

The Airplane of the Next Twenty Years

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Configuration Aerodynamics
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Presentation Overview

- Background Information
 - Evolution of designs
 - Comparison of designs
 - Penalties
 - Other Factors
 - Conclusion
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Background Information

- World traffic will almost double in the next 15 years – and triple in the next twenty years.¹
- This places a pressure on airlines to compensate for demand.

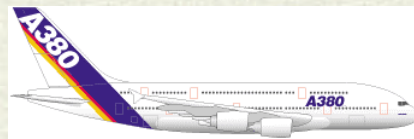
1. Numbers quoted from “Airbus Industrie Globe Market Forecast 1999”

Background Information

- High capacity / Long range class of aircraft makes up about 10% of the market.¹
 - BUT this class accounts for over 25% of the profits of the potential business, totaling over \$319 billion.¹
 - This has caused two major companies to compete for dominance over this market, Boeing and Airbus.
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Background Information

- Boeing plans to launch their solution – the 747X Stretch.
- Airbus plans to launch their solution – the A380-100



Boeing 747X Stretch picture:

<http://www.boeing.com/news/feature/747x/images/k60895.jpg>

Airbus A380-100 picture:

http://www.airbus.com/img/products/I_A380.gif

Evolution of 747X Stretch

- Boeing felt a entirely new airplane design was not worth the investment.
 - Boeing's solution is based on a reengineering of their highly popular 747-400.
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747-400 vs. 747X Stretch

	747-400	747X Stretch	% change
# of Passengers	416	522	25.5
Maximum thrust/engine	63,300	68,000	7.4
Wingspan (ft)	211.4	228.9	8.3
WingArea (ft²)	5,600	6,820	21.8
Wing Sweep	37.5°	37.5°	0.0
Aspect Ratio	7.89	7.68	3.8
Length (ft)	231.8	264.3	14.0
MTOW (lb)	875,000	1,043,000	19.2
Range w/ full payload	7,330	7,785	6.2

Other Changes

- Fuselage was stretched 31.5 ft
- 28% less noise generation
- Added tail skid
- High lift system
 - Single slot flaps as found on 777 instead of triple slot flaps

Evolution of A380-100

- Airbus felt that the market was ready for a new airplane to corner this market.
 - Marketed as the world's first Twin Aisle, Twin Deck aircraft.
 - The A380-100 was based on the design of the A340.
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A380-100 vs. A340-500/600

	A340	A380	% change
# of Passengers	380	555	46.1
Maximum thrust/engine	56,000	74,000	32.1
Wingspan (ft)	208.2	261.8	25.7
WingArea (ft²)	4,729	9,100	92.4
Wing Sweep	31.1	33.5	7.7
Aspect Ratio	9.17	7.53	17.9
Length (ft)	222.1	239.5	7.8
MTOW (lb)	804,700	1,235,000	53.4
Range w/ full payload	7,500	8,150	8.7

Another Contender: 777-200LR

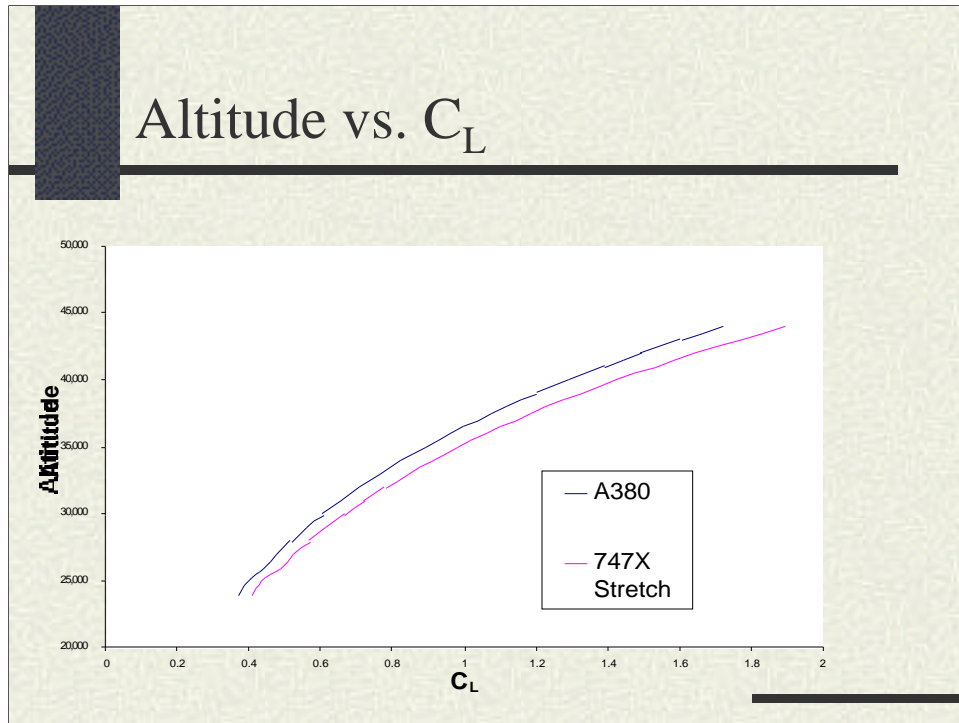
# of Passengers	301
Maximum thrust/engine	55,000
# of engines	2
Wingspan (ft)	212.6
WingArea (ft²)	4,605
Aspect Ratio	9.82
Length (ft)	209.1
MTOW (lb)	752,000
Range w/ full payload	8,860

Disqualified based on seating capacity and two-engine configuration.

A380-100 v.s 747X Stretch

	A380-100	747X Stretch
Wingloading (lb/ft ²)	136	153
Spanloading (lb/ft)	4,717.3	4,557.3
T/W ratio	0.24	0.26
Sweep	33.5°	37.5°
Long range cruise sp.	0.85	0.86
Range w/ full payload	8,150 nm. 116,550 lb	7,785 nm. 109,620 lb

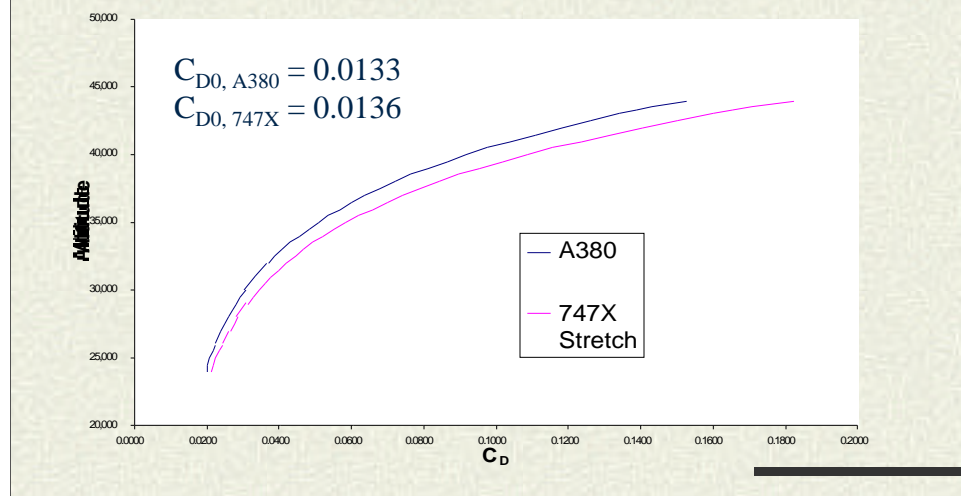
Altitude vs. C_L



Assuming $L/D, \max = 20$, a C_{D0} was then calculated assuming the Oswald Efficiency factor = 0.9. From this C_{D0} value, a C_L is then calculated. Using this C_L value, the pressure at which the $L/D, \max$ can be found. The pressure is then related to altitude ($p = \text{density} \cdot \text{gravity} \cdot \text{altitude}$). C_L 's and C_D are then calculated over a range of altitudes.

As can be seen, the A380 works at higher C_L 's and C_D 's than the 747X Stretch.

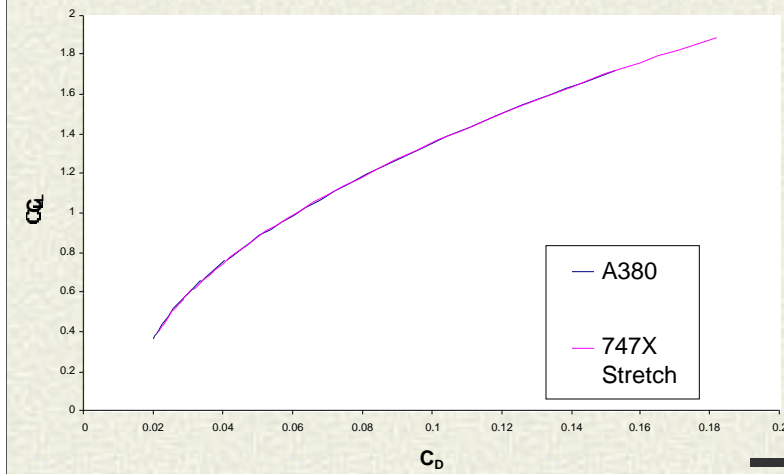
Altitude vs. C_D



Assumed L/D , max = 20

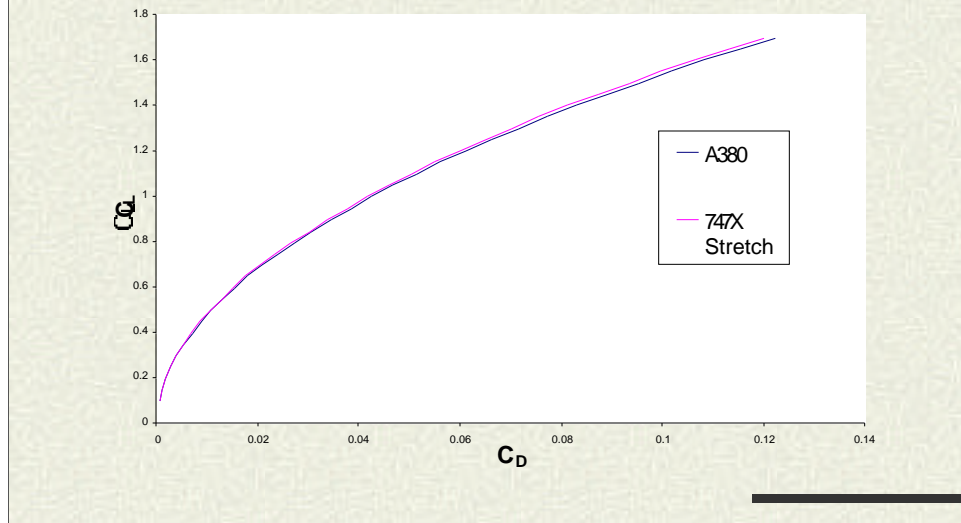
$E = 0.9$

Drag Polar



Combining both C_L and C_D plots versus altitude, a drag polar is created for both airplanes, showing similar performance. (Note: This is due to a similar L/D_{max} assumption for both aircrafts.)

Drag Polar Assuming 100% LES



$C_{D,I} = C_L / (\pi * AR)$ for 100% Leading Edge Suction

This result agrees with the previous plot.

The 80 meter Gate box

- A constraint placed on airplane wingspans, by the airport, to stay below 80 meters or 262 ft.

Penalties due to Gate box

	A380-100	747X Stretch
Aspect ratio	7.53 (old)	7.68 (old)
	9.17 (new)	7.98 (new)
Wingspan (ft)	261.8 (old)	228.9(old)
	288.9 (new)	233.3(new)
Spanloading (lb/ft)	4,717.3 (old)	4,557.3 (old)
	4,275.2 (new)	4,470.9 (new)
% reduction in drag up to	19.9	3.7

Drag comparison made during cruise and approach

Other Factors to Consider

- Takeoff Distance
 - A380-100 : <11,000 ft
 - 747X Stretch : 11,000 ft
- Passenger Comfort
- Economics
- Possible Derivatives
- Reputation

Passenger Comfort:

There has been a rather large surge in the ideas of passenger comfort in the airline industry. American Airlines has even gone as far as removing seats from all of its domestic flights in order to offer more leg room.² In this section of the market, non-stop 18 hours flights are the norm and passenger comfort becomes an extremely important idea. Airbus has designed the A380 with this particular notion in mind, and various major airlines have realized this.³

Economics:

Within the last two years, Boeing list prices have jumped almost 11%, meanwhile in order to get their new design out in the marketplace, Airbus has heavily discounted their own A380 to the point where it is more expensive to buy a version of the 747 now, then to secure an A380.⁴ With Boeing's list prices growing every year, they are no longer in a position to offer incentives in the market comparable to Airbus, thereby losing potential business.

On the other hand, a conservative view of the marketplace finds that Airbus just may corner the market with the A380 but never truly return a profit, which in the long run is bad business.⁵

Possible Derivatives:

Due to the low wingloading seen on the A380, it suggests that is the beginning of a new family or breed of airplane that can be tailored in the future to meet certain specific needs that could arise in this market. The relatively high wingloading seen on the 747X Stretch indicates that it is possibly near the end

Conclusion

- Though the A380-100 is a risky venture, it will pay itself off in the future.
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References

<http://www.boeing.com>

<http://www.airbus.com>

<http://aeroworldnet.com>

<http://www.air-transport.org>

<http://www.aviationNow.com>
