# A Shadow Critical Project Appraisal: The A380 Program

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# Executive Overview

The Shadow Critical Project Appraisal (CPA) indicates that projected revenues from the A380 project will not cover its projected total costs. In fact, the original (2002) analysis shows that over the period 2006-2025, inclusive, the program produces net negative cash flow of $8,143,000,000. The prospects are not better now (June 2004) since the number of A380s sold below cost has more than doubled.

Because the 1992 Agreement prescribes that a program receiving state aid be considered over a period of 17 years beginning when government direct support is first received (assumed to be 2001), it is noteworthy that at the end of 2017, the A380 program, as reflected in the CPA, shows a cumulative negative cash flow of $6,912,600,000. (As of 2004, given the increased sales of launch-priced A380s and the higher unit production cost of the A380, cumulative negative cash flow has also grown.)

The Shadow CPA is prepared as if it had been produced by Airbus in January, 2001. This date was chosen to correspond with the official program launch of the A380 and the assumed formal commencement of development support from EU member states. At this point such an analysis is required by the 1992 Bilateral Agreement. The 1992 Agreement also requires that the CPA be based upon “conservative assumptions”, more so than the Shadow CPA reflects. This suggests that the Shadow CPA is more favorable to the A380 program than perhaps a CPA actually drawn up by Airbus or EADS at that time would have been.

There is also recognition that developments subsequent to January, 2001 affect the A380 program in unfavorable ways. These include the acceleration of long-distance market fragmentation, including point-to-point flying, the rapid growth in intercontinental travel using executive jets (in both scheduled common-carrier service and traditional “corporate” flying), the need for ubiquitous investment in airport improvements to accommodate the A380, and the imperative to reduce A380 airframe weight, often requiring expensive materials. Again, because the Shadow CPA has been prepared as though it had been written in January, 2001, none of these factors is considered.

The Shadow CPA estimates the demand for the A380, both passenger and freight versions, over the first 20 years of deliveries. In January, 2001, Airbus could reasonably have projected 496 A380 deliveries over the first 20 years. (The study team itself holds the view that a more realistic expectation is about 350 A380 deliveries.) To the present, A380s have been sold at unit prices in the $130,000,000 to $145,000,000 range. This compares with the estimate (for the 100th production aircraft) that, as of June 2004, the passenger A380 will cost $199,700,000 (in 2001 dollars) and the freighter version $208,000,000 to produce. These costs do not reflect Airbus' obligation to repay direct development state aid of at least $2,200,000 over the aircraft delivered through 2017. Meeting this obligation only makes the A380 program an even greater burden for Airbus and EADS.

# A “Shadow” Critical Project Appraisal: The A380 Program

# Supplemental Preface

The study being updated was completed just over two years ago, in March, 2002.  It was not released at that time for reasons not shared with the study team.  In any case, it is now being made available to all interested in understanding a particularly important – and critical – aspect of the present and future civil air transport industry.

The update supports the original position that the assumptions underlying the "Shadow" Critical Project Appraisal (CPA) of 2002 (written as of 2001) were favorable to Airbus. As of now, the key factors, such as market size, development cost and cost of production have made the original "Shadow" CPA conclusions even more favorable to Airbus than before. Projected market size for the A380 has not increased and may be smaller and the costs of development and production have increased. Detailed explanations are provided in updates to the respective appendices.

As explained in the original preface, by the very nature of the report, an "executive summary" was not practical.  To realize full value from the report, it is necessary to consider the entire document.  It will be found a worthwhile commitment of your time.

# Section I: Preface

Under the terms of a 1992 agreement between the United States and the European Union, in order to qualify for "state aid" it is necessary to produce a "critical project appraisal" which forecasts the project's economic and financial viability. The "ground rules" for the requisite critical project appraisal are set out in the inter-governmental agreement:

> " Governments shall provide support for the development of a new large civil aircraft programme only where a critical project appraisal, based on conservative assumptions, has established that there is a reasonable expectation of recoupment, within 17 years from the date of first disbursement of such support, of all costs as defined in Article 6(2) of the Aircraft Agreement, including repayment of government supports on the terms and conditions specified . . ."

As far as is known, no critical project appraisal has been produced covering the A380 program. It clearly was a responsibility for Airbus (or EADS, it's 80% owner) to do so as a condition precedent to qualifying for public support of this program. Absent even a claim that a critical project appraisal was produced prior to receipt of the first state aid for the A380, it was decided to develop one—a "shadow" critical project appraisal.

Underlying any endeavor that focuses on the future are forecasts and expectations about all the factors impinging on that future. Some are explicit, others implicit. In context of the A380 (or any aircraft program), it all comes together in the projections of aircraft deliveries and costs (including payback of any state aid in a program subject to the disciplines of the EU-US agreement).

It follows that any analysis like a critical project appraisal cannot be fully appreciated without reference to substantially a full range of reasonable assumptions about, say, costs and deliveries. So it is necessary to consult the appendices to this report, not just the "shadow" critical project appraisal itself, to understand fully the bases of the conclusions that can be drawn.

As a consequence, the shadow critical project appraisal has one feature that would not be found in any such document prepared by Airbus: it has footnotes referring the reader to specific appendices which, as noted, are an integral part of this report.

Most appendices have tables reflecting alternative expectations. These should be considered so that choices are made which accord with the interests and concerns of the reader.

Financial resources for this study were provided by the Boeing Company in response to a proposal from the study team. At no time was Boeing consulted about the approach to be taken or informed as to progress being made or possible conclusions. Nor was any non-public data or information offered by Boeing or sought by the study team from Boeing. The final "product" is solely the responsibility of the study team.

The shadow critical project appraisal is <u>not</u> an executive summary of the report. No such summary is possible given the nature of the study. Perhaps this places an unprecedented burden upon the reader to consider the work in its entirety in order to draw the conclusions relevant to his particular interests, but that is the nature of this beast.

# Section II: A "Shadow" Critical Project Appraisal: The A380 Program

## II.1: Introduction

[What follows is a "critical project appraisal" (CPA), as if prepared by Airbus, as of January 2001, and as required by the agreement between the European Union (EU) and the United States (US) to enable Airbus to qualify for "state aid" for the A380 program.]

The CPA begins with an estimate of the demand for the A380, including both passenger and freight versions, as reflected in deliveries over the first 20 years, i.e., 2006-2025, inclusive. It is followed by projections of the unit costs of producing such aircraft and the revenues they will bring to Airbus.

Finally, costs and prices (revenues) are integrated to produce net returns (which need to be positive to unlock state aid for the A380 program).

## II.2: A Word About Method

Throughout the CPA it is assumed that, to the extent there is any inflation, it will effect the cost and revenue streams identically. Therefore, all cost and revenue projections are directly comparable. Put another way, all costs and prices are on a 2001 basis.

## II.3: A380 Delivery Projection

**Exhibit CPA-1**
**A380 Deliveries: 2006-2025**

| Year | Passenger | Freighter | Total |
|---|---|---|---|
| 2006 | 13 | 1 | 14 |
| 2007 | 12 | 1 | 13 |
| 2008 | 14 | 1 | 15 |
| 2009 | 14 | 1 | 15 |
| 2010 | 14 | 1 | 15 |
| 2011 | 15 | 1 | 16 |
| 2012 | 16 | 2 | 18 |
| 2013 | 18 | 2 | 20 |
| 2014 | 21 | 2 | 23 |
| 2015 | 24 | 2 | 26 |
| 2016 | 25 | 2 | 27 |
| 2017 | 27 | 3 | 30 |
| 2018 | 28 | 3 | 31 |
| 2019 | 26 | 3 | 29 |
| 2020 | 25 | 2 | 27 |
| 2021 | 27 | 3 | 30 |
| 2022 | 31 | 3 | 34 |
| 2023 | 35 | 3 | 38 |
| 2024 | 36 | 4 | 40 |
| 2025 | 32 | 3 | 35 |
| Total | 453 | 43 | 496 |

*Source: Appendix 3, Exhibit 3-25c*

The anticipated pattern of A380 aircraft deliveries from 2006 through 2025 is provided in Exhibit CPA-1. Over the 20-year span, 496 A380's will be delivered, of which 43 will be freighters.

The time pattern of these deliveries is of considerable importance in assessing the economic prospects of the A380 for several reasons. First, as will be discussed below, the prices realized will vary (rise) over time with lower prices being realized from "launch customer" sales than from subsequent deliveries. Second, "state aid" repayments are derived from the sale of each aircraft and interest on such state aid runs from the time such aid is first provided. Given that state aid is limited to support for development of the A380 and not for aircraft production, it is heavily front-ended. This, in turn, means that each aircraft from the initial delivery bears a significant cost related to the state aid received and to the interest accrued thereon.

## II.4: Prices and Revenues

The price charged to launch customers for the passenger version of the A380 is $144,000,000. The freighter brings $150,000,000. Fifty passenger aircraft will be delivered to launch customers at the price shown above as well as ten freighters. These represent discounts of 40 per cent (40%) from “catalog” prices for the A380 of $240,000,000 and $250,000,000 for passenger and freighter aircraft, respectively.

**Exhibit CPA-2**
**A380 Aircraft Revenues Assuming No Progress Payments: 2006-2025 ($ Millions)**

| Year | Passenger | Freighter | Total |
|---|---|---|---|
| 2006 | $ 1,872 | $ 150 | $ 2,022 |
| 2007 | 1,728 | 150 | 1,878 |
| 2008 | 2,016 | 150 | 2,166 |
| 2009 | 2,088 | 150 | 2,238 |
| 2010 | 2,352 | 150 | 2,502 |
| 2011 | 2,520 | 150 | 2,670 |
| 2012 | 2,688 | 300 | 2,988 |
| 2013 | 3,408 | 300 | 3,708 |
| 2014 | 4,032 | 350 | 4,382 |
| 2015 | 4,608 | 350 | 4,958 |
| 2016 | 4,800 | 350 | 5,150 |
| 2017 | 5,184 | 525 | 5,709 |
| 2018 | 5,376 | 575 | 5,951 |
| 2019 | 4,992 | 600 | 5,592 |
| 2020 | 4,800 | 400 | 5,200 |
| 2021 | 5,184 | 600 | 5,784 |
| 2022 | 5,952 | 600 | 6,552 |
| 2023 | 6,720 | 600 | 7,320 |
| 2024 | 6,912 | 800 | 7,712 |
| 2025 | 6,144 | 600 | 6,744 |
| Total | $ 83,376 | $ 7,850 | $ 91,226 |

*Source: Appendix 3, Exhibit 3-25c*

Beyond these early deliveries, for the next 60 aircraft (50 passenger and ten freighters), prices will be $168,000,000 and $175,000,000, respectively. Thereafter, A380s will be sold at an average discount from catalog of 20 per cent (20%). This results in prices of $192,000,000 and $200,000,000. Exhibit CPA-2 reflects the aircraft sales revenues assuming that all funds are received for each aircraft as it is delivered.

But this is not, in fact, the case. There will be progress payments. It is expected that, on average, an initial payment of ten per cent (10%) of the purchase price is paid when a firm order is placed or three years before delivery, whichever is later, with an additional 25 per cent (25%) paid in equal annual amounts in each of the years before delivery and the balance of 65 per cent (65%) paid on delivery. It is further assumed that, on average, the time between the placement of an order and delivery will be two years. Exhibit CPA-3 reflects Airbus receipts from A380 aircraft sales between 2001 and 2025 inclusive—the aircraft that will be delivered in the first 20 years of production, 2006-2025 inclusive.

The delivery of each A380 will trigger the purchase of parts and services of $20,000,000. Of this,

## Exhibit CPA-3
## A380 Revenues Assuming Progress Payments: 2006-2025 ($ Millions)

| Year | Passenger | Freighter | Total |
|---|---|---|---|
| 2004 | $ 421.2 | $ 33.8 | $ 455.0 |
| 2005 | 622.8 | 52.5 | 675.3 |
| 2006 | 1,886.4 | 150.0 | 2,036.4 |
| 2007 | 1,845.0 | 150.0 | 1,995.0 |
| 2008 | 2,100.6 | 150.0 | 2,250.6 |
| 2009 | 2,218.2 | 150.0 | 2,368.2 |
| 2010 | 2,448.6 | 183.8 | 2,632.4 |
| 2011 | 2,740.8 | 202.5 | 2,943.3 |
| 2012 | 3,080.4 | 311.3 | 3,391.7 |
| 2013 | 3,756.0 | 317.5 | 4,073.5 |
| 2014 | 4,276.8 | 350.0 | 4,626.8 |
| 2015 | 4,761.6 | 389.4 | 5,151.0 |
| 2016 | 4,977.6 | 422.5 | 5,400.1 |
| 2017 | 5,164.8 | 548.1 | 5,712.9 |
| 2018 | 5,198.4 | 538.8 | 5,737.2 |
| 2019 | 5,011.2 | 575.0 | 5,586.2 |
| 2020 | 5,107.2 | 470.0 | 5,577.2 |
| 2021 | 5,625.6 | 600.0 | 6,225.6 |
| 2022 | 6,264.0 | 645.0 | 6,909.0 |
| 2023 | 6,614.4 | 625.0 | 7,239.4 |
| 2024 | 5,260.8 | 595.0 | 5,855.8 |
| 2025 | 3,993.6 | 390.0 | 4,383.6 |
| Total | $ 83,376.0 | $ 7,850.0 | $ 91,226.0 |

$15,000,000 will be supplied by or through Airbus and will consist of spare airframe parts, training, etc. Airbus gross margin on this business is 67%. Thus, $10,000,000 in net revenue is realized per delivered aircraft. It is assumed that no other airframe spares and services are required in the first three years an aircraft is in service. Thereafter, from years four through ten inclusive, an average $1,500,000 in such parts and services will be required and thereafter $3,000,000 will be sold for each aircraft annually. Exhibit CPA-4 reflects the gross revenues generated by A380 deliveries of 496 aircraft over the 20-year span from 2006 through 2025. Exhibit CPA-5 provides the revenue stream from the sale of A380 parts, training and other services.

## Exhibit CPA-4
## Parts, Training, and Gross Ancillary Revenues: ($ Millions)

| Year | Revenue - Passenger | Revenue - Freighter | Total |
|---|---|---|---|
| 2006 | $ 195.0 | $ 15.0 | $ 210.0 |
| 2007 | 180.0 | 15.0 | 195.0 |
| 2008 | 210.0 | 15.0 | 225.0 |
| 2009 | 231.0 | 16.5 | 247.5 |
| 2010 | 252.0 | 18.0 | 270.0 |
| 2011 | 289.5 | 19.5 | 309.0 |
| 2012 | 328.5 | 37.5 | 366.0 |
| 2013 | 385.5 | 37.5 | 423.0 |
| 2014 | 462.0 | 43.5 | 505.5 |
| 2015 | 543.0 | 46.5 | 589.5 |
| 2016 | 616.5 | 51.0 | 667.5 |
| 2017 | 708.0 | 72.0 | 780.0 |
| 2018 | 787.5 | 78.0 | 865.5 |
| 2019 | 820.5 | 85.5 | 906.0 |
| 2020 | 870.0 | 73.5 | 943.5 |
| 2021 | 972.0 | 99.0 | 1,071.0 |
| 2022 | 1,114.5 | 106.5 | 1,221.0 |
| 2023 | 1,264.5 | 114.0 | 1,378.5 |
| 2024 | 1,374.0 | 139.5 | 1,513.5 |
| 2025 | 1,404.0 | 133.5 | 1,537.5 |
| Total | $ 13,008.0 | $ 1,216.5 | $ 14,224.5 |

## Exhibit CPA-5
## Net Revenues From Parts, Training, etc.:
## ($ Millions)

| Year | Ancillary Revenues | Associated Costs* | Net Revenue |
|---|---|---|---|
| 2006 | $ 210.0 | $ 70.0 | $ 140.0 |
| 2007 | 195.0 | 65.0 | 130.0 |
| 2008 | 225.0 | 75.0 | 150.0 |
| 2009 | 247.5 | 82.5 | 165.0 |
| 2010 | 270.0 | 90.0 | 180.0 |
| 2011 | 309.0 | 103.0 | 206.0 |
| 2012 | 366.0 | 122.0 | 244.0 |
| 2013 | 423.0 | 139.0 | 284.0 |
| 2014 | 505.5 | 168.5 | 337.0 |
| 2015 | 589.5 | 196.5 | 393.0 |
| 2016 | 667.5 | 222.5 | 445.0 |
| 2017 | 780.0 | 260.0 | 520.0 |
| 2018 | 865.5 | 288.5 | 577.0 |
| 2019 | 906.0 | 302.0 | 604.0 |
| 2020 | 943.5 | 314.5 | 629.0 |
| 2021 | 1,071.0 | 357.0 | 714.0 |
| 2022 | 1,221.0 | 407.0 | 814.0 |
| 2023 | 1,378.5 | 459.5 | 919.0 |
| 2024 | 1,513.5 | 504.5 | 1,009.0 |
| 2025 | 1,537.5 | 512.5 | 1,025.0 |
| Total | $ 14,224.5 | $ 4,739.5 | $ 9,485.0 |

* *Assumes 67% profit margin*

Exhibit CPA-6 reflects an amalgam of all A380 program revenues through 2025. It is consistent with the constant 2001-dollar assumption discussed above.

## Exhibit CPA-6
## Summation of All A380 Program Revenues:
## ($ Millions)

| Year | Aircraft Sales | Net Ancillary Revenue | Total Revenue |
|---|---|---|---|
| 2004 | $ 455.0 | $ 0.0 | $ 455.0 |
| 2005 | 675.3 | 0.0 | 675.3 |
| 2006 | 2,036.4 | 140.0 | 2,176.4 |
| 2007 | 1,995.0 | 130.0 | 2,125.0 |
| 2008 | 2,250.6 | 150.0 | 2,400.6 |
| 2009 | 2,368.2 | 165.0 | 2,533.2 |
| 2010 | 2,632.4 | 180.0 | 2,812.4 |
| 2011 | 2,943.3 | 206.0 | 3,149.3 |
| 2012 | 3,391.7 | 244.0 | 3,635.7 |
| 2013 | 4,073.5 | 284.0 | 4,357.5 |
| 2014 | 4,626.8 | 337.0 | 4,963.8 |
| 2015 | 5,151.0 | 393.0 | 5,544.0 |
| 2016 | 5,400.1 | 445.0 | 5,845.1 |
| 2017 | 5,712.9 | 520.0 | 6,232.9 |
| 2018 | 5,737.2 | 577.0 | 6,314.2 |
| 2019 | 5,586.2 | 604.0 | 6,190.2 |
| 2020 | 5,577.2 | 629.0 | 6,206.2 |
| 2021 | 6,225.6 | 714.0 | 6,939.6 |
| 2022 | 6,909.0 | 814.0 | 7,723.0 |
| 2023 | 7,239.4 | 919.0 | 8,158.4 |
| 2024 | 5,855.8 | 1,009.0 | 6,864.8 |
| 2025 | 4,383.6 | 1,025.0 | 5,408.6 |
| Total | $ 91,226.0 | $ 9,485.0 | $ 100,711.0 |

## II.5: Costs

In 2001 dollars, each A380 delivered for passenger service will cost $194,900,000 to produce, net of buyer-furnished equipment (BFE). Each freighter will require $201,900,000. These are average costs with overhead included. However, they do not reflect any apportionment of development costs, whether covered by state aid or not. State aid for the A380 program is to be $2,200,000,000. This reflects one-third of the development costs borne by Airbus of the $10,700,000,000 total development investment required, of which $4,100,000,000 will be provided by risk-sharing partners. Under the EU-US agreement of 1992, state aid is to be paid back over 17 years from the first receipt of such support. In the case of the A380 program, state aid will first be provided in 2001. Therefore, aircraft delivered through 2017 will bear the burden of paying back the state aid.

Such public support requires that interest be applied. The formula is that 75 per cent (75%) of the funds will bear four per cent interest (4%) and the remaining 25 per cent, five per cent (5%). A blended rate of four-and-one-quarter per cent (4.25%) is used in Exhibit CPA-7b which is based upon the deliveries reflected in Exhibit CPA-1 between 2006 and 2017 inclusive, 232 aircraft.

Given state aid of $2,200,000,000, each of the first 232 aircraft bears a burden of $9,482,759 without interest. Expecting state aid to be disbursed in equal amounts in 2001, 2002, and 2003, applying a four-and-one-quarter (4.25%) rate of interest to unpaid balances, provides the total burden of state aid repayment for each set of annual deliveries. This is also shown in Exhibit CPA-7b. In addition, Exhibit CPA-7c displays the amortization of the development costs provided directly by Airbus.

## II.6: Relating Costs and Revenues

Exhibit CPA-6 summarized the revenues received by Airbus from the sale of A380s and related parts and services for each year from 2001 (when development aid is first received) through 2025 (the 20th year of deliveries).

Exhibit CPA-8 indicates the costs incurred by Airbus in producing the 496 aircraft to be delivered between 2006 and 2025 inclusive. As previously noted, these are production costs including overhead, but do not include recovery of development costs incurred by Airbus, or its suppliers, or through state aid provided to Airbus under the 1992 EU-US agreement.

## Exhibit CPA-7a
## State Aid Receipts and Reimbursement: 2001-2017 ($ Millions)

| Year | State Aid Received | State Aid Repayment Without Interest |
|---|---|---|
| 2001 | $733.3 | $0.0 |
| 2002 | 733.3 | 0.0 |
| 2003 | 733.3 | 0.0 |
| 2004 | 0.0 | 0.0 |
| 2005 | 0.0 | 0.0 |
| 2006 | 0.0 | 131.6 |
| 2007 | 0.0 | 122.2 |
| 2008 | 0.0 | 141.0 |
| 2009 | 0.0 | 141.0 |
| 2010 | 0.0 | 141.0 |
| 2011 | 0.0 | 159.8 |
| 2012 | 0.0 | 169.2 |
| 2013 | 0.0 | 188.0 |
| 2014 | 0.0 | 216.2 |
| 2015 | 0.0 | 244.4 |
| 2016 | 0.0 | 263.2 |
| 2017 | 0.0 | 282.1 |
| Total | $2,200.0 | $2,200.0 |

*Note: State aid repayment is calculated by multiplying the burden per aircraft and the number of aircraft delivered in each year*

## Exhibit CPA-7b
## State Aid Receipts and Amortization Calculations: 2001-2017 ($ Millions)

| Year | State Aid Received | Interest on State Aid | Amount Financed | Amortization |
|---|---|---|---|---|
| 2001 | $ 733.3 | $ 31.2 | $ 0.0 | $ 0.0 |
| 2002 | 733.3 | 62.3 | 0.0 | 0.0 |
| 2003 | 733.3 | 93.5 | 0.0 | 0.0 |
| 2004 | 0.0 | 93.5 | 0.0 | 0.0 |
| 2005 | 0.0 | 93.5 | 0.0 | 0.0 |
| 2006 | 0.0 | | $ 2,574.0 * | 278.3 |
| 2007 | 0.0 | | | 278.3 |
| 2008 | 0.0 | | | 278.3 |
| 2009 | 0.0 | | | 278.3 |
| 2010 | 0.0 | | | 278.3 |
| 2011 | 0.0 | | | 278.3 |
| 2012 | 0.0 | | | 278.3 |
| 2013 | 0.0 | | | 278.3 |
| 2014 | 0.0 | | | 278.3 |
| 2015 | 0.0 | | | 278.3 |
| 2016 | 0.0 | | | 278.3 |
| 2017 | 0.0 | | | 278.3 |
| Total | $ 2,200.0 | $ 374.0 | | $ 3,339.1 |

*Note: Interest at 4.25% p.a. compounded*
** As of January 1, 2006*

# Exhibit CPA-7c
# Private Development Funding and Amortization: 2001-2030 ($ Millions)

| Year | Development Cost | Interest on Development Cost | Amount Financed | Amortization** |
|---|---|---|---|---|
| 2001 | $ 1,466.7 | $ 88.0 | $ 0.0 | $ 0.0 |
| 2002 | 1,466.7 | 176.0 | 0.0 | 0.0 |
| 2003 | 1,466.7 | 264.0 | 0.0 | 0.0 |
| 2004 | 0.0 | 264.0 | 0.0 | 0.0 |
| 2005 | 0.0 | 264.0 | 0.0 | 0.0 |
| 2006 | 0.0 | | $ 5,456.0 * | 426.8 |
| 2007 | 0.0 | | | 426.8 |
| 2008 | 0.0 | | | 426.8 |
| 2009 | 0.0 | | | 426.8 |
| 2010 | 0.0 | | | 426.8 |
| 2011 | 0.0 | | | 426.8 |
| 2012 | 0.0 | | | 426.8 |
| 2013 | 0.0 | | | 426.8 |
| 2014 | 0.0 | | | 426.8 |
| 2015 | 0.0 | | | 426.8 |
| 2016 | 0.0 | | | 426.8 |
| 2017 | 0.0 | | | 426.8 |
| 2018 | 0.0 | | | 426.8 |
| 2019 | 0.0 | | | 426.8 |
| 2020 | 0.0 | | | 426.8 |
| 2021 | 0.0 | | | 426.8 |
| 2022 | 0.0 | | | 426.8 |
| 2023 | 0.0 | | | 426.8 |
| 2024 | 0.0 | | | 426.8 |
| 2025 | 0.0 | | | 426.8 |
| 2026 | 0.0 | | | 426.8 |
| 2027 | 0.0 | | | 426.8 |
| 2028 | 0.0 | | | 426.8 |
| 2029 | 0.0 | | | 426.8 |
| 2030 | 0.0 | | | 426.8 |
| Total | $ 4,400.0 | | | $ 10,670.1 |

*Note: Interest at 6% p.a. compounded*

**As of January 1, 2006*

*** Amortized over 25 years, 2006 - 2030*

# Exhibit CPA-7d
# Amortization of State Aid and Airbus Development Costs: 2001-2030 ($ Millions)

| | Amortization | | |
|---|---|---|---|
| Year | State Aid | Airbus Development Funding | Total* |
| 2001 | $ 0.0 | $ 0.0 | $ 0.0 |
| 2002 | 0.0 | 0.0 | 0.0 |
| 2003 | 0.0 | 0.0 | 0.0 |
| 2004 | 0.0 | 0.0 | 0.0 |
| 2005 | 0.0 | 0.0 | 0.0 |
| 2006 | 278.3 | 426.8 | 705.1 |
| 2007 | 278.3 | 426.8 | 705.1 |
| 2008 | 278.3 | 426.8 | 705.1 |
| 2009 | 278.3 | 426.8 | 705.1 |
| 2010 | 278.3 | 426.8 | 705.1 |
| 2011 | 278.3 | 426.8 | 705.1 |
| 2012 | 278.3 | 426.8 | 705.1 |
| 2013 | 278.3 | 426.8 | 705.1 |
| 2014 | 278.3 | 426.8 | 705.1 |
| 2015 | 278.3 | 426.8 | 705.1 |
| 2016 | 278.3 | 426.8 | 705.1 |
| 2017 | 278.3 | 426.8 | 705.1 |
| 2018 | 0.0 | 426.8 | 426.8 |
| 2019 | 0.0 | 426.8 | 426.8 |
| 2020 | 0.0 | 426.8 | 426.8 |
| 2021 | 0.0 | 426.8 | 426.8 |
| 2022 | 0.0 | 426.8 | 426.8 |
| 2023 | 0.0 | 426.8 | 426.8 |
| 2024 | 0.0 | 426.8 | 426.8 |
| 2025 | 0.0 | 426.8 | 426.8 |
| 2026 | 0.0 | 426.8 | 426.8 |
| 2027 | 0.0 | 426.8 | 426.8 |
| 2028 | 0.0 | 426.8 | 426.8 |
| 2029 | 0.0 | 426.8 | 426.8 |
| 2030 | 0.0 | 426.8 | 426.8 |
| Total | $ 3,339.1 | $ 10,670.1 | $ 14,009.2 |

*Note: Interest on state aid calculated at 4.25% p.a compounded, interest on Airbus development costs calculated at 6% p.a. compounded*

** Amortized over 25 years, 2006 - 2030*

# Exhibit CPA-8
# Costs of Producing Delivered A380 Aircraft: 2006-2025
## 2001 Dollars ($Millions)

| | Number of Aircraft Delivered* | | | Cost of Aircraft** | | |
|---|---|---|---|---|---|---|
| **Year** | **Passenger** | **Freighter** | **Total** | **Passenger** | **Freighter** | **Total** |
| 2006 | 13 | 1 | 14 | $ 2,533.7 | $ 201.9 | $ 2,735.6 |
| 2007 | 12 | 1 | 13 | 2,338.8 | 201.9 | 2,540.7 |
| 2008 | 14 | 1 | 15 | 2,728.6 | 201.9 | 2,930.5 |
| 2009 | 14 | 1 | 15 | 2,728.6 | 201.9 | 2,930.5 |
| 2010 | 14 | 1 | 15 | 2,728.6 | 201.9 | 2,930.5 |
| 2011 | 15 | 1 | 16 | 2,923.5 | 201.9 | 3,125.4 |
| 2012 | 16 | 2 | 18 | 3,118.4 | 403.8 | 3,522.2 |
| 2013 | 18 | 2 | 20 | 3,508.2 | 403.8 | 3,912.0 |
| 2014 | 21 | 2 | 23 | 4,092.9 | 403.8 | 4,496.7 |
| 2015 | 24 | 2 | 26 | 4,677.6 | 403.8 | 5,081.4 |
| 2016 | 25 | 2 | 27 | 4,872.5 | 403.8 | 5,276.3 |
| 2017 | 27 | 3 | 30 | 5,262.3 | 605.7 | 5,868.0 |
| 2018 | 28 | 3 | 31 | 5,457.2 | 605.7 | 6,062.9 |
| 2019 | 26 | 3 | 29 | 5,067.4 | 605.7 | 5,673.1 |
| 2020 | 25 | 2 | 27 | 4,872.5 | 403.8 | 5,276.3 |
| 2021 | 27 | 3 | 30 | 5,262.3 | 605.7 | 5,868.0 |
| 2022 | 31 | 3 | 34 | 6,041.9 | 605.7 | 6,647.6 |
| 2023 | 35 | 3 | 38 | 6,821.5 | 605.7 | 7,427.2 |
| 2024 | 36 | 4 | 40 | 7,016.4 | 807.6 | 7,824.0 |
| 2025 | 32 | 3 | 35 | 6,236.8 | 605.7 | 6,842.5 |
| Total | 453 | 43 | 496 | $ 88,289.7 | $ 8,681.7 | $ 96,971.4 |

** Source: Exhibit CPA-1*

*** $194,900,000 for each passenger aircraft*
*$201,900,000 for each freighter aircraft*

*Source: Appendix 3*

Exhibit CPA-9 is a comparison of costs and revenues, year-by-year, as generated by the A380 program between 2001 and 2025. It therefore represents a summary of this "critical project appraisal".

### Exhibit CPA-9
### Comparison of A380 Costs And Revenues: 2006-2025
### 2001 Dollars ($Millions)

| Year | Total A380 Revenues* | Total A380 Costs | Total A380 Cash Flow |
|---|---|---|---|
| 2001 | $ 2,200.0 | $ 0.0 | $ 2,200.0 |
| 2002 | 2,200.0 | 1,320.0 | 880.0 |
| 2003 | 2,200.0 | 1,320.0 | 880.0 |
| 2004 | 455.0 | 1,320.0 | (865.1) |
| 2005 | 675.3 | 1,320.0 | (644.7) |
| 2006 | 2,176.4 | 4,760.7 | (2,584.3) |
| 2007 | 2,125.0 | 3,245.8 | (1,120.8) |
| 2008 | 2,400.6 | 3,635.6 | (1,235.0) |
| 2009 | 2,533.2 | 3,635.6 | (1,102.4) |
| 2010 | 2,812.4 | 3,635.6 | (823.3) |
| 2011 | 3,149.3 | 3,830.5 | (681.2) |
| 2012 | 3,635.7 | 4,227.3 | (591.7) |
| 2013 | 4,357.5 | 4,617.1 | (259.6) |
| 2014 | 4,963.8 | 5,201.8 | (238.0) |
| 2015 | 5,544.0 | 5,786.5 | (242.5) |
| 2016 | 5,845.1 | 5,981.4 | (136.3) |
| 2017 | 6,232.9 | 6,573.1 | (340.2) |
| 2018 | 6,314.2 | 6,489.7 | (175.6) |
| 2019 | 6,190.2 | 6,099.9 | 90.3 |
| 2020 | 6,206.2 | 5,703.1 | 503.1 |
| 2021 | 6,939.6 | 6,294.8 | 644.8 |
| 2022 | 7,723.0 | 7,074.4 | 648.6 |
| 2023 | 8,158.4 | 7,854.0 | 304.4 |
| 2024 | 6,864.8 | 8,250.8 | (1,386.0) |
| 2025 | 5,408.6 | 7,269.3 | (1,860.7) |
| Total | $ 107,311.0 | $ 115,447.0** | $ (8,136.0) ** |

*Sources: Exhibits CPA-6, CPA-7d, CPA-8*

**Includes state and private development funding*

*** Amortization of private development funding continues through 2030; $2,134.0 million remaining*

## Update to Appendix 1

- Regarding the unique airport investments required to accommodate the A380, Airbus has recently acknowledged that 22 destination airports will be necessary to meet the initial deployment of the A380. This will require at least $900,000,000 in net new investment. In addition, about 26 airports will be required to serve as alternates leading to at least another $100,000,000 of incremental investment.
- To the extent Airbus itself does not cover the unique airport investments, airport operators will have to do so if they are to cater to the A380 at all. To recover these investments, special charges will have to be levied against airlines flying the A380, or all airlines serving the airports being used by the A380 will be required to share the burden whether they operate the A380 or not.
- It is far from certain that every one of the airports deemed critical to the A380's operation will be able to accommodate the aircraft; especially in doubt are those airports with runways or taxiways incorporating bridge structures crossing roads or other rights-of-way.
- The implicit assumption that hub-to-hub flying will continue to dominate intercontinental airline operations has been called further into question by the advent of the Boeing 7E7, which will offer an often-attractive alternative to hub-to-hub flights.
- While the "catalog" price of the A380 has been raised (to about $265,000,000 to $275,000,000), <u>transaction</u> prices for the aircraft have remained well below cost, both catalog and list. The number of A380s sold at such "launch" prices (of about $145,000,000 in 2001 dollars) has risen from about 60 in 2002 to over 120 presently.

## Appendix 1: Why the “Shadow” Critical Project Appraisal is Favorable to Airbus

- Cost calculations are biased towards greater reliance on conventional metal structure than is now anticipated rather than on more expensive composite primary structure. In part, this is due to an aggressive weight-reduction effort to deal with an operating-weight-empty (OWE) at least 40,000 pounds greater than planned.

- Despite the several radical innovations incorporated in the A380 airframe (e.g. GLARE primary structure; a largely composite wing box; laser-welded structure), no exceptional certification costs and time are assumed which would drive up development investment and delay initial deliveries and sales receipts. It would also delay initial repayment of state aid.

- No account is taken of the incremental investment required to finalize the design of the A380 freighter and to certify it.

- No increased unit costs are assumed for early A380s although there will surely be a learning curve.

- Although Airbus derives no direct financial benefit from the very low prices assumed for engines and power-packs, it is likely that later A380 customers will face substantially higher prices for these components which will increase the price of the aircraft beyond what has been projected and chill some future interest in it.

- There are no explicit provisions for enabling risk-sharing “partners” to recoup their investments in the development of the A380. Implicitly, the prices charged for the components they supply will be higher than anticipated. Either way, the cost to produce each A380 will be increased.

- Unique airport investments required to accommodate the A380 may have to be covered by Airbus, at least at some airports. There is precedent for this: when the manufacturers sought to assure access to LaGuardia Airport (LGA) for the L-1011 and DC-10, each had to cover one-half of the investment required to do so.

- Given the delivery expectations for the passenger A380, it is implicitly assumed that intercontinental hubs (e.g. CDG, LHR, JFK, NRT) will continue to dominate in intercontinental markets even though several aircraft types (some from Airbus) will offer other attractive long-range point-to-point options.

- Also implicit is an assumption that a sufficient network of airports capable of accommodating the A380 will be available upon its introduction and subsequently.

- Higher than realistic “catalog” prices are assumed and, beyond the first 60 aircraft delivered, the discounts from catalog will, at times, be insufficient to obtain the projected orders.

## Update to Appendix 2

- Development costs of the A380 have certainly risen well above the $10,700,000,000 originally projected. Since risk-sharing partners largely continue to be unwilling to shoulder additional development support commitments, Airbus (or EADS) will have to do so. While this increases the state aid for which the A380 program is eligible (one-third of Airbus's development costs for the A380), it also increases the per-aircraft repayment burden through 2017.

- A380 aircraft sold at below-cost launch prices now exceed 100 compared with about 60 two years before.

- Many Airbus aircraft of other types (e.g. A320 series) have been sold in recent years at below-cost prices for delivery during the early years of A380 production, thus reducing Airbus' ability to use profits from such aircraft to cover its obligations to repay A380 launch aid.

- The US dollar has weakened against the euro by as much as 10% since the introduction of the euro and the start of the A380. It has declined by as much as 45% since the peak of the US dollar exchange rate against the euro which was reached after the launch of the A380. If the weak dollar continues beyond the time for which Airbus is hedged against exchange rate changes, its dollar-denominated sales receipts will shrink relative to its euro-denominated development costs.

- The Sonic Cruiser is no longer under development and therefore is not a competitive threat to the A380; however, the 7E7 is becoming a reality with its own challenges to the market viability and economic attractiveness of the A380.

- Given the persistent excess of airframe weight over what was intended for the A380, the ability of the aircraft to meet its performance guarantees is called into question; the potential financial jeopardy to Airbus (and EADS) is presently unknown.

- As it attempts to reduce airframe weight, Airbus has increased the use of expensive GLARE in the construction of the A380; it is adding the leading edges of the vertical and horizontal stabilizers to the list of items made of GLARE. It has also taken radical steps such as the introduction of aluminum wiring with significant implications for A380 certification even while it reduces weight marginally.

## Appendix 2: Recent Developments Affecting Prospects for the A380

The following could not have been known in January 2001, when the shadow critical project appraisal is assumed to have been produced. Nevertheless, these issues must now be addressed in assessing the market and economic prospects for the A380 program a year later.

- The risk-sharing partners in the A380 program have not been inclined to provide as much as $4,100,000,000 in development investment as was expected. If they come forward with, say, $3,100,000,000 of the $10,700,000,000 required, this raises allowable state aid to become $2,500,000,000 (of $7,500,000,000 provided by Airbus). This, in turn, increases the payback burden on each of the first 232 aircraft to approximately $9,500,000 plus interest.

- It appears that launch-customer prices will extend beyond the 60 aircraft previously projected; how far beyond is not yet known.

- The advent of the Sonic Cruiser, which will bid especially for the "premium" passengers on many routes, will strip away the most profitable A380 traffic from about 2008.

- The rapid growth in the use of corporate jets even for very long-range flights, is a trend likely to continue. This also jeopardizes at least premium-cabin load factor.

- Airline interest in smaller rather than larger long-range aircraft to facilitate hub-busting and greater frequency of service is continuing.

- An increase in A380 development costs are probable for two reasons: the need to lower airframe weight and to provide acceptable bases for certification of an aircraft incorporating its radical innovations; this has been made more critical because of the Long Island accident in November 2001.

- A general decline of passenger demand reflecting reduced economic activity from mid-2001.

- Acceleration in the decline in passenger demand following the events of September 11, 2001; has put airlines behind their anticipated growth path by at least two-to-three years.

- All in all, a scenario where about 350 A380s are delivered between 2006 and 2025 inclusive seems most likely.  About fifty of these aircraft will be freighters.

# Update to Appendix 3: A380 Market Analysis
## June 2004

## Current Orders

As of May 31, 2004, there were 129 orders for A380s, from 11 customers. Deliveries are not expected until 2006. According to *Speednews*, there were orders for 34 A380s placed between April 1, 2003 and March 31, 2004. There have been no (announced) orders since March 31, 2004.

## Airport Issues

There are two principal issues with respect to airports and the A380. First, will there be a sufficient number of airports ready to accommodate the A380 when it enters service in 2006, and second, what will be the cost of adapting these airports for the A380, along with determining which entities (airlines, the manufacturer or the airports themselves) will pay for the modifications.

With respect to the physical readiness of airports, there have been (albeit contradictory, in some cases) indications that certain airports would not be ready as quickly as had been hoped. Recently (May 18, 2004, *The Seattle Times*, for example), it was announced that

> Virgin Atlantic Airways postponed the delivery of its first Airbus A380 by 18 months, to the end of 2007, because Los Angeles International Airport and other airports may not be ready to handle the world's largest passenger plane.

However *USA Today* carried a conflicting item:

> "We are confident that LAX (Los Angeles International Airport) will be ready to accommodate the A380 with the highest standards of safety when the first airline begins using the aircraft at LAX in late 2006", operator Los Angeles World Airports said in a statement.

> Virgin said on Tuesday, following the statement by the operator of Los Angeles airports, that there was no change in its statement.

Officials at other U.S. airports, including Chicago's O'Hare and JFK in New York, indicated that their facilities would be ready for the A380's entry into service, without elaboration. At LAX's cross-state rival, SFO (San Francisco International), the airport is "…already rolling out blueprints and reconfiguring infrastructure to handle its arrival." (*San Francisco Chronicle*, June 20, 2002)

Illustrating the fact that there are significant variances between airports with respect to the cost of facilities/improvements necessary for A380 operations, the *Chronicle* article goes on to note that "SFO officials say getting ready to handle the A380 will cost the airport $76 million. The money, including a $10 million contingency fee, is earmarked for repaving taxiways, widening and thickening them slightly."

However, the article also states that

> In contrast to the $76 million price tag at SFO, Los Angeles International Airport, which competes with SFO for trans-Pacific business, will have to spend $700 million to modernize and accommodate the new plane, according to an estimate provided to the General Accounting Office.

Indeed, the GAO's February 2002 Report to Congressional Requesters about Airport Infrastructure makes clear, via its title, that information is far from definitive on the subject: *Unresolved Issues Make it Difficult to Determine the Cost to Serve New Large Aircraft*. The GAO surveyed 23 airports, and received responses from 22. Of the 14 airports that expected to have service with an aircraft in the size category of the A380 by 2010, "…the estimate for infrastructure changes is $2.1 billion". Airbus provided an estimate for the same 14 airports of only $520 million. While the GAO indicated that operational restrictions could mitigate the forecast expense to some degree, they also stated that "…we do not view this as a long-term solution to serving NLA [New Large Aircraft] because many of these airports have typically experienced delay and congestion problems that could be made worse by additional restrictions."

Clearly, there will be significant cost associated with the A380 for a number of airports, worldwide. At present, it is not yet possible to identify the full magnitude of this expense, nor who will bear this financial burden. To date, there has been no indication that Airbus is willing to do this, however, so that it is likely that it will be borne by suppliers and users of the air transport system, including airports, airlines and ultimately, passengers and shippers.

## Competitive Aircraft (Sonic Cruiser, 7E7)

At the time the original report was prepared, it appeared that the Boeing "Sonic Cruiser" would have an impact on the A380's market prospects. While we did not formally include this in the Shadow Critical Project Appraisal (since it could not have been known in January 2001, when the Shadow Critical Project Appraisal was assumed to have been produced), mention of this was made in Appendix 2, "Recent Developments Affecting Prospects for the A380".

Subsequently, work on the Sonic Cruiser was discontinued, before formal launch or the placing of any orders for the type. More recently, however, Boeing has proceeded with the development of another mid-sized/long-haul (in at least one of its variants) aircraft project, the 7E7. This program was launched during 2004, and currently has announced orders from two airline customers, Japan's ANA and Air New Zealand.

While the Sonic Cruiser appeared to be targeted largely at that component of the passenger market that valued (and theoretically, would pay for) speed, the 7E7 is likely to cut a wider swath in the market and appeal to a number of carriers in a variety of markets. It is still difficult to quantify the impact the 7E7 will have directly on the A380's market prospects (and this certainly would have been impossible to foresee in January 2001);

however, it is likely that the 7E7 will have a depressing effect on sales of the A380. As a result, the A380 Market Analysis contained in the original (2002) Shadow Critical Project Appraisal of the A380 program can be considered to be more favorable to Airbus and the A380 program than likely would be the case if the market analysis were undertaken today.

## **All-Coach High-Density A380**

From time-to-time there have been references to an extremely high-capacity (approximately 800 seats in an all-coach configuration) version of the A380:

> Airbus promotes the A380 as having a capacity of 555 passengers in three standard cabin classes: first, business and coach. That's 139 more passengers than the latest 747 carries. But Airbus says that the A380 will actually be able to carry more than 800 passengers. ("Whale of a plane can seat 800 Jonah's", by Joe Sharkey, *New York Times*, December 3, 2003.)

While this would seem to be an effective answer to very large markets and extreme airway and airport congestion situations, the operating economics of this variant are likely to be less than desirable from a profit-and-loss standpoint.

As shown in the following table, a mixed-class, "standard" size A380 (555 seats) can generate a reasonable level of revenue, both per available seat-mile and per mile. While the "premium" (first and business class) component of the traffic is smaller than the economy portion, premium traffic in fact generates over half of the total (passenger) revenue potential.

| **Class** | **Seats** | **Load Factor** | **Pax** | **Yield** | **Rev/Seat-Mile** | **Rev per Mile** | **% of Base Case** | **% of Tot Rev** |
|---|---|---|---|---|---|---|---|---|
| Premium | 125 | 70.0% | 87.5 | $0.500 | $0.350 | $43.75 | | 59% |
| Economy | 430 | 70.0% | 301 | $0.100 | $0.070 | $30.10 | | 41% |
| Total/Avg | 555 | 70.0% | 388.5 | $0.190 | $0.133 | $73.85 | 100.0% | 100% |

It is likely that a number of airlines could achieve profitability with this traffic/revenue mix on a long-haul sector.

However, if an all-economy, 800-seat version is substituted, with no change in economy-class yield, the revenue potential becomes worse:

| **Class** | **Seats** | **Load Factor** | **Pax** | **Yield** | **Rev/Seat-Mile** | **Rev per Mile** | **% of Base Case** | **% of Tot Rev** |
|---|---|---|---|---|---|---|---|---|
| Premium | 0 | 70.0% | 0 | $0.500 | $ - | $ - | | 0% |
| Economy | 800 | 70.0% | 560 | $0.100 | $0.070 | $56.00 | | 100% |
| Total/Avg | 800 | 70.0% | 560 | $0.100 | $0.070 | $56.00 | 75.8% | 100% |

While cost per ASM (available seat-mile) could decrease, due to the greater number of seats (although more fuel would be burned, due to the greater weight being carried), it is useful to note that the total revenue per mile would decline, to only 75.8% of the base case. It is unlikely that many, if any, carriers would be able to achieve profitability at these revenue levels, even at what is a relatively generous (i.e. revenue of $400 for a 4,000 statute-mile journey) average yield.

However, it is very unlikely that even this level of yield could be maintained in the face of the need to essentially double the number of economy passengers versus the base case. Accordingly, we also examined a case where half of the economy passengers would be carried at a yield designed to stimulate considerable incremental traffic:

| **Class** | **Seats** | **Load Factor** | **Pax** | **Yield** | **Rev/Seat-Mile** | **Rev per Mile** | **% of Base Case** | **% of Tot Rev** |
|---|---|---|---|---|---|---|---|---|
| Economy | 400 | 70.0% | 280 | $0.100 | $0.070 | $28.00 | | 67% |
| Economy | 400 | 70.0% | 280 | $0.050 | $0.035 | $14.00 | | 33% |
| Total/Avg | 800 | 70.0% | 560 | $0.075 | $0.053 | $42.00 | 56.9% | 100% |

Revenues are even lower than in the previous case, and only slightly greater than half of those in the base (premium and economy passengers) case. While benefiting many passengers, in terms of low-fare offerings, such results would not be very welcome from an airline P&L perspective.

In addition, an 800-seat A380 would have very little (if any) room for cargo, due to the large amount of passenger baggage that would need to be carried. On many long-haul routes, cargo represents the majority, and sometimes all, of a flight's profit. Eliminating cargo revenue potential in favor of marginal, incrementally-priced passengers would not be beneficial to the economics of the airlines operating this version.

Accordingly, while an 800-seat aircraft might merit inclusion in the *Guinness Book of Records*, the news associated with this feat in the financial press likely would strike a considerably more discordant note.

## Market Fragmentation Issues

In the intervening two years since the preparation of the Shadow Critical Project Appraisal, there has not been a resolution of the issue of whether long-haul international markets are "fragmenting". Airbus continues to believe either that they are not or that the trend is abating. Boeing believes that they are and is voting with its development money in favor of continuing (and perhaps accelerating) market fragmentation via the launch of the 7E7.

Although the Shadow CPA did not examine short-haul regional/domestic markets, it is clear that there is a continuing trend towards replacing "full-size" jets with regional jets in many markets, particularly in the U.S. This continued in the post-September 11, 2001 period, when virtually all other categories (including regional turboprops, narrowbody jets and widebody jets) were declining.

One of the reasons cited for this is the preference of business travelers, who often pay higher fares than their leisure counterparts, for flight frequency. Although mitigated to some extent by the difficulty of scheduling around time-zone changes, curfews and slots in long-haul international services, there is little doubt that intercontinental business travelers prefer to have a choice of departure times where this is feasible.

Long-haul travelers also prefer nonstops to connecting flights. While the A380 is well-suited to handle significant volumes of passengers in “hub-to-hub” service, this type of operation forces travelers to endure additional connections that may not be necessary. For example, to travel between Indianapolis and Bremen, Germany, today typically requires two connections, with routings such as IND-IAD-FRA-BRE, or IND-DTW-AMS-BRE. The use of smaller aircraft such as the 7E7 or the A330-200 (or the 767, for that matter) to add an Indianapolis “spoke” from Lufthansa’s Frankfurt hub, would reduce the IND-BRE trip to a single connection and clearly would be a more desirable alternative for high-yield business travelers than a double connection.

While individual city-pair markets like Indianapolis-Bremen are small on an individual basis, the aggregation of such markets from Indianapolis that can be served on a single-connection basis via a European hub such as Frankfurt could produce enough traffic to make nonstop IND-FRA service economically feasible. This would also enhance the Frankfurt hub; it should be apparent that having more, and diverse spokes makes that hub more competitive.

An excellent example of this is provided by the Cincinnati hub (of Delta and its regional partners). In addition to being highly-effective as a domestic entity, it has enabled Delta (and its code-share and alliance partners) to offer transatlantic services from a point with only modest origin-destination traffic. In the summer of 2004, nonstop transatlantic service is being added from Cincinnati to Amsterdam and Rome, even though both points were already served effectively from Cincinnati via Delta’s (SkyTeam Alliance) partner Air France’s Paris hub.  Numerous new single-connect opportunities will be created by the new Amsterdam and Paris services, however.

We believe that it is likely fragmentation will continue, and as longer-range aircraft (including Airbus products such as the A340-500) enter service, this phenomenon will spread further.  There will continue to be a need for large increments of hub-to-hub capacity in some instances, but even here additional frequency will be attractive in many cases.

# Appendix 3:  A380 Market Analysis

## 3.1:  Methodology

The A380 Market Analysis predicts demand (in terms of aircraft deliveries) and revenues for the first 20 years of the A380 program, commencing with the expected first delivery in 2006.  Demand is determined by first segmenting the market to include the portion of the market where the A380 will be operated—large aircraft, principally in long-haul operations.  Then future needs for this market segment are forecast by establishing parameters for both replacement of existing equipment, based on age, and expected future growth.  Traffic growth is impacted by structural issues in the worldwide market, including market "fragmentation", which will have a significant impact on the market sector served by the A380.

Fragmentation will, in fact, be a key issue in determining what portion of the market will accrue to the A380 once overall future growth and replacement needs have been determined.  This and competitive offerings determine the A380's market share and, therefore, expected annual deliveries.  In addition to forecasting demand for A380 passenger aircraft, this market analysis also predicts deliveries of freighter versions for 2006-2025.  Finally, once the delivery forecast has been determined, program revenues are calculated based on forecast prices for both the passenger and cargo versions of the A380.

### *3.1.1:  Market Segmentation*

Since the A380 will be utilized primarily as a long-range aircraft, this portion of the analysis begins by identifying the existing fleet of large, long-haul aircraft from the A310/767 to the 747-400 in passenger capacity.  The distribution of this group of aircraft at year-end 2000 is shown in Exhibit 3-1.  Only aircraft in commercial airline passenger service (including combis and convertibles) are included.

Nominal  "standard" seating capacities (three class) are indicated for each aircraft type, representing typical configurations for aircraft in this type of service (long-haul international), as well as the total number of seats in service.  This methodology permits determination of future capacity requirements without having to adjust for differing individual airline configurations; it also allows for the possibility of changes in the "mix" of aircraft types.  Replacement aircraft are assumed to perform missions similar to those of the aircraft shown in Exhibit 3-1 without significant changes in aircraft productivity (speed, load factor, utilization, etc.) Service to new markets, "fragmentation" of markets now served via a small number of traditional gateways

**Exhibit 3-1**

**World Passenger Widebody Fleet - Year End 2000**

| Aircraft | Seats* | Configuration | Number of Aircraft | Total Seats |
|---|---|---|---|---|
| A300-600 | 200 | 3-class | 191 | 38,200 |
| A310 | 170 | 3-class | 178 | 30,260 |
| A330-200 | 240 | 3-class | 79 | 18,960 |
| A330-300 | 260 | 3-class | 94 | 24,440 |
| A340-200 | 240 | 3-class | 19 | 4,560 |
| A340-300 | 270 | 3-class | 162 | 43,740 |
| B747-100 | 375 | 3-class | 31 | 11,625 |
| B747-200 | 375 | 3-class | 129 | 48,375 |
| B747-300 | 400 | 3-class | 58 | 23,200 |
| B747-400 | 420 | 3-class | 421 | 176,820 |
| B747-SP | 265 | 3-class | 18 | 4,770 |
| B767-200 | 170 | 3-class | 202 | 34,340 |
| B767-300 | 200 | 3-class | 530 | 106,000 |
| B767-400 | 230 | 3-class | 16 | 3,680 |
| B777-200 | 285 | 3-class | 279 | 79,515 |
| B777-300 | 350 | 3-class | 35 | 12,250 |
| DC-10-10 | 285 | 3-class | 19 | 5,415 |
| DC-10-15 | 285 | 3-class | 6 | 1,710 |
| DC-10-30 | 250 | 3-class | 91 | 22,750 |
| DC-10-40 | 250 | 3-class | 37 | 9,250 |
| L1011-500 | 205 | 3-class | 23 | 4,715 |
| MD-11 | 275 | 3-class | 105 | 28,875 |
| **Total** | | | **2,723** | **733,450** |

*Source: Jet Information Services, Inc. World Jet Inventory, YE 2000*
** estimated*

and new, extremely long-range nonstop services are properly included in the growth portion of the market rather than being accounted for under the replacement category.

### *3.1.2: Key Assumptions*

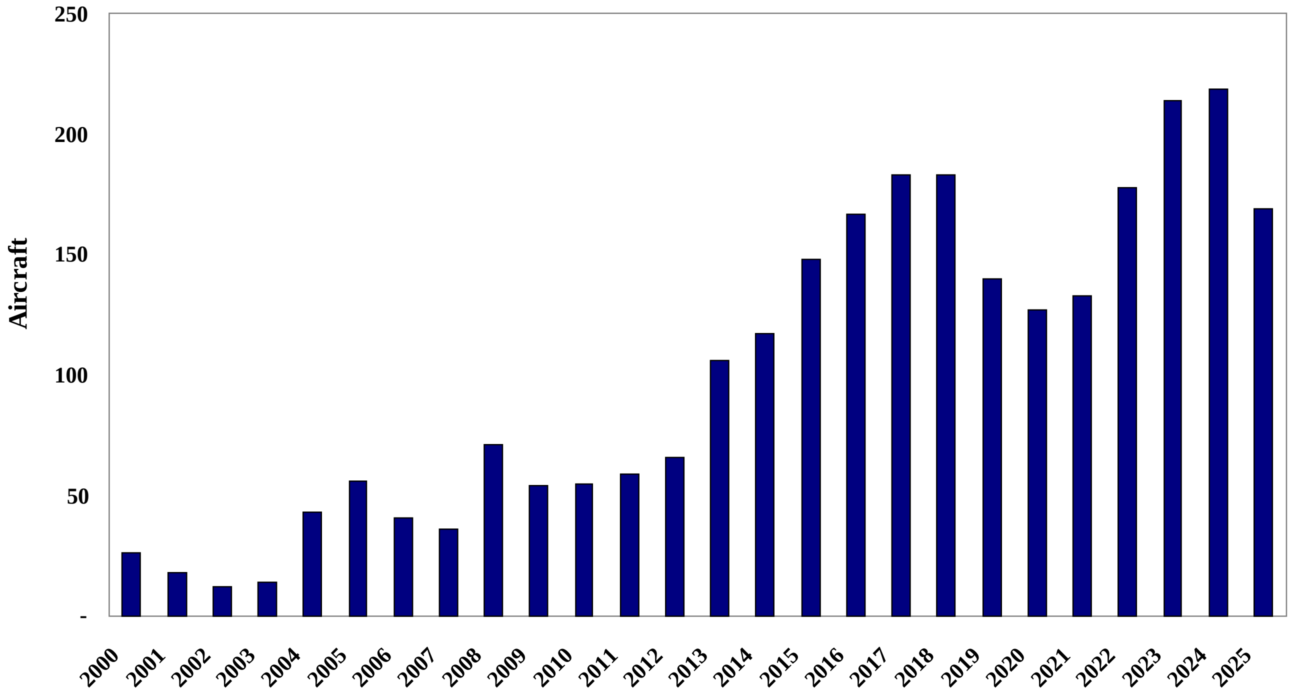
The A380 will be introduced into airline passenger service in 2006. Accordingly, the 20-year aircraft demand forecast covers the period 2006 through 2025. While a 20-year span is longer than a particular <u>model</u> of aircraft has typically been in production, the forecast does not attempt to anticipate precisely what sort of derivatives will evolve from the basic design. Based on the experience of the 747, the A380 could be in production in some form for well over 20 years, although the experience of the DC-10, MD-11 and Lockheed 1011 indicate that this is hardly guaranteed. Certainly within 20 years there will be some new product development which will render the 2006 models of the A380 and other contemporaneous aircraft less attractive, but it is not now possible to identify with precision what these aircraft will be. In addition, while the forecast covers a 20-year period, the first ten years (2006-2015) have the greatest bearing on assessing the forecast for purposes of A380 program economic viability.

### *3.1.3: Aircraft Retirement Assumptions*

Forecasts of demand for large commercial aircraft typically assume retirement or replacement dates between 25 and 30 years. Accordingly, the forecast examines two retirement assumptions (which correspond to these two timespans) to determine the demand for new aircraft to replace existing units. Exhibit 3-2a shows the results by year for the number of aircraft being retired from those identified in Exhibit 3-1; Exhibit 3-2b also displays the corresponding number of seats taken out of service. For the purposes of this analysis, a 25-year retirement was selected. This favors the addition of new capacity earlier than would a 30-year retirement assumption, Exhibits 3-2c and 3-2d.

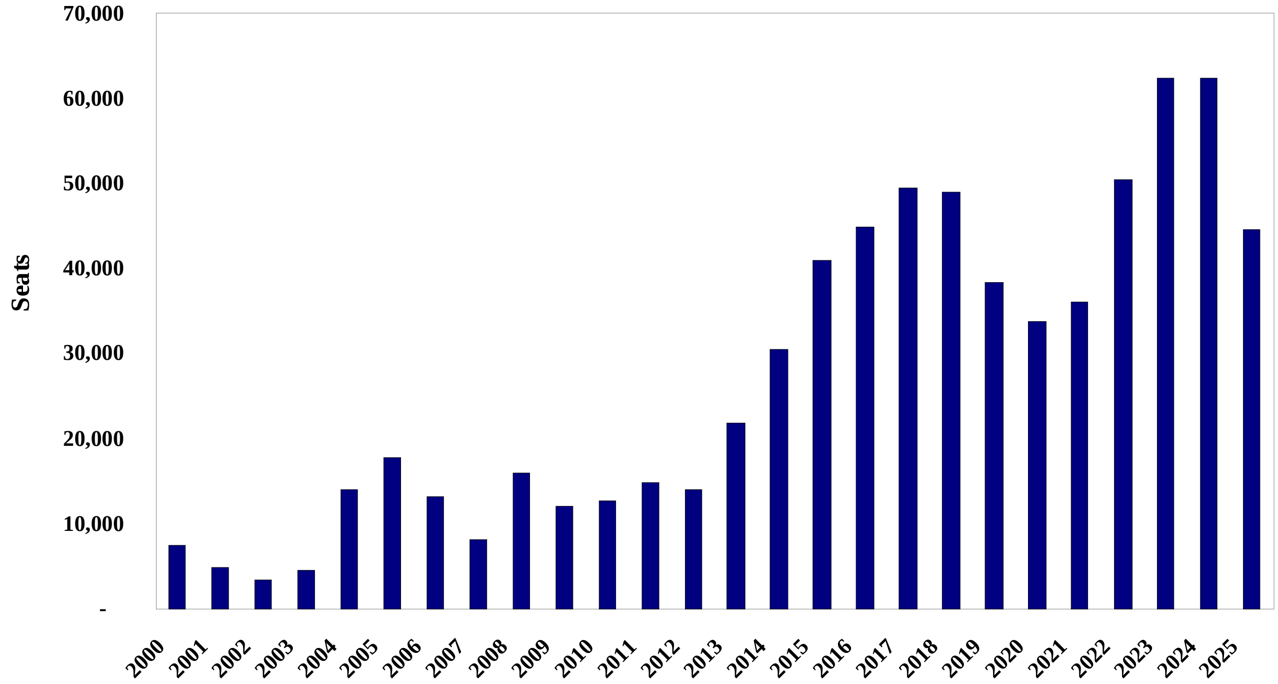
## Exhibit 3-2a

**Retired Widebody Aircraft (25 Year Lifespan)**
**2000 - 2025**



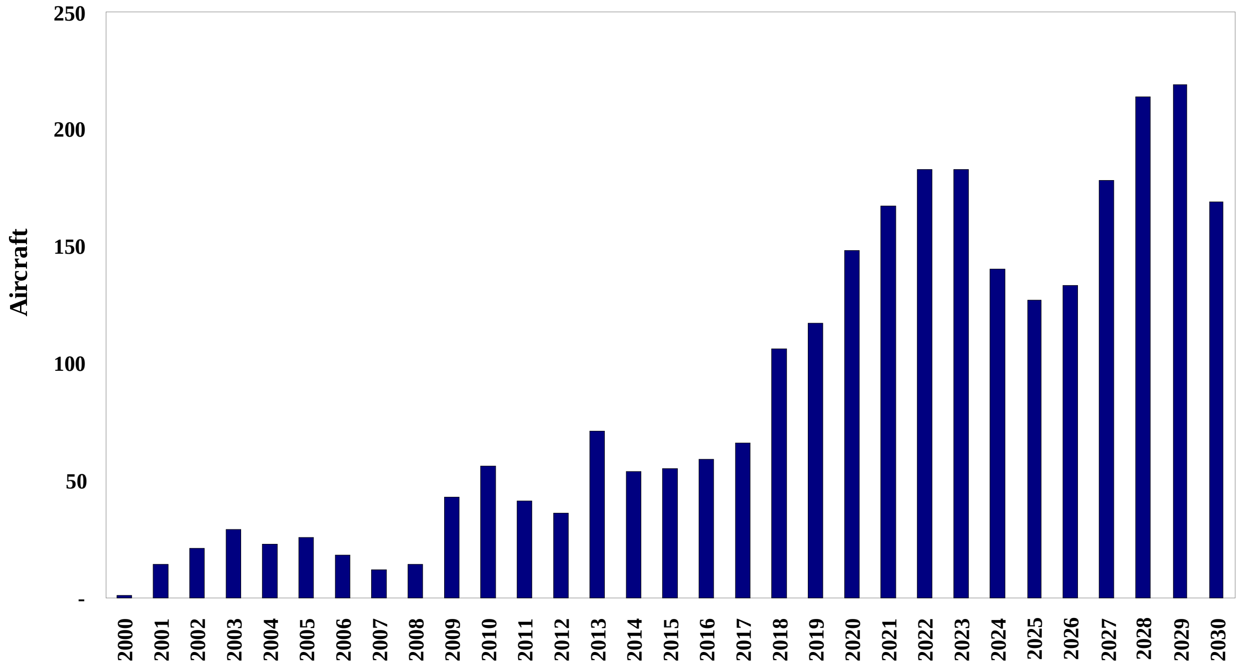
## Exhibit 3-2b

### Retired Seats (25 Year Lifespan)
### 2000 - 2025



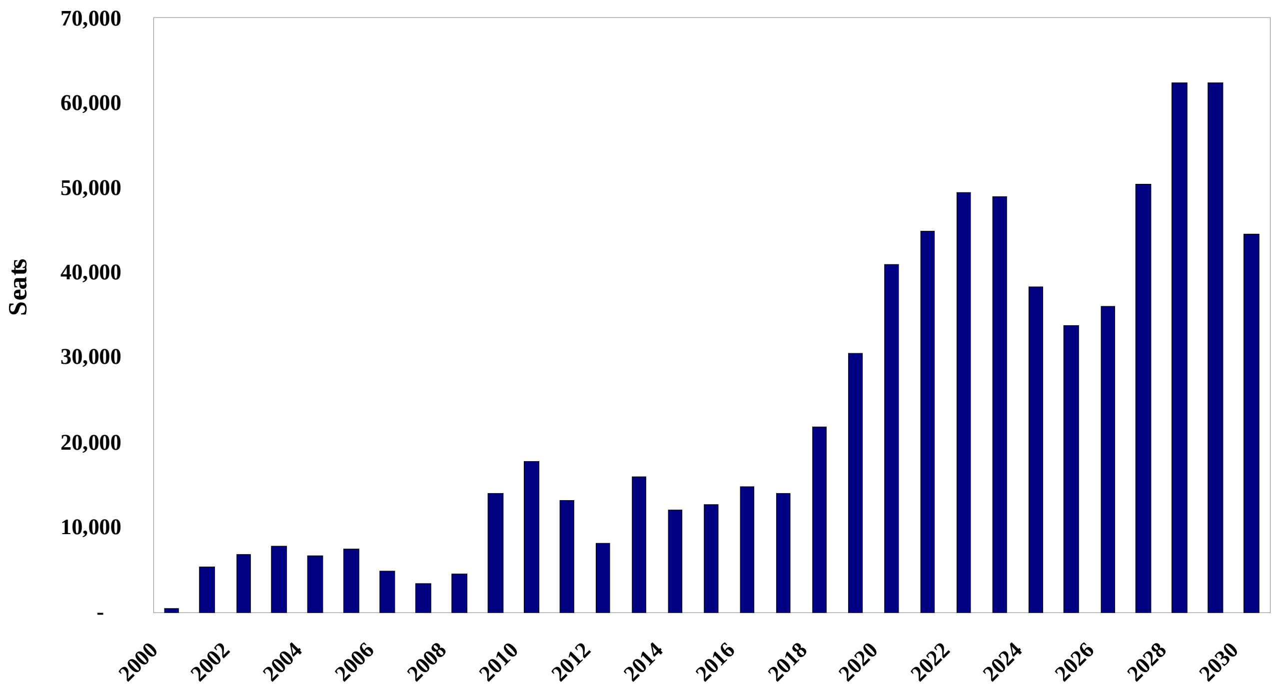
## Exhibit 3-2c

### Retired Widebody Aircraft (30 Year Lifespan)
### 2000 - 2030



## Exhibit 3-2d

### Retired Seats (30 Year Lifespan)
### 2000 - 2030



## <u>3.2: Passenger Demand Forecast</u>

### 3.2.1: Market Growth Rates

In forecasting demand, the time horizon is 20 years. The long-haul markets which the aircraft in Exhibit 3-1 will typically serve are expected to grow over the next 20 years, some at a pace exceeding the average growth rate for civil passenger air transportation generally. A number of long-term industry forecasts for the next 20 years call for average annual growth rates between four and five per cent (4.0 and 5.0%). Accordingly, the forecast considers market growth at rates of four, four-and-one-half, and five per cent (4.0, 4.5, and 5.0%) per year.

### *3.2.2: Market Structure Issues*

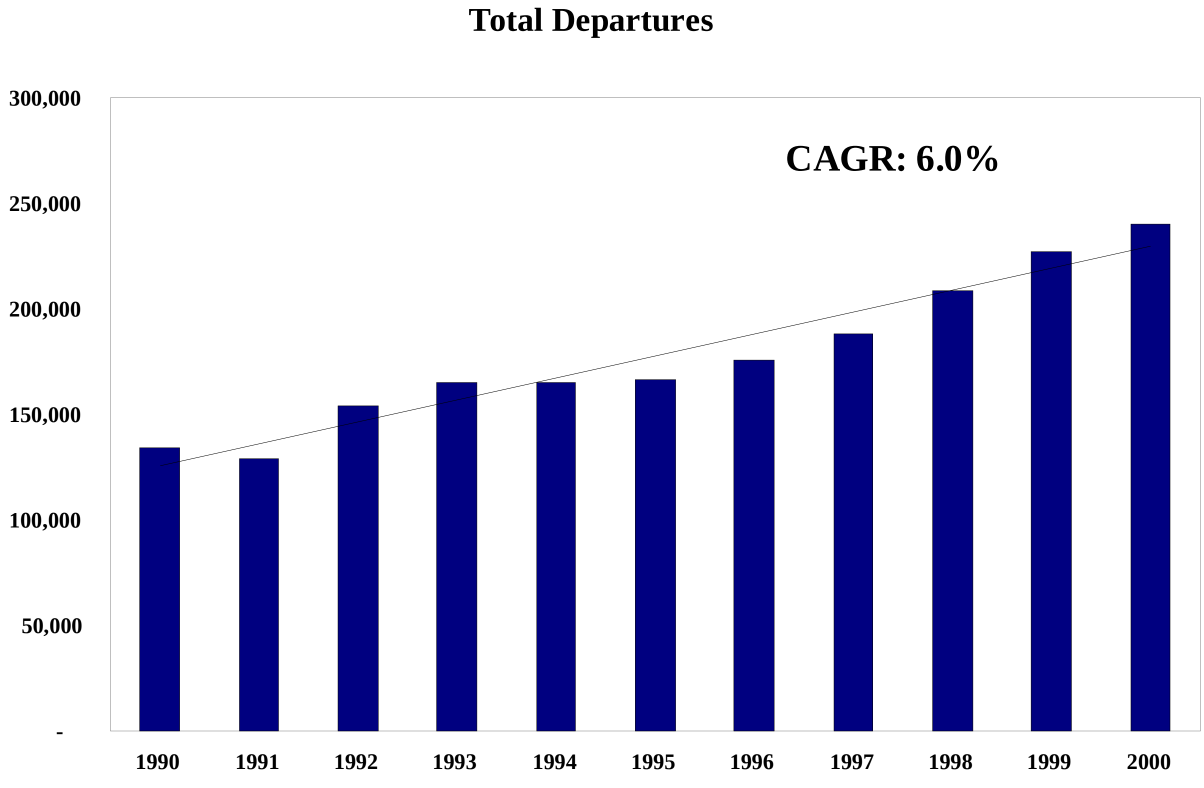
A key issue requiring consideration in forecasting market demand for the A380 is that of market "fragmentation". This refers to the proliferation of long-haul international services from "non-traditional" gateways—including points such as Atlanta, Munich and Osaka, as opposed to the historic gateways such as New York (JFK), London (Heathrow), San Francisco and Tokyo (NRT).

Although fragmentation on the Atlantic can be considered to have begun in earnest thirty-two years ago with National's Miami-London route, two aircraft-related developments have caused the trend to accelerate during the last ten- to 15-years. These are aircraft with greater range capability, beginning with the 747-400 in 1989, and followed by the MD-11, A340 and 777, together with widespread deployment of twin-engine aircraft on long overwater sectors, beginning in the 1980s.

## Transatlantic

As shown in Exhibits 3-3a and 3-3b, there has been greater growth in departures for U.S. transatlantic operations than there has been in total seats. (These data, as well as corresponding figures for transpacific in the next section, are derived from the U.S. DOT's T-100 database, which includes all carriers, both U.S. and foreign, operating in the U.S. transatlantic market.)

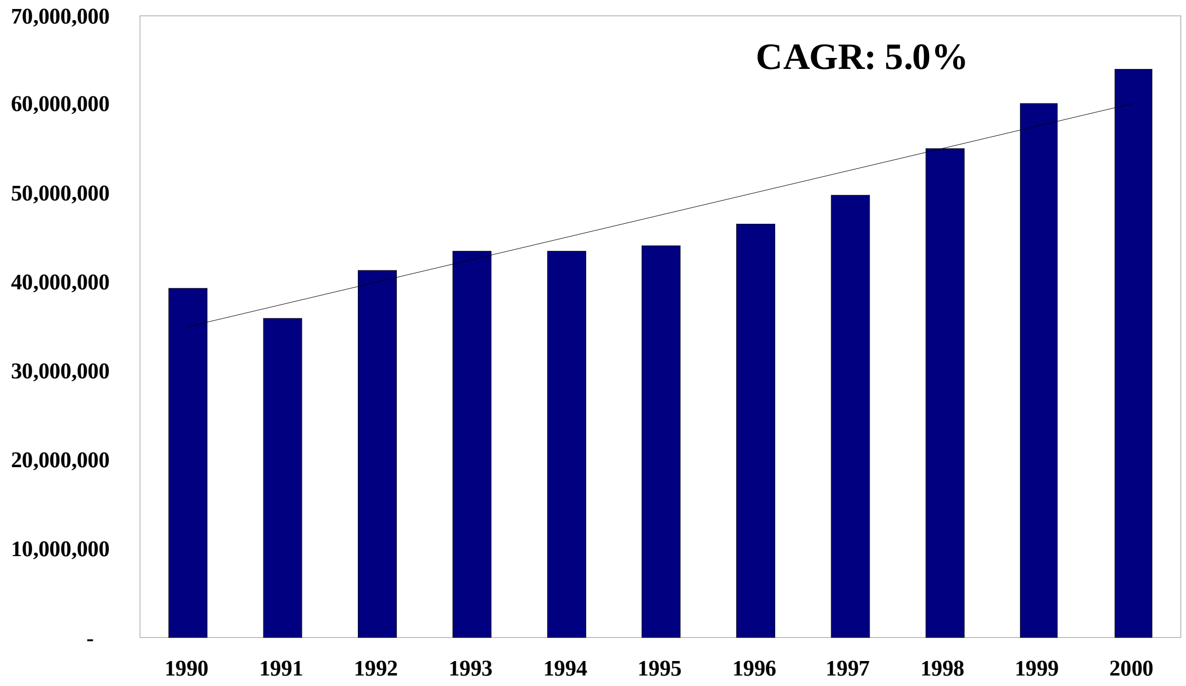
**Exhibit 3-3a**
**U.S. Transatlantic Service 1990 - 2000:**
**Departures Growing Faster Than Seats**



*Source: US DOT T-100*

## Exhibit 3-3b
## U.S. Transatlantic Service 1990 - 2000: Departures Growing Faster Than Seats

### Total Seats



*Source: US DOT T-100*

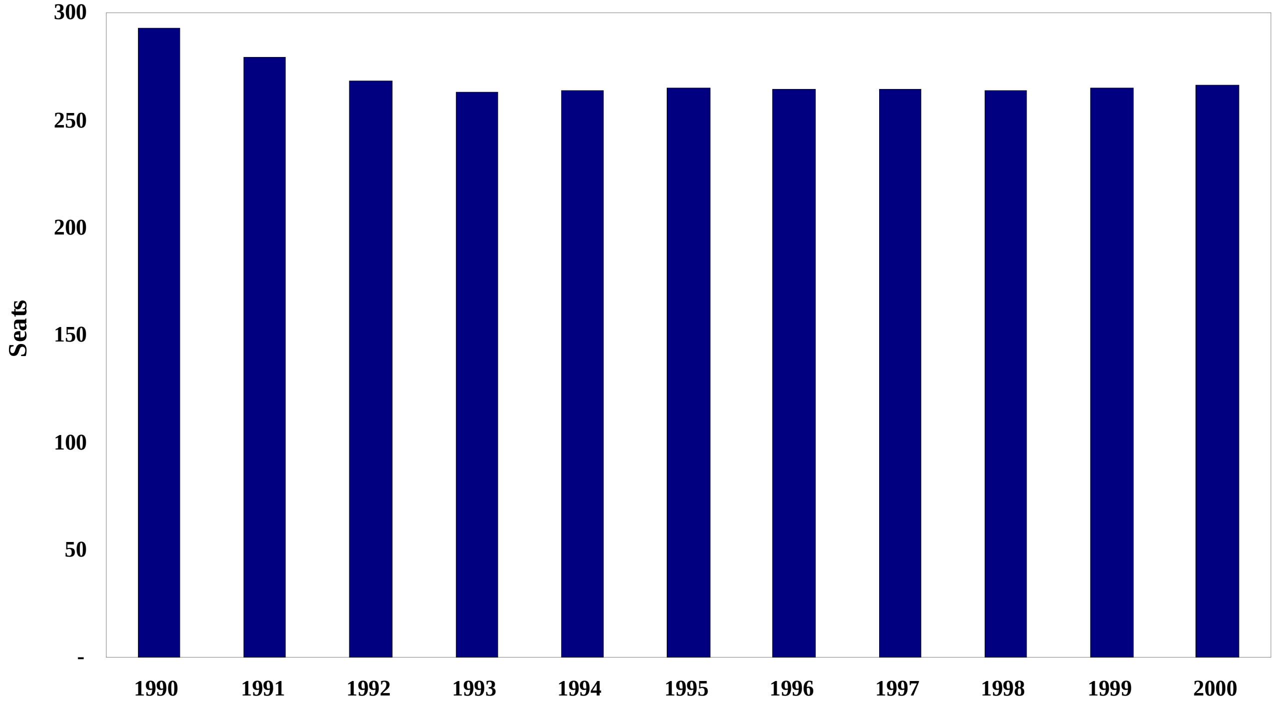
This trend is reflected in the decrease in average aircraft size in this market sector, as displayed in Exhibit 3-4.

While there have been modest changes in transatlantic length of haul during the 1990s, it is apparent from Exhibit 3-5 that there has not been a significant change in this metric.

Exhibit 3-6 indicates clearly that there was a compound annual growth rate (CAGR) of two-and-four-tenths per cent (2.4%) in the number of U.S. transatlantic markets with nonstop service during the 1990s, beginning with about 180 markets served, and growing to over 220 by 2000.

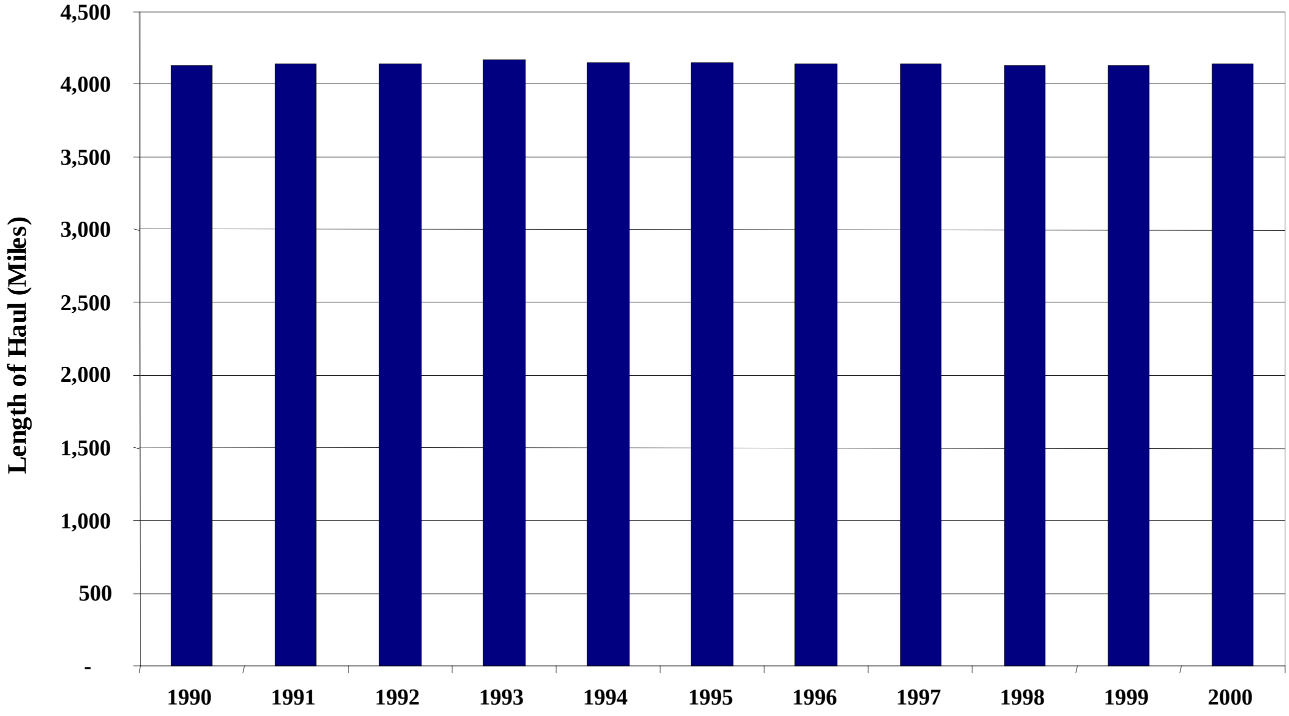
Exhibit 3-7 shows how this degree of fragmentation impacted aircraft usage in U.S. transatlantic markets during the period 1990-2000. At the beginning of the period, the greatest number of departures was performed by large widebody aircraft (747s), with only modest increments of small (767/A310) and

## Exhibit 3-4
## Average Aircraft Size - U.S. Transatlantic Service
## 1990 - 2000



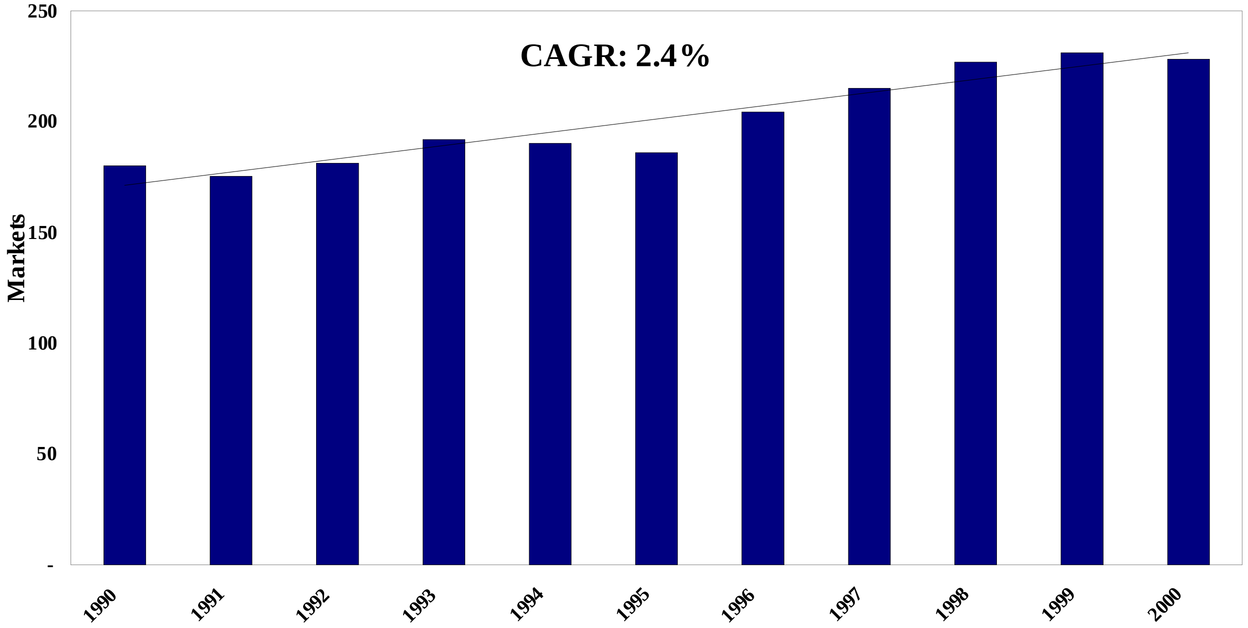
*Source: US DOT T-100*

## Exhibit 3-5
## Average Length of Haul - U.S. Transatlantic Service
## 1990 - 2000



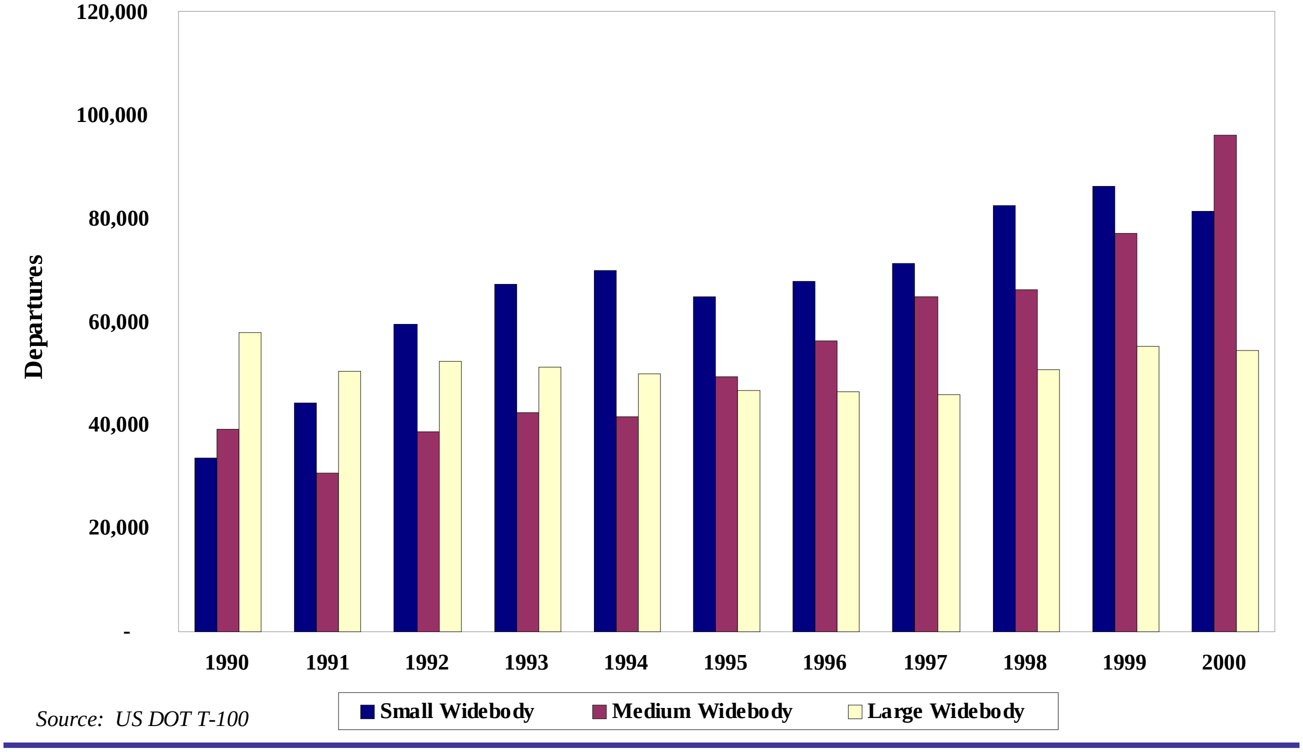
*Source: US DOT T-100*

## Exhibit 3-6
## Number of U.S. Transatlantic Nonstop Markets With Greater Than 50 Annual Departures (Each Way)
## 1990 - 2000



*Source: US DOT T-100*

## Exhibit 3-7
## U.S. Transatlantic Service 1990 - 2000: Departures by Equipment Type
## 1990 - 2000



*Source: US DOT T-100*

medium (DC-10, L1011) twin-aisle aircraft. By 2000, however, the combined small/medium categories held almost a three to one advantage over the large widebody sector and the medium category alone was almost twice the size of the large.

Further evidence of the degree of fragmentation which took place on the North Atlantic during the 1990s is found in Exhibit 3-8. While the number of nonstop markets served via the "traditional" gateways, such as JFK, BOS, ORD and LAX, either declined, or increased only modestly, other locations, including EWR, ATL, MIA, IAD, PHL and DTW experienced large increases.

## Exhibit 3-8

**Number of U.S. Transatlantic Markets Served Nonstop (>50 Annual Departures)**
**1990 - 2000**

**Selected U.S. Gateways**
**European Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JFK | 37 | 35 | 36 | 38 | 38 | 35 | 35 | 35 | 36 | 34 | 34 | -8.1% |
| EWR | 13 | 11 | 12 | 13 | 12 | 13 | 18 | 23 | 25 | 25 | 25 | 92.3% |
| ORD | 18 | 18 | 19 | 20 | 18 | 20 | 19 | 20 | 21 | 21 | 21 | 16.7% |
| ATL | 7 | 9 | 11 | 12 | 12 | 12 | 12 | 14 | 14 | 17 | 15 | 114.3% |
| BOS | 12 | 12 | 13 | 13 | 13 | 11 | 13 | 13 | 15 | 16 | 13 | 8.3% |
| MIA | 11 | 10 | 15 | 13 | 12 | 13 | 12 | 13 | 14 | 14 | 12 | 9.1% |
| IAD | 5 | 5 | 6 | 10 | 9 | 11 | 9 | 10 | 10 | 10 | 11 | 120.0% |
| LAX | 10 | 11 | 11 | 15 | 14 | 9 | 9 | 10 | 10 | 10 | 10 | 0.0% |
| MCO | 10 | 8 | 10 | 9 | 8 | 8 | 7 | 7 | 5 | 8 | 7 | -30.0% |
| SFO | 5 | 3 | 3 | 4 | 6 | 4 | 5 | 6 | 7 | 8 | 8 | 60.0% |
| PHL | 1 | 2 | 3 | 3 | 2 | 5 | 6 | 6 | 8 | 8 | 8 | 700.0% |
| Other | 42 | 42 | 41 | 40 | 40 | 41 | 48 | 53 | 59 | 58 | 63 | 50.0% |
| Total | 171 | 166 | 180 | 190 | 184 | 182 | 193 | 210 | 224 | 229 | 227 | 32.7% |

**Selected European Gateways**
**U.S. Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LGW | 17 | 20 | 18 | 19 | 20 | 19 | 22 | 22 | 23 | 23 | 24 | 41.2% |
| FRA | 16 | 16 | 16 | 17 | 17 | 18 | 18 | 18 | 17 | 18 | 20 | 25.0% |
| CDG | 13 | 11 | 10 | 10 | 10 | 11 | 12 | 13 | 15 | 16 | 17 | 30.8% |
| AMS | 12 | 12 | 12 | 14 | 13 | 16 | 18 | 18 | 18 | 16 | 15 | 25.0% |
| LHR | 12 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | -8.3% |
| ZRH | 6 | 7 | 6 | 8 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 83.3% |
| MXP | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 8 | 9 | 125.0% |
| MAD | 6 | 6 | 8 | 8 | 6 | 6 | 6 | 6 | 8 | 8 | 8 | 33.3% |
| BRU | 4 | 4 | 5 | 7 | 6 | 5 | 5 | 8 | 9 | 9 | 8 | 100.0% |
| MUC | 3 | 4 | 5 | 7 | 7 | 4 | 6 | 7 | 8 | 8 | 8 | 166.7% |
| MAN | 4 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 8 | 7 | 7 | 75.0% |
| Other | 77 | 70 | 76 | 77 | 76 | 75 | 81 | 86 | 89 | 93 | 86 | 11.7% |
| Total | 174 | 171 | 177 | 188 | 184 | 184 | 200 | 211 | 223 | 227 | 224 | 28.7% |

*Source: US DOT T-100*

The bottom half of the table indicates that the same is true in Europe. The constrained London-Heathrow gateway declined slightly, while London-Gatwick, Amsterdam, Zurich, Milan-Malpensa, Munich, and Rome-da Vinci all grew by considerable amounts. In a number of cases, this results from both the utilization of smaller aircraft and the development of airline “alliances”—an example being the Washington Dulles-Amsterdam route flown by Northwest (with a DC-10), which would not have been viable in the absence of the alliance structure.

Exhibits 3-9 and 3-10 display relative share data for the gateways listed in Exhibit 3-6 for both departures and seats.

## Exhibit 3-9

**Share of U.S. Transatlantic Departures By Gateway (>50 Annual Departures)**
**1990 - 2000**

**Selected U.S. Gateways**
**European Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JFK | 38.0% | 33.8% | 32.1% | 30.2% | 31.0% | 31.0% | 29.3% | 26.5% | 24.7% | 23.1% | 22.9% | **-39.6%** |
| EWR | 5.1% | 6.4% | 6.7% | 6.6% | 6.5% | 6.6% | 7.6% | 9.6% | 11.3% | 12.0% | 11.7% | **127.7%** |
| ORD | 9.9% | 10.2% | 10.2% | 10.0% | 9.8% | 10.5% | 10.2% | 10.6% | 10.9% | 11.3% | 11.2% | **13.1%** |
| ATL | 5.0% | 6.2% | 6.2% | 6.6% | 6.9% | 6.7% | 6.3% | 6.2% | 6.6% | 6.7% | 6.5% | **28.0%** |
| BOS | 5.7% | 5.8% | 5.8% | 5.6% | 5.8% | 5.5% | 5.7% | 5.5% | 5.4% | 5.6% | 5.5% | **-3.6%** |
| MIA | 4.6% | 5.4% | 5.9% | 5.9% | 4.8% | 5.3% | 5.5% | 5.3% | 4.6% | 4.3% | 4.2% | **-8.7%** |
| IAD | 4.1% | 4.6% | 5.2% | 6.1% | 6.7% | 6.3% | 6.2% | 5.9% | 6.1% | 6.1% | 6.7% | **62.8%** |
| LAX | 5.8% | 6.0% | 6.3% | 6.7% | 6.4% | 5.8% | 5.5% | 5.5% | 5.2% | 5.2% | 5.5% | **-4.8%** |
| MCO | 2.3% | 2.7% | 3.0% | 3.4% | 2.9% | 2.7% | 2.7% | 1.8% | 1.4% | 1.9% | 1.6% | **-28.9%** |
| SFO | 2.0% | 1.9% | 1.9% | 2.7% | 3.1% | 3.0% | 3.3% | 3.5% | 3.3% | 3.4% | 3.6% | **85.1%** |
| PHL | 0.5% | 0.5% | 1.2% | 1.0% | 1.1% | 1.5% | 2.1% | 2.7% | 3.3% | 3.6% | 3.3% | **547.5%** |
| Other | 17.0% | 16.5% | 15.3% | 15.2% | 15.1% | 15.1% | 15.6% | 16.9% | 17.2% | 16.8% | 17.3% | **1.8%** |

**Selected European Gateways**
**U.S. Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LGW | 12.4% | 13.7% | 11.8% | 10.4% | 10.3% | 10.3% | 10.3% | 10.6% | 10.9% | 11.0% | 10.7% | **-13.8%** |
| FRA | 13.4% | 14.1% | 14.4% | 13.9% | 13.4% | 13.8% | 12.9% | 11.6% | 10.4% | 10.2% | 10.6% | **-21.0%** |
| CDG | 8.6% | 8.5% | 8.1% | 7.3% | 7.2% | 7.0% | 7.2% | 8.2% | 9.0% | 10.0% | 12.0% | **39.6%** |
| AMS | 5.7% | 6.1% | 6.0% | 6.7% | 7.0% | 7.5% | 8.8% | 8.7% | 8.1% | 7.9% | 7.7% | **35.6%** |
| LHR | 16.7% | 15.1% | 16.0% | 17.2% | 18.7% | 20.0% | 19.3% | 20.0% | 20.7% | 20.1% | 19.7% | **17.8%** |
| ZRH | 3.9% | 3.6% | 3.4% | 3.4% | 3.6% | 3.5% | 3.7% | 3.6% | 3.8% | 3.8% | 4.5% | **14.8%** |
| MXP | 2.1% | 2.6% | 2.6% | 2.6% | 2.6% | 2.9% | 2.7% | 2.5% | 2.5% | 3.1% | 3.4% | **63.6%** |
| MAD | 3.4% | 3.5% | 3.9% | 3.7% | 3.2% | 3.4% | 3.2% | 3.5% | 3.4% | 3.5% | 3.3% | **-3.0%** |
| BRU | 4.3% | 3.6% | 3.2% | 4.1% | 3.6% | 3.3% | 3.6% | 3.2% | 3.2% | 3.4% | 3.5% | **-18.9%** |
| MUC | 1.4% | 1.5% | 2.0% | 2.4% | 2.3% | 1.4% | 1.7% | 2.1% | 2.3% | 2.3% | 2.2% | **52.4%** |
| MAN | 2.2% | 2.7% | 3.0% | 3.0% | 2.7% | 2.5% | 2.6% | 2.7% | 2.6% | 2.4% | 2.5% | **13.4%** |
| Other | 26.0% | 24.8% | 25.6% | 25.3% | 25.5% | 24.4% | 23.9% | 23.4% | 23.0% | 22.4% | 20.1% | **-22.8%** |

*Source: US DOT T-100*

## Exhibit 3-10

**Share of U.S. Transatlantic Seats By Gateway (>50 Annual Departures)**
**1990 - 2000**

**Selected U.S. Gateways**
**European Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JFK | 39.4% | 34.4% | 32.0% | 29.7% | 30.7% | 30.7% | 28.4% | 25.3% | 23.3% | 22.0% | 21.6% | -45.1% |
| EWR | 4.5% | 6.0% | 6.5% | 6.3% | 6.4% | 6.3% | 7.1% | 9.1% | 10.5% | 11.2% | 11.0% | 142.7% |
| ORD | 8.8% | 8.8% | 8.8% | 9.0% | 8.6% | 9.4% | 9.1% | 9.7% | 10.1% | 10.4% | 10.4% | 17.7% |
| ATL | 4.5% | 5.6% | 5.6% | 6.0% | 6.3% | 6.1% | 5.9% | 5.5% | 5.7% | 5.9% | 5.7% | 25.4% |
| BOS | 6.2% | 6.3% | 6.6% | 6.1% | 6.2% | 5.7% | 5.7% | 5.6% | 5.6% | 5.6% | 5.4% | -12.3% |
| MIA | 5.1% | 6.1% | 6.2% | 6.3% | 5.2% | 5.8% | 6.2% | 6.2% | 5.4% | 5.1% | 5.1% | -1.1% |
| IAD | 3.7% | 3.9% | 5.0% | 6.0% | 6.4% | 6.3% | 6.1% | 6.2% | 6.4% | 6.4% | 7.0% | 90.5% |
| LAX | 7.0% | 7.2% | 7.2% | 7.5% | 7.4% | 6.8% | 6.7% | 6.8% | 6.5% | 6.3% | 6.6% | -5.8% |
| MCO | 2.2% | 2.7% | 3.3% | 3.9% | 3.4% | 3.2% | 3.3% | 2.3% | 2.1% | 2.7% | 2.4% | 9.2% |
| SFO | 2.4% | 2.5% | 2.4% | 3.2% | 3.8% | 3.7% | 3.8% | 4.2% | 4.1% | 4.2% | 4.5% | 85.2% |
| PHL | 0.6% | 0.5% | 1.1% | 1.0% | 1.1% | 1.4% | 2.0% | 2.4% | 2.9% | 2.9% | 2.8% | 409.4% |
| Other | 15.6% | 15.9% | 15.2% | 14.8% | 14.5% | 14.6% | 15.7% | 16.8% | 17.5% | 17.2% | 17.6% | 12.4% |

**Selected European Gateways**
**U.S. Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LGW | 12.0% | 14.5% | 13.2% | 11.5% | 11.0% | 10.5% | 10.7% | 10.7% | 11.5% | 11.9% | 11.7% | -2.8% |
| FRA | 13.6% | 14.2% | 14.3% | 13.8% | 13.1% | 13.5% | 13.0% | 11.9% | 11.1% | 11.0% | 11.4% | -16.1% |
| CDG | 8.7% | 8.3% | 7.9% | 7.0% | 7.0% | 6.6% | 7.1% | 8.0% | 8.7% | 9.1% | 11.7% | 33.9% |
| AMS | 6.4% | 7.2% | 7.1% | 8.0% | 8.5% | 9.1% | 10.3% | 10.2% | 9.4% | 9.2% | 8.8% | 37.5% |
| LHR | 19.3% | 16.6% | 17.0% | 18.8% | 20.3% | 22.1% | 21.1% | 22.2% | 22.9% | 22.3% | 21.4% | 11.0% |
| ZRH | 3.6% | 3.5% | 3.3% | 3.6% | 3.7% | 3.5% | 3.5% | 3.4% | 3.6% | 3.5% | 3.7% | 2.5% |
| MXP | 2.7% | 3.2% | 2.9% | 2.8% | 2.7% | 2.7% | 2.4% | 2.1% | 2.1% | 2.7% | 3.2% | 16.3% |
| MAD | 3.7% | 3.6% | 4.1% | 3.6% | 3.4% | 3.5% | 3.4% | 3.4% | 3.3% | 3.3% | 3.2% | -14.3% |
| BRU | 3.7% | 3.2% | 2.7% | 3.5% | 3.1% | 2.9% | 2.8% | 2.6% | 3.0% | 3.2% | 3.1% | -16.3% |
| MUC | 1.1% | 1.1% | 1.4% | 1.9% | 1.8% | 1.2% | 1.4% | 1.8% | 1.8% | 2.0% | 1.9% | 83.6% |
| MAN | 2.0% | 2.2% | 2.7% | 2.7% | 2.4% | 2.2% | 2.4% | 2.5% | 2.5% | 2.4% | 2.6% | 31.5% |
| Other | 23.2% | 22.5% | 23.3% | 22.8% | 23.1% | 22.4% | 21.9% | 21.1% | 20.0% | 19.3% | 17.3% | -25.4% |

*Source: US DOT T-100*

### Transpacific

While the U.S. transpacific market is not as mature as the corresponding transatlantic sector, similar results were observed with respect to the development of a considerable degree of market fragmentation. Again, during the 1990-2000 period, departures grew faster than overall seat capacity (Exhibits 3-11a and 3-11b).

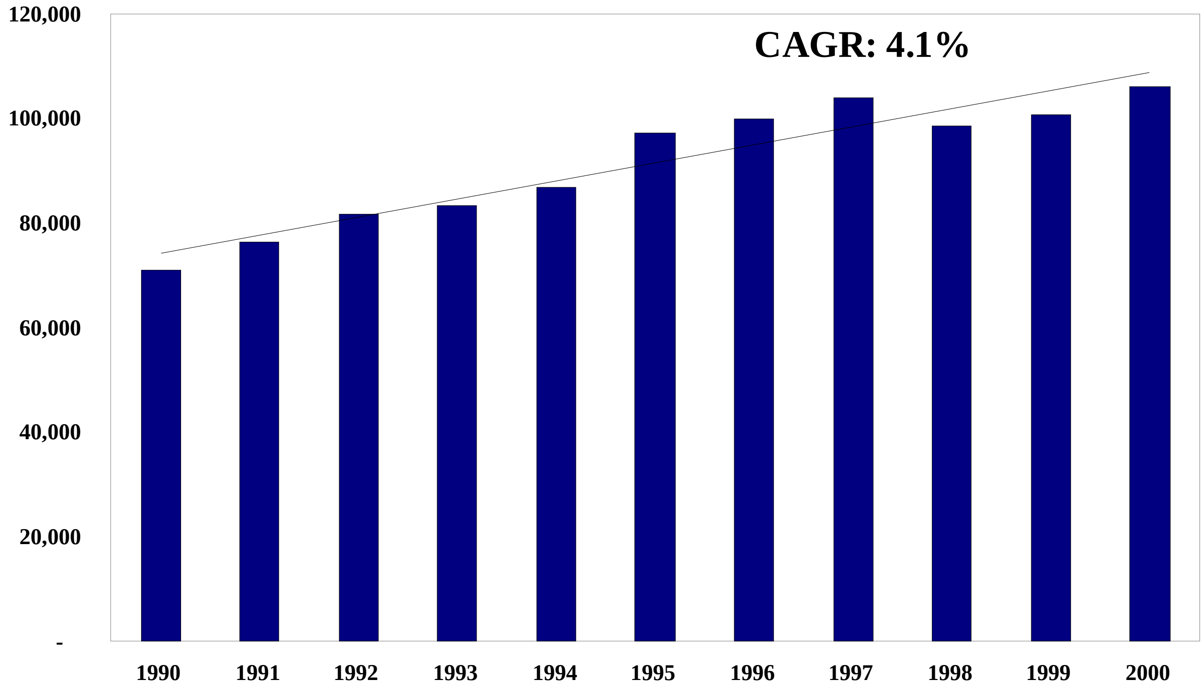
With respect to average aircraft size, there does not appear to be a discernible trend (Exhibit 3-12). However, it is clear that there was not an overall increase in average aircraft size in the U.S. transpacific market in the 1990s; if anything, there was a small decrease.

Length-of-haul did increase in this market, however, as shown by Exhibit 3-13. This reflects the availability and utilization of aircraft with greater range capabilities than such aircraft as the 747-200 and DC-10-30.

## Exhibit 3-11a

## U.S. Transpacific Service 1990 - 2000: Departures Growing Faster Than Seats

### Total Departures

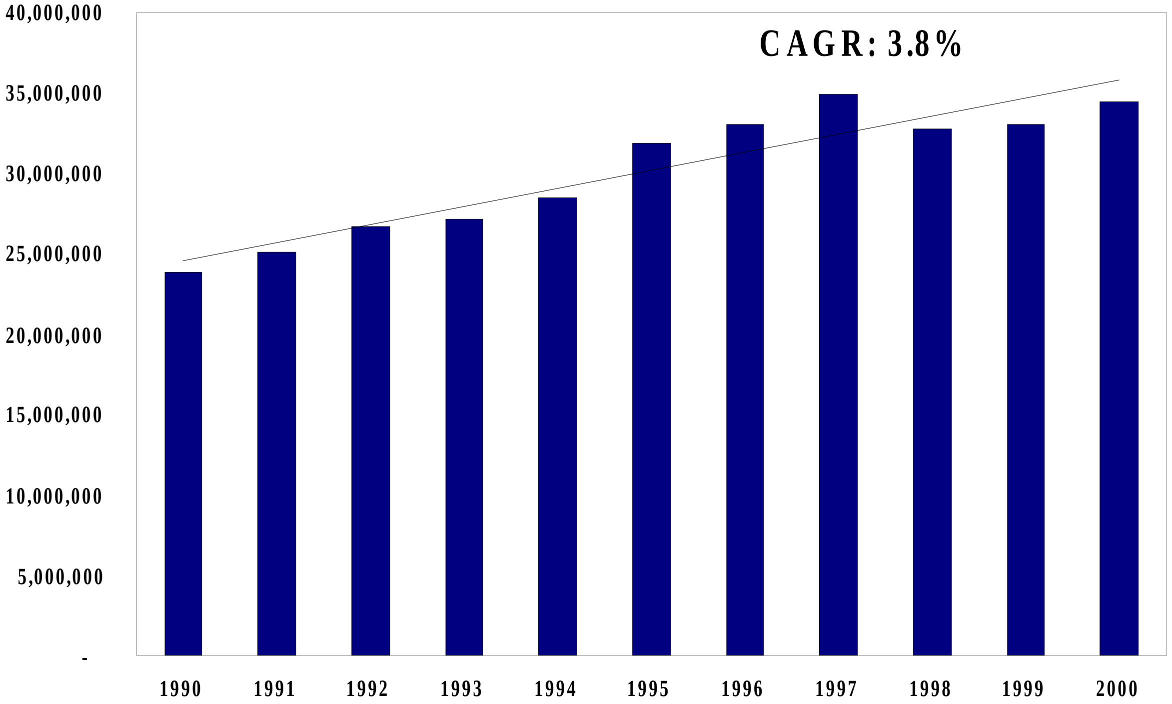


*Source: US DOT T-100*

## Exhibit 3-11b

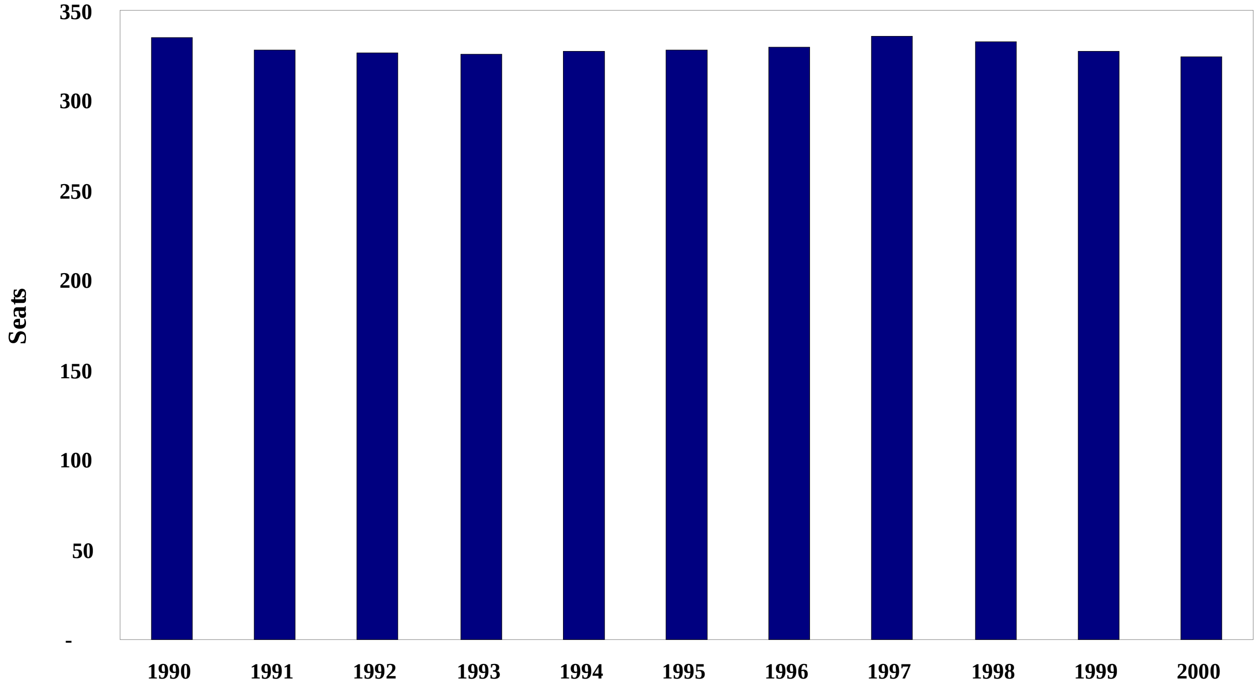
## U.S. Transpacific Service 1990 - 2000: Departures Growing Faster Than Seats

### Total Seats



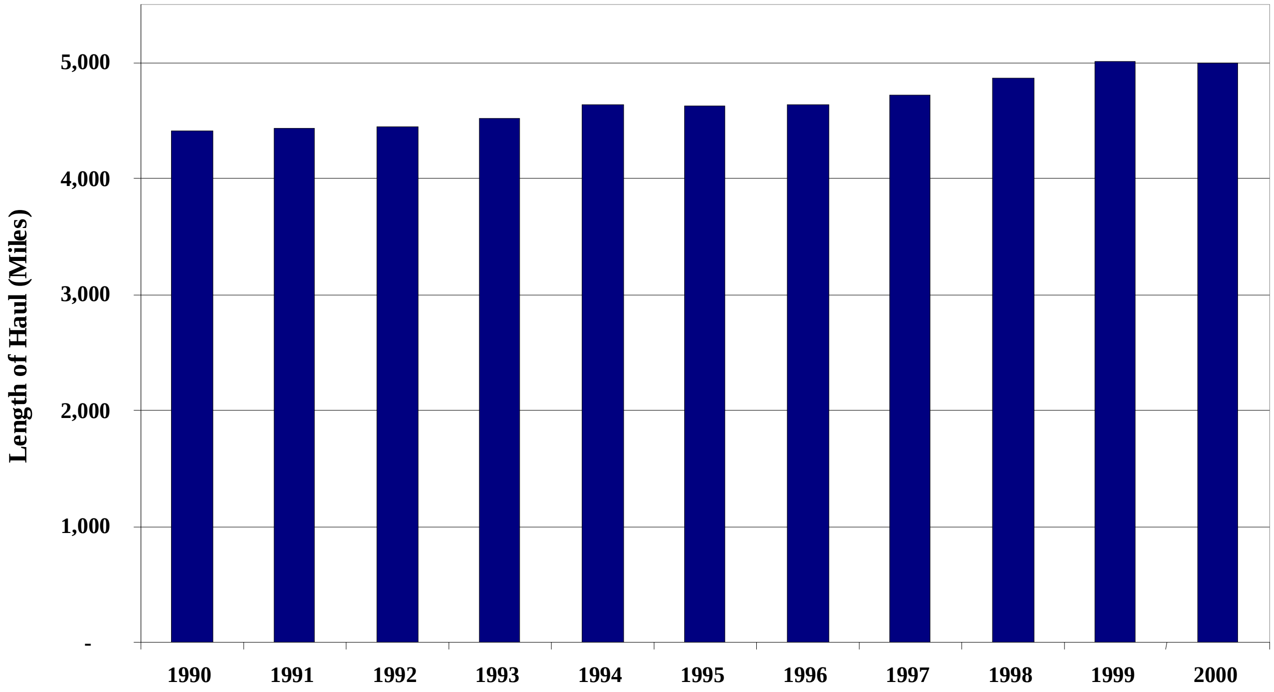
*Source: US DOT T-100*

## Exhibit 3-12
## Average Aircraft Size - U.S. Transpacific Service
## 1990 - 2000



*Source: US DOT T-100*

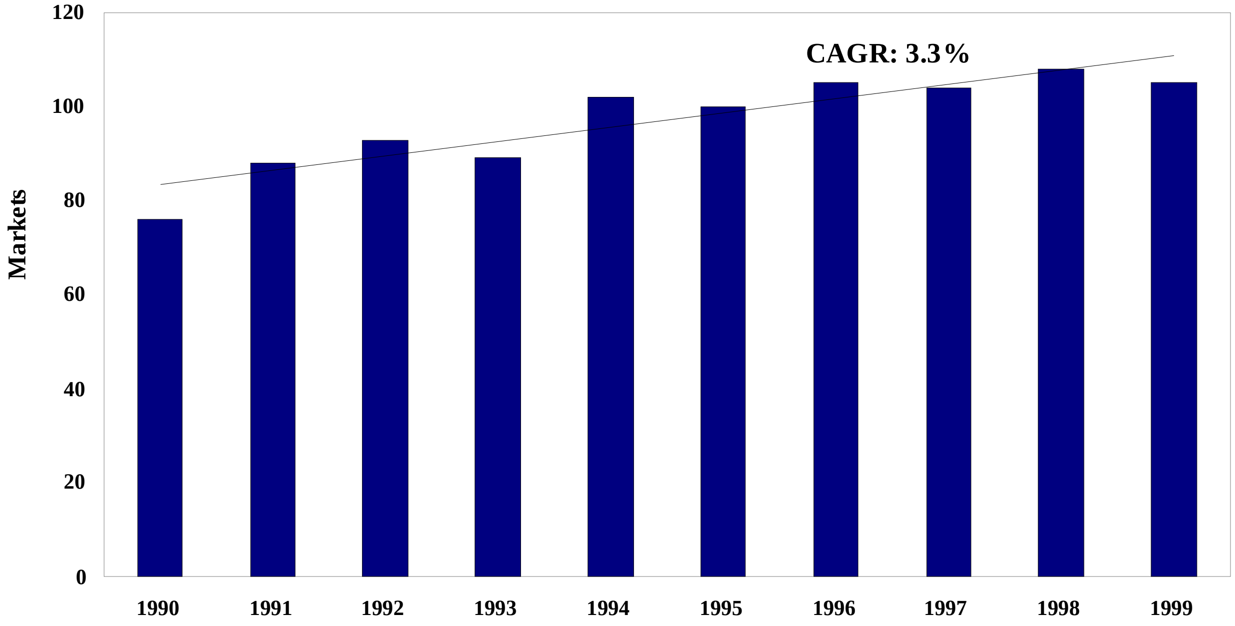
## Exhibit 3-13
## Average Length of Haul - U.S. Transpacific Service
## 1999 - 2000



*Source: US DOT T-100*

As on the Atlantic, the number of nonstop markets in U.S. transpacific service grew steadily during the 1990s (Exhibit 3-14). At a compound annual growth rate (CAGR) of three-and-three-tenths per cent (3.3%) during this period, the Pacific grew faster than the Atlantic (2.4% CAGR) by this measure.

**Exhibit 3-14**
**Number of U.S. Transpacific Nonstop Markets With Greater Than 50 Annual Departures (Each Way)**
**1999 - 2000**



*Source: US DOT T-100*

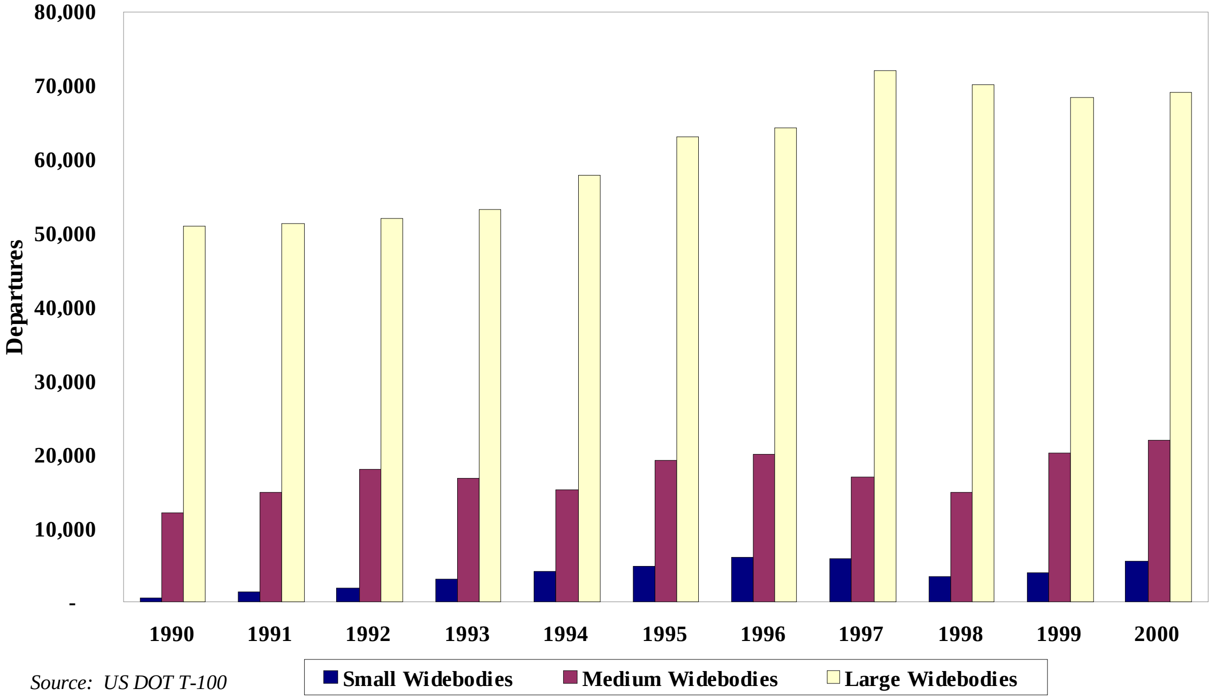
Exhibit 3-15 shows that the large widebody aircraft category has dominated the U.S. transpacific markets throughout the period between 1990 and 2000, with an absolute increase of approximately 40 per cent (40%). Nonetheless, medium widebodies showed a strong upward trend during this time and now constitute a significant share of total departures. During 2001 (prior to September 11), Japan's ANA converted the 747-400 on its NRT-ORD route to a smaller 777; such may be a harbinger of further downward adjustments in aircraft size in the U.S. transpacific market, reflecting additional competition, frequencies and gateways.

As with the Atlantic, a number of new gateway services began in the U.S. transpacific market during the 1990s (Exhibit 3-16). Here again, longstanding gateways such as HNL, SFO, SEA and JFK achieved little net increase (although the other major west coast gateway, LAX, was a notable exception), while locations such as DTW, ORD and DFW, as well as LAX, gained considerable new service.

## Exhibit 3-15

## U.S. Transpacific Service 1990 - 2000: Departures by Equipment Type

## 1990 - 2000



*Source: US DOT T-100*

## Exhibit 3-16

**Number of U.S. Transpacific Markets Served Nonstop (>50 Annual Departures)**
**1990 - 2000**

**Selected U.S. Gateways**
**Pacific Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HNL | 16 | 18 | 20 | 19 | 20 | 18 | 18 | 17 | 19 | 19 | 19 | 18.8% |
| LAX | 8 | 8 | 10 | 10 | 13 | 12 | 12 | 14 | 15 | 15 | 14 | 75.0% |
| SFO | 7 | 7 | 7 | 6 | 8 | 8 | 8 | 9 | 8 | 9 | 9 | 28.6% |
| DTW | 2 | 2 | 2 | 2 | 4 | 3 | 4 | 4 | 4 | 4 | 5 | 150.0% |
| ORD | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 300.0% |
| SEA | 4 | 4 | 4 | 3 | 2 | 5 | 5 | 5 | 4 | 4 | 4 | 0.0% |
| ANC | 4 | 5 | 5 | 5 | 5 | 5 | 7 | 6 | 7 | 5 | 3 | -25.0% |
| DFW | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 200.0% |
| IAD | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 100.0% |
| JFK | 2 | 3 | 3 | 3 | 2 | 2 | 4 | 3 | 2 | 2 | 2 | 0.0% |
| MSP | 1 | 1 | 1 |  |  |  | 1 | 2 | 3 | 2 | 2 | 100.0% |
| PDX | 2 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 2 | 0.0% |
| Other | 22 | 31 | 33 | 30 | 35 | 36 | 34 | 31 | 29 | 32 | 31 | 40.9% |
| Total | 71 | 85 | 92 | 86 | 97 | 97 | 100 | 99 | 101 | 102 | 100 | 40.8% |

**Selected Pacific Gateways**
**U.S. Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NRT | 15 | 16 | 15 | 15 | 15 | 15 | 17 | 16 | 17 | 19 | 19 | 26.7% |
| SEL | 9 | 10 | 11 | 11 | 10 | 11 | 11 | 11 | 9 | 9 | 11 | 22.2% |
| OSA / KIX | 6 | 7 | 7 | 5 | 6 | 7 | 7 | 8 | 9 | 10 | 10 | 66.7% |
| TPE | 4 | 6 | 7 | 8 | 8 | 9 | 8 | 8 | 8 | 7 | 7 | 75.0% |
| HKG | 3 | 4 | 5 | 5 | 4 | 5 | 6 | 6 | 6 | 5 | 5 | 66.7% |
| NGO | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 5 | 66.7% |
| SYD | 2 | 3 | 3 | 2 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 50.0% |
| AKL | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0.0% |
| CTS |  | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | n/a |
| FUK | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 0.0% |
| MNL | 4 | 4 | 4 | 4 | 5 | 6 | 6 | 6 | 5 | 4 | 2 | -50.0% |
| PEK |  |  |  |  |  | 2 | 1 | 1 | 1 | 2 | 2 | n/a |
| Other | 23 | 26 | 27 | 25 | 36 | 27 | 31 | 28 | 33 | 28 | 31 | 34.8% |
| Total | 73 | 87 | 92 | 88 | 100 | 99 | 103 | 100 | 104 | 100 | 101 | 38.4% |

*Source: US DOT T-100*

Finally, as shown in Exhibits 3-17 and 3-18, the relative departure and seat shares of the "traditional" gateways declined, or were stagnant.

**Exhibit 3-17**

**Share of U.S. Transpacific Departures By Gateway (>50 Annual Departures)**
**1990 - 2000**

**Selected U.S. Gateways**
**Pacific Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HNL | 28.7% | 27.7% | 27.8% | 25.1% | 23.2% | 21.8% | 21.1% | 20.6% | 18.3% | 16.3% | 16.1% | **-43.9%** |
| LAX | 17.0% | 18.1% | 20.1% | 22.7% | 24.6% | 23.6% | 23.6% | 24.8% | 28.1% | 27.9% | 27.6% | **62.0%** |
| SFO | 11.7% | 10.6% | 10.0% | 9.7% | 10.8% | 11.6% | 11.7% | 11.8% | 11.6% | 12.3% | 12.4% | **5.9%** |
| DTW | 1.5% | 1.7% | 1.8% | 2.0% | 2.4% | 2.8% | 3.1% | 2.5% | 2.4% | 2.7% | 2.5% | **63.6%** |
| ORD | 1.7% | 2.4% | 2.6% | 3.0% | 3.0% | 2.5% | 2.5% | 2.6% | 4.0% | 4.9% | 5.2% | **208.7%** |
| SEA | 5.0% | 4.4% | 3.3% | 2.4% | 2.1% | 3.3% | 3.3% | 3.3% | 3.4% | 3.8% | 3.5% | **-28.8%** |
| ANC | 5.8% | 3.2% | 2.6% | 2.0% | 1.9% | 1.5% | 2.2% | 2.3% | 3.5% | 3.2% | 2.4% | **-59.4%** |
| DFW | 0.9% | 0.9% | 0.9% | 0.9% | 0.8% | 0.7% | 0.7% | 0.7% | 0.7% | 1.8% | 2.3% | **161.1%** |
| IAD | 0.8% | 1.0% | 0.9% | 0.7% | 0.6% | 0.5% | 0.4% | 0.4% | 0.6% | 0.7% | 0.9% | **13.1%** |
| JFK | 4.6% | 4.2% | 3.8% | 4.6% | 4.7% | 4.5% | 4.9% | 5.3% | 4.0% | 3.9% | 3.7% | **-18.5%** |
| MSP | 0.4% | 0.3% | 0.3% | 0.0% | 0.0% | 0.0% | 0.3% | 1.3% | 1.2% | 1.0% | 1.1% | **183.5%** |
| PDX | 1.9% | 2.6% | 2.7% | 2.8% | 2.5% | 2.4% | 2.2% | 2.1% | 2.3% | 2.0% | 1.4% | **-24.6%** |
| Other | 20.1% | 23.0% | 23.4% | 24.2% | 23.5% | 24.8% | 24.0% | 22.3% | 19.9% | 19.6% | 20.9% | **4.1%** |

**Selected Pacific Gateways**
**U.S. Destinations**

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NRT | 47.9% | 43.4% | 40.4% | 38.9% | 37.2% | 33.7% | 32.9% | 32.3% | 35.1% | 37.7% | 36.1% | **-24.6%** |
| SEL | 11.1% | 9.8% | 11.7% | 13.0% | 14.0% | 14.2% | 14.6% | 15.1% | 10.2% | 9.5% | 10.9% | **-1.8%** |
| KIX / OSA | 5.4% | 5.6% | 5.4% | 4.9% | 6.2% | 10.8% | 11.4% | 12.1% | 12.4% | 11.0% | 10.7% | **97.7%** |
| TPE | 3.4% | 4.8% | 4.9% | 6.7% | 8.4% | 8.8% | 8.6% | 8.4% | 8.7% | 8.6% | 8.3% | **148.9%** |
| HKG | 3.6% | 3.7% | 4.0% | 4.2% | 4.5% | 4.8% | 4.6% | 4.7% | 5.1% | 5.4% | 5.0% | **36.3%** |
| NGO | 3.4% | 5.9% | 6.7% | 6.1% | 5.6% | 5.2% | 4.7% | 5.0% | 5.4% | 5.2% | 5.2% | **52.7%** |
| SYD | 4.4% | 4.9% | 4.5% | 4.2% | 3.4% | 4.0% | 4.2% | 4.0% | 4.4% | 4.6% | 5.0% | **13.9%** |
| AKL | 4.1% | 4.2% | 4.1% | 3.7% | 3.1% | 2.6% | 2.5% | 2.5% | 3.0% | 3.1% | 2.6% | **-35.9%** |
| CTS | 0.0% | 0.4% | 0.7% | 0.7% | 1.0% | 1.1% | 1.3% | 1.2% | 1.2% | 1.0% | 1.0% | **n/a** |
| FUK | 1.6% | 2.5% | 3.2% | 2.2% | 2.4% | 2.6% | 2.7% | 2.4% | 1.6% | 1.9% | 1.5% | **-4.4%** |
| MNL | 3.2% | 3.4% | 3.1% | 3.5% | 3.1% | 2.8% | 2.9% | 3.0% | 2.2% | 2.1% | 1.1% | **-65.7%** |
| PEK | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.3% | 0.2% | 0.3% | 0.4% | 0.7% | 0.8% | **n/a** |
| Other | 11.8% | 11.4% | 11.3% | 11.7% | 11.2% | 9.2% | 9.5% | 9.0% | 10.2% | 9.3% | 11.6% | **-1.9%** |

*Source: US DOT T-100*

## Europe-Asia

While there are no comprehensive data comparable to the T-100 available for the set of markets between Europe and Asia, its requirements need to be examined. This market area represents one of the three primary areas of use for long-haul, high-capacity aircraft (the other two being transatlantic and transpacific). Accordingly, OAG schedule data for several of the key traffic points for both 1990 and 2000 were examined; the results are summarized in Exhibits 3-19a and 3-19b.

It is apparent that the trends noted on the North Atlantic and North Pacific routes are also present in the Europe-Asia market. Departures and the number of destinations served have increased considerably during the 1990s, along with a greater proportion of small and medium-sized widebody equipment, although there also has been significant growth in large widebody operations in this market sector during the period

# Exhibit 3-18

## Share of U.S. Transpacific Seats By Gateway (>50 Annual Departures)

## 1990 - 2000

### Selected U.S. Gateways

Pacific Destinations

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HNL | 31.1% | 30.1% | 29.6% | 26.4% | 24.3% | 23.2% | 22.8% | 22.5% | 20.7% | 17.9% | 17.3% | -44.3% |
| LAX | 19.1% | 20.6% | 22.7% | 25.8% | 27.8% | 26.5% | 26.4% | 27.1% | 30.4% | 30.4% | 30.2% | 58.5% |
| SFO | 12.4% | 11.7% | 11.5% | 11.4% | 12.3% | 13.1% | 13.3% | 13.0% | 12.5% | 12.7% | 12.9% | 3.9% |
| DTW | 1.7% | 2.1% | 2.1% | 2.3% | 2.8% | 3.2% | 3.7% | 3.0% | 3.0% | 3.4% | 3.2% | 86.2% |
| ORD | 1.8% | 2.7% | 2.9% | 3.4% | 3.4% | 2.7% | 2.5% | 2.5% | 3.7% | 4.8% | 5.4% | 195.4% |
| SEA | 5.3% | 4.4% | 3.3% | 2.4% | 2.0% | 3.0% | 3.0% | 2.9% | 2.9% | 3.6% | 3.1% | -41.4% |
| ANC | 6.0% | 3.4% | 2.5% | 1.8% | 1.7% | 1.3% | 1.8% | 2.1% | 3.0% | 3.1% | 2.4% | -59.7% |
| DFW | 0.5% | 0.6% | 0.7% | 0.7% | 0.6% | 0.6% | 0.5% | 0.5% | 0.5% | 1.4% | 1.9% | 243.7% |
| IAD | 1.0% | 1.3% | 1.1% | 0.8% | 0.7% | 0.7% | 0.5% | 0.4% | 0.6% | 0.7% | 1.0% | 1.6% |
| JFK | 4.9% | 4.7% | 4.3% | 5.2% | 5.1% | 4.8% | 5.1% | 5.4% | 3.8% | 4.0% | 4.1% | -17.5% |
| MSP | 0.4% | 0.3% | 0.3% | 0.0% | 0.0% | 0.0% | 0.3% | 1.4% | 1.3% | 1.1% | 1.3% | 232.1% |
| PDX | 1.2% | 1.8% | 1.9% | 2.1% | 1.9% | 1.9% | 1.7% | 1.6% | 1.8% | 1.6% | 1.1% | -2.9% |
| Other | 14.6% | 16.6% | 17.3% | 17.8% | 17.3% | 19.0% | 18.4% | 17.6% | 15.7% | 15.4% | 16.1% | 10.4% |

### Selected Pacific Gateways

U.S. Destinations

| Gateway | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | % Ch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NRT | 52.5% | 47.8% | 44.9% | 43.1% | 40.4% | 36.7% | 35.7% | 34.9% | 37.0% | 38.7% | 37.6% | -28.4% |
| SEL | 10.3% | 9.2% | 11.3% | 12.4% | 13.5% | 13.7% | 14.1% | 14.4% | 9.9% | 9.3% | 10.9% | 5.6% |
| KIX / OSA | 6.5% | 7.0% | 6.6% | 5.9% | 7.2% | 11.5% | 12.2% | 13.0% | 13.4% | 11.8% | 11.5% | 76.9% |
| TPE | 3.4% | 5.0% | 5.3% | 6.9% | 8.3% | 8.5% | 8.2% | 8.1% | 8.8% | 8.9% | 8.7% | 154.5% |
| HKG | 3.7% | 4.0% | 4.5% | 4.7% | 4.9% | 5.3% | 5.3% | 5.3% | 5.5% | 5.6% | 5.2% | 41.0% |
| NGO | 2.7% | 4.5% | 5.6% | 5.1% | 4.7% | 4.5% | 4.2% | 4.7% | 4.7% | 4.5% | 4.5% | 70.1% |
| SYD | 4.6% | 5.1% | 4.7% | 4.7% | 4.1% | 4.7% | 5.0% | 4.7% | 5.2% | 5.3% | 5.4% | 18.1% |
| AKL | 4.6% | 4.5% | 4.0% | 3.9% | 3.4% | 2.8% | 2.7% | 2.8% | 3.2% | 3.3% | 2.9% | -36.7% |
| CTS | 0.0% | 0.4% | 0.6% | 0.6% | 0.7% | 0.8% | 0.9% | 0.9% | 0.9% | 0.8% | 0.8% | n/a |
| FUK | 0.8% | 1.5% | 1.9% | 1.5% | 1.6% | 1.9% | 1.9% | 1.7% | 1.5% | 1.7% | 1.3% | 72.6% |
| MNL | 2.5% | 2.8% | 2.7% | 3.0% | 2.7% | 2.4% | 2.5% | 2.5% | 1.8% | 1.7% | 0.6% | -76.9% |
| PEK | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.3% | 0.3% | 0.4% | 0.6% | 0.8% | 1.0% | n/a |
| Other | 8.4% | 8.2% | 7.8% | 8.3% | 8.4% | 6.9% | 7.0% | 6.7% | 7.6% | 7.5% | 9.6% | 14.2% |

*Source: US DOT T-100*

# Exhibit 3-19a

## Scheduled Service from Select European Gateways to Asia: 1990 vs. 2000

| | | Total Departures - August | | | Number of Asian Destinations | | |
|---|---|---|---|---|---|---|---|
| **Airport** | **Type of Aircraft** | **1990** | **2000** | **% Ch** | **1990** | **2000** | **% Ch** |
| CDG | Large Widebody | 145 | 333 | 129.7% | 8 | 10 | 25.0% |
| | Medium Widebody | | 244 | n/a | | 9 | n/a |
| | Small Widebody | | 22 | n/a | | 3 | n/a |
| **CDG Total** | | 145 | 599 | 313.1% | 8 | 16 | 100.0% |
| FRA | Large Widebody | 339 | 613 | 80.8% | 9 | 13 | 44.4% |
| | Medium Widebody | | 119 | n/a | | 8 | n/a |
| | Small Widebody | 9 | 98 | 988.9% | 1 | 6 | 500.0% |
| | Other | | 21 | n/a | | 3 | n/a |
| | Narrowbody | | 13 | n/a | | 2 | n/a |
| **FRA Total** | | 348 | 864 | 148.3% | 9 | 24 | 166.7% |
| LGW | Large Widebody | 67 | 8 | -88.1% | 3 | 1 | -66.7% |
| | Small Widebody | | 13 | n/a | | 1 | n/a |
| **LGW Total** | | 67 | 21 | -68.7% | 3 | 2 | -33.3% |
| LHR | Large Widebody | 364 | 864 | 137.4% | 6 | 9 | 50.0% |
| | Medium Widebody | | 193 | n/a | | 10 | n/a |
| | Narrowbody | | 18 | n/a | | 2 | n/a |
| | Small Widebody | | 8 | n/a | | 2 | n/a |
| **LHR Total** | | 364 | 1,083 | 197.5% | 6 | 20 | 233.3% |
| Total | Large Widebody | 915 | 1,818 | 98.7% | 10 | 15 | 50.0% |
| | Medium Widebody | - | 556 | n/a | - | 16 | n/a |
| | Small Widebody | 9 | 141 | 1466.7% | 1 | 8 | 700.0% |
| | Narrowbody | - | 31 | n/a | - | 2 | n/a |
| | Other | - | 21 | n/a | - | 3 | n/a |
| **Grand Total** | | 924 | 2,567 | 177.8% | 10 | 27 | 170.0% |

*Source: OAG*

**Exhibit 3-19b**

**Scheduled Service from Select Asian Gateways to Europe:
1990 vs. 2000**

| | | Total Departures - August | | | Number of European Destinations | | |
|---|---|---|---|---|---|---|---|
| **Airport** | **Type of Aircraft** | **1990** | **2000** | **% Ch** | **1990** | **2000** | **% Ch** |
| HKG | Large Widebody | 147 | 291 | 98.0% | 5 | 4 | -20.0% |
| | Medium Widebody | | 111 | n/a | | 5 | n/a |
| | Small Widebody | | 9 | n/a | | 1 | n/a |
| **HKG Total** | | 147 | 411 | 179.6% | 5 | 8 | 60.0% |
| NRT | Large Widebody | 273 | 448 | 64.1% | 7 | 8 | 14.3% |
| | Medium Widebody | 27 | 112 | 314.8% | 4 | 6 | 50.0% |
| | Small Widebody | 8 | 92 | 1050.0% | 1 | 3 | 200.0% |
| | Other | 79 | | -100.0% | 1 | | -100.0% |
| **NRT Total** | | 387 | 652 | 68.5% | 10 | 13 | 30.0% |
| SIN | Large Widebody | 187 | 462 | 147.1% | 7 | 5 | -28.6% |
| | Medium Widebody | | 107 | n/a | | 6 | n/a |
| | Small Widebody | 13 | | -100.0% | 2 | | -100.0% |
| **SIN Total** | | 200 | 569 | 184.5% | 9 | 8 | -11.1% |
| Total | Large Widebody | 607 | 1,201 | 97.9% | 11 | 8 | -27.3% |
| | Medium Widebody | 27 | 330 | 1122.2% | 4 | 11 | 175.0% |
| | Small Widebody | 21 | 101 | 381.0% | 3 | 3 | 0.0% |
| | Other | 79 | - | -100.0% | 1 | - | -100.0% |
| **Grand Total** | | 734 | 1,632 | 122.3% | 14 | 15 | 7.1% |

*Source: OAG*

examined, as well. Other markets, including Latin America and Africa have not been examined in detail since it is unlikely that they will constitute a significant portion of the demand for very large aircraft in the forecast time period.

### Conclusions-Market Structure

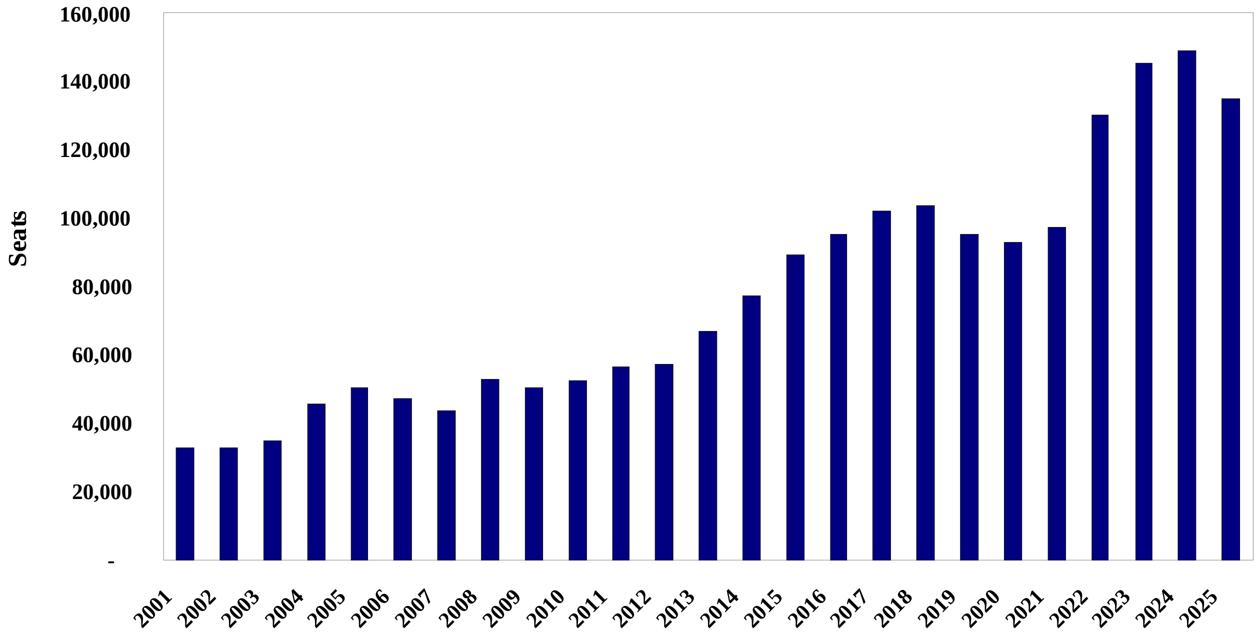
Market “fragmentation” is increasing in all three principal market areas (transatlantic, transpacific and Europe-Asia) where the fleet of large, long-haul aircraft identified in Exhibit 3-1 typically operate. In addition, there has been a significant trend towards smaller aircraft during the 1990s. The incidence of this trend has been greatest in the transatlantic market, appears to be accelerating in Europe-Asia, and has had a smaller impact in transpacific.

### *3.2.3: Capacity Requirements Forecast*

Exhibits 3-20a through 3-20f display the annual requirement for net new seats for long-haul international services for the years 2006-2025 inclusive. This consists of two elements: the replacement component (for either twenty-five or thirty years, as appropriate), and an incremental component representing four, four-and-one-half, and five per cent (4.0, 4.5 or 5.0 %) growth per annum of the seat capacity of the base fleet at year-end 2000, as shown in Exhibit 3-1. Even at four per cent (4.0%), the growth component is considerable due to the large installed base of existing capacity. This also allows for significant development of new routes and services.

## Exhibit 3-20a

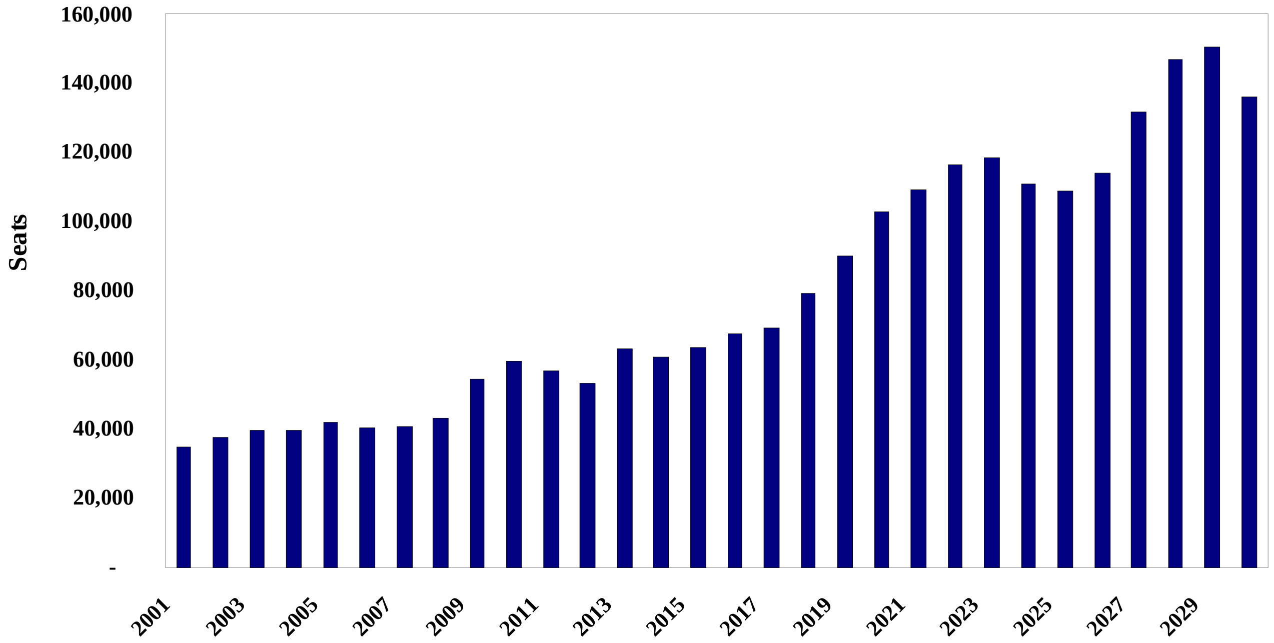
### Net New Seats Demanded
### 25 Year Lifespan and 4% Growth
### 2001 - 2025



It is clear in all three growth scenarios (4.0, 4.5 and 5.0%) that there is a significant increase in seats needed beginning after 2012 in the 25-year retirement case. This reflects both the buying “boom” of the late 1980s and corresponding high level of deliveries during the early 1990s, as well as the introduction of the 747-400. Under a 30-year retirement scenario, the sharp uptick in replacement need does not occur until after 2018. In either case (25 or 30 years) the “bubble” in replacement need comes significantly later than the A380’s entry into service date of 2006.

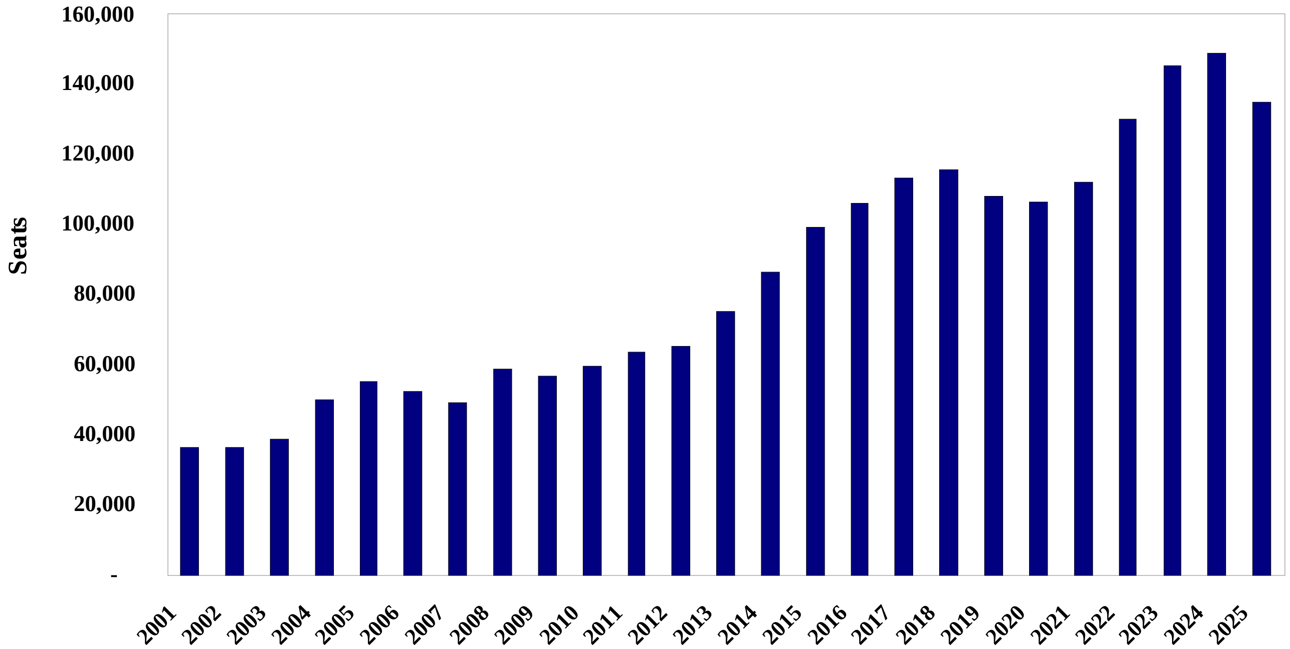
## Exhibit 3-20b

### Net New Seats Demanded
### 30 Year Lifespan and 4% Growth
### 2001 - 2030



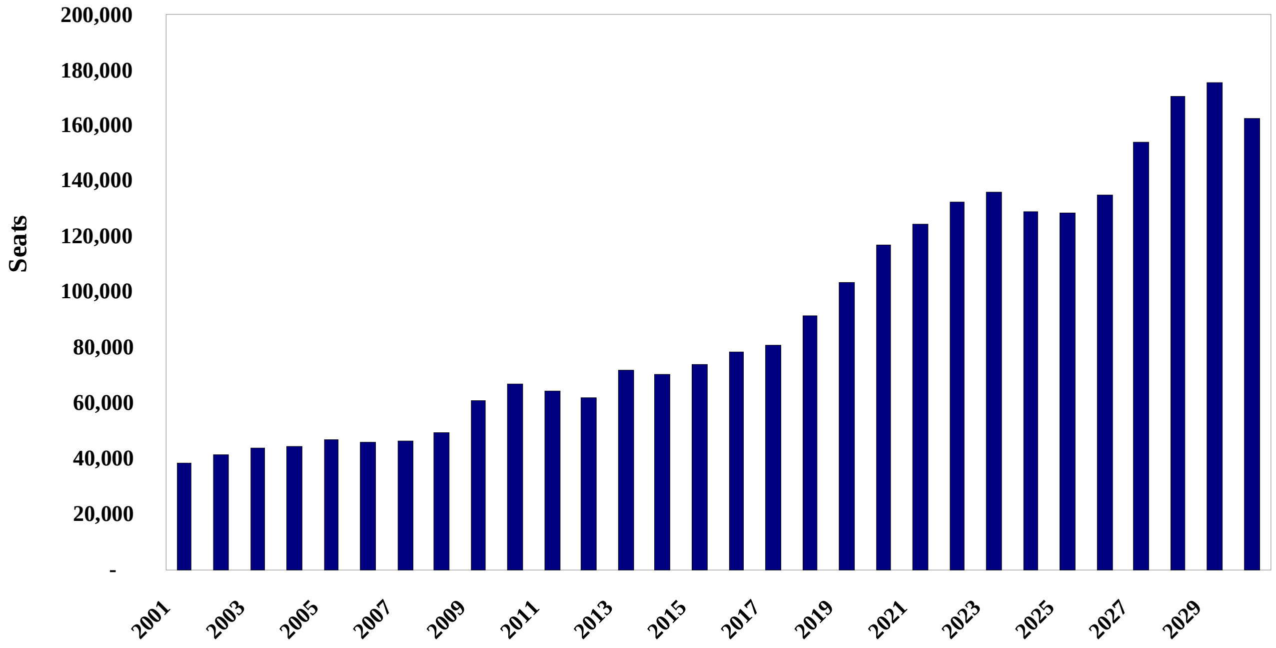
## Exhibit 3-20c

### Net New Seats Demanded
### 25 Year Lifespan and 4.5% Growth
### 2001 - 2025



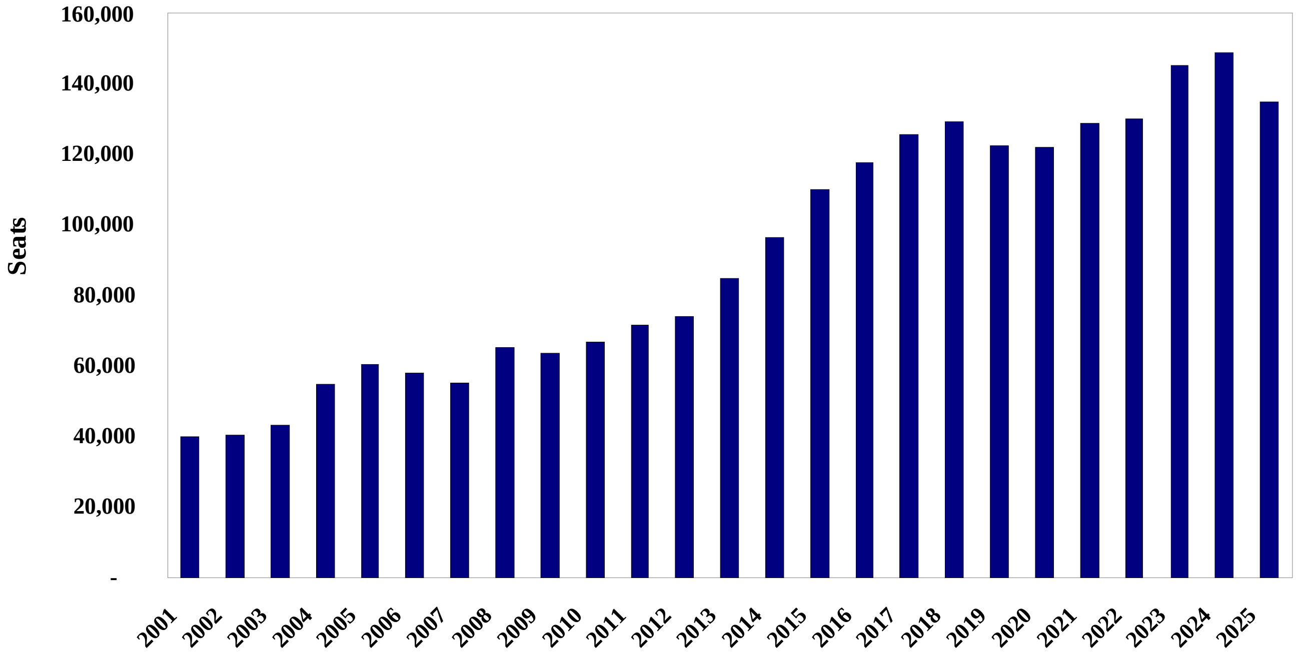
## Exhibit 3-20d

### Net New Seats Demanded
### 30 Year Lifespan and 4.5% Growth
### 2001 - 2030



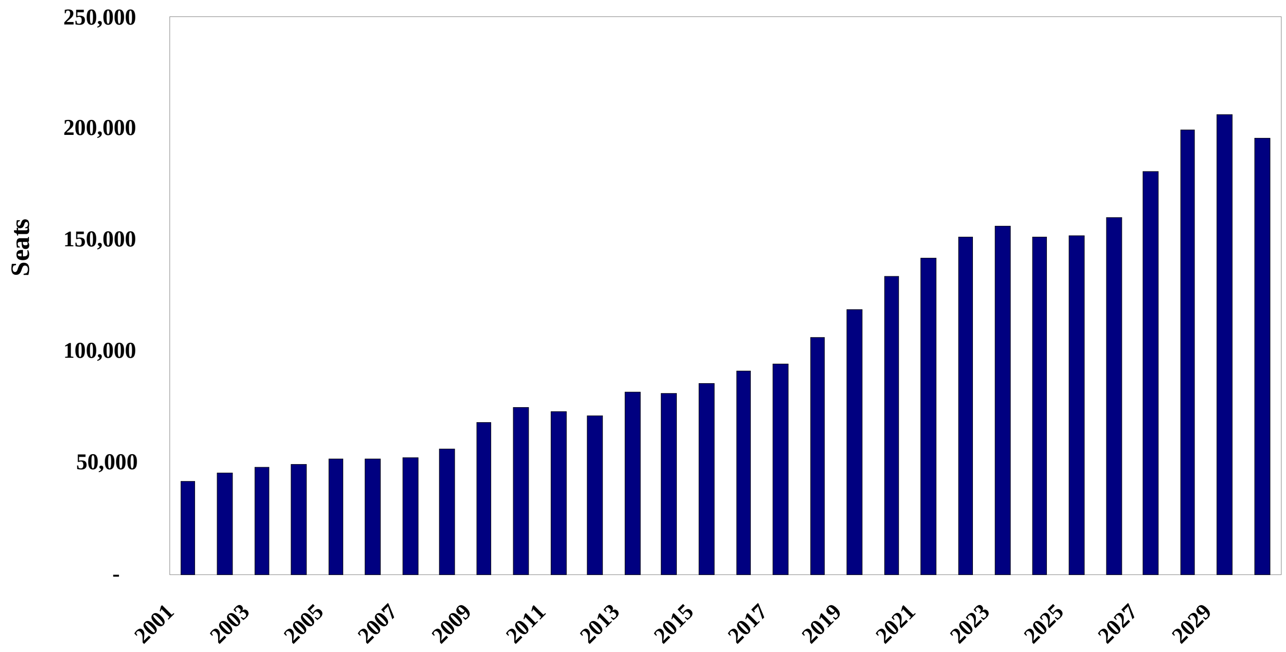
## Exhibit 3-20e

### Net New Seats Demanded
### 25 Year Lifespan and 5% Growth
### 2001 - 2025



## Exhibit 3-20f

### Net New Seats Demanded
### 30 Year Lifespan and 5% Growth
### 2001 - 2030



## 3.3: Passenger Aircraft Demand Forecast

Once the requirement for net new seats has been identified, it is possible to estimate the number of aircraft required in each year of the forecast period. If the A380 were the only aircraft available, this would be a simple matter. Since it is not the only relevant offering, competition and aircraft size mix need to be addressed prior to moving on to the actual aircraft forecast.

### *3.3.1: Competitive Considerations*

For the purposes of this analysis, competing aircraft available in this payload/range category during the forecast period are assumed to be as follows:

A330 (-200, -300)
A340 (-500, -600)
A380 (all models)
B767 (-300, -400)

B777 (-200, -300)

B747 (-400 and future derivatives; the proposed “Sonic Cruiser” was not considered)

As noted previously, by 2026 other aircraft, either new or derivative, will have entered the market, although there is no attempt to forecast these specifically.

### 3.3.2: Market Share/Delivery Forecasts

As shown in Exhibit 3-21, the proportion of large passenger widebodies as a percentage of total widebody deliveries has declined since the introduction of the 747 in 1970. During the 1970s, about 40% of total widebody deliveries were passenger versions of the 747, the only aircraft within the “large” cat-

## Exhibit 3-21
## Deliveries and Market Share by Aircraft Type: 1970 - 2000

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | *Decade Sub-total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Small Widebodies | - | - | - | - | 4 | 9 | 13 | 16 | 15 | 24 | *81* |
| Medium Widebodies | - | 13 | 69 | 96 | 88 | 68 | 35 | 25 | 26 | 50 | *470* |
| Large Widebodies | 92 | 69 | 30 | 30 | 22 | 21 | 27 | 20 | 32 | 67 | *410* |
| 747 Pax Versions | 92 | 69 | 29 | 30 | 19 | 13 | 22 | 11 | 17 | 44 | *346* |
| | 92 | 82 | 99 | 126 | 114 | 98 | 75 | 61 | 73 | 141 | *961* |
| Small Widebodies | 0.0% | 0.0% | 0.0% | 0.0% | 3.5% | 9.2% | 17.3% | 26.2% | 20.5% | 17.0% | *8.4%* |
| Medium Widebodies | 0.0% | 15.9% | 69.7% | 76.2% | 77.2% | 69.4% | 46.7% | 41.0% | 35.6% | 35.5% | *48.9%* |
| Large Widebodies | 100.0% | 84.1% | 30.3% | 23.8% | 19.3% | 21.4% | 36.0% | 32.8% | 43.8% | 47.5% | *42.7%* |
| Large Pax-Only WB | 100.0% | 84.1% | 29.6% | 23.8% | 17.1% | 14.4% | 31.4% | 21.2% | 29.3% | 37.3% | *38.6%* |

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | *Decade Sub-total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Small Widebodies | 39 | 38 | 66 | 91 | 77 | 67 | 56 | 69 | 98 | 84 | *685* |
| Medium Widebodies | 64 | 53 | 25 | 18 | 14 | 13 | 17 | 10 | 10 | 1 | *225* |
| Large Widebodies | 73 | 53 | 25 | 23 | 16 | 24 | 35 | 23 | 24 | 45 | *341* |
| 747 Pax Versions | 50 | 39 | 19 | 19 | 14 | 15 | 23 | 13 | 10 | 36 | *238* |
| | 176 | 144 | 116 | 132 | 107 | 104 | 108 | 102 | 132 | 130 | *1,251* |
| Small Widebodies | 22.2% | 26.4% | 56.9% | 68.9% | 72.0% | 64.4% | 51.9% | 67.6% | 74.2% | 64.6% | *54.8%* |
| Medium Widebodies | 36.4% | 36.8% | 21.6% | 13.6% | 13.1% | 12.5% | 15.7% | 9.8% | 7.6% | 0.8% | *18.0%* |
| Large Widebodies | 41.5% | 36.8% | 21.6% | 17.4% | 15.0% | 23.1% | 32.4% | 22.5% | 18.2% | 34.6% | *27.3%* |
| Large Pax-Only WB | 32.7% | 30.0% | 17.3% | 14.8% | 13.3% | 15.8% | 24.0% | 14.1% | 8.5% | 29.8% | *20.7%* |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | *Decade Sub-total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Small Widebodies | 97 | 106 | 109 | 95 | 65 | 55 | 60 | 50 | 62 | 52 | *751* |
| Medium Widebodies | 3 | 31 | 42 | 59 | 51 | 80 | 85 | 118 | 133 | 155 | *757* |
| Large Widebodies | 70 | 64 | 61 | 56 | 40 | 25 | 26 | 39 | 53 | 47 | *481* |
| 747 Pax Versions | 56 | 50 | 55 | 48 | 33 | 18 | 18 | 30 | 43 | 34 | *385* |
| | 170 | 201 | 212 | 210 | 156 | 160 | 171 | 207 | 248 | 254 | *1,989* |
| Small Widebodies | 57.1% | 52.7% | 51.4% | 45.2% | 41.7% | 34.4% | 35.1% | 24.2% | 25.0% | 20.5% | *37.8%* |
| Medium Widebodies | 1.8% | 15.4% | 19.8% | 28.1% | 32.7% | 50.0% | 49.7% | 57.0% | 53.6% | 61.0% | *38.1%* |
| Large Widebodies | 41.2% | 31.8% | 28.8% | 26.7% | 25.6% | 15.6% | 15.2% | 18.8% | 21.4% | 18.5% | *24.2%* |
| Large Pax-Only WB | 35.9% | 26.7% | 26.7% | 23.8% | 22.1% | 11.8% | 11.0% | 15.2% | 18.1% | 14.1% | *20.3%* |

| | 2000 | Total |
|---|---|---|
| Small Widebodies | 52 | 1,569 |
| Medium Widebodies | 121 | 1,573 |
| Large Widebodies | 25 | 1,257 |
| 747 Pax Versions | 9 | 978 |
| | 198 | 4,399 |
| Small Widebodies | 26.3% | 35.7% |
| Medium Widebodies | 61.1% | 35.8% |
| Large Widebodies | 12.6% | 28.6% |
| Large Pax-Only WB | 4.9% | 23.7% |

Note: Small, Medium and Large Widebody numbers include all deliveries - passenger, combi and freighter. "747 Pax Versions" and the corresponding market share number ("Large Pax-Only WB") include only the passenger 747s versus all other small and medium widebody deliveries.

*Source: Jet Information Services, Inc. World Jet Inventory, YE 2000* egory; this share dropped to about 20% for both the 1980s and 1990s.

Accordingly, the study forecasts that 20 per cent (20%) of the seat demand for large, long-haul aircraft during the 2006-2025 period will accrue to large widebodies, specifically the A380 and the 747. Within this category, two-thirds of the demand is forecast to go to the A380, with the remaining one-third to the 747. While it could be argued that the 747 will have been in service for 55 years by the end of the forecast period, it is highly unlikely that Boeing will abandon this market sector entirely to Airbus, and will choose to compete with some combination of derivatives of the 747 (a cost-effective means of competing, and one with which Boeing has considerable prior experience, both on the 747, as well as other programs including the 737) or a new design.

Exhibits 3-22a through 3-22f indicate the resulting forecast deliveries for the A380 under the varying retirement and growth rate assumptions. Only one alternative (25-year retirement, 4.5% growth rate), will be examined in detail, it shows that a total of 453 passenger versions of the A380 will be delivered between 2006 and 2025—about 23 on average per year. However, the market requires a delivery rate in the first ten years which is considerably lower; 160 units (16 per year) forecast to be delivered from 2006 until 2015, principally reflecting the relatively low replacement need in this time frame as discussed previously.

## Exhibit 3-22a

### Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **25** |
| **Growth Rate** | **4.0%** |

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 32,715 | 32,494 | 34,733 | 45,533 | 50,431 | 47,115 | 43,521 | 52,827 | 50,284 | 52,486 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 29 | 29 | 31 | 41 | 45 | 37 | 34 | 41 | 39 | 41 |
| Medium Widebody | 62.5% | 325 | | 73 | 72 | 77 | 101 | 112 | 91 | 84 | 102 | 97 | 101 |
| B747-400X | 6.7% | 475 | | 5 | 5 | 6 | 7 | 8 | 7 | 6 | 7 | 7 | 7 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **11** | **10** | **13** | **12** | **13** |
| Total | | | | 107 | 106 | 114 | 149 | 165 | 146 | 134 | 163 | 155 | 162 |

| | | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 56,163 | 57,119 | 66,612 | 76,998 | 89,341 | 95,238 | 101,798 | 103,414 | 94,968 | 92,664 | 97,317 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 44 | 44 | 52 | 60 | 69 | 74 | 79 | 80 | 74 | 72 | 76 |
| Medium Widebody | 62.5% | 325 | 108 | 110 | 128 | 148 | 172 | 183 | 196 | 199 | 183 | 178 | 187 |
| B747-400X | 6.7% | 475 | 8 | 8 | 9 | 11 | 13 | 13 | 14 | 15 | 13 | 13 | 14 |
| **A380-800** | **13.3%** | **555** | **13** | **14** | **16** | **18** | **21** | **23** | **24** | **25** | **23** | **22** | **23** |
| Total | | | 173 | 176 | 205 | 237 | 275 | 293 | 313 | 319 | 293 | 285 | 300 |

| | | | 2022 | 2023 | 2024 | 2025 | Total |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 114,248 | 128,608 | 131,314 | 116,172 | 1,864,113 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 89 | 100 | 102 | 90 | 1,472 |
| Medium Widebody | 62.5% | 325 | 220 | 247 | 253 | 223 | 3,645 |
| B747-400X | 6.7% | 475 | 16 | 18 | 19 | 16 | 265 |
| **A380-800** | **13.3%** | **555** | **27** | **31** | **31** | **28** | **398** |
| Total | | | 352 | 396 | 405 | 357 | 5,780 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **141** |
| **First 20 Years** | **398** |

*(Starting in 2006)*

# Exhibit 3-22b

## Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **30** |
| **Growth Rate** | **4.0%** |

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 34,573 | 37,276 | 39,466 | 39,609 | 41,714 | 40,421 | 40,508 | 43,067 | 54,201 | 59,446 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 31 | 33 | 35 | 36 | 37 | 31 | 32 | 33 | 42 | 46 |
| Medium Widebody | 62.5% | 325 | | 77 | 83 | 88 | 88 | 93 | 78 | 78 | 83 | 104 | 114 |
| B747-400X | 6.7% | 475 | | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 6 | 8 | 8 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **10** | **10** | **10** | **13** | **14** |
| Total | | | | 114 | 122 | 129 | 130 | 137 | 125 | 126 | 132 | 167 | 182 |

| | | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 56,490 | 53,271 | 62,967 | 60,830 | 63,453 | 67,569 | 68,981 | 78,948 | 89,828 | 102,684 | 109,115 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 44 | 41 | 49 | 47 | 49 | 53 | 54 | 61 | 70 | 80 | 85 |
| Medium Widebody | 62.5% | 325 | 109 | 102 | 121 | 117 | 122 | 130 | 133 | 152 | 173 | 197 | 210 |
| B747-400X | 6.7% | 475 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 11 | 13 | 14 | 15 |
| **A380-800** | **13.3%** | **555** | **14** | **13** | **15** | **15** | **15** | **16** | **17** | **19** | **22** | **25** | **26** |
| Total | | | 175 | 164 | 194 | 188 | 195 | 209 | 214 | 243 | 278 | 316 | 336 |

| | | | 2022 | 2023 | 2024 | 2025 | Total |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 116,230 | 118,423 | 110,578 | 108,899 | 1,698,548 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 90 | 92 | 86 | 85 | 1,342 |
| Medium Widebody | 62.5% | 325 | 224 | 228 | 213 | 209 | 3,326 |
| B747-400X | 6.7% | 475 | 16 | 17 | 16 | 15 | 245 |
| **A380-800** | **13.3%** | **555** | **28** | **28** | **26** | **26** | **362** |
| Total | | | 358 | 365 | 341 | 335 | 5,275 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **129** |
| **First 20 Years** | **362** |

*(Starting in 2006)*

# Exhibit 3-22c

## Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **25** |
| **Growth Rate** | **4.5%** |

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 36,212 | 36,288 | 38,842 | 49,979 | 55,235 | 52,298 | 49,108 | 58,842 | 56,754 | 59,438 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 32 | 33 | 35 | 45 | 50 | 41 | 38 | 46 | 44 | 46 |
| Medium Widebody | 62.5% | 325 | | 80 | 80 | 86 | 111 | 123 | 101 | 94 | 113 | 109 | 114 |
| B747-400X | 6.7% | 475 | | 6 | 6 | 6 | 8 | 9 | 7 | 7 | 8 | 8 | 8 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **13** | **12** | **14** | **14** | **14** |
| Total | | | | 118 | 119 | 127 | 164 | 182 | 162 | 151 | 181 | 175 | 182 |

| | | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 63,627 | 65,126 | 75,194 | 86,190 | 99,180 | 105,762 | 113,047 | 115,431 | 107,799 | 106,356 | 111,919 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 49 | 51 | 58 | 67 | 77 | 82 | 88 | 90 | 84 | 83 | 87 |
| Medium Widebody | 62.5% | 325 | 122 | 125 | 145 | 166 | 191 | 203 | 217 | 222 | 207 | 205 | 215 |
| B747-400X | 6.7% | 475 | 9 | 9 | 11 | 12 | 14 | 15 | 16 | 16 | 15 | 15 | 16 |
| **A380-800** | **13.3%** | **555** | **15** | **16** | **18** | **21** | **24** | **25** | **27** | **28** | **26** | **25** | **27** |
| Total | | | 195 | 201 | 232 | 266 | 306 | 325 | 348 | 356 | 332 | 328 | 345 |

| | | | 2022 | 2023 | 2024 | 2025 | Total |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 129,814 | 145,192 | 148,977 | 134,974 | 2,101,580 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 101 | 113 | 116 | 105 | 1,661 |
| Medium Widebody | 62.5% | 325 | 250 | 279 | 286 | 260 | 4,104 |
| B747-400X | 6.7% | 475 | 18 | 20 | 21 | 19 | 299 |
| **A380-800** | **13.3%** | **555** | **31** | **35** | **36** | **32** | **453** |
| Total | | | 400 | 447 | 459 | 416 | 6,517 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **161** |
| **First 20 Years** | **453** |

*(Starting in 2006)*

# Exhibit 3-22d

## Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **30** |
| **Growth Rate** | **4.5%** |

| | | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 38,238 | 41,253 | 43,774 | 44,270 | 46,749 | 45,855 | 46,364 | 49,373 | 60,983 | 66,734 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 34 | 37 | 39 | 40 | 42 | 36 | 36 | 38 | 47 | 52 |
| Medium Widebody | 62.5% | 325 | | 85 | 92 | 97 | 98 | 104 | 88 | 89 | 95 | 117 | 128 |
| B747-400X | 6.7% | 475 | | 6 | 7 | 7 | 7 | 8 | 6 | 7 | 7 | 9 | 9 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **11** | **11** | **12** | **15** | **16** |
| Total | | | | 125 | 136 | 143 | 145 | 154 | 141 | 143 | 152 | 188 | 205 |

| | | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 64,315 | 61,665 | 71,964 | 70,467 | 73,768 | 78,602 | 80,775 | 91,547 | 103,279 | 117,038 | 124,424 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 50 | 48 | 56 | 55 | 57 | 61 | 63 | 71 | 80 | 91 | 97 |
| Medium Widebody | 62.5% | 325 | 124 | 119 | 138 | 136 | 142 | 151 | 155 | 176 | 199 | 225 | 239 |
| B747-400X | 6.7% | 475 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 13 | 15 | 17 | 18 |
| **A380-800** | **13.3%** | **555** | **15** | **15** | **17** | **17** | **18** | **19** | **19** | **22** | **25** | **28** | **30** |
| Total | | | 198 | 191 | 221 | 218 | 227 | 242 | 248 | 282 | 319 | 361 | 384 |

| | | | **2022** | **2023** | **2024** | **2025** | **Total** |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 132,549 | 135,810 | 129,094 | 128,610 | 1,947,499 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 103 | 106 | 100 | 100 | 1,539 |
| Medium Widebody | 62.5% | 325 | 255 | 261 | 248 | 247 | 3,808 |
| B747-400X | 6.7% | 475 | 19 | 19 | 18 | 18 | 280 |
| **A380-800** | **13.3%** | **555** | **32** | **33** | **31** | **31** | **417** |
| Total | | | 409 | 419 | 397 | 396 | 6,044 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **147** |
| **First 20 Years** | **417** |

*(Starting in 2006)*

# Exhibit 3-22e

## Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **25** |
| **Growth Rate** | **5.0%** |

| | | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 39,708 | 40,116 | 43,027 | 54,544 | 60,208 | 57,708 | 54,984 | 65,216 | 63,661 | 66,914 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 36 | 36 | 39 | 49 | 54 | 45 | 43 | 51 | 50 | 52 |
| Medium Widebody | 62.5% | 325 | | 88 | 89 | 95 | 121 | 134 | 111 | 106 | 125 | 122 | 129 |
| B747-400X | 6.7% | 475 | | 6 | 7 | 7 | 9 | 10 | 8 | 8 | 9 | 9 | 9 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **14** | **13** | **16** | **15** | **16** |
| Total | | | | 130 | 132 | 141 | 179 | 198 | 178 | 170 | 201 | 196 | 206 |

| | | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 71,711 | 73,859 | 84,619 | 96,353 | 110,129 | 117,551 | 125,730 | 129,066 | 122,448 | 122,085 | 128,797 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 56 | 57 | 66 | 75 | 86 | 91 | 98 | 100 | 95 | 95 | 100 |
| Medium Widebody | 62.5% | 325 | 138 | 142 | 163 | 185 | 212 | 226 | 242 | 248 | 235 | 235 | 248 |
| B747-400X | 6.7% | 475 | 10 | 10 | 12 | 14 | 16 | 17 | 18 | 18 | 17 | 17 | 18 |
| **A380-800** | **13.3%** | **555** | **17** | **18** | **20** | **23** | **26** | **28** | **30** | **31** | **29** | **29** | **31** |
| Total | | | 221 | 227 | 261 | 297 | 340 | 362 | 388 | 397 | 376 | 376 | 397 |

| | | | **2022** | **2023** | **2024** | **2025** | **Total** |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 147,916 | 164,596 | 169,765 | 157,234 | 2,367,943 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 115 | 128 | 132 | 122 | 1,871 |
| Medium Widebody | 62.5% | 325 | 284 | 317 | 326 | 302 | 4,623 |
| B747-400X | 6.7% | 475 | 21 | 23 | 24 | 22 | 339 |
| **A380-800** | **13.3%** | **555** | **35** | **39** | **41** | **38** | **509** |
| Total | | | 455 | 507 | 523 | 484 | 7,342 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **178** |
| **First 20 Years** | **509** |

*(Starting in 2006)*

# Exhibit 3-22f

## Aircraft Delivery Forecast

| | |
|---|---|
| **Aircraft Lifespan** | **30** |
| **Growth Rate** | **5.0%** |

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | | 41,904 | 45,266 | 48,161 | 49,056 | 51,963 | 51,526 | 52,525 | 56,056 | 68,224 | 74,572 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | | 38 | 41 | 43 | 44 | 47 | 40 | 41 | 44 | 53 | 58 |
| Medium Widebody | 62.5% | 325 | | 93 | 100 | 107 | 109 | 115 | 99 | 101 | 108 | 131 | 143 |
| B747-400X | 6.7% | 475 | | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 8 | 10 | 11 |
| **A380-800** | **13.3%** | **555** | | **-** | **-** | **-** | **-** | **-** | **12** | **13** | **13** | **16** | **18** |
| Total | | | | 138 | 148 | 158 | 161 | 170 | 158 | 162 | 173 | 210 | 230 |

| | | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net New Seats | | | 72,790 | 70,820 | 81,845 | 81,121 | 85,247 | 90,961 | 94,071 | 105,841 | 118,637 | 133,527 | 142,118 |
| Aircraft | M/S | Seats | | | | | | | | | | | |
| Small Widebody | 17.5% | 225 | 57 | 55 | 64 | 63 | 66 | 71 | 73 | 82 | 92 | 104 | 111 |
| Medium Widebody | 62.5% | 325 | 140 | 136 | 157 | 156 | 164 | 175 | 181 | 204 | 228 | 257 | 273 |
| B747-400X | 6.7% | 475 | 10 | 10 | 12 | 11 | 12 | 13 | 13 | 15 | 17 | 19 | 20 |
| **A380-800** | **13.3%** | **555** | **17** | **17** | **20** | **19** | **20** | **22** | **23** | **25** | **28** | **32** | **34** |
| Total | | | 224 | 218 | 253 | 249 | 262 | 281 | 290 | 326 | 365 | 412 | 438 |

| | | | 2022 | 2023 | 2024 | 2025 | Total |
|---|---|---|---|---|---|---|---|
| Net New Seats | | | 151,526 | 156,152 | 150,888 | 151,947 | 2,226,742 |
| Aircraft | M/S | Seats | | | | | |
| Small Widebody | 17.5% | 225 | 118 | 121 | 117 | 118 | 1,761 |
| Medium Widebody | 62.5% | 325 | 291 | 300 | 290 | 292 | 4,350 |
| B747-400X | 6.7% | 475 | 21 | 22 | 21 | 21 | 318 |
| **A380-800** | **13.3%** | **555** | **36** | **37** | **36** | **36** | **474** |
| Total | | | 466 | 480 | 464 | 467 | 6,903 |

| **A380-800** | **Total Units** |
|---|---|
| **First 10 Years** | **165** |
| **First 20 Years** | **474** |

*(Starting in 2006)*

## 3.4: Cargo Aircraft Demand Forecast

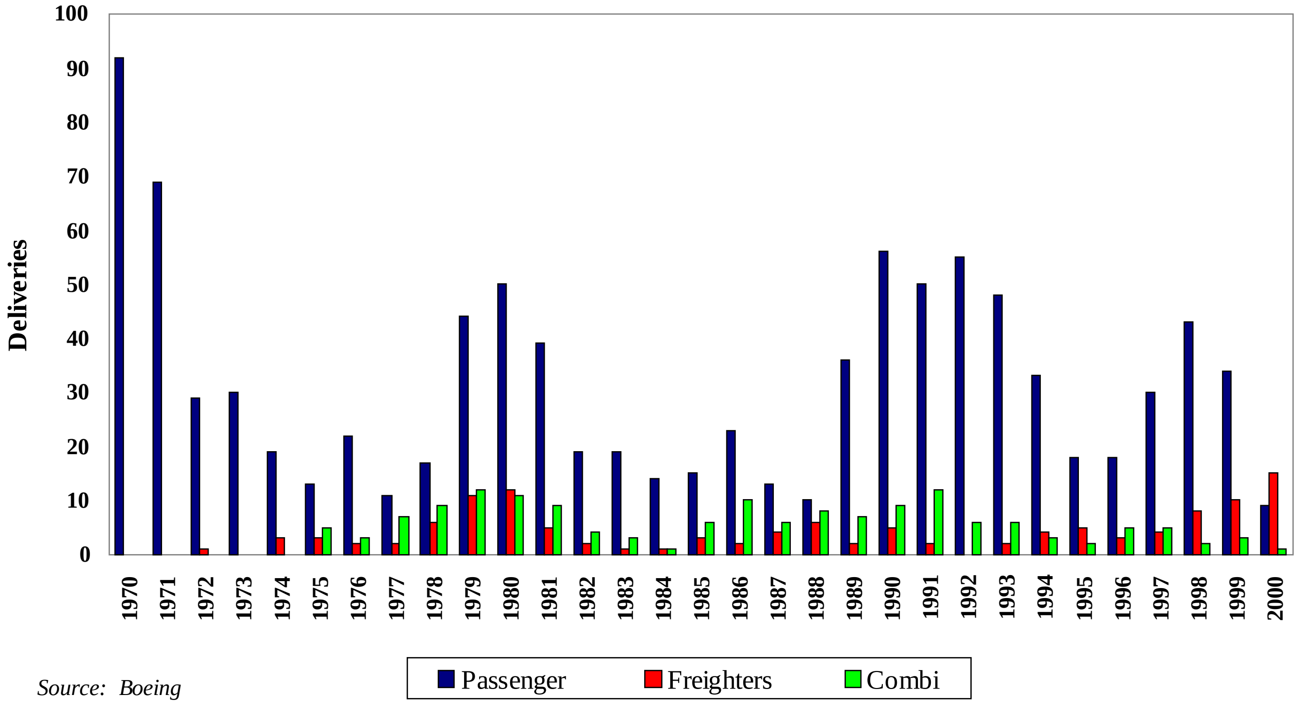
The cargo aircraft demand forecast for the A380 is based on the historic demand for 747 cargo aircraft. Specifically, as shown in Exhibits 3-23a and 3-23b, cargo aircraft represent eight-and-eight-tenths (8.8%) of the total of this type delivered between 1970 and the end of 1999. Even with the sharp increase noted in 2000, the total is still below ten per cent (9.9%) for the 1970-2000 period. The breakdown for each decade is as follows:

| | |
|---|---|
| 1970-79 | 6.8% |
| 1980-89 | 11.1% |
| 1990-99 | 8.9% |

(This includes only aircraft delivered as freighters; conversions are included in the previously-cited passenger aircraft figures.)

# Exhibit 3-23a

## 747 Passenger, Freighter and Combi Deliveries
1970 - 2000



*Source: Boeing*

# Exhibit 3-23b

## 747 Deliveries by Year and Type
1970 - 2000

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | Decade Total | % of Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger | 92 | 69 | 29 | 30 | 19 | 13 | 22 | 11 | 17 | 44 | 346 | 84.4% |
| Freighter | 0 | 0 | 1 | 0 | 3 | 3 | 2 | 2 | 6 | 11 | 28 | 6.8% |
| Combi | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 7 | 9 | 12 | 36 | 8.8% |
| Total | 92 | 69 | 30 | 30 | 22 | 21 | 27 | 20 | 32 | 67 | 410 | 100.0% |

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | Decade Total | % of Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger | 50 | 39 | 19 | 19 | 14 | 15 | 23 | 13 | 10 | 36 | 238 | 69.8% |
| Freighter | 12 | 5 | 2 | 1 | 1 | 3 | 2 | 4 | 6 | 2 | 38 | 11.1% |
| Combi | 11 | 9 | 4 | 3 | 1 | 6 | 10 | 6 | 8 | 7 | 65 | 19.1% |
| Total | 73 | 53 | 25 | 23 | 16 | 24 | 35 | 23 | 24 | 45 | 341 | 100.0% |

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Decade Total | % of Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Passenger | 56 | 50 | 55 | 48 | 33 | 18 | 18 | 30 | 43 | 34 | 385 | 80.0% |
| Freighter | 5 | 2 | 0 | 2 | 4 | 5 | 3 | 4 | 8 | 10 | 43 | 8.9% |
| Combi | 9 | 12 | 6 | 6 | 3 | 2 | 5 | 5 | 2 | 3 | 53 | 11.0% |
| Total | 70 | 64 | 61 | 56 | 40 | 25 | 26 | 39 | 53 | 47 | 481 | 100.0% |

| | 2000 | Grand Total | Type as a % of Total |
|---|---|---|---|
| Passenger | 9 | 978 | 77.8% |
| Freighter | 15 | 124 | 9.9% |
| Combi | 1 | 155 | 12.3% |
| Total | 25 | 1257 | 100.0% |

*Source: Boeing*

Accordingly, demand for the cargo version of the A380 is forecast at nine-and-nine-tenths per cent (9.9%) of the passenger aircraft deliveries, rounded to the nearest whole number, as shown in Exhibit 3-24.

## Exhibit 3-24

**A380 Freighter Delivery Forecast**

**Aircraft Lifespan (years): 25**
**Growth Rate: 4.5%**

| Year | Passenger/ Combi Aircraft | 9.9% Share | Freighter Forecast(Rounded) |
|---|---|---|---|
| 2006 | 13 | 1.3 | 1 |
| 2007 | 12 | 1.2 | 1 |
| 2008 | 14 | 1.4 | 1 |
| 2009 | 14 | 1.4 | 1 |
| 2010 | 14 | 1.4 | 1 |
| 2011 | 15 | 1.5 | 1 |
| 2012 | 16 | 1.6 | 2 |
| 2013 | 18 | 1.8 | 2 |
| 2014 | 21 | 2.1 | 2 |
| 2015 | 24 | 2.4 | 2 |
| Subtotal | | 15.9 | 14 |
| 2016 | 25 | 2.5 | 2 |
| 2017 | 27 | 2.7 | 3 |
| 2018 | 28 | 2.8 | 3 |
| 2019 | 26 | 2.6 | 3 |
| 2020 | 25 | 2.5 | 2 |
| 2021 | 27 | 2.7 | 3 |
| 2022 | 31 | 3.1 | 3 |
| 2023 | 35 | 3.5 | 3 |
| 2024 | 36 | 3.6 | 4 |
| 2025 | 32 | 3.2 | 3 |
| Subtotal | | 28.9 | 29 |
| **Total** | | **44.8** | **43** |

(It should be noted that this is a useful method for determining the total volume of cargo aircraft deliveries during the 20- year period covered by this forecast, but may not reflect the timing of when individual units enter service, due to the relatively small number of aircraft involved.)

This methodology likely is favorable to the A380, since it has not yet entered the market, and, as noted in Exhibit 3-23b, above, first-decade deliveries of the 747F were only six-and-eight-tenths (6.8%) of total 747 deliveries. The A380F appears to have an advantage in cubic capacity versus the 747F, and consequently, a lower design density. This is advantageous to integrators such as FedEx, although UPS, which currently operates the 747, has acquired only medium-sized widebodies—the 767-300, the A300-600 and converted MD-11s—for a number of years. In addition, the A380 freighter lacks outsize capability, by virtue of its twin-deck design, as well as the ability to accommodate very long pieces of cargo, since it does not have nose-loading capability.

The combination of these factors and the fact that Boeing is likely to defend its portion of the freighter market suggest that A380F sales may not contribute to a significant increase in production over the passenger model. This is in line with a recent independent assessment of air cargo industry prospects:

> Where is the freighter market headed? Obviously, it's undergoing a transition, but three things are clear. First, the retirement of older freighters over the next decade will result in a future fleet that looks considerably different from the current fleet. Second, the ongoing shift to wide-body freighters is expected to continue. Third, most freighters added in the coming years, as much as a 75 per cent (75%) share, will be used aircraft converted from passenger to freighter configuration when they are 20 years old.
>
> ...Looking forward, there will be substantial numbers of A300-600 and 767-200/300 conversions in the coming years. Also expect to see the launch of a 747-400 conversion program within the next two years, assuring the dominance of the 747 within the large-capacity freighter market for the next decade and beyond. The only questions unanswered in the wide-body market segment are the long-term market acceptance of the A380F, which will enter service in 2008, and how long it will take Boeing and Airbus to launch freighter variants of the 777 and A330/340 models which they say are now being studied.

Source: "Freighter Aircraft: Outlook Uncertain", by Robert V. Dahl, Director, Air Cargo Management Group, Aviation Week, January 14, 2002, pages 55-58

This is true even at the large, financially-robust integrators:

> "In the coming years, the MD-11 will be the primary aircraft flying our international trunk routes and it will be the centerpiece in our drive to enable global commerce," said UPS Airlines vice president Bob Lekites.

Source: Cargo Facts, October 2001, page 1

### 3.5: Pricing

One of the most difficult areas to address is that of pricing. Transaction prices are highly proprietary and there is little, if any, information on the subject published in financial or regulatory reports. Nonetheless, there is widespread knowledge of pricing trends in some sectors of the commercial aviation industry, particularly the aircraft trading community, and some of this is published in anecdotal format, rather than as a consistent set of reference data.

There is widespread agreement that discounting is rampant with respect to the recent pricing of large commercial aircraft. According to a respected industry source:

> For the past decade list prices have been an irrelevance, and remain so. Real pricing of new aircraft continues to be much lower. The starting point for most narrowbody negotiations, even for small order quantities, is a 15 percent discount. Large widebody orders may see 20 percent a more appropriate starting point. Market forces also play little part in determining the annual percentage rise in list prices. The hike in list price is a function of a rise in cost indices as produced by the Government and usually focused on the aerospace industry.

Source: Aircraft Value News, July 16, 2001, page 2

More recently,

> Bearden [Fred E. Bearden, President, Aircraft Information Services, Inc.] notes that the industry is in its third year of manufacturer discounts of up to 30%. A 737-800 with a 2001 list price of about $64.5m therefore comes up with a theoretical sales price today of $45m, which happens to be a common appraisal figure. The low-end list price of $57m discounted 30% equals $39.9m, which is lower than the typical EETC financing but where Fred Klein, president of Aviation Specialists, another appraisal firm, believes the 737-800 should be valued.

Source: Airline Monitor Weekly, January 22, 2002

This trend continues to be borne out by the first major transaction of 2002:

> Ryanair is not saying how much the deal is worth but stresses it received "an exceptionally competitive offer from Boeing." Boeing has typically granted discounts of up to 30%, which equates to a purchase price of $42.7m if that's the discount afforded Ryanair. Market talk is that this discount was as high as 34%, suggesting a price to Ryanair of just $40.26m.

Source: Airline Monitor Weekly, January 29, 2002

Given the importance of the A380 program, and the size and influence of the potential customers, it is not surprising that extensive discounting can be expected with respect to A380 pricing:

> The customers capable of supporting the B747, A340 or A3XX in terms of route structure and traffic buy in multiple units at significant discounts. Launch customers gain even more as manufacturers offer incentives to overcome uncertainty on the performance of new types. List price comparisons show around a 15-20 percent discount for a single unit increasing to 20-30+ percent for multiple units.

Source: Aircraft Value News 8 May 2000, page 2

Indeed, there are reports that early A380 customers obtained very favorable pricing on their A380 orders:

> Since Singapore, Emirates and Virgin Atlantic reportedly received extremely favorable guarantees on performance and fuel consumption—not to mention a price of less than $150 million per airplane—speculation continues that FedEx is receiving similar concessions in order to be a launch customer for the freighter version.

Source: Cargo Facts, January 2001, page 2

and:

> For such a massive order at such a critical time, Emirates will have received a massive discount such that a figure of $140-150 million, subject to escalation but representing a discount of more than 35 percent off the $239-263.5 million list price, may have been secured, as well as advantageous walkaway clauses. With so many customers achieving significant discounts, for the first time values may have to be based on something other than a single unit sale.

Source: Aircraft Value News, December 3, 201, page 8

This level of discounting apparently held for the freighter, as well as the passenger version of the A380:

> The FedEx deal with Airbus for ten A380-800Fs, announced in mid-January, is based on a memorandum of understanding between the two companies. The parties expect no problems in executing a definitive purchase agreement in the coming weeks. No prices were announced, but observers speculate that launch customer FedEx got at least a 30% discount from the $230 million list price for each A380F. A decision concerning engine selection is expected in March.

Source: Cargo Facts February 2001, page 12

While there have been claims that such large discounts will not persist beyond the “launch” period for the A380 program, there is no guarantee that this can be achieved. All launch customers will seek "most favored nation" (MFN) treatment, so that it is likely that the initial discount level will apply to this entire category of customers. This sort of pricing may have negative implications for the overall financial success of the program:

> Indeed, Boeing hasn't won a single order for a stretch version of the venerable 747 that it's offering as an alternative to the A380.
>
> A dazzling start, no doubt. But is it a good deal for Airbus? *Business Week* has learned that the company is giving extraordinarily generous terms to early buyers. It's selling the cargo model of the A380 for as low as $133 million and the passenger model for just over $140 million—about 40% off list prices and less than the going rate of $140 to $150 million for Boeing's 747. Airbus is accepting down payments as low as $500,000 per plane while giving customers the option of canceling orders 12 months before delivery without customary penalties. Airbus has offered lenient terms to buyers of established models before. But experts say it's unusual to offer them on a new plane.
>
> True, manufacturers always sweeten the pot for first-time buyers of new aircraft, discounting them and throwing in everything from free pilot training to spare parts. …But, says an airline executive who has seen the terms [Airbus's] Leahy is offering on the A380, "I don't know of a deal that has ever been quite this generous."
>
> These concessions only steepen the already difficult path to profitability for the A380. To meet its break-even targets, Airbus says it expects to deliver 250 superjumbos by 2011. But to offset the deep discounts and raise working capital, it will have to demand bigger up-front payments from future customers and charge them close to list prices—$218 to $235 million, says aerospace analyst Paul H. Nisbet, of Newport (R.I.)-based JSA Research. Cost-conscious airlines won't readily agree to pay 40% more than their competitors did, say industry watchers.

Source: Business Week, March 5, 2001 pages 52-53

> A recent, and somewhat more conservative assessment indicates that:
>
> The A380 has a list price of $240 million, though the first customers were given discounts by Airbus, which analysts have estimated at about 25%.

Source: "Airbus Outdoes Boeing in '01 Deals", Los Angeles Times, from Bloomberg News, January 10, 2002

Accordingly, this analysis assumes that, based on a 2001 "list" price of passenger aircraft of $240 million, the following level of discounting will apply:

| Category | Price Discount | Effective Price (2001$-M) |
|---|---|---|
| First 50 aircraft | 40% | $144 |
| Second 50 aircraft | 30% | $168 |
| Subsequent aircraft | 20% | $192 |

Based on the recent industry pricing conditions cited above, this represents a moderately conservative approach.

The price of the freighter version is assumed to be an additional $10 million per unit (list price $250 million), based on its higher production cost. The effective prices for the freighter aircraft are as follows:

| Category | Price Discount | Effective Price (2001$-M) |
|---|---|---|
| First 10 aircraft | 40% | $150 |
| Second 10 aircraft | 30% | $175 |
| Subsequent aircraft | 20% | $200 |

## 3.6: Expected Program Revenues

Once a pricing structure has been established, it is relatively easy to calculate the expected revenues for the A380 program. Accordingly, Exhibits 3-25a though 3-25f utilize information on forecast deliveries and pricing from the previous section to develop forecast A380 program revenues for the first twenty years of deliveries (2006-2025) and for the previously defined combination of retirement and growth rate scenarios.

## 3.7: Conclusions

During the period 2006-2025, based on four-and-one-half per cent (4.5%) growth and 25-year retirement of existing aircraft, 453 A380 passenger versions and 43 freighters will be delivered, for a total of 496. This generates total revenue of approximately $91 billion (in 2001 dollars). It is noteworthy that far more medium and small widebodies will be delivered during the same time period, reflecting continuing market fragmentation.

# Exhibit 25a

## Aircraft Delivery Forecast - A380 Revenue

**($ in Millions)**

Aircraft Lifespan **25**
Growth Rate **4.0%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 144 | $ 161 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 11 | 10 | 13 | 12 | 13 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 1 | 1 | 1 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,584 | $ 1,440 | $ 1,872 | $ 1,728 | $ 2,093 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| Total Del | | - | - | - | - | - | 12 | 11 | 14 | 13 | 14 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,734 | $ 1,590 | $ 2,022 | $ 1,878 | $ 2,243 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 168 | $ 171 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 150 | $ 150 | $ 163 | $ 175 | $ 175 | $ 175 | $ 175 | $ 188 | $ 200 | $ 200 |
| A380-800 Pax | 13 | 14 | 16 | 18 | 21 | 23 | 24 | 25 | 23 | 22 | 23 |
| A380-800 Fr | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Pax AC Rev | $ 2,184 | $ 2,352 | $ 2,736 | $ 3,456 | $ 4,032 | $ 4,416 | $ 4,608 | $ 4,800 | $ 4,416 | $ 4,224 | $ 4,416 |
| Fr AC Rev | $ 150 | $ 150 | $ 300 | $ 326 | $ 350 | $ 350 | $ 350 | $ 350 | $ 376 | $ 400 | $ 400 |
| Total Del | 14 | 15 | 18 | 20 | 23 | 25 | 26 | 27 | 25 | 24 | 25 |
| Total Rev | $ 2,334 | $ 2,502 | $ 3,036 | $ 3,782 | $ 4,382 | $ 4,766 | $ 4,958 | $ 5,150 | $ 4,792 | $ 4,624 | $ 4,816 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 27 | 31 | 31 | 28 | **398** |
| A380-800 Fr | 3 | 3 | 3 | 3 | **37** |
| Pax AC Rev | $ 5,184 | $ 5,952 | $ 5,952 | $ 5,376 | **$ 72,821** |
| Fr AC Rev | $ 600 | $ 600 | $ 600 | $ 600 | **$ 6,652** |
| Total Del | 30 | 34 | 34 | 31 | **435** |
| Total Rev | $ 5,784 | $ 6,552 | $ 6,552 | $ 5,976 | **$ 79,473** |

# Exhibit 25b

## Aircraft Delivery Forecast - A380 Revenue

**($ in Millions)**

Aircraft Lifespan **30**
Growth Rate **4.0%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 144 | $ 156 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 10 | 10 | 10 | 13 | 14 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 1 | 1 | 1 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,440 | $ 1,440 | $ 1,440 | $ 1,872 | $ 2,184 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| Total Del | | - | - | - | - | - | 11 | 11 | 11 | 14 | 15 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,590 | $ 1,590 | $ 1,590 | $ 2,022 | $ 2,334 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 168 | $ 168 | $ 190 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 | $ 175 | $ 175 | $ 175 | $ 175 | $ 175 | $ 200 |
| A380-800 Pax | 14 | 13 | 15 | 15 | 15 | 16 | 17 | 19 | 22 | 25 | 26 |
| A380-800 Fr | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 |
| Pax AC Rev | $ 2,352 | $ 2,184 | $ 2,520 | $ 2,850 | $ 2,880 | $ 3,072 | $ 3,264 | $ 3,648 | $ 4,224 | $ 4,800 | $ 4,992 |
| Fr AC Rev | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 | $ 350 | $ 350 | $ 350 | $ 350 | $ 350 | $ 600 |
| Total Del | 15 | 14 | 16 | 16 | 16 | 18 | 19 | 21 | 24 | 27 | 29 |
| Total Rev | $ 2,502 | $ 2,334 | $ 2,670 | $ 3,000 | $ 3,030 | $ 3,422 | $ 3,614 | $ 3,998 | $ 4,574 | $ 5,150 | $ 5,592 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 28 | 28 | 26 | 26 | **362** |
| A380-800 Fr | 3 | 3 | 3 | 3 | **35** |
| Pax AC Rev | $ 5,376 | $ 5,376 | $ 4,992 | $ 4,992 | **$ 65,898** |
| Fr AC Rev | $ 600 | $ 600 | $ 600 | $ 600 | **$ 6,250** |
| Total Del | 31 | 31 | 29 | 29 | **397** |
| Total Rev | $ 5,976 | $ 5,976 | $ 5,592 | $ 5,592 | **$ 72,148** |

# Exhibit 25c

## Aircraft Delivery Forecast - A380 Revenue

**($ in Millions)**

Aircraft Lifespan **25**
Growth Rate **4.5%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 149 | $ 168 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 13 | 12 | 14 | 14 | 14 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 1 | 1 | 1 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,872 | $ 1,728 | $ 2,016 | $ 2,086 | $ 2,352 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| Total Del | | - | - | - | - | - | 14 | 13 | 15 | 15 | 15 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 2,022 | $ 1,878 | $ 2,166 | $ 2,236 | $ 2,502 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 168 | $ 189 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 150 | $ 150 | $ 175 | $ 175 | $ 175 | $ 175 | $ 192 | $ 200 | $ 200 | $ 200 |
| A380-800 Pax | 15 | 16 | 18 | 21 | 24 | 25 | 27 | 28 | 26 | 25 | 27 |
| A380-800 Fr | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 3 |
| Pax AC Rev | $ 2,520 | $ 2,688 | $ 3,402 | $ 4,032 | $ 4,608 | $ 4,800 | $ 5,184 | $ 5,376 | $ 4,992 | $ 4,800 | $ 5,184 |
| Fr AC Rev | $ 150 | $ 300 | $ 300 | $ 350 | $ 350 | $ 350 | $ 525 | $ 576 | $ 600 | $ 400 | $ 600 |
| Total Del | 16 | 18 | 20 | 23 | 26 | 27 | 30 | 31 | 29 | 27 | 30 |
| Total Rev | $ 2,670 | $ 2,988 | $ 3,702 | $ 4,382 | $ 4,958 | $ 5,150 | $ 5,709 | $ 5,952 | $ 5,592 | $ 5,200 | $ 5,784 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 31 | 35 | 36 | 32 | **453** |
| A380-800 Fr | 3 | 3 | 4 | 3 | **43** |
| Pax AC Rev | $ 5,952 | $ 6,720 | $ 6,912 | $ 6,144 | **$ 83,368** |
| Fr AC Rev | $ 600 | $ 600 | $ 800 | $ 600 | **$ 7,851** |
| Total Del | 34 | 38 | 40 | 35 | **496** |
| Total Rev | $ 6,552 | $ 7,320 | $ 7,712 | $ 6,744 | **$ 91,219** |

# Exhibit 25d

## Aircraft Delivery Forecast - A380 Revenue

**($ in Millions)**

Aircraft Lifespan **30**
Growth Rate **4.5%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 144 | $ 167 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 11 | 11 | 12 | 15 | 16 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 1 | 1 | 2 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,584 | $ 1,584 | $ 1,728 | $ 2,160 | $ 2,672 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 300 |
| Total Del | | - | - | - | - | - | 12 | 12 | 13 | 16 | 18 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,734 | $ 1,734 | $ 1,878 | $ 2,310 | $ 2,972 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 168 | $ 185 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 150 | $ 150 | $ 175 | $ 175 | $ 175 | $ 175 | $ 175 | $ 200 | $ 200 | $ 200 |
| A380-800 Pax | 15 | 15 | 17 | 17 | 18 | 19 | 19 | 22 | 25 | 28 | 30 |
| A380-800 Fr | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| Pax AC Rev | $ 2,520 | $ 2,520 | $ 3,145 | $ 3,264 | $ 3,456 | $ 3,648 | $ 3,648 | $ 4,224 | $ 4,800 | $ 5,376 | $ 5,760 |
| Fr AC Rev | $ 150 | $ 150 | $ 300 | $ 350 | $ 350 | $ 350 | $ 350 | $ 350 | $ 400 | $ 600 | $ 600 |
| Total Del | 16 | 16 | 19 | 19 | 20 | 21 | 21 | 24 | 27 | 31 | 33 |
| Total Rev | $ 2,670 | $ 2,670 | $ 3,445 | $ 3,614 | $ 3,806 | $ 3,998 | $ 3,998 | $ 4,574 | $ 5,200 | $ 5,976 | $ 6,360 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 32 | 33 | 31 | 31 | **417** |
| A380-800 Fr | 3 | 3 | 3 | 3 | **40** |
| Pax AC Rev | $ 6,144 | $ 6,336 | $ 5,952 | $ 5,952 | **$ 76,473** |
| Fr AC Rev | $ 600 | $ 600 | $ 600 | $ 600 | **$ 7,250** |
| Total Del | 35 | 36 | 34 | 34 | **457** |
| Total Rev | $ 6,744 | $ 6,936 | $ 6,552 | $ 6,552 | **$ 83,723** |

# Exhibit 25e

## Aircraft Delivery Forecast - A380 Revenue

($ in Millions)

Aircraft Lifespan **25**
Growth Rate **5.0%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 157 | $ 168 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 14 | 13 | 16 | 15 | 16 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 2 | 1 | 2 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 2,016 | $ 1,872 | $ 2,304 | $ 2,355 | $ 2,688 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 300 | $ 150 | $ 300 |
| Total Del | | - | - | - | - | - | 15 | 14 | 18 | 16 | 18 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 2,166 | $ 2,022 | $ 2,604 | $ 2,505 | $ 2,988 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 180 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 163 | $ 175 | $ 175 | $ 175 | $ 175 | $ 200 | $ 200 | $ 200 | $ 200 | $ 200 |
| A380-800 Pax | 17 | 18 | 20 | 23 | 26 | 28 | 30 | 31 | 29 | 29 | 31 |
| A380-800 Fr | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Pax AC Rev | $ 2,856 | $ 3,240 | $ 3,840 | $ 4,416 | $ 4,992 | $ 5,376 | $ 5,760 | $ 5,952 | $ 5,568 | $ 5,568 | $ 5,952 |
| Fr AC Rev | $ 300 | $ 326 | $ 350 | $ 350 | $ 525 | $ 525 | $ 600 | $ 600 | $ 600 | $ 600 | $ 600 |
| Total Del | 19 | 20 | 22 | 25 | 29 | 31 | 33 | 34 | 32 | 32 | 34 |
| Total Rev | $ 3,156 | $ 3,566 | $ 4,190 | $ 4,766 | $ 5,517 | $ 5,901 | $ 6,360 | $ 6,552 | $ 6,168 | $ 6,168 | $ 6,552 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 35 | 39 | 41 | 38 | **509** |
| A380-800 Fr | 3 | 4 | 4 | 4 | **51** |
| Pax AC Rev | $ 6,720 | $ 7,488 | $ 7,872 | $ 7,296 | **$ 94,131** |
| Fr AC Rev | $ 600 | $ 800 | $ 800 | $ 800 | **$ 9,426** |
| Total Del | 38 | 43 | 45 | 42 | **560** |
| Total Rev | $ 7,320 | $ 8,288 | $ 8,672 | $ 8,096 | **$ 103,557** |

# Exhibit 25f

## Aircraft Delivery Forecast - A380 Revenue

($ in Millions)

Aircraft Lifespan **30**
Growth Rate **5.0%**

| Aircraft | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | | $ - | $ - | $ - | $ - | $ - | $ 144 | $ 144 | $ 144 | $ 150 | $ 168 |
| Fr AC Price | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 150 | $ 150 |
| A380-800 Pax | | - | - | - | - | - | 12 | 13 | 13 | 16 | 18 |
| A380-800 Fr | | - | - | - | - | - | 1 | 1 | 1 | 2 | 2 |
| Pax AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,728 | $ 1,872 | $ 1,872 | $ 2,400 | $ 3,024 |
| Fr AC Rev | | $ - | $ - | $ - | $ - | $ - | $ 150 | $ 150 | $ 150 | $ 300 | $ 300 |
| Total Del | | - | - | - | - | - | 13 | 14 | 14 | 18 | 20 |
| Total Rev | | $ - | $ - | $ - | $ - | $ - | $ 1,878 | $ 2,022 | $ 2,022 | $ 2,700 | $ 3,324 |

| Aircraft | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pax AC Price | $ 168 | $ 168 | $ 173 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 | $ 192 |
| Fr AC Price | $ 150 | $ 163 | $ 175 | $ 175 | $ 175 | $ 175 | $ 188 | $ 200 | $ 200 | $ 200 | $ 200 |
| A380-800 Pax | 17 | 17 | 20 | 19 | 20 | 22 | 23 | 25 | 28 | 32 | 34 |
| A380-800 Fr | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| Pax AC Rev | $ 2,856 | $ 2,856 | $ 3,460 | $ 3,648 | $ 3,840 | $ 4,224 | $ 4,416 | $ 4,800 | $ 5,376 | $ 6,144 | $ 6,528 |
| Fr AC Rev | $ 300 | $ 326 | $ 350 | $ 350 | $ 350 | $ 350 | $ 376 | $ 400 | $ 600 | $ 600 | $ 600 |
| Total Del | 19 | 19 | 22 | 21 | 22 | 24 | 25 | 27 | 31 | 35 | 37 |
| Total Rev | $ 3,156 | $ 3,182 | $ 3,810 | $ 3,998 | $ 4,190 | $ 4,574 | $ 4,792 | $ 5,200 | $ 5,976 | $ 6,744 | $ 7,128 |

| Aircraft | 2022 | 2023 | 2024 | 2025 | **Total** |
|---|---|---|---|---|---|
| Pax AC Price | $ 192 | $ 192 | $ 192 | $ 192 | |
| Fr AC Price | $ 200 | $ 200 | $ 200 | $ 200 | |
| A380-800 Pax | 36 | 37 | 36 | 36 | **474** |
| A380-800 Fr | 4 | 4 | 4 | 4 | **48** |
| Pax AC Rev | $ 6,912 | $ 7,104 | $ 6,912 | $ 6,912 | **$ 86,884** |
| Fr AC Rev | $ 800 | $ 800 | $ 800 | $ 800 | **$ 8,852** |
| Total Del | 40 | 41 | 40 | 40 | **522** |
| Total Rev | $ 7,712 | $ 7,904 | $ 7,712 | $ 7,712 | **$ 95,736** |

A380 deliveries in the first half of the 2006-2025 time frame will be significantly lower than in the second half of this period, reflecting the lower level of replacement need prior to the latter part of the 2010 decade. This will have a significant impact on the economics of the overall program, particularly with respect to recoupment of development costs, including the interest on direct launch aid provided by governments.

## Update to Appendix 4: A380 Production Cost Estimate

### New Information

Since the initial Shadow Critical Project Appraisal was completed more than two years ago, a relatively modest amount of new information has become available on the design and manufacturing of the A380. Articles were published in EADS in-house journals, professional journals and the general media reporting the achievement of significant project milestones. Data and other new information, revealed as the A380 project has been progressing, is the basis for this update to the original production cost estimate.

The most significant information from a design and production cost perspective has been the news of an overweight problem with the A380 airframe. The cost of producing an aircraft increases with its weight. Analyzing an existing design for weight-reduction opportunities and revising the design to mitigate the problem also increase the cost of development and design. Cost is also heightened by selecting more exotic materials to produce lighter-weight components.

Indications of an overweight problem have been persistent since the summer of 2001. Until recently, Airbus brushed them off as mere rumors without substance. During the last few months, however, several articles have appeared in which Airbus not only acknowledges having had to deal with a higher-than-specified airframe weight; such articles as well as industry sources also provide insight into the measures Airbus has taken to ameliorate the problem. The following weight reduction measures have been brought to bear:

- Manufacturing the leading edges of the horizontal and vertical stabilizers of GLARE instead of conventional aluminum.
- Specifying aluminum instead of copper wire for the aircraft’s electrical system.
- Urging the suppliers of BFE to lower significantly (of the order of 30 percent) the weight of all BFE, including seats, galleys and lavatories. (This item is of note

even though it does not enter directly into the cost analysis of this study. Interestingly, 30 percent weight reduction in estimated BFE weight would correspond to about 9,000 pounds, which is close to the 11,000 pound excess weight assumed in this update for the airframe, as detailed below).

- Making the 24 largest ribs – out of a total of 61 – in each wing out of composite material. Each of the composite ribs is encased in an aluminum frame. New production methods had to be developed to accommodate this change.

In addition to considering the overweight problem in the updated production cost analysis, use was also made of any new information that allowed for a refinement of the airframe weight estimate as well as of the weights of the individual major airframe components and of major systems. Updated information has become available when a major airframe component or system was completed in manufacturing and shipped to Toulouse for final assembly. Prime examples are the wings and tail cone assembly.

## Updated Estimate of Airframe Weight

Following the methodology of the original analysis, the airframe weight is estimated by subtracting the weight of all non-airframe systems and components from the operating empty weight, OEW. To reflect the overweight problem, the OEW has been increased by 11,000 lbs.(5 metric tons) over that used in the original analysis, (which was the OEW published by Airbus at the time of program launch). An overweight problem of 40,000 lbs. to 60,0000 lbs. had been rumored to exist in the past. The 11,000 lbs. estimate is intended to be a conservative one, favoring Airbus. It is in line with estimates which recently appeared in the media. The relatively modest estimated weight increase represents the result of aggressive weight reduction efforts by Airbus. The new estimate of airframe weight is shown in Updated Exhibit 4-1.

## Updated Exhibit 4-1
## Development of Airframe Weight

| Component | | Weight |
|---|---|---|
| OEW | | 617,000 |
| 4x Engines | 56,000 | |
| 4x Power packs | 4,000 | |
| 2x Thrust reversers | 4,000 | |
| Landing gear | 48,000 | |
| Systems | 16,000 | |
| BFE | 30,000 | |
| Subtotal | 158,000 | |
| Airframe weight | | 459,000 |

*Note: All weights in pounds*

Following the same methodology for estimating production cost as that employed in the original study, the airframe weight has been broken down into its major components to account for different materials used in construction. The new breakdown is shown in Updated Exhibit 4-4

## Updated Exhibit 4-4
## Breakdown of Airframe Weight into its Major Elements

| Component | Weight |
|---|---|
| Fuselage from aft of cockpit to rear bulkhead | 165,000 |
| Nose and cockpit section | 20,000 |
| Tail cone | 28,000 |
| Wing box | 22,000 |
| Empennage | 44,000 |
| Wing | 180,000 |
| Total airframe weight | 459,000 |

*Note: All weights in pounds*

### **Updated Estimate of Production Cost of Airframe**

All cost estimates, as before, are in 2001 U.S. dollars.

The same methodology as that applied in the initial study is again applied to develop the production cost estimate for the airframe, using the revised weight estimates, with one exception: In the case of the wing, the production cost factor was increased from $270 per pound to $300 per pound to account for the higher cost of the composite ribs. In the case of the empennage, making the leading edges of the horizontal and vertical stabilizers from GLARE instead of less expensive conventional aluminum, as originally planned by Airbus, certainly increases production cost. While the size of the leading edges has not been revealed by Airbus it can be safely assumed that the amount of material involved is very small relative to total empennage weight. Consequently, the incremental cost increase due to the conversion to GLARE is a small fraction of total empennage cost. Indeed, it is considered less than the inherent uncertainty in the overall cost estimate for the production of the empennage caused by the uncertainty in the cost-to-weight factor used in the analysis. Thus, it was ignored.

The result of the analysis is shown in Updated Exhibit 4-5.

## Updated Exhibit 4-5
## Estimate for Production Cost of Airframe

| **Component** | **Weight (lbs.)** | **Cost ($ million)** |
|---|---|---|
| Fuselage from aft of cockpit to rear bulkhead | 165,000 | 52.7 |
| Nose and cockpit section | 20,000 | 4.8 |
| Tail cone | 28,000 | 14.0 |
| Wing box | 22,000 | 8.7 |
| Empennage | 44,000 | 22.0 |
| Wing | 180,000 | 54.0 |
| Total airframe | 459,000 | 156.2 |

The new, updated estimate for the production cost of the airframe alone is 3.2 percent higher than the original one developed more than two years ago. Still in 2001 U.S. dollars, total production cost for the 100th A380 is estimated to be $199,700,000, keeping the estimated costs of non-airframe systems unchanged. This represents an overall 2.5 percent increase over the original cost estimate.

The same relative increase applies to the estimated production cost of the cargo version of the A380, which consequently becomes $208,000,000.

# Appendix 4: A380 Production Cost Estimate

## 4.1: Introduction

This estimate of the cost of manufacturing the A380, both passenger and cargo versions, considers the aircraft once the manufacturing process has matured and the start-up problems have been resolved. It focuses upon the cost the 100th airplane.

Only the incremental production costs are considered in this analysis. Related indirect costs, such as cost of facilities or costs associated with maturing the manufacturing processes for advanced materials and new assembly methods are not included. This is an especially conservative assumption, particularly since the A380 relies upon more first-time applications of advanced materials to primary structure and more advanced assembly techniques than for any previous large civil transport aircraft.

## 4.2: Pioneering applications of advanced composite materials to primary structure and innovative assembly processes

The most significant examples of the advanced materials and assembly techniques used on the A380 are:

- GLARE fuselage panels on the upper half of the fuselage immediately fore and aft of the center section for the passenger version; for the cargo version, GLARE is also applied to the upper crown of the center section. These are intended to be first-ever applications of GLARE to primary structure in large transport aircraft which are certificated.

- Center wing box of CFRP (carbon fiber reinforced plastic) – another first for civil aircraft.

- The un-pressurized aft fuselage cone section assembled with skins, stringers and some of the frames made of composites; (other frames are made of aluminum). The empennage attaches to this section. This fuselage section is primary structure.

- Advanced light-weight aluminum alloys for inner and mid-wing cover panels (used on the A340-500/600).

- Light-weight outer wing design. Again, a first. It will most likely be made of composites, since recently-obtained information indicates that both wing and fuselage are significantly over their target weights. (Further discussion of the overweight problem is presented below.)

- Laser-beam welding of stringers to lower-fuselage aluminum panels. This advanced assembly technique is being used on the A318.

- Rear pressure bulkhead of CFRP – introduced on the A340-600.

- Composite empennage – in use on all Airbus models since 1987.

Any first-time application of advanced materials or processes to primary structure poses the challenge to designers of obtaining certification from civil aviation authorities for the new design. This is a lengthy process partially because many different civil aviation authorities have to be satisfied. The primary certification authorities for the A380 are the European Joint Airworthiness Authority (JAA) and the civil aviation authorities of France and Germany. Traditionally, the U.S. FAA and the authorities of other nations accept the European certification provided it is supported by agreed-upon data and analysis. If, however, the FAA were to decide that it should have more direct technical involvement in the certification process due to the many technology "firsts" in A380 primary structure, the certification process could become longer - and more expensive - than would be the case if the aircraft were of more conventional design.

By mid-year 2001, it seemed that the introduction of some of the advanced technologies, especially that of GLARE, might be postponed until later in the production run and that the initial units would use conventional technology rather than GLARE. This approach would have made the certification process more predictable in terms of length and cost.

However, later, with the A380 being significantly overweight, designers again stressed GLARE for its weight-saving capability and also looked to other materials partially for the same reason. Correcting the A380 weight problem is likely to force Airbus to use even more advanced weight-saving materials and assembly techniques, possibly to an even larger extent than originally planned. One example is the outer wing section for each wing. While a composite outer section had been considered earlier, aluminum was selected for production aircraft. Now, the composite approach may be reconsidered. For estimating A380 production cost, however, it was assumed there will be an all-metal wing.

Underlying the cost estimate are the following assumptions:

- GLARE fuselage panels;
- Composite wing box (with aluminum ribs);
- Composite tail cone;
- All-aluminum wing, using considerable aluminum-lithium alloy material;
- Laser beam welding of stringers to lower fuselage panels;
- Composite rear pressure bulkhead;
- Composite empennage.

## 4.3: Cost estimating methodology

The production cost of the airframe has been calculated primarily from the weight of airframe components. Cost-per-weight factors are employed for the primary materials used in the A380. The costs for engines and power packs, avionics, systems and landing gear are added to the cost of the airframe.

## 4.4: Estimate of airframe weight and production cost – Passenger A380

A380 airframe weight is estimated by subtracting from the operating empty weight (OEW) the weights of the four engines, associated power packs, two thrust reversers, buyer-furnished equipment (BFE, e.g. seats, galleys) and systems (e.g. APU, avionics, hydraulics, electrics). The OEW was published as 606,000 pounds in the January 1, 2001 issue of Aviation Week & Space Technology. All other weights have been estimated by extrapolation from known weights for other aircraft models while allowing for scaling to greater size. A tabulation of the weights is shown in Exhibit 4-1. The BFE weight estimate is derived below.

**Exhibit 4-1**
**Development of Airframe Weight**

| Component | | Weight |
|---|---|---|
| OEW | | 606,000 |
| 4x Engines | 56,000 | |
| 4x Power packs | 4,000 | |
| 2x Thrust reversers | 4,000 | |
| Landing gear | 31,000 | |
| Systems (APU, etc.) | 9,000 | |
| BFE | 30,000 | |
| Subtotal | 134,000 | |
| Airframe weight | | 472,000 lbs. |

*Note: All weights in pounds*

### 4.4.1: Estimate of BFE weight

The weight of BFE was estimated on the basis of the seat weights for the 555-passenger configuration shown in Exhibit 4-2 and weights for lavatories and galleys shown in Exhibit 4-3.

**Exhibit 4-2**
**Weight of Seat Units for 555-Passenger Configuration**

| Class/Type | Number of Units | Unit Weight | Extended Weight |
|---|---|---|---|
| Coach/double | 28 | 75 | 2,100 |
| Coach/triple | 71 | 95 | 6,745 |
| Coach/quadruple | 42 | 140 | 5,880 |
| Business/double | 48 | 100 | 4,800 |
| First/double | 11 | 150 | 1,650 |
| Total seat weight | | | 21,175 lbs. |

*Note: All weights in pounds*

**Exhibit 4-3**
**Weight of Lavatories and Galleys**

| Category | Number of Units | Unit Weight | Extended Weight |
|---|---|---|---|
| Lavatory | 17 | 300 | 5,100 |
| Galley | 10 | 250 | 2,500 |
| Total weight | | | 7,600 lbs. |

*Note: All weights in pounds*

From Exhibits 4-2 and 4-3 the total weight for all seats, lavatories and galleys is estimated as 28,775 pounds. Allowing for the weight of miscellaneous items, total BFE weight is estimated at 30,000 pounds.

### 4.4.2: Accounting for advanced materials in airframe weight

Since the airframe consists of aluminum as well as advanced materials such as GLARE and other composites, each with a different cost-to-weight factor, airframe weight has been broken down further to a level where the impact on cost of the various advanced materials can be estimated. Also, by developing weight estimates for the major elements of the airframe, use can be made of published information regarding the weight savings projected to be achieved with the advanced materials relative to what the weights would be if the entire airframe were made of aluminum. Published weight savings claims can be used as a check on the reasonableness of the weight assumptions made, as further explained below. The breakdown of airframe weight into major airframe components is shown in Exhibit4-4. Cost estimates for each airframe element will now be discussed in detail.

### Exhibit 4-4
### Breakdown of Airframe Weight into its Major Elements

| Component | Weight |
|---|---|
| Fuselage from aft of cockpit to rear bulkhead | 176,000 |
| Nose and cockpit section | 12,000 |
| Tail cone | 12,000 |
| Wing box | 22,000 |
| Empennage | 44,000 |
| Wing | 206,000 |
| Total airframe weight | 472,000 lbs. |

*Note: All weights in pounds*

### 4.4.2.1: Fuselage from aft of cockpit to rear bulkhead

For this estimate the following cost assumptions are made (explanation provided below):

For primary Aluminum structure: $240 per pound
For primary complete GLARE panels: 3 x $240 per pound = $720

The fuselage is comprised of the "fuselage barrel" consisting of skin (aluminum or GLARE), aluminum tear straps, doublers and stringers, as well as frames and two decks (main deck and upper deck). The fuselage from aft of the cockpit to the rear bulkhead consists of three major fuselage sections: the center section containing the wing box, the forward section up to the cockpit and the aft section to the rear bulkhead. The latter two sections contain GLARE.

GLARE panels are laid up in a mold and cured in an autoclave with aluminum stringers bonded to the inside surfaces. Cost information could only be obtained by comparing information regarding these built-up panels against similar, assembled, all-aluminum panels ready for installation on the airframe. Thus, to estimate the cost implications of GLARE, the weight of the "fuselage barrel" consisting only of panels and stringers has to be estimated. Its weight is assumed to be 60 per cent (60%) of the total weight of this fuselage section, i.e. 105,600 pounds. On this basis, the fraction, by area, of the “fuselage barrel” consisting of GLARE panels is calculated as follows for the passenger A380:

- From an Airbus drawing showing a side view of the A380 which is assumed to be to scale, 52 per cent (52%) of the total length of the “fuselage barrel” (weighing 105,600 pounds) contains GLARE – and only in the upper part of the fuselage.
- From published dimensions for the width and height of the “fuselage barrel” and information obtained from knowledgeable sources, a total of 380 square meters of GLARE are used; it follows that approximately 55 per cent (55%) of the circumference consists of GLARE panels.
- By multiplying 52 per cent (52%) (length fraction of GLARE) by 55 per cent (55%) (circumferential fraction of GLARE) the GLARE fraction of the surface of the “fuselage barrel” is found to be 29 per cent (29%).

Built-up GLARE panels, in primary structure, have been reported variously as costing from three to ten times as much as equivalent assembled aluminum panels. In order to be conservative, the area of the “fuselage barrel” consisting of GLARE is assumed to cost three times as much to manufacture compared with a conventional aluminum structure.

The cost of the “fuselage barrel” can now be estimated as follows:

- First, the area fractions for the Al and GLARE panels given above have to be converted to weight fractions. Since aluminum panels are heavier than GLARE panels, the 71 per cent (71%) area covered by aluminum weighs somewhat more than 71 per cent (71%) of the overall “fuselage barrel” weight. Correspondingly, the 29 per cent (29%) area covered by GLARE weighs less than 29 per cent (29%) of the overall weight. This relationship can be expressed in the following equation:

  $$105{,}600 = 0.71 \text{ x } 105{,}600 \text{ x } C(\text{Al}) + 0.29 \text{ x } 105{,}600 \text{ x } C(\text{GLARE}),$$

  where C(Al) and C(GLARE) are the transformation constants which lead from area to weight fractions for Al and GLARE, respectively.

From reports and information provided by GLARE experts at conferences, it is known that GLARE skin material can be anywhere from five to 15 per cent (5-15%) lighter than aluminum. It is assumed here that the built-up panels are seven per cent (7%) lighter, given their integral aluminum stringers. Then,

$$C(GLARE) = 0.93 \times C(Al)$$

from these two equations one readily obtains the following values for the constants:

$$C(Al) = 1.02 \text{ and } C(GLARE) = 0.95$$

The cost of the "fuselage barrel" is determined as follows:

$$(0.71 \times 1.02 + 0.29 \times 0.95 \times 3) \times 105{,}600 \times 240 = \$39.3 \text{ million}$$

To get the total cost of the fuselage section from cockpit to rear bulkhead, the remaining 70,400 lb. of Al structure, corresponding to $16.9 million, is added, for a total of $56.2 million.

The remaining 40 per cent (40%) of the structure actually contains composite components for the upper deck. This is partially secondary structure; it is assumed to cost as much to produce as primary aluminum structure.

#### 4.4.2.2: Nose and cockpit section

For this aluminum structure the aluminum factor is used, resulting in a cost of $2.9 million.

#### 4.4.2.3: Tail cone

This section consists almost entirely of composite materials. It is primary structure. The cost of manufacturing primary composite structure is on a learning curve. It has decreased from as high as $1,500 per pound several years ago to the range of $600 to $1,000 currently. According to knowledgeable sources, it might come down to $500 to $600 in the near future. Long term (10 years), the aerospace community is hopeful that the cost might decrease to the $300 to $400 range. For this analysis, the figure of $500 per pound is assumed as being realistic for the 100th aircraft.

At $500 per pound the cost of the tail cone is $6.0 million.

### 4.4.2.4: Wing box

According to the most recently available information (Aerospace Engineering, October 2001) the wing box consists of approximately 13,200 pounds of composite material and 8,800 pounds of aluminum cross members and rib tees. Using the factors of $500 per pound and $240 per pound for the composite and aluminum components, respectively, the estimated cost of the wing box is $8.7 million.

### 4.4.2.5: Empennage

At $500 per pound, the estimated cost is $22 million.

### 4.4.2.6: Wing

The wing will incorporate advanced light-weight aluminum alloys, such as Al-Li alloys, to reduce its weight. It also may have composite outer wings. These had originally been considered, but then were not selected for the early versions of the aircraft. Now, in view of the fact that the wing is said to be overweight, composite outer wings may yet make it onto the aircraft from the start.

To account for the advanced -- and more costly -- aluminum alloys, the cost factor used for the wing is $270 per pound. The resulting cost of the wing is $55.6 million.

The results are summarized in Exhibit 4-5.

**Exhibit 4-5**
**Estimate for Production Cost of Airframe**

| Component | Weight | Cost ($ million) |
|---|---|---|
| Fuselage from aft of cockpit to rear bulkhead | 176,000 | $ 56.2 |
| Nose and cockpit section | 12,000 | 2.9 |
| Tail cone | 12,000 | 6.0 |
| Wing box | 22,000 | 8.7 |
| Empennage | 44,000 | 22.0 |
| Wing | 206,000 | 55.6 |
| Total airframe weight | 472,000 lbs. | $ 151.4 |

*Note: All weights in pounds*

### *4.4.3: Estimate of production cost of aircraft*

The total estimated production cost of the A380 is $194.9 million. It is reflected in Exhibit 4-6. This estimate takes into account the fact that it has been determined that Rolls Royce is basically donating the engines at $1 million each for launch customers. (Rolls Royce obviously expects to recoup through parts sales.)

**Exhibit 4-6**
**Total Estimated Production Cost of A380**

| Component | Estimated Cost ($ million) |
|---|---|
| Airframe | $ 151.4 |
| Engines and Power packs | 8.0 |
| Avionics | 15.0 |
| Systems | 10.0 |
| Landing Gear | 10.5 |
| Total | $ 194.9 |

### *4.4.4: Validating the GLARE weight-saving estimate*

From an article in the Wall Street Journal and from interviews with people from the GLARE supplier community, it has been learned that the prospective weight savings attributable to GLARE for the passenger version are estimated to be about 2,200 pounds. This weight-saving from GLARE compared to aluminum is calculated as follows:

- From the above, total weight of the GLARE panels is calculated to be:

  W(GLARE panels) = 0.29 x 0.95 x 105,600 = 29,093 lb.

- Using the weight ratio of GLARE to aluminum of 0.93, panel weight would be 31,283 pounds if such panels were made entirely of aluminum. The weight difference is therefore 2,190 pounds, which is in close agreement with previously stated weight-reduction estimates.

## 4.5: Estimated airframe weight and production cost – cargo aircraft

Judging from the limited information Airbus has made public on the cargo version, the most significant difference between passenger and cargo A380s with the biggest impact on production cost is the addition of GLARE to the center fuselage section for the latter. Another difference, with a minor net impact on cost, is the replacement of the composite floor beams in the upper deck of the passenger version with aluminum floor beams for the cargo A380. The main deck has aluminum floor beams for both types of aircraft.

### *4.5.1: Accounting for increased GLARE in fuselage*

In general, the same methodology is used for the cargo version as was employed in the case of the passenger aircraft, discussed in Section 4.4.2. The same source of information was used for the OEW, which is given as 549,000 pounds. A tabulation of the estimated weights of major subsystems to derive the airframe weight is presented in Exhibit 4-7.

### Exhibit 4-7
### Development of Airframe Weight for Cargo Version

| Component | | Weight |
|---|---|---|
| OEW | | 549,000 |
| 4xEngines | 56,000 | |
| 4x Power packs | 4,000 | |
| 2x Thrust reversers | 4,000 | |
| Landing gear | 31,000 | |
| Systems (APU, etc.) | 9,000 | |
| Subtotal | 104,000 | |
| Air Frame Weight | | 445,000lbs. |

*Note: All weights in pounds*

The cargo airframe is 27,000 pounds lighter than that of the passenger version without BFE. This weight reduction is due to the elimination of certain interior panels and all wiring for passenger seats (including entertainment systems) as well as for galleys and lavatories. In addition, the floor support structure is simpler and lighter since no support structure is needed for galleys and lavatories. Moreover, the weight of much of the air conditioning plumbing is eliminated.

#### 4.5.1.1: Fuselage from aft of cockpit to rear pressure bulkhead

The cargo aircraft has double the amount of GLARE of the passenger A380. Thus, from the analysis in Section 4.4.2, it is concluded that the fuselage weight is reduced by another 2,200 pounds. Following the methodology in Section 4.2.1, but inserting the lighter fuselage weight from taking into account that GLARE is applied to 100 per cent (100%) of the upper fuselage barrel length, one obtains a cost of $68.2 million for the fuselage barrel section, or $12 million more than for the passenger version.

The elimination of 27,000 pounds, as discussed above, is estimated to save about $5 million. A cost factor of $185 per pound is used to account for the fact that a part of the weight savings comes from the elimination of wiring and plumbing. This cost, on a per pound basis, is lower than that of fabricated aluminum structure. In sum, there is a net cost increase of $7 million for the cargo version fuselage as compared with the passenger A380.

### *4.5.2: Cost of remaining aircraft components and of total aircraft*

The remaining costs of the cargo aircraft are approximately the same as those for the passenger aircraft. Consequently, the total estimated production cost is $201.9 million.

# Appendix 5: A380 Development Cost and Public Financial Support

## 5.1: Introduction

Estimating the total development cost of the A380 is made difficult by two factors. First, Airbus is asking its major suppliers to be risk-sharing partners, bearing some or all of the development costs for their components in addition to contributing to Airbus' own development costs. It is not known if such risk-sharing contributions to development are appropriately accounted for in the published total development cost figure. In addition, some of the suppliers may be receiving direct state aid to defray all or part of their own development cost and any direct cash contributions to Airbus. Second, the accuracy of the total development cost projected by Airbus is questionable since it is making very aggressive use of advanced technologies in the design and manufacture of the A380 in order to keep airframe weight within limits. Some of these technologies are being applied for the first time to a large civil transport aircraft; this makes uncertain both time to start of production and the costs associated with completing A380 development and obtaining regulatory approval.

## 5.2: Overall Breakdown

At the official start of the A380 project in late December of 2000, Airbus projected a total development cost of $10.7 billion. Of this, $7.4 billion (69%) is for aircraft development and $3.3 billion (31%) for non-recurring tooling investment. More recently, Airbus has claimed it will use $5.1 billion of its own funds while $3.1 billion will come from risk-sharing partners. The remaining $2.5 billion would be financed by European government loans, which are repayable.

The above split of total development cost between Airbus, its suppliers' contributions and government support is in accord with the 1992 Agreement on Trade in Large Civil Aircraft between the EU and the U.S. (cf. Appendix 6). Under the terms of this agreement, the amount of development cost covered by the suppliers ($3.1 billion) has to be subtracted from the total amount ($10.7 billion) before the maximum amount of allowable government support can be calculated at 33 per cent (33%) of $7.6 billion, or $2.51 billion.

## 5.3: Risk-sharing Partnerships

Current Airbus plans call for risk-sharing partners to provide $3.1 billion in development funding, or 29 per cent of total projected A380 development costs. Airbus' original target was 38 per cent ($4.1

billion), but this was reduced, probably due to lack of enthusiasm shown by potential partners. Of the $3.1 billion, Airbus would like $2.1 billion to be in the form of traditional risk-sharing partnerships. The remaining $1 billion is expected to be cash contributions from suppliers. The concept of receiving cash contributions from suppliers is new and risky for the vendors. A supplier participating in a risk-sharing partnership typically covers a portion of the up-front, non-recurring costs in exchange for a defined share of revenue and profit associated with future deliveries.

Judging by vendor reactions, most potential partners appear to have no interest in the co-funding, risk-sharing approach. For example, Japanese industry eschewed any major A380 role. (It was offered an eight per cent (8%) participation in the A380 program.) Taiwan's Aero Industry Development Center (AIDC) in July 2001, rejected an offered A380 stake. AIDC officials said the one per cent (1%) share required a $100 to $120 million commitment and that the potential reward did not justify the investment.

As for U.S. suppliers, several have decided not to become risk-sharing partners. In the case of BF Goodrich (main landing gear supplier), it appears that the company is funding the development of the landing gear but is not making a cash contribution to Airbus.

Alenia of Italy was offered a five per cent (5%) stake in the Airbus enterprise, but after a company forecast showed a market for only 485 aircraft above 500 seats from 2000-2019, it chose instead a seven per cent (7%) share in the A380 program alone. The reluctance of Alenia to accept a higher sake implies a requirement to insulate the company from risk. As a result of the half-hearted response from potential partners, there is some uncertainty as to whether Airbus can reach its goal of 29 per cent (29%) partnership funding of A380 development.

Among the companies that did decide to take a stake in the A380 program is the Dutch Fokker (Stork) Group, which has signed an MOU to take a two-and-one-half per cent (2.5%) participation in the A380. The company's main contribution is considered to be the provision of GLARE panels. However, it needs to find additional work to reach the two-and-one-half per cent (2.5%) goal.

As a consequence of Airbus' push for risk sharing partnerships for the A380, this program is becoming the Airbus aircraft with the highest proportion of European content yet. So far, non-European suppliers have been chosen for only three major systems: Pratt & Whitney Canada will provide the APUs, Goodrich the main landing gear and Rockwell Collins the avionics data bus. In addition, Honeywell will supply some its proprietary avionics products. It appears a given that all major structural airframe components and systems (except landing gear) will come from European suppliers.

## 5.4: New Facilities*

In addition to the $5.1 billion Airbus itself intends to spend on development – out of a total estimated development cost of $10.7 billion – at least $1.44 billion (1.6 billion euros) will have to be spent on new building construction and other capital investments:

| | |
|---|---|
| New facilities at Toulouse | 500 million euros |
| New facilities at Hamburg | 500 million euros |
| New autoclaves and expansion at Nantes | 170 million euros |
| Assembly improvements at Meaulte | 30 million euros |
| Improvements at Nordenham | 100 million euros |
| Investments at BAe's Filton and Broughton facilities | 200 million euros |
| New factory for Latecoere | 100 million euros |
| Total | 1,600 million euros = $1.44 billion |

Moreover, improvements to sea and river ports and to highways are needed to allow transportation of A380 fuselage sections and wings by several modes of transportation. For example, fuselage barrels will move by ship from Hamburg to a port near Bordeaux where they are transferred to a barge going up-river; finally they are placed on a trailer for movement to Toulouse. None of these investments and costs associated with development of the A380 seem to be considered in its total development cost. Instead, they appear to be covered by various government programs designed to stimulate local industrial activity. The investments are assumed to be recovered later from increased tax revenues.

## 5.5: Airport Facilities

Finally, consideration needs to be given to the fact that some or all of the following investments must be made at airports where the A380 will be operated:

- Strengthened runway and taxiway bridges;
- Strengthened airside pavement;
- Modified or new runway turnoffs and taxiway filets;

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* Section 5.4: Available figures for new, unique, facilities are in Euros; therefore both dollar and Euro costs are shown.

- Expanded gate spacing at a sufficient number of gates.
- Addition of jetways;
- Accommodations for second-deck passenger access and egress;
- Especially at international airports, expanded space and facilities for handling a greater number of passengers, including for customs and immigration services, per unit of time.

While this analysis does not attempt to quantify these items, it is very likely they will result in additional cost for the overall A380 program.

# Appendix 6:  State Aid and Reimbursements

Under the terms of the bilateral agreement of 1992 between the U.S. and the European Union concerning trade in large civil aircraft, the amounts of direct and indirect state support that either party can provide to the development of a large transport aircraft are limited.  Direct government support must not exceed 33 per cent (33%) of the total development cost.  Indirect support must not exceed three per cent (3%) of the total annual revenues of the civil air transport manufacturing industry in a party's domain.  No government support for production is permitted.

## 6.1:  Direct Support

Development costs qualifying for direct support are defined under the Agreement to include:

- Preliminary design
- Engineering design
- Wind-tunnel, structural, system and laboratory tests
- Engineering simulations
- Equipment development work, except for work directly financed by equipment and engine manufacturers
- Flight tests, including associated ground support, and analysis necessary to obtain certification
- Documentation required for certification
- The cost of manufacture of prototypes and test aircraft, including spares and such.  Modifications as may be necessary to obtain certification, less the estimated fair market value of flight aircraft after refurbishment
- Jigs and tools, except machine tools, for use on specific programs

All direct support must be repaid. An amount equal to 25 per cent (25%) of the total development cost (75% of direct support) must be recouped through royalty payments at an interest rate no less than the cost of borrowing to the government; the remaining eight per cent (8%) (25% of direct support) with royalties at that interest rate plus one per cent (cf. Exhibit 6-1).  Both royalty streams must be repaid "within no more than 17 years."

## Exhibit 6-1

## Sources of A380 Development Support

| | |
|---|---|
| Direct state support and repayment terms: | |
| At government interest rate: | 25% |
| At government interest rate plus 1% | 8% |
| Subtotal – Direct support: | 33% |
| Commercial: | 67% |
| Total: | 100% |

"Royalty payments" per aircraft must be calculated at the time of commitment of the development support to be repaid on the following scheduled basis:

> 20 and 70 per cent of the aggregate payments are payable on the basis of the delivery of a number of aircraft corresponding to 40 and 85 per cent, respectively, of forecast deliveries for the first 17 years. This means that the payback stream is back-loaded.

### 6.2: Indirect Support

Indirect support constitutes state-supported research which conveys identifiable benefits to the development or production of a transport aircraft. It is subject to the limitation of the Agreement and does not have to be repaid. The amount of indirect support available to Airbus has been significant and is growing. Indirect support is provided through the European Commission as well as by the individual nations with interest in Airbus, primarily France, Germany and the UK and, to a lesser extent, Italy, Spain and Belgium.

In earlier research it was estimated that the total amount of indirect support of benefit to Airbus was between $745 to $1,275 million in 1997. The amount of such support has increased since then. The contribution by the European Commission has been doubled for the years 1999- 2002 (Fifth Framework Programme), while the amounts from the various countries has either remained stable or been increased. (Going forward, the EC's "Vision 20/20" statement strongly indicates the trend of civil aviation research and development supported significantly by public funds will be up for many years to come.)

Under accepted European practice, industry matching of government R&D support puts industry in a position of defining all jointly-funded R&D projects. This means that over the five-year development period of the A380, between $4 and $6 billion of indirect state aid may be supporting Airbus R&D requirements, mostly for the A380.

## Appendix 7: New Technology - Focus on GLARE

### 7.1: Introduction

With the A380 program, Airbus announced plans for introducing, all at once, several advanced technologies, some for the first time on civil transports. In fact, the A380 has the most ambitious technology goals of any large transport aircraft since the advent of the jet age (see Appendix 4).

Since GLARE is central to Airbus achieving projected A380 performance results, a detailed discussion of this material follows, together with its principle applications to the aircraft.

### 7.2: Principle Applications of GLARE

Airbus will make the upper part of the fuselage (down to and including lower window belts) of GLARE. For the initial passenger aircraft the center section will not have GLARE, but the cargo version is expected to have GLARE along the entire upper fuselage (except for cockpit and tail cone sections).

GLARE (GLAss fiber REinforced Aluminum) has been under development for some 20 years. It is an advanced fiber-metal laminate (FML) consisting of several alternating thin layers of “traditional” aircraft-quality aluminum (Al) and glass fiber prepreg material. (Prepreg material consists of sheets of glass fibers and a bonding material.) GLARE is produced by preparing a laminate lay-up in a mold followed by curing in an autoclave. The number of aluminum and fiber layers can have an Al-to-prepeg ratio of from three-to-two to nine-to-eight, or even more.

GLARE panels are made by placing several aluminum sheets, butted together, in a single layer into a mold. Next, at least two layers of prepreg, with the fibers oriented at 90 degrees to each other, are placed on top of the Al. Then, another layer of Al panels is put on top of the prepreg such that the butt joints are offset from the joints in the first layer. And so on, until all layers have been placed into the mold. This assembly is cured in an autoclave at a temperature of about 350 degrees F.

While GLARE panels can be bent into shape to some extent (they are less bendable than monolithic aluminum), typically they are molded into shape in the autoclave. This curing process can also be used to bond certain structural components to the skin, such as stringers. Airbus is planning to use this entire process to save assembly cost.

The process lends itself to the production of GLARE panels substantially larger than monolithic aluminum panels. An Airbus paper at AeroMat 2001 quoted the maximum size for GLARE panels as 3.5m x 14m (11.5 ft x 45.9 ft).

A bit of history is in order. Advanced FMLs were first developed at the Technical University (TU) Delft in the Netherlands during the 1980s with the goal of producing more fatigue- and damage-resistant fuselage and wing structure. One of the initial industrial partners was the chemical company Akzo. Because it produces a Kevlar-type aramid material, the first FML developed contained aramid fibers and was called Arall. It was successfully applied to the main rear cargo door of the first 41 C-17 U. S. Air Force cargo aircraft. This was the first application of an FML on a large aircraft component. (The cargo door is not considered a full primary structural element – it falls halfway between primary and secondary structure.) On subsequent C-17s, Arall was replaced by regular, monolithic aluminum in order to reduce cost. The weight savings of Arall (about 150 pounds per cargo door) was no longer justifiable when Air Force priorities shifted from weight to cost considerations. The C-17 application was deemed technically successful. However, aramid fibers are very costly and have certain inherent drawbacks, such as a negative temperature coefficient. This means that they expand with decreasing and contract with rising temperature, respectively; this is the opposite of aluminum. For both reasons, aramid was subsequently replaced by glass fibers in the GLARE FMLs for commercial use.

## 7.3: First Application to Primary Structure

The use of GLARE for the upper fuselage of the A380 is the first application to primary structure in a large transport aircraft. GLARE sheets have superior strength and damage tolerance characteristics compared with monolithic aluminum and are 5 to 20 per cent (5-20%) lighter than aluminum sheets of comparable strength and fatigue-resistance. The integrity of GLARE depends heavily on the integrity of the bonding between the layers of the laminate. The C-17 application proved that such materials can be manufactured with the necessary integrity. In addition, the C-17 application also pioneered joining of panels by drilling and riveting. It took several years, including the development of special tools, to perfect the assembly process to the point where it produced acceptable joints.

## 7.4: Certification Risk

One major concern with GLARE panels is that there exists as yet relatively limited experience on how to assure integrity of the material during long-term operational use, including aging effects and damage repair. The newness of the material and the lack of experience with it as primary structure are likely to pose certification challenges. In addition, some information from Airbus indicates that Airbus, wanting to fully utilize the superior damage tolerance characteristics of GLARE, may ask for an unprecedented certification that would eliminate the usual requirement for inspection during the first "design service goal". ("Design service goal" defines the length of the period during which the aircraft is designed to operate without any major repair or life-extension work.)

## 7.5: Cost

Proponents of GLARE maintain that, on a built-up panel-for-panel comparison with conventional aluminum panels, once all its advantages are utilized fully, the cost of GLARE panels is expected to be three times more than that of equivalent sized aluminum panels. This figure represents the minimum estimated cost of GLARE panels. It can realistically be achieved if full advantage is taken of the larger potential size of GLARE panels compared to aluminum and if stringers are bonded to the panels in the autoclave. As the discussion below will point out, the cost depends to some extent on whether the structure is built for light weight with the acceptance of the need for fatigue crack inspection or with greater strength (and heavier weight), possibly eliminating the need for inspection during the design service goal period. In the latter case, the cost would be higher but the cost of maintenance might be lower – assuming that such an inspection-free approach can be certificated.

A real-life comparison data point is provided by the experience with Arall on the C-17. There, on a per pound basis, Arall was about ten times more expensive than monolithic aluminum. Even though this example cites Arall, with its more expensive, aramid fiber prepeg material, it reinforces the fact that the assumption of a factor of three cost increase for GLARE is conservative, i.e. favorable to GLARE.

## 7.6: Other Applications of GLARE

In addition to Boeing (C-17) and Delft/Fokker/Airbus, Bombardier has been pursuing an internal R&D program to qualify GLARE for primary fuselage structure on future regional and business jets. Bombardier is said to be within two years of concluding its development and validation program. It is expected to be fully successful. Bombardier has been working with the National Research Council of Canada. At the AeroMat 2001 Conference, it reported on its extensive program of validating GLARE for subsequent deployment. R&D is being conducted at Toronto, in cooperation with TU Delft and Aviation Equipment, Inc. Detailed design and manufacturing will be done at Bombardier's Belfast plant.

At Bombardier, development and testing of GLARE have reached an advanced stage. The greatest remaining challenges appear to be getting its cost reduced to a level where it can compete with monolithic aluminum and in obtaining certification.

## 7.7: GLARE Properties

### *7.7.1: Damage Tolerance*

GLARE is considered an attractive material for fatigue-prone aircraft structure because it promises superior strength and durability as well as excellent damage-tolerance properties in combination with essentially aluminum-like operational characteristics-- all, possibly, at lower weight than monolithic aluminum. Its impact-damage behavior is similar to that of aluminum (a major advantage over "pure" composite materials) and GLARE panels can be repaired with processes similar to those used on aluminum. It can be made with all of the standard aluminum alloys. For instance, with 2024 aluminum, GLARE panels benefit from the high degree of corrosion resistance of this alloy. It is typically made with 2024. (If made with 2024-T3, it is classified as GLARE 3.) The superior damage-tolerance behavior of 2524 is not needed, however, because the laminate structure of GLARE is inherently and significantly more damage-tolerant because crack growth is impeded by the fiber layers.

The decreased rate of crack growth in GLARE, compared to that of monolithic aluminum, is because the fiber layers, by absorbing strain around cracks in the aluminum, reduce the load at the cracks. This means that the residual strength of the material is better preserved, an essential feature for damage tolerance. Thus, the material is better able to tolerate major damage from, for example, the impact of a fragment from a disintegrating rotating engine part, because the GLARE itself offers superior resistance to such impact. The impact from such a fragment can lead to the breach of one or more of both aluminum and fiber layers, even though any fatigue damage is limited to the aluminum layers.

Similar to aluminum structure, crack-stopping features have been designed into GLARE panels. They consist of localized additional strips of fiber layers strategically placed for optimum effectiveness. Certainly, such strengthening increases the weight and thickness of GLARE panels.

### *7.7.2: Strength*

GLARE is considerably stronger than monolithic aluminum of equal weight. GLARE displays its advantages best under tensile loads, such as those experienced by upper fuselage skin. Since the thermal expansion coefficients for aluminum and prepreg are not identical, but are both positive, GLARE panels have a small degree of residual tensile stress from the curing process during manufacturing which can be used to advantage to increase structural strength.

### *7.7.3: Design Options for Inspection and Related Certification Issues*

The slower crack growth and higher residual strength of GLARE provide the designer with two options: One, design for lowest weight and inspect for cracks during the design service goal of the structure. Or, two, make the structure more crack-resistant, thus heavier, and eliminate the need for inspection during the design service goal. At AeroMat 2001, Airbus and TU Delft representatives indicated that they are pursuing the latter course. If they do, that will certainly pose a challenge to the civil aviation certification authorities because, contrary to established practice, such authorities would have to accept that the A380 be allowed to fly with cracks without repair and without inspection during the design service goal. The latter design approach would also not realize the full, or potentially any, benefit of lower weight, but would have the benefit of reducing A380 operating cost.

### *7.7.4: Damage Mechanisms*

The superior residual strength and damage tolerance characteristics of GLARE depend on the integrity of the bond between the various layers. Delamination between any of the layers, especially at high stress points where aluminum fatigue cracking first occurs, seriously degrades the strength and crack-resistance of the material. As is known from other bonded materials, the quality of the bond depends critically on the quality and integrity of the manufacturing and assembly processes. In the case of GLARE, this not only includes the lay up procedures and autoclave cure (which have become routine), but also the process of drilling rivet holes and installing of rivets. The latter was developed by an Alcoa/Boeing team for the C-17 rear cargo door. Different drill designs as well as drilling and riveting parameters were found to be required.

The greatest threat to panel integrity in service, apart from impact damage, is from intrusion of moisture in the GLARE panels because this weakens the bonds. Therefore, edges of new panels must be completely sealed. However, accidental damage or poor repair work can still jeopardize the seals and bonds.

### *7.7.5: Weight*

As discussed above, there is a design trade-off between light-weight panels that exhibit fatigue-cracking performance roughly equivalent to that of monolithic aluminum panels versus heavier panels with superior crack growth characteristics. Panels designed for minimum weight promise a total weight reduction (taking into account the fact that larger GLARE panels require fewer rivets to fasten them to the fuselage) of up to 15 to 20 per cent (15-20%). As the panels are designed for better crack-resistance, the weight advantage is reduced and may disappear completely.

## 7.8: Summary of Experience

### *7.8.1: Boeing/Alcoa*

The first major application of FML (Arall) was to the rear cargo door of the C-17, a component somewhere between secondary and primary structure. As the supplier of Arall, Alcoa developed a number of manufacturing patents. Alcoa is evaluating whether to become a supplier of GLARE panels. Fokker Aerostructures, which is part of the Dutch Stork Group, is currently the only supplier of this material to Airbus.

### *7.8.2: Aviation Equipment, Inc.*

This company is a U.S. licensee for secondary structure GLARE. GLARE has been applied in the U.S. mostly to cargo aircraft floor structures. GLARE components have been installed in secondary structure in B737, MD-80 and B757 cargo decks. It is also found on the B777 bulk cargo deck.

### *7.8.3: Bombardier*

This company has been working on GLARE primary structure applications since 1986. It reports very good progress and expects to utilize it on the fuselage of one or more of its new designs for regional and/or business jets. Bombardier's first application was on the Learjet 45 business jet's forward radome bulkhead. (It has conducted a durability program with the National Research Council of Canada. The FAA may well have access to this work through their cooperative relationship with NRC.) Bombardier is currently in the middle of performing tests on an "advanced technical test" fuselage. As the result of a recently completed trade-off study of a new CRJ 700 fuselage, Bombardier has concluded that the business case for GLARE can be made, primarily based on weight saving.

### *7.8.4: Airbus*

Airbus and its risk-sharing A380 partner, Fokker Aerostructures, are furthest along. GLARE was first flown as a test section of primary structure on an A310 in October 1999; the aircraft was not certificated. Design codes have been developed and validated – or are still undergoing validation – and a large fuselage test bed for fatigue testing has been constructed and is being used. The A380 team made its initial presentation on the GLARE-equipped fuselage to the JAA in 2001.

It must be noted that, for the passenger version, GLARE crown skin panels will only be used in the two large fuselage sections supplied by Deutsche Airbus, the sections aft and in front of the center section. The fuselage section containing the center wing, manufactured by Airbus France, will use monolithic aluminum. Since the crown area in the center (wing) section will experience the highest loads, it was considered prudent not to use GLARE, at least initially. For the cargo aircraft, use of GLARE is extended to the center section.

Some of the comments made at AeroMat 2001 by technical representatives from several organizations involved in, or closely following, the A380 GLARE application indicated that the decision on the use of GLARE for the A380 may not be final. For example, some Airbus engineers are skeptical about its weight-saving potential and concerned about cost and technical risks as well as certification problems.

## 7.9: Sources of information

a) Communication with experts in academia, government and industry

b) AeroMat 2001 Conference presentations

c) Aviation Week article *"Low-Fatigue Material Saves Weight on A380"*, AW&ST Vol. 154, No. 25, June 18, 2001, pp. 126.