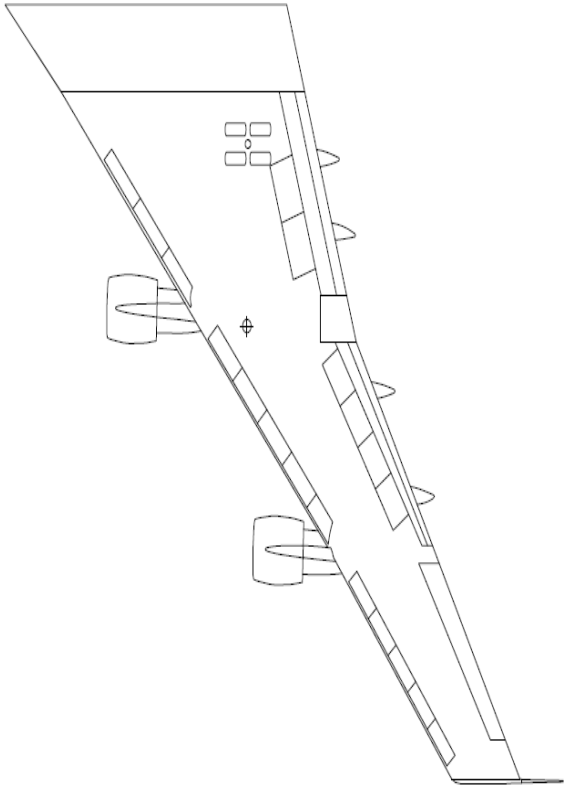
- Area:
  5500 ft^2
- Span:

  195 ft 8 in
- AR:

  6.97
- MAC:
  27.3 ft
- Sweep:

  37°
- Taper Ratio:

  0.30

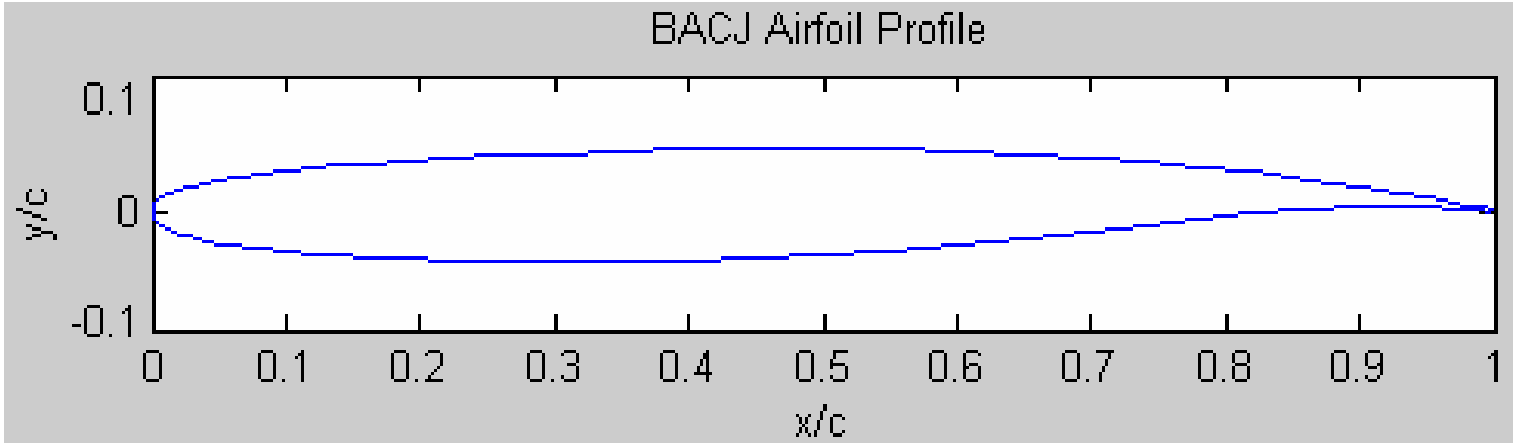


High Lift Devices

- Triple slotted trailing edge flaps
- Krueger style leading edge slats
  - Outboard of inboard nacelles – variable camber and slotted
  - Inboard – standard/unslotted

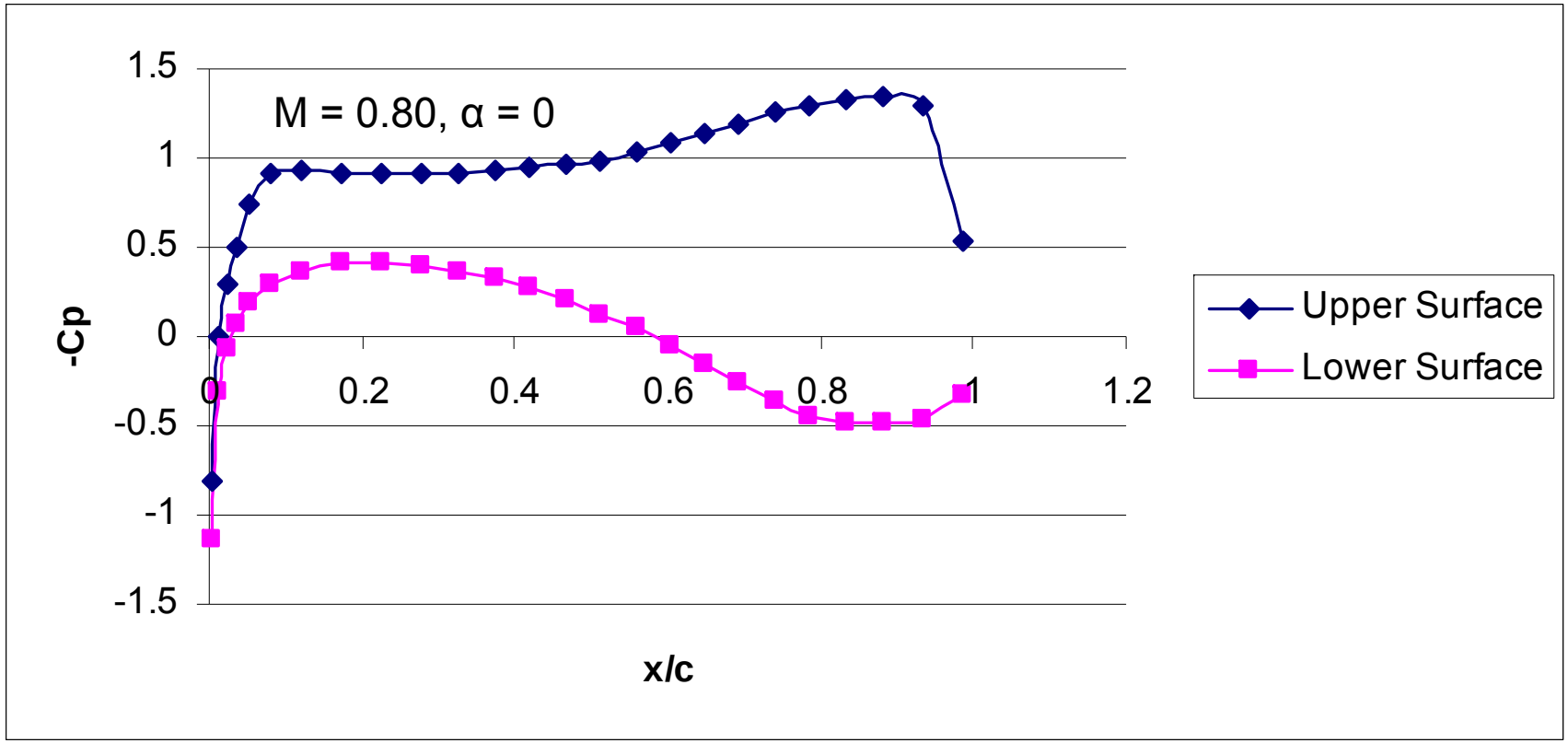
Airfoils

- At the root: BAC 463 ~ BAC 468
- At the tip: BAC 469 ~ BAC 474
- Could not find the coordinates so a ‘similar’ airfoil was used: BACJ, Boeing’s supercritical airfoil

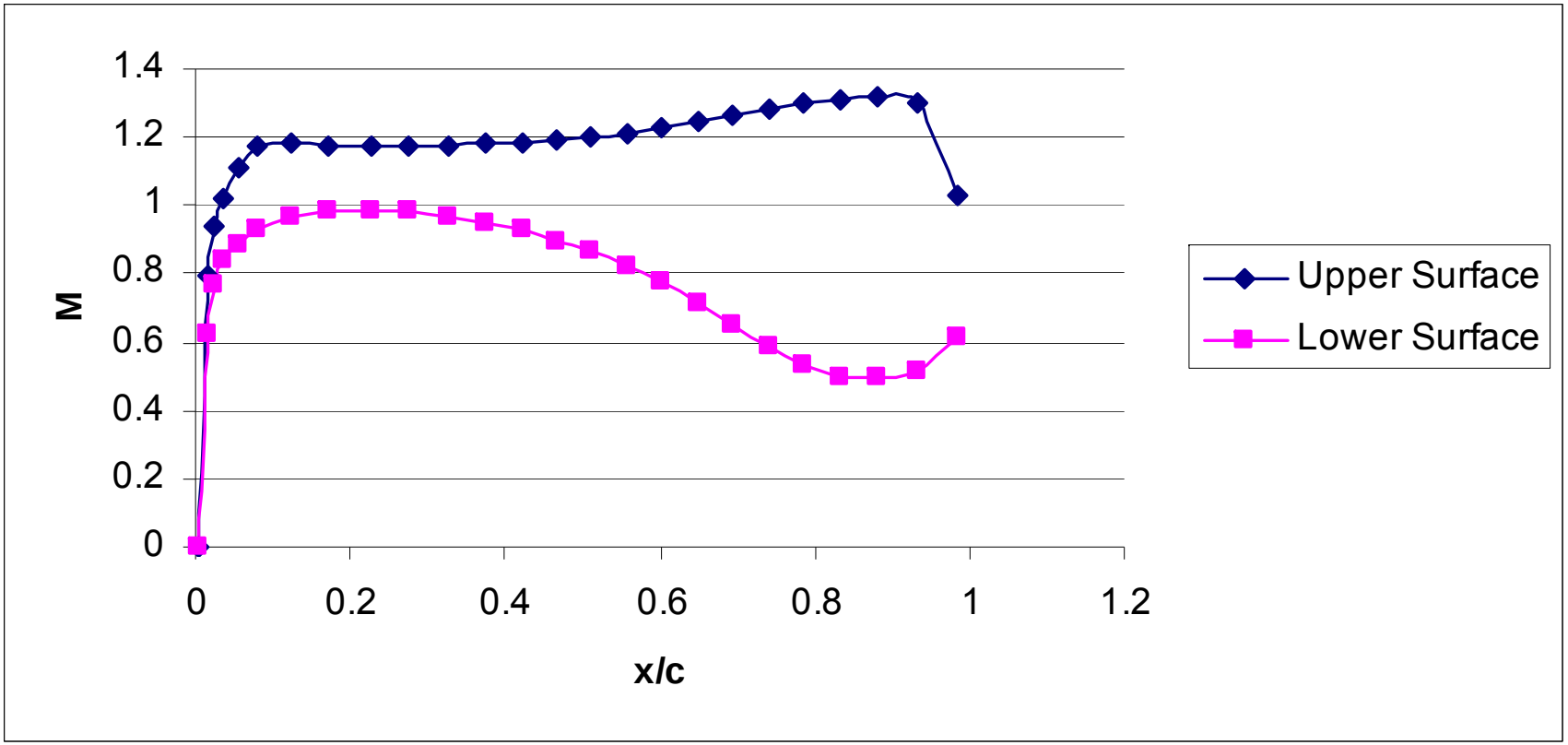


http://www.ae.uiuc.edu/m-selig/ads/aircraft.html

B747 Cp Distribution (TSFOIL)

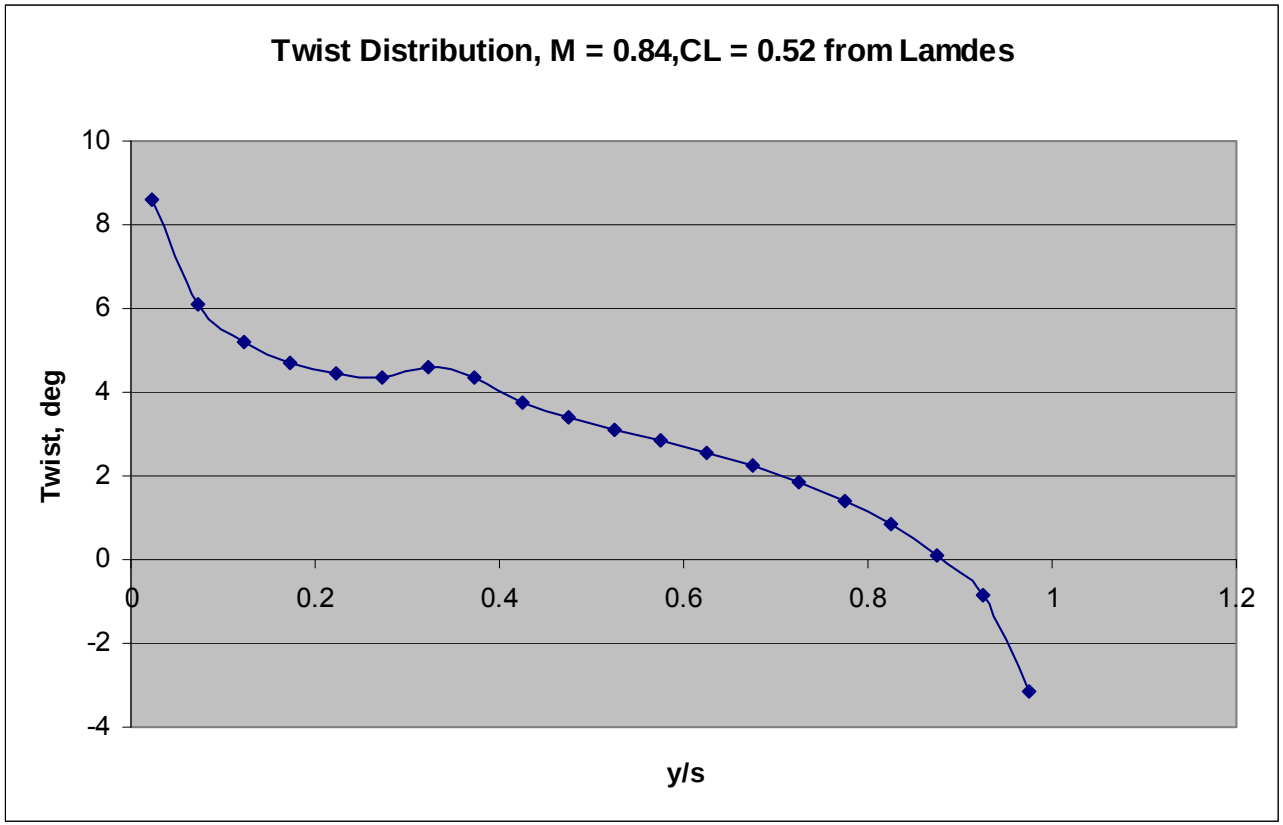


B747 Mach Distribution (TSFOIL)



B747-100 Twist Distribution

- Could not find actual twist distribution
- LAMDES was used to find twist at cruise



Center of Gravity/Static Margin

- CG Range: 13~33 % mac
- Static Margin Range: 5.74~5.886
- Neutral Point Range: 34~54.6% mac
- Using cg at 25% mac-

  static margin: 5.827

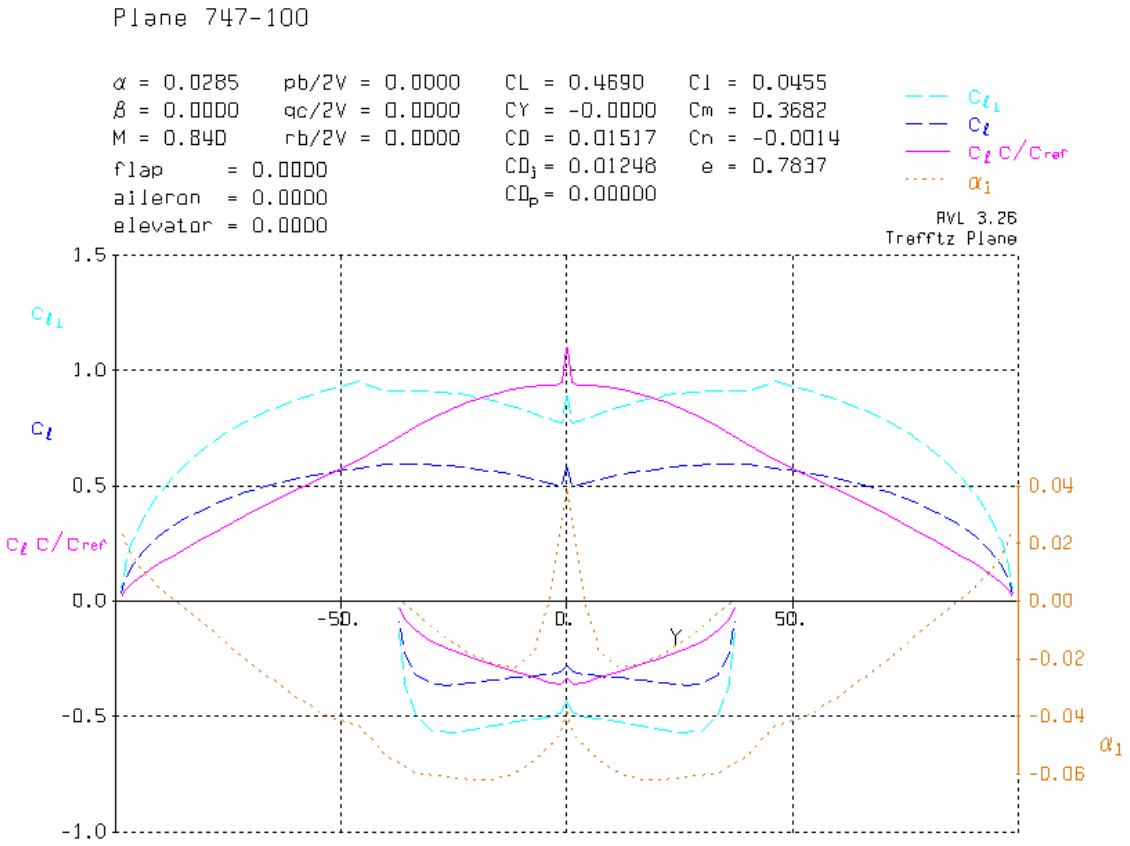
  neutral point: 46.35 % mac

Chai, S. and Mason, W. *Landing Gear Integration in Aircraft Conceptual Design, Ch. 2*. http://www.aoe.vt.edu/~mason/Mason_f/M96SC02.pdf

Roskam, J. *Flight Dynamics and Control, Appendix B*.

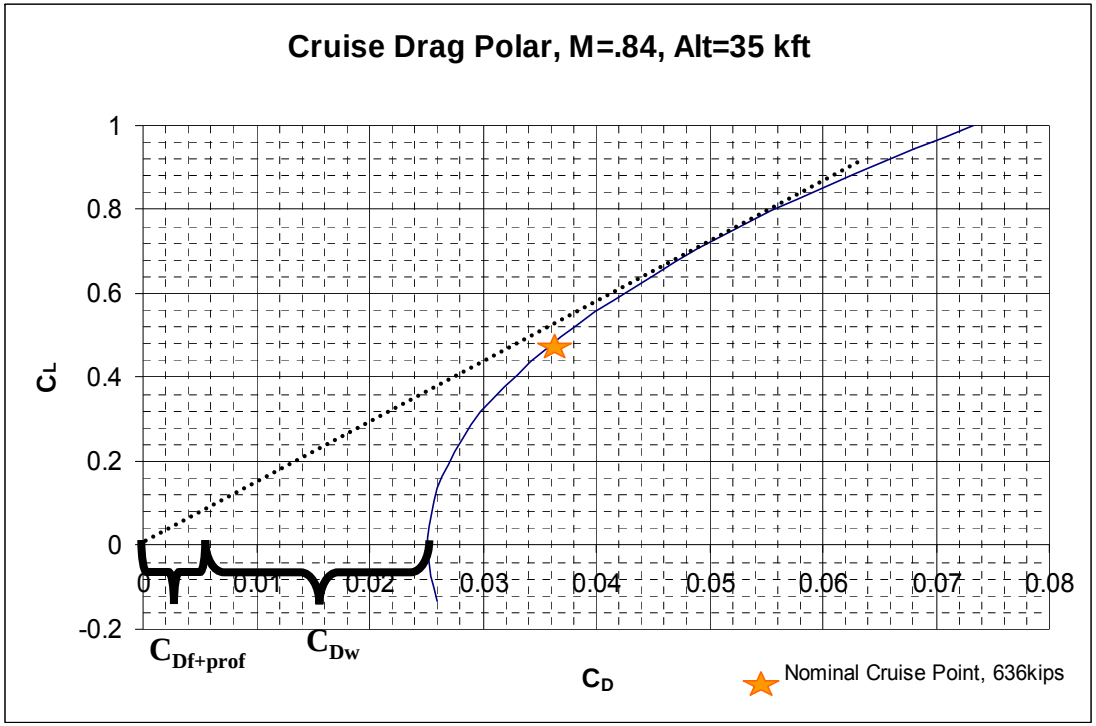
Vehicle Aerodynamic Data

- Cruise Case: M=.84, 35000ft, W=636 klbs
  - C_L=.47
- Landing Case: M=0.198, 0ft, W=564klbs
  - C_L=1.76



Cruise Drag Polar

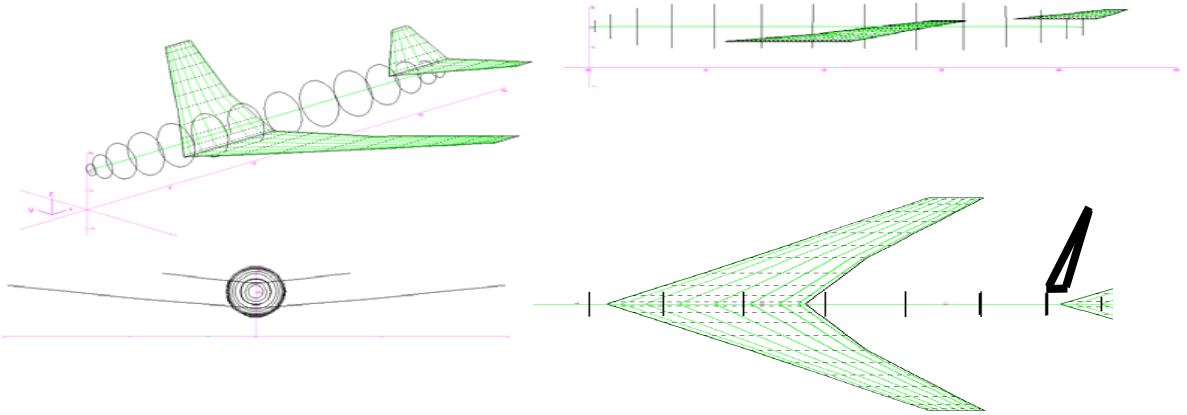
- Calculated
  - e=.95
  - C_{Df}=.0042
  - $C_{D\_Profile}$=.00088
  - L/D_{MAX}=14.4
- Researched*
  - Cruise C_{D_0}=.025
  - C_{DWave}=.020
  - Follows transport design principle



*Roskam, Dr. Jan; Airplane Flight Dyn & Automatic Flight Controls

Trim Case

- Cruise M=.84, Alt=35000, C_L=.469
- Untrimmed
  - C_{D_ind}=.0151
- Trimmed
  - C_{D_ind}=.0158
  - Trim Drag = .0007



747-100 AVL* Output, Elevator Overlay

AVL (Athena Vortex Lattice)
http://web.mit.edu/drela/Public/web/avl/

Revisions to B-747*

- **747-200 - 1971**
  - New engines, higher take-off weight
- **747-300 - 1983**
  - Fuselage plugs for increased capacity
- **747-400 - 1989**
  - Tip extensions and winglets, improved engines, glass cockpit
- **Future: 747-8**
- One-off's
  - 747-LCF, Shuttle Carrier Aircraft, VC-25

*http://en.wikipedia.org/wiki/Boeing_747

References

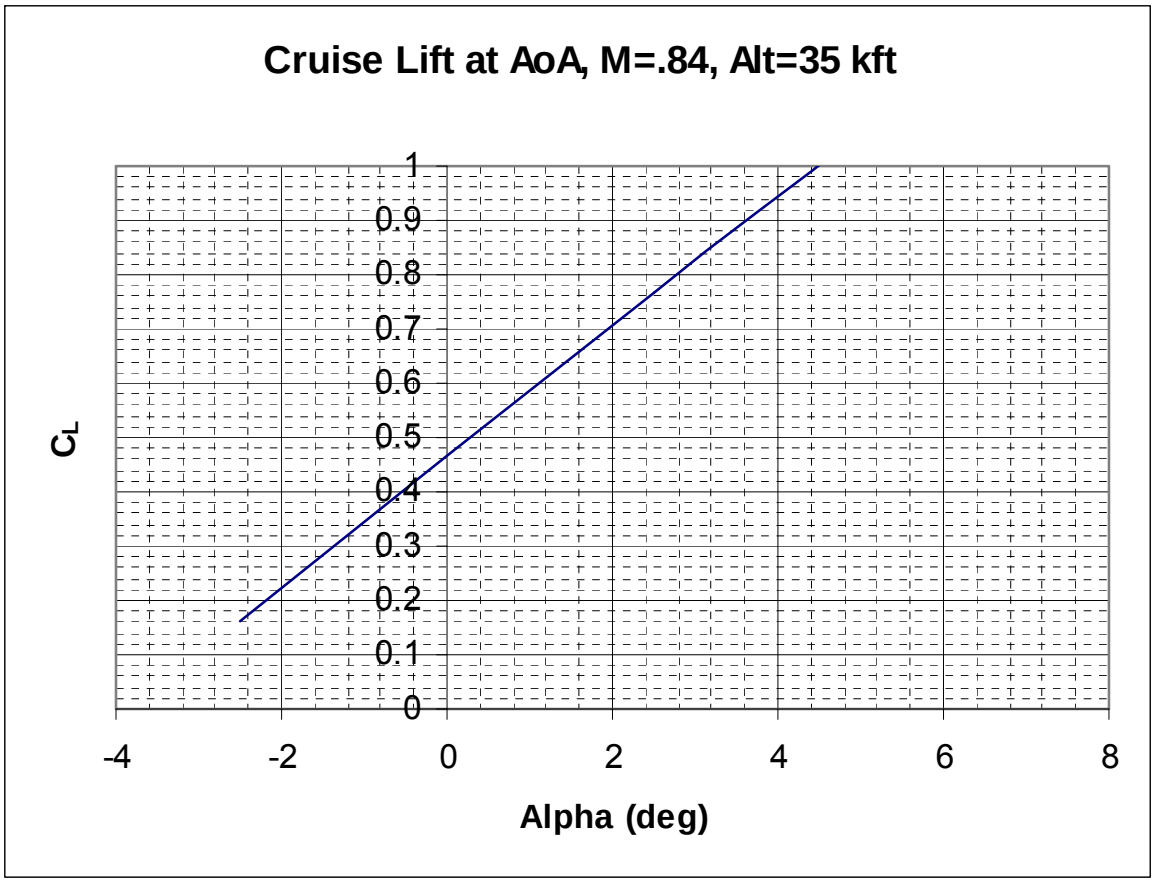
- AVL (Athena Vortex Lattice) Homepage. http://web.mit.edu/drela/Public/web/avl/
- Chai, S. and Mason, W. *Landing Gear Integration in Aircraft Conceptual Design, Ch. 2*. http://www.aoe.vt.edu/~mason/Mason_f/M96SC02.pdf
- NASA CR-2144. 747-100
- Olason, M.L. *Performance and Economic Design Apsects of the 747 Familiy of Airplanes*. Journal of Aircraft, Vol. 6, No. 6
- Roskam, J. *Flight Dynamics and Control, Appendix B*.
- Roskam, Dr. Jan. Airplane Flight Dyn & Automatic Flight Controls. pg 543-549.
- http://www.ae.uiuc.edu/m-selig/ads/aircraft.html
- http://www.boeing.com/commercial/747family/index.html
- http://www.boeing.com/commercial/747family/pf/pf_classics.html
- http://www.centennialofflight.gov/essay/Aerospace/Boeing_747/Aero21.htm
- http://en.wikipedia.org/wiki/Boeing_747

- Pictures

- http://upload.wikimedia.org/wikipedia/commons/d/dc/800pix.jal.b747-400.ja8079.jpg
- http://news.bbc.co.uk/nol/shared/spl/hi/pop_ups/06/technology_jumbo_overhaul/img/6.jpg
- http://www.aerospace-technology.com/projects/747/7474.html

Backup

Cruise C_L vs α



Interesting Facts

- By 1990, the plant could produce a new B747-400 once every six days
- In 1993, the 1000th plane was delivered.
- Boeing used a new method of spotting potential hazards known as "fault tree analysis," where engineers could easily see the impact of a failure of one part or system on other parts. The 747 became the first airplane to use this accurate method of forecasting possible trouble.

http://www.centennialofflight.gov/essay/Aerospace/Boeing_747/Aero21.htm