### Boeing 747 Specs & Dimensions

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
<td>195 ft 8 in</td>
</tr>
<tr>
<td>Length</td>
<td>231 ft 10.2 in</td>
</tr>
<tr>
<td>Height</td>
<td>63 ft 5 in</td>
</tr>
<tr>
<td>Cabin Width</td>
<td>20 ft</td>
</tr>
<tr>
<td>Cruise</td>
<td>M = 0.84</td>
</tr>
<tr>
<td>Cruise Alt.</td>
<td>35,000 ft</td>
</tr>
<tr>
<td>TOGW</td>
<td>735,000 lbs</td>
</tr>
<tr>
<td>Fuel Cap.</td>
<td>48,445 lbs</td>
</tr>
<tr>
<td>Thrust</td>
<td>46,500 lbs P &amp; W JT9D-7A</td>
</tr>
<tr>
<td>Range</td>
<td>6,100 miles</td>
</tr>
<tr>
<td>Pax</td>
<td>Up to 452</td>
</tr>
</tbody>
</table>

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

Engines cont’d

Payload range.

Cruise characteristics.

<table>
<thead>
<tr>
<th>Thrust per Engine (lb)</th>
<th>JT9D-3 Max Thrust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takeoff</td>
<td>45000</td>
</tr>
<tr>
<td>Cruise</td>
<td>10000</td>
</tr>
</tbody>
</table>

Wing Specifications/Geometry for 747-100

- Area: 5500 ft²
- 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)

M = 0.80, $\alpha = 0$
B747 Mach Distribution (TSFOIL)
B747-100 Twist Distribution

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

![Twist Distribution Graph](image)
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:**
  - $M=0.84$, 35000ft,
  - $W=636$ klbs
  - $C_L=0.47$

- **Landing Case:**
  - $M=0.198$, 0ft,
  - $W=564$ klbs
  - $C_L=1.76$
Cruise Drag Polar

- **Calculated**
  - $e = 0.95$
  - $C_{Df} = 0.0042$
  - $C_{D_{Profile}} = 0.00088$
  - $L/D_{MAX} = 14.4$

- **Researched**
  - Cruise $C_{D_{0}} = 0.025$
  - $C_{D_{Wave}} = 0.020$
  - 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

References

• AVL (Athena Vortex Lattice) Homepage.  http://web.mit.edu/drela/Public/web/avl/
• NASA CR-2144. 747-100
• Roskam, J. Flight Dynamics and Control, Appendix B.
• 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 $\alpha$

Cruise Lift at AoA, $M=0.84$, Alt=35 kft
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