easy read: The Sporty Game
- a few more

10/6

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# Airline Fleet Planning Overview

16.71J/1.232J/15.054J/ESD217J
The Airline Industry
Dr. Peter P. Belobaba
October 6, 2010

## AIRLINE PLANNING DECISIONS

1. FLEET PLANNING: What aircraft to acquire/retire, when and how many?
2. ROUTE EVALUATION: What network structure to operate and city-pairs to be served?
3. SCHEDULE DEVELOPMENT: How often, at what times and with which aircraft on each route?
4. PRICING: What products, fares and restrictions for each O-D market?
5. REVENUE MANAGEMENT: How many bookings to accept, by type of fare, to maximize revenue on each flight and over the network?

Flow
also decreasing time frame

first 1/3 of chap 6 - rest in spring semester

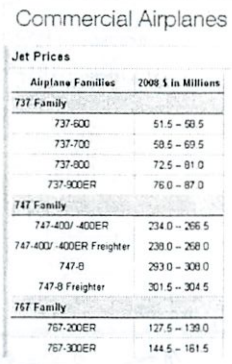
## FLEET PLANNING

- **Fleet composition is critical long-term strategic decision for an airline.**
  - Fleet is the total number of aircraft that an airline operates, as well as the specific aircraft types that comprise the total fleet.
  - Each aircraft type has different technical performance characteristics e.g. capacity to carry payload over a maximum flight distance, or "range."
  - Affects financial position, operating costs, and especially the ability to serve specific routes.
- **Huge capital investment with a long-term horizon:**
  - US $40-60 million for narrow-body 150-seat airplane
  - $250+ million for wide-body long-range 747-400
  - Depreciation impacts on balance sheet last 10-15 years
  - Some aircraft have been operated economically for 30+ years

2 most important

→ 40

## Boeing and Airbus Catalog Prices



Commercial Airplanes

Jet Prices

| Airplane Families | 2008 $ in Millions |
|---|---|
| **737 Family** | |
| 737-600 | 51.5 – 58.5 |
| 737-700 | 58.5 – 69.5 |
| 737-800 | 72.5 – 81.0 |
| 737-900ER | 76.0 – 87.0 |
| **747 Family** | |
| 747-400/ -400ER | 234.0 – 266.5 |
| 747-400/ -400ER Freighter | 238.0 – 268.0 |
| 747-8 | 293.0 – 308.0 |
| 747-8 Freighter | 301.5 – 304.5 |
| **767 Family** | |
| 767-200ER | 127.5 – 139.0 |
| 767-300ER | 144.5 – 161.5 |

**AIRBUS AIRCRAFT**
**Range of 2008 LIST PRICES**
**(mio USD)**

| | Min | Max | Average |
|---|---|---|---|
| A318 | 56.0 | 62.1 | 59.1 |
| A319 | 63.3 | 77.3 | 70.3 |
| A320 | 73.2 | 80.6 | 76.9 |
| A321 | 87.7 | 92.8 | 90.3 |
| A330-200 | 176.3 | 185.5 | 180.9 |
| A330-200F | 180.6 | 187.7 | 184.2 |
| A330-300 | 195.9 | 205.7 | 200.8 |
| A340-300 | 211.8 | 219.2 | 215.5 |
| A340-500 | 233.0 | 241.1 | 237.1 |
| A340-600 | 245.0 | 253.7 | 249.4 |

Airbus prices include standard engine / Boeing prices for airframe only
Sources: http://www.airbus.com/store/mm_repository/pdf/att00011726/media_object_file_ListPrices2008.pdf
http://www.boeing.com/commercial/prices/

most important long term decision

~~eng.~~ everyone pays a different price
- everyone gets a discount
- competition

10/6

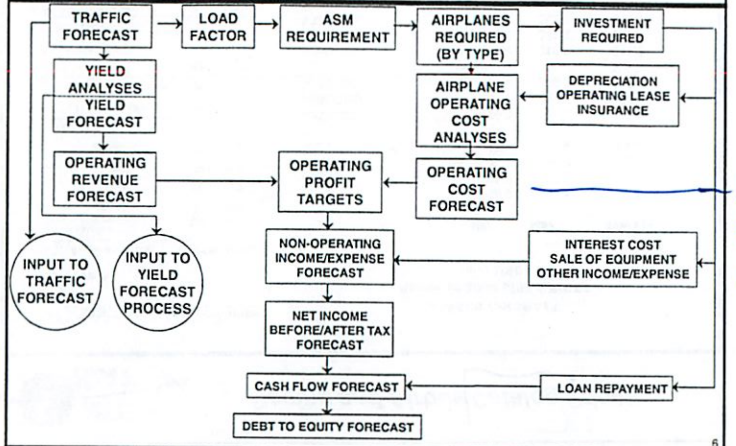
buying new airplane like a new car
- lower fuel cost + maintance
- but ~~[illegible]~~ high maintance cost

Revenue management
harder to get to 100 since avg. demand varies i season, time
turning people away
*freq competition*

## Fleet Planning Process

- **Fleet planning requires an evaluation process for assessing the impacts of new aircraft (see next slide):**
  - Traffic and yield forecasts used to estimate revenues
  - Planning ALF determines ASMs and number of aircraft required
  - Aircraft acquisition has financial impacts in terms of investment funding, depreciation, and interest expenses
  - Operating cost and revenue forecasts provide profit projections
  - Used to predict effects on balance sheet, cash flow, and debt load
- **This planning process is ideally an ongoing effort requiring input from many sources within the airline:**
  - A critical component of a long-term strategic planning process

## Fleet Planning Evaluation Process



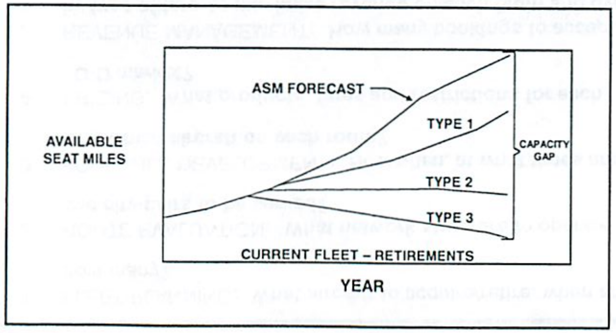
hard to calculate for planes that have not flown yet

*tremendous uncertainty
- So scenarios + spreadsheets

## "Top-Down" (Macro) Approach

- **Aggregate demand and cost spreadsheets used to evaluate financial impacts of aircraft options for a defined sub-system, region, or route:**
  - "Planning Load Factor" establishes ASMs needed to accommodate forecast RPM growth (e.g., 70% planned ALF)
  - "Capacity Gap" defined as required future ASMs minus existing ASMs and planned retirements
  - Assumptions about average aircraft stage length and daily utilization determine "aircraft productivity" in ASMs per day, used to calculate number of aircraft required
  - Estimates of aircraft operating costs can then be used to compare economic performance of different aircraft types

## Capacity Gap Analysis



what types of airplanes can we use to fill each type

*Frequency

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## Aircraft Categories

- **Commercial aircraft are most commonly defined by their range and size:**
  - The "range" is the maximum distance that it can fly without stopping for additional fuel, while still carrying a reasonable payload of passengers and/or cargo.
  - The "size" of an aircraft can be represented by measures such as its weight, its seating or cargo capacity, as indicators of the amount of payload that it can carry.
- **Broad categories such as "small, short-haul" or "large, long-haul" aircraft can include several different aircraft types by different manufacturers.**
  - Aircraft with similar capabilities are regarded as "competitors" in the airline's fleet planning decisions.
  - For example, the Airbus A320 and Boeing 737-800 are competing aircraft types, as they are both new generation aircraft with approximately 150 seats with similar range capabilities.

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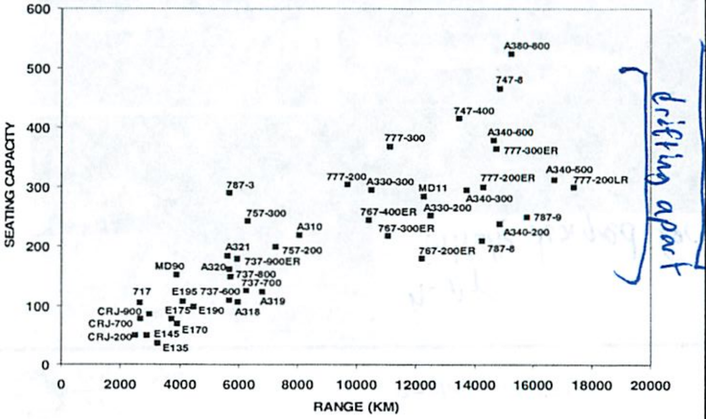
## Commercial Aircraft by Size and Range



missing some most recent developments

w/ consolidation - both manufactures will sell any combo to airlines

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## Aircraft Categories - Trends

- **Historically, largest aircraft were designed for routes with the longest flight distances.**
  - Relationship between aircraft size and range was almost linear.
  - Airlines wishing to serve a very long-haul non-stop route had to acquire the Boeing 747.
- **Airlines now have a much wider choice of products by range and capacity in each category:**
  - Range of new aircraft in the "small" category (100-150 seats) has increased dramatically.
  - US transcontinental routes are now being flown with Boeing 737 and Airbus 320 series aircraft.
  - Sizes of new "long-range" aircraft have decreased substantially.
  - Airlines even now serve certain low-demand long-haul non-stop international routes with Boeing 757 (180 seats) e.g., Newark to Lisbon, and Los Angeles to Maui.

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## Boeing 717

evolution of DC9

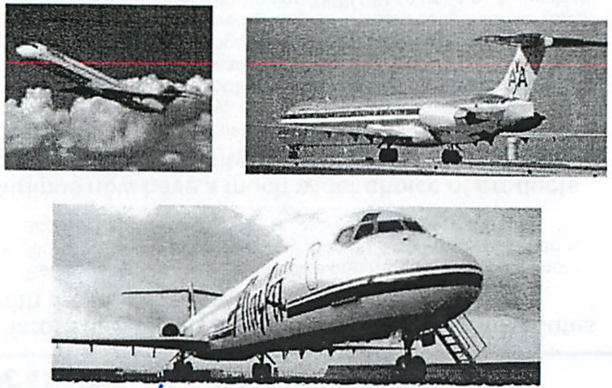
~~AA made deal if loved w/ them can return for free~~

- are fun books about competition between boeings airbus
  - every sale competed for agressivly
- big #
- international trade + espinage important

now international service from hubs
- not really gateway services JFK, Montreal

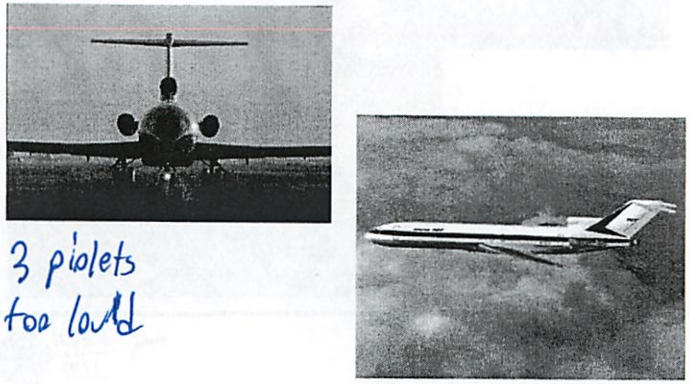
→ its all hub traffic
- claim will allow more point to point - false

## Boeing MD-80/90



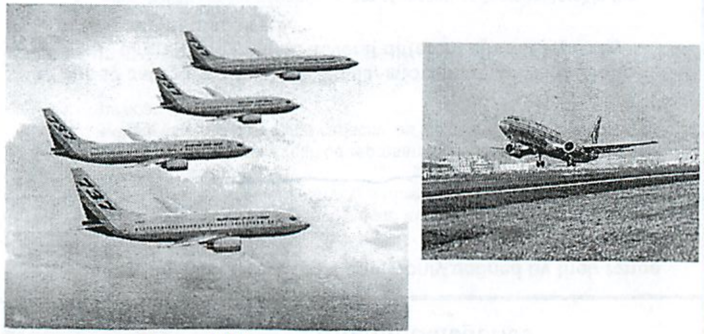
AA made dea if lose $ can return them

## Boeing 727-200



3 piolets
too loud

## Boeing 737-600/700/800/900

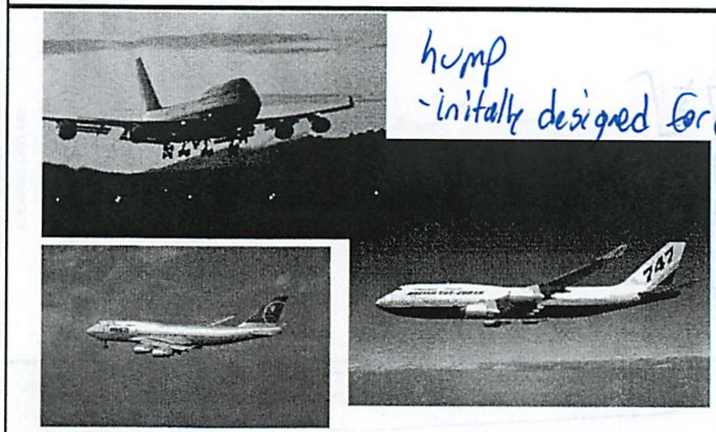


most widly used

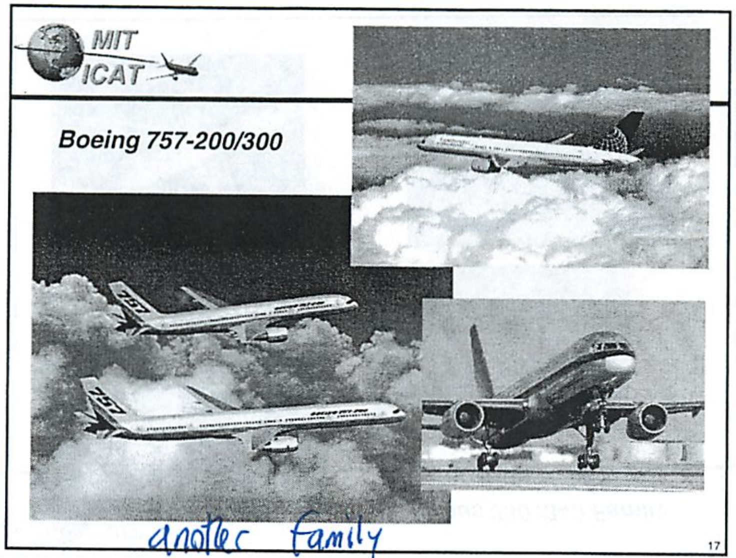
family -sales branding
-also same parts, etc
-same piolets

Scheduling flexibility
-dynamically swap
airplanes

## Boeing 747-400



hump
-initally designed for cargo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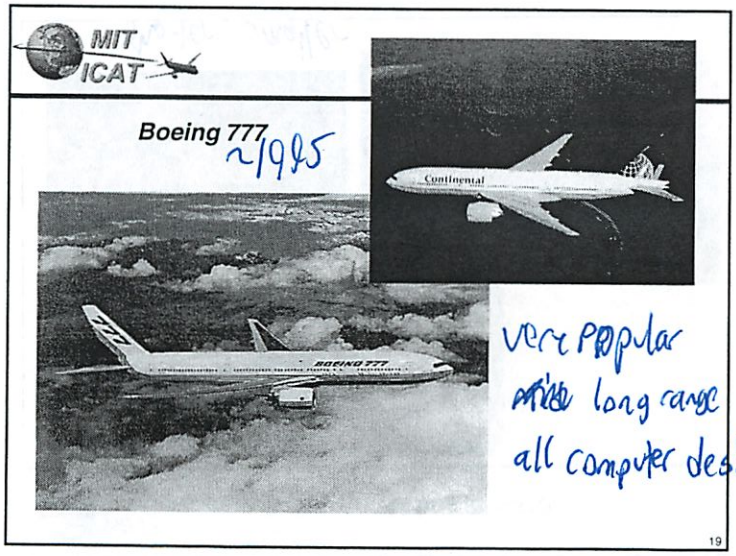
**Boeing 757-200/300**

another family
not in production any more


**Boeing 767-200/300/400**

2-3-2
-bad in
preimum class - too narrow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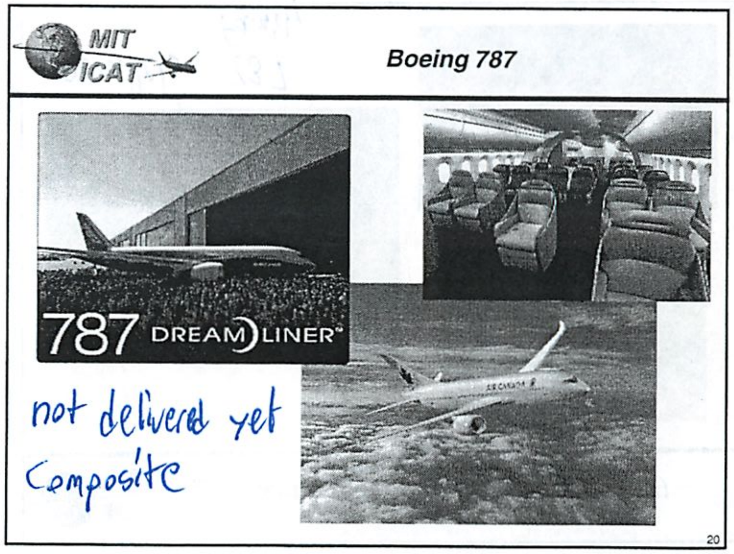
**Boeing 777** ~1995

very popular
long range
all computer designed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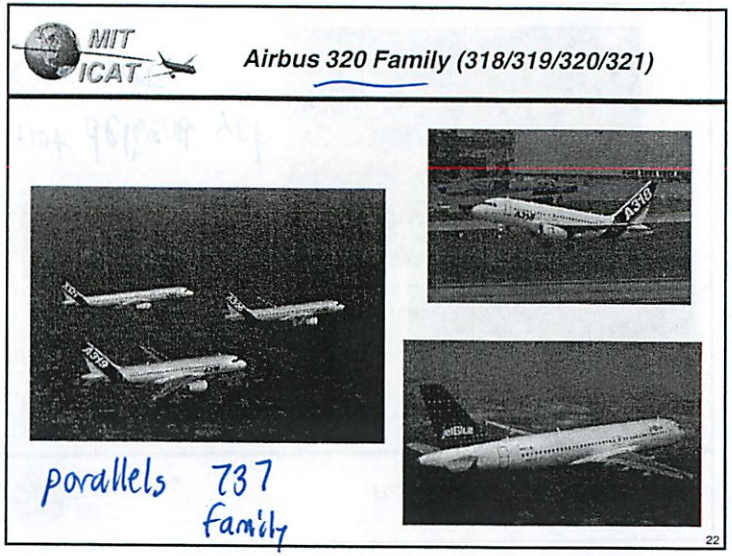
**Boeing 787**

not delivered yet
Composite

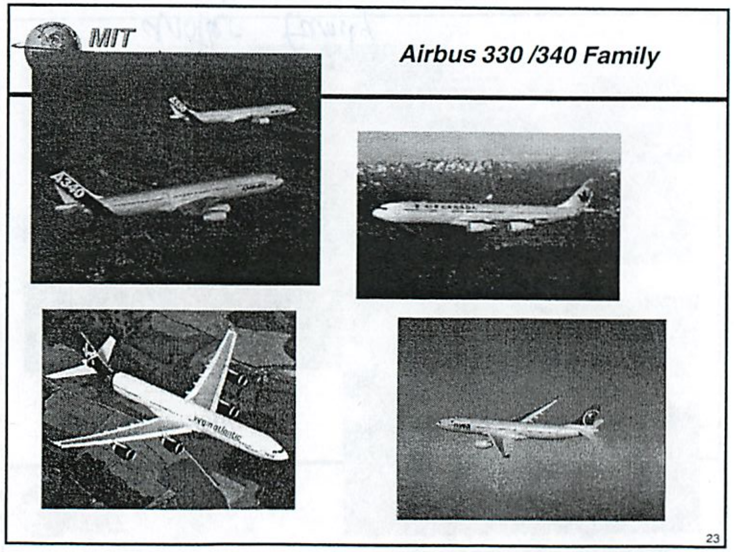
## Airbus 300/310

shorter, smaller

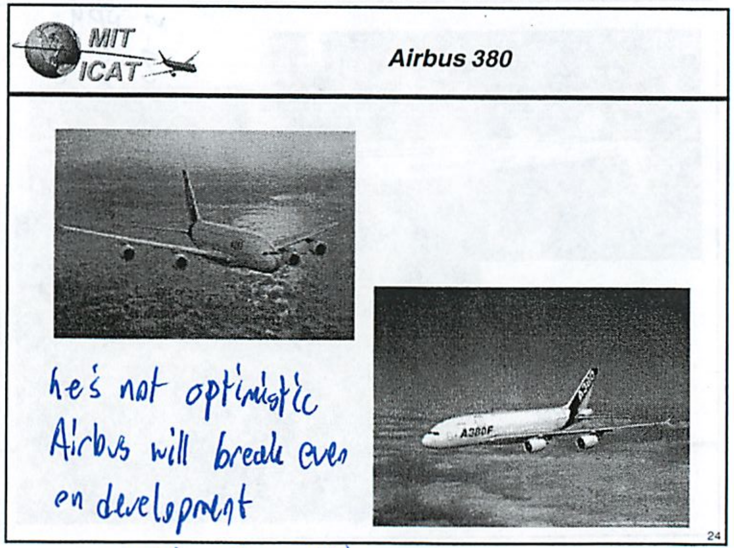


## Airbus 320 Family (318/319/320/321)

parallels 737 family



## Airbus 330 /340 Family



## Airbus 380

he's not optimistic Airbus will break even on development

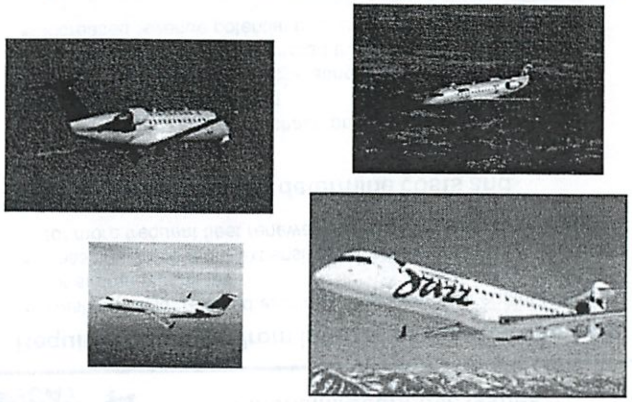
- need 400-500

- bad econ
- very limited # of markets

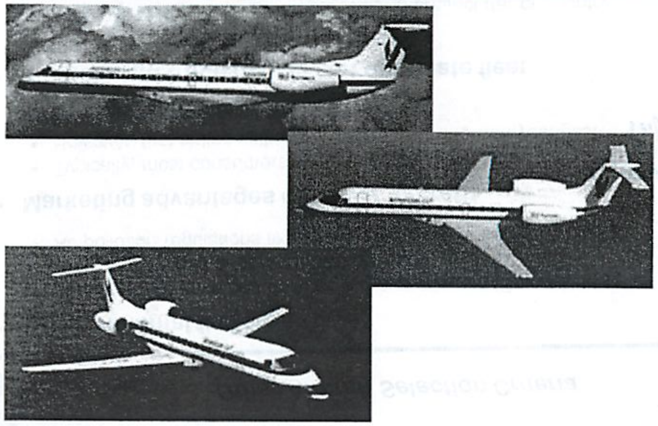
First jets at 50 seats

~50 seats - labor issues

## Bombardier CRJ 100/200/700



## Embraer Regional Jets (ERJ 135/140/145)



## Embraer E175/E190

~100 seat

Airbus + Boing avoided this marketplace

## Aircraft Selection Criteria

- **Fleet composition is an optimal staging problem:**
  - Number and type of aircraft required
  - Timing of deliveries and retirement of existing fleet - order book grew to 7 years
  - Tremendous uncertainty about future market conditions
  - Constrained by existing fleet, ability to dispose of older aircraft, and availability of future delivery slots - need to match competitor's schedule
- **Aircraft evaluation criteria for airlines include:**
  - Technical and performance characteristics
  - Economics of operations and revenue generation
  - Marketing and environmental issues
  - Political and international trade concerns

leasers: every slot we get is 1 less for airlines

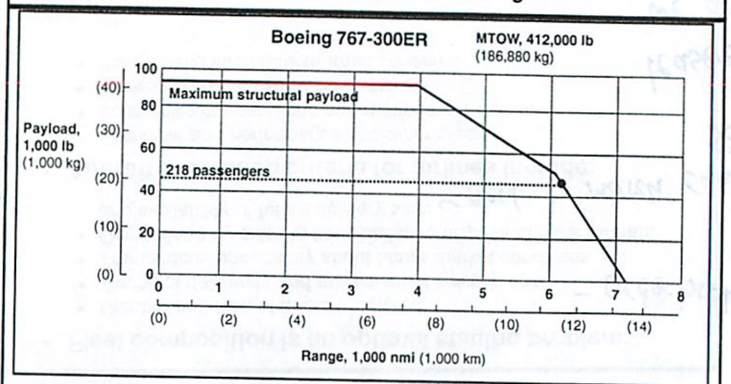
## Technical/Performance Characteristics

- "Payload/range curve" is most important (next slide):
  - Defines capability of each aircraft type to carry passengers and cargo over a maximum flight distance.
  - Affected by aerodynamics, engine technology, fuel capacity and typical passenger/cargo configuration
  - Typical shape of curve allows trade-off of payload for extra fuel and flight range, before maximum operational range is reached
- Other important technical factors include:
  - Maximum take-off and landing weights determine runway length requirements and feasible airports
  - Fleet commonality with existing airline fleet reduces costs of training, new equipment and spare parts inventory for new types

assumption on weather, etc

## 767-300ER Payload-Range Curve

### General Electric Engines



airlines pushing the limit

– in winter may need to stop midway

## Financial/Economic Issues

- Required financing from internal or external sources:
  - Cash on hand, retained earnings, debt (loans) or equity (stocks) for aircraft purchases
  - Leasing can be more expensive, but also more flexible, allowing for more frequent fleet renewal and requiring less up-front capital
- Financial evaluation to determine costs and revenues:
  - Up-front costs include purchase price, spare engines and parts, ground equipment, training
  - Newer aircraft offer lower operating costs at higher initial purchase price (vs. older aircraft that have been depreciated)
  - Increased revenue potential from larger and/or newer aircraft

Unions use it as an excuse for pay raise

## Other Aircraft Selection Criteria

- Environmental factors:
  - Noise performance has become a major concern (Stage 3 noise requirements and airport curfews on louder aircraft)
  - Air pollution regulations likely to ground older aircraft
- Marketing advantages of newer aircraft:
  - Typically, most consumers have little aircraft preference
  - However, first airline with newest type or airline with youngest fleet can generate additional market share
- Political and trade issues can dominate fleet decisions:
  - Pressure to purchase from a particular manufacturer or country, especially at government-owned national airlines

Marketers will claim this – can't tell

10/9

United States Government Accountability Office

GAO

Testimony
Before the Committee on Commerce, Science, and Transportation, U.S. Senate

For Release on Delivery
Expected at 10:00 a.m. EDT
Thursday, May 27, 2010

# AIRLINE MERGERS

## Issues Raised by the Proposed Merger of United and Continental Airlines

Statement for the Record by Susan Fleming,
Director, Physical Infrastructure Issues

GAO
Accountability * Integrity * Reliability

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# Highlights

Highlights of GAO-10-778T, testimony before the Committee on Commerce, Science, and Transportation, U.S. Senate

May 27, 2010

# AIRLINE MERGERS

## Issues Raised by the Proposed Merger of United and Continental Airlines

### Why GAO Did This Study

Earlier this month, United Air Lines (United) and Continental Airlines (Continental) announced plans to merge the two airlines and signed a merger agreement. This follows the acquisition of Northwest Airlines by Delta Air Lines (Delta) in 2008, which propelled Delta to become the largest airline in the United States. This latest merger, if not challenged by the Department of Justice (DOJ), would surpass Delta's merger in scope to create the largest passenger airline in terms of capacity in the United States. The passenger airline industry has struggled financially over the last decade, and these two airlines believe a merger will strengthen them. However, as with any proposed merger of this magnitude, this one will be carefully examined by DOJ to determine if its potential benefits for consumers outweigh the potential negative effects.

At the Committee's request, GAO is providing a statement for the record that describes (1) an overview of the factors that are driving mergers in the industry, (2) the role of federal authorities in reviewing merger proposals, and (3) key issues associated with the proposed merger of United and Continental. To address these objectives, GAO drew from previous reports on the potential effects of the proposed merger between Delta and Northwest and the financial condition of the airline industry, and analyzed Department of Transportation (DOT) airline operating and financial data.

View GAO-10-778T or key components.
For more information, contact Susan Fleming at (202) 512-2834 or flemings@gao.gov.

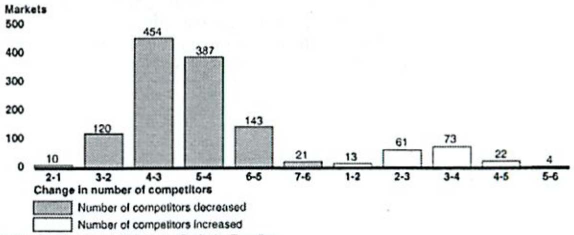
### What GAO Found

As GAO has previously reported, airlines seek to merge with or acquire other airlines to increase their profitability and financial sustainability, but must weigh these potential benefits against operational costs and challenges. The principal benefits airlines consider are cost reductions—by combining complementary assets, eliminating duplicate activities, and reducing capacity—and increased revenues from higher fares in existing markets and increased demand for more seamless travel to more destinations. Balanced against these potential benefits are operational costs of integrating workforces, aircraft fleets, and systems.

DOJ's antitrust review is a critical step in the airline merger and acquisition process. DOJ uses an integrated analytical framework set forth in the *Horizontal Merger Guidelines* to determine whether the merger poses any antitrust concerns. Under that process, DOJ assesses the extent of likely anticompetitive effects of reducing competition in the relevant markets—in this case, between cities or airports. DOJ further considers the likelihood that airlines entering these markets would counteract any anticompetitive effects. It also considers any efficiencies that a merger or acquisition could bring—for example, consumer benefits from an expanded route network. Finally, it examines whether one of the airlines proposing to merge would fail and its assets exit the market in the absence of a merger.

One of the most important issues in this merger will be its effect on competition in the airline industry. For example, GAO's analysis of 2009 ticket data showed that combining these airlines would result in a loss of one effective competitor (defined as having at least 5 percent of total traffic between airports) in 1,135 markets (called airport pairs) affecting almost 35 million passengers while creating a new effective competitor in 173 airport pairs affecting almost 9.5 million passengers (fig.). However, in all but 10 of these airports pairs there is at least one other competitor.

**Change in Effective Competitors for Airport-Pair Markets from United-Continental Combination, 2009**



Source: GAO Analysis of DOT Origin and Destination Ticket Data.

Mr. Chairman and Members of the Committee:

We appreciate the opportunity to provide a statement for the record on the potential implications of the merger proposal recently announced by United Air Lines (United) and Continental Airlines (Continental). Earlier this month, these two airlines announced plans for United to merge with Continental through a stock swap the airlines valued at $8 billion. This follows the acquisition of Northwest Airlines (Northwest) by Delta Air Lines (Delta) in 2008, which propelled Delta to become the largest airline in the United States. The United-Continental merger, if not challenged by the Department of Justice (DOJ), would surpass Delta's in scope to create the largest passenger airline in terms of capacity in the United States. However, as with any proposed merger of this magnitude, this one will be carefully examined by DOJ to determine if its potential benefits for consumers outweigh the potential negative effects.

Extensive research and the experience of millions of Americans underscore the benefits that have flowed to most consumers from the 1978 deregulation of the airline industry, including dramatic reductions in fares and expansion of service. These benefits are largely attributable to increased competition from the entry of new airlines into the industry and established airlines into new markets. At the same time, however, airline deregulation has not benefited everyone; some communities—especially smaller communities—have suffered from relatively high airfares and a loss of service. We have been analyzing aviation competition issues since the enactment of the Airline Deregulation Act of 1978.[1] Our work over the last decade has focused on the challenges to competition and industry performance, including the financial health of the airline industry, the growth of low-cost airlines, changing business models of airlines, and prior mergers.[2] In the airline context, DOJ has the primary responsibility to evaluate most mergers in order to carry out its antitrust responsibilities.[3] In its review, DOJ considers a number of factors,

on balance
been very good

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[1] Pub. L. No. 95-504, 92 Stat. 1705.

[2] A list of related GAO products is attached to this statement.

[3] Under the Hart-Scott-Rodino Act, an acquisition of voting securities and/or assets above a set monetary amount must be reported to DOJ (or the Federal Trade Commission for certain industries) so the department can determine whether the merger or acquisition poses any antitrust concerns. 15 U.S.C. § 18a(d)(1). Both DOJ and the Federal Trade Commission have antitrust enforcement authority, including reviewing proposed mergers and acquisitions. DOJ is the antitrust enforcement authority charged with reviewing proposed mergers and acquisitions in the airline industry.

including increases in market concentration; potential adverse effects on competition; the likelihood of new entry in affected markets and possible counteraction of anticompetitive effects that the merger may have posed; verified "merger specific" efficiencies or other competitive benefits; and whether, absent the merger, one of the airlines is likely to fail and its assets exit the market.

This statement presents (1) an overview of the factors that are driving mergers in the airline industry, (2) the role of federal authorities in reviewing merger proposals, and (3) key issues associated with the proposed merger of United and Continental. This statement is based on two previously issued reports—our 2008 report for this Committee on airline mergers and our 2009 report on the financial condition of the airline industry and the various effects of the industry's contraction on passengers and communities[4]—as well as our other past work on aviation issues. In addition, we conducted some analysis of the proposed United and Continental merger, including analysis of the airlines' financial, labor, fleet, and market conditions.

To identify the factors that help drive mergers in the airline industry, we relied on information developed for our 2008 and 2009 reports on the airline industry, updated as necessary. To describe the role of federal authorities, in particular DOJ and the Department of Transportation (DOT), in reviewing airline merger proposals we relied on information developed for our 2008 report, also updated as necessary.[5] To identify the key issues associated with the proposed merger of United and Continental, we reviewed airline merger documents and financial analyst reports and analyzed data submitted by the airlines to DOT (Bureau of Transportation Statistics financial Form 41, origin and destination ticket, and operations data). We also analyzed airline schedule data. We assessed the reliability of these data by (1) performing electronic testing of required data elements, (2) reviewing existing information about the data and the system that produced them, and (3) interviewing agency officials knowledgeable about the data. We determined that the data were sufficiently reliable for

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[4] GAO, *Airline Industry: Potential Mergers and Acquisitions Driven by Financial and Competitive Pressures*, GAO-08-845 (Washington, D.C.: July 31, 2008); and *Commercial Aviation: Airline Industry Contraction Due to Volatile Fuel Prices and Falling Demand Affects Airports, Passengers, and Federal Government Revenues*, GAO-09-393 (Washington, D.C.: Apr. 21, 2009).

[5] GAO-08-845.

the purposes of this report. We conducted this audit work in May 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

## Background

On May 3, 2010, United and Continental announced an agreement to merge the two airlines. The new airline would retain the United name and headquarters in Chicago while the current Continental Chief Executive Officer would keep that title with the new airline. The proposed merger will be financed exclusively through an all-stock transaction with a combined equity value of $8 billion split roughly with 55 percent ownership to United shareholders and 45 percent to Continental shareholders. The airlines have not announced specific plans for changes in their networks or operations that would occur if the proposed merger is not challenged by DOJ.

why not? → - hiding

The airline industry has experienced considerable merger and acquisition activity since its early years, especially immediately following deregulation in 1978 (fig. 1 provides a timeline of mergers and acquisitions for the seven largest surviving airlines). A flurry of mergers and acquisitions during the 1980s, when Delta Air Lines and Western Airlines merged, United Airlines acquired Pan Am's Pacific routes, Northwest acquired Republic Airlines, and American Airlines and Air California merged. In 1988, merger and acquisition review authority was transferred from the Department of Transportation (DOT) to DOJ. Since 1998, despite tumultuous financial periods, fewer mergers and acquisitions have occurred. In 2001, American Airlines acquired the bankrupt airline TWA, in 2005 America West acquired US Airways while the latter was in bankruptcy, and, in October 2008, Delta acquired Northwest. Certain other attempts at merging in the last decade failed because of opposition from DOJ or from employees and creditors. For example, in 2000, an agreement was reached that allowed Northwest to acquire a 50 percent stake in Continental (with limited voting power) to resolve the antitrust suit brought by DOJ against Northwest's proposed acquisition of a controlling interest in Continental.[6] A proposed merger of United Airlines and US Airways in 2000 also resulted in opposition from DOJ, which found that, in its view, the merger would violate antitrust laws by reducing competition, increasing air fares, and harming consumers on airline routes throughout the United States. Although DOJ expressed its intent to sue to block the transaction, the parties abandoned the transaction before a suit was filed. More recently, the 2006 proposed merger of US Airways and Delta fell apart because of opposition from Delta's pilots and some of its creditors, as well as its senior management.

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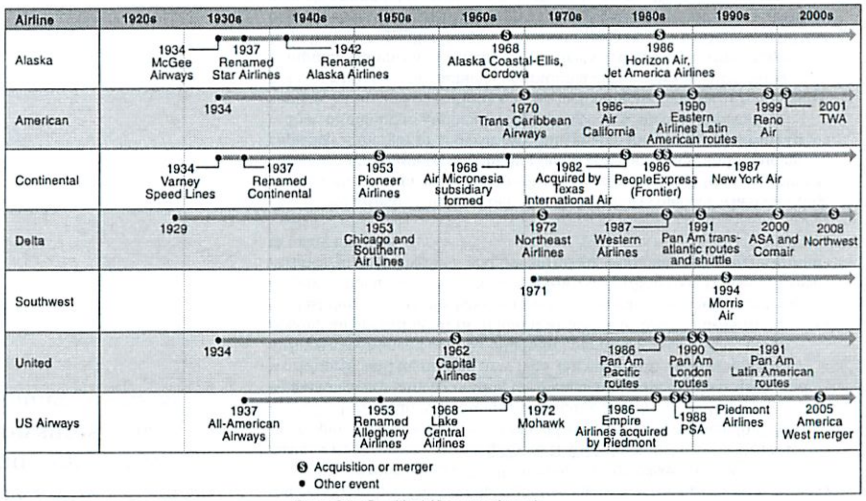
[6] GAO, *Aviation Competition: Issues Related to the Proposed United Airlines-US Airways Merger*, GAO-01-212 (Washington, D.C.: Dec. 15, 2000) p. 10, footnote 6.

**Figure 1: Highlights of Domestic Airline Mergers and Acquisitions**



Sources: Cathay Financial and airline company documents.

Now

Pan Am

Since deregulation in 1978, the financial stability of the airline industry has become a considerable concern for the federal government owing, in part, to the level of financial assistance it has provided to the industry by assuming terminated pension plans and other forms of assistance. Between 1978 and 2008, there have been over 160 airline bankruptcies. While most of these bankruptcies affected small airlines that were eventually liquidated, 4 of the more recent bankruptcies (Delta, Northwest, United, and US Airways) are among the largest corporate bankruptcies ever, excluding financial services firms. ~~During these bankruptcies,~~ United and US Airways terminated their pension plans and $9.7 billion in claims was shifted to the Pension Benefit Guarantee Corporation (PGBC).[7] Furthermore, to respond to the shock to the industry from the September 11, 2001, terrorist attacks, the federal government provided airlines with $7.4 billion in direct assistance and authorized $1.6 billion (of $10 billion available) in loan guarantees to six airlines.[8]

Although the airline industry has experienced numerous mergers and bankruptcies since deregulation, growth of existing airlines and the entry of new airlines have contributed to a steady increase in capacity, as measured by available seat miles. Previously, we reported that although one airline may reduce capacity or leave the market, capacity returns relatively quickly.[9] Likewise, while past mergers and acquisitions have, at least ~~in part,~~ sought to reduce capacity, any resulting declines in industry capacity have been short-lived, as existing airlines have expanded or new airlines have expanded. Capacity growth has slowed or declined just before and during recessions, but not as a result of large airline liquidations.

planes would be sold off

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[7] PBGC was established under the Employee Retirement Income Security Act of 1974 (ERISA) and set forth standards and requirements that apply to defined benefit plans. PBGC was established to encourage the continuation and maintenance of voluntary private pension plans and to insure the benefits of workers and retirees in defined benefit plans should plan sponsors fail to pay benefits. PGBC operations are financed, for example, by insurance premiums paid by sponsors of defined benefit plans, investment income, assets from pension plans trusted by PBGC, and recoveries from the companies formerly responsible for the plans.

[8] The six airlines receiving loan guarantees were Aloha, World, Frontier, US Airways, ATA, and America West.

[9] GAO, *Commercial Aviation: Bankruptcy and Pensions Problems Are Symptoms of Underlying Structural Issues*, GAO-05-945 (Washington, D.C.: Sept. 30, 2005).

## Airline Mergers Are Driven by Financial and Competitive Pressures, but Challenges Exist

Volatile earnings and structural changes in the industry have spurred some airlines to explore mergers as a way to increase their profitability and financial viability. Over the last decade, the U.S. passenger airline industry has incurred more than $15 billion in operating losses. Several major airlines went through bankruptcy ~~to reduce their~~ costs and restructure their operations, while others ceased to operate or were acquired. Most recently, U.S. airlines responded to volatile fuel prices and then a weakening economy by cutting their capacity, reducing their fleets and workforces, and instituting new fees, but even with these actions, the airlines experienced over $5 billion in operating losses in 2008 before posting an operating profit of about $1 billion ~~in 2009.~~[10] Furthermore, over the last decade, airfares have generally declined (in real terms), owing largely to the increased presence of low-cost airlines, such as Southwest Airlines, in more markets and the shrinking dominance of a single airline in many markets.

One of the primary financial benefits that airlines consider when merging with another airline is the cost reduction that may result from combining complementary assets, eliminating duplicative activities, and reducing capacity. A merger or acquisition could enable the combined airline to reduce or eliminate duplicative operating costs, such as duplicative service, labor, and operations costs—including inefficient (or redundant) hubs or routes—or to achieve operational efficiencies by integrating computer systems and similar airline fleets. Other cost savings may stem from facility consolidation, procurement savings, and working capital and balance sheet restructuring, ~~such as~~ renegotiating aircraft leases. Airlines may also pursue mergers or acquisitions to more efficiently manage capacity—both to reduce operating costs and to generate revenue—in their networks. Given recent economic pressures, particularly increased fuel costs, the opportunity to lower costs by reducing redundant capacity may be especially appealing to airlines seeking to merge. Experts have said that industry mergers and acquisitions could lay the foundation for more rational capacity reductions in highly competitive domestic markets

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[10] Collectively, U.S. airlines reduced domestic capacity, as measured by the number of seats flown, by about 12 percent from the fourth quarter of 2007 to the fourth quarter of 2009. As we reported in April 2009, to reduce capacity, airlines reduced the overall number of active aircraft in their fleets by eliminating mostly older, less fuel-efficient, and smaller (50 or fewer seats) aircraft. Airlines also collectively reduced their workforces by about 38,000 full-time-equivalent positions, or about 9 percent, from the first quarter of 2008 to the first quarter of 2010. In addition to reducing capacity, most airlines instituted new fees, such as those for checked baggage, which resulted in $3.9 billion in added revenue during 2008 and 2009.

and could help mitigate the significant impact that economic cycles have historically had on airline cash flow.

The other primary financial benefit that airlines consider with mergers and acquisitions is the potential for increased revenues through additional demand, which may be achieved by more seamless travel to more destinations and increased market share and higher fares on some routes.

- *Increased demand from an expanded network*: An airline may seek to merge with or acquire an airline as a way to generate greater revenues from an expanded network, which serves more city-pair markets and better serves passengers. Mergers and acquisitions may generate additional demand by providing consumers more domestic and international city-pair destinations. Airlines with expansive domestic and international networks and frequent flier benefits particularly appeal to business traffic, especially corporate accounts. Results from a recent Business Traveler Coalition (BTC) survey indicate that about 53 percent of the respondents were likely to choose a particular airline based on the extent of its route network.[11] Therefore, airlines may use a merger or acquisition to enhance their networks and gain complementary routes, potentially giving the combined airline a stronger platform from which to compete in highly profitable markets.
- *Increased market share and higher fares on some routes*: Capacity reductions in certain markets after a merger could also serve to generate additional revenue through increased fares on some routes. Some studies of airline mergers and acquisitions during the 1980s showed that prices were higher on some routes from the airline's hubs soon after the combination was completed.[12] Several studies have also shown that increased airline dominance at an airport results in increased fare

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[11] Respondents were travel managers responsible for negotiating and managing their firms' corporate accounts.

[12] See Severin Borenstein, "Airline Mergers, Airport Dominance, and Market Power," *American Economic Review*, Vol. 80, May 1990, and Steven A. Morrison, "Airline Mergers: A Longer View," *Journal of Transport Economics and Policy*, September 1996; and Gregory J. Werden, Andrew J. Joskow, and Richard L. Johnson, "The Effects of Mergers on Price and Output: Two Case Studies from the Airline Industry," *Managerial and Decision Economics*, Vol. 12, October 1991.

From my ~~B~~4
biz classes
I ~~am~~ now
understand how
you create these
models

premiums, in part because of competitive barriers to entry.[13] At the same time, though, even if the combined airline is able to increase prices in some markets, the increase may be transitory if other airlines enter the markets with sufficient presence to counteract the price increase. In an empirical study of airline mergers and acquisitions up to 1992, Winston and Morrison suggest that being able to raise prices or stifle competition does not play a large role in airlines' merger and acquisition decisions.[14]

Cost reductions and the opportunity to obtain increased revenue could bolster a merged airline's financial condition, enabling the airline to better compete in a highly competitive international environment. Many industry experts believe that the United States will need larger, more economically stable airlines to be able to compete with the merging and larger foreign airlines that are emerging in the global economy. The airline industry is becoming increasingly global; for example, the Open Skies agreement between the United States and the European Union became effective in March 2008.[15]

Despite these benefits, there are several potential barriers to successfully consummating a merger. The most significant operational challenges involve the integration of workforces, aircraft fleets, and information technology systems and processes, which can be difficult, disruptive, and costly as the airlines integrate.[16]

- *Workforce integration*: Workforce integration is often particularly challenging and expensive and involves negotiation of new labor

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[13] See Severin Borenstein, 1989, "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *RAND Journal of Economics*, 20, 344-365; GAO, *Airline Deregulation: Barriers to Entry Continue to Limit Competition in Several Key Markets*, GAO/RCED-97-4 (Washington, D.C.: Oct. 18, 1996); GAO, *Airline Competition: Effects of Airline and Market Concentration and Barriers to Entry on Airfares*, GAO/RCED-91-101 (Washington, D.C.: Apr. 16, 1991).

[14] See Steven A. Morrison, and Clifford Winston, "The Remaining Role for Government Policy in the Deregulated Airline Industry." *Deregulation of Network Industries: What's Next?* Sam Peltzman and Clifford Winston, eds. Washington, D.C., Brookings Institution Press, 2000 pp. 1-40.

[15] Open Skies seeks to enable greater access of U.S. airlines to Europe, including expanded rights to pick up traffic in one country in Europe and carry it to another European or third country (referred to as fifth freedom rights). Additionally, the United States will expand EU airlines' rights to carry traffic from the United States to other countries.

[16] Airlines also face potential challenges to mergers and acquisitions from DOJ's antitrust review, which is discussed in the next section.

contracts. Labor groups—including pilots, flight attendants, and mechanics—may be able to demand concessions from the merging airlines during these negotiations, several experts explained, because labor support would likely be required for a merger or acquisition to be successful. Some experts also note that labor has often opposed mergers, fearing employment or salary reductions. Obtaining agreement from each airline's pilots' union on an integrated pilot seniority list—which determines pilots' salaries, as well as what equipment they can fly—may be particularly difficult. According to some experts, as a result of these labor integration issues and the challenges of merging two work cultures, airline mergers have generally been unsuccessful. For example, although the 2005 America West–US Airways merger has been termed a successful merger by many industry observers, labor disagreements over employee seniority, and especially pilot seniority, are not fully resolved. More recently, labor integration issues derailed merger talks—albeit temporarily—between Northwest and Delta in early 2008, when the airlines' labor unions were unable to agree on pilot seniority list integration. Furthermore, the existence of distinct corporate cultures can influence whether two firms will be able to merge their operations successfully. For example, merger discussions between United and US Airways broke down in 1995 because the employee-owners of United feared that the airlines' corporate cultures would clash.

Why are they able to block? How hard is it to integrate a li seniority list?

- remember American Casino

& are airline corp. cultures all that different?

- *Fleet integration*: The integration of two disparate aircraft fleets may also be costly. Combining two fleets may increase costs associated with pilot training, maintenance, and spare parts. These costs may, however, be reduced after the merger by phasing out certain types of aircraft from the fleet mix. Pioneered by Southwest Airlines and copied by other low-cost airlines, simplified fleets have enabled airlines to lower costs by streamlining maintenance operations and reducing training times. If an airline can establish a simplified fleet, or "fleet commonality"—particularly by achieving an efficient scale in a particular aircraft—then many of the cost efficiencies of a merger or acquisition may be set in motion by facilitating pilot training, crew scheduling, maintenance integration, and inventory rationalization.
- *Information technology integration*: Finally, integrating information technology processes and systems can also be problematic and time-consuming after a merger. For example, officials at US Airways told us that while some cost reductions were achieved within 3 to 6 months of its merger with America West, the integration of information technology processes took nearly 2 ½ years. Systems integration issues are increasingly daunting as airlines attempt to integrate a complex mix of modern in-house systems, dated mainframe systems, and outsourced information technology. The US Airways-America West merger highlighted the potential challenges associated with combining reservation systems, as there were initial integration problems.

? This is what I call work in

## The Department of Justice's Antitrust Review Is a Critical Step in the Airline Merger and Acquisition Process

DOJ's review of airline mergers and acquisitions is a key step for airlines hoping to consummate a merger. For airlines, as with other industries, DOJ uses an analytical framework set forth in the *Horizontal Merger Guidelines* (the Guidelines) to evaluate merger proposals.[17] In addition, DOT plays an advisory role for DOJ and, if the combination is consummated, may conduct financial and safety reviews of the combined entity under its regulatory authority.

Most proposed airline mergers or acquisitions must be reviewed by DOJ as required by the Hart-Scott-Rodino Act. In particular, under the act, an acquisition of voting securities or assets above a set monetary amount must be reported to DOJ (or the Federal Trade Commission (FTC) for certain industries) so the department can determine whether the merger or acquisition poses any antitrust concerns.[18] To analyze whether a proposed merger or acquisition raises antitrust concerns—whether the proposal will create or enhance market power or facilitate its exercise[19]—DOJ follows an integrated five-part analytical process set forth in the

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[17] The Guidelines were jointly developed by DOJ's Antitrust Division and the Federal Trade Commission and describe the inquiry process the two agencies follow in analyzing proposed mergers. The most current version of the Guidelines was issued in 1992; Section 4, relating to efficiencies, was revised in 1997. DOJ has proposed some changes in the Guidelines to better reflect its merger review process and the public comment period on these changes has been extended to June 4, 2010.

[18] See 15 U.S.C. § 18a(d)(1). Both DOJ and FTC have antitrust enforcement authority, including reviewing proposed mergers and acquisitions. DOJ is the antitrust enforcement authority charged with reviewing proposed mergers and acquisitions in the airline industry. Additionally, under the Hart-Scott-Rodino Act, DOJ has 30 days after the initial filing to notify companies that intend to merge whether DOJ requires additional information for its review. If DOJ does not request additional information, the firms can close their deal (15 U.S.C. § 18a(b)). If more information is required, however, the initial 30-day waiting period is followed by a second 30-day period, which starts to run after both companies have provided the requested information. Companies often attempt to resolve DOJ competitive concerns, if possible, before the second waiting period expires. Any restructuring of a transaction—e.g., through a divestiture—is included in a consent decree entered by a court, unless the competitive problem is unilaterally fixed by the parties before the waiting period expires (called a "fix-it first").

[19] Market power is the ability to maintain prices profitably above competitive levels for a significant period of time.

I never knew the criteria

Guidelines.[20] First, DOJ defines the relevant product and geographic markets in which the companies operate and determines whether the merger is likely to significantly increase concentration in those markets. Second, DOJ examines potential adverse competitive effects of the merger, such as whether the merged entity will be able to charge higher prices or restrict output for the product or service it sells. Third, DOJ considers whether other competitors are likely to enter the affected markets and whether they would counteract any potential anticompetitive effects that the merger might have posed. Fourth, DOJ examines the verified "merger specific" efficiencies or other competitive benefits that may be generated by the merger and that cannot be obtained through any other means. Fifth, DOJ considers whether, absent the merger or acquisition, one of the firms is likely to fail, causing its assets to exit the market. The commentary to the Guidelines makes clear that DOJ does not apply the Guidelines as a step-by-step progression, but rather as an integrated approach in deciding whether the proposed merger or acquisition would create antitrust concerns.

In deciding whether the proposed merger is likely anticompetitive DOJ considers the particular circumstances of the merger as it relates to the Guidelines' five-part inquiry. The greater the potential anticompetitive effects, the greater must be the offsetting verifiable efficiencies for DOJ to clear a merger. However, according to the Guidelines, efficiencies almost never justify a merger if it would create a monopoly or near monopoly. If DOJ concludes that a merged airline threatens to deprive consumers of the benefits of competitive air service, then it will seek injunctive relief in a court proceeding to block the merger from being consummated. In some cases, the parties may agree to modify the proposal to address anticompetitive concerns identified by DOJ—for example, selling airport assets or giving up slots at congested airports—in which case DOJ ordinarily files a complaint with the court along with a consent decree that embodies the agreed-upon changes.

DOT conducts its own analyses of airline mergers and acquisitions. While DOJ is responsible for upholding antitrust laws, DOT conducts its own competitive analysis and provide it to DOJ in an advisory capacity. DOT reviews the merits of any airline merger or acquisition and submits its views and relevant information in its possession to DOJ. DOT also provides some essential data that DOJ uses in its review.. In addition, presuming the merger moves forward after DOJ review, DOT can undertake several other reviews if the situation warrants. Before commencing operations, any new, acquired, or merged airlines must obtain separate authorizations from DOT—"economic" authority from the Office of the Secretary and "safety" authority from the Federal Aviation Administration (FAA). The Office of the Secretary is responsible for deciding whether applicants are fit, willing, and able to perform the service or provide transportation. To make this decision, the Secretary assesses whether the applicants have the managerial competence, disposition to comply with regulations, and financial resources necessary to operate a new airline. FAA is responsible for certifying that the aircraft and operations conform to the safety standards prescribed by the Administrator—for instance, that the applicants' manuals, aircraft, facilities, and personnel meet federal safety standards. Also, if a merger or other corporate transaction involves the transfer of international route authority, DOT is responsible for assessing and approving all transfers to ensure that they are consistent with the public interest.[21]

## In Creating the Largest U.S. Passenger Airline, a United-Continental Merger May Face Integration Challenges and Analysis of Some Overlapping Markets

If not challenged by DOJ, the merged United-Continental would surpass Delta as the largest U.S. passenger airline. As table 1 indicates, combining United and Continental Airlines would create the largest U.S. airline based on 2009 capacity as measured by available seat miles, and a close second based on total assets and operating revenue. The combined airline would also have the largest workforce among U.S. airlines based on March 2010 employment statistics, with a combined 76,900 employees as measured by full-time-equivalent employees (table 2). The airlines' workforces are represented by various unions, and in some cases the same union represents similar employee groups, such as the union for the pilots (table 3). Finally, the combined airline would need to integrate 692 aircraft (table 4). The two airlines share some of the same aircraft types, which could make integration easier.

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[20] United States Department of Justice and Federal Trade Commission, *Horizontal Merger Guidelines* (Washington, D.C., rev. Apr. 8, 1997).

[21] 49 U.S.C. § 41105. DOT must specifically consider the transfer of certificate authority's impact on the financial viability of the parties to the transaction and on the trade position of the United States in the international air transportation market, as well as on competition in the domestic airline industry.

Table 1: Total Assets, Operating Revenue, and Capacity of Major U.S. Airlines (2009)

| | Capacity as measured by available seat miles (thousands) | Total assets | Total operating revenue |
|---|---|---|---|
| United-Continental | 217,166,074 | $125,742,402 | $28,720,624 |
| Delta | 197,701,800 | 195,546,148 | 28,909,882 |
| American | 151,772,113 | 89,629,364 | 19,898,245 |
| Southwest | 98,170,797 | 55,190,553 | 10,350,338 |
| US Airways | 70,721,007 | 28,901,241 | 10,780,838 |
| Airtran | 23,304,612 | 8,649,482 | 2,341,442 |
| Alaska | 23,148,960 | 18,045,385 | 3,005,999 |

Source: GAO analysis of Bureau of Transportation Statistics Form 41 data.

Table 2: Full-Time-Equivalent Employees of Top U.S. Airlines (March 2010)

| Rank | Airline | Total full-time-equivalent employees (thousands) |
|---|---|---|
| 1 | Delta | 74.7 |
| 2 | American[a] | 75.2 |
| 3 | United | 43.7 |
| 4 | Southwest | 34.6 |
| 5 | Continental | 33.2 |
| 6 | US Airways | 29.5 |
| 7 | JetBlue | 11.2 |
| 8 | Alaska | 9.2 |

Source: GAO analysis of Bureau of Transportation Statistics data.

[a] Includes American Eagle.

Table 3: Union Representation for Various Employee Groups

| | Employee groups | | | | | |
|---|---|---|---|---|---|---|
| | Pilots | Flight attendants | Mechanics | Public contact, ramp and stores, and other workers | | Dispatchers |
| United | Air Line Pilots Association (ALPA) | Association of Flight Attendants (AFA) | International Brotherhood of Teamsters (IBT) | International Association of Machinists (IAM) | | Professional Airline Flight Control Association (PAFCA) |
| | Pilots | Flight attendants | Mechanics | Fleet service | Ticket agents | Dispatchers |
| Continental | ALPA | IAM | IBT | IBT | Nonunion | Transport Workers Union (TWU) |

Source: United Air Lines and Continental Airlines.

Note: In addition, The International Federation of Professional and Technical Engineers (IFPTE) represent more than 260 United engineers and related employees.

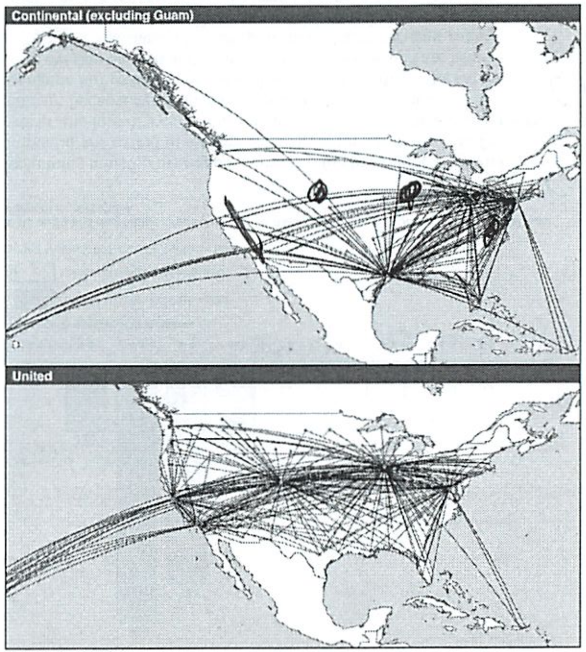
Table 4: United and Continental Aircraft Fleet

| Aircraft | United | Continental | Merged |
|---|---|---|---|
| Boeing 737 | | 226 | 226 |
| Boeing 747 | 24 | | 24 |
| Boeing 757 | 96 | 61 | 157 |
| Boeing 767 | 35 | 26 | 61 |
| Boeing 777 | 52 | 20 | 72 |
| Airbus 319/320 | 152 | | 152 |
| **Total** | **359** | **333** | **692** |

Source: United Air Lines.

If not challenged by DOJ, the airlines would attempt to combine two distinct networks, United with major hubs, where the airline connects traffic feeding from smaller airports, in San Francisco (SFO), Los Angeles (LAX), Denver (DEN), Chicago O'Hare (ORD), and Washington DC Dulles (IAD) and Continental with hubs in Houston Intercontinental (IAH), Cleveland (CLE), Guam (GUM), and New York Newark (EWR), as shown in figure 2.

Figure 2: United and Continental Domestic Route Maps (May 2010)



Source: agpDat, Dilo LLC.

good visualization

The amount of overlap in airport-pair combinations between the two airlines' networks is considerable if considering all connecting traffic; however, for most of the overlapping airport-pair markets there is at least one other competitor. Based on 2009 ticket sample data, for 13,515 airport pairs with at least 520 passengers per year, there would be a loss of one effective competitor in 1,135 airport-pair markets[22] affecting almost 35 million passengers by merging these airlines (see fig. 3).[23] However, only 10 of these airport-pair markets would not have any other competitors in it after a merger. In addition, any effect on fares would be dampened by the presence of a low-cost airline in 431 of the 1,135 airport pairs losing a competitor.[24] The combination of the two airlines would also create a new effective competitor in 173 airport-pair markets affecting almost 9.5 million passengers.

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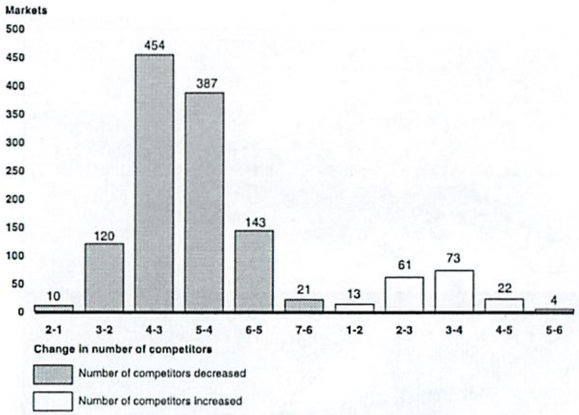
[22] It is generally preferable, time permitting, to assess city-pair, rather than airport-pair, changes in competition. Some larger U.S. cities (New York, Chicago, Los Angeles, Washington D.C.) have more than one commercial airport that can compete for passenger traffic. DOJ generally considers the relevant market to be a city-pair combination.

[23] For this airport-pair analysis, we considered any airport-pair market with less than 520 annual passengers to be too small to ensure accuracy. We defined an effective competitor as having at least 5 percent of total airport-pair traffic. This is the same minimum market share that we have previously applied to assess whether an airline has sufficient presence in a market to affect competition. See GAO-08-845, p. 21 and 42.

[24] We defined low-cost airlines as JetBlue, Frontier/Midwest, AirTran, Allegiant, Spirit, Sun Country, and Southwest.

Figure 3: Change in Effective Competition from United-Continental Combination (2009)



Source: GAO Analysis of DOT Origin and Destination Ticket Data.

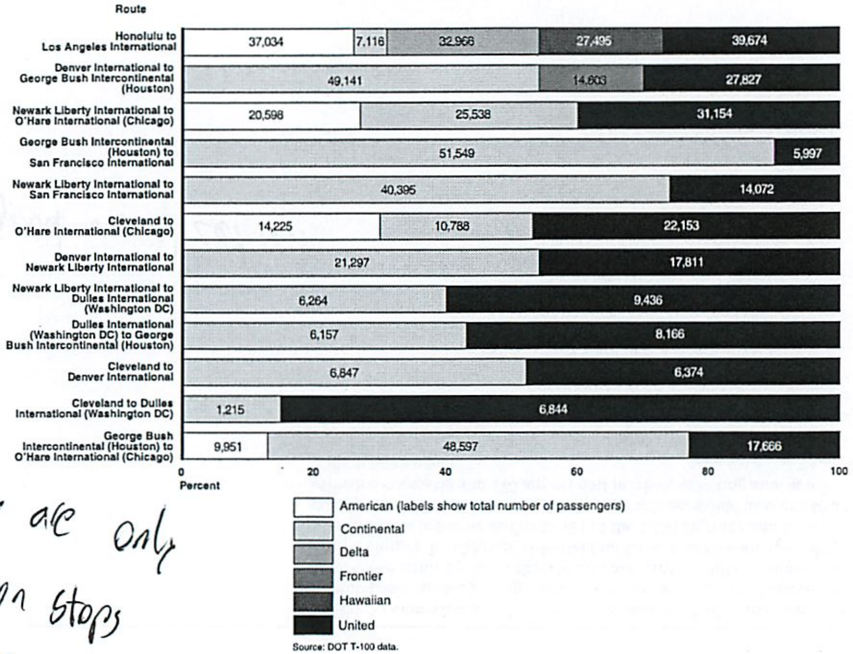
Note: All origin and destination airport pairs with at least 520 passengers. A competitor holds at least 5 percent of market share.

In examining nonstop overlapping airport pairs between United and Continental, the extent of overlap is less than for connecting traffic. However, the loss of a competitor in these nonstop markets is also more significant because nonstop service is typically preferred by some passengers. For example, based on January 2010 traffic data, the two airlines overlap on 12 nonstop airport-pair routes, which are listed in figure 4.[25] For 7 of these 12 nonstop overlapping airport-pair routes (generally between a United hub and a Continental hub), there are currently no other competitors. However, of these 7 airport-pair markets, all but the Cleveland-Denver market may have relevant competition between other airports in at least one of the endpoint cities. For example, passengers traveling from San Francisco (SFO) to Newark (EWR) could consider airlines serving other airports at both endpoints—Oakland or San Jose instead of SFO and John F. Kennedy (JFK) or LaGuardia instead of EWR.

Oh they are only
2 non stops
others are connecting

and other airports
plus LCCs would enter

Figure 4: Total Passengers on Overlapping Nonstop Airport Pairs (January 2010)



Source: DOT T-100 data.

If not challenged by DOJ, the combined airline could be expected to rationalize its network over time, including where it maintains hubs. Currently, the two airlines do not have much market share that overlaps at

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[25] In March 2010, Continental initiated nonstop service between Los Angeles (LAX) and Kahului Airport (OGG) in Hawaii, which is also served by United. This compares to 12 nonstop overlaps (7 highly concentrated) in the Delta-Northwest merger.

8 wow!

their respective hubs (see table 5). However, it is uncertain whether the combined airline would retain eight domestic hubs. There is considerable overlap between markets served by United out of Chicago (ORD) and Continental out of Cleveland (CLE). For example, 52 out of 62 domestic airports served by Continental from Cleveland are also served by United from Chicago (ORD).

Table 5: Passenger Market Share at Hub Airports (2009)

| Continental hub airports | Continental share (%) | United hub airports | United share (%) | Total (%) |
|---|---|---|---|---|
| Houston (IAH) | 72 | | 5 | 77 |
| Newark (EWR) | 68 | | 5 | 73 |
| Cleveland (CLE) | 53 | | 6 | 59 |
| | 1 | Washington Dulles (IAD) | 51 | 52 |
| | 4 | Chicago (ORD) | 38 | 42 |
| | 6 | San Francisco (SFO) | 33 | 39 |
| | 4 | Denver (DEN) | 29 | 33 |
| | 6 | Los Angeles (LAX) | 17 | 23 |

Source: GAO analysis of DOT Origin and Destination ticket data.

if you live in the hub they decide to close - bad for you

Both United and Continental have extensive world wide networks and serve many international destinations. Between the two airlines, over 100 international cities are served from the United States. The two airlines do not directly compete on a city-to-city route basis for any international destinations. Nevertheless, for international routes, airlines aggregate traffic from many domestic locations at a hub airport where passengers transfer onto international flights. In other words, at Newark, where Continental has a large hub, passengers traveling from many locations across the United States onto Continental's international flights. Likewise, United aggregates domestic traffic at its Washington Dulles hub for many of its international flights. Hence, a passenger traveling from, for example Nashville, may view these alternative routes to a location in Europe as substitutable. Continental and United serve many of the same international destinations in Europe and the Americas from their Newark and Dulles hubs, respectively. These destinations include Amsterdam, Brussels, Frankfort, London, Montreal, Paris, Rome, Sao Paulo, and Toronto. Similarly, both airlines also serve many international destinations from their Midwest hubs—most notably United's hub at Chicago and Continental's hub at Houston. Such destinations include Amsterdam, Cancun, Edmonton, London, Paris, San Jose Cabo, Tokyo, and Vancouver. In total, according to current schedules, they serve 30 common international destinations, representing 65 percent of their total international seat capacity. Whether service to international destinations from different domestic hubs will be viewed as a competitive concern will likely depend on a host of factors, such as the two airlines' market share of traffic to that destination and whether there are any barriers to new airlines entering or existing airlines expanding service at the international destination airports.

wow

To compete internationally, both Continental and United are part of the Star Alliance, one of the three major international airline alliances.[26] In 2009, Continental left the SkyTeam Alliance and joined the Star Alliance. As part of joining this alliance, the Star Alliance members, including Continental, applied for antitrust immunity, which allows the member airlines to coordinate schedules, capacity, and pricing in selected markets. DOT has authority to approve these antitrust immunity applications,[27] but DOJ may also comment if it has antitrust concerns. On June 26, DOJ filed comments that objected to immunity for the alliance in some markets and requested some conditions, called carve-outs, in which the immunity would not be granted. On July 10, 2009, DOT approved the Star Alliance application for antitrust immunity but with special conditions, including carve-outs.[28] Among the markets not granted immunity were New York-Copenhagen, New York-Lisbon, New York-Geneva, New York-Stockholm, Cleveland-Toronto, Houston-Calgary, Houston-Toronto, New York-Ottawa, and U.S.-Beijing.[29]

weird
- how enforce?

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[26] An airline alliance is an agreement between two or more airlines to cooperate on a substantial level. The three largest passenger airline alliances are the *Star Alliance*, *SkyTeam* and *Oneworld*. Alliances provide a network of connectivity and convenience for international passengers. Alliances also provide a marketing brand to passengers making interairline codeshare connections within countries.

[27] 49 U.S.C. §§ 41308, 41309.

[28] Department of Transportation, Joint Application of Air Canada, et al., Final Order, to Amend Order 2007-2-16 under 49 U.S.C. §§ 41308, 41309, DOT-OST-2008-0234 (July 10, 2009).

[29] In addition, the order modified and placed conditions on pre-existing carve outs for this alliance.

## Contact and Acknowledgments

For further information on this testimony, please contact Susan Fleming at (202) 512-2834.

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# Related GAO Products

*Airline Industry: Airline Industry Contraction Due to Volatile Fuel Prices and Falling Demand Affects Airports, Passengers, and Federal Government Revenues.* GAO-09-393. Washington, D.C.: April 21, 2009.

*Airline Industry: Potential Mergers and Acquisitions Driven by Financial Competitive Pressures.* GAO-08-845. Washington, D.C.: July 31, 2008.

*Commercial Aviation: Bankruptcy and Pension Problems Are Symptoms of Underlying Structural Issues.* GAO-05-945. Washington, D.C.: September 30, 2005.

*Commercial Aviation: Preliminary Observations on Legacy Airlines' Financial Condition, Bankruptcy, and Pension Issues.* GAO-05-835T. Washington, D.C.: June 22, 2005.

*Airline Deregulation: Reregulating the Airline Industry Would Likely Reverse Consumer Benefits and Not Save Airline Pensions.* GAO-06-630. Washington, D.C.: June 9, 2005.

*Private Pensions: Airline Plans' Underfunding Illustrates Broader Problems with the Defined Benefit Pension System.* GAO-05-108T. Washington, D.C.: October 7, 2004.

*Commercial Aviation: Legacy Airlines Must Further Reduce Costs to Restore Profitability.* GAO-04-836. Washington, D.C.: August 11, 2004.

*Transatlantic Aviation: Effects of Easing Restrictions on U.S.-European Markets.* GAO-04-835. Washington, D.C.: July 21, 2004.

*Commercial Aviation: Despite Industry Turmoil, Low-Cost Airlines Are Growing and Profitable.* GAO-04-837T. Washington, D.C.: June 3, 2004.

*Commercial Aviation: Financial Condition and Industry Responses Affect Competition.* GAO-03-171T. Washington, D.C.: October 2, 2002.

*Commercial Aviation: Air Service Trends at Small Communities since October 2000.* GAO-02-432. Washington, D.C.: March 29, 2002.

*Proposed Alliance Between American Airlines and British Airways Raises Competition Concerns and Public Interest Issues.* GAO-02-293R. Washington, D.C: December 21, 2001.

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*Aviation Competition: Issues Related to the Proposed United Airlines-US Airways Merger*. GAO-01-212. Washington, D.C: December 15, 2000.

MIT ICAT

MIT International Center for Air Transportation

# Route Planning and Schedule Development

16.71J/1.232J/15.054J/ESD217
The Airline Industry
Dr. Peter P. Belobaba
October 13, 2010

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## Lecture Outline

1. **Hub Economics and Network Structure**
   - Basic airline hub economics
   - Operational advantages and incremental costs
2. **Route Planning and Evaluation**
   - Route evaluation issues
   - Route planning models
   - Measuring route profitability
3. **Schedule Development Process**
   - Airline supply terminology
   - Frequency Planning
   - Timetable Development

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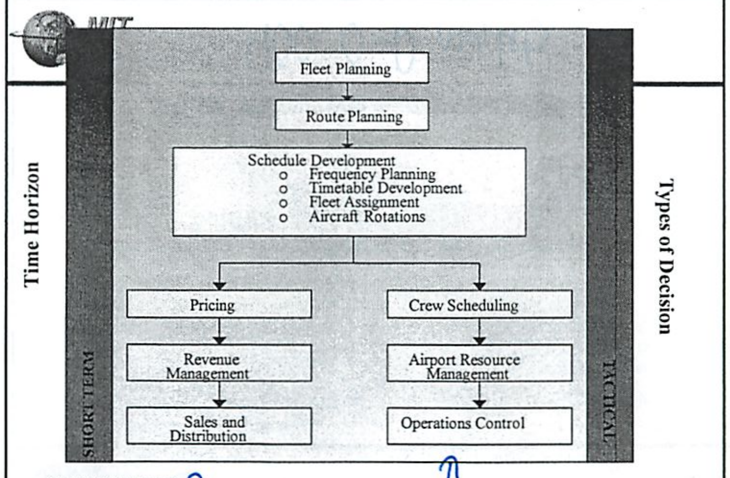


Time Horizon

SHORT TERM

Fleet Planning

Route Planning

Schedule Development
- Frequency Planning
- Timetable Development
- Fleet Assignment
- Aircraft Rotations

Pricing

Revenue Management

Sales and Distribution

Crew Scheduling

Airport Resource Management

Operations Control

TACTICAL

Types of Decision

SOURCE: Prof. C. Barnhart

commerical

Operations

weird split

---

myth: hubs are inefficent

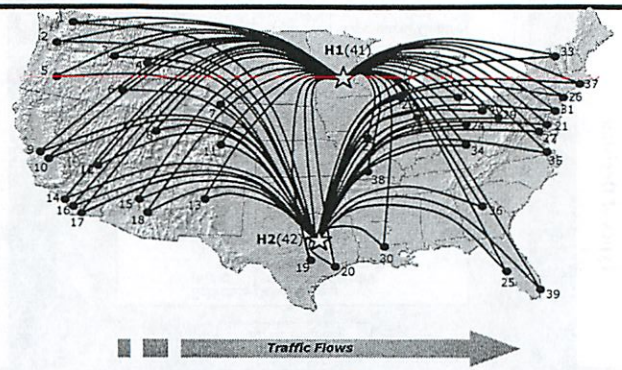
## 1. Hub Economics and Network Structure

- **Hub/spoke network structures allow airlines to serve many O-D markets with fewer flight departures.**
- **Consider a hub network with 20 flights in and 20 flights out of a single "connecting bank" at a hub:**
  - Each flight serves 21 O-D markets (1 local + 20 connecting)
  - Total of 440 O-D markets served with only 40 flight legs and as few as 20 aircraft flying through the hub
  - Consolidation of loads into and out of the hub allows connecting service to be provided to low demand O-D markets that cannot support non-stop flights
  - Several connecting departures per day in these markets may be more convenient for travelers than 1 daily non-stop flight ("Total Trip Time" is lower, when schedule displacement time included)

10/13

2 hubs

## Example: Competitive Hub Networks



400 O-D markets

20 · 20 markets
+ 20 + 20 for 2 local hubs

## Basic Airline Hub Economics

- Routing flights and passengers through a hub is more profitable for the airline if:
  - → COST SAVINGS from operating fewer flights with larger aircraft and more passengers per flight

    IS GREATER THAN
  - → REVENUE LOSS from passengers who reject connecting service and choose a non-stop flight instead, if it exists
- Passenger preference for multiple connecting departures vs. 1 or 2 non-stops per day:
  - Large multiple hub network operated by Delta, for example, provides over a dozen daily connections Boston-San Diego

-definition of total trip time

) if wanted point to point → 440 flights
w/ 1 hub → 42 flights

## The Revenue Power of Hub Networks

- Large hub networks result in market share advantages that translate into increased revenue for the airline:
  - Potential for greater departure frequency for many O-D markets, meaning more convenient schedules and higher market shares
  - On-line "seamless" connections improve passenger convenience, compared to inter-line connections
  - Greater frequent flyer program earning and reward options for passengers given larger network coverage
  - Market dominance of "local" markets in/out of hub may lead to pricing and revenue advantages
- Over 50% of American Airlines' revenue comes from passengers connecting at hubs

e used to be 10-15% [illegible]

if you dominate a hub - you have best service X → hub since 6-8 flights/day

## Operational Advantages of Hubs

- Consolidation of airline operations at a large hub airport has operational advantages:
  - Fewer aircraft and crew bases required, meaning reduced crew and aircraft maintenance expenses
  - Fewer locations where passengers or bags misconnect
  - Large volume of operations at the hub can result in economies of scale in aircraft maintenance, catering facilities, etc.
- Scheduled connecting banks allow for:
  - Simplified (if less flexible) aircraft and crew scheduling
  - Greater opportunities for "swapping" of aircraft in response to delays, cancellations and irregular operations
  - Planning for aircraft swaps in response to changing demand ("Demand Driven Dispatch")

H2 was other airline
-As the 6 carriers built hubs each now competed in each OD market

*strongest hubs where lots of local traffic and OK location

Middle East Dubai hub sucessful b/c no local market

anywhere in area

54% of Southwest is hubs
- they don't call it that or explicity time it
- but so much Freq - de facto hub

International

## Incremental Costs of Hub Networks

- **Hub operations also raise the potential of reduced aircraft and crew utilization:**
  - Reduced flexibility in scheduling of departures, rotations due to fixed connecting bank timing at hubs
  - Increased ground times at hubs, to accommodate connections
  - Greater turn-around times at spoke cities, waiting for a given departure time to meet next connecting bank
- **Congestion and delay costs at the hub airport:**
  - Connecting banks create extreme staffing peaks
  - Peaks of scheduled operations above and beyond runway capacity
  - Weather delays at a hub will affect the airline's entire network

Dalas once had 11 banks (sum both directions)

best place to break down → hub

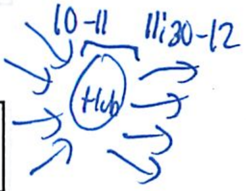
## Hub Impacts on Route Planning

- **New routes to smaller spoke cities become much easier to justify in an established hub network:**
  - An airline needs only 1 or 2 passengers per flight to each of 30+ connecting destinations to make a 100-seat aircraft "profitable"
  - However, such incremental analysis leads to a tendency to overlook potential displacement of other traffic on connecting legs
  - Same "incremental" logic makes it more difficult to stop service to a potentially unprofitable destination, which provides connecting traffic support to other flights

Network issues

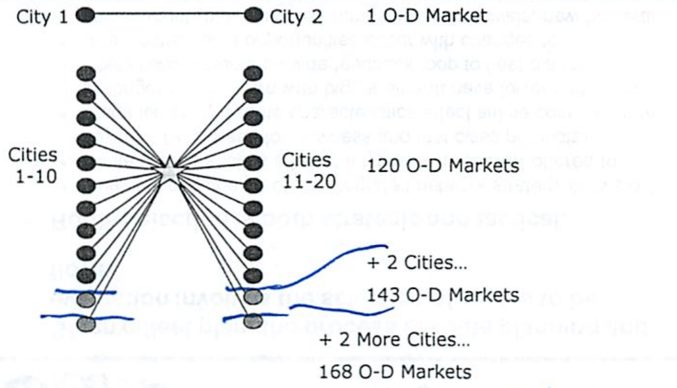
- **Difficult to justify a new non-stop service to by-pass the hub, as it might steal traffic from hub flights:**
  - However, large number of departures in a connecting market can allow airline to build market share and perhaps introduce a non-stop flight supported by many connecting opportunities

slight decrease in efficiencys
- need to leave too early
- aircraft utilization
- more banks increases flexibility



- Capicaty of airport
- crew use inefficent

## Hub Growth by Adding Cities



exponential growth

## Recent Trends: Hub Strengthening

- **Despite forecasts of more non-stop flights, a trend toward bigger and stronger hubs has re-emerged:**
  - Largest US and European airlines have cut virtually all flights that do not originate or terminate at their hubs
  - Several smaller, weaker US hubs have been shut down

esp when things go bad

- **Factors that continue to reinforce hub growth:**
  - Liberalized bilateral agreements have allowed airlines to fly even low-density international routes from their hubs (e.g., CVG-MUC)
  - Small regional jets are being used to increase frequency of flights to small spoke cities, not to over-fly the hub with non-stops
  - Airline alliances focus on linkages between major hub networks
- **Hub operations will continue to be important, given their fundamental economics.**

point to point works in high demand markets

~~Best place~~

Aliance Model

LCCs have cherry picked best O-D markets
-but Southwest is out of markets

## 2. Route Planning and Evaluation

- **Given a fleet plan, the process of route planning and evaluation involves the selection of routes to be flown**
- **Route selection is both strategic and tactical:**
  - Essential component of an integrated network strategy or "vision"
  - Route characteristics affect the types of "products" offered to travelers (e.g., need for business and first class products)
  - Stage length and route characteristics affect airline cost structure, as longer routes flown with bigger aircraft have lower unit costs
  - Route requirements provide feedback loop to fleet planning
  - Unexpected route opportunities occur with changes to environment (bankruptcies, competitor withdrawals, new bilateral agreements)

## Route Evaluation Issues

- **Economic considerations dominate route evaluation:**
  - Forecasts of potential passenger and cargo demand (as well as expected revenues) for planned route are critical to evaluations
  - Origin-destination market demand is primary source of demand and revenues for a given route, but far from the only source
  - In large airline hub networks, traffic flow support to the new route from connecting flights can make it profitable
  - Airline's market share of total forecast demand for the new route depends on existence of current and expected future competition
  - The fundamental economic criterion for a planned route is potential for incremental profitability in the short run, given the opportunity cost of taking aircraft from another route

best use?

profitable but is their a better use??

## Route Evaluation Issues

- **Practical considerations can be just as important:**
  - Technical capability to serve a new route depends on availability of aircraft with adequate range and proper capacity
  - Performance and operating cost characteristics of available aircraft in the airline's fleet determine economic profitability
  - If the route involves a new destination, additional costs of airport facilities, staff re-location, and sales offices must be considered
  - Regulations, bilaterals, and limited airport slots can impose constraints on new route operations, to the point of unprofitability
- **Strategic considerations can overlook lack of route profit:**
  - Longer term competitive and market presence benefits of entering a new route even if it is expected to be unprofitable in short run

US not really slot controlled

-adds up quickly

-airlines have plans for buying assets if an aircraft goes bankrupt

## Route Planning Models

- **Route planning requires a detailed evaluation approach:**
  - Demand, cost and revenue forecasts required for specific route, perhaps for multiple years into the future
  - Assumed market share of total demand based on models of passenger choice of different airline and schedule options
  - Depends to a large extent on presence and *expected response* of competitors to route entry
- **"Route Profitability Models"**
  - Computer models designed to perform such route evaluations, but ability to integrate competitive effects is limited
  - Profit estimates entirely dependent on assumptions used

Updated but real #

-Massport hired a Consultant

-attract demand of flights

## Route Evaluation Example: Boston-Rome

- Case Study – Delta Air Lines considers introduction of new daily non-stop flights between Boston and Rome: Alitalia
  - No current year-round non-stop (AZ via Milan)
  - Cooperation with AZ as SkyTeam member
  - Delta wishes to build up international gateway at Boston

**FLIGHT OPERATING INFORMATION**

| | |
|---|---|
| Total Annual Flights (each direction)<br>(Reflects 98% completion of daily schedule) | 358 |
| Block Hours BOS to ROM | 08:00 |
| Block Hours ROM to BOS | 09:00 |
| Non-stop miles BOS/ROM | 4087 |

## Estimated DL Operating Costs

**Direct Operating Costs**

| | |
|---|---|
| Aircraft Type | B767-300 |
| Number of Seats | 204 |

← Start w/ smallest airplane

**Cost per Block-Hour:**

| | |
|---|---|
| Crew Cost | 1050 |
| Fuel/Oil | 2400 |
| Ownership | 970 |
| Maintenance | 650 |
| **Total per Block-Hour** | **5070** |

**Indirect Operating Costs**

| | |
|---|---|
| Passenger Service | 0.015 per RPM |
| Traffic Servicing | $26 per Enplanement |
| Aircraft Servicing | $1,700 per Departure |
| Promotion and Sales | 9.00% of Passenger Revenues |
| General and Administrative | $0.002 per ASM |

Prof thinks little high → prices are always matched so not factor

inc 5-10% stimulation

-This % # actually harder to determine

## Boston-Rome Revenue Estimates

| DEMAND AND FARE ESTIMATES FOR 2006 | DEMAND | PRORATED DL One Way Revenue | REVENUE |
|---|---|---|---|
| Total BOS-ROM Local O-D passengers (both directions) | 96,000 | | |
| Expected Market Share for one daily flight | 70.00% | | |
| Local BOS-ROM passengers on new flight | 67,200 | $440 | $ 29,568,000 |
| Additional Traffic (Estimated for DL at BOS) | | | |
| Connections US destinations behind Boston to/from ROM | 22,400 | $380 | $ 8,512,000 |
| Connections to/from BOS beyond ROM | 9,600 | $330 | $ 3,168,000 |
| Connections behind BOS to/from destinations beyond ROM | 3,200 | $350 | $ 1,120,000 |
| Total passengers (both directions) | 102,400 | | $ 42,368,000 |
| Additional Cargo Revenue | | 11 percent of passenger revenue | $ 4,660,480 |
| | | **TOTAL** | **$ 47,028,480** |

what share can we get?

where is this from?

-all estimates to fight over it

-other airlines

-booking data

-still very much shot in dark

## Estimated Annual Operating Profit

| | |
|---|---|
| Aircraft Type | B767-300 |
| Number of Seats | 204 |
| ASM | 596,963,568 |
| Seat Departures | 146064 |
| Passengers Enplaned | 102400 |
| Average Load Factor | 70.11% |
| DIRECT OP COSTS | $ 30,856,020 |
| PAX SERVICE | $ 6,277,632 |
| TRAFFIC SERVICE | $ 2,662,400 |
| AIRCRAFT SERVICE | $ 1,217,200 |
| PROMOTION/SALES | $ 3,813,120 |
| GEN ADMINISTRN | $ 1,193,927 |
| OPERATING COSTS | $ 46,020,299 |
| **OPERATING PROFIT** | **$ 1,008,181** |

← 2.5-3% margin

-not great

-subject to all assumptions

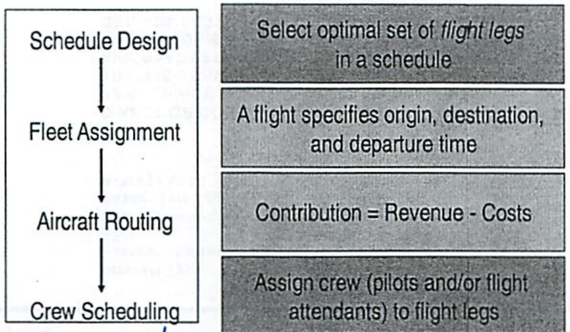
So kinda breakeven

What else could they do?

## 3. SCHEDULE DEVELOPMENT

- **Given a set of routes to be operated in a network, and a fleet of aircraft, schedule development involves**
  - Frequency planning (how often?)
  - Timetable development (at what times?)
  - Fleet assignment (what type of aircraft?)
  - Aircraft rotation planning (network balance)
- **The process begins a year or more in advance and continues until actual departure time:**
  - Frequency plans established first, based on routes and aircraft
  - Timetables and aircraft rotations defined 2-6 months in advance
  - Final revisions and "irregular operations" until the flight departs

## Aircraft and Crew Schedule Planning: Sequential Approach



Schedule Design → Fleet Assignment → Aircraft Routing → Crew Scheduling

Select optimal set of *flight legs* in a schedule

A flight specifies origin, destination, and departure time

Contribution = Revenue - Costs

Assign crew (pilots and/or flight attendants) to flight legs

← airline management class
- if too big airplane — costs are too high

└ lots of rules
just as complex as aircraft

## Frequency Planning

- **Frequency of departures on increases market share:** + biz markets
  - Frequency is much more important in short-haul markets than for long-haul routes where actual flight time dominates "wait time"
  - In competitive markets, airline frequency share is most important to capturing time sensitive business travelers
- **Demand and competition drive frequency decisions:**
  - Estimates of total demand between origin and destination
  - Expected market share of total demand, which is determined by frequency share relative to competitors
- **"Load consolidation" affects frequency and aircraft size:**
  - Single flight with multiple stops provides service to several origin-destination markets at the same time
  - Allows airline to operate higher frequency and/or larger aircraft

## Timetable Development

- **For a chosen frequency of service on each route, need a specific timetable of flight departures:**
  - Goal is to provide departures at peak periods (0900 and 1700)
  - But, not all departures can be at peak periods on all possible routes, given aircraft fleet and rotation considerations
  - Minimum "turn-around" times required at each stop to deplane/enplane passengers, re-fuel and clean aircraft
- **Most airlines try to maximize aircraft utilization:**
  - Keep ground "turn-around" times to a minimum
  - Fly even off-peak flights to maintain frequency share and to position aircraft for peak flights at other cities
  - Leaves little buffer time for maintenance and weather delays

peak times 9AM, 5PM
└ but need to fill rest of day

one strategy
try to pack as many flights in
- bad when fuel ↑
- but no demand for 4:30 AM flight

BOS → FRA don't want 12 PM → 2AM
So wait to 5PM → 7AM } much nicer

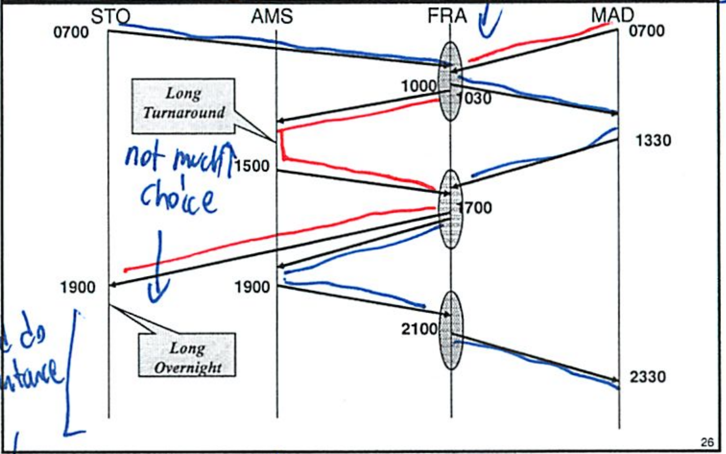
connecting bank targets - must be hit!

## Timetable Development Constraints

- **Numerous constraints affect timetable development:**
  - Hub networks require that flights arrive from spoke cities within a prescribed time range, to facilitate passenger connections
  - Time zone differences limit feasible departure times (e.g., flights from US to Europe do not depart before 1700, as passengers do not want to arrive at their destination before 0600)
  - Airport slot times, noise curfews limit scheduling flexibility
- **Complexity and size of timetable development problem make most schedule changes incremental:**
  - A single change in departure time of a flight from A can have major impacts on down-line times, connections, aircraft rotations, and even number of aircraft required to operate the schedule
  - Further complicated by crew and maintenance schedule needs, requiring coordination with several airline operational departments

## Example of a Schedule Map

### 2 aircraft; 10 flight legs; 9 block-hr/aircraft-day e.g.

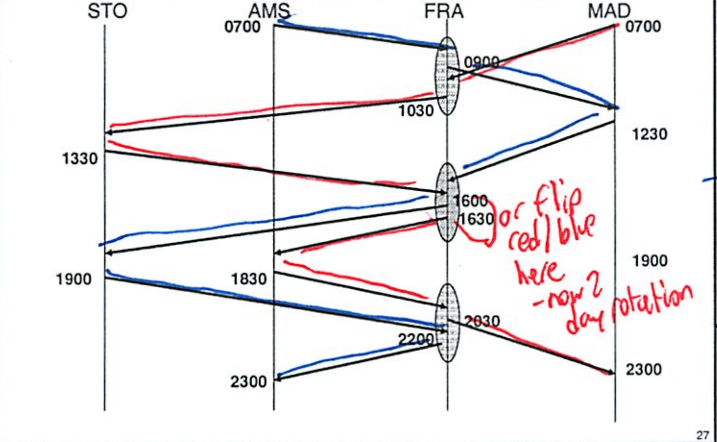


and crew rest requirements

~~each~~ flip colors each day
must end where start

## Revised Schedule Map

### 2 aircraft; 12 flight legs; 11 block-hr/aircraft-day



- nano buffer for delays
- 2 diff maintance bays

## OR Models in Airline Scheduling

- **Airline scheduling problems have received most operations research (OR) attention**
- **Use of schedule optimization models has led to impressive profit gains in:**
  - Aircraft rotations; fleet assignment
  - Crew rotations; maintenance scheduling
- **Current focus is on solving larger problems:**
  - Bigger aircraft fleets, more constraints, and more realistic representations of demand
  - Optimized solutions minimize planned costs, not actual costs under conditions of operational uncertainty and disruptions

now actual

have crew quality of life issues
- have a say

endless OR game
not solvable by computers

↑ good on aircraft utilization e aircraft plan on this
destroyed crew cost

biggest contribution of aircraft OR - optional chap in book

Massachusetts Institute of Technology

# Airline Network Evolution/Strategies

William S. Swelbar, Research Engineer, MIT

October 2010

Whats going on in this market -help w/ final project

w/ US Airways domestic

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## The Evolution of Networks
## Loosely Defined Periods

- 1978 – 1985: The mad rush to take advantage of the freedom to enter markets without government approval. The "market share mentality" is born
  ↳ Freq. share
- 1985 – 1990: Initial wave of merger activity with focus on building hubs with scope and scale. Often the purchase of a direct competitor. Most significant labor event was the "B-Scale Wage Construct" that enabled further growth
  building hubs
- 1991 – 1995: Recession, Gulf War and the unwinding of many rich labor agreements. American takes down hubs and tries unsuccessfully to alter pricing approach. Industry losses
- 1996 – 2001: The regional jet comes of age – over-exuberance? The formation of the "tech bubble" gets underway. Unprecedented period of profitability. LCC presence in domestic market begins in earnest. Infrastructure issues rear their head. Labor chokes the "golden goose". Then 9/11
  everyone did it

led to industry that even in best times makes 5-7%

-at top of cycle negotiate rich labor contracts

size of plane, demand at macro level

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## Evolving Network Strategies

- From linear – to hub construction – to hub-to-hub flying
  w/ government
- From US regional dominance – to a US footprint – to a global focus
- From mainline-oriented mainline aircraft feeding mainline-oriented aircraft - to mainline-oriented aircraft augmented by turbo prop feed – to fewer mainline-oriented aircraft supported by a mix of turbo prop and small regional jet feed – to even fewer mainline-oriented aircraft supported by small and larger regional jet feed.......
  - Where does it end?
- Domestic networks supporting international growth
  - International expansion contributed to improved on board revenue for the domestic operation

rely on international traffic on domestic routes

like Jet Blue in NYC (which one?)

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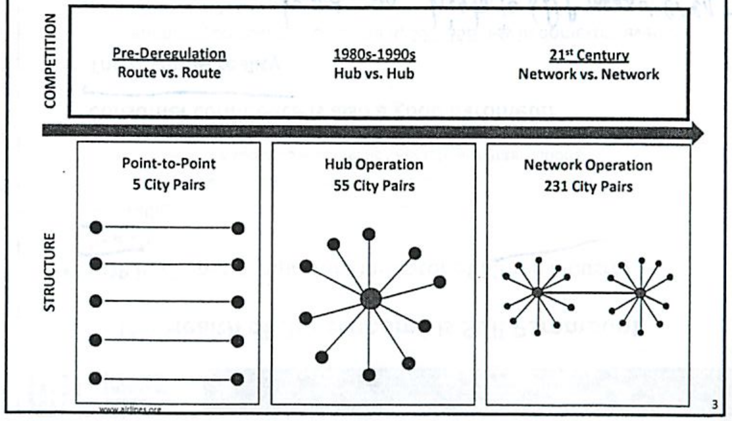
## The Evolution of Networks
## Leveraging Capacity Is Easy; De-leveraging Is Tricky



COMPETITION

Pre-Deregulation
Route vs. Route

1980s-1990s
Hub vs. Hub

21st Century
Network vs. Network

STRUCTURE

Point-to-Point
5 City Pairs

Hub Operation
55 City Pairs

Network Operation
231 City Pairs

www.airlines.org

hub is not efficent everywhere
1-1.2 cents more expensive
but can offer lots of routes = lots of revenue
LCCs do hubs

10/18

LCC took large O-D markets

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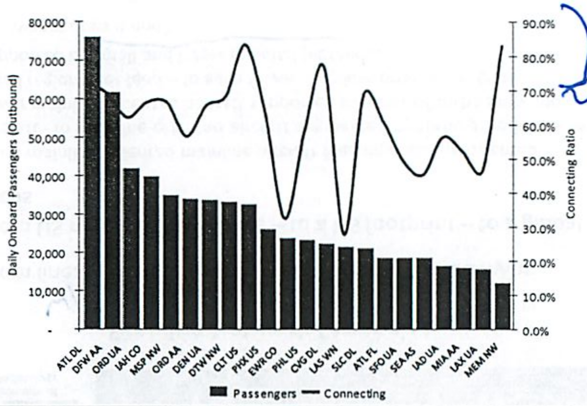
## Hubs: Local v. Connecting Traffic Lies at the Heart of Network Architecture/Strategies



30% local

70% is connecting

Local + Connecting

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## The Health of the Economy Is Still Paramount

- GDP is still most important indicator of airline industry health
  - Traffic
    - Today's world is less domestic, and ……
      - More about how domestic interacts with International
- Consumer confidence is also a good barometer
- The revenue reality
  - Depending on how you calculate it, $25-35B less in domestic revenue to the US industry
  - One year ago, it was fuel and the need to raise fares
  - Today, what needs to be done to invigorate slumping demand

based on historic GDP measurement

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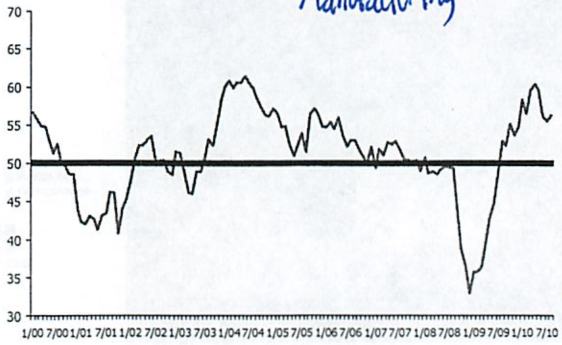
## Institute of Supply Management Index

Manufacturing



Expanding Econ

Contracting Econ

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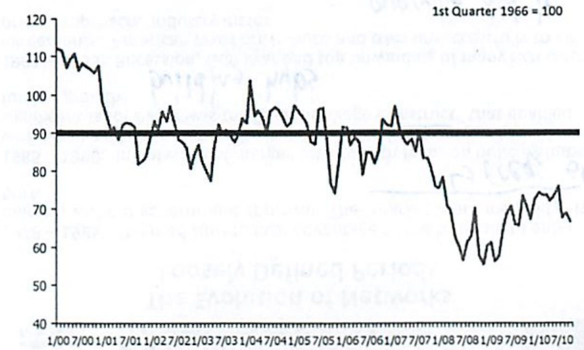
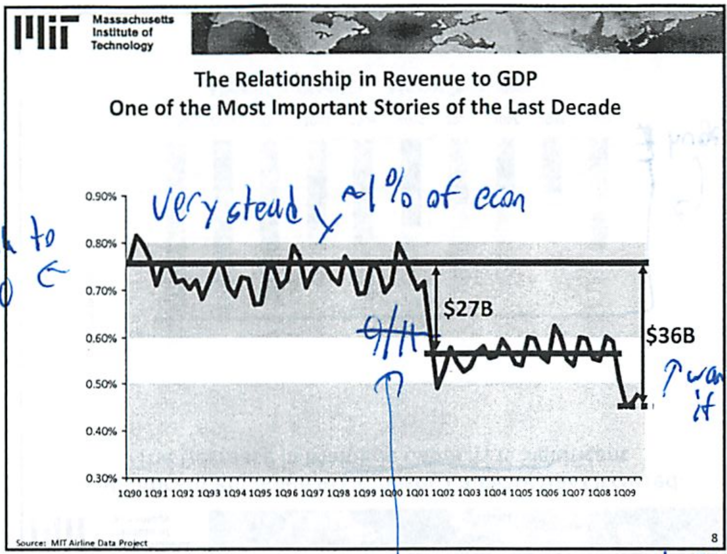
## Consumer Confidence

University of Michigan Consumer Sentiment Survey



more important

not feeling good



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## The Relationship in Revenue to GDP
## One of the Most Important Stories of the Last Decade

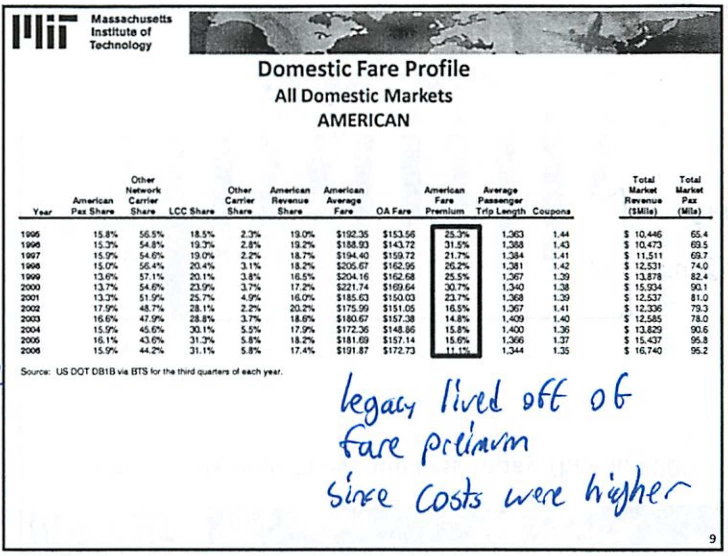
Source: MIT Airline Data Project

Back to 1940 ←

very steady ~1% of econ

9/11

? wants to believe it will come back



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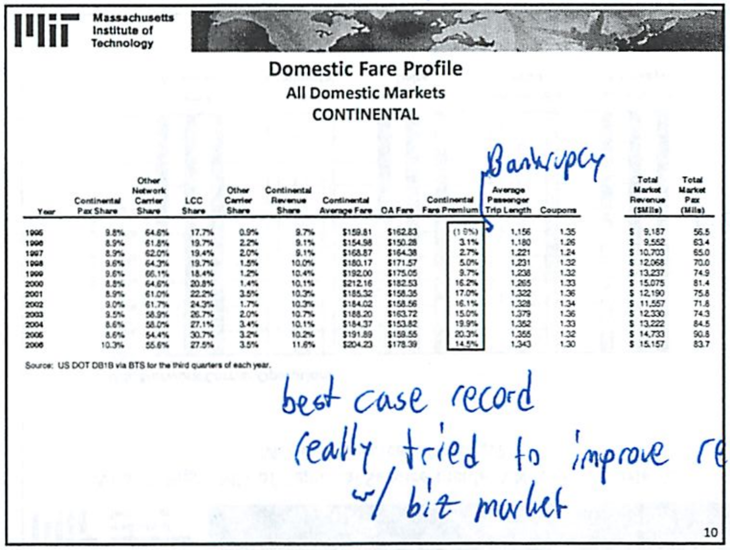
## Domestic Fare Profile
All Domestic Markets
AMERICAN

| Year | American Pax Share | Other Network Carrier Share | LCC Share | Other Carrier Share | American Revenue Share | American Average Fare | OA Fare | American Fare Premium | Average Passenger Trip Length | Coupons | Total Market Revenue ($Mils) | Total Market Pax (Mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 15.8% | 56.5% | 18.5% | 2.3% | 19.0% | $192.35 | $153.56 | 25.3% | 1,363 | 1.44 | $ 10,446 | 65.4 |
| 1996 | 15.3% | 54.8% | 19.3% | 2.8% | 19.2% | $188.93 | $143.72 | 31.5% | 1,388 | 1.43 | $ 10,473 | 69.5 |
| 1997 | 15.9% | 54.6% | 19.0% | 2.2% | 18.7% | $194.40 | $159.72 | 21.7% | 1,384 | 1.41 | $ 11,511 | 69.7 |
| 1998 | 15.0% | 56.4% | 20.4% | 3.1% | 18.2% | $205.67 | $162.95 | 26.2% | 1,381 | 1.42 | $ 12,531 | 74.0 |
| 1999 | 13.6% | 57.1% | 20.1% | 3.8% | 16.5% | $204.16 | $162.68 | 25.5% | 1,367 | 1.39 | $ 13,878 | 82.4 |
| 2000 | 13.7% | 54.6% | 23.9% | 3.7% | 17.2% | $221.74 | $169.64 | 30.7% | 1,340 | 1.38 | $ 15,934 | 90.1 |
| 2001 | 13.3% | 51.9% | 25.7% | 4.9% | 16.0% | $185.63 | $150.03 | 23.7% | 1,368 | 1.39 | $ 12,537 | 81.0 |
| 2002 | 17.9% | 48.7% | 28.1% | 2.2% | 20.2% | $175.99 | $151.05 | 16.5% | 1,367 | 1.41 | $ 12,336 | 79.3 |
| 2003 | 16.6% | 47.9% | 28.8% | 3.7% | 18.6% | $180.67 | $157.38 | 14.8% | 1,409 | 1.40 | $ 12,585 | 78.0 |
| 2004 | 15.9% | 45.6% | 30.1% | 5.5% | 17.9% | $172.36 | $148.86 | 15.8% | 1,400 | 1.36 | $ 13,829 | 90.6 |
| 2005 | 16.1% | 43.6% | 31.3% | 5.8% | 18.2% | $181.69 | $157.14 | 15.6% | 1,366 | 1.37 | $ 15,437 | 95.8 |
| 2006 | 15.9% | 44.2% | 31.1% | 5.8% | 17.4% | $191.87 | $172.73 | 11.1% | 1,344 | 1.35 | $ 16,740 | 95.2 |

Source: US DOT DB1B via BTS for the third quarters of each year.

legacy lived off of fare premium since costs were higher

2/3 damage was before 9/11 → LCCs + interest
9/11 ensured old relationship not responsible
└ transparent prices



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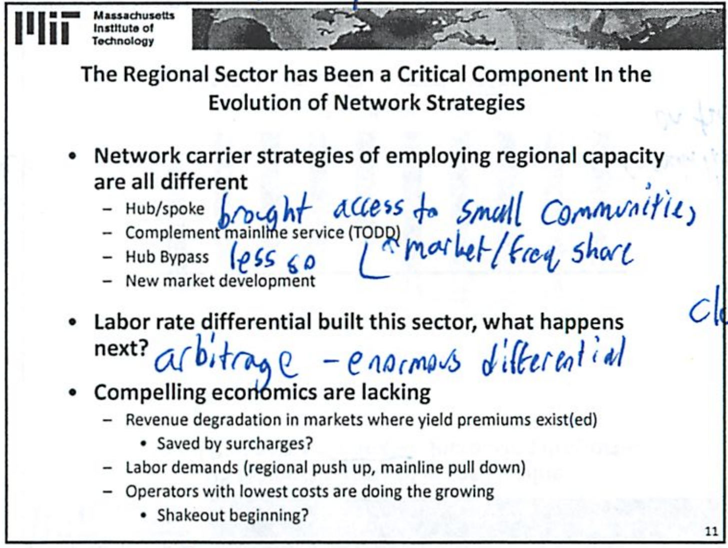
## Domestic Fare Profile
All Domestic Markets
CONTINENTAL

Bankrupcy

| Year | Continental Pax Share | Other Network Carrier Share | LCC Share | Other Carrier Share | Continental Revenue Share | Continental Average Fare | OA Fare | Continental Fare Premium | Average Passenger Trip Length | Coupons | Total Market Revenue ($Mils) | Total Market Pax (Mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 9.8% | 64.6% | 17.7% | 0.9% | 9.7% | $159.81 | $162.83 | (1.9%) | 1,156 | 1.35 | $ 9,187 | 56.5 |
| 1996 | 8.9% | 61.8% | 19.7% | 2.2% | 9.1% | $154.98 | $150.28 | 3.1% | 1,180 | 1.26 | $ 9,552 | 63.4 |
| 1997 | 8.9% | 62.0% | 19.4% | 2.0% | 9.1% | $168.87 | $164.38 | 2.7% | 1,221 | 1.24 | $ 10,703 | 65.0 |
| 1998 | 9.6% | 64.3% | 19.7% | 1.5% | 10.0% | $180.17 | $171.57 | 5.0% | 1,231 | 1.32 | $ 12,068 | 70.0 |
| 1999 | 9.6% | 66.1% | 18.4% | 1.2% | 10.4% | $192.00 | $175.05 | 9.7% | 1,238 | 1.32 | $ 13,237 | 74.9 |
| 2000 | 8.8% | 64.6% | 20.8% | 1.4% | 10.1% | $212.16 | $182.53 | 16.2% | 1,265 | 1.33 | $ 15,075 | 81.4 |
| 2001 | 8.9% | 61.0% | 22.2% | 3.5% | 10.3% | $185.32 | $158.35 | 17.0% | 1,322 | 1.36 | $ 12,190 | 75.8 |
| 2002 | 9.0% | 61.7% | 24.3% | 1.7% | 10.3% | $184.02 | $158.56 | 16.1% | 1,328 | 1.34 | $ 11,557 | 71.8 |
| 2003 | 9.5% | 58.9% | 26.7% | 2.0% | 10.7% | $188.20 | $163.72 | 15.0% | 1,379 | 1.36 | $ 12,330 | 74.3 |
| 2004 | 8.6% | 58.0% | 27.1% | 3.4% | 10.1% | $184.37 | $153.82 | 19.9% | 1,352 | 1.33 | $ 13,222 | 84.5 |
| 2005 | 8.6% | 54.4% | 30.7% | 3.2% | 10.2% | $191.89 | $159.55 | 20.3% | 1,355 | 1.32 | $ 14,733 | 90.8 |
| 2006 | 10.3% | 55.6% | 27.5% | 3.5% | 11.6% | $204.23 | $178.39 | 14.5% | 1,343 | 1.30 | $ 15,157 | 83.7 |

Source: US DOT DB1B via BTS for the third quarters of each year.

best case record
really tried to improve revenue w/ biz market



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## The Regional Sector has Been a Critical Component In the Evolution of Network Strategies

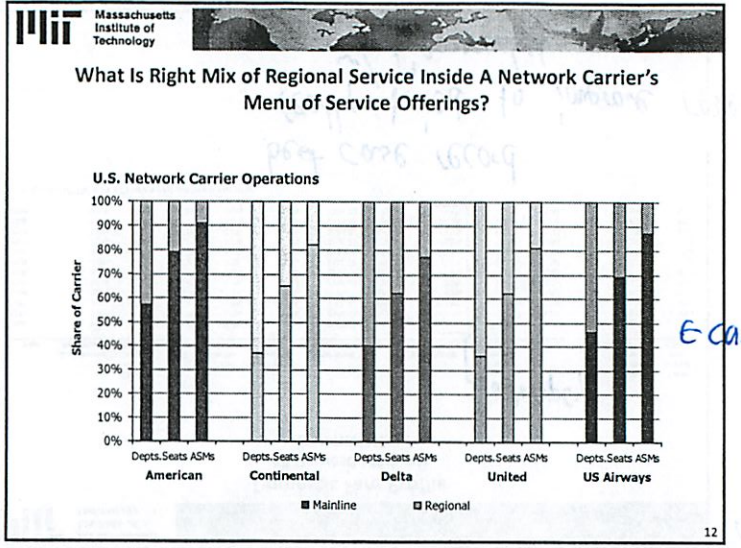
- Network carrier strategies of employing regional capacity are all different
  - Hub/spoke brought access to small communities
  - Complement mainline service (TODD)
  - Hub Bypass less so └ ↑ market/freq share
  - New market development
- Labor rate differential built this sector, what happens next? arbitrage - enormous differential
- Compelling economics are lacking
  - Revenue degradation in markets where yield premiums exist(ed)
    - Saved by surcharges?
  - Labor demands (regional push up, mainline pull down)
  - Operators with lowest costs are doing the growing
    - Shakeout beginning?

cluttered up the skies

but this aall all at $30/barrel
lots of fare competition

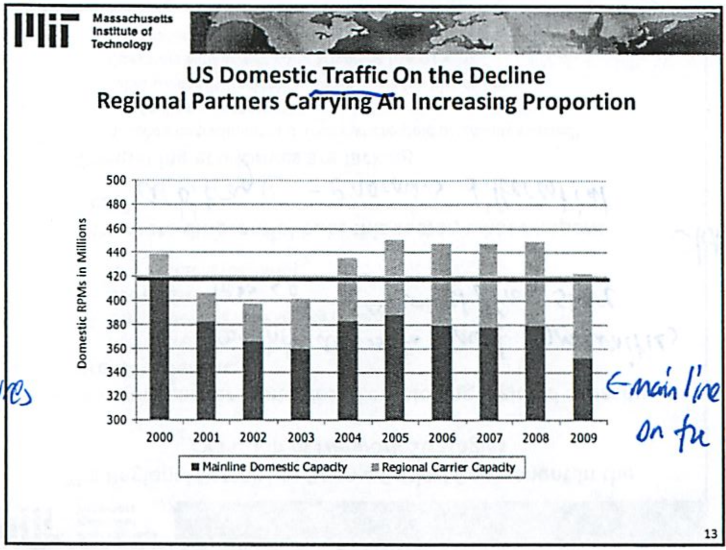
Changed w/ Colgan aircrash ← Will be more cost

degrade the 6-7% margin in regional
Why everyone is trying to get out of this biz



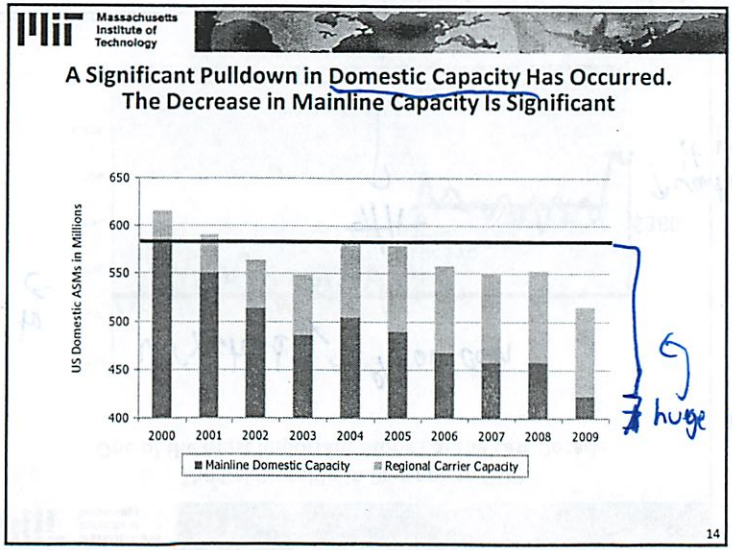
### What Is Right Mix of Regional Service Inside A Network Carrier's Menu of Service Offerings?

← can be 50% of departures



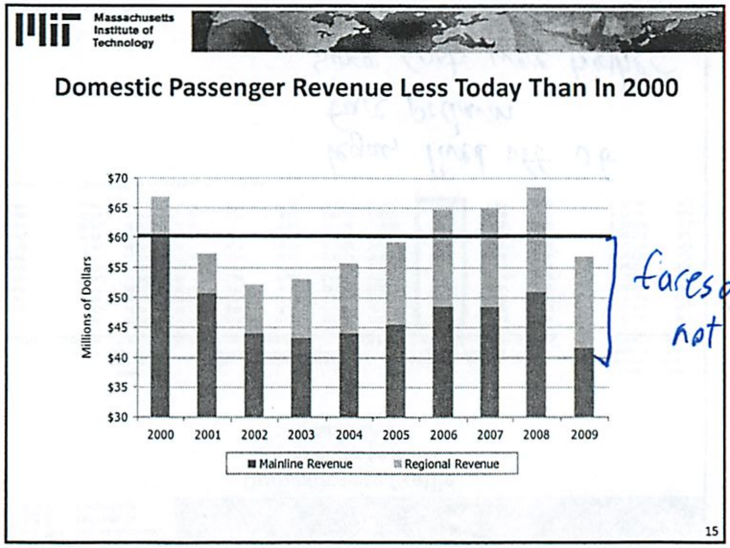
### US Domestic Traffic On the Decline
### Regional Partners Carrying An Increasing Proportion

← mainline really on the decline



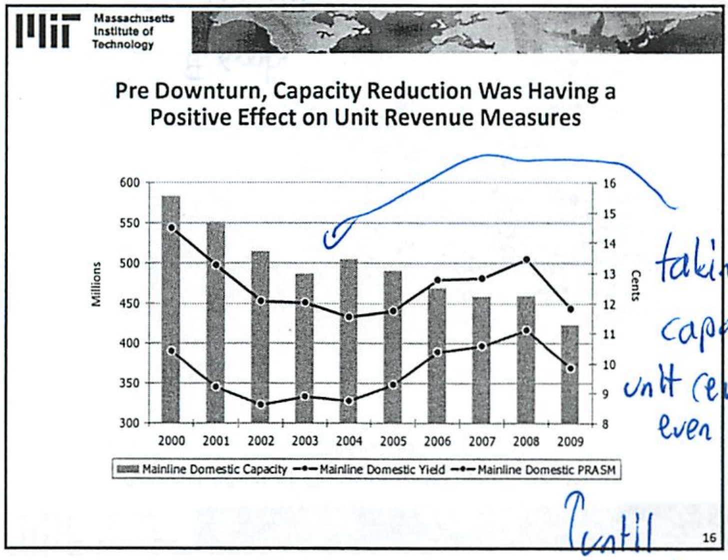
### A Significant Pulldown in Domestic Capacity Has Occurred.
### The Decrease in Mainline Capacity Is Significant

huge decrease



### Domestic Passenger Revenue Less Today Than In 2000

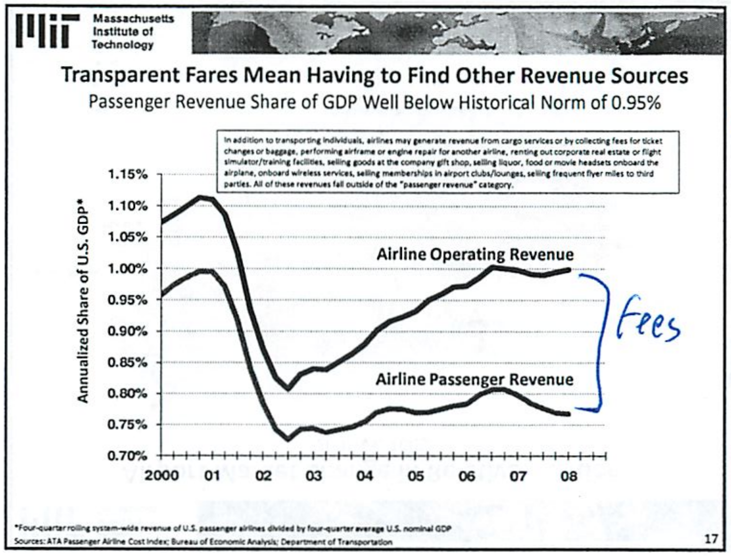
fares are still not back



## Pre Downturn, Capacity Reduction Was Having a Positive Effect on Unit Revenue Measures

taking down capacity ↑ unit revenues even in 03-04

↑until recession



## Transparent Fares Mean Having to Find Other Revenue Sources

### Passenger Revenue Share of GDP Well Below Historical Norm of 0.95%

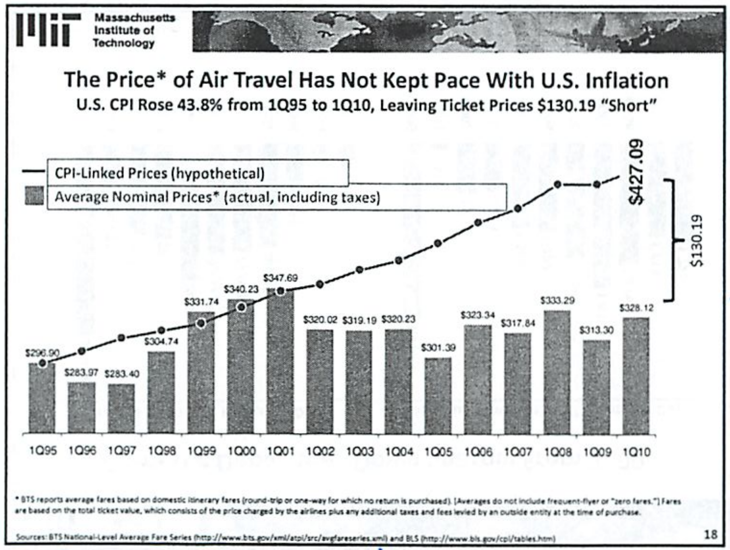
In addition to transporting individuals, airlines may generate revenue from cargo services or by collecting fees for ticket changes or baggage, performing airframe or engine repair for another airline, renting out corporate real estate or flight simulator/training facilities, selling goods at the company gift shop, selling liquor, food or movie headsets onboard the airplane, onboard wireless services, selling memberships in airport clubs/lounges, selling frequent flyer miles to third parties. All of these revenues fall outside of the "passenger revenue" category.

*Four-quarter rolling system-wide revenue of U.S. passenger airlines divided by four-quarter average U.S. nominal GDP

Sources: ATA Passenger Airline Cost Index; Bureau of Economic Analysis; Department of Transportation

Fees

gensis of fees was also revenue
-weight burns fuel
not going to come from ~~operating~~ pax revenue



## The Price* of Air Travel Has Not Kept Pace With U.S. Inflation

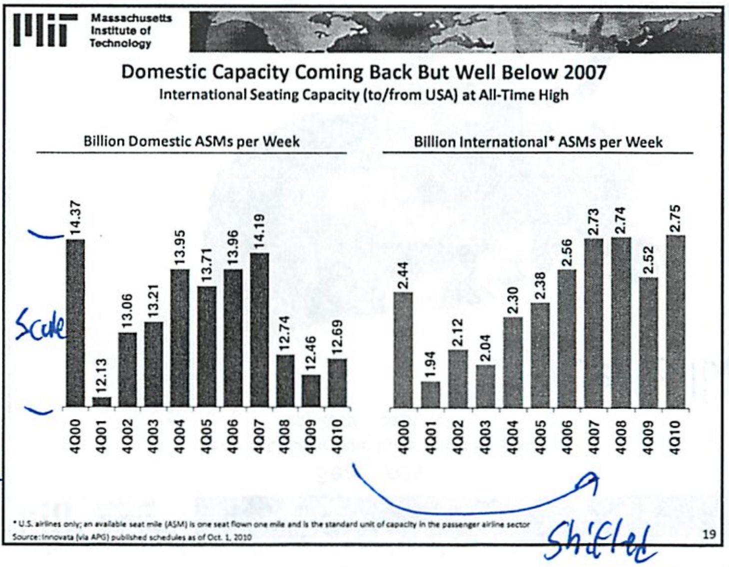
### U.S. CPI Rose 43.8% from 1Q95 to 1Q10, Leaving Ticket Prices $130.19 "Short"

* BTS reports average fares based on domestic itinerary fares (round-trip or one-way for which no return is purchased). [Averages do not include frequent-flyer or "zero fares."] Fares are based on the total ticket value, which consists of the price charged by the airlines plus any additional taxes and fees levied by an outside entity at the time of purchase.

Sources: BTS National-Level Average Fare Series (http://www.bts.gov/xml/atpi/src/avgfareseries.xml) and BLS (http://www.bls.gov/cpi/tables.htm)

assume fares rise w/ inflation

don't make assumption
-competition dictates fares
-costs don't go up at rate of inflation



## Domestic Capacity Coming Back But Well Below 2007

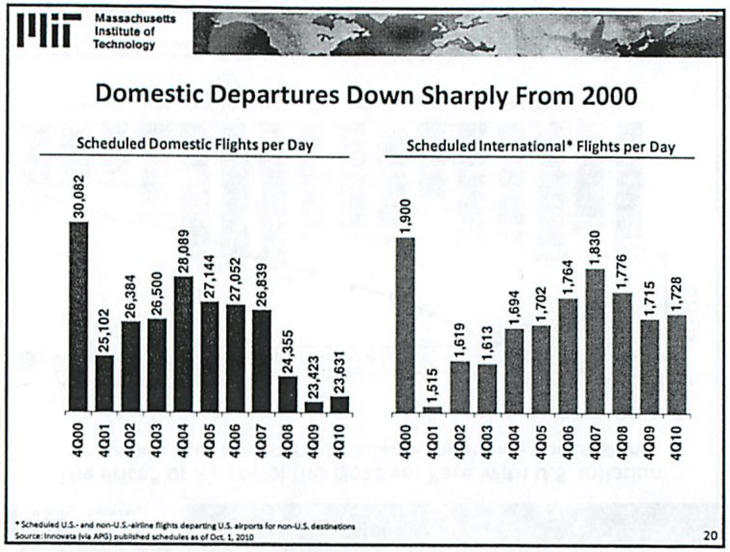
### International Seating Capacity (to/from USA) at All-Time High

* U.S. airlines only; an available seat mile (ASM) is one seat flown one mile and is the standard unit of capacity in the passenger airline sector

Source: Innovata (via APG) published schedules as of Oct. 1, 2010

Scale

Shifted international



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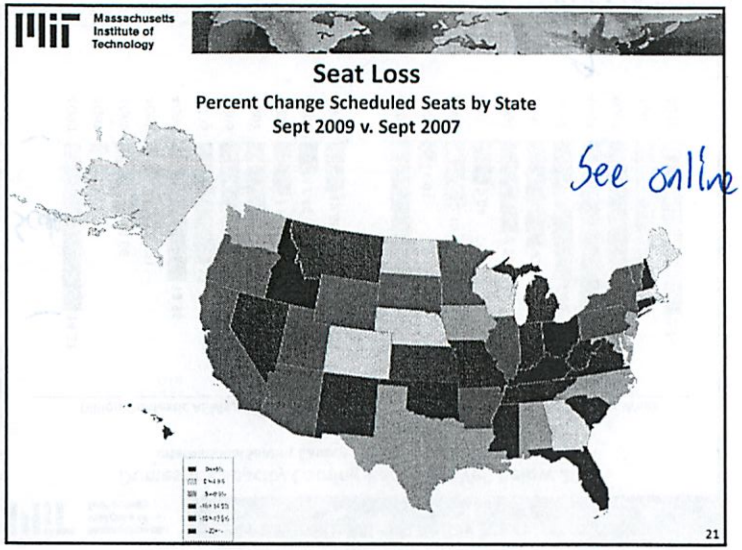
## Domestic Departures Down Sharply From 2000

* Scheduled U.S.- and non-U.S.-airline flights departing U.S. airports for non-U.S. destinations
Source: Innovata (via APG) published schedules as of Oct. 1, 2010

20



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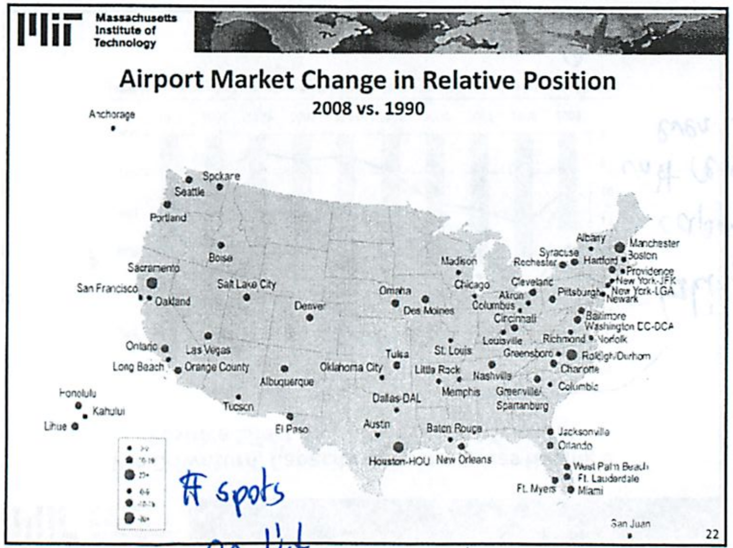
## Seat Loss

Percent Change Scheduled Seats by State
Sept 2009 v. Sept 2007

21

See online Color Slides



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## Airport Market Change in Relative Position

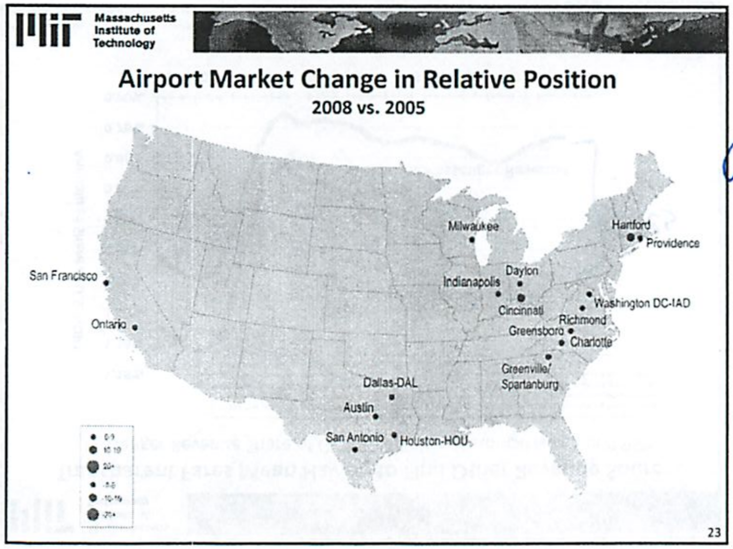
2008 vs. 1990

22

\# spots on list of airport "size"

red −
blue +

big blue dots = Southwest cities



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## Airport Market Change in Relative Position

2008 vs. 2005

23

Very little change

change already taken place

can't add markets

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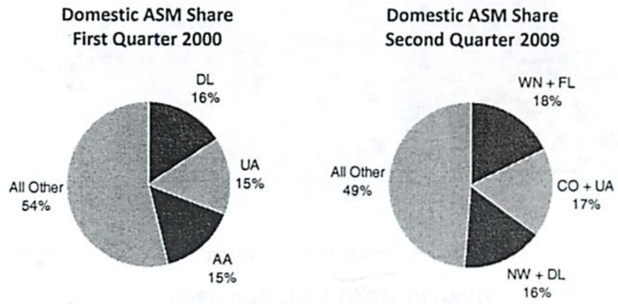
## Domestic Market Concentration Virtually Unchanged

Southwest Has Overtaken United *and* American in Domestic Capacity



Notes: Mainline only. Excludes Regional Operations.

domestic pie still looks approx the same

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## The LCCs

- Arguably the greatest catalyst to change for the legacy carriers
- **Network carrier revenue is fully - or close to – exposed to pricing threats from the LCCs.**
  - The network carriers have become much, much better competitors
  - Structural cost disadvantage STILL
  - A 10 point market share loss by the network carriers in a market with $25B less in revenue should have been a lesson, but…..
- **Head to head competition with the LCCs is evident across each network carrier's domestic route portfolios**
  - Delta and Northwest have the most exposure
- **Domestic market share gains in the next phase will largely occur as a result of Network Legacy Carrier attrition**

oil 2nd

Atlanta

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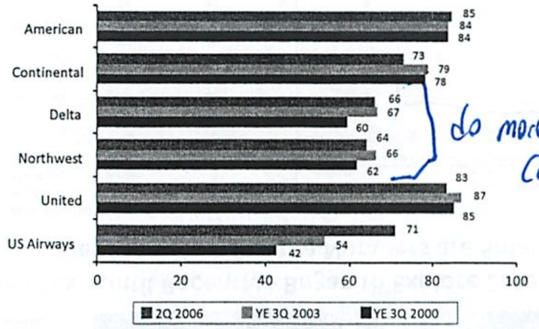
## Other than Delta and Northwest, the LCC's Have Little to Attack Within the Network Carrier Domestic Portfolio

**Percent of Revenue Exposed to Direct LCC Competition**



do more small communities

top bar

middle bar

not much more to compete w/

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## Picking Markets Is a Tough Decision Today

hardest thing for an airline

- **Growth – organic growth is vital to every sector**
  - Network carriers today cannot seem to remove domestic capacity fast enough
  - Markets just too small for the LCCs that are operating larger narrowbody aircraft
  - For the regional carriers, growth has slowed. We are creating legacy, regional carriers – high relative seniority as labor costs are the differentiating factor when competing for business
- **As the LCCs increasingly compete with one another, revenue generation degrades**
  - No secret why growth, planned or actual, has slowed
  - No secret why even the LCCs are looking for new revenue sources
  - High fuel prices disproportionately impact this sector
- **The network carriers have positioned themselves to at least maintain a defensive posture when it comes to domestic markets**

wanting organic growth

avg down labor cost

## The LCCs - Until Recently - Began to Explore Entering Smaller Markets – But the Numbers are Small

LCC Markets Entered

| | Total City Pairs | Large Hub Airports to/from | | | Medium Hub Airports to/from | | Small Hub Airports to/from |
|---|---|---|---|---|---|---|---|
| | | Large Hub | Medium Hub | Small Hub | Medium Hub | Small Hub | Small Hub |
| 1994 | 3 | 3 | -- | -- | -- | -- | -- |
| 1995 | 54 | 8 | 30 | 3 | 12 | 1 | -- |
| 1996 | 44 | 12 | 23 | 4 | 4 | 1 | -- |
| 1997 | 56 | 15 | 26 | 9 | 1 | 4 | 1 |
| 1998 | 51 | 19 | 20 | 9 | 1 | 2 | -- |
| 1999 | 57 | 20 | 26 | 5 | 6 | -- | -- |
| 2000 | 55 | 20 | 31 | 4 | -- | -- | -- |
| 2001 | 53 | 24 | 21 | 6 | 2 | -- | -- |
| 2002 | 24 | 10 | 10 | 4 | -- | -- | -- |
| 2003 | 20 | 9 | 7 | 3 | 1 | -- | -- |
| 2004 | 53 | 20 | 17 | 14 | 2 | -- | -- |
| 2005 | 68 | 24 | 29 | 9 | 3 | 3 | -- |
| Total | 538 | 184 | 240 | 70 | 32 | 11 | 1 |
| % of Total | | 34.2% | 44.6% | 13.0% | 5.9% | 2.0% | 0.2% |
| Cumulative % of Total | | | 78.8% | 91.8% | 97.8% | 99.8% | 100% |

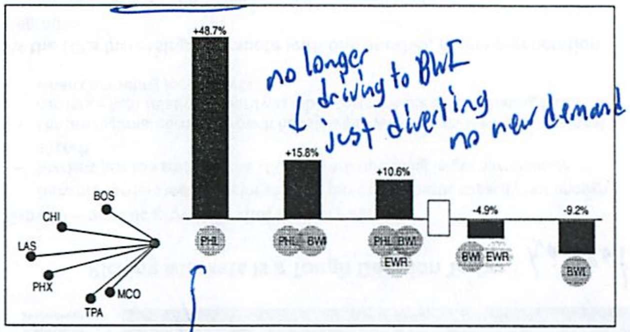
Southwest stimulating traffic

starting to See activity

>1,000,000 | >100,000 enplanments
>500,000

## Market Stimulation Just Ain't What It Used to Be

10 Years Ago Market Stimulation Was Real, Today It Is a Different Story



no longer
↓ driving to BWI
just diverting
no new demand

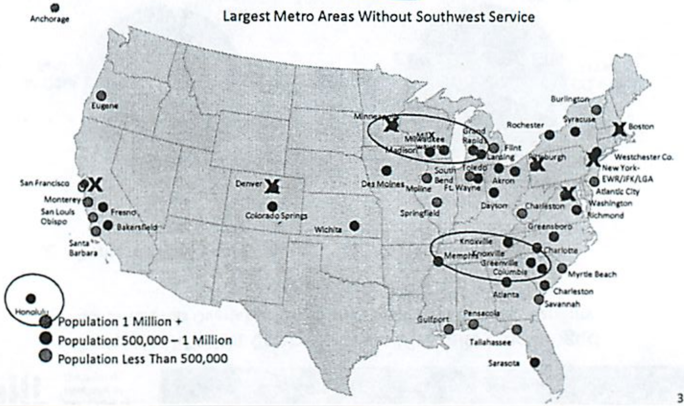
when first went into PHL
stimulated traffic

all result
of entering PHL

Saturated
taking away
traffic from
other airports
-catchment
area

## Southwest's Recent Growth Has Only Been Into the Largest Markets

Largest Metro Areas Without Southwest Service



X = entered recently

○ where will you go?

## Domestic Fare Profile

All Domestic Markets

SOUTHWEST

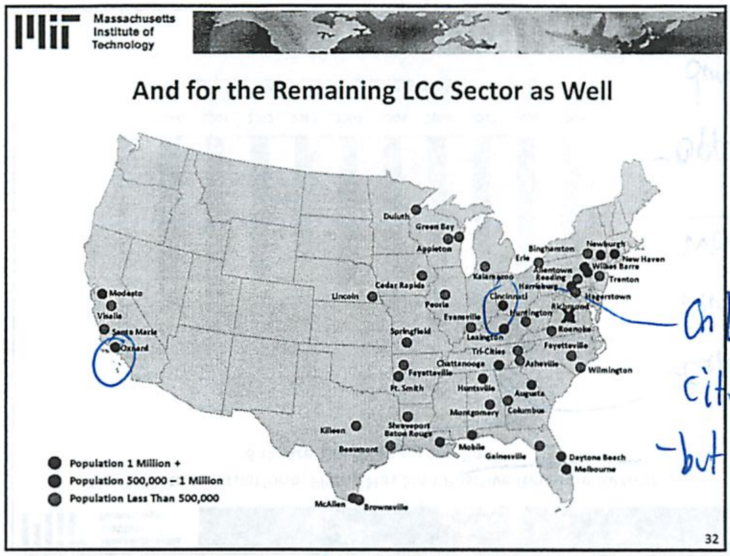
| Year | Southwest Pax Share | Network Carrier Share | Other LCC Share | Other Carrier Share | Southwest Revenue Share | Southwest Average Fare | OA Fare | Southwest Fare Premium | Average Passenger Trip Length | Coupons | Total Market Revenue ($Mils) | Total Market Pax (Mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 38.8% | 44.1% | 7.0% | 5.4% | 25.0% | $71.18 | $135.80 | (47.6%) | 525 | 1.13 | $ 3,329 | 30.1 |
| 1996 | 34.8% | 47.7% | 6.9% | 5.0% | 22.6% | $72.64 | $132.98 | (45.4%) | 560 | 1.13 | $ 4,128 | 36.9 |
| 1997 | 31.9% | 51.1% | 7.1% | 4.1% | 20.0% | $80.64 | $151.11 | (46.6%) | 568 | 1.12 | $ 5,259 | 40.9 |
| 1998 | 32.6% | 51.4% | 6.7% | 4.5% | 21.3% | $86.75 | $154.91 | (44.0%) | 616 | 1.15 | $ 5,767 | 43.5 |
| 1999 | 31.6% | 52.8% | 7.0% | 4.4% | 21.3% | $91.60 | $156.38 | (41.4%) | 623 | 1.15 | $ 6,431 | 47.3 |
| 2000 | 33.2% | 52.3% | 7.0% | 4.0% | 22.1% | $97.61 | $171.24 | (43.0%) | 652 | 1.15 | $ 7,373 | 50.2 |
| 2001 | 34.7% | 49.6% | 7.9% | 4.3% | 25.2% | $92.36 | $145.91 | (36.7%) | 688 | 1.16 | $ 6,030 | 47.4 |
| 2002 | 35.6% | 47.7% | 9.2% | 4.8% | 26.4% | $94.93 | $146.80 | (35.3%) | 717 | 1.16 | $ 5,921 | 46.1 |
| 2003 | 37.9% | 44.9% | 9.9% | 5.1% | 27.5% | $98.33 | $158.49 | (38.0%) | 729 | 1.15 | $ 6,172 | 45.5 |
| 2004 | 35.1% | 47.6% | 11.0% | 4.4% | 26.9% | $101.27 | $149.11 | (32.1%) | 763 | 1.16 | $ 6,868 | 51.9 |
| 2005 | 30.2% | 49.9% | 13.7% | 4.0% | 22.1% | $107.26 | $163.68 | (34.5%) | 788 | 1.16 | $ 10,214 | 69.6 |
| 2006 | 30.9% | 49.6% | 12.9% | 4.5% | 23.1% | $120.52 | $179.57 | (32.9%) | 818 | 1.16 | $ 11,465 | 71.1 |

Source: US DOT DB1B via BTS for the third quarters of each year.

needs to find new markets

very diff revenue picture

Costs must stay low



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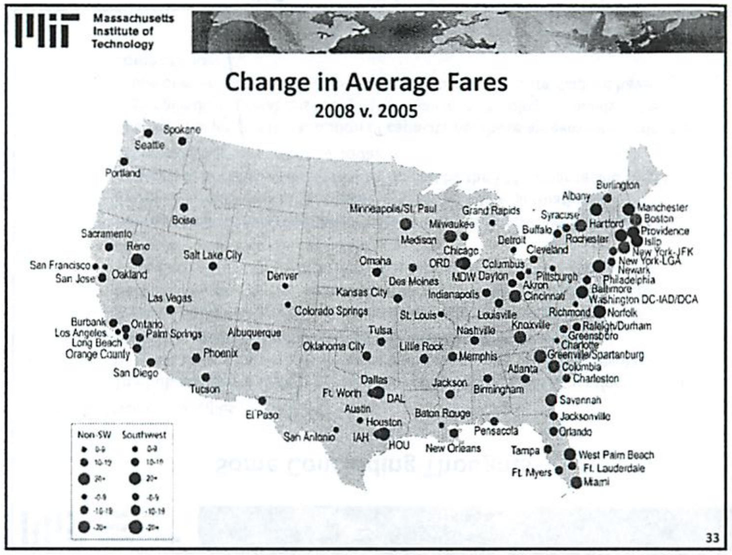
## And for the Remaining LCC Sector as Well

Only real City to enter -but drivable

drivable to big hub



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## Change in Average Fares

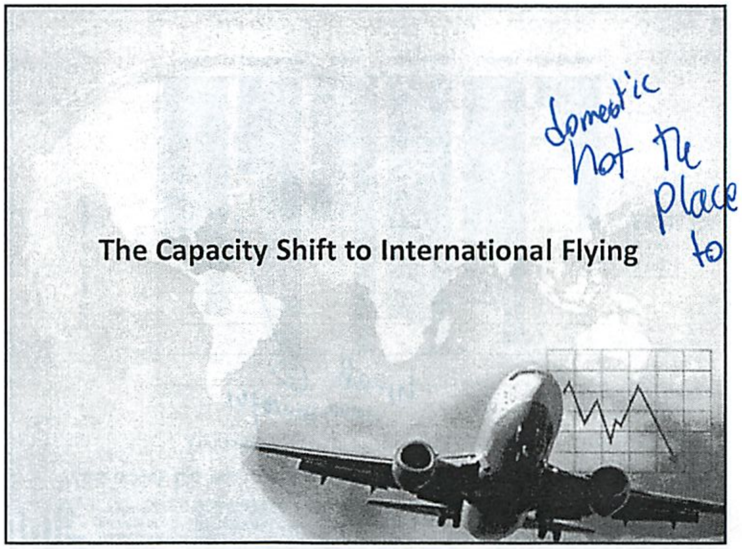
2008 v. 2005

Sathwest not only low fare player

-SW raised their fares as well

fares went up in every SW market on this map

08 vs 05



## The Capacity Shift to International Flying

domestic not the place to be

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## International Growth

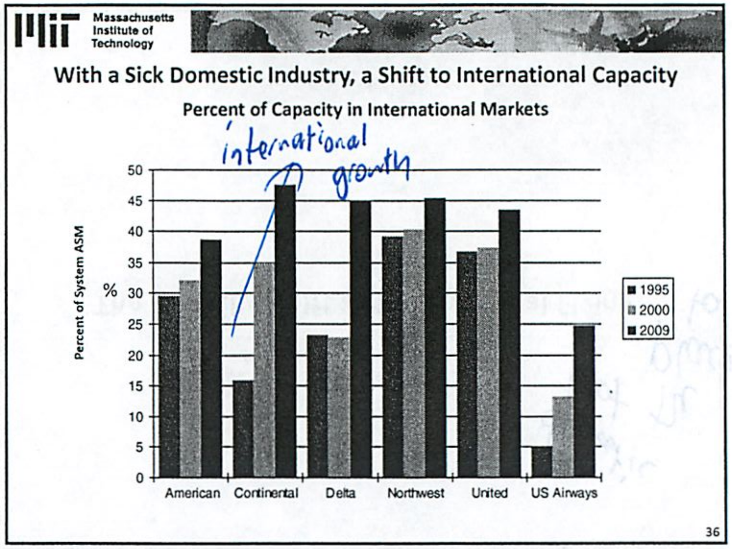
- **Transatlantic growth successful in conjunction with alliance partners**
  - An important question: at what point will US carrier growth move from inter-alliance competition to intra-alliance competition?
  - Transpacific growth becomes dependant on economies like China and India becoming consuming economies
  - Caribbean/Mexico/Deep South America flying showing the greatest increase
    - Deceiving as most of growth with narrowbody aircraft
    - 50% of Latin demand centered on Brazil and Mexico
    - Becoming an extension of the US domestic market?
- **Yield trends positive but as you learned, added capacity has its negative consequences**
  - Are we beginning to see product competition?
  - The growth in international operations has been an important contributor to improved US network carrier performance

Lan Tan

Middle East expanding rapidly

outsource domestic to regional players

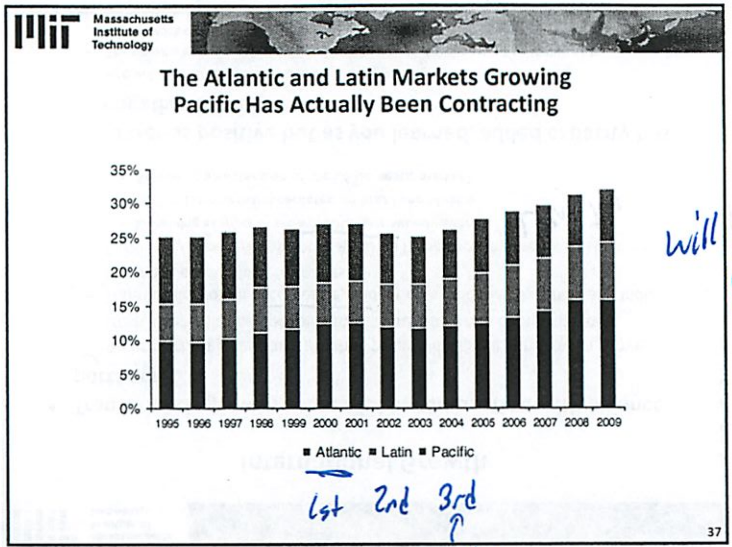
alliances if gets too big you start to ~~damage~~ compete inside alliance



## With a Sick Domestic Industry, a Shift to International Capacity

Percent of Capacity in International Markets

international growth

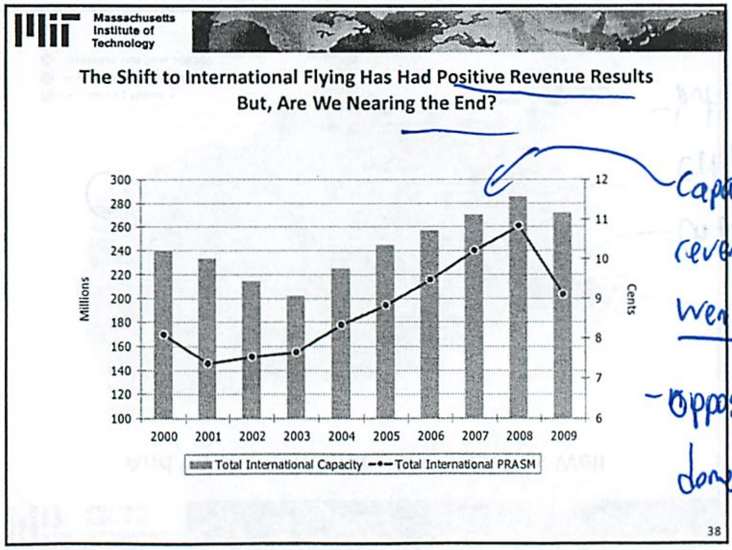


## The Atlantic and Latin Markets Growing Pacific Has Actually Been Contracting

1st 2nd 3rd

not done much

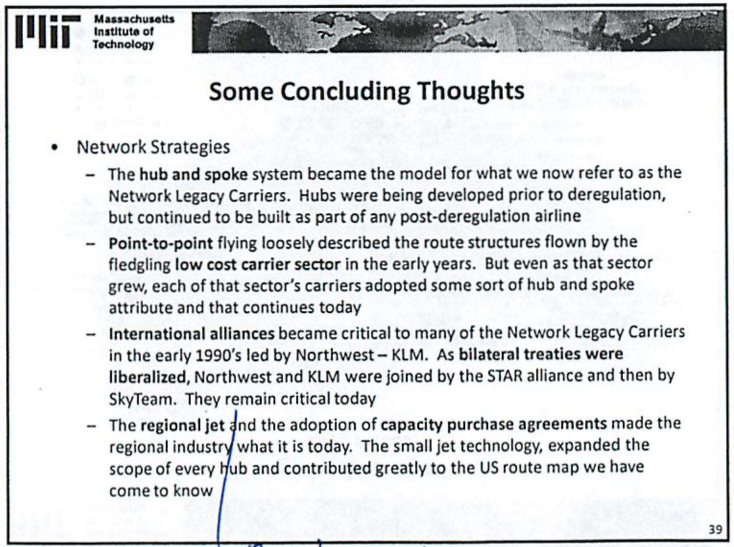
will look different in 2012



## The Shift to International Flying Has Had Positive Revenue Results But, Are We Nearing the End?

Capacity + revenue/seat went up

- opposet of domestic

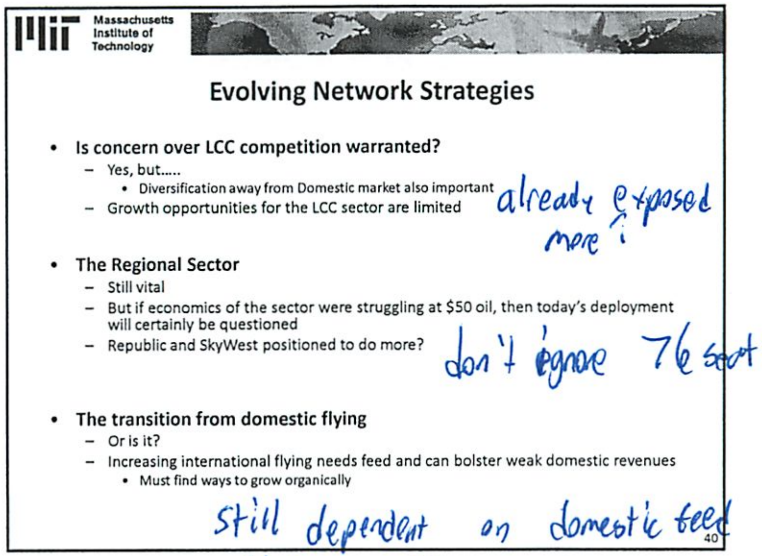


## Some Concluding Thoughts

- Network Strategies
  - The **hub and spoke** system became the model for what we now refer to as the Network Legacy Carriers. Hubs were being developed prior to deregulation, but continued to be built as part of any post-deregulation airline
  - **Point-to-point** flying loosely described the route structures flown by the fledgling **low cost carrier sector** in the early years. But even as that sector grew, each of that sector's carriers adopted some sort of hub and spoke attribute and that continues today
  - **International alliances** became critical to many of the Network Legacy Carriers in the early 1990's led by Northwest – KLM. As **bilateral treaties were liberalized,** Northwest and KLM were joined by the STAR alliance and then by SkyTeam. They remain critical today
  - The **regional jet** and the adoption of **capacity purchase agreements** made the regional industry what it is today. The small jet technology, expanded the scope of every hub and contributed greatly to the US route map we have come to know

very important

participate w/o $200 million/planes



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## Evolving Network Strategies

- Is concern over LCC competition warranted?
  - Yes, but.....
    - Diversification away from Domestic market also important
  - Growth opportunities for the LCC sector are limited
- The Regional Sector
  - Still vital
  - But if economics of the sector were struggling at $50 oil, then today's deployment will certainly be questioned
  - Republic and SkyWest positioned to do more?
- The transition from domestic flying
  - Or is it?
  - Increasing international flying needs feed and can bolster weak domestic revenues
    - Must find ways to grow organically

40

already exposed more?

) how much more can they do

don't ignore 76 seat planes

will see more consolidation

still dependent on domestic feed

-higher quality revenue

Industry struggling to grow organically

What do we call an LCC

Vigilance on cost control

-Stringent

-out source?

capital hill pays attention as well

# Fleet

10/19

Can be a lot more focused

Their sample ~~was not very much~~

did not compare w/ other airlines

Spend more time writing than making graphs

increase in mainline aircraft

large ↑ in seat capacity

and stage lenght

-contracting

-more than rest of industry?

Europe serice from PHL

↳ Terminal A West

9 regional partners

↑ productivity w/ air born hrs

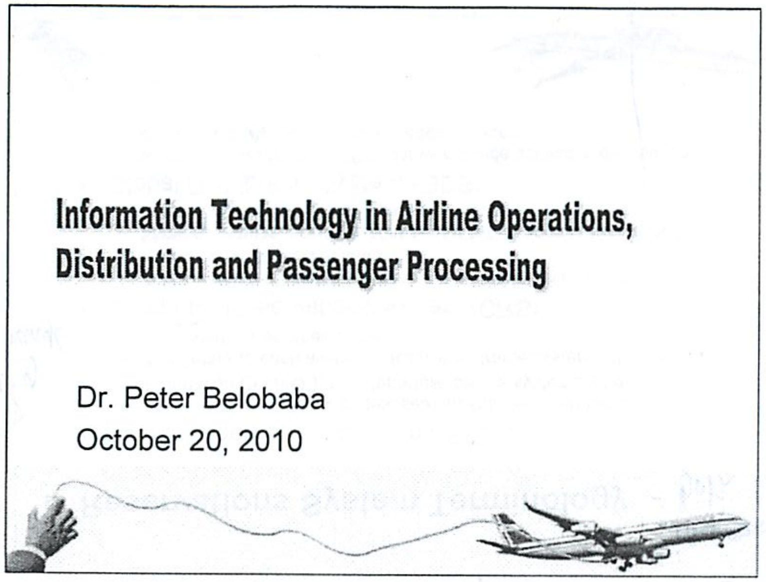
?, airborn vs block hrs?

but still departures per day ↓

✱ just data from 2000!

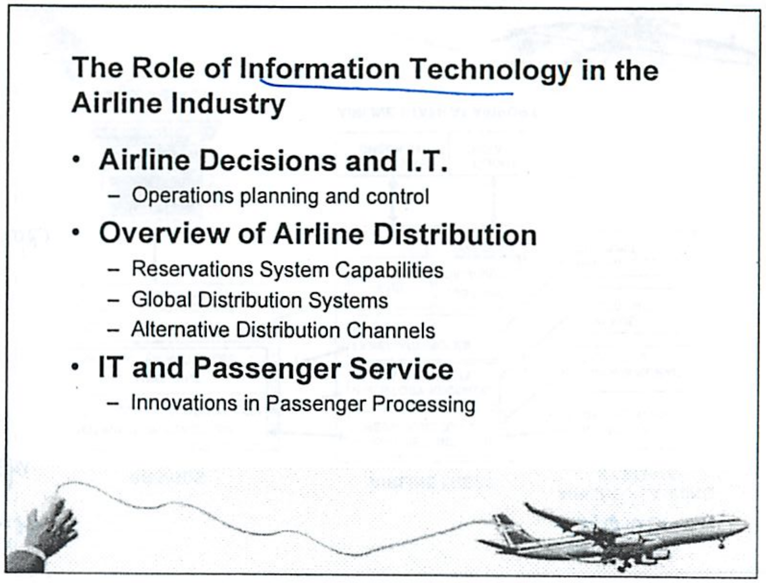
Get Transport Related expenses

fuel!



# Information Technology in Airline Operations, Distribution and Passenger Processing

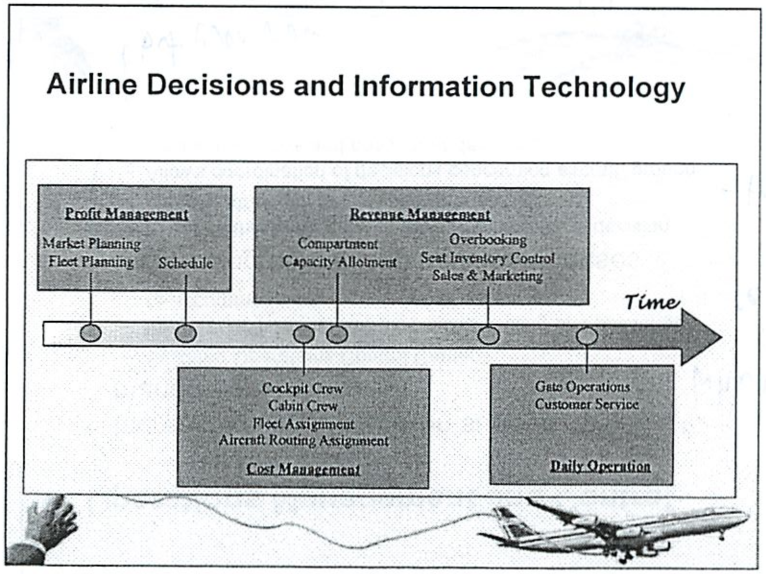
Dr. Peter Belobaba
October 20, 2010



## The Role of Information Technology in the Airline Industry

- Airline Decisions and I.T.
  - Operations planning and control
- Overview of Airline Distribution
  - Reservations System Capabilities
  - Global Distribution Systems
  - Alternative Distribution Channels
- IT and Passenger Service
  - Innovations in Passenger Processing

Chap 15



## Airline Decisions and Information Technology

**Profit Management**
Market Planning
Fleet Planning
Schedule

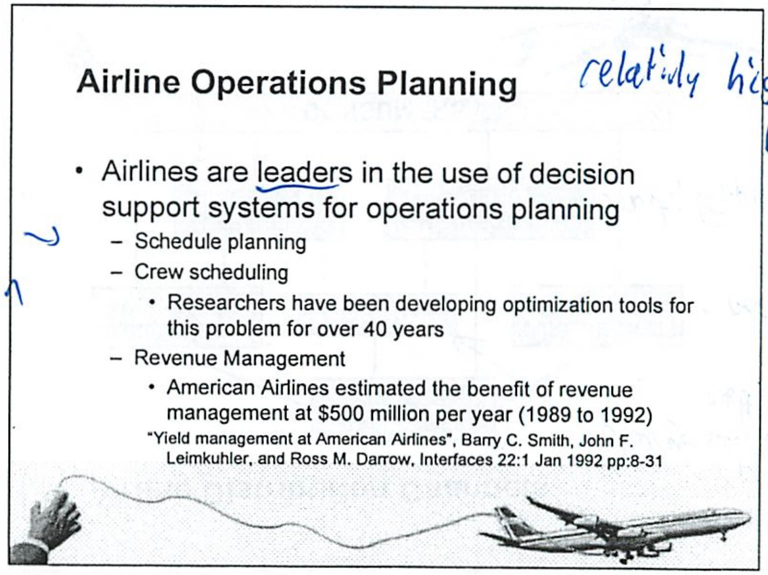
**Revenue Management**
Compartment
Capacity Allotment
Overbooking
Seat Inventory Control
Sales & Marketing

Time

Cockpit Crew
Cabin Crew
Fleet Assignment
Aircraft Routing Assignment
**Cost Management**

Gate Operations
Customer Service
**Daily Operation**

lots of attention ~



## Airline Operations Planning

relatively high tech biz

- Airlines are leaders in the use of decision support systems for operations planning
  - Schedule planning
  - Crew scheduling
    - Researchers have been developing optimization tools for this problem for over 40 years
  - Revenue Management
    - American Airlines estimated the benefit of revenue management at $500 million per year (1989 to 1992)

"Yield management at American Airlines", Barry C. Smith, John F. Leimkuhler, and Ross M. Darrow, Interfaces 22:1 Jan 1992 pp:8-31

"leaders in IT systems"

10/20

## Operations Management and Control

- Increasing use of decision support systems to manage operations
  - Systems Operations Control Center
  - Irregular operations, aircraft/crew re-routing and passenger re-accommodation
- Developing centralized data warehouses
  - Provides the same data, at the same time, to all decision makers, strategic, tactical and operational
  - Allows coordination of decisions concerning aircraft, ground resources, crews and passenger decisions

which flights to cancle? reroute pax and crew

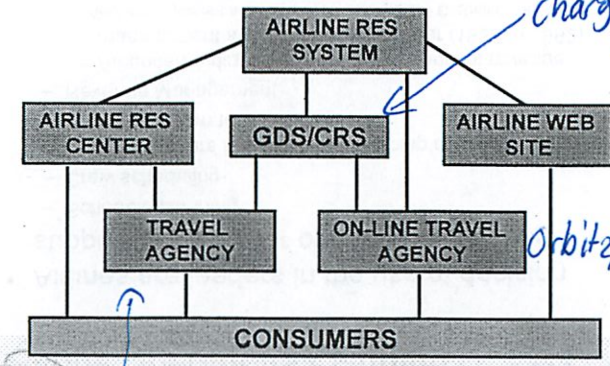
- tech has not been used

a lot are not doing this
-only top ones

but even now they are doing this

most airlines still operate in silos (like DB)
- inconsistant decisions
- both have diff data

## Airline Distribution Channels



charge airlines $2-3
- half of worldwide revene
- need to do to build biz
- moving ahead into search

Orbitz, Expedia

before 1994 ~10% comission + bribes

## Reservations System Terminology

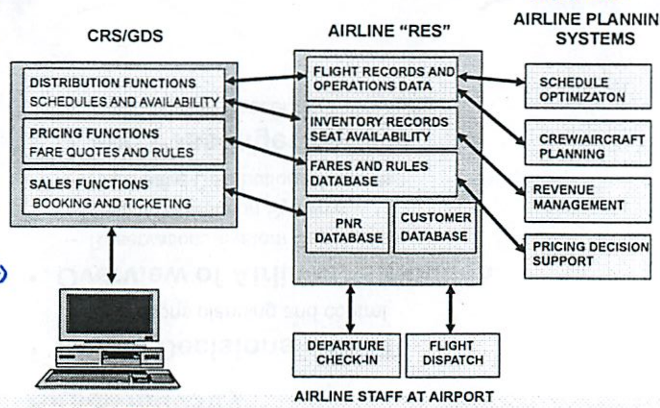
- Airline Reservations System ("RES")
  - Contains all schedules, prices, seat inventories, operational information ("FLIFO"), and departure control systems (check-in)
  - Proprietary to each airline; typically mainframe system either owned or "hosted" by another airline
- Computer Reservations System (CRS)
  - Public version of (certain) airline res. systems, developed for travel agencies to use for distribution
  - Show schedules, prices, availability for "all" airlines in "unbiased" manner (e.g., Sabre, Worldspan, Apollo)
- Global Distribution System (GDS)
  - Alliance of two or more CRSs for world-wide access to distribution of channels (Apollo/Galileo, Amadeus, Sabre)

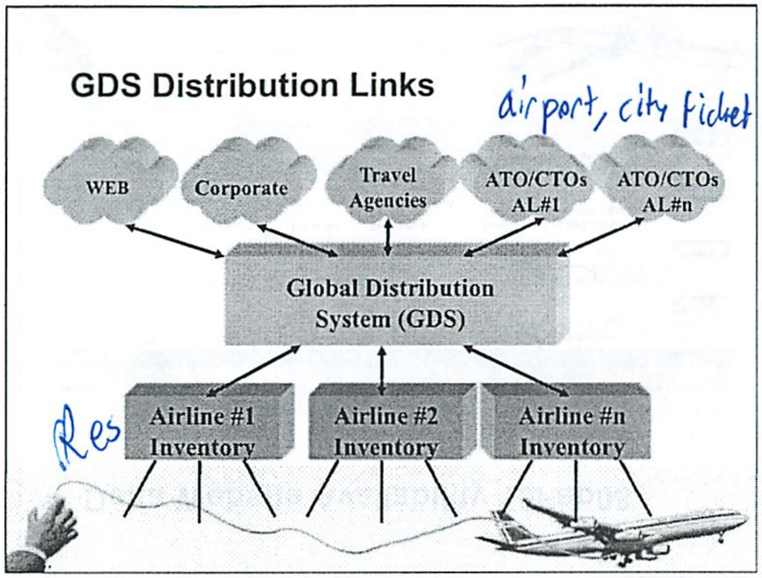
old programing lang really hard to change

1st class was full - but w/ free upgrades

schedules made to show flights higher in res system

Inside

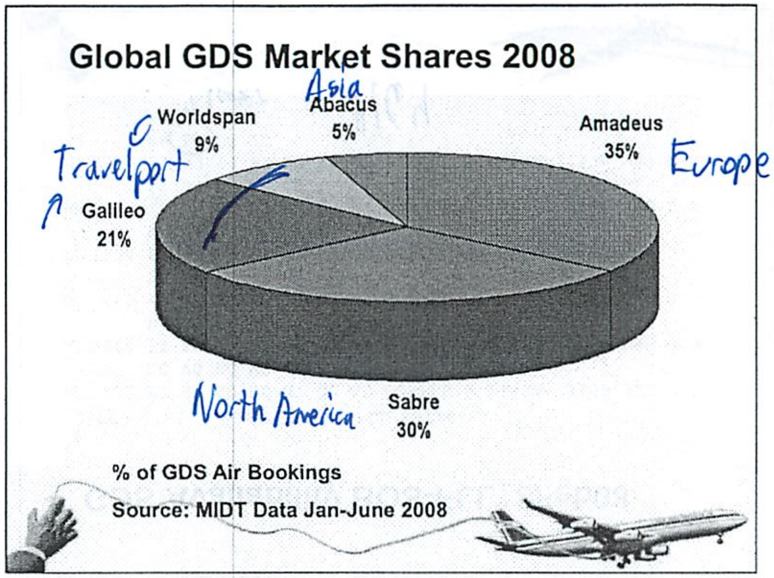




## GDS Distribution Links

airport, city ticket office

Res



## Global GDS Market Shares 2008

% of GDS Air Bookings

Source: MIDT Data Jan-June 2008

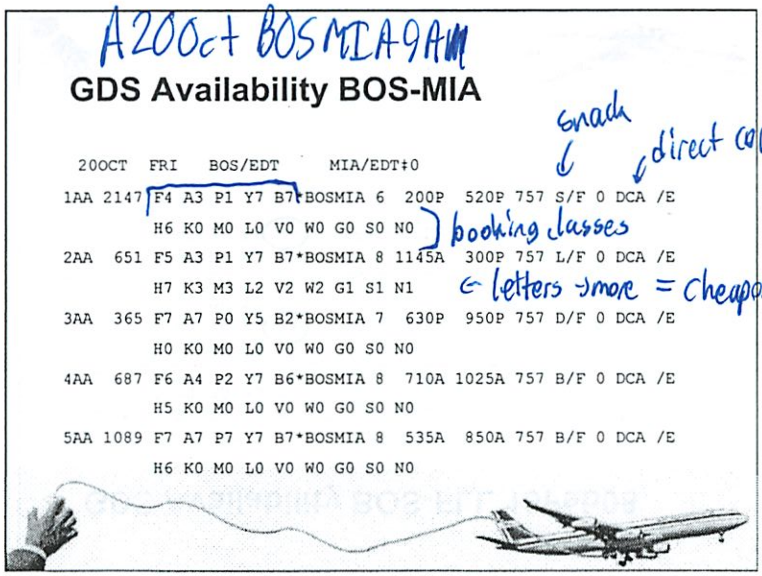
Asia

Europe

Travelport

North America

Old Res systems can't really handle load



A20Oct BOSMIA9AM

## GDS Availability BOS-MIA

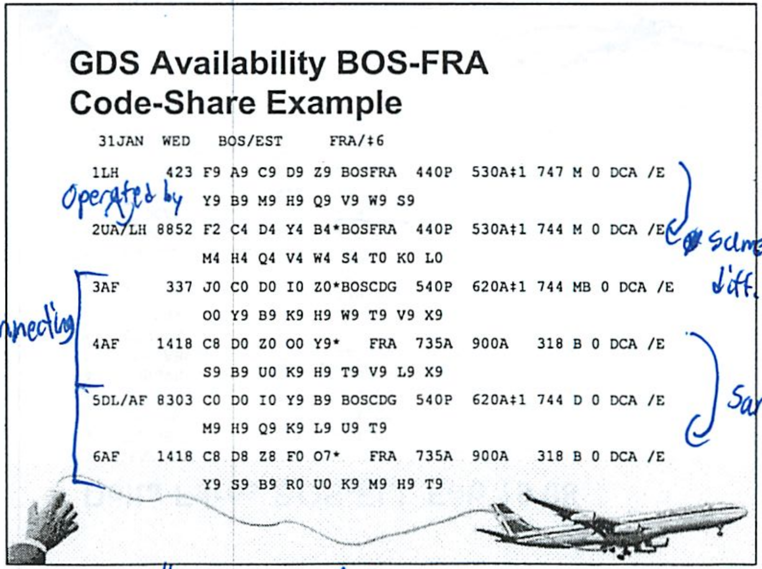
```
 20OCT  FRI   BOS/EDT       MIA/EDT‡0
1AA 2147 F4 A3 P1 Y7 B7*BOSMIA 6  200P  520P 757 S/F 0 DCA /E
         H6 K0 M0 L0 V0 W0 G0 S0 N0
2AA  651 F5 A3 P1 Y7 B7*BOSMIA 8 1145A  300P 757 L/F 0 DCA /E
         H7 K3 M3 L2 V2 W2 G1 S1 N1
3AA  365 F7 A7 P0 Y5 B2*BOSMIA 7  630P  950P 757 D/F 0 DCA /E
         H0 K0 M0 L0 V0 W0 G0 S0 N0
4AA  687 F6 A4 P2 Y7 B6*BOSMIA 8  710A 1025A 757 B/F 0 DCA /E
         H5 K0 M0 L0 V0 W0 G0 S0 N0
5AA 1089 F7 A7 P7 Y7 B7*BOSMIA 8  535A  850A 757 B/F 0 DCA /E
         H6 K0 M0 L0 V0 W0 G0 S0 N0
```

snack

direct correct access

booking classes

← letters → more = cheaper fares



## GDS Availability BOS-FRA Code-Share Example

```
 31JAN  WED   BOS/EST      FRA/‡6
1LH      423 F9 A9 C9 D9 Z9 BOSFRA  440P  530A‡1 747 M 0 DCA /E
             Y9 B9 M9 H9 Q9 V9 W9 S9
2UA/LH 8852 F2 C4 D4 Y4 B4*BOSFRA  440P  530A‡1 744 M 0 DCA /E
             M4 H4 Q4 V4 W4 S4 T0 K0 L0
3AF      337 J0 C0 D0 I0 Z0*BOSCDG  540P  620A‡1 744 MB 0 DCA /E
             O0 Y9 B9 K9 H9 W9 T9 V9 X9
4AF     1418 C8 D0 Z0 O0 Y9*    FRA  735A  900A   318 B 0 DCA /E
             S9 B9 U0 K9 H9 T9 V9 L9 X9
5DL/AF 8303 C0 D0 I0 Y9 B9 BOSCDG  540P  620A‡1 744 D 0 DCA /E
             M9 H9 Q9 K9 L9 U9 T9
6AF     1418 C8 D8 Z8 F0 O7*    FRA  735A  900A   318 B 0 DCA /E
             Y9 S9 B9 R0 U0 K9 M9 H9 T9
```

Operated by

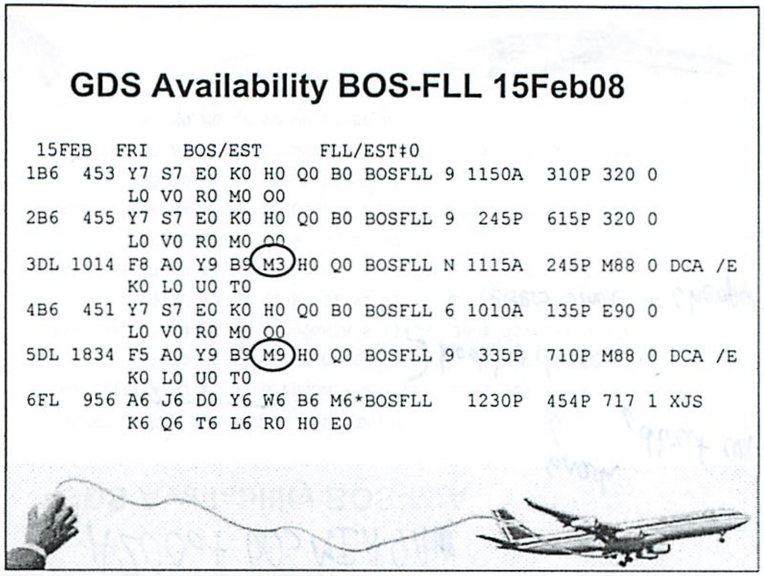
same flight diff. flight codes + prices

connecting

Same Flight

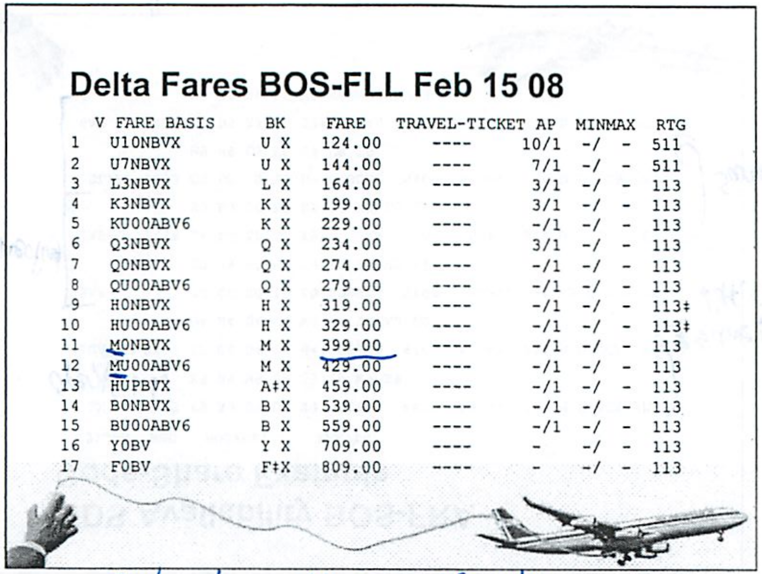
all non stop 1st

can get better share on code share



## GDS Availability BOS-FLL 15Feb08

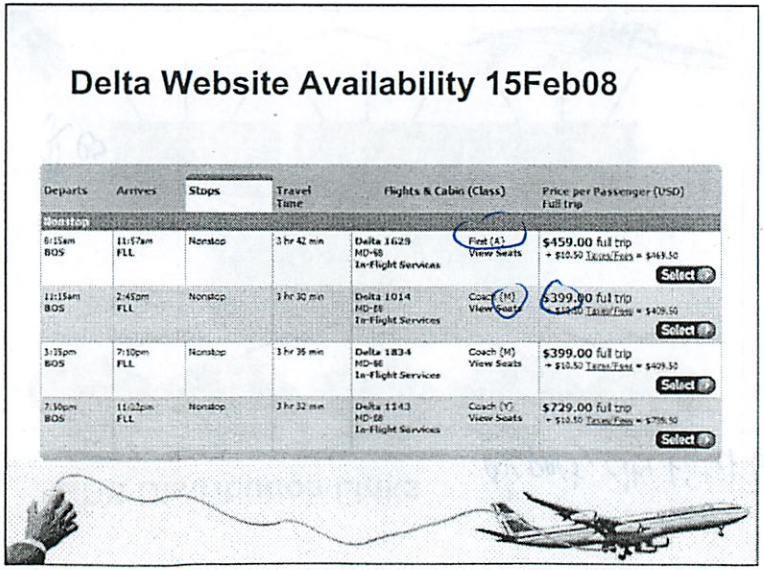
```
 15FEB  FRI     BOS/EST       FLL/EST‡0
1B6   453 Y7  S7  E0  K0  H0  Q0  B0  BOSFLL 9 1150A   310P 320 0
          L0  V0  R0  M0  O0
2B6   455 Y7  S7  E0  K0  H0  Q0  B0  BOSFLL 9  245P   615P 320 0
          L0  V0  R0  M0  O0
3DL 1014  F8  A0  Y9  B9  M3  H0  Q0  BOSFLL N 1115A   245P M88 0 DCA /E
          K0  L0  U0  T0
4B6   451 Y7  S7  E0  K0  H0  Q0  B0  BOSFLL 6 1010A   135P E90 0
          L0  V0  R0  M0  O0
5DL 1834  F5  A0  Y9  B9  M9  H0  Q0  BOSFLL 9  335P   710P M88 0 DCA /E
          K0  L0  U0  T0
6FL   956 A6  J6  D0  Y6  W6  B6  M6*BOSFLL    1230P   454P 717 1 XJS
          K6  Q6  T6  L6  R0  H0  E0
```



## Delta Fares BOS-FLL Feb 15 08

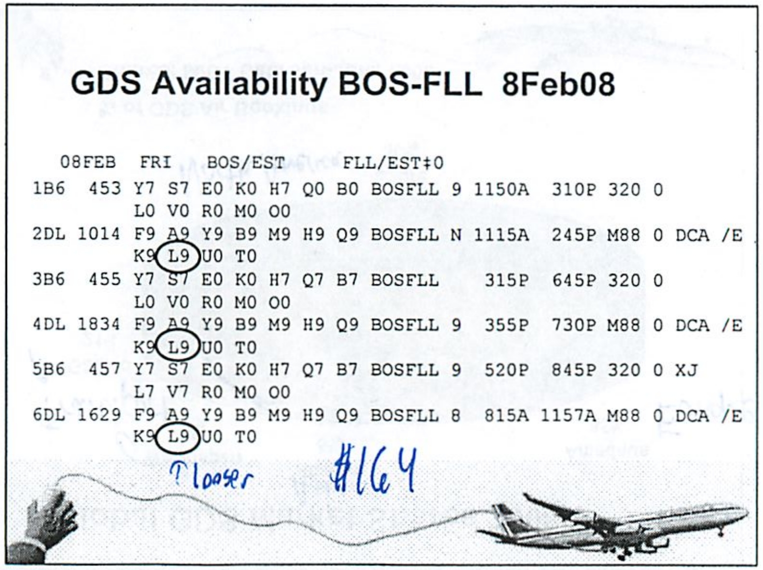
```
  V FARE BASIS        BK    FARE    TRAVEL-TICKET AP  MINMAX   RTG
 1    U10NBVX         U X   124.00      ----     10/1  -/   -  511
 2    U7NBVX          U X   144.00      ----      7/1  -/   -  511
 3    L3NBVX          L X   164.00      ----      3/1  -/   -  113
 4    K3NBVX          K X   199.00      ----      3/1  -/   -  113
 5    KU00ABV6        K X   229.00      ----     -/1   -/   -  113
 6    Q3NBVX          Q X   234.00      ----      3/1  -/   -  113
 7    Q0NBVX          Q X   274.00      ----     -/1   -/   -  113
 8    QU00ABV6        Q X   279.00      ----     -/1   -/   -  113
 9    H0NBVX          H X   319.00      ----     -/1   -/   -  113‡
10    HU00ABV6        H X   329.00      ----     -/1   -/   -  113‡
11    M0NBVX          M X   399.00      ----     -/1   -/   -  113
12    MU00ABV6        M X   429.00      ----     -/1   -/   -  113
13    HUPBVX          A‡X   459.00      ----     -/1   -/   -  113
14    B0NBVX          B X   539.00      ----     -/1   -/   -  113
15    BU00ABV6        B X   559.00      ----     -/1   -/   -  113
16    Y0BV            Y X   709.00      ----      -    -/   -  113
17    F0BV            F‡X   809.00      ----      -    -/   -  113
```

each has 4 pgs of rules



## Delta Website Availability 15Feb08

| Departs | Arrives | Stops | Travel Time | Flights & Cabin (Class) | | Price per Passenger (USD) Full trip |
|---|---|---|---|---|---|---|
| Nonstop | | | | | | |
| 8:15am<br>BOS | 11:57am<br>FLL | Nonstop | 3 hr 42 min | Delta 1629<br>MD-88<br>In-Flight Services | First (A)<br>View Seats | $459.00 full trip<br>+ $10.50 Taxes/Fees = $469.50<br>Select |
| 11:15am<br>BOS | 2:45pm<br>FLL | Nonstop | 3 hr 30 min | Delta 1014<br>MD-88<br>In-Flight Services | Coach (M)<br>View Seats | $399.00 full trip<br>+ $10.50 Taxes/Fees = $409.50<br>Select |
| 3:35pm<br>BOS | 7:10pm<br>FLL | Nonstop | 3 hr 35 min | Delta 1834<br>MD-88<br>In-Flight Services | Coach (M)<br>View Seats | $399.00 full trip<br>+ $10.50 Taxes/Fees = $409.50<br>Select |
| 7:30pm<br>BOS | 11:02pm<br>FLL | Nonstop | 3 hr 32 min | Delta 1143<br>MD-88<br>In-Flight Services | Coach (Y)<br>View Seats | $729.00 full trip<br>+ $10.50 Taxes/Fees = $739.50<br>Select |



## GDS Availability BOS-FLL 8Feb08

```
 08FEB  FRI    BOS/EST       FLL/EST‡0
1B6   453 Y7  S7  E0  K0  H7  Q0  B0  BOSFLL 9 1150A   310P 320 0
          L0  V0  R0  M0  O0
2DL 1014  F9  A9  Y9  B9  M9  H9  Q9  BOSFLL N 1115A   245P M88 0 DCA /E
          K9  L9  U0  T0
3B6   455 Y7  S7  E0  K0  H7  Q7  B7  BOSFLL    315P   645P 320 0
          L0  V0  R0  M0  O0
4DL 1834  F9  A9  Y9  B9  M9  H9  Q9  BOSFLL 9  355P   730P M88 0 DCA /E
          K9  L9  U0  T0
5B6   457 Y7  S7  E0  K0  H7  Q7  B7  BOSFLL 9  520P   845P 320 0 XJ
          L7  V7  R0  M0  O0
6DL 1629  F9  A9  Y9  B9  M9  H9  Q9  BOSFLL 8  815A 1157A M88 0 DCA /E
          K9  L9  U0  T0
```

↑ looser #164

## Delta Website Availability 8Feb08

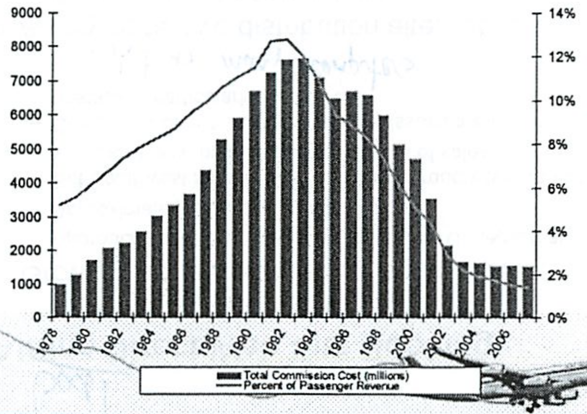
| Departs | Arrives | Stops | Travel Time | Flights & Cabin (Class) | | Price per Passenger (USD) Full trip |
|---|---|---|---|---|---|---|
| Nonstop | | | | | | |
| 8:15am<br>BOS | 11:57am<br>FLL | Nonstop | 3 hr 42 min | Delta 1629<br>MD-88<br>In-Flight Services | Coach (L)<br>View Seats | $164.00 full trip<br>+ $10.50 Taxes/Fees = $174.50<br>Select |
| 11:15am<br>BOS | 2:45pm<br>FLL | Nonstop | 3 hr 30 min | Delta 1014<br>MD-88<br>In-Flight Services | Coach (L)<br>View Seats | $164.00 full trip<br>+ $10.50 Taxes/Fees = $174.50<br>Select |
| 3:55pm<br>BOS | 7:30pm<br>FLL | Nonstop | 3 hr 35 min | Delta 1834<br>MD-88<br>In-Flight Services | Coach (L)<br>View Seats | $164.00 full trip<br>+ $10.50 Taxes/Fees = $174.50<br>Select |
| 7:50pm<br>BOS | 11:22pm<br>FLL | Nonstop | 3 hr 32 min | Delta 1143<br>MD-88<br>In-Flight Services | Coach (U)<br>View Seats | LOWEST<br>$124.00 full trip<br>+ $10.50 Taxes/Fees = $134.50<br>Select |

## Airline Distribution Costs

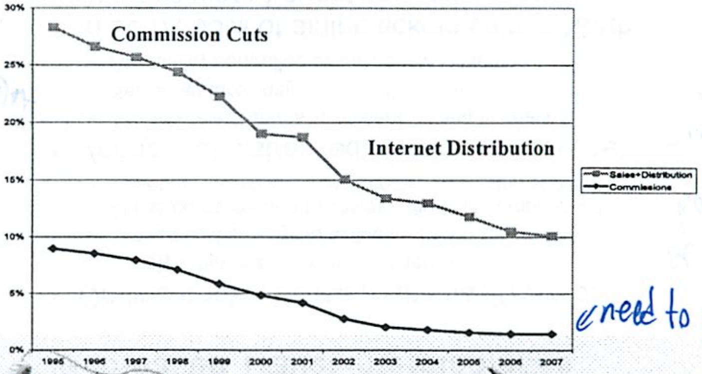
- Historically, airline sales and distribution costs approached 20% of total expenses
  - Travel agency commission caps first introduced in 1994
  - Subsequent reductions in commission rates have led to substantial cost savings
  - Most domestic travel agency commissions have now been eliminated
- $5 billion reduction in annual commission costs for US major airlines 1994-2004
  - % of revenue spent on commissions was cut from 13% in 1994 to less than 2% after 2004

but not really $5 billion in revenue

## US Airline Commission Costs



## Sales and Distribution Costs (% of Passenger Revenue)



← need to play the game in Japan even as US airline

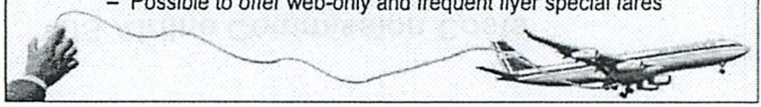
Goal

## Airline Direct Web Site Booking

- Growing penetration for consumer sales:
  - Approaching 40% of total sales for largest US legacy airlines
  - Approximately 25% world wide
  - But Southwest sells 75% of its tickets through its own web site, JetBlue website accounts for 80% of sales
  - Complexity of use and trust/security issues are major obstacles, particularly outside US

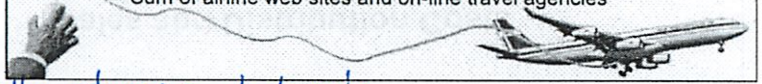
Not as many computers

- A very attractive distribution alternative:
  - Airline control of own fares and seat availability
  - Possible to offer web-only and frequent flyer special fares



## Web-based Travel Intermediaries

- On-line booking sites (Expedia, Travelocity)
  - Simply replace existing travel agency functions
  - Limited cost savings to airlines
  - Orbitz co-developed by major airlines to compete with Expedia, Travelocity (lower costs, ownership stake,…)
- Vendors of distressed inventory (Priceline)
  - Actually "electronic wholesalers" of empty seats
  - Sell at net fares negotiated with airlines
  - Availability controlled by airline RM systems
- In 2007, 63% of airline tickets sold in North America were bought on the Internet
  - Sum of airline web sites and on-line travel agencies



he thinks tide has shifted

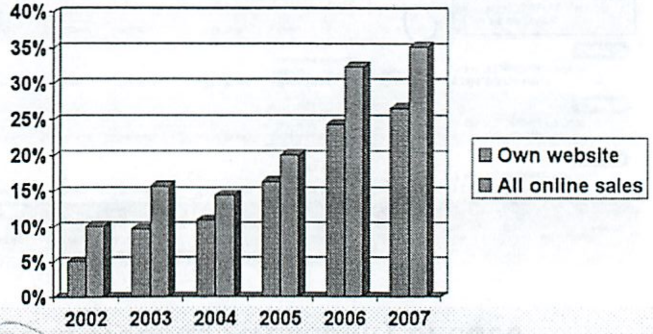
└ not much cost savings to airline

gaming →

priceline bought or agreement at fixed price

- then priceline chooses what price to tell you

## Percentage of Total Ticket Sales – World Airline Survey

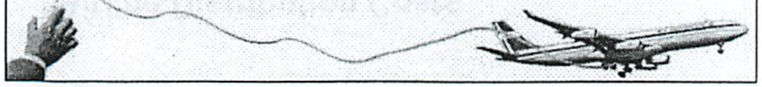


Source: Airline Business, July 2008

## Electronic Ticketing

done deal

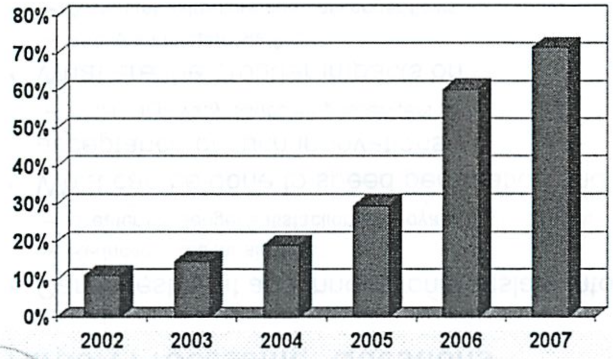
- Penetration and acceptance continue to grow:
  - Well over 90% of US domestic tickets in 2007
  - IATA set goal of 100% e-ticketing worldwide by June 2008
  - Initially used by short-haul and leisure travelers with simple itineraries and few changes to travel plans
  - Now also used by corporate and international travelers
- Growing acceptance has also reduced costs:
  - Elimination of paper ticket infrastructure and processing
  - Major obstacle was inability to inter-line with e-tickets, but bilateral agreements have overcome this limitation



prof: best way: search Expedia, etc
then go to airline website

For rebooking: order based on what
~~do~~ you pay + where you buy it

## E-tickets Issued – World Airline Survey



Source: Airline Business, July 2008

## Major IT Challenges of Distribution

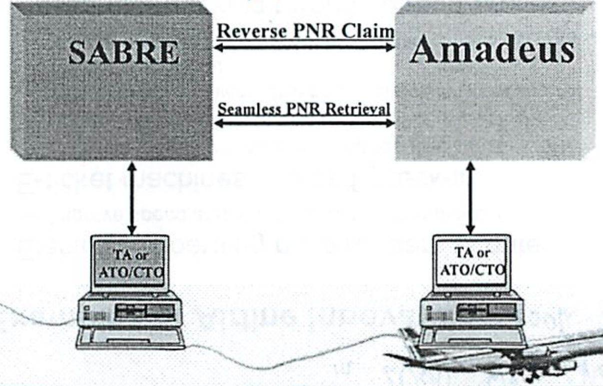
- Synchronization of information in GDSs
  - Reservations systems programmed in obsolete languages, making large-scale changes difficult
- Consistency of lowest fare quotes by channel
  - Advanced RM controls by O-D to maximize network revenue requires "seamless" request directly to airline RES System
  - But, most RES systems can't handle volume of website "shoppers" – leads to inconsistency among sites, over time
- Interlining of electronic ticket information
  - Competitive strategy issues in addition to IT requirements

everyone shall have same fares
- cached fares

how in all world can you do electronic seat assignments

## Consequences on Applications: Synchronization between GDSs

API not there yet

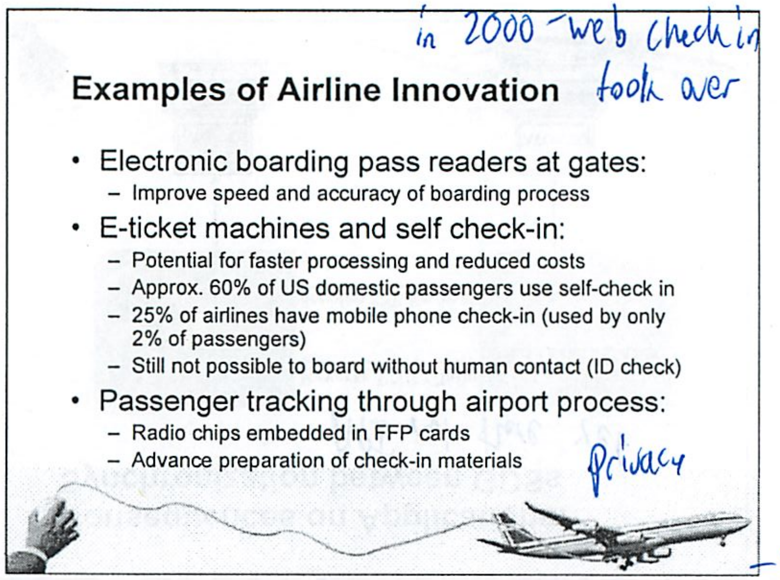


## Passenger Processing

- Most consumer complaints stem from airport processing of passengers and baggage:
  - Check-in delays and seat assignment problems
  - Lost baggage or slow delivery at destination
  - Information flow and poor treatment during unusual events (irregular operations, misconnects)
- Many believe in-flight service is a commodity:
  - I.T. innovations and linkages to e-distribution channels might represent a competitive advantage

thinking is most airlines are alike

Air Canada over invested in 2000 - web check in took over

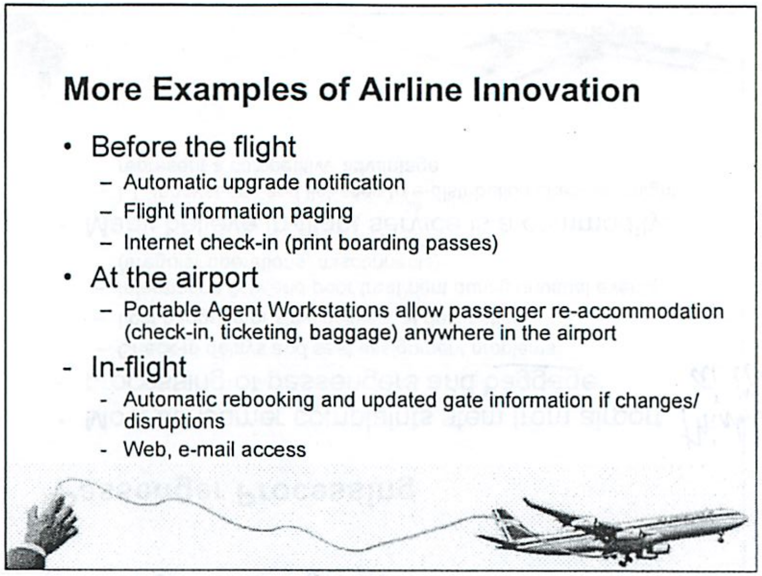


## Examples of Airline Innovation

- Electronic boarding pass readers at gates:
  - Improve speed and accuracy of boarding process
- E-ticket machines and self check-in:
  - Potential for faster processing and reduced costs
  - Approx. 60% of US domestic passengers use self-check in
  - 25% of airlines have mobile phone check-in (used by only 2% of passengers)
  - Still not possible to board without human contact (ID check)
- Passenger tracking through airport process:
  - Radio chips embedded in FFP cards
  - Advance preparation of check-in materials

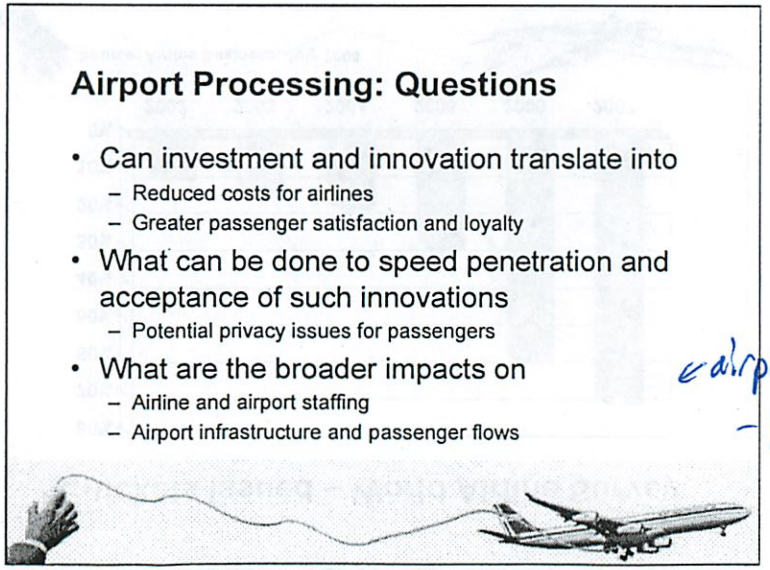
privacy

- same w/ DB



## More Examples of Airline Innovation

- Before the flight
  - Automatic upgrade notification
  - Flight information paging
  - Internet check-in (print boarding passes)
- At the airport
  - Portable Agent Workstations allow passenger re-accommodation (check-in, ticketing, baggage) anywhere in the airport
- In-flight
  - Automatic rebooking and updated gate information if changes/ disruptions
  - Web, e-mail access



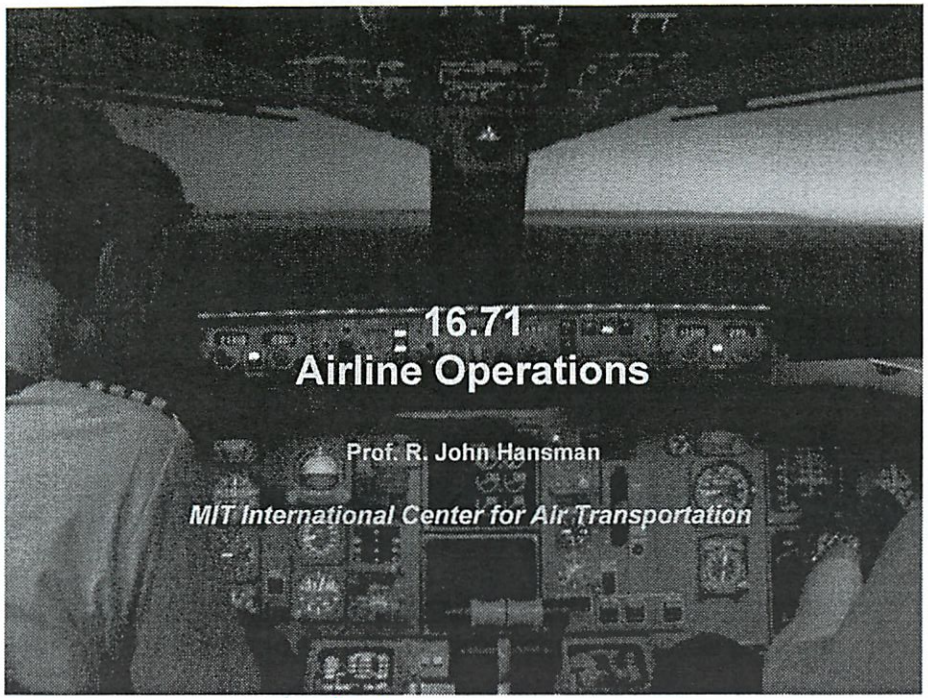
## Airport Processing: Questions

- Can investment and innovation translate into
  - Reduced costs for airlines
  - Greater passenger satisfaction and loyalty
- What can be done to speed penetration and acceptance of such innovations
  - Potential privacy issues for passengers
- What are the broader impacts on
  - Airline and airport staffing
  - Airport infrastructure and passenger flows

← airport planner

- less chek in hall + security

10/20



# 16.71 Airline Operations

Prof. R. John Hansman

*MIT International Center for Air Transportation*

? Boeing 757 ?

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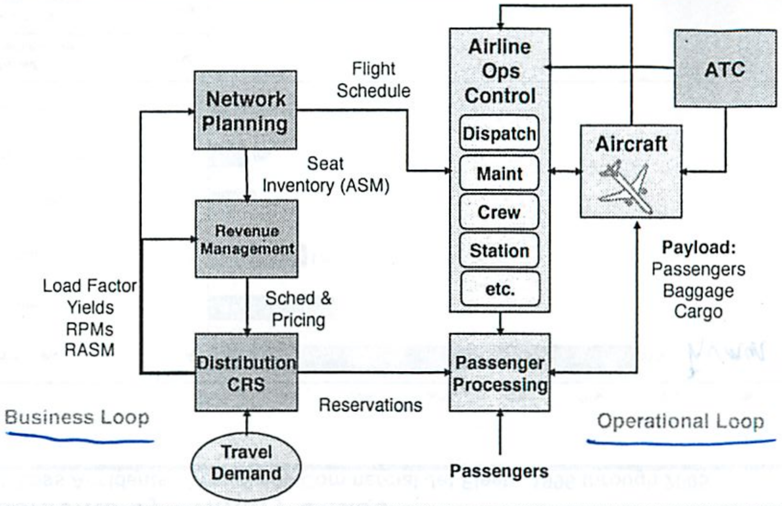
## Airline System Level



Controls RASM

Controls CASM

---

## Overview

- **Operations are:**
  - ❑ Complex
  - ❑ Regulated
    - ◆ Federal Aviation Regulations
    - ◆ International Civil Aviation Organization
    - ◆ Local Regulations (e.g. Airport, Port Authority)
    - ◆ International (Customs, Bilaterals)
    - ◆ Labor Agreements
  - ❑ Constrained
- **Will focus on aircraft departure process to illustrate elements which must come together to fly a single flight**

not trival to start airline

---

US - similar rules in other countries

## Federal Aviation Regulations
### Part 121 - Air Carrier Operating Rules

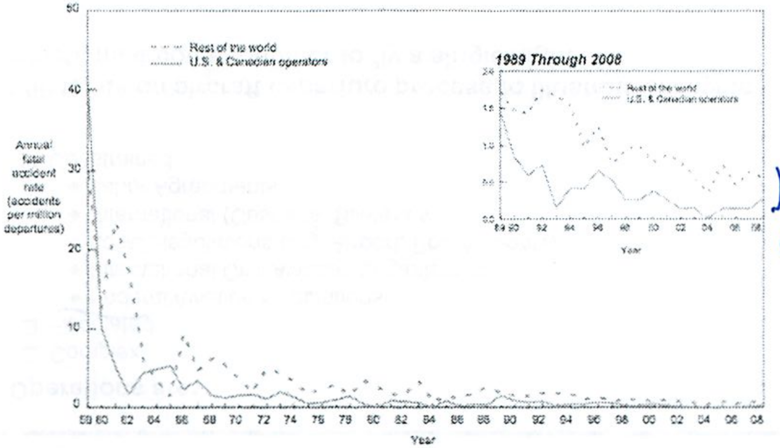
- **Air Carrier Operating Certificate Required (FAR Part 119)**
  - ❑ Standard Operating Procedures
  - ❑ Training
  - ❑ Maintenance
  - ❑ Equipment (Owned, Dry Lease, Wet Lease)
  - ❑ Accountability - name 4 people on certificate
- **Air Transport Aircraft (Part 25)** very redundant
- **Flight Crew**
  - ❑ Airline Transport Pilot
    - ◆ Type Rating (12,500 lbs. TOGW or Turbojet) need licence for that plane
    - ◆ Class 1 Medical
  - ❑ Flight Attendants
- **High Safety Focus on Operating Rules**
  - ❑ Balanced Field, Dispatch Release, ..

all for "saftey"

10/20

## U.S. and Canadian Operators Accident Rates by Year

### Fatal Accidents – Worldwide Commercial Jet Fleet – 1959 Through 2008

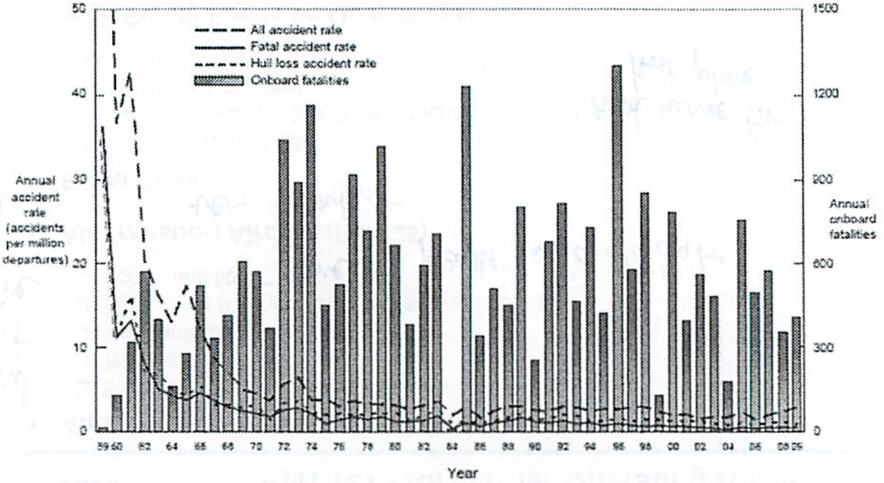


gap narrowing
rest of world
getting
safer

**BOEING**

## Accident Rates and Onboard Fatalities by Year

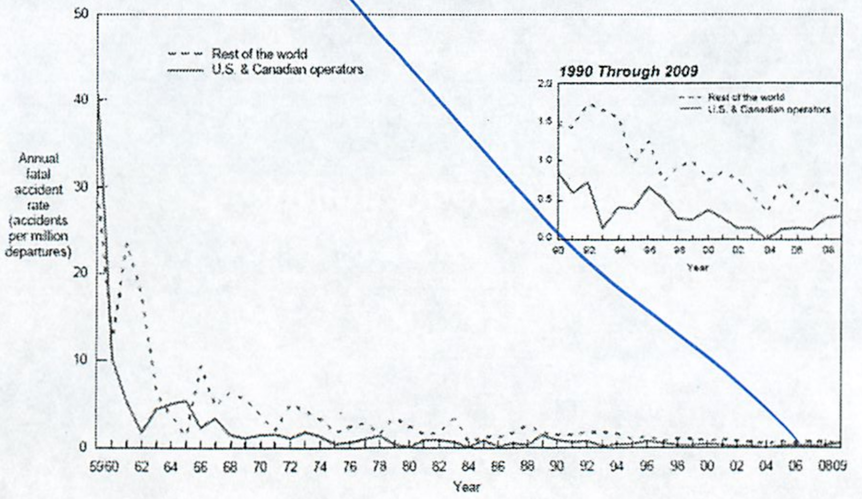
### Worldwide Commercial Jet Fleet – 1959 Through 2009



**BOEING**

## U.S. and Canadian Operators Accident Rates by Year

### Fatal Accidents – Worldwide Commercial Jet Fleet – 1959 Through 2009



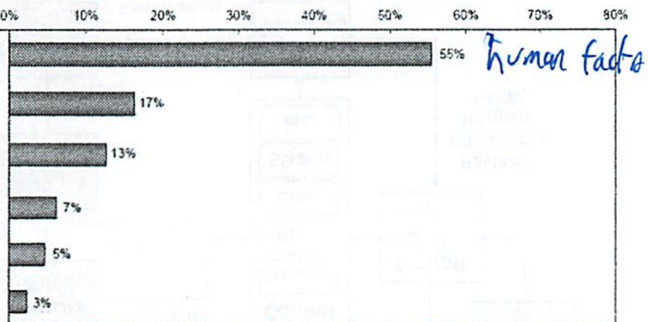
**BOEING**

don't really do anymore

## Accidents by Primary Cause*

### Hull Loss Accidents – Worldwide Commercial Jet Fleet – 1996 through 2005

| | |
|---|---|
| Flight Crew | 74 |
| Airplane | 23 |
| Weather | 17 |
| Misc./Other | 10 |
| Airport/Air Traffic Control | 6 |
| Maintenance | 4 |
| Total with known causes | 134 |
| Unknown or awaiting reports | 49 |
| Total | 183 |



human factor

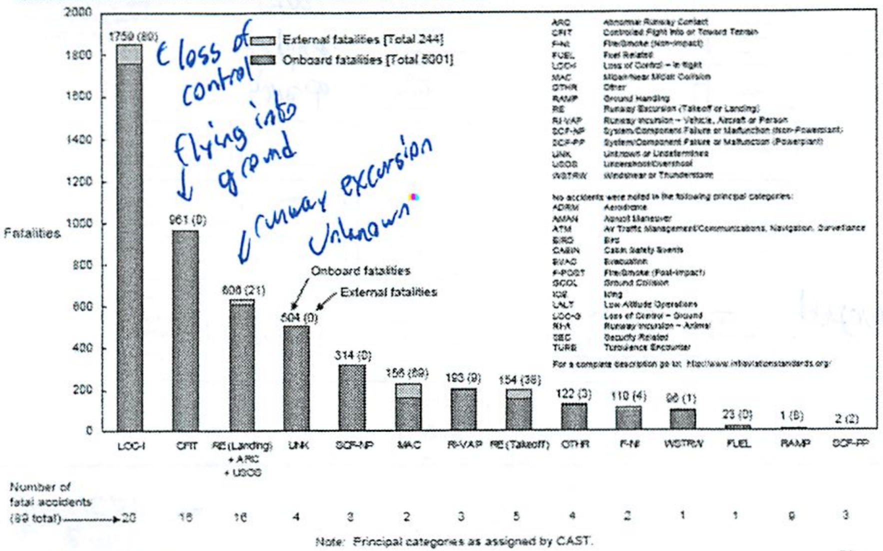
*As determined by the investigating authority, percent of accidents with known causes.

**BOEING**

do it this way now

## Fatalities by CAST/ICAO Common Taxonomy Team (CICTT) Aviation Occurrence Categories

### Fatal Accidents – Worldwide Commercial Jet Fleet – 2000 Through 2009



← loss of control

flying into ground ↓

↓ runway excursion

Unknown

| | |
|---|---|
| ARC | Abnormal Runway Contact |
| CFIT | Controlled Flight Into or Toward Terrain |
| F-NI | Fire/Smoke (Non-Impact) |
| FUEL | Fuel Related |
| LOC-I | Loss of Control – In flight |
| MAC | Midair/Near Midair Collision |
| OTHR | Other |
| RAMP | Ground Handling |
| RE | Runway Excursion (Takeoff or Landing) |
| RI-VAP | Runway Incursion – Vehicle, Aircraft or Person |
| SCF-NP | System/Component Failure or Malfunction (Non-Powerplant) |
| SCF-PP | System/Component Failure or Malfunction (Powerplant) |
| UNK | Unknown or Undetermined |
| USOS | Undershoot/Overshoot |
| WSTRW | Windshear or Thunderstorm |

No accidents were noted in the following principal categories:

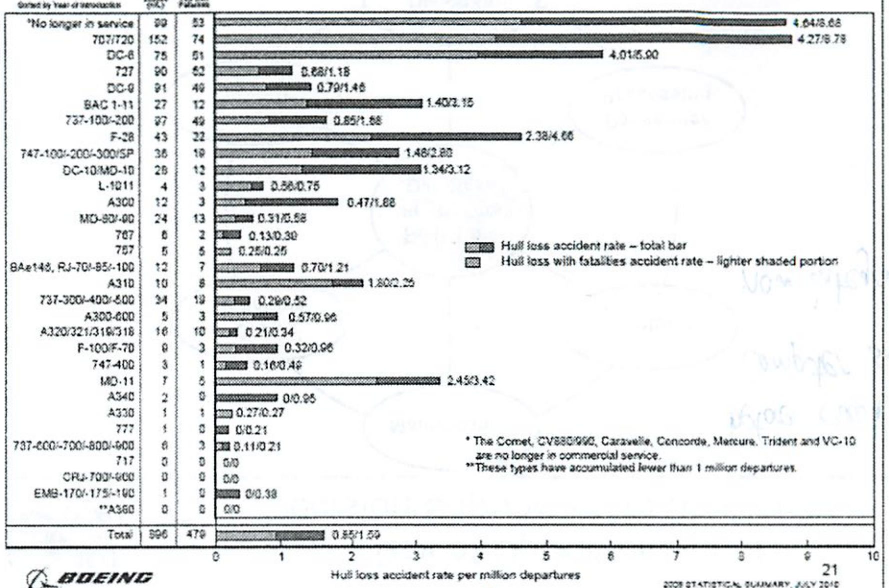
| | |
|---|---|
| ADRM | Aerodrome |
| AMAN | Abrupt Maneuver |
| ATM | Air Traffic Management/Communications, Navigation, Surveillance |
| BIRD | Bird |
| CABIN | Cabin Safety Events |
| EVAC | Evacuation |
| F-POST | Fire/Smoke (Post-Impact) |
| GCOL | Ground Collision |
| ICE | Icing |
| LALT | Low Altitude Operations |
| LOC-G | Loss of Control – Ground |
| RI-A | Runway Incursion – Animal |
| SEC | Security Related |
| TURB | Turbulence Encounter |

For a complete description go to: http://www.intlaviationstandards.org/

Note: Principal categories as assigned by CAST.

## Accident Rates by Airplane Type

### Hull Loss Accidents – Worldwide Commercial Jet Fleet – 1959 Through 2009



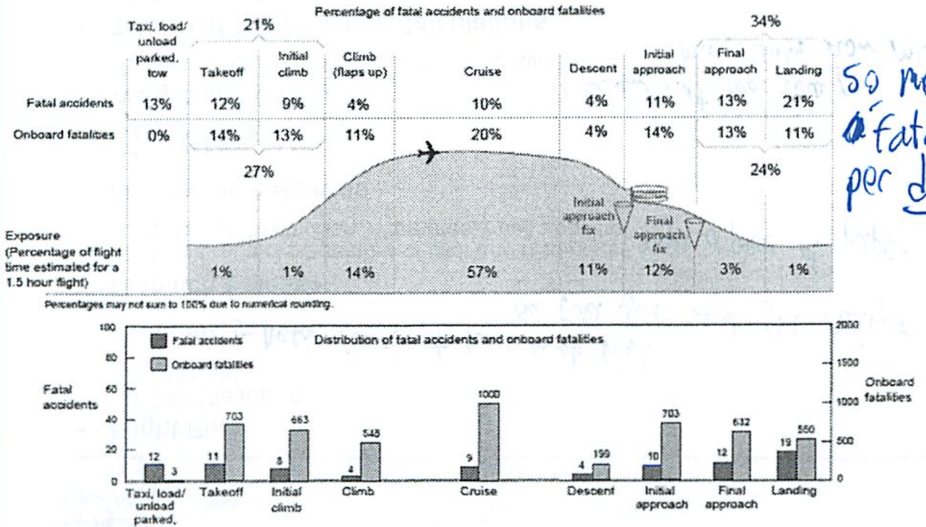
| Sorted by Year of Introduction | Hull Losses (HL) | HL with Fatalities | |
|---|---|---|---|
| *No longer in service | 99 | 53 | 4.64/8.68 |
| 707/720 | 152 | 74 | 4.27/8.78 |
| DC-8 | 75 | 51 | 4.01/5.90 |
| 727 | 90 | 52 | 0.68/1.18 |
| DC-9 | 91 | 49 | 0.79/1.46 |
| BAC 1-11 | 27 | 12 | 1.40/3.15 |
| 737-100/-200 | 97 | 49 | 0.85/1.88 |
| F-28 | 43 | 22 | 2.38/4.66 |
| 747-100/-200/-300/SP | 36 | 19 | 1.48/2.80 |
| DC-10/MD-10 | 28 | 12 | 1.34/3.12 |
| L-1011 | 4 | 3 | 0.56/0.75 |
| A300 | 12 | 3 | 0.47/1.88 |
| MD-80/-90 | 24 | 13 | 0.31/0.58 |
| 767 | 6 | 2 | 0.13/0.30 |
| 757 | 5 | 5 | 0.25/0.25 |
| BAe146, RJ-70/-85/-100 | 12 | 7 | 0.70/1.21 |
| A310 | 10 | 8 | 1.80/2.25 |
| 737-300/-400/-500 | 34 | 19 | 0.29/0.52 |
| A300-600 | 5 | 3 | 0.57/0.96 |
| A320/321/319/318 | 16 | 10 | 0.21/0.34 |
| F-100/F-70 | 9 | 3 | 0.32/0.96 |
| 747-400 | 3 | 1 | 0.16/0.49 |
| MD-11 | 7 | 5 | 2.45/3.42 |
| A340 | 2 | 0 | 0/0.95 |
| A330 | 1 | 1 | 0.27/0.27 |
| 777 | 1 | 0 | 0/0.21 |
| 737-600/-700/-800/-900 | 6 | 3 | 0.11/0.21 |
| 717 | 0 | 0 | 0/0 |
| CRJ-700/-900 | 0 | 0 | 0/0 |
| EMB-170/-175/-190 | 1 | 0 | 0/0.38 |
| **A380 | 0 | 0 | 0/0 |
| Total | 896 | 479 | 0.85/1.59 |

* The Comet, CV880/990, Caravelle, Concorde, Mercure, Trident and VC-10 are no longer in commercial service.
**These types have accumulated fewer than 1 million departures.

newer airplanes safer or less hrs of flying?

## Fatal Accidents and Onboard Fatalities by Phase of Flight

### Worldwide Commercial Jet Fleet – 2000 Through 2009



| | Taxi, load/ unload parked, tow | Takeoff | Initial climb | Climb (flaps up) | Cruise | Descent | Initial approach | Final approach | Landing |
|---|---|---|---|---|---|---|---|---|---|
| Fatal accidents | 13% | 12% | 9% | 4% | 10% | 4% | 11% | 13% | 21% |
| Onboard fatalities | 0% | 14% | 13% | 11% | 20% | 4% | 14% | 13% | 11% |
| Exposure (Percentage of flight time estimated for a 1.5 hour flight) | | 1% | 1% | 14% | 57% | 11% | 12% | 3% | 1% |

Percentages may not sum to 100% due to numerical rounding.

short → flight

So measure ~~a~~ fatalities per departure

MIT ICAT

## Flight Phases

- Pre-Flight
- Gate Operations
- Push-back
- Engine Start
- Taxi
- Takeoff
- Climb (SID)
- Cruise
  - ☐ Step-Climb
- Descent
- Terminal Area (STAR)
- Approach
- Landing
- Taxi
- Parking
- Unload

# Flight Release

- **Flight Plan**
  - ❑ FAA Clearance
  - ❑ Onboard
- **Fuel Slip** ← need record of how much fuel so fuel guy must give reciept
- **Dispatch Release**
  - ❑ Flight requires signature of pilot and dispatcher
  - ❑ Weather, Flight Plan, Alternates, Fuel, Loading

  Sign a piece of paper
- **Maintenance Release**
  - ❑ Logbook
  - ❑ MEL Items
- **Weight and Balance**
  - ❑ Final loads (i.e. Bag Count), Trim Settings

  know not too heavy may only now min before
- **Take - Off Performance Calculations**
  - ❑ Balanced Field Length
  - ❑ De-Rated Takeoff ← save engine life
- **Head Count**

  └ flight attendants count for evacuation

---

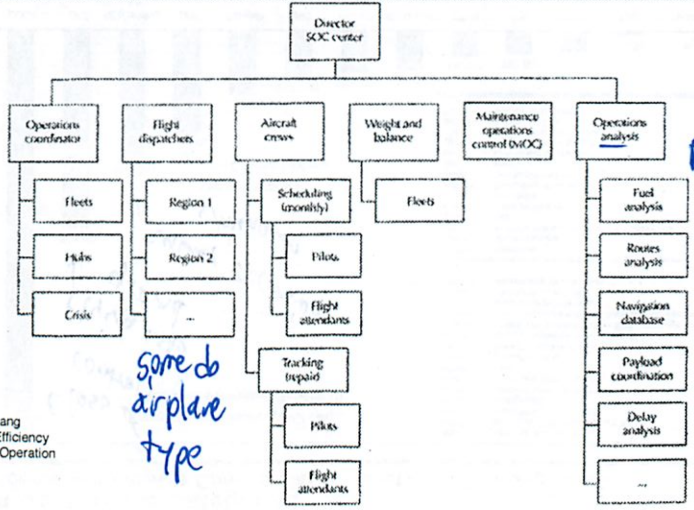
Diff. Airports have diff names

# Systems Operations Center

- **Dispatch**
- **Crew Scheduling**
- **Aircraft Scheduling** You can't get on the gate because they are waiting for late crew (ya) "kiss of death"
- **ATC Coordination**
- **Weather**
- **System Recovery** massive interuption -readjust entire network
- **Crisis Center**

---

# Systems Operations Control Structure



performance

some do airplane type

Source: Michael Irrgang
Airline Operational Efficiency
Handbook of Airline Operation

**Figure 12-5** The SOC Center of an Efficient Airline.

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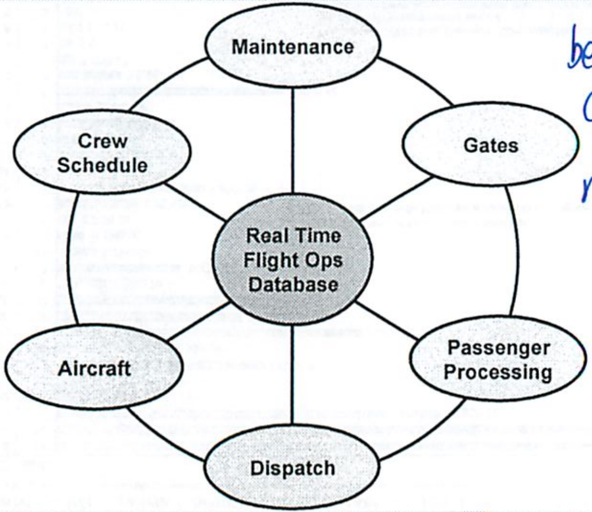
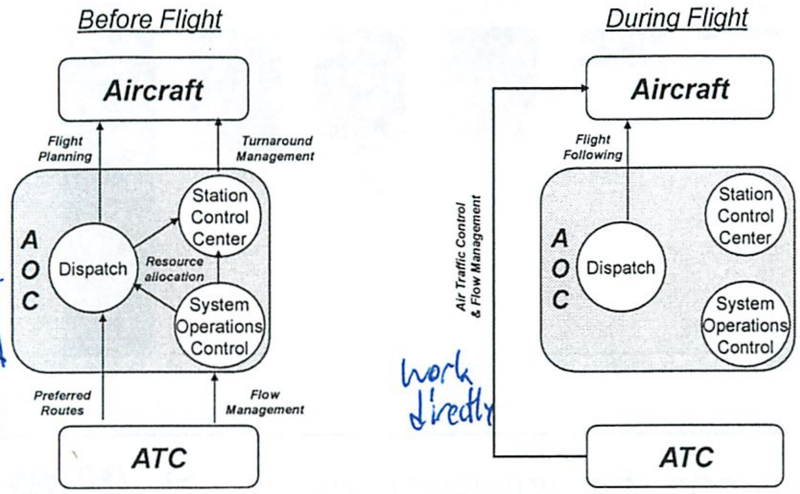
# Day of Operations Decision Support - Info Sharing



before each diff Computer system now integrating

# Role of AOC in Decision Flows



doing pre flight planning →

work directly

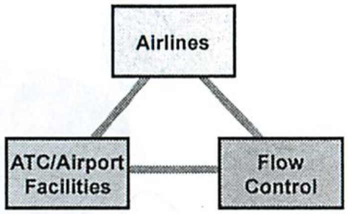
---

became poplar

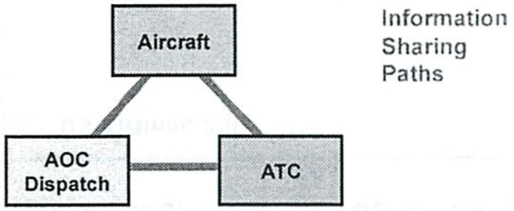
# Collaborative Decision Making

- **Strategic Level**
  - ☐ Schedule
  - ☐ Response to Severe Weather
  - ☐ Response to Traffic

before FAA would not know what airlines responded



- **Tactical Level**
  - ☐ Diversions
  - ☐ Routing
  - ☐ Sequencing



---

# Crew Scheduling

- **Seniority Based System**
  - ☐ Bid sheets
  - ☐ "Lines"
  - ☐ Reserve
  - ☐ Trading
- **Cockpit Crew**
  - ☐ Aircraft Type Qualification
  - ☐ Common Type Ratings (757/767, A319/320/340)
- **Cabin Crew**
- **Crew Desk**
- **Duty Time Limitations**
  - ☐ FAR's (eg.hrs in 24, "Bunkies")
  - ☐ Contracts
- **Commuting**

most, not all

people bid for different reasons
- #
- weekends off
- like certain trips
- overnight

hot standby in airport only do in hubs

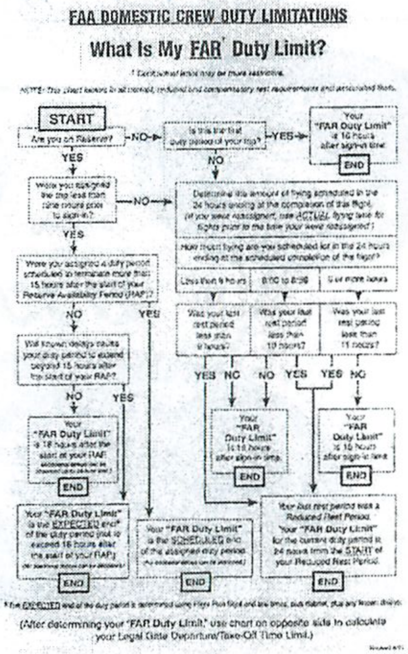
expensive to maintain diff. ratings

if not full, will cut out a person

dangerous if a pilot never does take off or landings

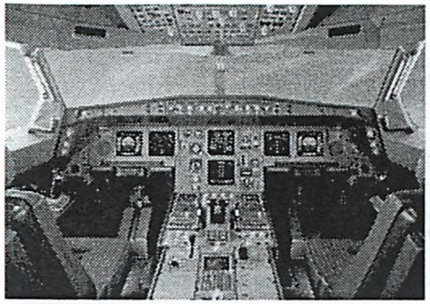
controversy w/ Continental if don't live in airplane's home base

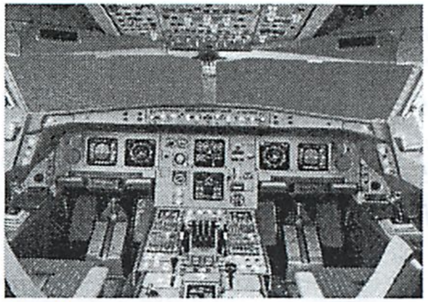
---



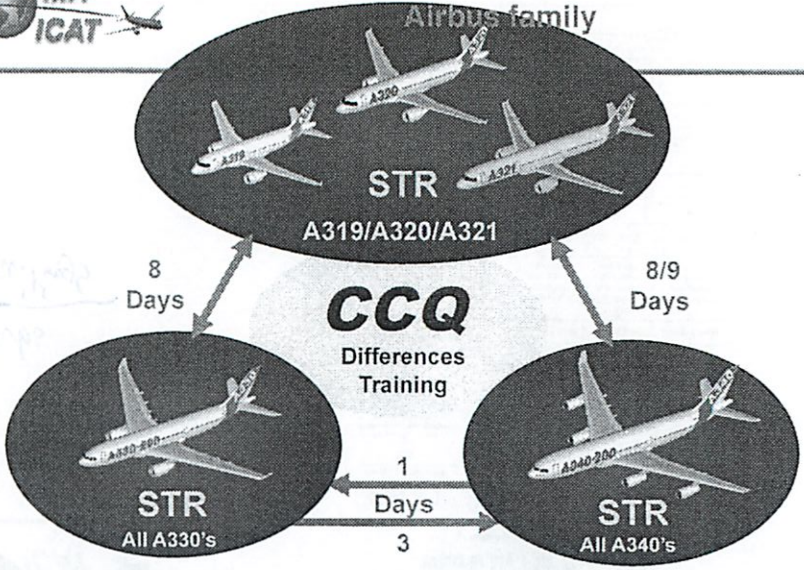
## Cross Crew Qualification

### A330/A340


**A330**

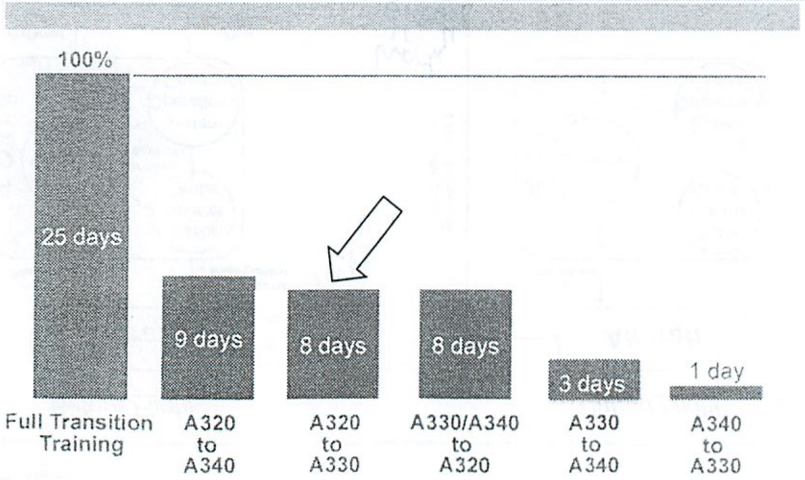

**A340**

almost identical

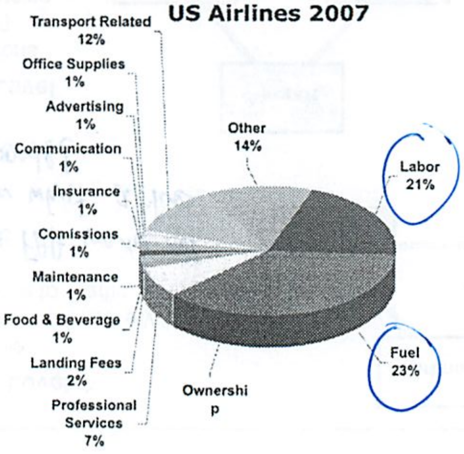


minimal difference training

## Transition training / CCQ

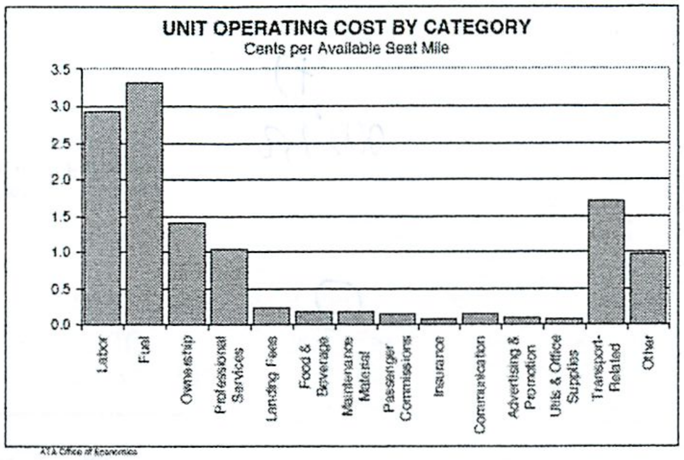


## Typical Cost Structure (US Airlines)



*Source: "ATA US Airline Cost Index: Major & National Passenger Carriers, Q3 2007.*

## Typical Cost Structure (US Airlines)



*Source: "ATA US Airline Cost Index: Major & National Passenger Carriers, Q3 2007.*

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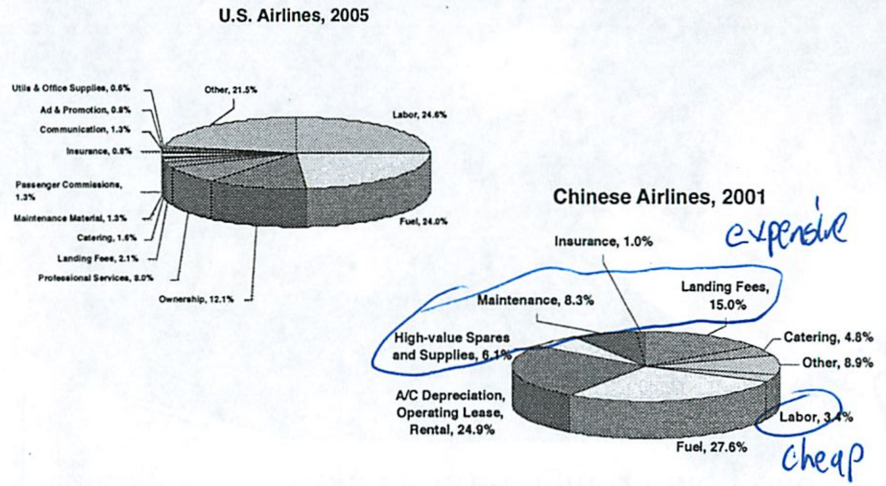
## Comparison of Cost Structure Chinese vs US Airlines



expensive

cheap

*Source: "Cost Analysis of China Airline Industry", Aviation Industry Development Research Center of China, 10/14/2003. ATA US Airline Cost Index: Major & National Passenger Carriers, Q3 2005.*

pilot makes $10,-15,000/year

---

## Dispatch

- Shared responsibility with Captain
- Flight Planning
- Fuel
- Weight and Balance
- Maintenance
- Rerouting
- Diversions ← but can explode
- Emergencies
- Typical Dispatch Load 10 - 20 flights at a time

---

## Flight Plan Example
## JFK - SJU

**Requested Routing** ⟶

FL = Flight Level
SD = Standard Distance
ST = Standard Time
SB = Standard Burn

```
                                   Aain.dat

 - IFR AAL699/16 084/N80084 JFK  SJU  ALTN STX
   FUBO 42681 RLS FUEL 063116

  ALTN RTE - R41 /FL170 SJU.DCT.PALCO.DCT.STX

 *******************  CRITICAL FLIGHT  *******************

 STX - PLAN 1 OF 1 - RTE 41  - CTLD CALC/RTE/FL


 FP KZNYZOZX KZNYZRZX KZWYZOZX TJZSZQZX KZNYZOZX
 180946 KTULAALD
 FPL-AAL699-IS
 -A306/H-SDHI/S
 -KJFK1115
 -M080F330 DCT SHIPP DCT LINND DCT KWINN/M080F330 DCT
 GABES/N0474F330 A523 GRANN A523 VERMO DCT SAALR STE3
 -TJSJ0315 TISX
 -EET/KZNY0029 GABE0105 KZNY0139 TJZS0227
  SEL/AMJQ      REG/N80084


 TO                  LAT     LONG     MC  MK  GS  TD  SD   ST   SB
 IDENT           FL. WIND    WCP      MH  TRR TAS  I  TLDR TTLT TTLB

 SHIPP               N40197 W073148 141             P05 0031
 SHIPP               29064  P063    144 002 368  0
 ----------------------------------------------------------------
 TOP OF CLIMB                       141     433 P03 0089 0018 0087
 TOC              33 26091  P065    148 000 368  0  1328 0018 0087
 ----------------------------------------------------------------
 LINND               N39245 W071426 141 800 532 P03 0061 0000 0000
 LINND            33 26091  P064    147 000 468  0  1327 0018 0087
 ----------------------------------------------------------------
 KWINN               N38060 W070420 162 800 495 P03 0090 0011 0023
 KWINN            33 26070  P026    171 000 469  0  1237 0029 0110
 ----------------------------------------------------------------
 GABES               N34000 W067410 163 800 471 P06 0268 0036 0079
 GABES            33 24066  P000    172 000 471  0  0949 0105 0169
 ----------------------------------------------------------------
 PRUIT               N29486 W066335 181 800 460 P08 0256 0034 0071
 PRUIT            33 25028  M014    186 000 474  0  0691 0139 0260
 ----------------------------------------------------------------

                                   Page 1
```

time fuel

HOWGOZIT ← how it actually went

ETA ATA

BURN +/-

Old teletype Format
– very terse

## Flight Plan Example
## JFK - SJU
## Page 2

```
                                Aain.dat

BIZZY            N27140 W066143 188 800 475 P09 0155 0020 0040
BIZZY         33 28013  P000    190 000 475  0  0536 0159 0300
---------------------------------------------------------------
GRANN            N23300 W065480 188 795 480 P09 0224 0028 0057
GRANN         33 02012  P008    188 000 472  0  0312 0227 0357
---------------------------------------------------------------
THANK            N21276 W066032 200 795 483 P09 0123 0015 0031
THANK         33 02011  P011    200 000 472  0  0189 0242 0388
---------------------------------------------------------------
VERMO            N20075 W066129 199 795 483 P09 0080 0010 0019
VERMO         33 34012  P011    199 000 472  0  0103 0252 0407
---------------------------------------------------------------
BGN DESCENT                     199 795 481 P09 0010 0001 0003
BOO           33 34012  P010    200 000 472  0  0099      0410
---------------------------------------------------------------
SAALR            N19068 W066202 199             P15 0051
SAALR            10012  P005    199 000 280  0
---------------------------------------------------------------
LUIS MUNOZ M     N18263 W066001 166             P12 0048 0022 0017
SJU              11016  P012    164 008 280  0  1448 0315 0427
---------------------------------------------------------------

RAMP WT P03000 TIME M02 FUEL P0374 COST P0047 FL 330
RAMP WT M03000 TIME M02 FUEL M0316 COST M0041 FL 330

RWT 339566 PLD 068100 DOT7433 GND25/06 QOZ M800 SKD1115/1513
BIAS P04.6 AVG WIND DIR/COMP 254/P008 AVG TO P008

            ARPT      FUEL TIME DIST
TAXI        JFK      01250 0025
FUBO        SJU     041431 0315 1448
---------------------------------------------------------------
E/RSV                03817 0020
RSV                  04418 0030
ADD                  02662
ALTN        STX      04613 0022 0088
HOLD                 04925 0035
MEL/CDL              00000
                    ------
TOTAL               063116

RLS FUEL JFK        063116

ENDURNC 0450 ADJ 05.5 MINS/1000 LB
```

weight

**Fuel Burn Analysis** →

how much **Reserves**

piolet can always add add. fuel for added buffer

└ may need to kick off pax

min: fly there +designated alternate + 45 min extra

---

## Flight Plan Example
## JFK - SJU
## Page 3

**MEL Items Open**
**Dispatchers Release**
**Captains Signature**
**Weather**

```
                                Asin.dat

RMKS/ ADTNL FUEL FOR PSBL ENRTE CHOP

ACFT RESTR -NONE

MEL ITEMS
0238...APU        APU AVAIL LIGHT- OPTION 1..............49 03A

PDL ITEMS -NONE

SEL ITEMS
300 37 MOD TO CG CONTROL COMPUTER AND FWC
300 47 POWER PORTS FOR LAP TOP COMPUTERS
300 48 RUDDER TRIM CONTROL MOD
300 50 NEW AUTOMATED ALTITUDE CALLOUTS
300 51 EMER PA/CABIN INTERPHONE SWITCH
300 52 TERRAIN AWARENESS AND ALERTING DISP
300 53 AUTOMATIC CALLOUT DEACTIVATION

 FOR SEL ITEM DESCRIPTIONS, REFER TO
A300 OPERATING MANUAL - VOL I - SYSTEMS 1

DISP FD39 7139  TOM OLSON                 ICS-967/LDST-817-967-EXT

CAPT SAUNDERS GJ                  CAT1 YES
F/O SLOAN SJ                      CAT2 YES
                                  CAT3 YES

AUBD CAPT SIGNATURE.......................... 18OCT01/180946

                    ////// APPENDED MESSAGES //////

                  ***  FORECAST USED FOR PLANNING  ***

JFK  TAF/
VALID 18/0800Z-19/0100Z OCT 01
28012KT P6SM CLR
FM13Z 28014G22KT P6SM CLR
FM18Z 28012KT P6SM FEW060
FM23Z 25008KT P6SM CLR.
AA WEATHER SERVICES/SHR
SJU TAF TJSJ 180530Z 180606 VRB03KT P6SM FEW025 SCT100 TEMPO 061
0
```

minimum equipment list
- always something broken
- can still fly

---

## Flight Plan Example
## JFK - SJU
## Page 4

**Weather**
**Winds Aloft Forecast**

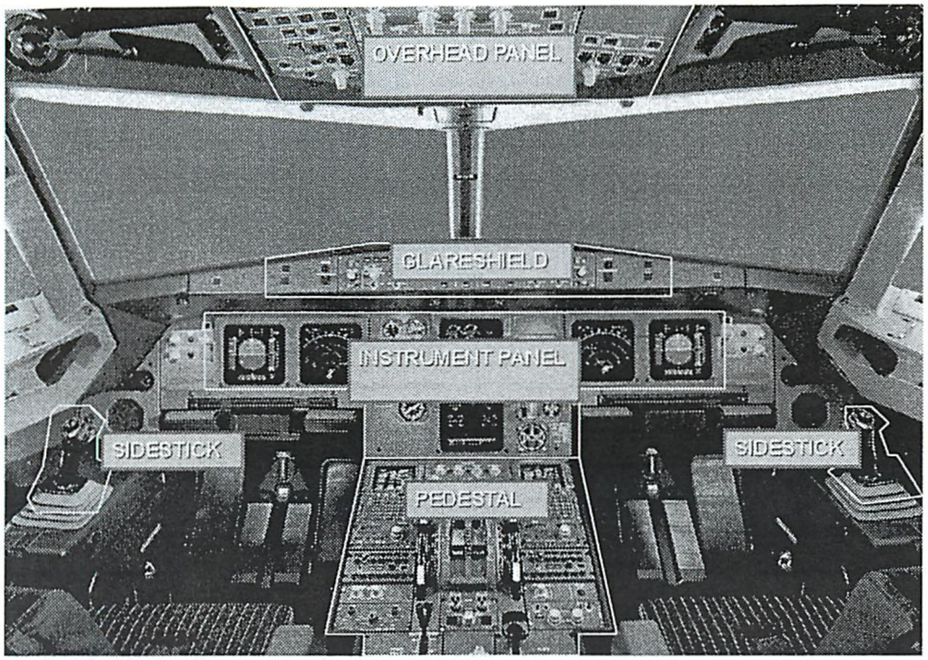
```
                                Aain.dat

        09010KT 6SM -SHRA SCT020 BKN030 BKN100
        FM1400 07012G17KT P6SM FEW025 SCT040 TEMPO 1721 4SM SHRA
        SCT015 BKN030
        FM2200 09007KT P6SM SCT030 PROB30 2301 -SHRA BKN030
STX TAF TISX 180530Z 180606 07009KT P6SM FEW024 TEMPO 0610 -SHRA

        SCT020 BKN030
        FM1500 11014G19KT P6SM FEW020 SCT040 PROB40 1721 4SM
        SHRA SCT020 BKN030
        FM2100 09010KT P6SM SCT020 PROB40 0205 6SM -SHRA SCT020
        BKN030

ENRT WX FL 240             FL 300            FL 340             FL 390
    I TD  WIND WCP I TD  WIND WCP I TD  WIND WCP I TD  WIND WCP
LIN 0P03/27085P064 0P02/27090P069 0P03/27085P060 0P02/26085P051
KWI 0P04/26058P021 0P03/27064P022 0P03/26073P020 0P01/26076P012
GAB 0P11/23044M007 0P08/23061M008 0P05/24067M002 0M02/24076P002
PRU 0P12/24019M007 0P10/25025M003 0P07/25028M002 0M02/27035P006
BYZ 0P13/25007M001 0P11/27011P001 0P08/28014P003 0M01/29018P006
GRA 0P14/02006P005 0P11/01010P010 0P09/03013P011 0M01/01014P014
THA 0P14/04005P004 0P11/36010P010 0P09/02012P012 0M01/03013P017
VER 0P14/05004P003 0P11/34011P010 0P09/34012P010 0M01/01012P012
```

24,000
ft

---

## Cockpit Pre-Flight & FMC Load

walk around -tires good



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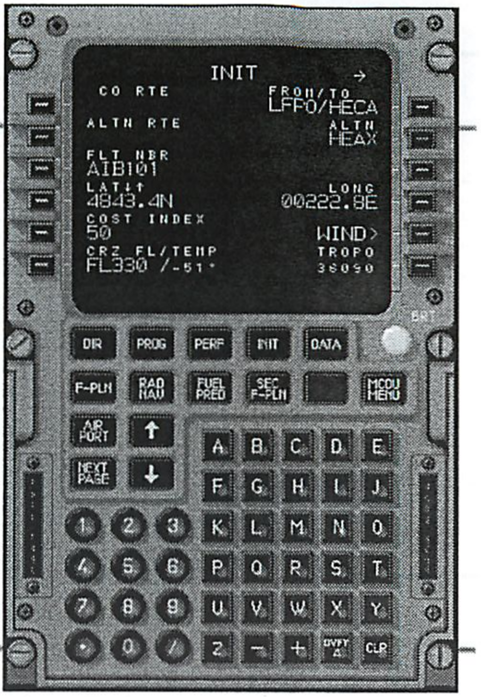
MIT ICAT

## FMS - A320

- Control Display Unit

akward, but
u get used to it

→ input flight plan into
computer



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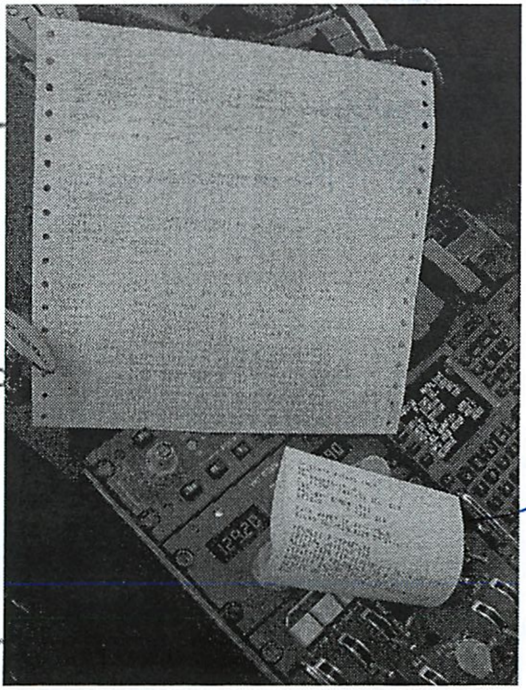
MIT ICAT

## Flight Plan
## &
## Pre Departure Clearanc
## (PDC)

From FAA

may varry a little from requested

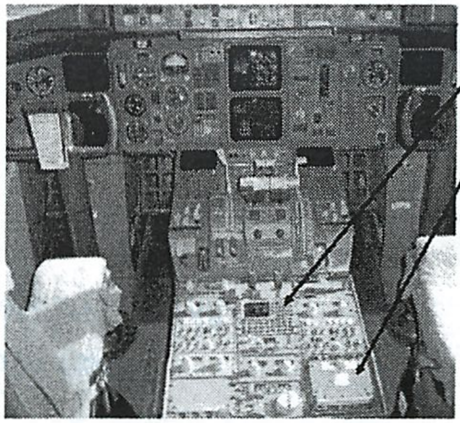


via →

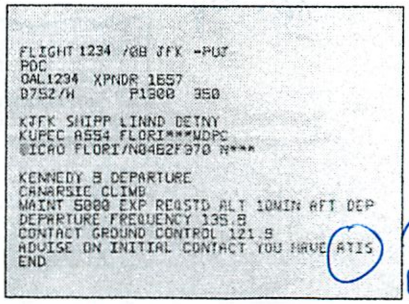
---

MIT ICAT

## Sample ACARS Message



Center console



```
FLIGHT 1234 /08 JFK -PUJ
PDC
OAL1234  XPNDR 1657
B752/H        P1300  350

KJFK SHIPP LINND DETNY
KUPEC A554 FLORI***WDPC
@ICAO FLORI/N0462F370 N***

KENNEDY 8 DEPARTURE
CANARSIE CLIMB
MAINT 5000 EXP REQSTD ALT 10MIN AFT DEP
DEPARTURE FREQUENCY 135.8
CONTACT GROUND CONTROL 121.9
ADVISE ON INITIAL CONTACT YOU HAVE ATIS
END
```

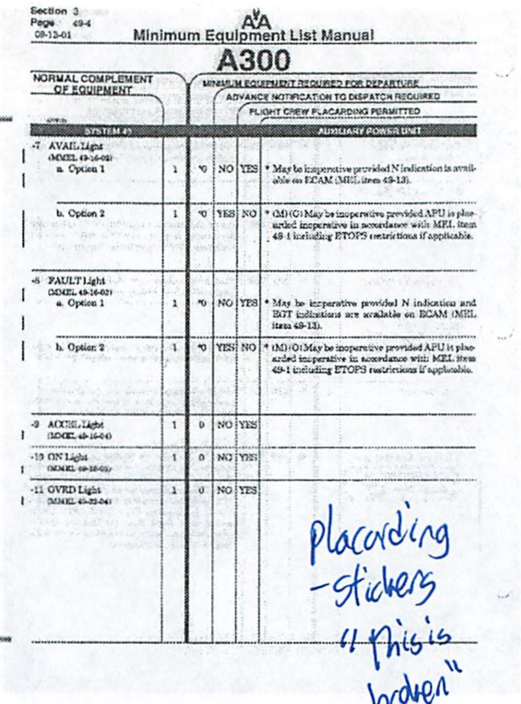
runway weather

Sample ACARS output: PDC

prints in airplane

# Minimum Equipment List

400 pg book



Section 3
Page 49-4
09-13-01

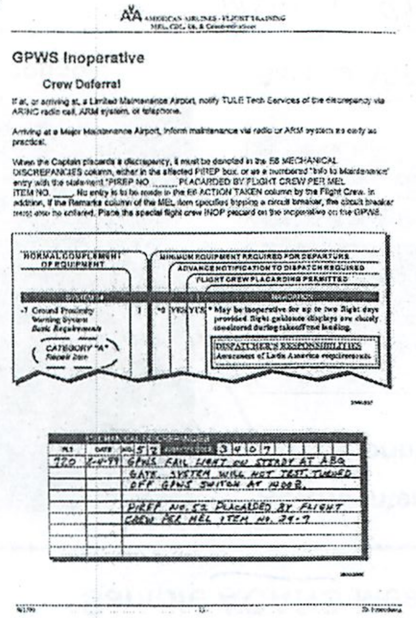
## Minimum Equipment List Manual

## A300

| SYSTEM 49 | NORMAL COMPLEMENT OF EQUIPMENT | MINIMUM EQUIPMENT REQUIRED FOR DEPARTURE | ADVANCE NOTIFICATION TO DISPATCH REQUIRED | FLIGHT CREW PLACARDING PERMITTED | AUXILIARY POWER UNIT |
|---|---|---|---|---|---|
| -7 AVAIL Light (MMEL 49-16-02) | | | | | |
| a. Option 1 | 1 | *0 | NO | YES | * May be inoperative provided N indication is available on ECAM (MEL item 49-13). |
| b. Option 2 | 1 | *0 | YES | NO | * (M) (O) May be inoperative provided APU is placarded inoperative in accordance with MEL item 49-1 including ETOPS restrictions if applicable. |
| -8 FAULT Light (MMEL 49-16-02) | | | | | |
| a. Option 1 | 1 | *0 | NO | YES | * May be inoperative provided N indication and EGT indications are available on ECAM (MEL item 49-13). |
| b. Option 2 | 1 | *0 | YES | NO | * (M) (O) May be inoperative provided APU is placarded inoperative in accordance with MEL item 49-1 including ETOPS restrictions if applicable. |
| -9 ACCEL Light (MMEL 49-16-04) | 1 | 0 | NO | YES | |
| -10 ON Light (MMEL 49-16-05) | 1 | 0 | NO | YES | |
| -11 OVRD Light (MMEL 49-22-04) | 1 | 0 | NO | YES | |

placarding
- stickers
"this is broken"

base from maint.
can negotiate w/ FAA



AMERICAN AIRLINES - FLIGHT TRAINING
MEL, CDL, E6, & Communications

## GPWS Inoperative

### Crew Deferral

If at, or arriving at, a Limited Maintenance Airport, notify TULE Tech Services of the discrepancy via ARINC radio call, ARM system, or telephone.

Arriving at a Major Maintenance Airport, inform maintenance via radio or ARM system as early as practical.

When the Captain placards a discrepancy, it must be denoted in the E6 MECHANICAL DISCREPANCIES column, either in the affected PIREP box, or as a numbered "Info to Maintenance" entry with the statement "PIREP NO. ____ PLACARDED BY FLIGHT CREW PER MEL ITEM NO. ____. No entry is to be made in the E6 ACTION TAKEN column by the Flight Crew. In addition, if the Remarks column of the MEL item specifies tripping a circuit breaker, the circuit breaker must also be collared. Place the special flight crew INOP placard on the inoperative on the GPWS.

| SYSTEM 34 | NORMAL COMPLEMENT OF EQUIPMENT | MINIMUM EQUIPMENT REQUIRED FOR DEPARTURE | ADVANCE NOTIFICATION TO DISPATCH REQUIRED | FLIGHT CREW PLACARDING PERMITTED | NAVIGATION |
|---|---|---|---|---|---|
| -7 Ground Proximity Warning System<br>*Basic Requirements*<br>CATEGORY "A" Repair Item | 1 | *0 | YES | YES | * May be inoperative for up to two flight days provided flight guidance displays are closely monitored during takeoff and landing.<br>DISPATCHER'S RESPONSIBILITIES<br>Assessment of Latin America requirements. |

MECHANICAL DISCREPANCIES

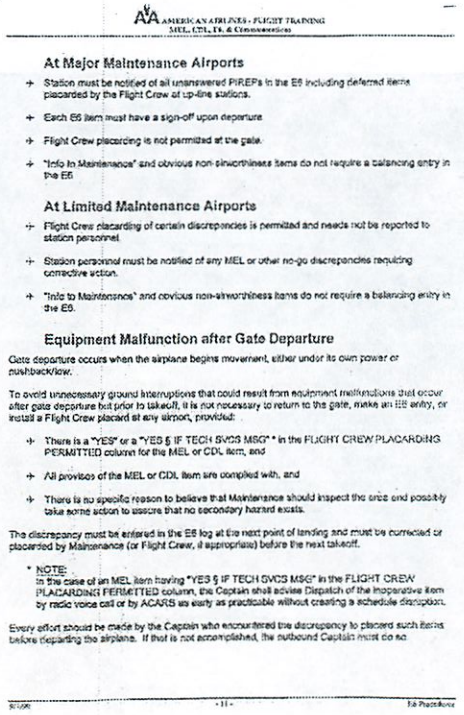
FLT | DATE | NO. 5 2 | 3 4 0 7

720 2-4-99 GPWS FAIL LIGHT ON STEADY AT ABQ GATE. SYSTEM WILL NOT TEST. TURNED OFF GPWS SWITCH AT 1400Z.

PIREP NO. 52 PLACARDED BY FLIGHT CREW PER MEL ITEM NO. 34-7

how you write it up

Can fly 1 leg to maint. base



AMERICAN AIRLINES - FLIGHT TRAINING
MEL, CDL, E6, & Communications

### At Major Maintenance Airports

- Station must be notified of all unanswered PIREPs in the E6 including deferred items placarded by the Flight Crew at up-line stations.
- Each E6 item must have a sign-off upon departure.
- Flight Crew placarding is not permitted at the gate.
- "Info to Maintenance" and obvious non-airworthiness items do not require a balancing entry in the E6.

### At Limited Maintenance Airports

- Flight Crew placarding of certain discrepancies is permitted and needs not be reported to station personnel.
- Station personnel must be notified of any MEL or other no-go discrepancies requiring corrective action.
- "Info to Maintenance" and obvious non-airworthiness items do not require a balancing entry in the E6.

### Equipment Malfunction after Gate Departure

Gate departure occurs when the airplane begins movement, either under its own power or pushback/tow.

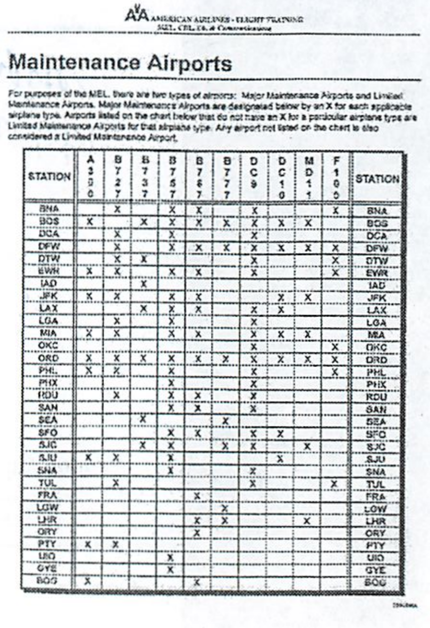
To avoid unnecessary ground interruptions that could result from equipment malfunctions that occur after gate departure but prior to takeoff, it is not necessary to return to the gate, make an E6 entry, or install a Flight Crew placard at any airport, provided:

- There is a "YES" or a "YES § IF TECH SVCS MSG" * in the FLIGHT CREW PLACARDING PERMITTED column for the MEL or CDL item, and
- All provisos of the MEL or CDL item are complied with, and
- There is no specific reason to believe that Maintenance should inspect the area and possibly take some action to assure that no secondary hazard exists.

The discrepancy must be entered in the E6 log at the next point of landing and must be corrected or placarded by Maintenance (or Flight Crew, if appropriate) before the next takeoff.

* NOTE:
In the case of an MEL item having "YES § IF TECH SVCS MSG" in the FLIGHT CREW PLACARDING PERMITTED column, the Captain shall advise Dispatch of the inoperative item by radio voice call or by ACARS as early as practicable without creating a schedule disruption.

Every effort should be made by the Captain who encountered the discrepancy to placard such items before departing the airplane. If that is not accomplished, the outbound Captain must do so.



AMERICAN AIRLINES - FLIGHT TRAINING
MEL, CDL, E6, & Communications

## Maintenance Airports

For purposes of the MEL, there are two types of airports: Major Maintenance Airports and Limited Maintenance Airports. Major Maintenance Airports are designated below by an X for each applicable airplane type. Airports listed on the chart below that do not have an X for a particular airplane type are Limited Maintenance Airports for that airplane type. Any airport not listed on the chart is also considered a Limited Maintenance Airport.

| STATION | A300 | B727 | B737 | B757 | B767 | B777 | DC9 | DC10 | MD11 | F100 | STATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BNA | | X | | X | X | | X | | | X | BNA |
| BOS | X | | X | X | X | X | X | X | X | | BOS |
| DCA | | X | | X | | | X | | | | DCA |
| DFW | | X | | X | X | X | X | X | X | X | DFW |
| DTW | | X | X | | | | X | | | X | DTW |
| EWR | X | X | | X | X | | X | | | X | EWR |
| IAD | | | X | | | | | | | | IAD |
| JFK | X | X | | X | X | | | X | X | | JFK |
| LAX | | | X | X | X | | X | X | | | LAX |
| LGA | | X | | X | | | X | | | | LGA |
| MIA | X | X | | X | X | | X | X | X | | MIA |
| OKC | | | | | | | X | | | X | OKC |
| ORD | X | X | X | X | X | X | X | X | X | X | ORD |
| PHL | X | X | | X | | | X | | | X | PHL |
| PHX | | | | X | | | X | | | | PHX |
| RDU | | X | | X | X | | X | | | | RDU |
| SAN | | | | X | X | | X | | | | SAN |
| SEA | | | X | | | X | | | | | SEA |
| SFO | | | | X | X | | X | X | | | SFO |
| SJC | | | X | X | | X | X | | X | | SJC |
| SJU | X | X | | X | | | | X | | | SJU |
| SNA | | | | X | | | X | | | | SNA |
| TUL | | X | | | | | X | | | X | TUL |
| FRA | | | | | X | | | | | | FRA |
| LGW | | | | | | X | | | | | LGW |
| LHR | | | | | X | X | | | X | | LHR |
| ORY | | | | | X | | | | | | ORY |
| PTY | X | X | | | | | | | | | PTY |
| UIO | | | | X | | | | | | | UIO |
| GYE | | | | X | | | | | | | GYE |
| BOG | X | | | | X | | | | | | BOG |

totally out of date

They don't really share parts
—perhaps w/ alliances
Delta has $2.5 billion in parts
issue w/ counterfit parts

rotate spare parts
don't have hanger queens —airplanes for parts

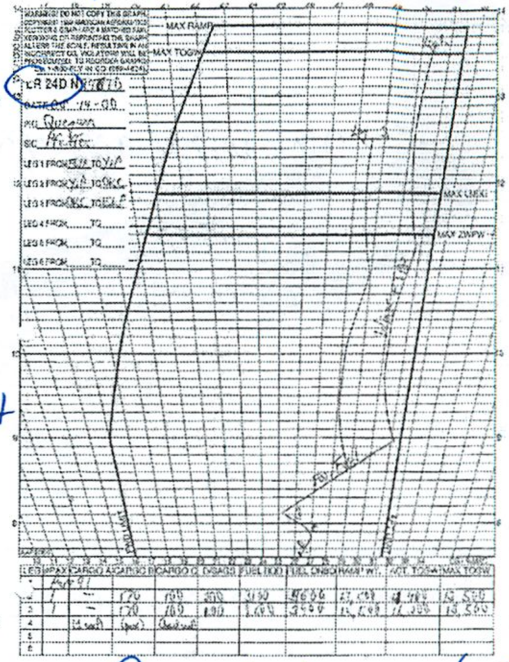
## Weight And Balance Data

```
******************** WEIGHT AND BALANCE DATA ******************

-----LOAD-----------TOTALS---------LIMITS------CMPT MAX---AS LDED--
EOW       204092  ZFW  256152  MZFW 288000   FC 35686    21217
PSGR WT    10920  FUEL  94000P >*< STD *<*   AC 25870     9593
CGO WT     35240  RMP  350152  MRMP 409000   AP  6456     1530
BALLAST        0  TXI    1100
                  TOW  349052
                               CNFIG F 14 P  0 C 30 Y163
                               PSGRS F 12 P  0 C 25 Y 79 W-0 X-0
CRT ADDRESS LOSS    AGENT ELSA GEREMEW   -V PHONE 967-7339
```

estimate avg person's weight
`was an accident where estimate was not updated to fatter america

## Example Weight And Balance Envelope



Weight

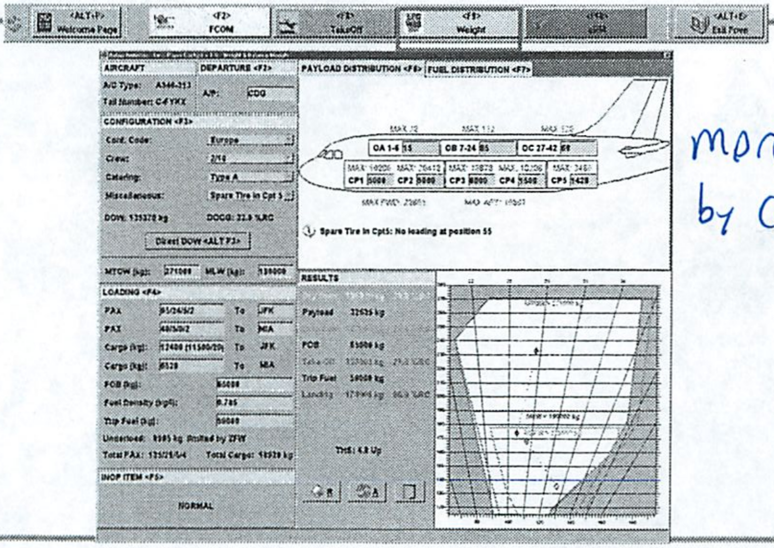
Center of Gravity

need to get it right to set proper trim

? where is location of CoG

Can only land w/ Certain amt of fuel

## Shifting Planning to the Cockpit
## A380 Weight & Balance Page



Spare Tire in Cpt5: No loading at position 55

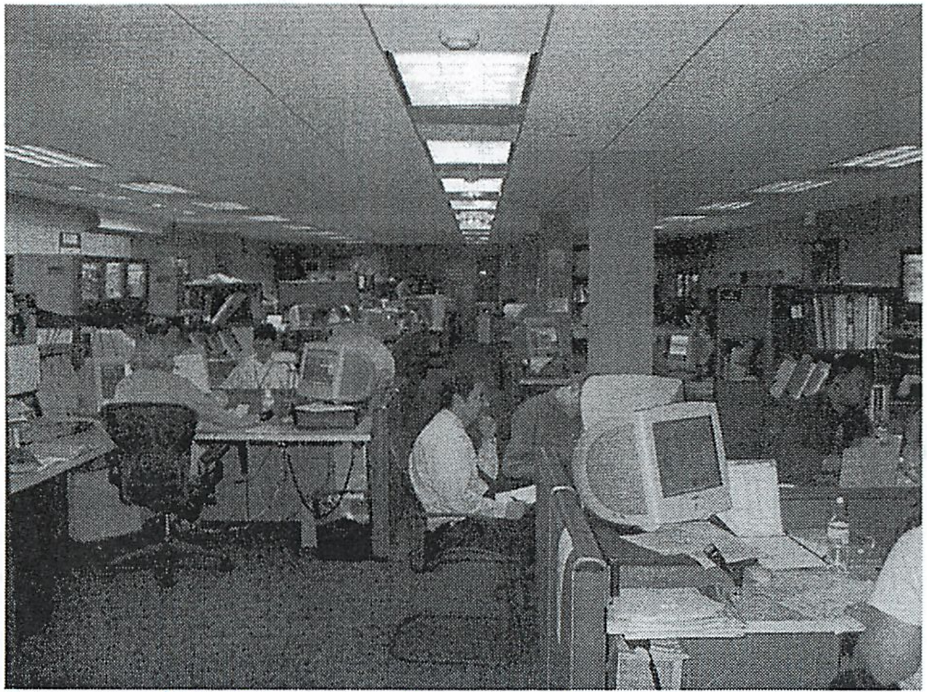
more done by crew

JetBlue Laptop Implementation

saves in labor cost

## Station Control

- Pax Service
- Gates
- Maintenance
- Baggage
- Load Planning (varies)
- De-Ice
- Push crews
- Security (FAM)



1st floor of Dullas airport

10/27

## Pax Service

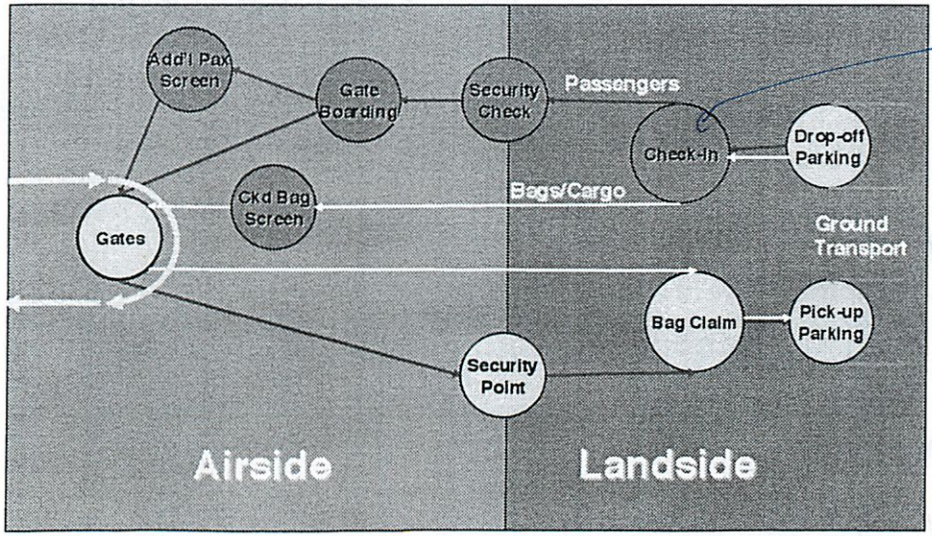
- **Ticketing**
- **Baggage Check-In**
- **Passenger Check In**
  - ☐ Terminal (Ticket Agents)
  - ☐ Gate (Gate Agents)
- **Security Screening**
  - ☐ ID and CAPPS Profile
  - ☐ Checked Bag Screen
  - ☐ Carry on Screen
- **Seat Assignment**
- **Upgrades**

) pain

- **Specials**
  - ☐ UM unacominied minor
  - ☐ Wheelchairs
  - ☐ Non-Rev
- **Boarding**
  - ☐ Ticket Count (Card Readers) –
  - ☐ Bag Check 100% checked bag screening – must pull bag
  - ☐ Closeout
- **Performance Metrics**

end of day

## Key Terminal System Flows

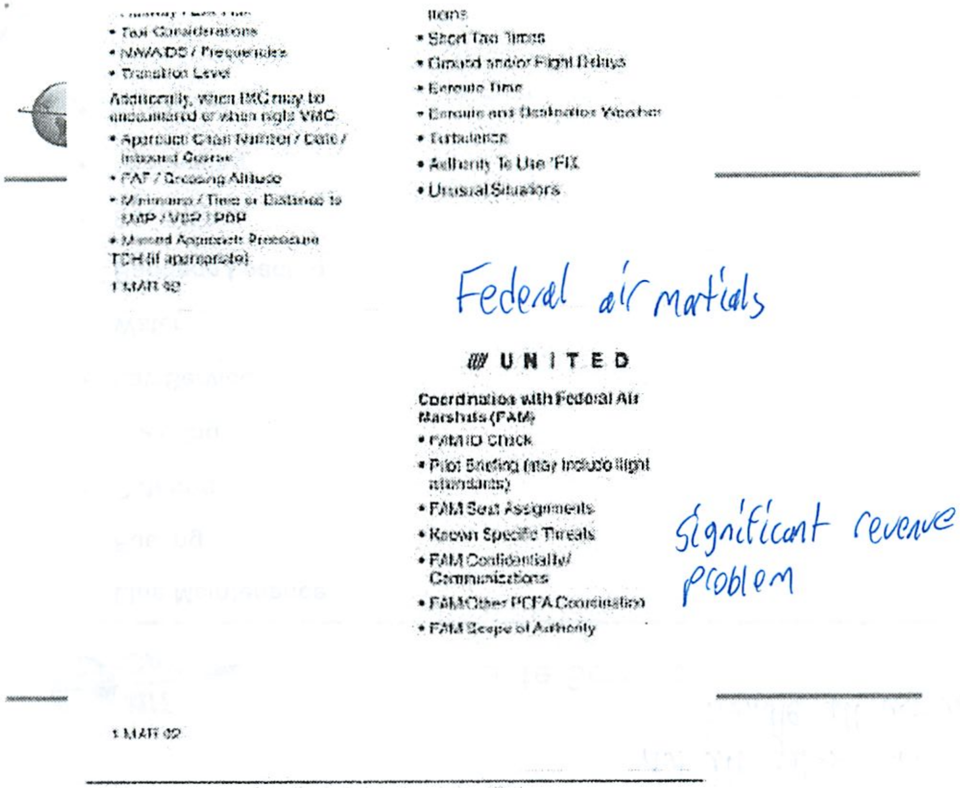


shaded circle are security issues

## CTX 9000 Explosive Detector

500 Bags/hr

20% false alarm rate



- Taxi Considerations
- NAVAIDS / Frequencies
- Transition Level

Additionally, when IMC may be encountered or when night VMC

- Approach Chart Number / Date / Inbound Course
- FAF / Crossing Altitude
- Minimums / Time or Distance to MAP / VDP / PDP
- Missed Approach Procedure

TCH (if appropriate)

1 MAR 02

Items

- Short Taxi Times
- Ground and/or Flight Delays
- Enroute Time
- Enroute and Destination Weather
- Turbulence
- Authority To Use 'FIX
- Unusual Situations

Federal air martials

UNITED

Coordination with Federal Air Marshals (FAM)

- FAM ID Check
- Pilot Briefing (may include flight attendants)
- FAM Seat Assignments
- Known Specific Threats
- FAM Confidentiality/ Communications
- FAM/Other PCFA Coordination
- FAM Scope of Authority

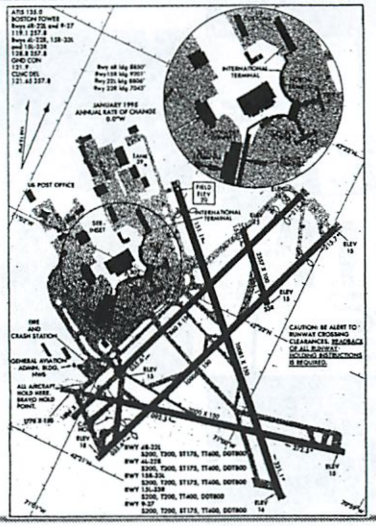
significant revenue problem

1 MAR 02

How manage gates

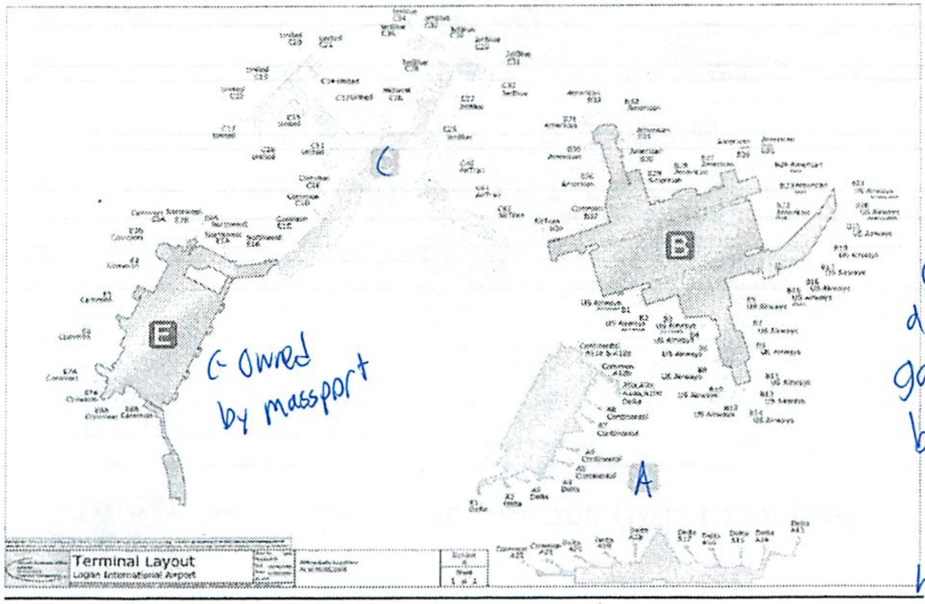
## Gates

### (eg KBOS Boston Logan International Airport)



- The nation's seventeenth busiest airport and the world's twenty-sixth busiest airport based on passenger volume
- In 1999 the airport served (494,816) flight operations and over 27 million passengers
- The sixth most delay-prone airport in the nation, one of the most constrained and complex airports
- Noise constraints due to proximity to downtown Boston
- 42 percent of the yearly operations are props and general aviation
- Not a hub airport

## Limited Gate Capacity



C

A

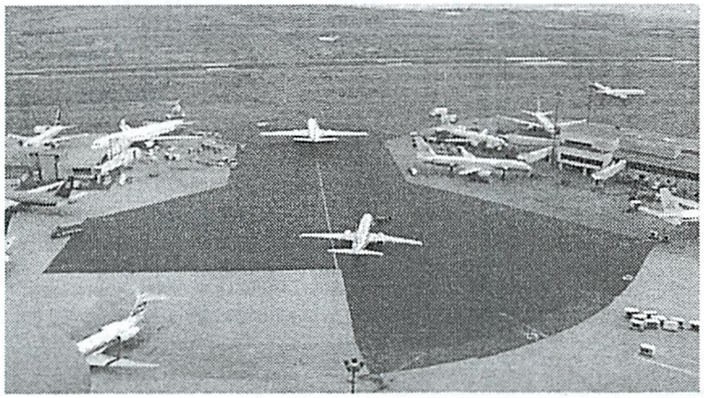
C owned by massport

gates move around - gates/terminal built by airlines

hard to move gates around

## "Horse Shoe" Alley

### Limited Capacity for Pushback and Ramp Operations, and Competition between Airlines



logan is particular bad

# Gate Restrictions (IAD Example)

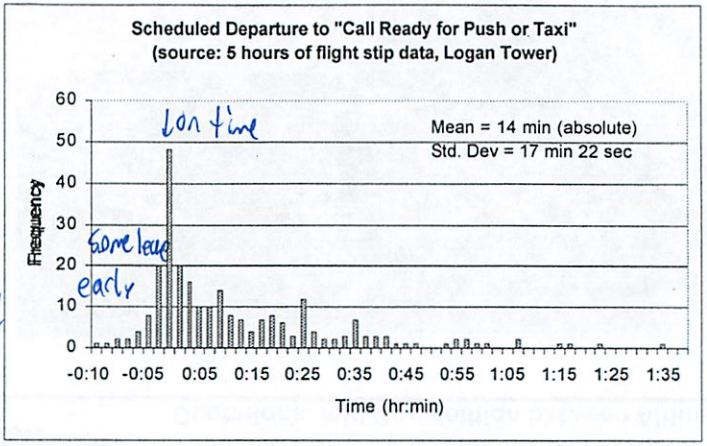
**DULLES C-GATE CAPABILITIES** REVISED 01/15/01

| C | 747 400 | 747 200 | 777 | 767 | 10/ 10 | 10/ 30 | DC 9 | 757 | 727 | 737 | 319 320 | B/S | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | X | X | X | X | X |  | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 27 spot, A340 gate now, A310-200 now A330/200 on 67 stop |
| 2 | X | X | X | X | X | X |  | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 27 spot, A340 gate now, A310-200 now A330/200 on 67 stop |
| 3 | X | X | X | X | X | X |  | X | X | X | X | Y | MD-11 gate, SP on 67 spot, DC-9/10 on 37 spot, A340 gate now, A310-200 now [1L/2L] |
| 4 |  | X | X | X | X | X |  | X | X | X | X | Y | MD-11 park on 10 spot, SP on 67 spot, DC-9/80 on 27 spot, A310-200 now A330/200 on 67 stop |
| 5 |  |  |  | X | X |  |  | X | R |  |  | Y | 727 storage only- NO jetway, A310-200 now |
| 6 |  |  |  | X | X | X |  | X | X | X | X | Y | A310-200 now |
| 7 |  |  | X | X | X | X |  |  |  |  | X | Y | 727 storage only- NO jetway, A310-200 now |
| 8 |  |  | X | X | X | X |  | X | X | X | X | Y | MD-11 park on 10 spot, A-310-200 now [A300]<br>NOTE: 727 or 737, PULL bridge away fm A/C and raise bridge to 767 height BEFORE moving to box |
| 9 | R | R | R | R | R | R |  |  | X | X | X | Y | <u>C11-Out of Service</u> w/67, 77, all 747, 10/10, 10/30, A340, MD11, A310 on C9<br><u>LUFTHANSA</u> WILL USE gate flying A340 on wide body line - <u>**SHUTS DOWN**</u> gate **C11** |
| 11 |  |  |  |  |  |  |  | R | R | R | R | Y | <u>C11 Out of Service</u> w/67, 77, 10/10, 10/30, A340, MD11, A310 on C9 |
| 12 |  |  | R | X | X |  |  | X | X | X | X | Y | No DC10-30, A310-200 now, 27,37,57,A-319-320 req tanker fill [A300]<br>777 on gate ***RESTRICTS*** *C14 to 737, 727 or A319/320* ***<u>ONLY</u>*** |
| 14 |  |  |  | R | R |  |  |  | X | X | Re | Y | DC-9/80 park on 67 spot. **A319** = e-<u>EMERGENCY ONLY</u> A319 MUST BE TANKER FILL<br>777 on gate C12 - ***RESTRICTS*** *gate to 737,727 or A320* ***<u>ONLY</u>*** |
| 16 |  |  |  |  |  |  |  | R |  | X |  | Y | 757 on C16 INOP C18. CL65 spot marked.<br>757/C16 w/ACA on C18 remote,757 first in, last out NO CL65 on C18 if 57 on C16<br>DC9/80 on C18 - <u>CL65 ONLY</u> an C16 |
| 17 |  |  |  | X | X |  |  | X | X | X | X | Y | NO ACFT on C17 w/mobile lounges on Intl arvl C19 [A300] |
| 18 |  |  |  |  |  |  | R |  |  | R |  | Y | DC-9/80 park on 37 spot,*<u>RESTRICTS C16 to CL-65 ONLY</u>*<br>757 on C16, INOP C18. CL-65 SPOT MARKED<br>NO CL65 w/57 on C16. A-319-320 on C20 <u>INOP</u> C18. OK UAX remote |
| 18R |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 |  |  |  | X | X |  |  | X | X | X | X | Y | DC-9/80 park on 37 spot. 67 Intl arvl ok JB on Int'l spot ***NO ACFT C17 til lounge leaves*** |
| 20 |  |  |  |  |  |  | X | R | R | X | R | Y | (R) 57on C20 INOP C18, C22 - CL65 O.K. NO RESTRICTIONS DC-9/80 park on 27 spot<br>(R)A319/320 on C20 -- C18 & C22 - CL65 O.K. NO RESTRICTIONS<br>727 on C20 INOP C-22. CL65 spot mrkd, 57 can arrive C20 w/UAX on C18 remote |
| 22 |  |  |  |  |  |  | R |  |  | R |  | Y | DC-9 park on 37 spot, *<u>RESTRICTS C24 to NO 757</u>*<br>CL65 spot mrkd, MD80, 27,57,A319-320 on C20 INOP C22<br>CL65 on C22 - CANNOT have 27,57,A319-320 on C20 |
| 22R |  |  |  |  |  |  |  |  |  | Xx |  |  | Xx = CL65 on 737 SPOT - 737 REQUIRES REMOTE STAIR AVAILABILITY |
| 23 |  |  |  | X | X |  |  | X | X | X | X | Y | [A300] |
| 24 |  |  |  |  |  |  |  | R | X | X | [illegible] | Y | DC-9 on C22 *RESTRICTS C24 to NO 757*<br>57 on gate <u>NO</u> A319/320 on C26. DC-9/80 park on 27 spot<br>NO 57, A320 w/inop APU,ground power WON'T support<br>CL65 on 727 spot - <u>no jet bridge</u> |
| 26 |  |  |  | R | R |  |  | R | X | X | R | Y | DC-9/80 park on 67 spot (R) 67,10/10,10/30 on C26 INOP C28 (R),<br>(R)A319/320 on C26 - NO 757 on C24 wingtip pass-by<br>27,37,57 on C28 WILL block C-26, 57 on C26 must be first in, last out<br>757 on C24 NO A319/320 on C26 |

width
weight
if too
close to road
need to
shut down
engines

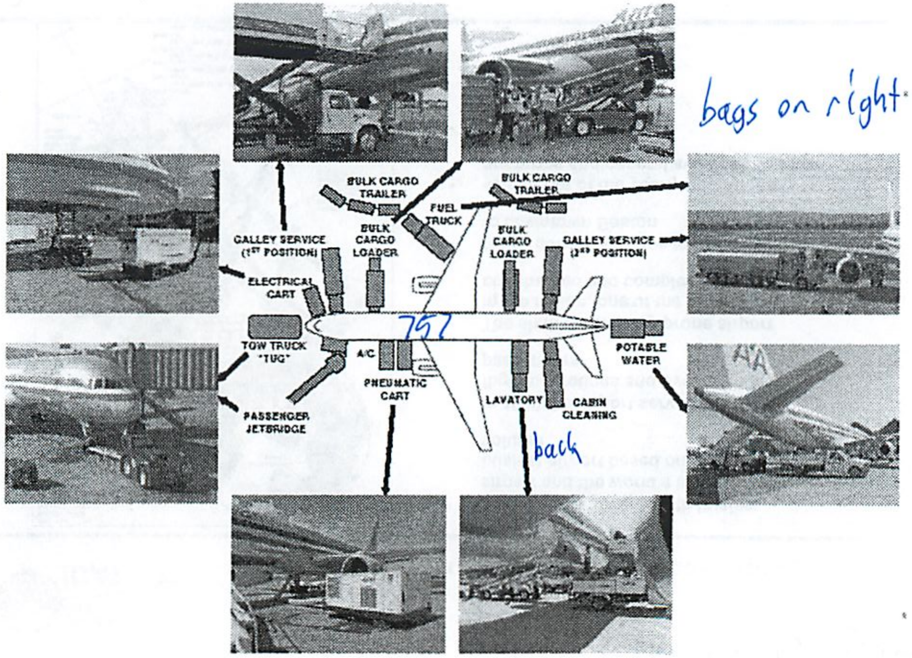
not all gates can
handle all aircraft

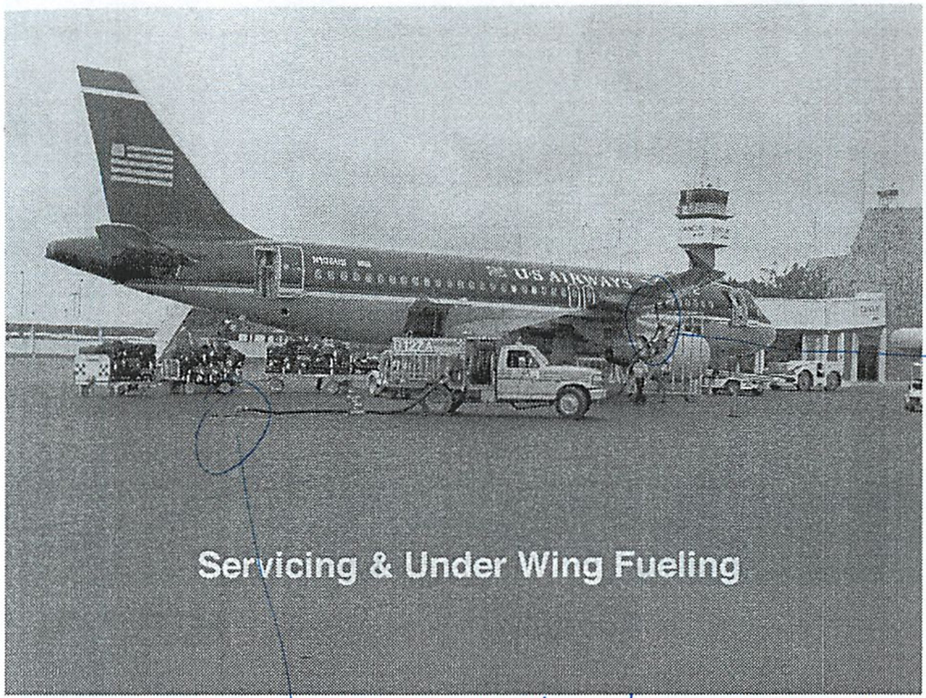
# Low Predictability of Departure Demand based on Schedule


Scheduled Departure to "Call Ready for Push or Taxi"
(source: 5 hours of flight stip data, Logan Tower)

# Gate Service

- Line Maintenance
- Fueling
- Catering
- Cleaning
- Lav Service
- Water
- Baggage Loading
- Security
- Marshaling
- Pushback



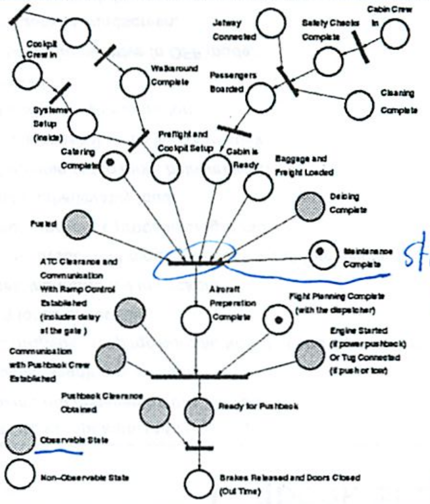


Servicing & Under Wing Fueling

w/ pressure

Underground line in most airports
just pump truck

# On Gate Departure Preparation



states that have to be complete before next step

Petri Net Analysis

LCCs want rapid turnaround
Southwest .5 hrs

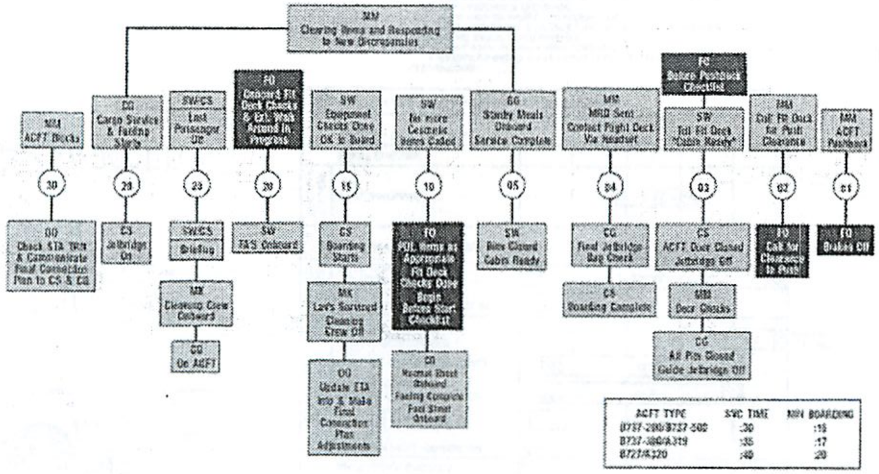
---

**UNITED**

14.20.7
Administration
5 AUG 01 Operating Policies and Rules

30 MINUTE TIMELINE

Countdown

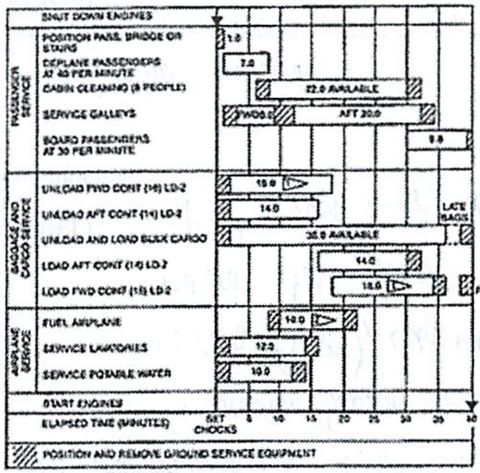


| ACFT TYPE | SVC TIME | MIN BOARDING |
|---|---|---|
| B737-200/B737-500 | :30 | :15 |
| B737-300/A319 | :35 | :17 |
| B727/A320 | :40 | :20 |

---

## Turnaround Tasks

## B 767-300ER



ASSUMPTIONS:
- ESTIMATES BASED ON 18 FIRST-CLASS AND 251 TOURIST PASSENGER MIX WITH 100% LOAD FACTOR.
- FRONT ENTRY DOOR LOADING.
- FUEL RATE OF 800 GPM (3029 LPM) UP TO 12,700 GAL (48,244 L), THEN RATE CHANGES TO 350 GPM (1325 LPM).
- THIS DATA IS PROVIDED TO ILLUSTRATE THE GENERAL SCOPE AND TYPES OF TASKS INVOLVED IN TERMINAL OPERATIONS. VARYING AIRLINE PRACTICES AND OPERATING CIRCUMSTANCES THROUGHOUT THE WORLD WILL RESULT IN DIFFERENT SEQUENCES AND TIME INTERVALS TO ACCOMPLISH THE TASKS SHOWN. BECAUSE OF THIS, GROUND OPERATIONS REQUIREMENTS SHOULD BE COORDINATED WITH THE USING AIRLINES PRIOR TO RAMP PLANNING.

▷ WITH THE LARGE CARGO DOOR BULK [illegible] LOADED/UNLOADED IN APPROXIMATELY 3 MINUTES.

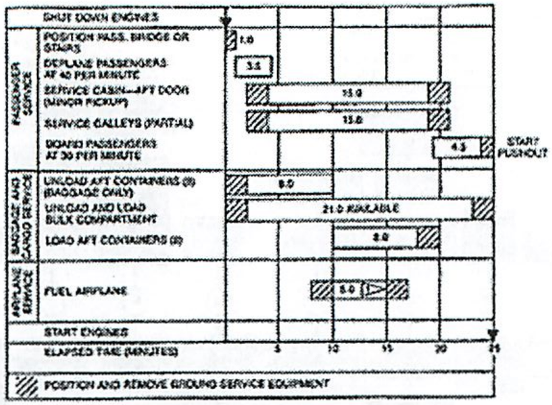
▷ 15 MINUTES AVAILABLE FOR 300ER

Source: Boeing Airport Characteristics for Airport Planning

Source: 767 Airplane Characteristics for Airport Planning, Boeing Aircraft Co., February 1989

## Optimized Turnaround Tasks

B 767-300ER



ASSUMPTIONS:
- ESTIMATES BASED ON 24 FIRST-CLASS AND 237 TOURIST PASSENGER MIX WITH 100% LOAD FACTOR.
- FRONT ENTRY DOOR LOADING.
- FUEL RATE OF 800 GPM (3028 LPM) UP TO 16,700 GAL (63,214 L). THEN RATE CHANGES TO 310 GPM (1173 LPM).
- 50% PASSENGER EXCHANGE.
- THIS DATA IS PROVIDED TO ILLUSTRATE THE GENERAL SCOPE AND TYPES OF TASKS INVOLVED IN TERMINAL OPERATIONS. VARYING AIRLINE PRACTICES AND OPERATING CIRCUMSTANCES THROUGHOUT THE WORLD WILL RESULT IN DIFFERENT SEQUENCES AND TIME INTERVALS TO ACCOMPLISH THE TASKS SHOWN. BECAUSE OF THIS, GROUND OPERATIONS REQUIREMENTS SHOULD BE COORDINATED WITH THE USING AIRLINES PRIOR TO RAMP PLANNING.

▷ 11 MINUTES AVAILABLE FOR [illegible]

*Source: 767 Airplane Characteristics for Airport Planning,* Boeing Aircraft Co., February 1989.

**Figure 12-4** Boeing's Assessment of Efficient Transit

---

important dispatch reliability
- important in selling

## Maintenance

- Line Maintenance
  - ☐ Line Replaceable Units
  - ☐ ACARS Codes
  - ☐ Logbooks
- **Maintenance Stations**
- **In-Flight Support**
  - call maint. staff
- **ACARS**
  - ☐ Discrepancy Reporting
  - ☐ Engine Monitoring
- **Minimum Equipment List (MEL)**
- **Progressive Maintenance Schedule**
  - ☐ A Check (overnight)
  - ☐ B Check
  - ☐ C Check
  - ☐ D Check (major overhaul) redo interior from scratch
    ↳ 4-5 years

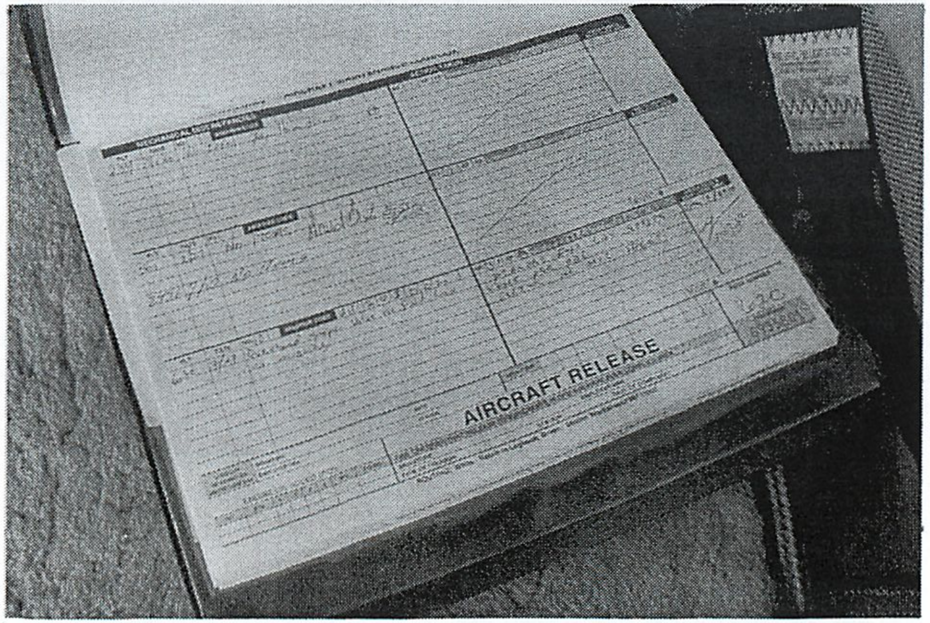
fast maintenance in 1 hr turnover
- if problem known ahead a time (during flight), can email ahead maint. staff meet plan w/ part = just swap the unit

know curve where engine starts to degrade →

you buy engines ~~different~~ sepertly from airplane

---

## Logbook



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## Logbook Entries

- Pilot: Test flight OK, except autoland very rough.
- *Mechanic: Autoland not installed on this aircraft.*
- Pilot: No. 2 propeller seeping prop fluid.
- *Mechanic: No. 2 propeller seepage normal. Nos. 1, 3 and 4 propellers lack normal seepage.*
- Pilot: Something loose in cockpit.
- *Mechanic: Something tightened in cockpit.*
- Pilot: Autopilot in altitude-hold mode produces a 200-fpm descent.
- *Mechanic: Cannot reproduce problem on ground.*
- Pilot: DME volume unbelievably loud.
- *Mechanic: DME volume set to more believable level.*
- Pilot: Friction locks cause throttle levers to stick.
- *Mechanic: That's what they're there for!*
- Pilot: IFF inoperative.
- *Mechanic: IFF always inoperative in OFF mode.*
- Pilot: Suspected crack in windscreen.
- *Mechanic: Suspect you're right.*
- Pilot: Number 3 engine missing.
- *Mechanic: Engine found on right wing after brief search.*
- Pilot: Aircraft handles funny.
- *Mechanic: Aircraft warned to straighten up, fly right, and be serious.*

## Fueling

- **Fuel Slip**
  - ☐ Original Fuel Load from Dispatcher
  - ☐ Captain can supplement
  - ☐ Quantity (typical load 100,000 lbs. +)
  - ☐ Location
    - ◆ Wing, Fuselage, Tail
- **Source**
  - ☐ In-ground fuel points
  - ☐ Tankers
- **Contractors**
  - ☐ Fuel Flow Charges, Fees and Taxes
- **Tankering**

Want COG to be as far back in airplane

fuel cost varries in different location

now only do this in 3rd world
catering too

## Baggage & Cargo

- **Types**
  - ☐ Passenger Bags
  - ☐ Cargo - important on some routes
  - ☐ Mail - stopped after 9/11, FedEx does it now
  - ☐ Live Cargo (e.g. Animals) horses
  - ☐ Hazardous Cargo (Dry Ice, Nuclear) ValueJet
  - ☐ Organs- Medical
  - ☐ Company Materials ATC preference
- **Standard Containers**
  - ☐ Loaders
- **Coding and Tracking**
  - ☐ Positive Bag Match

in small planes load each bag by hand

large use these containers

## De-Icing

- **Required when Ice or Snow on Wings**
- **Fluid Types**
  - ☐ Type 1 - Glycol-Water
  - ☐ Type 2-4 - Thixiotropic with Glycol
- **De-Icing Trucks**
- **Hold Over Times**

antifreeze, heated

to prevent snow from sticking until takeoff

## De-Icing

- **Type 1 and Type 2 Fluids**
- **De-Icing Hold Over Times**

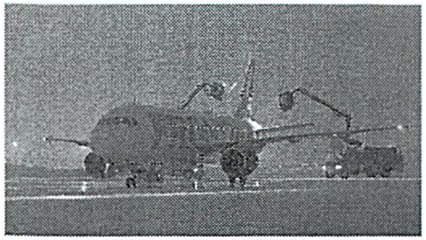
On MD-80
fuel in wing freezes
lands in humid areas
Clear ice forms

Paint wing black to hide ice

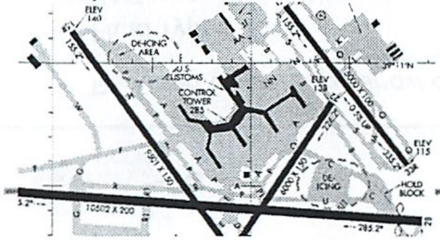
#1 cause ~~#~~of damage to airplanes is people driving ~~into~~ trucks to airplanes

## Aircraft De-Icing

- **Aircraft being de-iced at BWI**



- **Designated de-icing areas at some airports**



- **<u>De-Icing Fluids</u>: composed of ethylene glycol or propylene glycol, thickening agents, corrosion inhibitors, and colored dye.**

  **Propylene glycol is more common (less toxic than ethylene glycol)**
- **For four types of deicing fluids:**
  - ❑ Type I:
    - ◆ low viscosity,
    - ◆ short term protection,
    - ◆ sprayed on hot at high pressure to remove snow, ice, and frost,
    - ◆ dyed orange.
  - ❑ Type II: "pseudoplastic"
    - ◆ high viscosity ( with thickening agents),
    - ◆ remain in place until the aircraft attains 100 knots.
  - ❑ Type III: compromise between type I and type II fluids.
    - ◆ used for slower aircraft.
  - ❑ Type IV: same viscosity as type II fluids
    - ◆ longer holdover time,
    - ◆ typically dyed green.
- **Fluid performance measured by holdover time**
  - ❑ Holdover time influenced by:
    - ◆ ambient temperature, wind, precipitation, humidity
  - ❑ Holdover time: Type I – 15 minutes  
    Type IV – 30 and 80 minutes
- **Deicing fluids are toxic**
  - ❑ Airports have designated areas where the fluid is collected

**Source: [Picture: Airliners.net], [Map: Airnav] and *"Approved Deicing Program Updates", Winter 2004-2005.***

## Push Back

- **Push Crew**
  - ❑ Tug Driver
  - ❑ Talker
  - ❑ Wing Walkers
- **Ramp Control**
  - ❑ Push Back Clearance
- **Push**
- **Clearance for Engine Start**
  - ❑ Ingestion Hazards
  - ❑ APU vs. Power Cart Start
- **Release from Flight Guidance**

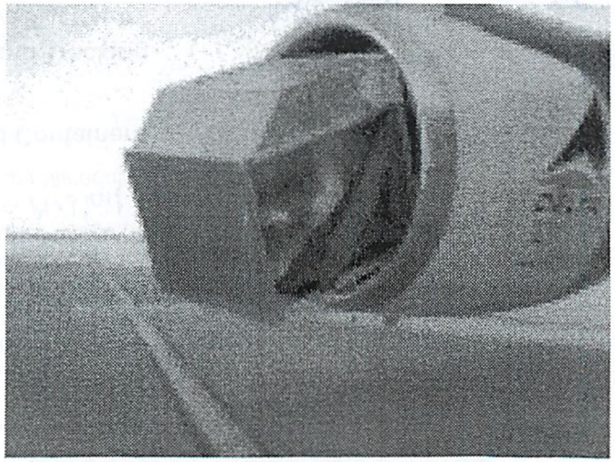
salute

need air from some source
- small engine in back starts
- runs ac
- so turn off ac to use air to start engine

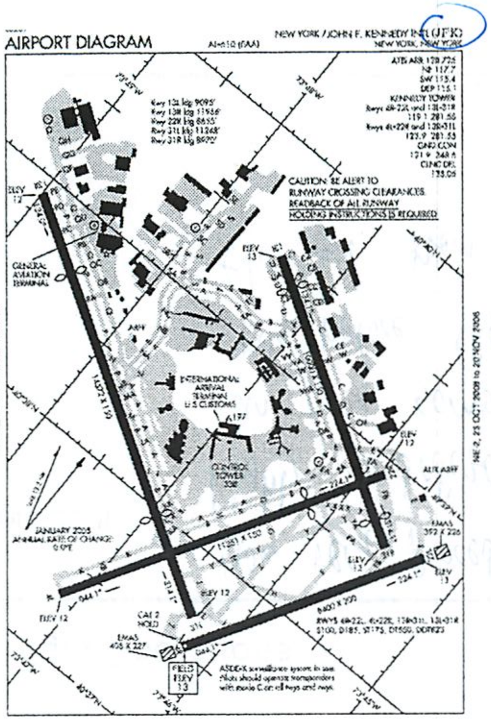
## Tow Bar & Chocks

## Cargo Container Ingestion

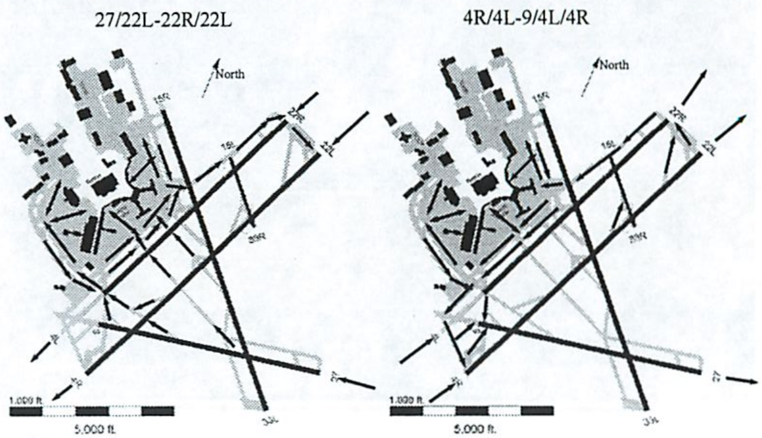
pull in lots of air



Taxi



## Runway Configuration Flow Patterns



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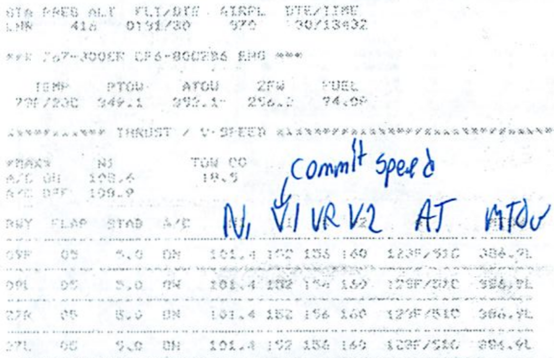
## Runway Performance (De-Rate) V-Speeds



```
STA PRES ALT  FLT/DTE  AIRPL  DTE/TIME
LHR   416    0191/30   970    30/13432

*** 767-300ER CF6-80C2B6 ENG ***

  TEMP     PTOW    ATOW    ZFW    FUEL
 73F/23C  349.1   392.1   256.2   74.0P

*********** THRUST / V-SPEED ***********************************

*MAX*     N1         TOW CG
A/C ON   108.6        19.5
A/C OFF  109.9

RWY  FLAP  STAB  A/C
--------------------------------------------------------------
09R   05    5.0  ON   101.4 152 156 160  123F/51C  386.9L
--------------------------------------------------------------
09L   05    5.0  ON   101.4 152 156 160  123F/51C  386.9L
--------------------------------------------------------------
27R   05    5.0  ON   101.4 152 156 160  123F/51C  386.9L
--------------------------------------------------------------
27L   05    5.0  ON   101.4 152 156 160  123F/51C  386.9L
--------------------------------------------------------------
```

commit speed

N1 V1 VR V2 AT MTOW

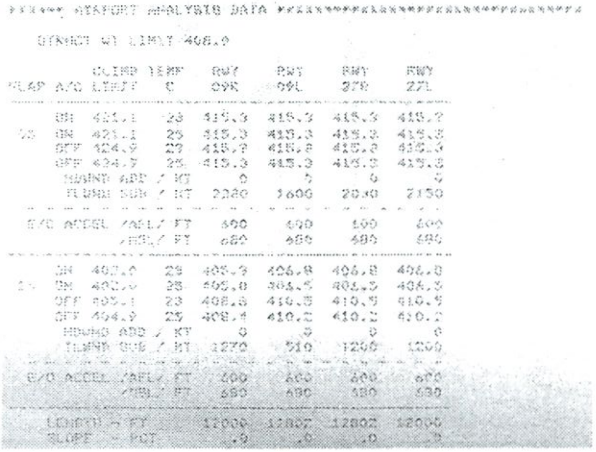
Speed dependant on weight

**V1 = Decision Speed**
**VR = Rotation Speed**
**V2 = Engine Out Climb**
**Bugs**

if something goes bang at $V_1$
- abort?
- if blew a tire - no! can't break

---

## Runway Performance Data Max Weights for runways



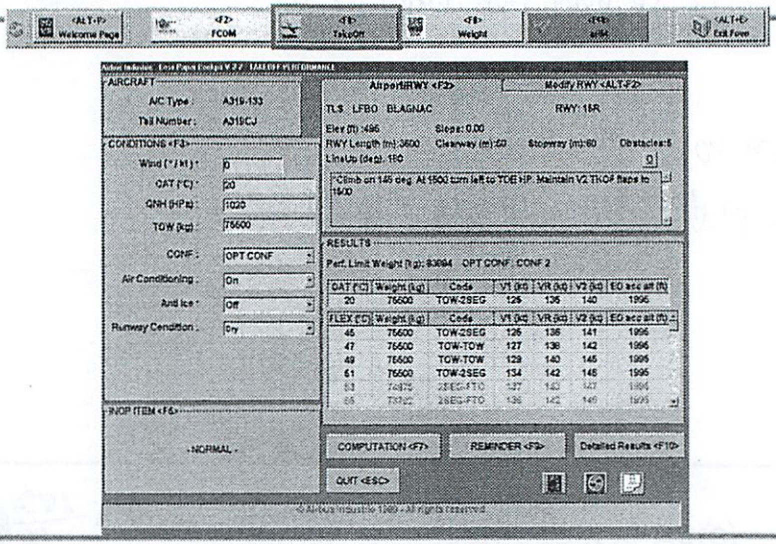
```
****** AIRPORT ANALYSIS DATA ***********************************

  STRUCT WT LIMIT 408.9

          CLIMB TEMP   RWY    RWY    RWY    RWY
FLAP A/C  LIMIT   C    09R    09L    27R    27L
--------------------------------------------------------
      ON  421.1   23  415.3  415.3  415.3  415.3
 05   ON  421.1   25  415.3  415.3  415.3  415.3
     OFF  424.9   23  415.3  415.3  415.3  415.3
     OFF  424.7   25  415.3  415.3  415.3  415.3
      HDWND ADD / KT      0      0      0      0
      TLWND SUB / KT   2280   1600   2040   2150
 - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 E/O ACCEL /AFL/ FT     600    600    600    600
           /MSL/ FT     680    680    680    680
--------------------------------------------------------
      ON  402.0   23  405.9  406.8  406.8  406.8
 15   ON  402.0   25  405.0  404.5  404.5  404.5
     OFF  405.1   23  408.8  410.5  410.5  410.5
     OFF  404.9   25  408.4  410.2  410.2  410.2
      HDWND ADD / KT      0      0      0      0
      TLWND SUB / KT   1270    510   1200   1200
 - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 E/O ACCEL /AFL/ FT     600    600    600    600
           /MSL/ FT     680    680    680    680
--------------------------------------------------------
   LENGTH - FT        12000  12807  12802  12000
   SLOPE  - PCT          .9     .0     .0     .9
```

**Flap Settings**
**APU On or Off**

## A380 TakeOff Page



Airbus Industrie Less Paper Cockpit V 2.2 - TAKEOFF PERFORMANCE

AIRCRAFT
A/C Type : A319-133
Tail Number : A319CJ

CONDITIONS <F3>
Wind (°/kt) : 0
OAT (°C) : 20
QNH (HPa) : 1020
TOW (kg) : 75600
CONF : OPT CONF
Air Conditioning : On
Anti Ice : Off
Runway Condition : Dry

INOP ITEM <F6>
- NORMAL -

Airport/RWY <F2> | Modify RWY <ALT-F2>

TLS LFBO BLAGNAC RWY: 15R
Elev (ft) :496 Slope: 0.00
RWY Length (m):3500 Clearway (m):60 Stopway (m):60 Obstacles:5
LineUp (deg): 150 0

"Climb on 145 deg. At 1500 turn left to TOE HP. Maintain V2 TKOF flaps to 1500

RESULTS
Perf. Limit Weight (kg): 83884 OPT CONF : CONF 2

| OAT (°C) | Weight (kg) | Code | V1 (kt) | VR (kt) | V2 (kt) | EO acc alt (ft) |
|---|---|---|---|---|---|---|
| 20 | 75600 | TOW-2SEG | 125 | 135 | 140 | 1996 |

| FLEX (°C) | Weight (kg) | Code | V1 (kt) | VR (kt) | V2 (kt) | EO acc alt (ft) |
|---|---|---|---|---|---|---|
| 45 | 75600 | TOW-2SEG | 126 | 136 | 141 | 1996 |
| 47 | 75600 | TOW-TOW | 127 | 138 | 142 | 1996 |
| 49 | 75600 | TOW-TOW | 129 | 140 | 145 | 1995 |
| 51 | 75600 | TOW-2SEG | 134 | 142 | 148 | 1995 |
| 53 | 74875 | 2SEG-FTO | 137 | 143 | 147 | 1996 |
| 55 | 73722 | 2SEG-FTO | 136 | 142 | 149 | 1995 |

COMPUTATION <F7> | REMINDER <F9> | Detailed Results <F10>
QUIT <ESC>

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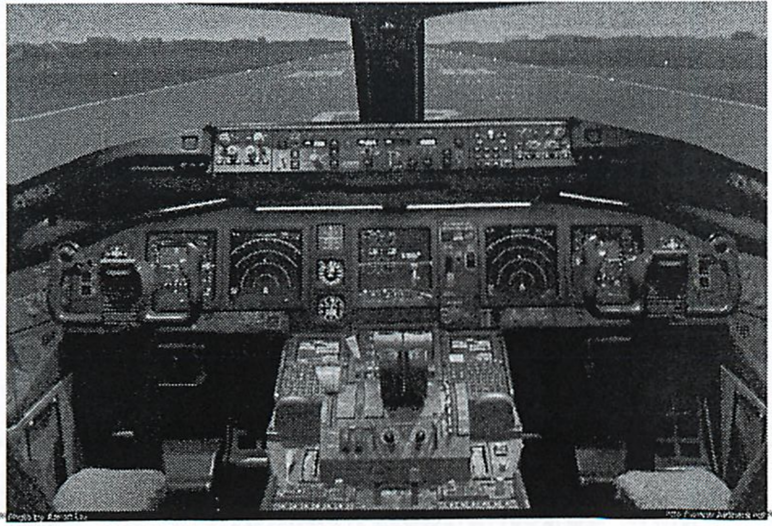
## Takeoff Video

## Flight Operations

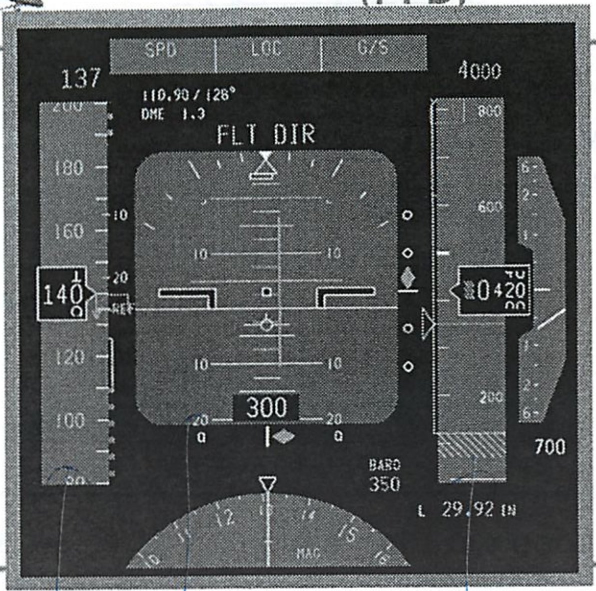
- **Procedures**
  - ☐ Flight Crew Operating Manual (FCOM)
  - ☐ Checklists
    - ◆ Standard
      - ➪ Preflight
      - ➪ Push-Back
      - ➪ Engine Start
      - ➪ Taxi
      - ➪ Takeoff
      - ➪ After-Takeoff
      - ➪ In-Range
      - ➪ Descent
      - ➪ Approach Briefing
      - ➪ Before Landing
      - ➪ After Landing
      - ➪ Shutdown
    - ◆ Emergency

how very procedural
highly standardized
Can meet someone 15
min before flight +
fly w/ them

## B777 Cockpit



# Primary Flight Display (PFD)



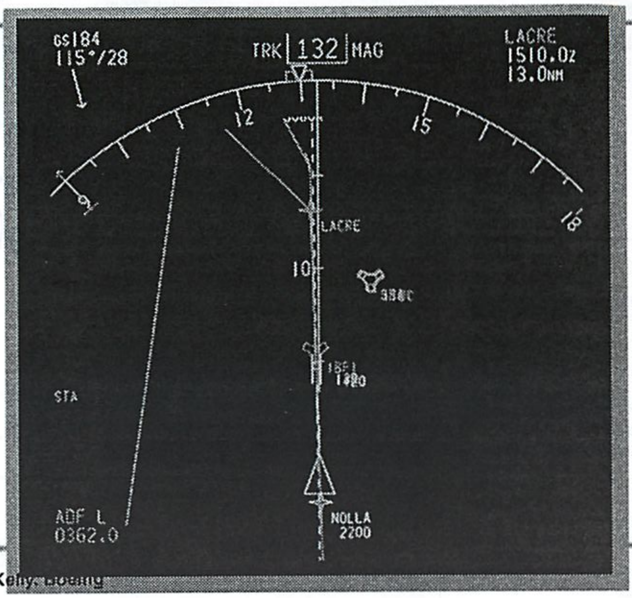
Source: Brian Kelly, Boeing

missed some

altitude

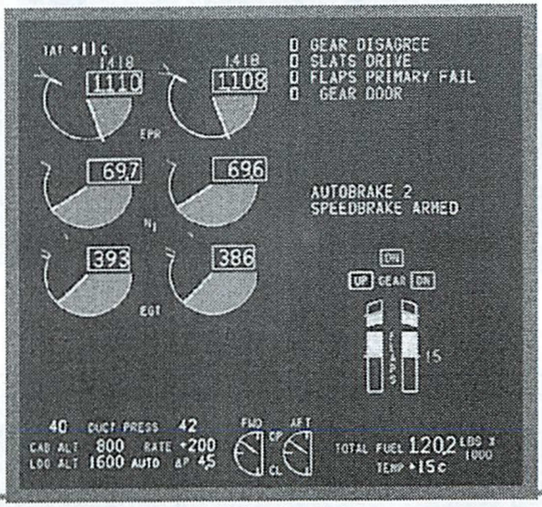
vertical speed

# Navigation Display (ND)



Source: Brian Kelly, Boeing

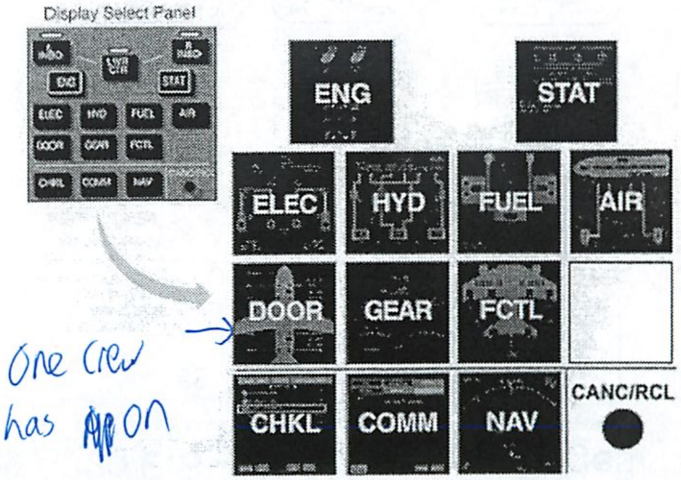
# 777 EICAS



Source: Brian Kelly, Boeing

engine system

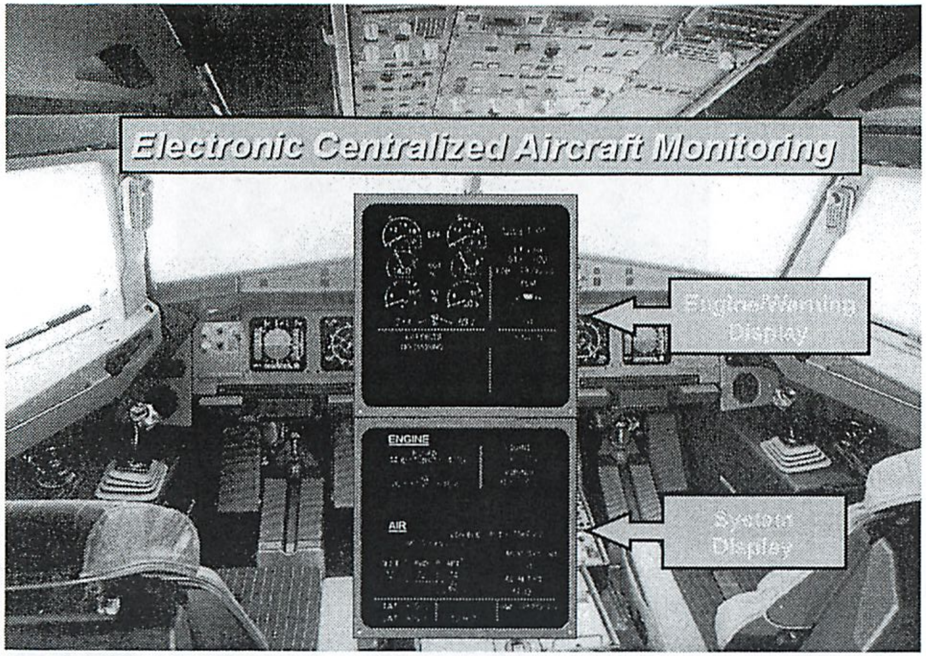
# Multifunction Display Management



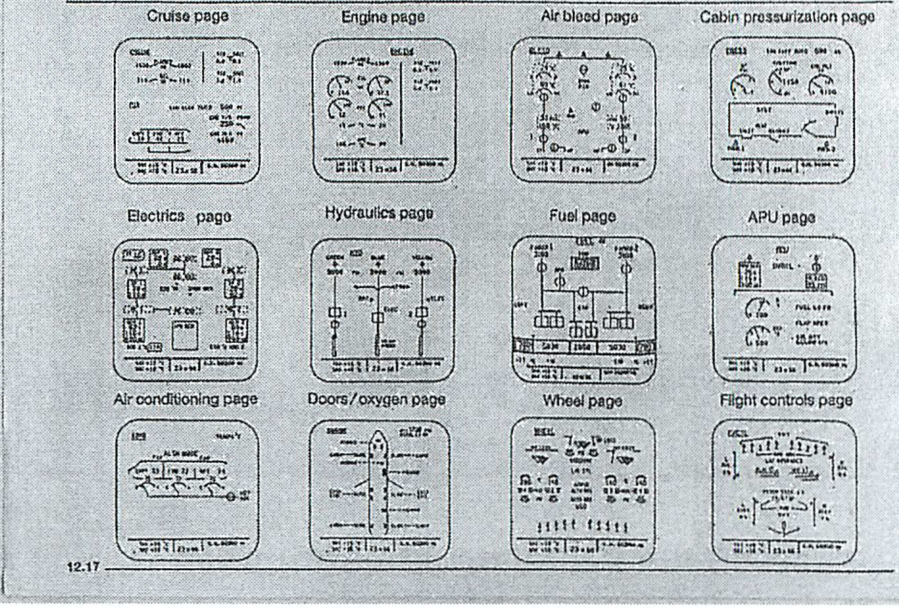
One crew has ~~app~~ on

Source: Brian Kelly, Boeing

## Electronic Centralized Aircraft Monitoring



## A320 EIS - ECAM system pages



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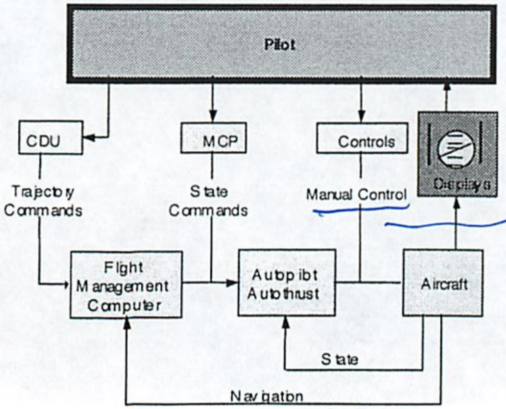
## Vehicle Control Loops

automation
is 95% of
flight



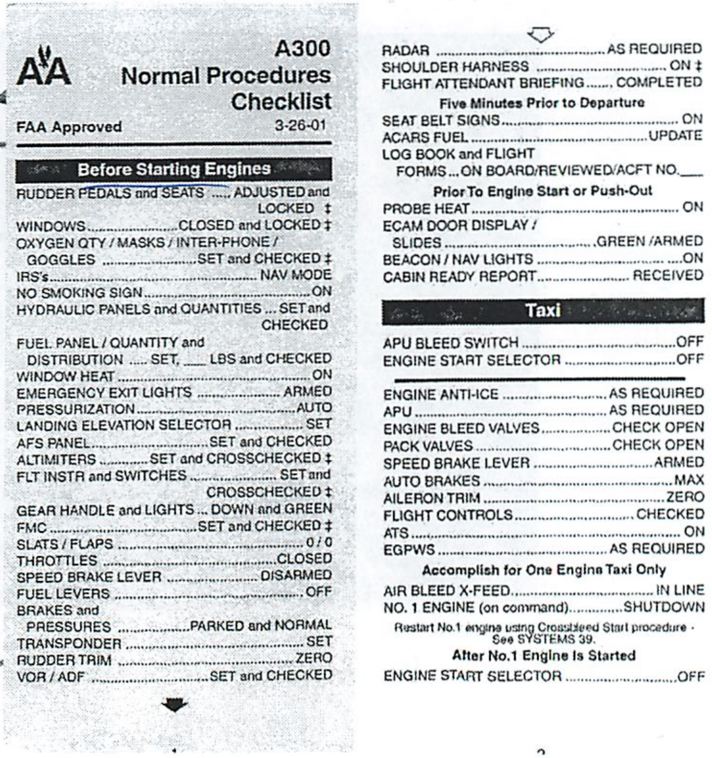
On modern aircraft via computer

Envelope Protection: Hard vs Soft Limits

---

## Normal Procedures Checklist Example

challenge response b/w piolets



**A300**
**Normal Procedures Checklist**

FAA Approved 3-26-01

### Before Starting Engines

RUDDER PEDALS and SEATS ..... ADJUSTED and LOCKED ‡
WINDOWS ........ CLOSED and LOCKED ‡
OXYGEN QTY / MASKS / INTER-PHONE / GOGGLES ........ SET and CHECKED ‡
IRS's ........ NAV MODE
NO SMOKING SIGN ........ ON
HYDRAULIC PANELS and QUANTITIES ... SET and CHECKED
FUEL PANEL / QUANTITY and DISTRIBUTION ..... SET, ___ LBS and CHECKED
WINDOW HEAT ........ ON
EMERGENCY EXIT LIGHTS ........ ARMED
PRESSURIZATION ........ AUTO
LANDING ELEVATION SELECTOR ........ SET
AFS PANEL ........ SET and CHECKED
ALTIMITERS ........ SET and CROSSCHECKED ‡
FLT INSTR and SWITCHES ........ SET and CROSSCHECKED ‡
GEAR HANDLE and LIGHTS ... DOWN and GREEN
FMC ........ SET and CHECKED ‡
SLATS / FLAPS ........ 0 / 0
THROTTLES ........ CLOSED
SPEED BRAKE LEVER ........ DISARMED
FUEL LEVERS ........ OFF
BRAKES and PRESSURES ........ PARKED and NORMAL
TRANSPONDER ........ SET
RUDDER TRIM ........ ZERO
VOR / ADF ........ SET and CHECKED

RADAR ........ AS REQUIRED
SHOULDER HARNESS ........ ON ‡
FLIGHT ATTENDANT BRIEFING ...... COMPLETED

**Five Minutes Prior to Departure**

SEAT BELT SIGNS ........ ON
ACARS FUEL ........ UPDATE
LOG BOOK and FLIGHT FORMS ... ON BOARD/REVIEWED/ACFT NO.___

**Prior To Engine Start or Push-Out**

PROBE HEAT ........ ON
ECAM DOOR DISPLAY / SLIDES ........ GREEN /ARMED
BEACON / NAV LIGHTS ........ ON
CABIN READY REPORT ........ RECEIVED

### Taxi

APU BLEED SWITCH ........ OFF
ENGINE START SELECTOR ........ OFF

ENGINE ANTI-ICE ........ AS REQUIRED
APU ........ AS REQUIRED
ENGINE BLEED VALVES ........ CHECK OPEN
PACK VALVES ........ CHECK OPEN
SPEED BRAKE LEVER ........ ARMED
AUTO BRAKES ........ MAX
AILERON TRIM ........ ZERO
FLIGHT CONTROLS ........ CHECKED
ATS ........ ON
EGPWS ........ AS REQUIRED

**Accomplish for One Engine Taxi Only**

AIR BLEED X-FEED ........ IN LINE
NO. 1 ENGINE (on command) ........ SHUTDOWN

Restart No.1 engine using Crossbleed Start procedure - See SYSTEMS 39.

**After No.1 Engine Is Started**

ENGINE START SELECTOR ........ OFF

AA AMERICAN AIRLINES - FLIGHT TRAINING
A300 Flight Training Manual

## Summary of Standard Litany/Actions

**Normal Take-Off**
At TOGA
"Thrust," "SRS," "Runway" (or "Heading")
"V1"
"Rotate"
"V2"
"V2 + 10"
At positive rate of climb,
"Positive Rate, Gear Up."

At 1000':
"Check Speed, Level Change."

At "F" speed:
"Flaps Up." (if 15 or 20) "Climb Power."

At "S" speed:
"Slats Retract."

**All Engine Go-Around**
Press TOGA levers.
"Flaps."
"Positive Rate, Gear Up."
"Set missed approach altitude."

"NAV."(if required)

At 1000':
Check Speed, Level Change."

At "F" speed:
"Flaps Up. Climb Power."

AT "S" speed:
"Slats Retract."

**Take-Off With Engine Failure After V1**
At TOGA
"Thrust," "SRS," "Runway" (or "Heading")
"V1"
"Rotate"
"V2"
"V2 + 10"
At positive rate of climb,
"Positive Rate, Gear Up."

At 1000' or obstruction clearance altitude
"Check Speed, Altitude Hold."

At "F" speed:
"Flaps Up." (if 15 or 20)

At "S" speed: (if returning for immediate landing)
"Level Change."
"Set 'S' Speed."
"MCT"

AT 1000':
"Auto-Pilot and Auto-Throttle On."

**One Engine Approach and Go-Around**
Press TOGA levers.
"Flaps."
"Positive Rate, Gear Up."
"Set missed approach altitude."

"NAV." (if required)

At 1000':
"Check Speed, Altitude Hold."

At "F" speed:
"Flaps UP."

At "S" speed: (if returning to land)
Level Change. Set 'S' speed. MCT"

When above 1000'
"Auto-Pilot and Auto-Throttle ON."

10/1/99 - 17 - Maneuvers and Profiles

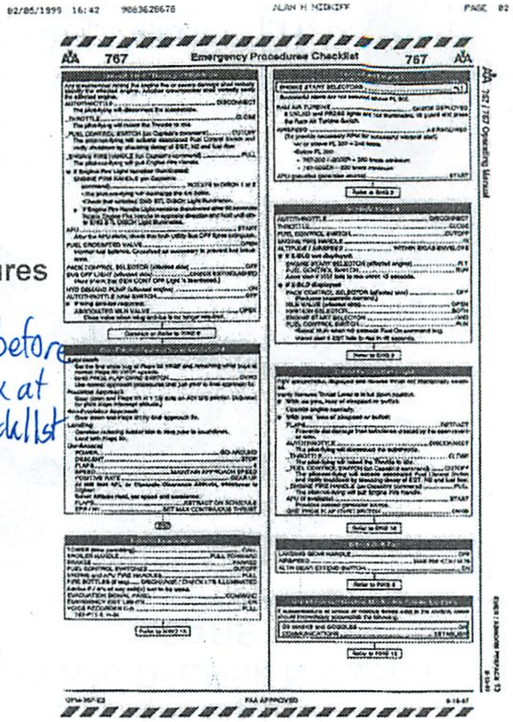
---

## Checklist Example "Quick Reference" Emergency Procedures

- Memory Items - do before
- Checklist Items look at checklist

- Aviate
- Navigate
- Communicate

laminated quick sheet


02/05/1999 16:42 9083628676 ALAN H MIDKIFF PAGE 02

AA 767 Emergency Procedures Checklist 767 AA

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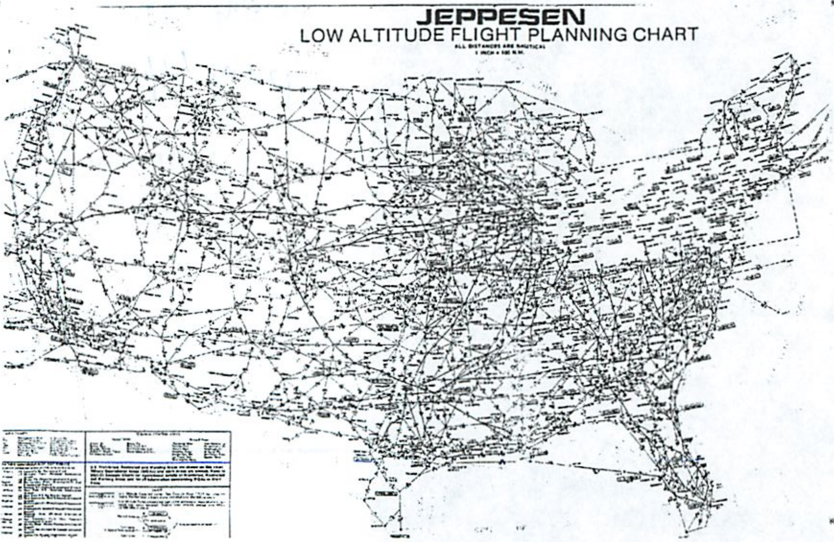
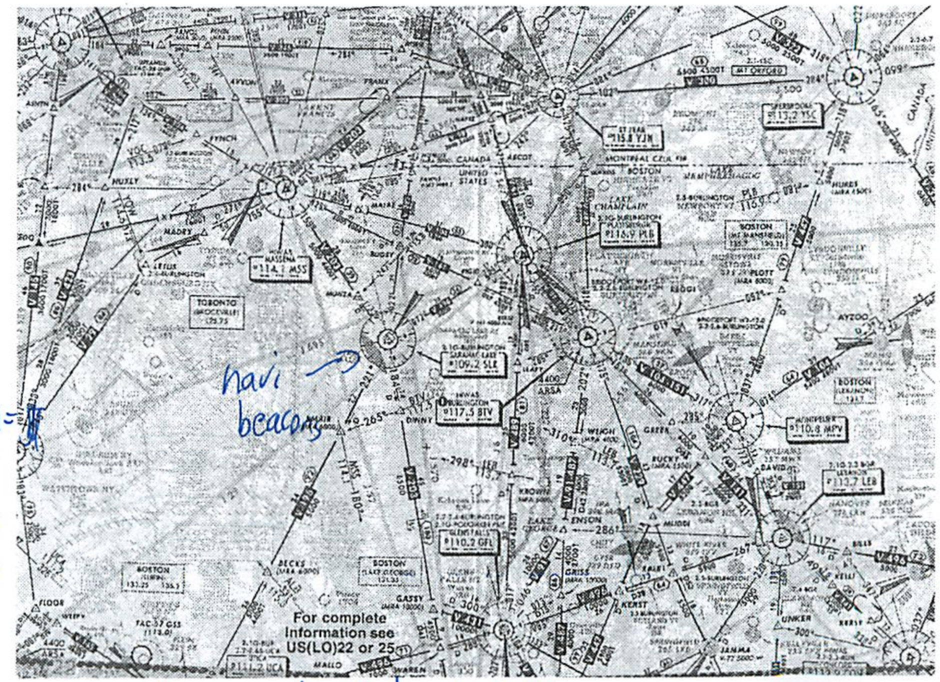
## US Airway Structure



green = Jet

blue = other



For complete information see US(LO)22 or 25

navi beacons

most now inertial + GPS

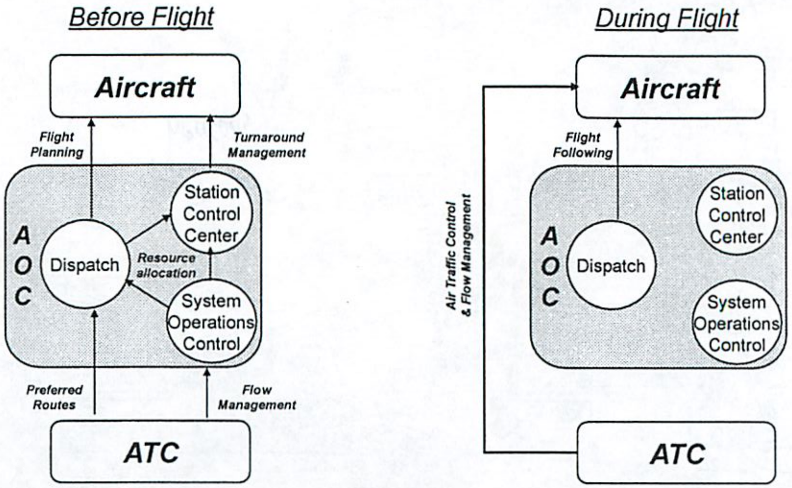
## Weather Deviation

try to not fly through weather

Stay 20 miles from thunderstorm

injuries againts flight attendants

## Role of AOC in Decision Flows



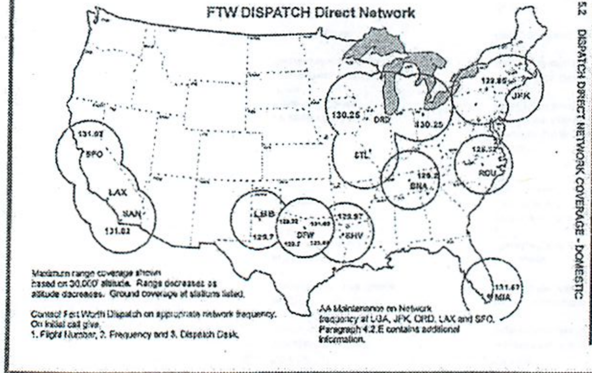
AMERICAN AIRLINES - FLIGHT TRAINING
MEL, CDL, E6, & Communications

## FTW Dispatch Direct Network

The following graphic illustrates the domestic network system for both airborne and ground direct Pilot and Dispatcher communication. Network air coverage at approximately 30,000 feet is depicted on this graphic. Ground coverage is also provided at airports where the transceivers are located - these airports are depicted on the Terminal Information page in Section 1 (Domestic Division only) with the Dispatch frequency.

Section 2 Communications FLIGHT MANUAL PART II
Page AA-29 DOMESTIC COVERAGE

5.2 DISPATCH DIRECT NETWORK COVERAGE - DOMESTIC



Maximum range coverage shown based on 30,000' altitude. Range decreases as altitude decreases. Ground coverage at stations listed.

Contact Fort Worth Dispatch on appropriate network frequency. On initial call give,
1. Flight Number, 2. Frequency and 3. Dispatch Desk.

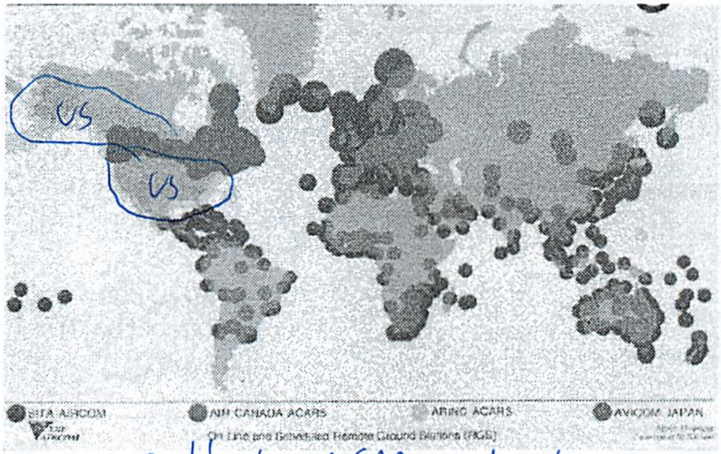
AA Maintenance on Network frequency at LGA, JFK, ORD, LAX and SFO. Paragraph 4.2.E contains additional information.

- 22 -

The company

old

## Combined Datalink Networks ACARS

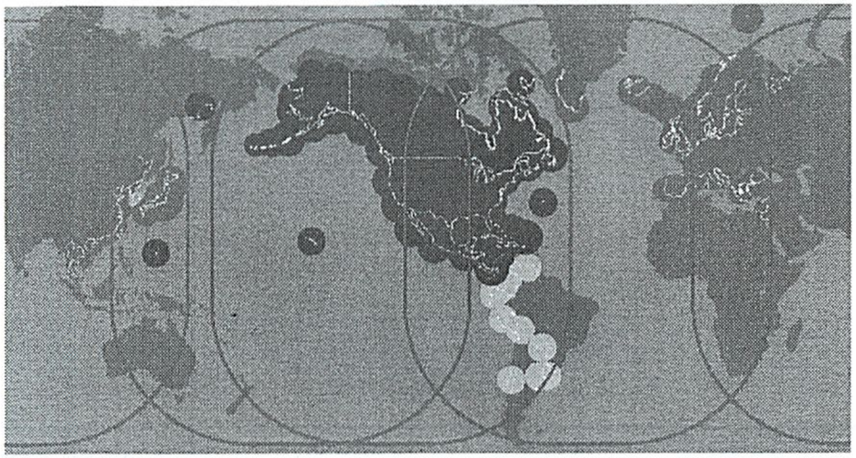


Combined ACARS network

very low bandwidth email link

# ARINC Datalink Network
# ACARS

Satilight equipped



---

# Airline-Aircraft Example
# ACARS Applications

### Taxi

From Aircraft

- Link Test/Clock Update
- Fuel/Crew Information
- Delay Reports
- Out

To Aircraft

- PDC
- ATIS
- Weight and Balance
- Airport Analysis
- V-Speeds Flight Plan-Hard Copy
- Load FMC____

### Takeoff

From Aircraft

- Off

### Departure

From Aircraft

- Engine Data

To Aircraft

- Flight Plan Update Weather Reports

### En Route

From Aircraft

- Position Reports
- Weather Reports
- Delay Info/ETA
- Voice Request
- Engine Information
- Maintenance Reports

To Aircraft

- ATC Oceanic Clearances
- Weather Reports
- Reclearance
- Ground Voice Request (SELCAL)

### Approach

From Aircraft

- Provisioning
- Gate Requests
- Estimated Time-of-Arrival
- Special Requests
- Engine Information
- Maintenance Reports

To Aircraft

- Gate Assignment
- Connecting Gates
- Passengers and Crew
- ATIS

### Land

From Aircraft

- On

### Taxi

From Aircraft

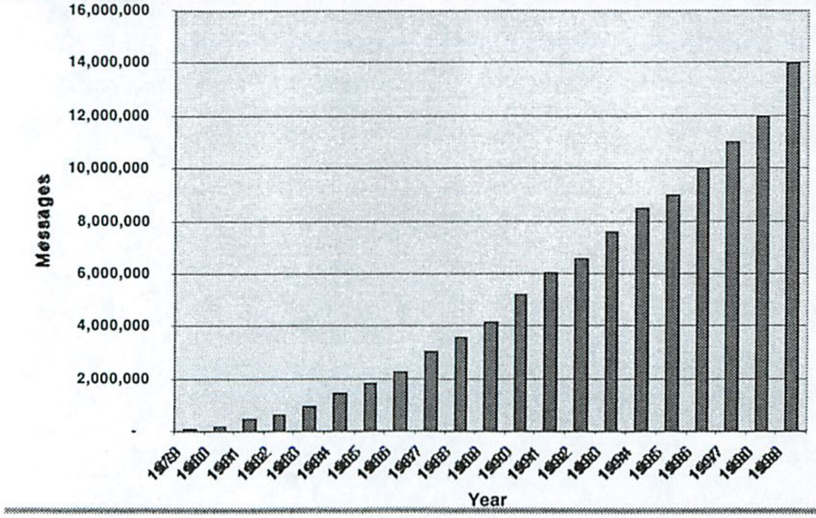
- In
- Fuel Information
- Crew Information
- Fault Data (from Central Maintenance Computer)

Courtesy of AIRINC

inital killer app was monitoring time
crew always overestimated since they are paid by minute

---

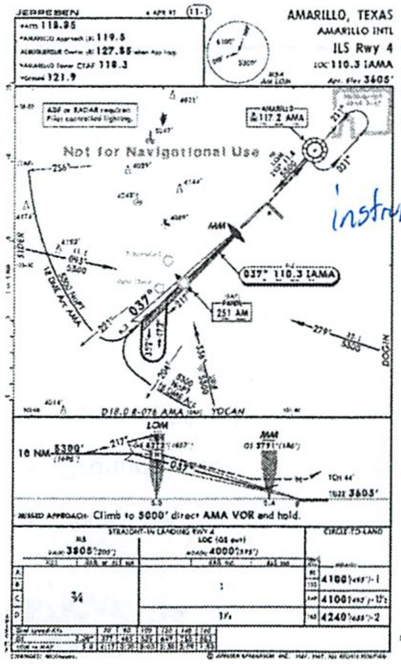
# Airline-Aircraft Example
# ACARS Monthly Message Traffic



exponential growth in messages

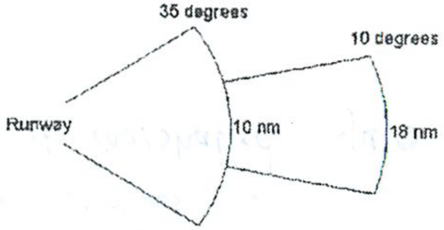
---

# GATION TRENDS
# (APPROACH)



instrument based landing

Localizer Service Volume (C) Jay Schnedorf 1997



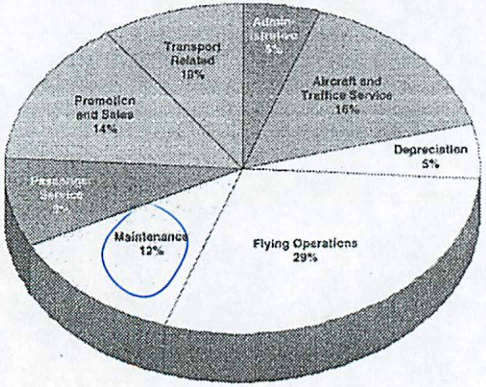
## Arrival

- **Marshaler**
- **Ground Power**
- **Jetway (Driver)**

Some airlines do
Self marshalled gates

---

## Typical Cost Breakdown



*Source:* Air Transport Association 1998.

**Figure 31-3** Breakdown of Airline Operating Costs..

Source: Adel Zeki
How Can Airplane Operators Reduce Maintenance Cost
Handbook of Airline Operation

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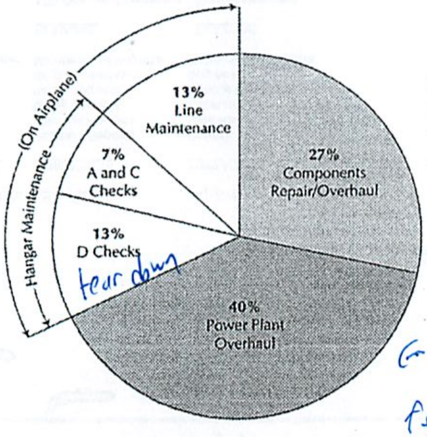
## Typical Maintenance Cost Breakdown



tear down

← engine overhalls
rebuild engines

**Figure 33-4** An Approximate Breakdown of Direct Maintenance Cost.

Source: Manish Mallikarjuna
Aircraft Maintenance and Engineering Operations
Handbook of Airline Operation

# Maintenance

- **Scheduled Maintenance**
  - ☐ Periodic (e.g. Annual)
  - ☐ On Time (Time Between Overhaul) (TBO)
  - ☐ Progressive (Inspection Based e.g. Cracks)
  - ☐ Conditional (Monitoring Based e.g. Engines - ACARS)
  - ☐ Heavy Maintenance Checks
- **Unscheduled**
  - ☐ "Squawks" = Reported Anomalies
    - ◆ Logbook Entries (ACARS)
  - ☐ Line Replacement Units (LRU)
  - ☐ Airworthiness Directives, Service Difficulty Reports
- **Parts Inventory**
  - ☐ Parts Tracking
  - ☐ Glass Cockpits

Cracks propagate at known rates

↑aircraft may need to be fixed

must be legal airplane parts

---

# Maintenance Breakdown

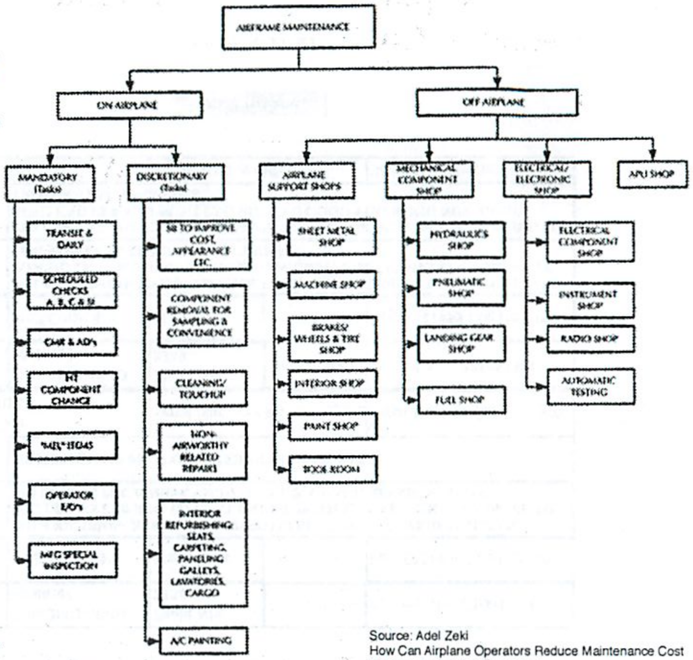


Figure 33-1 Airframe Maintenance Tasks.

Source: Adel Zeki
How Can Airplane Operators Reduce Maintenance Cost
Handbook of Airline Operation

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# Maintenance Breakdown

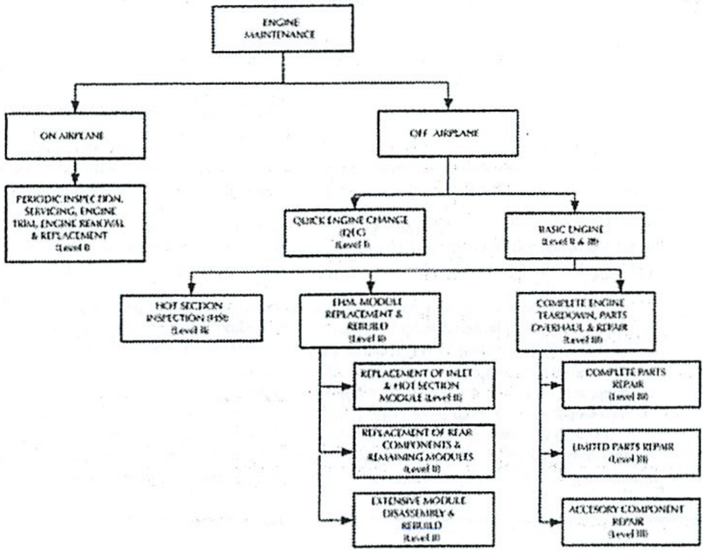

Figure 33-2 Engine Maintenance Tasks.

Source: Adel Zeki
How Can Airplane Operators Reduce Maintenance Cost
Handbook of Airline Operation

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# Example Emergency AD

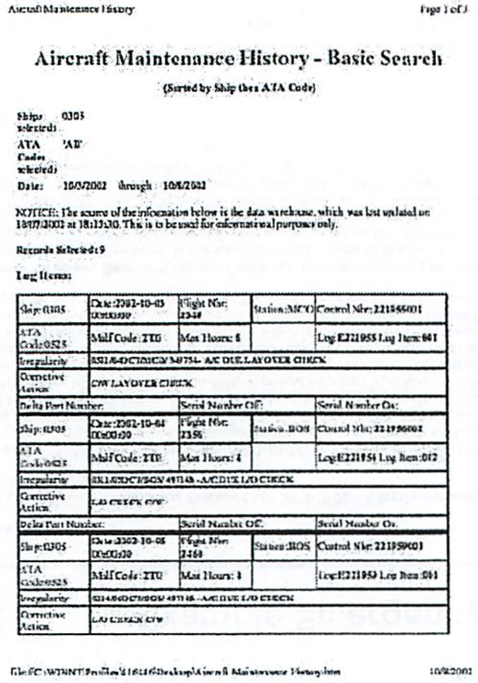
- **DATE: September 18, 2002 AD #: 2002-19-51 R1**
- Transmitted as follows is emergency airworthiness directive (AD) 2002-19-51 R1, for the attention of all owners and operators of all Boeing Model 737 series airplanes.
- **Background** On September 13, 2002, the FAA issued AD 2002-19-51, applicable to all Boeing Model 737 series airplanes, to require, for certain airplanes, an inspection to determine whether flight control modules (FCM) having part number (P/N) 65-44891-7 with serial number (S/N) 8726 or greater (hereafter referred to as "suspect FCMs") are installed, and corrective actions if necessary. The corrective actions include replacing the suspect FCM(s) with a serviceable FCM(s) having P/N 65-44891-7 with a S/N less than 8726, and revising the FAA-approved Airplane Flight Manual (AFM) to include procedures for certain airplanes to identify failures of suspect FCMs before dispatch and to provide the flightcrew with operating procedures in the event of failure of an FCM in flight. The AD also requires certain operators to submit inspection findings to the FAA. That action was prompted by reports of failed FCMs, which resulted in sluggish response of the aileron, elevator, and rudder surfaces. The actions required by that AD are intended to prevent operation with one failed FCM, which could result in reduced controllability of the airplane, or with two failed FCMs, which could result in loss of control of the airplane.
- **Clarification of Affected Airplanes** Because of reports of some operators misinterpreting the applicability of AD 2002-19-51, we find that clarification is necessary. Operators should note that this AD affects all Boeing Model 737 series airplanes. Operators of Model 737-600, -700, -700C, -800, and -900 series airplanes, having line numbers 1136 through 1230 inclusive, are subject to all requirements of this AD. However, operators of all Model 737-100, -200, -200C, -300, 400, and -500 series airplanes; and Model 737-600, -700, -700C, -800, and -900 series airplanes, having line numbers other than 1136 through 1230 inclusive; are only required to adhere to paragraphs (j) and (k) of this AD (i.e., parts installation paragraphs) to ensure that spare replacement FCMs and compensators identified in those paragraphs are not installed on any Model 737 series airplane in the future. No change to this AD is necessary in this regard.
- **Actions Since Issuance of Previous Rule**
- Since the issuance of AD 2002-19-51, the FAA has approved an alternative method of compliance (AMOC) for the replacement required by paragraphs (d)(1), (d)(2), and (h) of that AD. The AMOC allows FCMs having P/Ns other than 65-44891-7 that are approved for installation on Boeing Model 737-600, -700, -700C, -800, and -900 series airplanes to be installed during the replacements required by those paragraphs. In addition, we have determined that a suspect FCM can continue to be used once the compensator has been replaced with an airworthy compensator. Therefore, we have revised those

# Example Emergency AD

- **Clarification of Affected Airplanes** Because of reports of some operators misinterpreting the applicability of AD 2002-19-51, we find that clarification is necessary. Operators should note that this AD affects all Boeing Model 737 series airplanes. Operators of Model 737-600, -700, -700C, -800, and -900 series airplanes, having line numbers 1136 through 1230 inclusive, are subject to all requirements of this AD. However, operators of all Model 737-100, -200, -200C, -300, 400, and -500 series airplanes; and Model 737-600, -700, -700C, -800, and -900 series airplanes, having line numbers other than 1136 through 1230 inclusive; are only required to adhere to paragraphs (j) and (k) of this AD (i.e., parts installation paragraphs) to ensure that spare replacement FCMs and compensators identified in those paragraphs are not installed on any Model 737 series airplane in the future. No change to this AD is necessary in this regard.
- **Inspection** (a) For Model 737-600, -700, -700C, -800, and -900 series airplanes, having line numbers 1136 through 1230 inclusive: Before further flight after receipt of AD 2002-19-51, do an inspection to determine the serial number (S/N) of both FCMs having part number (P/N) 65-44891-7.
- **Neither FCM Has S/N 8726 or Greater** (b) If neither FCM has S/N 8726 or greater (hereafter referred to as a "suspect FCM"), no further action is required by this AD, except for the requirements specified in paragraphs (j) and (k) of this AD....
- **"Pre-Flight Flight Control Module (FCM) Checks:**
- **Special Flight Permits ...**

---

Record of part # on plane



Aircraft Maintenance History — Page 1 of 3

## Aircraft Maintenance History - Basic Search

(Sorted by Ship then ATA Code)

**Ships selected:** 0305
**ATA Codes selected:** 'All'
**Date:** 10/3/2002 through 10/8/2002

NOTICE: The source of the information below is the data warehouse, which was last updated on 10/07/2002 at 18:13:30. This is to be used for informational purposes only.

**Records Selected: 9**

**Log Items:**

| | | | | |
|---|---|---|---|---|
| Ship: 0305 | Date:2002-10-03 00:00:00 | Flight Nbr: 2349 | Station:MCO | Control Nbr: 221955001 |
| ATA Code:0525 | Malf Code: 2T0 | Man Hours: 6 | | Log:E221955 Log Item:001 |
| Irregularity | [illegible] A/C DUE LAYOVER CHECK | | | |
| Corrective Action | C/W LAYOVER CHECK | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-04 00:00:00 | Flight Nbr: 2356 | Station:BOS | Control Nbr: 221956001 |
| ATA Code:0525 | Malf Code: 2T0 | Man Hours: 4 | | Log:E221954 Log Item:002 |
| Irregularity | [illegible] -A/C DUE L/O CHECK | | | |
| Corrective Action | L/O CHECK C/W | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-05 00:00:00 | Flight Nbr: 2460 | Station:BOS | Control Nbr: 221959001 |
| ATA Code:0525 | Malf Code: 2T0 | Man Hours: 1 | | Log:E221959 Log Item:001 |
| Irregularity | [illegible] -A/C DUE L/O CHECK | | | |
| Corrective Action | L/O CHECK C/W | | | |

10/8/2002

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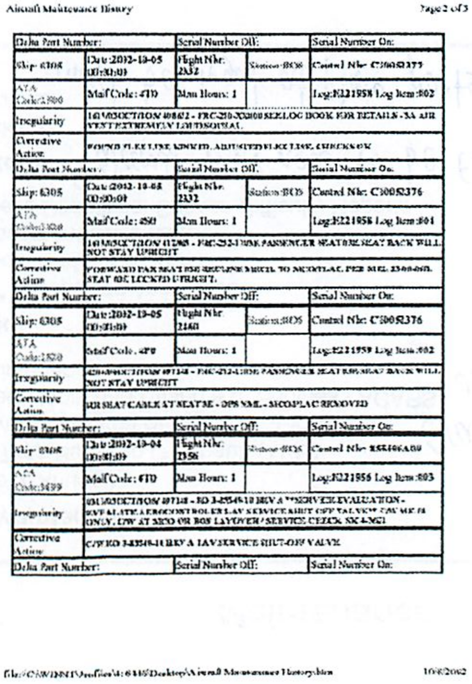

Aircraft Maintenance History — Page 2 of 3

| | | | | |
|---|---|---|---|---|
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-05 00:00:00 | Flight Nbr: 2332 | Station:BOS | Control Nbr: [illegible] |
| ATA Code:[illegible] | Malf Code: 4T0 | Man Hours: 1 | | Log:E221958 Log Item:002 |
| Irregularity | [illegible] SEE LOG BOOK FOR DETAILS - 3A AIR VENT EXTREMELY LOUD/SQUEAL. | | | |
| Corrective Action | FOUND FLEX LINE KINKED. ADJUSTED FLEX LINE. CHECKS OK | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-05 00:00:00 | Flight Nbr: 2332 | Station:BOS | Control Nbr: C10052376 |
| ATA Code:[illegible] | Malf Code: 4S0 | Man Hours: 1 | | Log:E221958 Log Item:001 |
| Irregularity | [illegible] PASSENGER SEAT [illegible] SEAT BACK WILL NOT STAY UPRIGHT | | | |
| Corrective Action | [illegible] SEAT [illegible] LOCKED UPRIGHT. | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-05 00:00:00 | Flight Nbr: 2460 | Station:BOS | Control Nbr: C10052376 |
| ATA Code:2520 | Malf Code: 4P0 | Man Hours: 1 | | Log:E221959 Log Item:002 |
| Irregularity | [illegible] PASSENGER SEAT [illegible] SEAT BACK WILL NOT STAY UPRIGHT | | | |
| Corrective Action | RR SEAT CABLE AT SEAT [illegible] - OPS NML - [illegible] REMOVED | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |
| Ship: 0305 | Date:2002-10-04 00:00:00 | Flight Nbr: 2356 | Station:BOS | Control Nbr: [illegible] |
| ATA Code:3499 | Malf Code: 4T0 | Man Hours: 1 | | Log:E221956 Log Item:003 |
| Irregularity | [illegible] SERVICE EVALUATION - [illegible] ONLY. C/W AT MCO OR BOS LAYOVER / SERVICE CHECK [illegible] | | | |
| Corrective Action | C/W RO [illegible] LAV SERVICE SHUT-OFF VALVE | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |

10/8/2002

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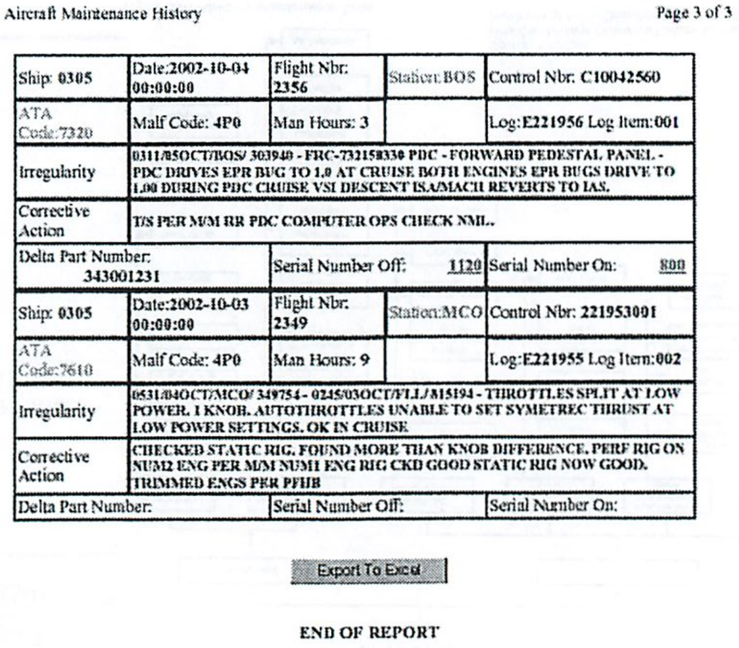

Aircraft Maintenance History — Page 3 of 3

| | | | | |
|---|---|---|---|---|
| Ship: 0305 | Date:2002-10-04 00:00:00 | Flight Nbr: 2356 | Station:BOS | Control Nbr: C10042560 |
| ATA Code:7320 | Malf Code: 4P0 | Man Hours: 3 | | Log:E221956 Log Item:001 |
| Irregularity | 0311/05OCT/BOS/ 303940 - FRC-73215B330 PDC - FORWARD PEDESTAL PANEL - PDC DRIVES EPR BUG TO 1.0 AT CRUISE BOTH ENGINES EPR BUGS DRIVE TO 1.00 DURING PDC CRUISE VSI DESCENT ISA/MACH REVERTS TO IAS. | | | |
| Corrective Action | T/S PER M/M RR PDC COMPUTER OPS CHECK NML. | | | |
| Delta Part Number: 343001231 | | Serial Number Off: 1120 | | Serial Number On: 800 |
| Ship: 0305 | Date:2002-10-03 00:00:00 | Flight Nbr: 2349 | Station:MCO | Control Nbr: 221953001 |
| ATA Code:7610 | Malf Code: 4P0 | Man Hours: 9 | | Log:E221955 Log Item:002 |
| Irregularity | 0531/04OCT/MCO/ 349754 - 0245/03OCT/FLL/ 815194 - THROTTLES SPLIT AT LOW POWER. 1 KNOB. AUTOTHROTTLES UNABLE TO SET SYMETREC THRUST AT LOW POWER SETTINGS. OK IN CRUISE | | | |
| Corrective Action | CHECKED STATIC RIG. FOUND MORE THAN KNOB DIFFERENCE. PERF RIG ON NUM2 ENG PER M/M NUM1 ENG RIG CKD GOOD STATIC RIG NOW GOOD. TRIMMED ENGS PER PFHB | | | |
| Delta Part Number: | | Serial Number Off: | | Serial Number On: |

END OF REPORT

# Delta Maintenance Checks

- **Line environment**
  - ☐ Trip (At least once per 24 hours)
  - ☐ Layover (Aircraft remains overnight in a maintenance station)
  - ☐ Service (or industry A check)
- **Hangar environment**
  - ☐ Packaged Service Visit - PSV - (or industry C check)
  - ☐ other fleets, Letter Check - LC - (roughly 1/2 of a C check)
  - ☐ Heavy Maintenance Visit - HMV - (or industry 4C check)
- **ATA Maintenance Steering Groups** everyone operating that plane
  - ☐ Monitor and Make Recommendations for Service Elements and Intervals
- **Maintenance Program Negotiated and Approved with Local FAA Office**
  - ☐ POI

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# Maintenance Check Description

- A Check or Service Check  A checks are Line Maintenance visits focused on aircraft general condition and limited system checks. A check intervals are typically 200-500 flight hours (30-50 days).
- C Check or Letter Check  C Checks are hangar visits focused on aircraft systems. Systems checks are performed to ensure the system is performing correctly or restoration is performed to allow the system to operate until the next letter check. Minor structure inspections and minor cabin restoration is performed also. C check intervals are typically 6-18 months.
- D Check or Heavy Maintenance Visit (HMV) D Checks, or HMVs are hangar visits in which the aircraft undergoes a major overhaul. The majority of the interior components are removed and refurbished (seats, galleys, lavatories, etc). The aircraft structure is inspected in detail. To perform inspections at an HMV, special access such as opening wing fuel tanks, removing fairings, opening access panels not normally opened in other maintenance visits. Many major repairs are performed at HMV such as structural repairs for corrosion and fatigue cracks. Major modifications are also typically performed at HMV. HMVs intervals are typically 5-8 years.

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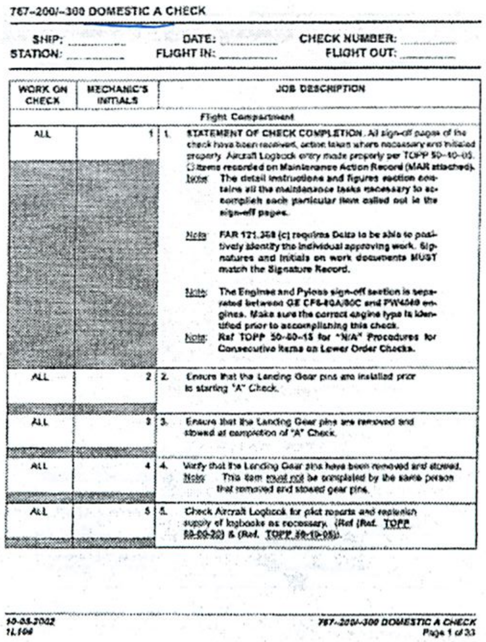

767-200/-300 DOMESTIC A CHECK

SHIP: ________ DATE: ________ CHECK NUMBER: ________
STATION: ________ FLIGHT IN: ________ FLIGHT OUT: ________

| WORK ON CHECK | MECHANIC'S INITIALS | JOB DESCRIPTION |
|---|---|---|
| | | Flight Compartment |
| ALL | 1 | 1. STATEMENT OF CHECK COMPLETION. All sign-off pages of the check have been received, action taken where necessary and initialed properly. Aircraft Logbook entry made properly per TOPP 50-10-05. ☐ Items recorded on Maintenance Action Record (MAR attached).<br>Note: The detail instructions and figures section contains all the maintenance tasks necessary to accomplish each particular item called out in the sign-off pages.<br>Note: FAR 121.368 (c) requires Delta to be able to positively identify the individual approving work. Signatures and initials on work documents MUST match the Signature Record.<br>Note: The Engines and Pylons sign-off section is separated between GE CF6-80A/80C and PW4040 engines. Make sure the correct engine type is identified prior to accomplishing this check.<br>Note: Ref TOPP 50-60-15 for "N/A" Procedures for Consecutive Items on Lower Order Checks. |
| ALL | 2 | 2. Ensure that the Landing Gear pins are installed prior to starting "A" Check. |
| ALL | 3 | 3. Ensure that the Landing Gear pins are removed and stowed at completion of "A" Check. |
| ALL | 4 | 4. Verify that the Landing Gear pins have been removed and stowed.<br>Note: This item must not be completed by the same person that removed and stowed gear pins. |
| ALL | 5 | 5. Check Aircraft Logbook for pilot reports and replenish supply of logbooks as necessary. (Ref (Ref. TOPP 50-00-20) & (Ref. TOPP 50-10-05)). |

10-03-2002
1L104

767-200/-300 DOMESTIC A CHECK
Page 1 of 33

check list of what to do

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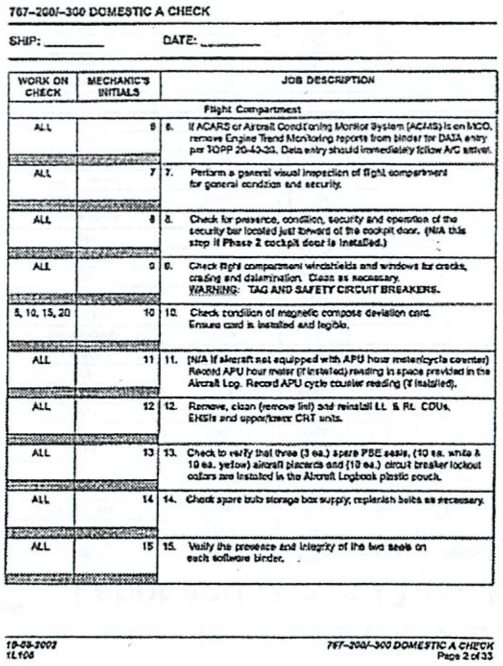


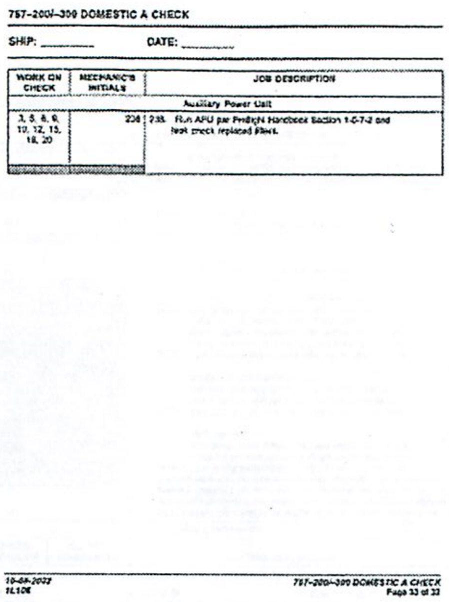
767-200/-300 DOMESTIC A CHECK

SHIP: ________ DATE: ________

| WORK ON CHECK | MECHANIC'S INITIALS | JOB DESCRIPTION |
|---|---|---|
| | | Flight Compartment |
| ALL | 6 | 6. If ACARS or Aircraft Conditioning Monitor System (ACMS) is on MCO, remove Engine Trend Monitoring reports from binder for DATA entry per TOPP 20-40-20. Data entry should immediately follow A/C arrival. |
| ALL | 7 | 7. Perform a general visual inspection of flight compartment for general condition and security. |
| ALL | 8 | 8. Check for presence, condition, security and operation of the security bar located just forward of the cockpit door. (N/A this step if Phase 2 cockpit door is installed.) |
| ALL | 9 | 9. Check flight compartment windshields and windows for cracks, crazing and delamination. Clean as necessary.<br>WARNING: TAG AND SAFETY CIRCUIT BREAKERS. |
| 5, 10, 15, 20 | 10 | 10. Check condition of magnetic compass deviation card. Ensure card is installed and legible. |
| ALL | 11 | 11. (N/A if aircraft not equipped with APU hour meter/cycle counter) Record APU hour meter (if installed) reading in space provided in the Aircraft Log. Record APU cycle counter reading (if installed). |
| ALL | 12 | 12. Remove, clean (remove lint) and reinstall Lt. & Rt. CDUs, EHSIs and upper/lower CRT units. |
| ALL | 13 | 13. Check to verify that three (3 ea.) spare PSE seals, (10 ea. white & 10 ea. yellow) aircraft placards and (10 ea.) circuit breaker lockout collars are installed in the Aircraft Logbook plastic pouch. |
| ALL | 14 | 14. Check spare bulb storage box supply; replenish bulbs as necessary. |
| ALL | 15 | 15. Verify the presence and integrity of the two seals on each software binder. |

10-03-2002
1L106

767-200/-300 DOMESTIC A CHECK
Page 2 of 33



757-200/-300 DOMESTIC A CHECK

SHIP: ________ DATE: ________

| WORK ON CHECK | MECHANIC'S INITIALS | JOB DESCRIPTION |
|---|---|---|
| | | Auxiliary Power Unit |
| 3, 5, 8, 9, 10, 12, 15, 18, 20 | 238 | 238. Run APU per Preflight Handbook Section 1-6-7-2 and leak check replaced filters. |

10-04-2002
IL106

757-200/-300 DOMESTIC A CHECK
Page 33 of 33

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# Maintenance Check
# Labor and Ground Time Estimates

| Fleet | Visit | Frequency | Labor Required | Routine | Non Routine | EO | Ground Time* |
|---|---|---|---|---|---|---|---|
| 727 | Service Check | 175 hrs | 26 | | | | Overnight |
| | Letter Check | 7.5 Mo | 606 | 400 | 200 | 6 | 24 hrs |
| | MID1 | 30 Mo | 5,421 | 1,806 | 2,555 | 1,060 | 11.0 |
| | | | 2,000 | 720 | 1,130 | 150 | 12.0 |
| | MID2 | 5 yrs | 11,817 | 4,385 | 6,074 | 1,358 | 20.2 |
| | MID2 | 5 yrs | 5,050 | 3,000 | 1,800 | 250 | 21.0 |
| | HMV1 | 7.5 yrs | | | | | |
| | MID4 | 10 yrs | 10,815 | 3,921 | 5,336 | 1,558 | 22.5 |
| | MID5 | 12.5 yrs | | | | | |
| | HMV2 | 15 yrs | 16,950 | 6,936 | 8,224 | 1,791 | 35.9 |
| 737-200 Express | Service Check | 200 hrs | 18 | | | | Overnight |
| | Letter Check | ~~6 Mo~~ | 570 | 340 | 220 | 10 | 14.5 hrs |
| | CV | 24 Mo | 1,584 | 309 | 919 | 356 | 10.0 |
| | MID | 4 yrs | 9,898 | 3,818 | 4,474 | 1,606 | 19.4 |
| | MID | 4 yrs | 6,310 | 4,104 | 1,206 | 1,000 | 24.0 |
| | HMV | 8 yrs | 19,920 | 7,505 | 9,991 | 2,424 | 35.5 |
| 737-200/300 Domestic | Service Check | 200 hrs | 24 | | | | Overnight |
| | Letter Check | 6 Mo | 1,124 | 544 | 549 | 30 | 3.4 |
| | PSV Transition | | 1,745 | 883 | 837 | 25 | 4.5 |
| | CV | 24 Mo | 1,587 | 353 | 812 | 423 | 10.3 |
| | MID | 4 yrs | 10,797 | 4,088 | 4,927 | 1,782 | 24.8 |
| | HMV | 8 yrs | 12,785 | 7,146 | 4,926 | 713 | 28.6 |
| 737-800 | Service Check | 50 days | 32 | | | | Overnight |
| | PSV1 | 12 Mo | 823 | 576 | 246 | 1 | 2.4 |
| | PSV1 | 12 Mo | 650 | 520 | 110 | 20 | 1.5 |
| | PSV2 | 24 Mo | 1,265 | 865 | 379 | 21 | 3.5 |
| | PSV3 | 36 Mo | 1,206 | 691 | 453 | 62 | 2.6 |
| | PSV4 | 48 Mo | 2,400 | | | | 5.0 |

Wow

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# Maintenance Check
# Labor and Ground Time Estimates

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 757 | Service Check | 400 hrs | 25 | | | | Overnight |
| | PSV 0-6 yrs | 4000 hrs | 2,128 | 1,508 | 595 | 26 | 4.3 |
| | | | 1,040 | 689 | 333 | 18 | 2.5 |
| | PSV 6-12 yrs | | 3,891 | 1,988 | 1,838 | 66 | 8.1 |
| | | | 1,962 | 944 | 976 | 42 | 4.8 |
| | PSV 12-18 yrs | | 3,696 | 2,078 | 1,537 | 81 | 6.7 |
| | | | 2,221 | 894 | 1,275 | 52 | 5.3 |
| | MID1 | 5 yrs | 8,646 | 3,690 | 3,821 | 1,135 | 22.6 |
| | HMV1 | 8 yrs | 12,966 | 5,750 | 6,266 | 949 | 35.2 |
| | HMV2 | 16 yrs | 23,654 | 7,802 | 12,364 | 3,488 | 44.6 |
| | HMV3 | 24 yrs | 45,621 | 10,635 | 27,737 | 7,249 | 76.9 |
| 767-200/300 Domestic | Service Check | 400 hrs | 32 | | | | Overnight |
| | PSV 0-6 yrs | 4000 hrs | 2,310 | 1,397 | 788 | 125 | 4.5 |
| | PSV 6-12 yrs | | 4,258 | 2,219 | 1,830 | 210 | 7.4 |
| | PSV 12-18 yrs | | 4,030 | 1,842 | 1,995 | 193 | 7.5 |
| | MID | 5 yrs | 27,938 | 6,333 | 16,390 | 5,215 | 45.4 |
| | HMV1 | 8 yrs | | | | | |
| | HMV2 | 16 yrs | 19,572 | 8,726 | 9,521 | 1,325 | 35.2 |
| | HMV3 | 24 yrs | 29,322 | 8,937 | 15,725 | 4,661 | 42.0 |
| 767-300 International | Service Check | 400 hrs | 48 | | | | Overnight |
| | PSV 0-6 yrs | 5300 hrs | 2,408 | 1,375 | 872 | 160 | 4.1 |
| | PSV 6-12 yrs | | 3,188 | 1,547 | 1,457 | 184 | 5.2 |
| | MID1 | 5 yrs | 7,442 | 3,307 | 1,975 | 2,160 | 17.2 |
| | HMV1 | 8 yrs | 11,250 | 6,286 | 3,773 | 1,191 | 20.3 |
| 767-400 | Service Check | 500 hrs | 48 | | | | |
| | PSV1 | 18 Mo | 2,000 | | | | |
| | HMV1 | 6 yrs | 12,000 | | | | |

more modern
aircraft
longer time
b/w maintance
and less
labor

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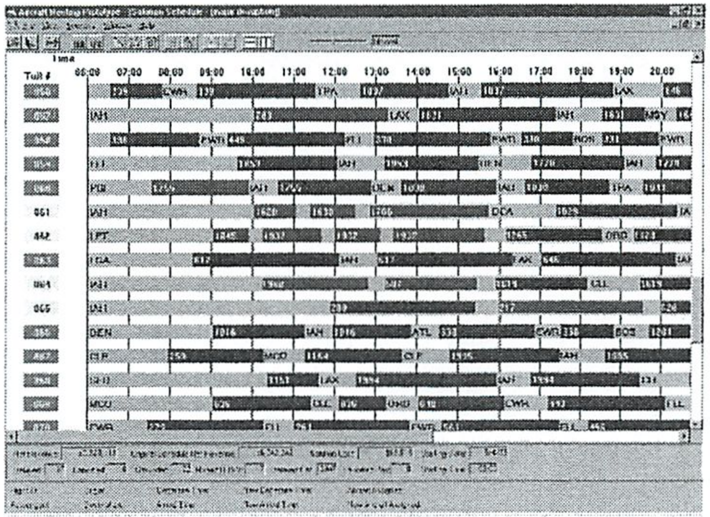
# Maintenance Check
# Labor and Ground Time Estimates

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 777 | Service Check | 500 hrs | 48 | | | | |
| | PSV1 | 12 Mo | 2,315 | 1,520 | 750 | 45 | 4.9 |
| | PSV2 | 24 Mo | 2,851 | 1,842 | 972 | 38 | 4.1 |
| | PSV3 | 36 Mo | 3,000 | | | | 4.0 |
| | PSV4 | 48 Mo | 6,500 | | | | 8.0 |
| MD11 | Service Check | 500 hrs | 48 | | | | Overnight |
| | Letter Ck (1/2C) | 3000 hrs | 2,889 | 1,497 | 1,268 | 124 | 4.8 |
| | HMV1 | 6 yrs | | | | | |
| | HMV2 | 11 yrs | 40,654 | 13,268 | 16,829 | 10,558 | 67.2 |
| MD88 | Service Check | 450 hrs | 24 | | | | Overnight |
| | Letter Ck (1/2C) | 1750 hrs | 550 | 325 | 200 | 25 | 15 hrs |
| | HMV1 | 19000 hrs (6.5 yrs) | 10,526 | 3,883 | 4,546 | 2,097 | 22.0 |
| | HMV2 | 36000 hrs (12.5 yrs) | 15,941 | 5,023 | 8,376 | 2,542 | 28.5 |
| MD90 | Service Check | 450 hrs | 24 | | | | Overnight |
| | Letter Ck (1/2C) | 1800 hrs | 1,200 | 462 | 699 | 39 | 3.7 |
| | HMV1 | 19000 hrs (6.5 yrs) | 14,796 | 5,023 | 8,851 | 922 | 32.2 |

## Maintenance Scheduling



maint. scheduling is part
of scheduling part

if disrupted operation - will not be
in maintance base