



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

# ***A Predictive Model of User Equipage Costs for Future Air Traffic Services and Capabilities: An ADS-B Example***

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*NDIA Systems Engineering Conference*

*October 26, 2006*





# Overview

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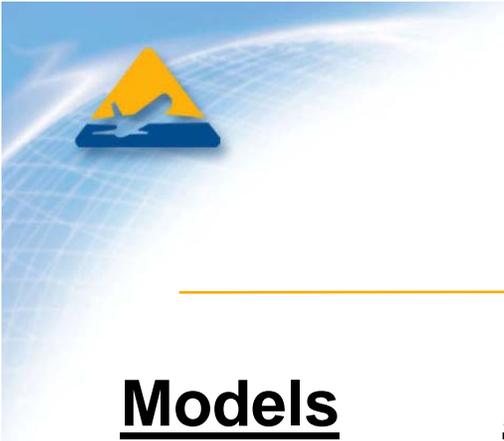
- **The air transport model-specific fleet forecast**
- **The general aviation type-specific forecast**
- **Aircraft classification, equipage states and costs**
- **Possible user responses to FAA implementation**
- **Equipage costs of voluntary responses and mandates**



## Why a Model-Specific Fleet Forecast?

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- **Most forecasts provide detail only to the level of “narrow body” and “wide body”**
- **In most cases, the cost to modify a DC-9 can be greatly different than a B737-800**
- **Model-specific equipage knowledge allows for forecasting penetration of various technologies**

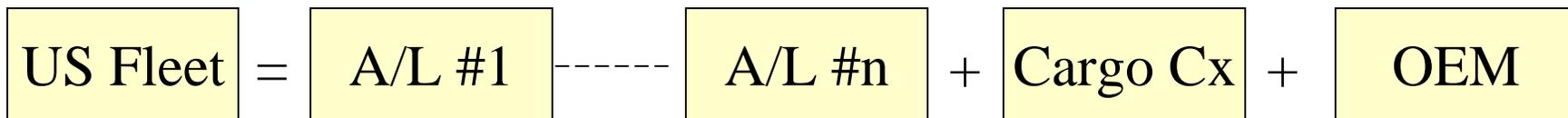


## Bottom-up Approach

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Models      2002   2003   2004   2005 ..... 2030

Forecast = Actual aircraft in past years (per airline)  
+ Firm commitments by year (per airline)  
- Retirements by year (per airline)  
+ Cargo conversions (airline unknown)  
+ Future deliveries to unknown airlines





# SEC Filings of Publicly Traded Airlines

UNITED STATES SECURITIES AND EXCHANGE  
COMMISSION  
WASHINGTON, D.C. 20549  
FORM 10-K

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ANNUAL REPORT PURSUANT TO SECTION 13 or 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934  
FOR THE FISCAL YEAR ENDED DECEMBER 31, 2003

OR

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DELAWARE  
(STATE OR OTHER JURISDICTION OF INCORPORATION  
OR ORGANIZATION)

111 WEST RIO SALADO PARKWAY  
TEMPE, ARIZONA 85281  
(ADDRESS OF PRINCIPAL EXECUTIVE OFFICES)

(I.R.S. EMPLOYER IDENTIFICATION NO.)

(480) 693-0800  
(REGISTRANT'S TELEPHONE NUMBER, INCLUDING  
AREA CODE)

OR

SECURITIES REGISTERED PURSUANT TO SECTION 12(b) OF THE ACT:

TITLE OF EACH CLASS  
CLASS B COMMON STOCK, \$0.01 PAR VALUE

TRANSITION REPORT PURSUANT TO SECTION 13 or 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

COMMISSION FILE NUMBER 1-12649

## AMERICA WEST HOLDINGS CORPORATION

(EXACT NAME OF REGISTRANT AS SPECIFIED IN ITS CHARTER)

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(STATE OR OTHER JURISDICTION OF INCORPORATION  
OR ORGANIZATION)

111 WEST RIO SALADO PARKWAY  
TEMPE, ARIZONA 85281  
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86-0847214  
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NEW YORK STOCK EXCHANGE



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NEW YORK STOCK EXCHANGE

## Actual Aircraft

| Aircraft<br>Types | Approx.<br>No. Seats | Number 12/31 |      | Average Age (Yrs.) 12/31 |      |
|-------------------|----------------------|--------------|------|--------------------------|------|
|                   |                      | 2003         | 2004 | 2003                     | 2004 |
| B737-200          | 113                  | 8            | 0    | 22.1                     | n/a  |
| B737-300          | 132                  | 37           | 37   | 15.9                     | 16.9 |
| B757-200          | 190                  | 13           | 13   | 17.2                     | 18.2 |
| A319-100          | 124                  | 32           | 33   | 3.3                      | 4.2  |
| A320-200          | 150                  | 49           | 54   | 7.8                      | 8.5  |
| Totals            |                      | 139          | 137  | 10.7                     | 10.7 |

## Firm Commitments

|  | 2004             | 2005             | 2006 | 2007 | 2008 |
|--|------------------|------------------|------|------|------|
| Firm orders (A318-100/A319-100/A320-200) | 2                | 2                | 7    | 8    | 0    |
| Lessor put options                       | 4 <sup>(a)</sup> | 2                | 4    | 0    | 0    |
| Lease terminations:                      |                  |                  |      |      |      |
| Scheduled lease expirations              | 7                | 13               | 16   | 10   | 11   |
| Lessor call options                      | 9 <sup>(b)</sup> | 1 <sup>(c)</sup> | 0    | 0    | 0    |



## Firm Commitments (as of Dec. 2003)

| US Aircraft Orders          | 2004       | 2005       | 2006       | 2007       |
|-----------------------------|------------|------------|------------|------------|
| A300                        | 8          | 10         | 10         | 11         |
| A310                        | 1          | 0          | 0          | 1          |
| A318                        | 2          | 2          | 0          | 0          |
| A319                        | 11         | 32         | 12         | 13         |
| A320                        | 21         | 16         | 32         | 23         |
| A321                        | 1          | 4          | 4          | 4          |
| A330                        | 3          | 4          | 4          | 7          |
| A380                        | 0          | 0          | 0          | 0          |
| B717                        | 13         | 9          | 4          | 0          |
| B737-700                    | 52         | 33         | 27         | 30         |
| B737-800                    | 18         | 26         | 31         | 40         |
| B737-900                    | 1          | 2          | 0          | 0          |
| B757-300                    | 6          | 0          | 0          | 0          |
| B767-200                    | 2          | 3          | 0          | 0          |
| B777                        | 0          | 2          | 4          | 2          |
| MD-11                       | 4          | 1          | 0          | 0          |
| <b>Total Large Aircraft</b> | <b>143</b> | <b>144</b> | <b>128</b> | <b>131</b> |



# Retirements Forecasted at 25 Years of Age

|                       |            |      |    |    |
|-----------------------|------------|------|----|----|
| AMERICA WEST AIRLINES | A319       | 2023 | 3  |    |
|                       |            | 2024 | 7  |    |
|                       |            | 2025 | 11 |    |
|                       |            | 2026 | 10 |    |
|                       |            | 2027 | 1  |    |
|                       | A319 Total |      |    | 32 |
|                       | A320       | 2014 | 12 |    |
|                       |            | 2015 | 3  |    |
|                       |            | 2016 | 2  |    |
|                       |            | 2017 | 1  |    |
|                       |            | 2019 | 1  |    |
|                       |            | 2020 | 4  |    |
|                       |            | 2021 | 1  |    |
|                       |            | 2022 | 3  |    |
|                       |            | 2023 | 4  |    |
|                       |            | 2024 | 7  |    |
|                       |            | 2025 | 5  |    |
|                       |            | 2026 | 3  |    |
|                       |            | 2027 | 3  |    |
|                       | 2028       | 3    |    |    |
| A320 Total            |            |      | 52 |    |
| B737-200              | 2006       | 4    |    |    |
|                       | 2007       | 5    |    |    |
| B737-200 Total        |            |      | 9  |    |



## Cargo Conversions of Certain Models

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| EQUIPMENTMODEL | FC2004 | FC2005 | FC2006 | FC2007 | FC2008 |
|----------------|--------|--------|--------|--------|--------|
| B737-200       | 13     | 2      | 8      | 11     | 10     |
| B747-100       | 4      | 1      | 1      | 0      | 0      |
| B747-200       | 8      | 4      | 2      | 1      | 1      |
| B747-300       | 0      | 0      | 0      | 0      | 1      |
| B757-200       | 0      | 0      | 0      | 0      | 4      |
| B767-200       | 0      | 0      | 0      | 3      | 15     |



## Reconciliation with FAA Forecast

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- **Since the model-specific forecast uses only Firm Commitments (which are zero after 2012), provision must be made for additional aircraft that will be delivered**
- **A preliminary summation forecast is compared to FAA forecasts to determine the gaps**
- **Use both**
  - *FAA Aerospace Forecasts Fiscal Years 2004 – 2015*
  - *FAA Long-Range Aerospace Forecasts Fiscal Years 2015, 2020, 2025 and 2030*



# FAA Aerospace Forecasts Fiscal Years 2004 – 2015

TABLE 22

## U.S. LARGE AIR CARRIERS PASSENGER JET AIRCRAFT

| CALENDAR<br>YEAR  | LARGE NARROWBODY |          |          |       | LARGE WIDEBODY |          |          |       | LARGE<br>JETS | REGIONAL<br>JETS | TOTAL<br>JETS |
|-------------------|------------------|----------|----------|-------|----------------|----------|----------|-------|---------------|------------------|---------------|
|                   | 2 ENGINE         | 3 ENGINE | 4 ENGINE | TOTAL | 2 ENGINE       | 3 ENGINE | 4 ENGINE | TOTAL |               |                  |               |
| <u>Historical</u> |                  |          |          |       |                |          |          |       |               |                  |               |
| 1998              | 2,949            | 508      | 32       | 3,489 | 309            | 226      | 122      | 657   | 4,146         | 10               | 4,156         |
| 1999              | 3,139            | 436      | 21       | 3,596 | 361            | 204      | 129      | 694   | 4,290         | 18               | 4,308         |
| 2000              | 3,362            | 385      | 9        | 3,756 | 424            | 169      | 120      | 713   | 4,469         | 26               | 4,495         |
| 2001              | 3,432            | 228      | 11       | 3,671 | 461            | 105      | 98       | 664   | 4,335         | 18               | 4,353         |
| 2002              | 3,406            | 145      | 0        | 3,551 | 482            | 86       | 90       | 658   | 4,209         | 1                | 4,210         |
| 2003E             | 3,370            | 101      | 0        | 3,471 | 480            | 56       | 74       | 610   | 4,081         | 9                | 4,090         |
| <u>Forecast</u>   |                  |          |          |       |                |          |          |       |               |                  |               |
| 2004              | 3,399            | 101      | 0        | 3,500 | 492            | 51       | 73       | 616   | 4,116         | 9                | 4,125         |
| 2005              | 3,504            | 100      | 0        | 3,604 | 514            | 42       | 73       | 629   | 4,233         | 16               | 4,249         |
| 2006              | 3,633            | 99       | 0        | 3,732 | 534            | 34       | 73       | 641   | 4,373         | 35               | 4,408         |
| 2007              | 3,728            | 98       | 0        | 3,826 | 554            | 33       | 73       | 660   | 4,486         | 53               | 4,539         |
| 2008              | 3,846            | 97       | 0        | 3,943 | 570            | 31       | 71       | 672   | 4,615         | 71               | 4,686         |
| 2009              | 3,972            | 96       | 0        | 4,068 | 581            | 29       | 68       | 678   | 4,746         | 89               | 4,835         |
| 2010              | 4,096            | 95       | 0        | 4,191 | 596            | 29       | 64       | 689   | 4,880         | 107              | 4,987         |
| 2011              | 4,219            | 94       | 0        | 4,313 | 611            | 30       | 64       | 705   | 5,018         | 124              | 5,142         |
| 2012              | 4,331            | 94       | 0        | 4,425 | 625            | 30       | 64       | 719   | 5,144         | 139              | 5,283         |
| 2013              | 4,451            | 94       | 0        | 4,545 | 637            | 30       | 64       | 731   | 5,276         | 149              | 5,425         |
| 2014              | 4,575            | 94       | 0        | 4,669 | 646            | 30       | 64       | 740   | 5,409         | 159              | 5,568         |
| 2015              | 4,721            | 94       | 0        | 4,815 | 654            | 30       | 64       | 748   | 5,563         | 169              | 5,732         |



# OEM Plug (deliveries to unknown airlines)

| EQUIPMENTMODEL | FC2004 | FC2005 | FC2006 | FC2007 | FC2008 | FC2009 | FC2010 | ... |
|----------------|--------|--------|--------|--------|--------|--------|--------|-----|
| A300           |        | 7      | 8      | 7      | 13     | 6      |        |     |
| A318           | 3      |        | 6      | 4      | 8      | 14     | 24     |     |
| A319           | 6      |        | 15     | 6      | 20     | 25     | 45     |     |
| A320           | 6      |        | 15     | 6      | 20     | 25     | 45     |     |
| A321           |        |        |        | 1      | 4      | 9      | 14     |     |
| A330           |        | 6      | 8      | 8      | 17     | 12     | 21     |     |
| A380           |        |        |        |        |        |        | 4      |     |
| B737-700       | 6      |        | 15     | 7      | 22     | 31     | 56     |     |
| B737-800       | 6      |        | 15     | 7      | 22     | 31     | 56     |     |
| B737-900       | 3      |        | 5      | 3      | 8      | 12     | 16     |     |
| B777-200       |        | 14     | 17     | 15     | 30     | 18     | 21     |     |
| CRJ200         |        | 9      | 22     | 20     | 16     | 16     | 16     |     |
| CRJ440         |        | 2      | 7      | 7      | 5      | 6      | 8      |     |
| CRJ700         |        | 9      | 22     | 22     | 16     | 17     | 18     |     |
| CRJ900         |        | 3      | 18     | 18     | 16     | 17     | 18     |     |
| Do328Jet       |        | 4      | 10     | 12     | 12     | 12     | 12     |     |
| ERJ-135        |        | 4      | 10     | 6      | 6      | 6      | 3      |     |
| ERJ-140        |        | 4      | 10     | 6      | 6      | 6      | 3      |     |
| ERJ-145        |        | 8      | 30     | 29     | 6      | 6      | 11     |     |
| ERJ-170        |        | 7      | 12     | 16     | 18     | 19     | 21     |     |
| ERJ-190        |        |        | 6      | 10     | 16     | 19     | 21     |     |
| TOTAL Plug     | 30     | 77     | 251    | 210    | 281    | 307    | 433    |     |



## Final Product (Example)

| EQUIPMENT MODEL | FC2002 | FC2003 | FC2004 | FC2005 | FC2006 | FC2007 | FC2008 | FC2009 | ... |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|-----|
| 360             | 3      | 3      | 3      | 3      | 3      | 3      | 3      | 3      |     |
| A300            | 102    | 116    | 124    | 141    | 159    | 177    | 200    | 216    |     |
| A310            | 51     | 51     | 52     | 52     | 52     | 53     | 53     | 53     |     |
| A318            | 0      | 4      | 9      | 11     | 17     | 21     | 29     | 43     |     |
| A319            | 221    | 243    | 260    | 292    | 319    | 338    | 368    | 396    |     |
| A320            | 281    | 319    | 346    | 362    | 409    | 438    | 477    | 520    |     |
| A321            | 31     | 31     | 32     | 36     | 40     | 46     | 55     | 68     |     |
| A330            | 9      | 14     | 17     | 27     | 39     | 54     | 78     | 94     |     |
| A380            | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 3      |     |
| ATR 42          | 59     | 50     | 50     | 52     | 55     | 60     | 69     | 69     |     |
| ATR 72          | 64     | 64     | 64     | 64     | 64     | 64     | 64     | 64     |     |
| B707            | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |     |
| B717            | 85     | 95     | 108    | 117    | 121    | 121    | 121    | 121    |     |
| B727            | 265    | 272    | 186    | 173    | 162    | 160    | 159    | 159    |     |
| B737-200        | 143    | 144    | 123    | 121    | 108    | 90     | 75     | 42     |     |
| B737-300        | 489    | 490    | 490    | 490    | 490    | 490    | 490    | 490    |     |
| B737-400        | 88     | 90     | 90     | 90     | 90     | 90     | 90     | 90     |     |
| B737-500        | 145    | 145    | 145    | 145    | 145    | 145    | 145    | 145    |     |
| B737-700        | 198    | 222    | 280    | 313    | 355    | 392    | 432    | 471    |     |
| B737-800        | 253    | 273    | 297    | 323    | 369    | 416    | 462    | 516    |     |
| B737-900        | 18     | 23     | 27     | 29     | 34     | 37     | 48     | 60     |     |



# Final Product (By Airline)

## America West Airlines

| EQUIPMENTMODEL                  | AC02       | AC03       | FC2004     | FC2005     | FC2006     | FC2007     | FC2008     | FC2009     | FC2010     | FC2011     | FC2012     | FC2013     | FC2014     |
|---------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| A319                            | 32         | 32         | 33         | 34         | 37         | 41         | 41         | 41         | 41         | 41         | 41         | 41         | 41         |
| A320                            | 49         | 49         | 54         | 55         | 59         | 63         | 63         | 63         | 63         | 63         | 63         | 63         | 50         |
| B737-200                        | 9          | 8          | 8          | 8          | 4          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | 0          |
| B737-300                        | 37         | 37         | 37         | 37         | 37         | 37         | 37         | 37         | 34         | 27         | 11         | 7          | 6          |
| B757-200                        | 13         | 13         | 13         | 13         | 13         | 13         | 13         | 10         | 7          | 4          | 3          | 3          | 0          |
| <b>Total</b>                    | <b>140</b> | <b>139</b> | <b>145</b> | <b>147</b> | <b>150</b> | <b>154</b> | <b>154</b> | <b>151</b> | <b>145</b> | <b>135</b> | <b>118</b> | <b>114</b> | <b>97</b>  |
| Future Uknown                   | 0          | 0          | -2         | 0          | 2          | 2          | 7          | 15         | 26         | 41         | 63         | 73         | 95         |
| <b>3% Growth<br/>Projection</b> | <b>140</b> | <b>139</b> | <b>143</b> | <b>147</b> | <b>152</b> | <b>156</b> | <b>161</b> | <b>166</b> | <b>171</b> | <b>176</b> | <b>181</b> | <b>187</b> | <b>192</b> |



## GA Forecast Sources

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- **New GA piston deliveries projected from GAMA delivery history 1990 through 2002**
- **Turbine & rotorcraft deliveries based on *Aviation Week & Space Technology* forecasts**
- **Sport aircraft counts determined from FAA forecast**
  - model assumes rapid market growth for several years, then fixed quantity per year thereafter
- **Retirements based on adjusted yearly fleet counts:**
  - Retirements are implied by yearly fleet projection from FAA forecast and new aircraft deliveries
  - Retirement by aircraft group based on formula:  
prior year fleet + new aircraft entering fleet – retiring aircraft = current year fleet



# The GA Type-Specific Forecast

Forecast: Active Fleet (2003-2020)

Piston

Single Engine

Multi-Engine

Turbine

Turboprop

Turbojet

Rotorcraft

Piston

Turbine

Experimental

Sport (Sport Acft Cat)

Other

**Total**

|  |                        | FAA Forecast   |                |                |                |                |                |                |                |                |                |                |                |
|--|------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|  |                        | 2003           | 2004           | 2005           | 2006           | 2007           | 2008           | 2009           | 2010           | 2011           | 2012           | 2013           | 2014           |
|  | Piston                 |                |                |                |                |                |                |                |                |                |                |                |                |
|  | Single Engine          | 144,550        | 144,900        | 145,363        | 145,829        | 146,295        | 146,763        | 147,233        | 147,704        | 148,177        | 148,651        | 149,127        | 149,604        |
|  | Multi-Engine           | 18,204         | 18,167         | 18,131         | 18,095         | 18,058         | 18,022         | 17,986         | 17,950         | 17,914         | 17,878         | 17,843         | 17,807         |
|  | Turbine                |                |                |                |                |                |                |                |                |                |                |                |                |
|  | Turboprop              | 6,692          | 6,813          | 6,925          | 7,039          | 7,155          | 7,272          | 7,392          | 7,514          | 7,637          | 7,763          | 7,890          | 8,020          |
|  | Turbojet               | 8,200          | 8,397          | 8,723          | 9,063          | 9,415          | 9,782          | 10,162         | 10,557         | 10,968         | 11,395         | 11,838         | 12,298         |
|  | Rotorcraft             |                |                |                |                |                |                |                |                |                |                |                |                |
|  | Piston                 | 2,470          | 2,500          | 2,529          | 2,558          | 2,587          | 2,616          | 2,646          | 2,676          | 2,707          | 2,738          | 2,769          | 2,800          |
|  | Turbine                | 4,352          | 4,374          | 4,395          | 4,417          | 4,439          | 4,460          | 4,482          | 4,504          | 4,526          | 4,548          | 4,571          | 4,593          |
|  | Experimental           | 20,400         | 20,451         | 20,549         | 20,648         | 20,747         | 20,846         | 20,947         | 21,047         | 21,148         | 21,250         | 21,352         | 21,454         |
|  | Sport (Sport Acft Cat) | 0              | 1,000          | 2,300          | 2,600          | 3,100          | 3,600          | 4,100          | 4,600          | 5,000          | 5,400          | 5,800          | 6,200          |
|  | Other                  | 6,500          | 6,520          | 6,539          | 6,559          | 6,578          | 6,598          | 6,618          | 6,638          | 6,658          | 6,678          | 6,698          | 6,718          |
|  | <b>Total</b>           | <b>211,368</b> | <b>213,121</b> | <b>215,455</b> | <b>216,806</b> | <b>218,374</b> | <b>219,961</b> | <b>221,566</b> | <b>223,191</b> | <b>224,735</b> | <b>226,300</b> | <b>227,887</b> | <b>229,495</b> |



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

# *Application of Model to ADS-B Avionics Equipage*



## Typical ADS-B Equipage Questions

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- **What is the current level of ADS-B broadcast capability?**
- **What will be the future levels?**
- **What will be the costs to modify the fleet?**

A detailed analysis of the fleet is required before these questions can be answered



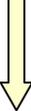
# Classification of Aircraft Models and Types

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- **Large Air Transport**
  - **Classic: Analog aircraft without Flight Management Systems (FMS)**
  - **Neo-Classic: Semi-integrated systems with FMS**
  - **Modern: Digital aircraft with integrated displays**
- **Regional Jets and Turboprops**
- **GA:**
  - **Turbine Fixed Wing (Jets)**
  - **Turboprop Fixed Wing**
  - **All Other**
- **Military Aircraft**
  - **Can be categorized similarly to Large Air Transport, regardless of platform or mission**



# Categorize Models with Project Knowledge

|  US Fleet Summary | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|------|------|------|
| c A300   | 125  | 137  | 147  | 157  | 174  | 198  | 216  | 226  |
| c A310   | 45   | 46   | 47   | 47   | 48   | 48   | 48   | 48   |
| n A318   | 0    | 0    | 3    | 10   | 18   | 24   | 29   | 32   |
| n A319   | 227  | 229  | 235  | 245  | 265  | 276  | 280  | 286  |
| n A320   | 291  | 308  | 325  | 348  | 371  | 394  | 409  | 425  |
| n A321   | 28   | 28   | 28   | 28   | 30   | 35   | 44   | 52   |
| n A330   | 9    | 10   | 17   | 22   | 30   | 44   | 76   | 93   |
| n A340   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| m A380   | 0    | 0    | 0    | 0    | 0    | 3    | 6    | 23   |
| c B707   | 5    | 5    | 5    | 5    | 4    | 4    | 3    | 3    |
| m B717   | 63   | 97   | 109  | 111  | 111  | 111  | 111  | 111  |
| c B727   | 398  | 375  | 373  | 363  | 362  | 365  | 367  | 358  |
| c B737-100   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| c B737-200   | 145  | 125  | 115  | 94   | 77   | 65   | 54   | 47   |
| c B737-300   | 508  | 505  | 499  | 501  | 505  | 509  | 514  | 516  |
| n B737-400   | 86   | 87   | 87   | 87   | 87   | 87   | 87   | 87   |
| n B737-500   | 147  | 147  | 147  | 147  | 147  | 147  | 147  | 138  |
| n B737-600   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| m B737-700   | 219  | 238  | 261  | 289  | 319  | 349  | 365  | 369  |
| m B737-800   | 262  | 269  | 277  | 303  | 341  | 370  | 399  | 425  |
| m B737-900   | 21   | 23   | 27   | 32   | 36   | 38   | 44   | 50   |



# Summarization of Model Categories

---

## Large Air Transport

| Year        | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | ... |
|-------------|------|------|------|------|------|------|------|------|-----|
| Classic     | 1865 | 1777 | 1759 | 1726 | 1692 | 1680 | 1641 | 1600 |     |
| Neo-Classic | 2560 | 2582 | 2623 | 2672 | 2741 | 2815 | 2887 | 2935 |     |
| Modern      | 731  | 800  | 849  | 911  | 993  | 1092 | 1206 | 1347 |     |
|             | 5156 | 5159 | 5231 | 5309 | 5426 | 5587 | 5734 | 5882 |     |



## Aircraft States of Equipage

---

- **Not Equipped:**
  - Requires major component additions or equipment replacement
- **Latent:**
  - Capable of operation by adding link capabilities or interfacing to existing equipment or applying a service bulletin to achieve ADS-B capabilities
- **Capable:**
  - Operating either with 1090 ES (DO-260) or UAT ADS-B
  - Broadcast Only or with CDTI

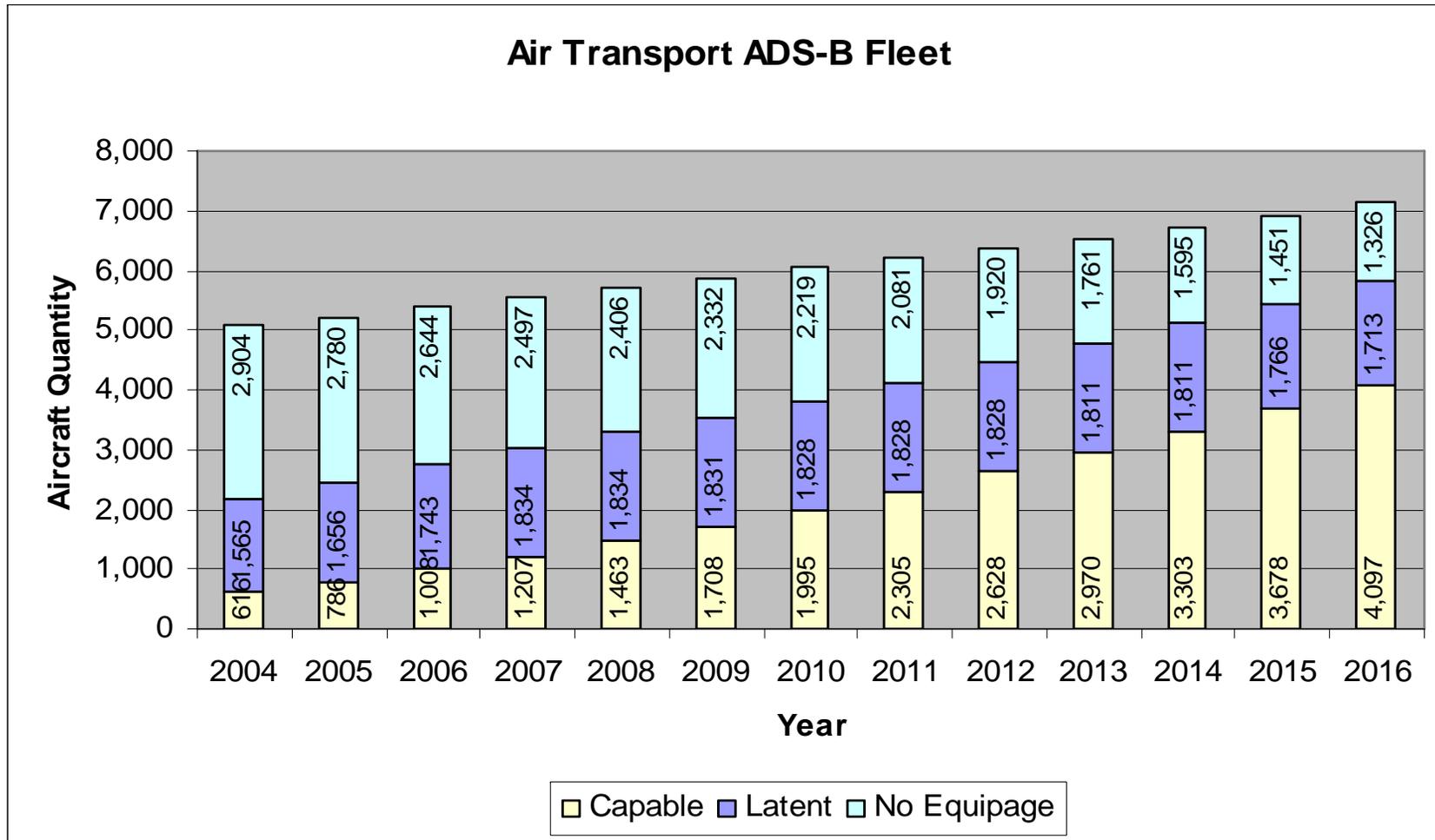


# Baseline Large Air Transport Quantities

| <b>Response 4 BASELINE</b> |              | <b>2004</b> | <b>2005</b> | <b>2006</b> | <b>2007</b> | <b>2008</b> | <b>2009</b> |
|----------------------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>Classic</b>             |              |             |             |             |             |             |             |
|                            | Not Equipped | 1759        | 1726        | 1692        | 1680        | 1641        | 1600        |
|                            | Latent       | 0           | 0           | 0           | 0           | 0           | 0           |
|                            | Bdcst        | 0           | 0           | 0           | 0           | 0           | 0           |
|                            | CDTI         | 0           | 0           | 0           | 0           | 0           | 0           |
|                            | Total        | 1759        | 1726        | 1692        | 1680        | 1641        | 1600        |
| <b>Neo-classic</b>         |              |             |             |             |             |             |             |
|                            | Not Equipped | 1141        | 1001        | 847         | 687         | 656         | 630         |
|                            | Latent       | 1379        | 1518        | 1657        | 1791        | 1790        | 1790        |
|                            | Bdcst        | 101         | 151         | 235         | 335         | 439         | 513         |
|                            | CDTI         | 0           | 0           | 0           | 0           | 0           | 0           |
|                            | Total        | 2621        | 2670        | 2739        | 2813        | 2885        | 2933        |
| <b>Modern</b>              |              |             |             |             |             |             |             |
|                            | Not Equipped | 85          | 85          | 85          | 85          | 85          | 85          |
|                            | Latent       | 301         | 301         | 301         | 301         | 301         | 301         |
|                            | Bdcst        | 463         | 525         | 607         | 706         | 820         | 961         |
|                            | CDTI         | 0           | 0           | 0           | 0           | 0           | 0           |
|                            | Total        | 849         | 911         | 993         | 1092        | 1206        | 1347        |
| <b>TOTAL BASELINE</b>      |              | <b>5229</b> | <b>5307</b> | <b>5424</b> | <b>5585</b> | <b>5732</b> | <b>5880</b> |



# Baseline Large Air Transport Forecast





# Baseline General Aviation Quantities

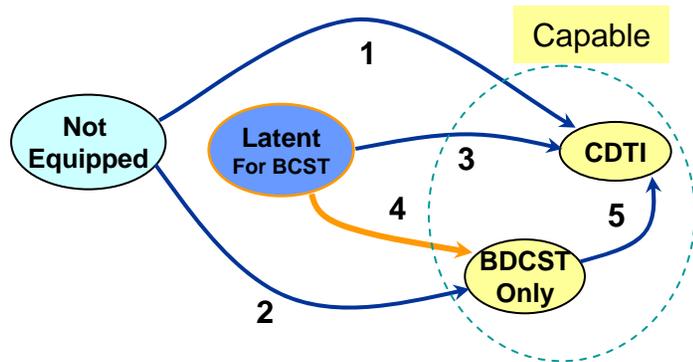
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|              | 2003    | 2004    | 2005    | 2006    | 2007    | 2008    | 2009    | ... |
|--------------|---------|---------|---------|---------|---------|---------|---------|-----|
| Not Equipped | 161,126 | 152,115 | 145,469 | 139,163 | 133,146 | 127,282 | 121,645 |     |
| Latent       | 44,658  | 49,898  | 55,076  | 59,283  | 63,717  | 68,030  | 72,150  |     |
| Bcst Only    | 5,266   | 10,791  | 14,594  | 18,042  | 21,195  | 24,331  | 27,453  |     |
| CDTI         | 317     | 317     | 317     | 317     | 317     | 317     | 317     |     |



# Air Transport ADS-B Transition Costs (2004 \$) (Dual Transponder)

**Assumption:**  
No significant AT/Regional Costs increases



## Air Transport Aircraft

| Constant Year (2004) Unit Cost (\$K) | 2004 - 2008 | 2009 - 2012 | 2013 - 2016 | 2017 - 2020 |
|--------------------------------------|-------------|-------------|-------------|-------------|
| <b>Classic</b>                       |             |             |             |             |
| Path 1 (NE -> CDTI)                  | \$ 251.5    | \$ 251.5    | \$ 251.5    | \$ 251.5    |
| Path 2 (NE -> BCST)                  | \$ 169.0    | \$ 169.0    | \$ 169.0    | \$ 169.0    |
| Path 3 (L -> CDTI)                   | \$ 123.4    | \$ 123.4    | \$ 123.4    | \$ 123.4    |
| Path 4 (L -> BCST)                   | \$ 25.5     | \$ 25.5     | \$ 25.5     | \$ 25.5     |
| Path 5 (BCST -> CDTI)                | \$ 81.2     | \$ 81.2     | \$ 81.2     | \$ 81.2     |



| <b>Neo-Classical</b>  |          |          |          |          |
|-----------------------|----------|----------|----------|----------|
| Path 1 (NE -> CDTI)   | \$ 564.3 | \$ 564.3 | \$ 564.3 | \$ 564.3 |
| Path 2 (NE -> BCST)   | \$ 143.5 | \$ 143.5 | \$ 143.5 | \$ 143.5 |
| Path 3 (L -> CDTI)    | \$ 436.2 | \$ 436.2 | \$ 436.2 | \$ 436.2 |
| Path 4 (L -> BCST)    | \$ 16.6  | \$ 16.6  | \$ 16.6  | \$ 16.6  |
| Path 5 (BCST -> CDTI) | \$ 419.6 | \$ 419.6 | \$ 419.6 | \$ 419.6 |



| <b>Modern</b>         |          |          |          |          |
|-----------------------|----------|----------|----------|----------|
| Path 1 (NE -> CDTI)   | \$ 357.6 | \$ 357.6 | \$ 357.6 | \$ 357.6 |
| Path 2 (NE -> BCST)   | \$ 141.7 | \$ 141.7 | \$ 141.7 | \$ 141.7 |
| Path 3 (L -> CDTI)    | \$ 231.3 | \$ 231.3 | \$ 231.3 | \$ 231.3 |
| Path 4 (L -> BCST)    | \$ 16.5  | \$ 16.5  | \$ 16.5  | \$ 16.5  |
| Path 5 (BCST -> CDTI) | \$ 214.8 | \$ 214.8 | \$ 214.8 | \$ 214.8 |



| <b>Regional - TurboProp</b> |          |          |          |          |
|-----------------------------|----------|----------|----------|----------|
| Path 1 (NE -> CDTI)         | \$ 178.8 | \$ 178.8 | \$ 178.8 | \$ 178.8 |
| Path 2 (NE -> BCST)         | \$ 70.9  | \$ 70.9  | \$ 70.9  | \$ 70.9  |
| Path 3 (L -> CDTI)          | \$ 115.6 | \$ 115.6 | \$ 115.6 | \$ 115.6 |
| Path 4 (L -> BCST)          | \$ 8.3   | \$ 8.3   | \$ 8.3   | \$ 8.3   |
| Path 5 (BCST -> CDTI)       | \$ 107.4 | \$ 107.4 | \$ 107.4 | \$ 107.4 |



| <b>Regional - TurboJet</b> |          |          |          |          |
|----------------------------|----------|----------|----------|----------|
| Path 1 (NE -> CDTI)        | \$ 178.8 | \$ 178.8 | \$ 178.8 | \$ 178.8 |
| Path 2 (NE -> BCST)        | \$ 70.9  | \$ 70.9  | \$ 70.9  | \$ 70.9  |
| Path 3 (L -> CDTI)         | \$ 115.6 | \$ 115.6 | \$ 115.6 | \$ 115.6 |
| Path 4 (L -> BCST)         | \$ 8.3   | \$ 8.3   | \$ 8.3   | \$ 8.3   |
| Path 5 (BCST -> CDTI)      | \$ 107.4 | \$ 107.4 | \$ 107.4 | \$ 107.4 |



Cost of Latent to BCST is lowest path to ADS-B





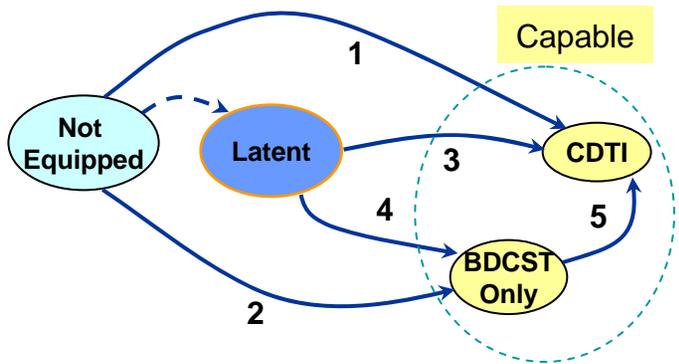
# ADS-B Avionics Upgrade Costs

| AT Classic               |  |                        | NE --> CDTI (ATc1) |                |                | NE --> BDCST Out (ATc2) |                |                | Latent --> CDTI (ATc3) |                |                |                |
|--------------------------|--|------------------------|--------------------|----------------|----------------|-------------------------|----------------|----------------|------------------------|----------------|----------------|----------------|
|                          |  |                        | 2004-2006          | 2007-2010      | 2011-2016      | 2004-2006               | 2007-2010      | 2011-2016      | 2004-2006              | 2007-2010      | 2011-2016      |                |
| <b>Display &amp; GPS</b> |  | <b>% of install \$</b> |                    |                |                |                         |                |                |                        |                |                |                |
|                          |  | Display                | 40%                | 37,800         | 37,800         | 37,800                  | -              | -              | -                      | 37,800         | 37,800         | 37,800         |
|                          |  | GPS                    | 25%                | 52,725         | 52,725         | 52,725                  | 52,725         | 52,725         | 52,725                 | -              | -              | -              |
| <b>Link Cost</b>         |  |                        |                    |                |                |                         |                |                |                        |                |                |                |
|                          |  | Transponder            | 20%                | 62,340         | 62,340         | 62,340                  | 62,340         | 62,340         | 62,340                 | -              | -              | -              |
|                          |  | Upgrade                | 2%                 |                |                |                         |                |                |                        | 15,400         | 15,400         | 15,400         |
|                          |  | Control                | 8%                 | 20,400         | 20,400         | 20,400                  | 20,400         | 20,400         | 20,400                 | 20,400         | 20,400         | 20,400         |
|                          |  | 1090 Mhz RCV link      | 5%                 | 15,000         | 15,000         | 15,000                  | -              | -              | -                      | 15,000         | 15,000         | 15,000         |
| <b>Installation</b>      |  |                        |                    | 63,200         | 63,200         | 63,200                  | 33,496         | 33,496         | 33,496                 | 34,760         | 34,760         | 34,760         |
| <b>Total</b>             |  |                        |                    | <b>251,465</b> | <b>251,465</b> | <b>251,465</b>          | <b>168,961</b> | <b>168,961</b> | <b>168,961</b>         | <b>123,360</b> | <b>123,360</b> | <b>123,360</b> |
| <b>GPS &amp; Display</b> |  |                        |                    | <b>90,525</b>  | <b>90,525</b>  | <b>90,525</b>           | <b>52,725</b>  | <b>52,725</b>  | <b>52,725</b>          | <b>37,800</b>  | <b>37,800</b>  | <b>37,800</b>  |
| <b>Link Cost</b>         |  |                        |                    | <b>97,740</b>  | <b>97,740</b>  | <b>97,740</b>           | <b>82,740</b>  | <b>82,740</b>  | <b>82,740</b>          | <b>50,800</b>  | <b>50,800</b>  | <b>50,800</b>  |



# General Aviation ADS-B Transition Costs

**Assumption:**  
Competition lowers costs for GA over time



| General Aviation Aircraft              |             |           |             |
|--|-------------|-----------|-------------|
| Constant Year (2004) Unit Costs (\$K)  | 2004 - 2006 | 2007-2010 | 2011 - 2020 |
| <b>Turbine Fixed Wing (Turboprop)</b>  |             |           |             |
| Path 1 (NE -> CDTI)                    | \$139.6     | \$136.8   | \$134.2     |
| Path 2 (NE -> Bcst)                    | \$31.0      | \$29.4    | \$28.3      |
| Path 3 (L -> CDTI)                     | \$113.5     | \$111.6   | \$109.5     |
| Path 4 (L -> Bcst)                     | \$4.7       | \$4.0     | \$3.8       |
| Path 5 (Bcst -> CDTI)                  | \$111.3     | \$109.6   | \$107.7     |
| <b>Turbine Fixed Wing (Jet)</b>        |             |           |             |
| Path 1 (NE -> CDTI)                    | \$266.7     | \$264.8   | \$263.0     |
| Path 2 (NE -> Bcst)                    | \$52.5      | \$51.1    | \$49.6      |
| Path 3 (L -> CDTI)                     | \$218.0     | \$217.2   | \$216.5     |
| Path 4 (L -> Bcst)                     | \$4.4       | \$4.1     | \$3.7       |
| Path 5 (Bcst -> CDTI)                  | \$213.6     | \$213.2   | \$212.8     |
| <b>All Other (Majority of GA here)</b> |             |           |             |
| Path 1 (NE -> CDTI)                    | \$12.5      | \$8.8     | \$5.5       |
| Path 2 (NE -> Bcst)                    | \$9.5       | \$7.8     | \$7.0       |
| Path 3 (L -> CDTI)                     | \$9.0       | \$6.0     | \$2.5       |
| Path 4 (L -> Bcst)                     | \$5.0       | \$4.0     | \$4.0       |
| Path 5 (Bcst -> CDTI)                  | \$9.0       | \$6.0     | \$2.5       |

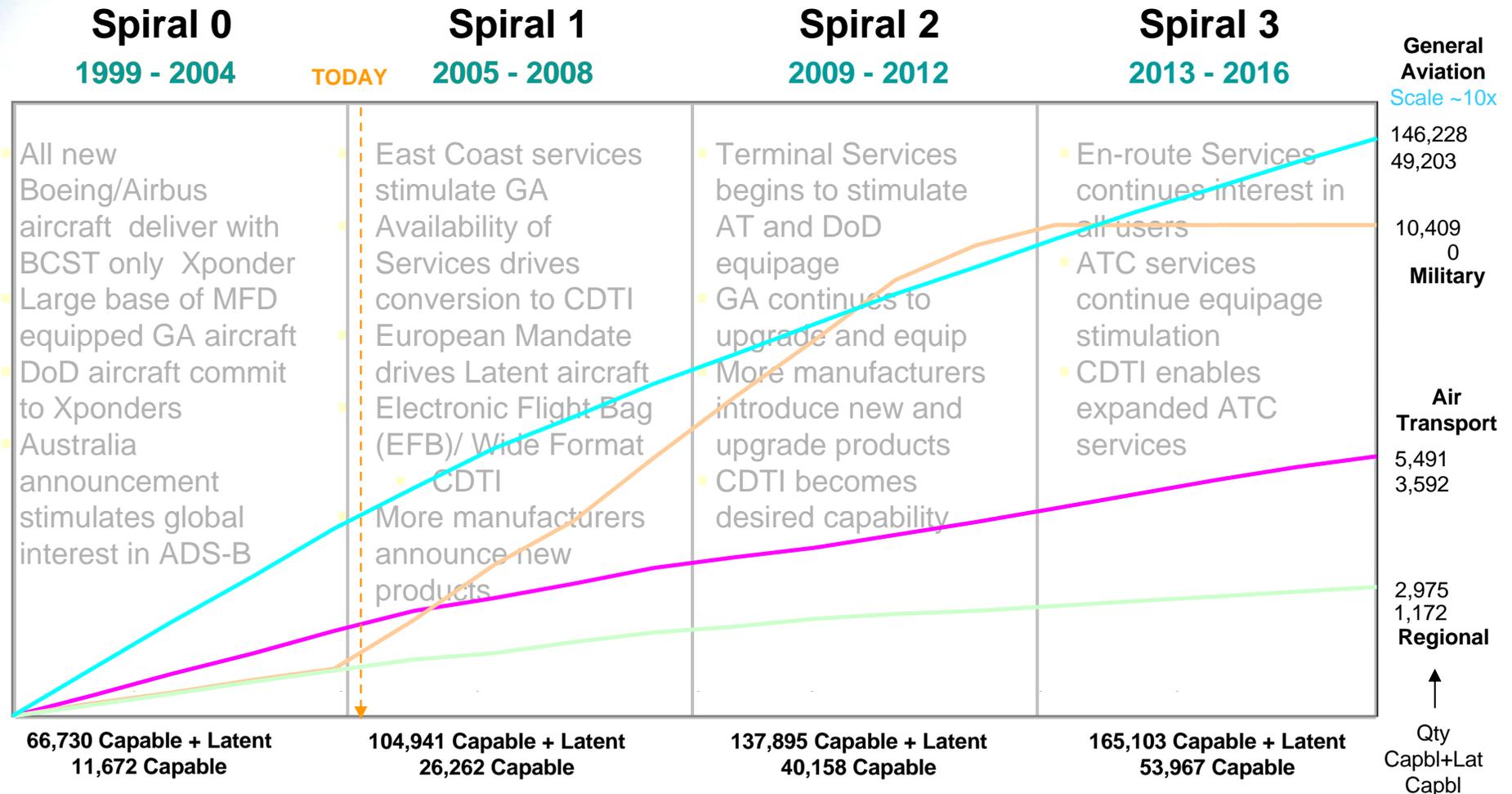
Cost of Latent to BCST is lowest path to ADS-B  
Latent to CDTI is also low, except for high end GA

**\*Costs are allocated for ADS-B (equipment acquisition costs are higher)**



# Avionics Drivers and User Responses

## Baseline



ADS-B capable and latent are growing





## Range of Potential FAA ADS-B Actions

---

- **FAA Actions are the drivers that FAA provides regarding ADS-B Program**
  - **FAA<sub>1</sub>: Per Plan**
    - Fully funded and implemented per current spirals
  - **FAA<sub>2</sub>: 4 Year Delay**
    - Delay in start or slower implementation
  - **FAA<sub>3</sub>: 6 Year Delay**
    - Delay in start or even slower implementation
  - **FAA<sub>4</sub>: No Commitment**
    - Insufficient infrastructure or applications



# AT Response Equipage Definitions

## AT large and Regional

### Response AT<sub>1</sub> **Extreme Joy**

AT CDTI STD in 2008; **RJ CDTI STD in 2010**

Retrofit to CDTI

Classic 2008 – 2012; Neo-classic 2010 – 2016;  
Modern 2009 – 2013

**RJ; jets 2009-2014; TurboP 2012-2014 (60%)**

Retrofit to BCST

Modern (parts commonality) 2006, 2007, 2008  
(33% each)

**RJ; Jets and TurboP none**

### Response AT<sub>3</sub> **Lower Equipage Realism**

CDTI A380 only 2012 Option, 2016 STD; **RJ  
FF in 2018**

Retrofit to CDTI

Classic 50% 2014 – 2018; Neo-classic 40%  
2016 – 2020; Modern 65% 2014 – 2018

**RJ; jets 65% 2015-2020; TurboP 20% 2018-  
2020**

Retrofit to BCST

Modern 50% 2008 – 2010

**RJ; none**

### Response AT<sub>2</sub> **Higher Equipage Realism**

CDTI Optional 2008, STD 2012; **RJ  
FF in 2014**

Retrofit to CDTI

Classic 75% 2012 – 2016; Neo-  
classic 60% 2014 – 2018; Modern  
85% 2012 – 2016

**RJ; Jets 85% 2013-2018; TurboP 40%  
2016-2018**

Retrofit to BCST

Modern 80% 2008 – 2010

**RJ; none**

### Response AT<sub>4</sub> **Baseline**

BCST FF for **RJ starts 2007**

No retrofits for AT or **RJ**

No CDTI in FF for AT or **RJ**



# GA Response Equipage Definitions

---

## **GA<sub>1</sub> Response: Rapid Transition to ADS-B**

Significant new GA aircraft equipage with CDTI as services become available in Spiral 1 and EFIS becomes standard on most new aircraft

## **GA<sub>2</sub> Response: Moderate Delay**

Reduced new GA aircraft equipage with CDTI as services become available in Spiral 1 and EFIS becomes standard on most new aircraft

## **GA<sub>3</sub> Response: Significant Delay**

Significantly reduced new GA aircraft equipage with CDTI through Spiral 1 build out

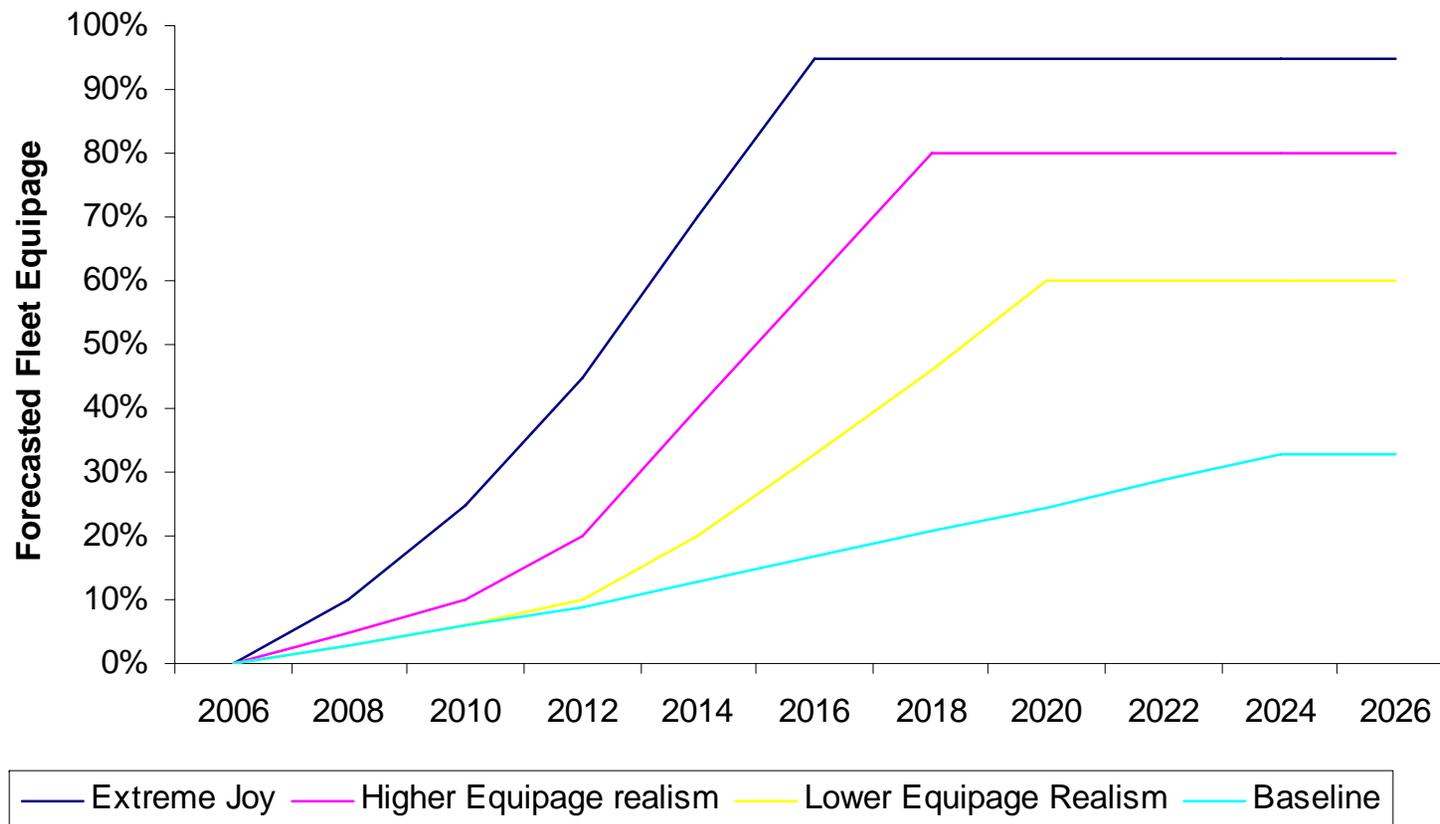
## **GA<sub>4</sub> Response: CDTI Only In Pockets**

Continued sale of TIS/1090ES capable transponders for 'GA-All Other'; no conscious desire for 1090ES, but function packaged with TIS capability



# Graphical Depiction of User Responses

User (Air Transport and GA) CDTI Responses





# Implementation Plan Definition

## (Mandated Equipage)

---

- **Defines a specific timeframe of implementation that can be applied to all Responses to develop Total Costs**
- **All retrofits prior to a specified implementation date are considered Voluntary Costs**
- **Any retrofits after the defined implementation date are considered forced and therefore considered Involuntary Costs**

Only Involuntary Costs should be considered against benefits



## Implementation Plan 1 (IP<sub>1</sub>)

- **Implementation starts January 2017**
- **Required ADS-B capability starting January 2021**
- **All aircraft equipage from 2004 – 2016 are Voluntary**
- **All transitions starting January 2017 are considered Involuntary**
- **Involuntary aircraft will equip from 2017- 2020**
  - **The 2020 unit cost is used to compute Involuntary costs**
- **Assumes no airspace access without ADS-B equipage:**
  - **...above FL 100**
  - **...into Class B airspace**
  - **...top ~70 airports**

Defines the conditions for estimating total costs



# Total Voluntary and Straggler Costs for IP1 Summary (\$M)

DoD fleet costs **NOT** included

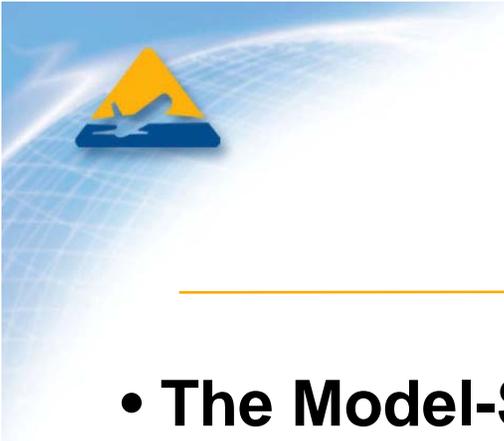
## Voluntary and Straggler Costs

| 2004       | Large AT   |            | Regional  |           | GA         |            | GA + All AT |            |
|------------|------------|------------|-----------|-----------|------------|------------|-------------|------------|
|            | Voluntary  | Straggler  | Voluntary | Straggler | Voluntary  | Straggler  | Total       |            |
| Response 1 | 2004-2016  | 2017-2020  | 2004-2016 | 2017-2020 | 2004-2016  | 2017-2020  | Voluntary   | Straggler  |
|            | TTL        | TTL        | TTL       | TTL       | TTL        | TTL        | TTL         | TTL        |
| BCST Only  |            | \$ -       |           | \$ 0.1    |            | \$ 275.9   |             | \$ 276.0   |
|            | \$ 1,744.9 |            | \$ 370.7  |           | \$ 1,058.2 |            | \$ 3,173.8  |            |
| CDTI       |            | \$ -       |           | \$ 3.1    |            | \$ 1,466.5 |             | \$ 1,469.6 |
|            |            |            |           |           |            |            |             |            |
| Response 2 | 2004-2016  | 2017-2020  | 2004-2016 | 2017-2020 | 2004-2016  | 2017-2020  | Voluntary   | Straggler  |
|            | TTL        | TTL        | TTL       | TTL       | TTL        | TTL        | TTL         | TTL        |
| BCST Only  |            | \$ 23.6    |           | \$ 6.4    |            | \$ 353.8   |             | \$ 383.8   |
|            | \$ 924.4   |            | \$ 213.2  |           | \$ 898.2   |            | \$ 2,035.8  |            |
| CDTI       |            | \$ 565.3   |           | \$ 189.8  |            | \$ 1,730.2 |             | \$ 2,485.3 |
|            |            |            |           |           |            |            |             |            |
| Response 3 | 2004-2016  | 2017-2020  | 2004-2016 | 2017-2020 | 2004-2016  | 2017-2020  | Voluntary   | Straggler  |
|            | TTL        | TTL        | TTL       | TTL       | TTL        | TTL        | TTL         | TTL        |
| BCST Only  |            | \$ 67.0    |           | \$ 18.0   |            | \$ 548.0   |             | \$ 633.0   |
|            | \$ 480.1   |            | \$ 49.5   |           | \$ 660.3   |            | \$ 1,189.9  |            |
| CDTI       |            | \$ 1,443.7 |           | \$ 395.4  |            | \$ 2,301.9 |             | \$ 4,141.0 |
|            |            |            |           |           |            |            |             |            |
| Response 4 | 2004-2016  | 2017-2020  | 2004-2016 | 2017-2020 | 2004-2016  | 2017-2020  | Voluntary   | Straggler  |
|            | TTL        | TTL        | TTL       | TTL       | TTL        | TTL        | TTL         | TTL        |
| BCST Only  |            | \$ 141.3   |           | \$ 32.9   |            | \$ 676.0   |             | \$ 850.2   |
|            | \$ -       |            | \$ -      |           | \$ 231.7   |            | \$ 231.7    |            |
| CDTI       |            | \$ 2,567.2 |           | \$ 462.6  |            | \$ 4,168.7 |             | \$ 7,198.5 |



**Broadcast only is a very affordable alternative**





## Conclusion

---

- **The Model-Specific US Fleet Forecast is a very useful tool, when combined with aircraft specific knowledge, to forecast:**

- **Future capabilities of the fleet**

- **Future fleet modification costs**

- **For detailed information, see:**

<http://www.mitrecaasd.org/library/documents/MTR05W0000082.pdf>



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

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# Questions?

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