Analysis of Impacts & Costs of Diversions

A Study Conducted by:

American Airlines

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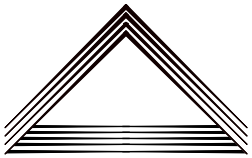


FLIGHT DYNAMICS, INC.

February - May, 1992

American Airlines Cost of Diversions
Purpose of Study

- To define for American Airlines the impact and cost of weather-related diversions and Irregular Operations
- To define the quantity of these diversions which could be avoided using the HUGHES  ***FLIGHT DYNAMICS, INC.*** Heads-Up Display (HUD)
- To use all this information together to provide a cost justification for the Hughes Flight Dynamics HUD

American Airlines Cost of Diversions
Basic Premises

- The costs of weather-related diversions/disruptions do not exist in a usable form within AA
    - Some information is resident in bits and pieces in different departments which need it to resolve specific problems
    - Some costs have been quantified in the past, but not updated recently.
    - Some information can only be extracted during the Irregular Operation, as it is not in anyway "tagged" as being part of the Irregular Operation
    - Some costs may exist during normal operations, but would be exacerbated during the Irregular Operation

- It is not the job today of people to **track** the Irregular Operation, but rather it is their job to **recover** from it, as it should be. An apt analogy would be a firefighter

- In order to make the study manageable, assumptions were often made. The major one was to **allocate** all costs to diversions, as a common unit, even when specific items were not directly **attributable** to the diversions.
    - Justification: If a cost is *$x* when there are *n* diversions, it will likely exceed *$2x* when there are *2n* diversions. This approach is therefore conservative

American Airlines Cost of Diversions
How We Accomplished It

- Devised a model of cost components and an approach, and reviewed these extensively with a wide variety of groups within AA

- Conducted an in-depth analysis of two disruption case studies:

    - Snow at LGA on 3/19, with 31 cancellations
    - Fog at DFW on 4/7, with 9 diversions and 27 cancellations

- Researched a list of other costs and built a model based on the difference between good-weather-day costs and bad-weather-day costs

- Used the AADT Passenger Ill-Will Model conservatively to estimate revenue loss potential. This model was devloped in connection with the Ramp Manager Project, and is generally accepted as valid

- Used the Maintenance & Engineering Plans Book (1992) cancellation costs model. This model's validity is subject to question, so the costs derived were used as soft costs.

American Airlines Cost of Diversions
Results

- Extrapolated results based on a very conservative interpretation of the data

- LGA 3/19 incident primarily showed:

    - Hub-hub passenger loss probably washes out between airlines
    - Probable major spoke passenger losses from cancellations
    - Major additional data acquisition and study should be performed. There is no accepted manner in which to identify when passengers are lost, or how to interpret available data

- DFW 4/7 incident primarily showed:

    - There is enormous disruption which can stem from a relatively minor incident, any time it is necessary to delay a complex
    - Disruptions are due to interconnections of crew & equipment throughout the system on a tight schedule
    - Many impacts, particularly those to stations other than the diversion station, were not possible to quantify
    - Information on most extra flying activity is not possible to extract unless one is actually monitoring the Irregular Operation in real time

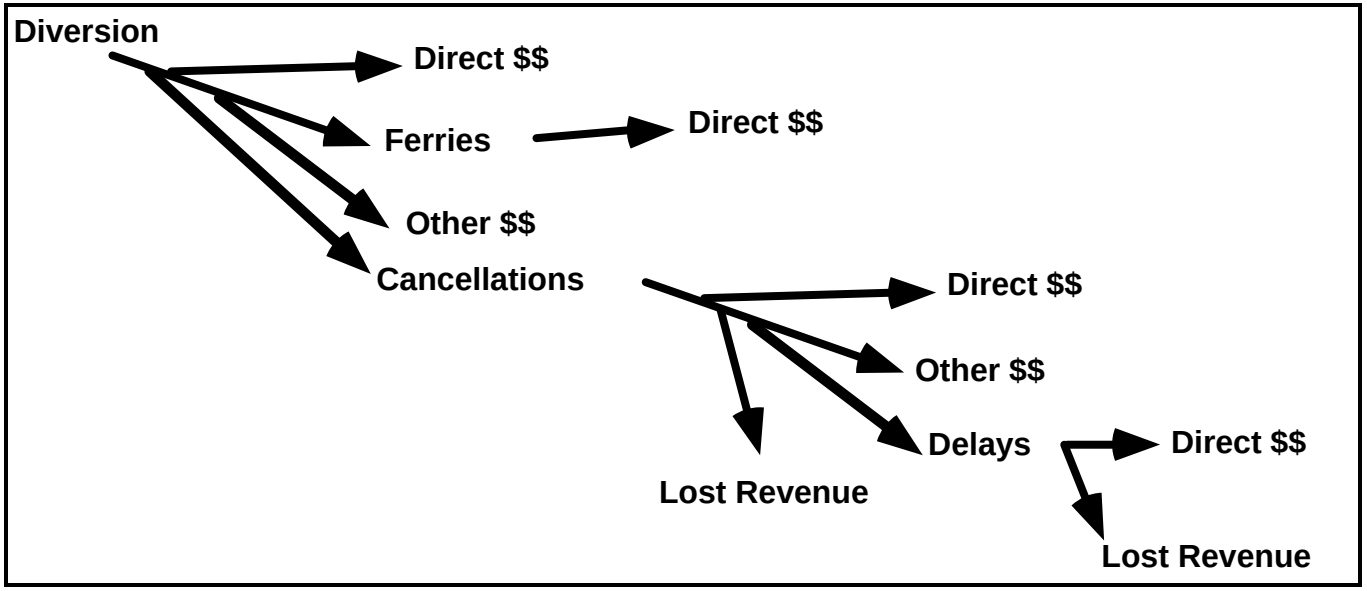
American Airlines
Total Cost of Diversions

- Per diversion:
  - Hard costs (based on extrapolation of incident plus other data elements): $34,794
  - Soft costs (using M & E Plans Book, assuming all cancellations narrowbody): $18,180
  - Ill will revenue loss potential (AADT Model, but assuming passengers in weather have no ill will (very conservative, cuts numbers by 1/3)): $69,432
  - Direct lost revenue: Not computed
  - Total cost per diversion: **$122,406**
  - Alternative computations, total cost per cancellation: **$39,387**
  - System-wide arrivals within 15 dependability drops **4% per diversion**
- Average 1400 WX diversions per year, 4500 WX cancellations
- Costs per year:
  - Hard costs: $50 million
  - Soft costs: $25 million
  - Ill will revenue loss potential: $97 million
  - Total costs per year: **$170 million!!**

American Airlines Cost of Diversions
Sources of Data: People and Places

- Yield Management
- Operations Analysis
- SOC/Dispatch
- Crew Tracking/Scheduling
- AA Decision Technologies
- Finance - Airline Profitability Analysis
- DFW Ramp Services
- DFW Passenger Services
- DFW Operations
- DFW Controllers Office
- CAArgo Ops.
- AA Decision Technologies
- Sabre Computer Services
- Flight following system (DECS)
- Maintenance & Engineering Plans Book (1992)

Diversions Cost Tree
Basic Approach for Attribution & Allocation



Approach to Diversions Analysis
Types of Diversions

- There are five different types of diversions. In increasing <u>per-diversion</u> cost impact, these are:

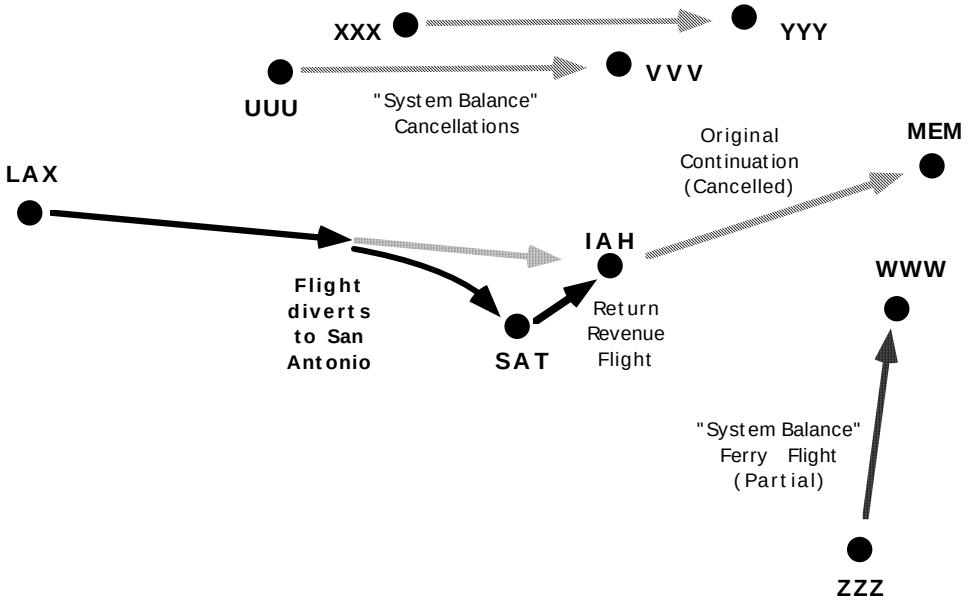
  - A few hub diversions: 10-15% of a hub complex (arrival bank) diverts. Many opportunities for equipment & crew substitution, only diverted inbound flights necessarily affected
  - A spoke diversion: Both inbound and outbound flights always affected
  - An international diversion near destination

>>>>

  - A hub "blowout": Enough of a hub complex diverts, and there is an ATC ground stop, creating major delays, or complex out-of-sequence
  - An international diversion far away from destination (usually mechanical)

- The April 7 diversion scenario was the major one extrapolated from. However, its impacts were minimized due to complexes remaining in sequence

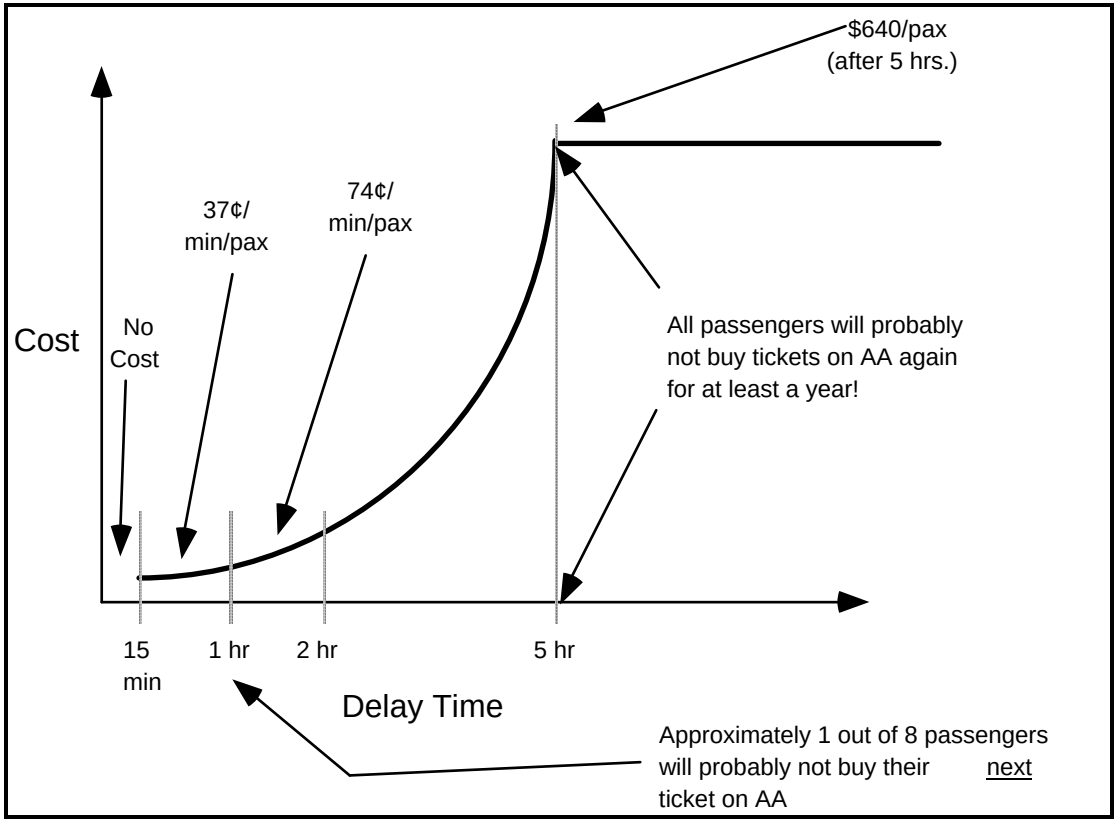
Diversion Impacts
Worst Case - “Hub Blowout” Diversions



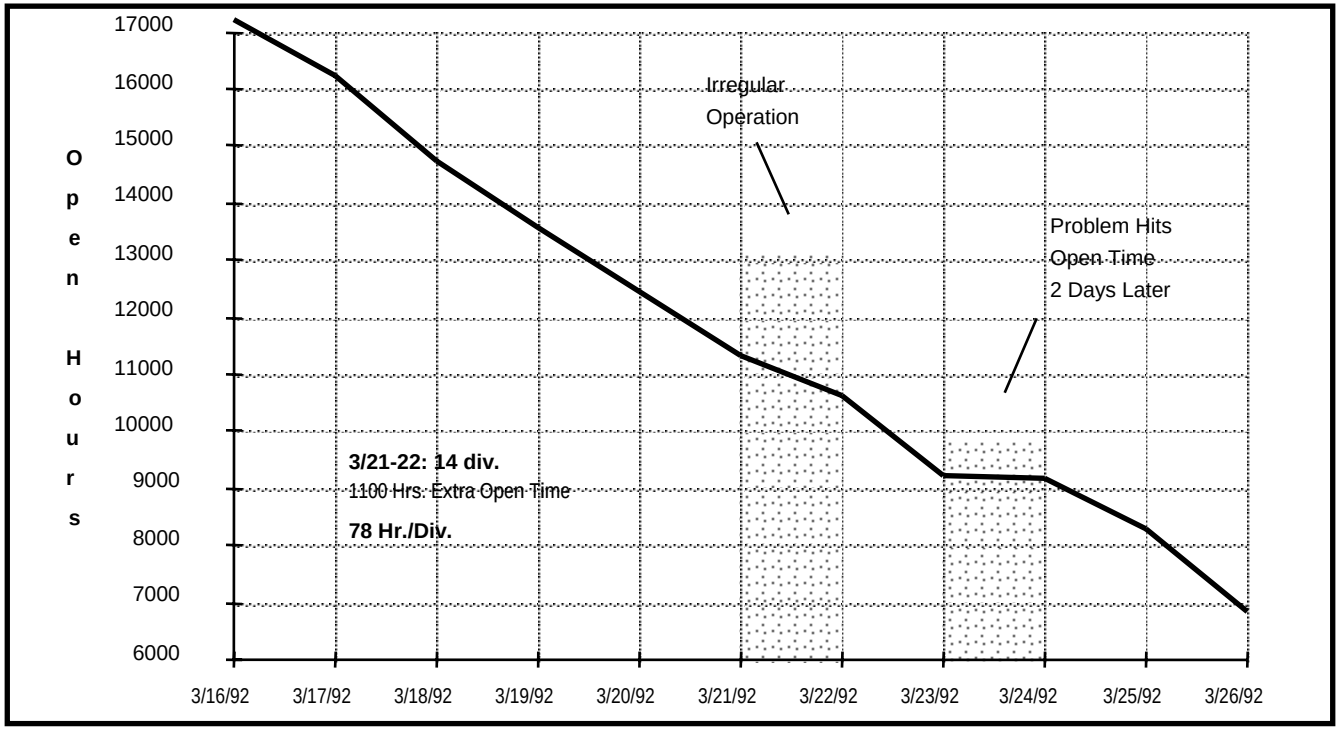
American Airlines Cost of Diversions
Cost Items

- Direct tracking of items:
  - Unrecorded ferry flights
  - Extra flying & operation hours
  - Delayed passengers. Cost of ill will generated assumes passengers who are caught in the direct Irregular Operation will have no ill will
  - Delayed flights
- Indirect tracking of items. Selected a set of recent days system-wide perfect weather vs. days with DFW diversions. Computed delta of these costs, allocated to diversions:
  - DFW mishandled bags
  - DFW Ramp Services & Passenger Services overtime
  - DFW passenger meals and hotel costs
  - DFW misconnects (counts only)
  - DFW passenger oversales costs
  - DFW FIMS (Flight Interrupt Manifests) costs
  - System-wide cargo refusal costs
  - Spotting for schedule recovery ferries. Costs estimated as if all are narrowbody
  - Spotting for maintenance ferries. Costs estimated as if all are narrowbody
  - SOC overtime
  - Cancelled flights
  - Crew open time cost as a trailing function of the Irregular Operation
- Cost items not covered:
  - Any cost items resulting from ruboffs to other stations where shown above for DFW
  - Cost of misconnected passengers
  - Lost passenger revenue during the Irregular Operation. The Ill Will Model applies only to lost future revenue
  - Hard cost elements of items in M & E Plans Book

American Airlines Cost of Diversions
AADT Passenger Ill Will Model

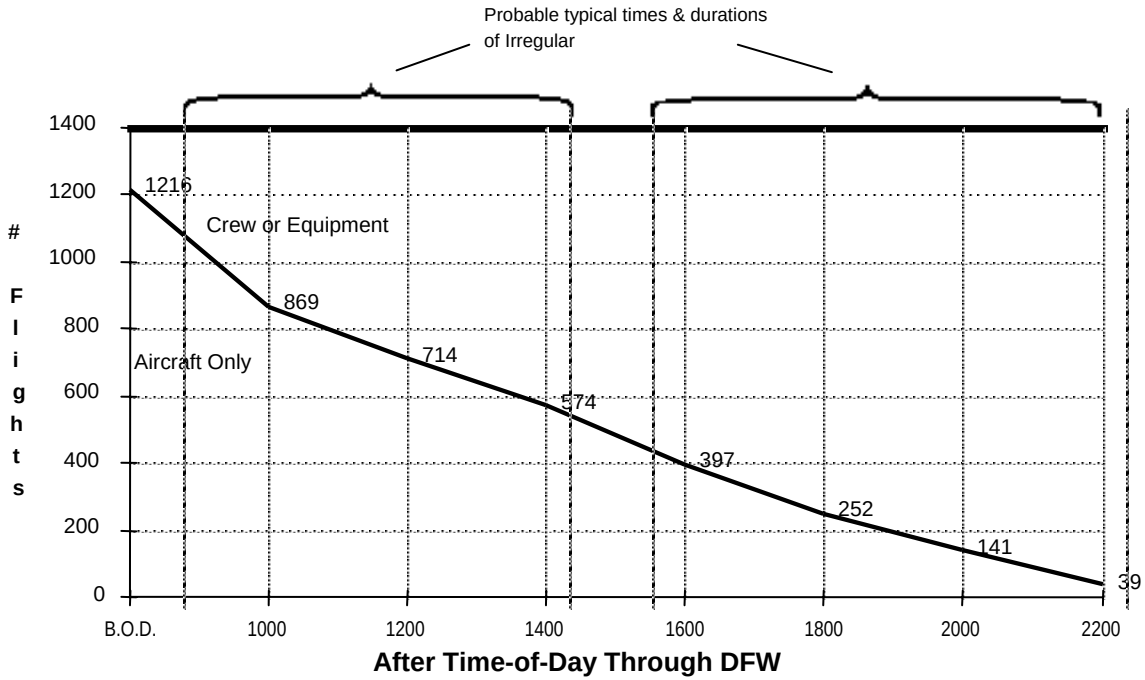


American Airlines Cost of Diversions
Crew Impact Approach



Crew vs. Weather

American Airlines
System Ruboffs from Delaying a Complex at DFW



- Following crew and equipment throughout the system shows these potential impacts from a DFW-only Irregular Operation
- If a problem occurs at the beginning of the day, could ruboff to 1216 flights. Likely resolution by 1400, eliminating 574 potential ruboffs, for a typical morning ruboff of up to 1216 - 574 = 642.
- If a problem occurs at 1400 or later, likely will not be resolved until end-of-day, resulting in up to 574 potential ruboffs

American Airlines Cost of Diversions
Summary of All Factors & Results Studied

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		DFW	DFW	DFW	DFW	DFW	DFW	DFW	DFW	DFW	DFW	DFW	DFW
2		Bag	Bag		Ramp	OTime	PSvc	OTime	Psgr	Psgr	Psgr	Psgr	Psgr
3		Tracers	Tracers	Ratio	OTime	Cost	OTime	Cost	Meals	Hotels	Osales	Osales	MisCn
4	Average	37.5	$2,064	-13.9	67.1	$1,771	6.3	$187	$33	$84	-4.3	($1,664)	49.5
5		Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div
6													
7		DFW	DFW	DFW	System	System	System	System	System	System	System	System	System
8		Psgr	Psgr	Depend	Depend	Depend	Cargo	Cargo	SptSkd	Ferry	SptFerry	Maint	Ferry
9		FIMS	FIMS	Arr<15	Arr<15	Blk In	b Refus	Refusal	Ferry	Time	Cost	Ferry	Time
10	Average	7.9	$1,040	-3%	-4%	-1%	5257	$2,823	0.0	-2.2	($67)	0.0	11.3
11		Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div
12													
13		System	System	System	System	System	System	System	System	System	System	System	System
14		MntFerry	SOC	SOC	UnrFry	UnrFry	UnrFry	DivRtn	DivRtn	DivRtn	Extra	Extra	Flts
15		Cost	Otime	Otime	Flight	Time	Cost	Flight	Time	Cost	OpHrs	OpHrs	Dlyd
16	Average	$319	0.0	$2	0.6	99.1	$2,275	0.4	30.4	$885	9.7	$17,243	49.9
17		Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div	Per Div
18													
19		System	System	System	System	System							
20		Dlyd	Crew	Flts	Cxld	IllWill							
21		PAX	Costs	Cxld	Costs	Costs							
22	Average	4013.4	$7,800	4.1	$18,180	$69,432							
23		Per Div	Per Div	Per Div	Per Div	Per Div							
24													
25	Per Div	$34,794	=Hard Costs		$18,180	=Soft Costs		$69,432	=Lost Revenue Potential				
26	Per Yr	$48.7	Million		$25.5	Million		$97.2	Million				
27	Per Cxl	$11,789	=Hard Costs		$4,454	=Soft Costs		$23,144	=Lost Revenue Potentia			1400	Div/Yr
28	Per Yr	$53.1	Million		$20.0	Million		$104.1	Million			4500	WX Cxl./

American Airlines Cost of Diversions
What Can We Do?

- The weather cannot be prevented, and it is what causes the Irregular Operation

- Three things can be used to reduce costs:
  - Cut the **number** of the diversions, with the HUGHES  ***FLIGHT DYNAMICS, INC.*** Heads-Up Display (HUD)
  - Cut the **severity** of the diversions' impact, with the "DFW Dump Plan", as proposed in 1991
  - Cut the **recovery time** from the disruption caused by the diversions, with the development and implementation of Irregular Operations decision support systems for Dispatch

- These are best if they are all used together. Only in such a fashion will AA be able to significantly cut these costs!

American Airlines Cost of Diversions
LGA Cancellation Study

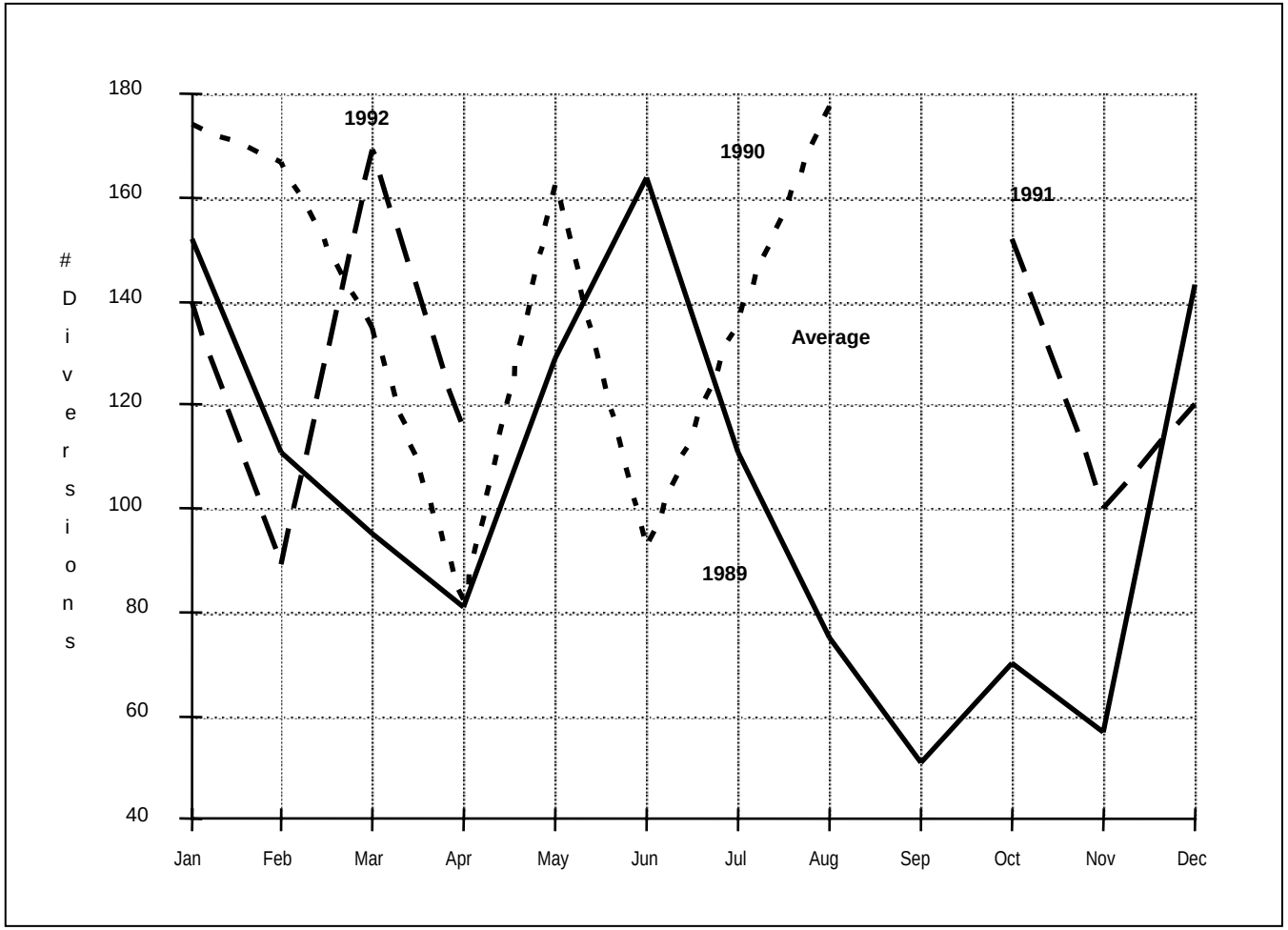
- An LGA snowstorm (3/19) was an isolated weather event, offering an ideal scenario for costing out cancellations, to follow *all* impacts, and trace *all* PNR's on at least some flights:

  - 31 cancellations
  - 30 hours direct *departure* delays, but 37 hours *arrival* delays, on 101 affected flights
  - *Indirect* effects to an additional 70 flights of same tails, causing total 48 hours departure delays and 58 hours arrival delays
  - On cancelled flights, 2500 pax, 2000 local and 500 connecting to 134 flights, a 4x multiplier
  - Selected 5 flights to follow *all* PNR's, 2 ORD-LGA, 2 LGA-ORD, 1 YYZ-LGA.
  - Accounting for likely no-show factors, retained all passengers from LGA-ORD & ORD-LGA. 9% flew on other airlines, but possible no-shows
  - Retained 56% pax on spoke-to-hub flight, but while 20% went OA, 9% *disappeared* from RES, even allowing for likely no-show factor. Implied is we pay FIMS to half of pax with cheap, restricted tickets, lose full revenue on higher revenue tickets.

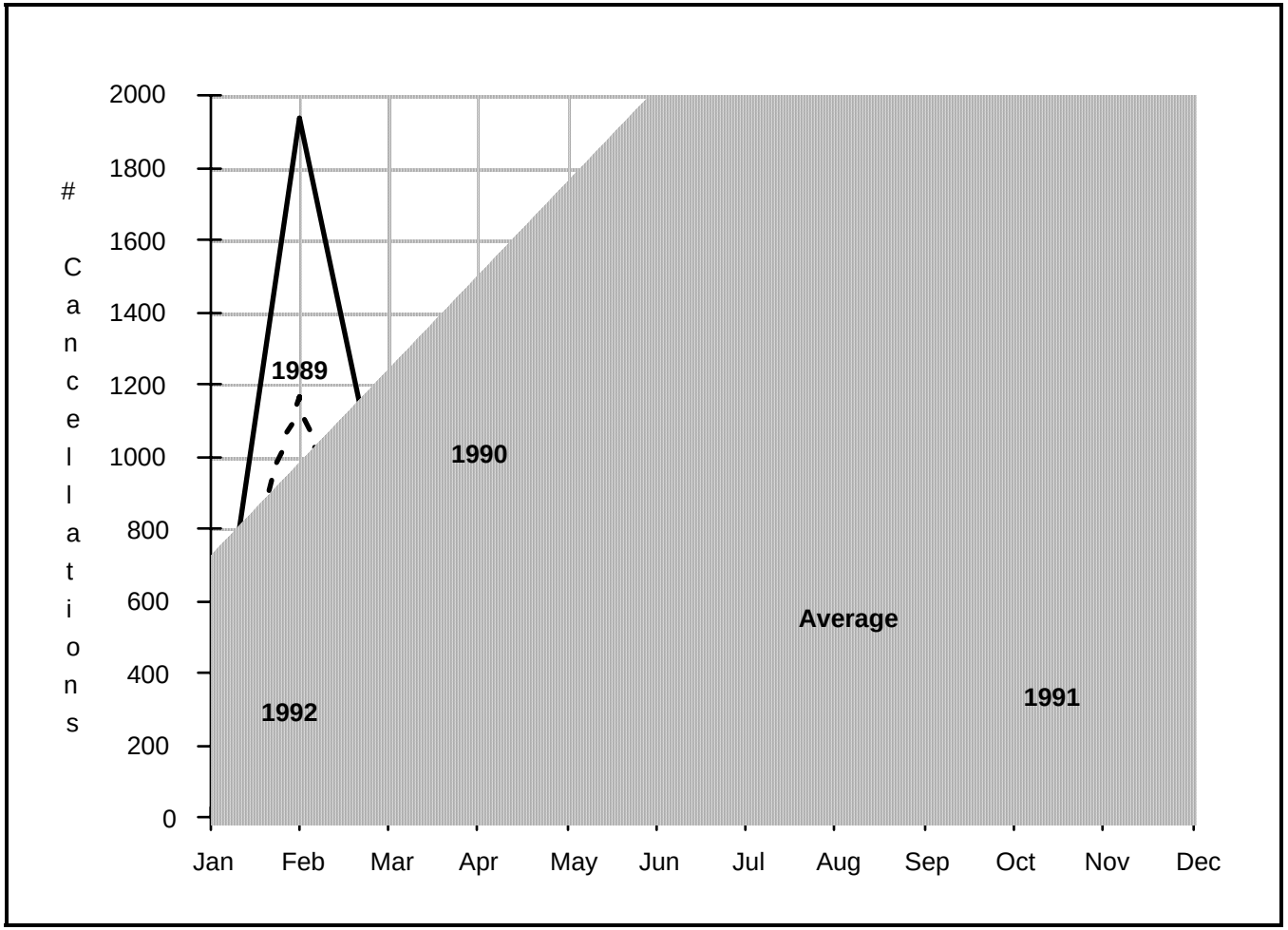
American Airlines Cost of Diversions
DFW Diversion Study

- A DFW morning fog episode (4/7) was an isolated weather event, offering an ideal scenario for costing out diverions, to follow *all* impacts:
  - 9 diversions, 27 cancellations, with an ATC-imposed DFW ground stop for 1 1/2 hours during fog
  - System-wide delay ruboff to 449 flights (departure > 15) or 529 flights (arrival > 15)
  - 401 hours direct *departure* delays, but 488 hours *arrival* delays, causing 87 hours of extra aircraft operating time
  - On cancelled & diverted flights, 1334 pax, 827 connecting to 247 flights, a 4x multiplier
  - 4 recorded “spotting for schedule” ferry flights, for a total operating time of 247 minutes at a cost of $9,425
  - 4 hard-to-track diversion return flights (to DFW) for a total of 274 minutes at a cost of $7,962
  - 9 hard-to-track “overflights” (ferrying crew or aircraft empty to a downline leg) for a total of 892 minutes at a cost of $20,477
  - Delayed 36,121 passengers (9,372 with connections) with a potential ill will cost of $969,432.
  - Only counted passenger delays in ill will model who were on downline delay ruboffs, on 352 flights, with 29747 passengers, for an ill will cost of $624,887

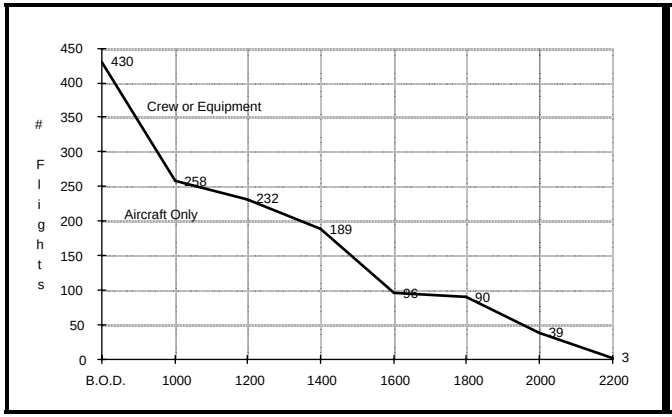
American Airlines System-Wide WX Diversions
1989-1992, by Month, Partial Data



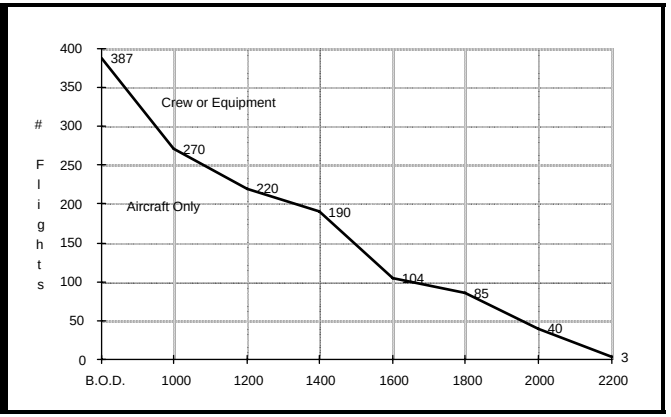
American Airlines System-Wide WX Cancellations
1989-1992, by Month, Partial Data



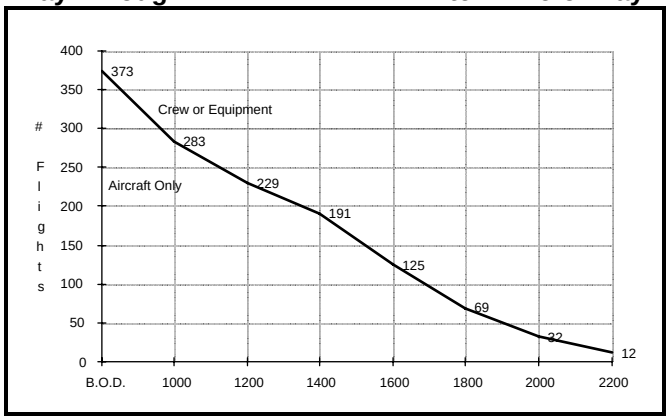
American Airlines Hub Complex Delay Ruboffs
Other Hubs



After Time-of-Day Through BNA

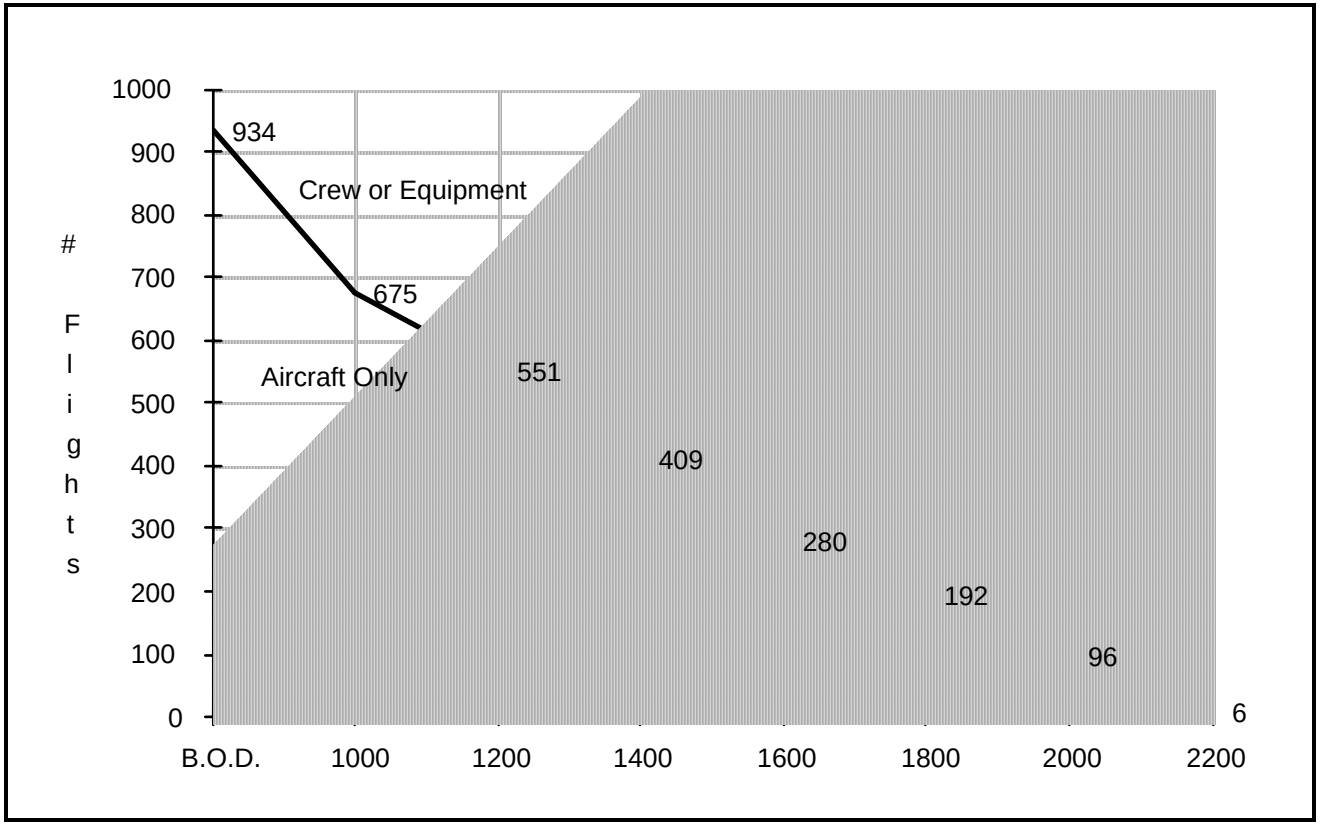


After Time-of-Day Through RDU



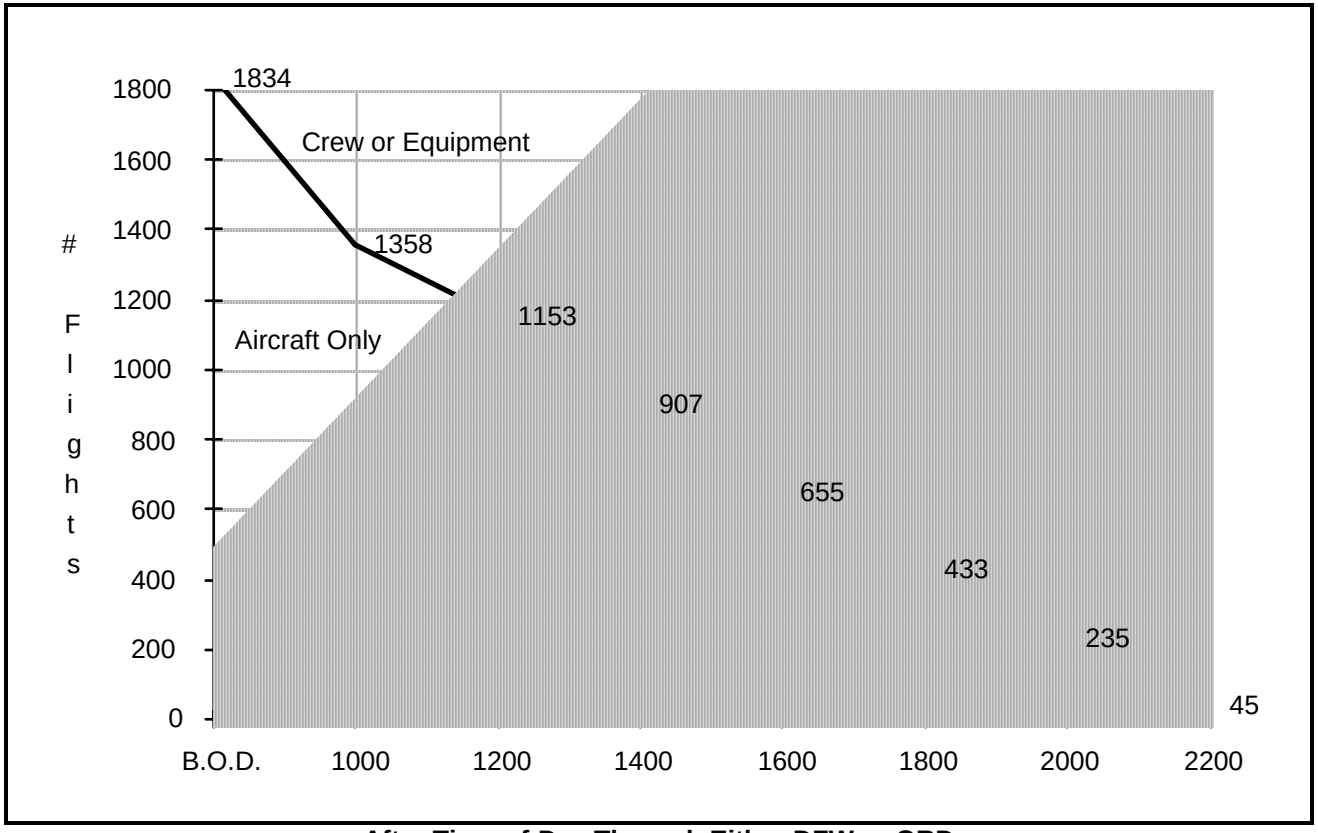
After Time-of-Day Through MIA

American Airlines Hub Complex Delay Ruboffs
Other Hubs



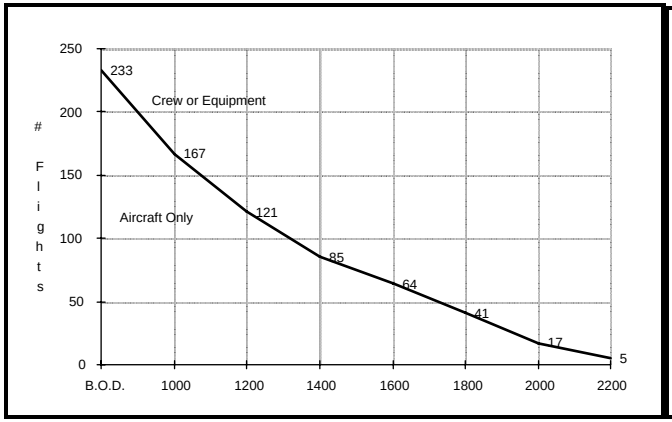
After Time-of-Day Through ORD

American Airlines Hub Complex Delay Ruboffs
Other Hubs

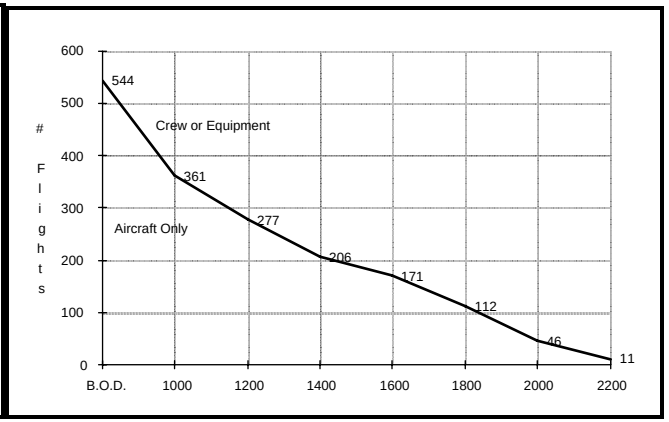


After Time-of-Day Through Either DFW or ORD

American Airlines Hub Complex Delay Ruboffs
Other Hubs



After Time-of-Day Through LGA



After Time-of-Day Through LGA/JFK/EWR/ISP/SWF

American Airlines Diversion Cost Avoidance
Applying This Study to Compute Potential HUD Avoidance of Diversions

- Actual data of which flights diverted due to reduced visibility is not available
- Can apply AA's schedule to NOAA weather data available and tracked by Hughes Flight Dynamics (visibility by station by time of day)
- If a flight was scheduled to land during a period of reduced minima that lasted < 30 min., there was no diversion. If > 30 min., then a diversion occurred.
    - ATC would give an EFC (Expect Further Clearance) beyond the actual airport re-open time (usually 60 minutes), even though there might be fuel oin board to avoid a diversion
    - When an airport reopens, it is usually at a reduced flow rate
- During any period of reduced minima, all flights scheduled to land prior to the last 15 minutes of reduced minima would divert
    - The same arguments apply here

American Airlines Cost of Irregular Operations

Dallas-Ft. Worth Study Results

On April 7, 1992, DFW exprienced heavy fog conditions beginning at about 0545 and lifting at around 0930. The number and type of impacts during and following this event were monitored and recorded.

- **Dallas-Ft. Worth airport runways were badly impacted for approximately four hours**
- **9 diversions and 27 cancellations were documented, affecting 1,334 passengers, with 827 of them connecting to 247 flights**
- **System-Wide impact on 449 departure flights and 529 arrival flights (>15 min.)**
- **889 hours of accumulated delays on direct flights (401 hours of departure delays & 488 hours of arrival delays) - 87 hours extra aircraft operating time**

American Airlines Cost of Irregular Operations

Cancellation Costs

- **All cancellation costs are derived from the M & E Plans book (1992) Cancellation Cost Model. This is used to make comparisons between alternatives, but is generally not used for cost justifications. However, this study uses the numbers conservatively, by assuming all cancellations to be spot departure narrowbody cancellations.**

- **Cancellation costs of this model include:**

  - **Food, Catering Services, Catering Supplies, Liquor, Passenger Commissions, Freight Commissions, Credit Card Fees, Fuel, Oil & Taxes, Fuel & Oil Servicing, Air/Ground Communications, Landing Fees, Direct Maintenance, Aircraft User Fees, Terminal User Fees, Passenger Insurance, Cargo Insurance, Passenger Inconvenience, Passenger Bad Debt, Freight Bad Debt, Cargo Loss and Damage**

- **There is no overlap between these costs and the rest of the study. The rest of the study does not address impact to passengers directly involved in the cancellations and diversions**

American Airlines Cost of Irregular Operations

Cancellation Costs

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American Airlines

Weather Related Irregular Operations

- **Irregular Operations produce Diversions, Cancellations, and Delays**
- **Annually, Irregular Operations produce 1400 Diversions, 4500 Cancellations. Delays observed in the study are in a ratio of 50 Delays per Diversion**
- **Costs considered in this study include:**
  - **Extra Operating Hours, Additional Cockpit Crew Hours, Ferry Flights, Diversion Return Flights, Ramp Services Overtime, Passenger Services Overtime, Baggage Mishandling, Passenger Meals & Hotels, Passenger Oversales, Passenger Misconnects, Passenger FIMS (Flight Interrupt Manifests), Cargo Refusals, SOC Overtime, Crew Open Time Costs, Passenger Ill Will**