Airline schedules: variability and recovery

- What causes irregular operations
- Who are the players
- What are the fixes
- External factors
- Other discussion
My Aviation Background

Commercial/Research

- MAXjet Airways (2003-2008)
- eJet Aviation Holdings (2008-Present)

Policy/Regulatory Consulting

- Marks Aviation (2008-Present)
- American Aviation Institute (2010-Present)
My Commercial Focus Areas

* Real-world airline operations
* Policy and regulatory strategy
* Global alliances and antitrust

Irregular operations play a role in each of these areas

* Impact of weather and airport capacity on cancellations
* Policy of crew duty limits and passenger rights
* Availability of alternate itineraries
How do airlines define IRROPS?

Deviation from planned flight operation(s)

* Uncontrollable causes: weather, ATC, security, medical

* Controllable causes: mechanical delay, aircraft substitutions, delayed or sick crew, catering delay, denied boarding, etc.

* Other terms used: IROPS, OSO, etc.
There are two kinds of schedule deviation from an airline operations perspective.

1. **Isolated events** (i.e. 15-30 minutes late) to a specific flight where few passenger misconnects occur, but **follow-on flight segments** are not impacted; and

2. **Systemic events** (cancellations, long delays, diversions) where **multiple aircraft** and their **follow-on flight segments** are impacted.
IRROPS Stakeholders

- Airline system managers
- Airline vendors (fueling, mechanics, catering)
- Airline crewmembers and mechanics
- Airport operators
- Airport services (hotels, ground transportation)
- Air traffic control (airport, regional, system)
- TSA and CBP
- And Passengers!
Your planned flight operation is impacted by factors that make an on-time departure unlikely or impossible. What are your options?

* **Defined Delay.** Reschedule with a new departure time;

* **Indefinite/Rolling Delay.** Delay without posting a new departure time, to determine if conditions improve; or

* **Cancel** the flight, re-protect passengers and reallocate/re-position the aircraft and crew.
Who makes these decisions?

* Decisions in advance of departure will be made by the operations command team based on available info.

* Cancellations after gate departure are decided by the pilot in command and the dispatcher for the flight, plus airline airport managers and system operations teams.

* Cancellations at diversion airports are decided on a one-off basis, with all available facts considered.
What’s Normal in Operations?

On-Time Arrivals % (Red Line) vs. Level of Operations Reported (Green Line) (100% = 1991)
But is the aggregate on-time performance in the system really useful for strategic schedule planning and tactical operational decisions?

Hundreds of airports, millions of flights each year... IRROPS is about specific flight and event recovery, not advance (strategic) optimization of the network...
Example: Monthly vs. Daily OTP

Graph: Monthly OTDP%
May-Sep 2010 (Part 234)

**Monthly On-Time Departure Performance (May-Sep 2010)**
Example: Monthly vs. Daily OTP

Graph: Daily OTDP%
May-Sep 2010 (Part 234)

Daily On-Time Departure Performance (May-Sep 2010)
Annual or monthly on-time statistics do not capture the extreme variability of airport-specific performance.

IRROPS weather events tend to be airport-specific or regional, not national or systemwide in scope.

As a result smooth operations in one region can be accompanied by flight-cancelling events in another.

Significant implications for national networks with hubs distributed across the US (or world).
What does a delay cost an airline?

To think about this, consider delay responses by airlines and by air traffic control:

- **Strategic** – airline builds **probable delays** into schedules
- **Tactical advance** – delay implemented pre-departure
- **Tactical enroute** – flight is delayed after gate departure: on the taxiway or in an airborne hold

**Estimating Delay Cost**
Tactical (Direct) Delay Cost

- Direct Operating Costs (B737-800)
  - Fuel:
    - Airborne hold – 700 gallons/hour, $3/gal = $35/minute
    - Ground taxi – 200 gallons/hour, $3/gal = $10/minute
  - Direct maintenance:
    - Per operating hour $800 = $13/minute
  - Crew:
    - Annual direct cost $430K, 1000 flight hours = $7/minute
- Direct cost of a ground delay = $30 per minute
Passenger missed connections

- Minimum connect time padding?
- Hotel and vouchers - $100 or more per passenger
- Revenue displacement and revenue loss
- Prorate charges from other carriers

Follow-on impact

- Passenger compensation and fines
- Customer economic productivity
* Domestic US – between $30 and $55 per minute in direct delay costs to the airline
* But notice that passenger delay cost isn’t a primary factor in airline delay decisions
  * It takes a lot of delay minutes before passengers decide to “go home” rather than take the flight
  * This is a primary reason why (historically) airlines have expressed a strong preference to delay vs. cancel
* But what does a cancellation cost?
Various estimates of the cost of a flight cancellation

- $14,800 by DOT (domestic flight)
- $50,000 or more for international flights

What are relevant factors?

- Fuel and direct maintenance savings
- Wasted crew time, catering and airport services
- Passenger revenue loss and re-accommodation
Re-accommodation Procedures

* First: seats on the impacted airline
* Second: seats on preferred partner carriers
  * Joint venture alliances – full revenue credit
  * e.g. United has full access to inventory on Lufthansa and Continental, and vice versa – int’l and domestic
* Third: seats on marketing partners (UA → US)
* Fourth: seats on the enemy (UA → AA or DL)
* Airlines negotiate discounted rates for economy and premium seats for use only during IRROPS
Passenger Cost: Rebooking Time

**Average Passenger Delay (hrs) By Network Load Factor**

<table>
<thead>
<tr>
<th>Systemwide Load Factor</th>
<th>Passenger Re-Accommodation Delay (hours)</th>
<th>% of Passengers Reaccommodated after 48 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>8.4</td>
<td>100%</td>
</tr>
<tr>
<td>65%</td>
<td>9.1</td>
<td>100%</td>
</tr>
<tr>
<td>70%</td>
<td>10.1</td>
<td>100%</td>
</tr>
<tr>
<td>75%</td>
<td>12.6</td>
<td>100%</td>
</tr>
<tr>
<td>80%</td>
<td>15.6</td>
<td>100%</td>
</tr>
<tr>
<td>85%</td>
<td>20.6</td>
<td>95%</td>
</tr>
<tr>
<td>90%</td>
<td>23.0</td>
<td>90%</td>
</tr>
<tr>
<td>95%</td>
<td>28.2</td>
<td>66%</td>
</tr>
</tbody>
</table>

How does an airline balance the decision to cancel a flight versus delay it?

There are two types of decisions:

- The easy ones, and
- The hard ones.
Easy Cancellation Decisions

Easy cancellation decisions:

* Absolute safety factors (e.g. maintenance, ice pellets)
* Absolute resource factors (crew sick & no reserves, etc.)
* Critical vendor issues (fueling not available, etc.)
* Curfew, slot and noise restrictions
* Security-related issues with no resolution time given

Delays likely to impact the current flight and one or more follow-on operations using the assigned resources
Easy Delay Decisions:

- Minor catering or vendor delays
- Late arriving crew
- Ramp congestion and/or minor ATC holds
- Security checkpoint or CBP delays
- Known short-term weather events (minor thunderstorms)
- Maintenance issues where deferral acceptable

The delay decision **has minor or no impact on follow-on flight operations using the resources allocated to the flight**
What makes the decision difficult?

When the probability is significant that delay decisions will **materially impact follow-on flights**, either due to revenue loss (missed connections) or operational factors (resources out of position)
Illustrating Follow-On Impact

N291AA (MD-82) on 9/1/2010

- Five flight segments scheduled
- 55-60 minute turns
- Flights to/from congested airports

What are decision factors for AA if weather/ATC factors cause long morning delays at LaGuardia?
Domestic Segments per AC Day

- Southwest: 6.2
- Mesa: 6.2
- AirTran: 4.9
- Frontier: 4.9
- ExpressJet: 4.6
- Pinnacle: 4.4
- Alaska: 4.4
- Delta: 4.4
- United: 4.2
- American: 3.7
- JetBlue: 3.7

Domestic Flight Segments per Unique Narrowbody Aircraft
September 15, 2010 – Part 234 Reports
Relevant factors: delay or cancel

* Aircraft at base? How many flights to base?
* Strategic delays already built into schedule
* Scheduled turn times at intermediate points
  * Can turns be accelerated?
* Crew pairings – is the crew staying with the aircraft?
* Blown connections to/from outstations
* Load factors, revenue and number of passengers
* Schedule frequency to the destination(s)
Decisions at Base or Outstation

* Cancelling a flight at a base is **not** the same decision process as cancelling at a spoke city
  
  * Alternate uses for the aircraft and crew
  
  * If crews away from base, need hotels and rest time
  
  * Passengers in transit need accommodation
  
  * Passengers at either origin or destination may require accommodation if cause is controllable
So as an operator you have two fundamental choices:

1. Continue the flight operation and risk significant impact to follow-on flight operations, or

2. Cancel the flight operation, take the pain now, notify & reroute passengers, and focus on clean re-start

Need to look at advance warning & cause of IRROPS
Causes of IRROPS

* Carrier factors
  * Mechanical
  * Crew
* Weather factors
* ATC and security factors
* Upstream factors
Last Minute vs. Advance

Last-Minute Factors
* Crew no-show
* Pop-up weather (e.g. thunderstorms)
* Maintenance failure
* Security event
* ATC congestion or other ATC failures

Advance Warning
* Crew shortages
* Large-scale storms (blizzards, hurricanes)
* Runway construction and/or terminal factors
* Peak schedules
* Mx deferral expiry
Weather

Winter weather

* NWS advisories +12 to +48 hours (watch, warning)
* Airport capabilities during snow vary (Boston vs. Las Vegas)
* Relatively precise except at snow/rain boundaries (icing!)
* Longer duration events

Summer weather

* Severe weather watches impact broad areas
* Hit and miss with convective activity
* Short impact, but potential for repeat during period
Winter Weather: Broad Impact

- Major airport impacted
Summer Weather: Focused Impact

Major airport impacted
Summer vs. Winter

* Advance notice
* Duration of event
* Airport capability during event
* Ramp access during event
* Airport recovery capability
* Availability of diversion airports
* Tarmac delay risk during event (de-icing queues)
* Passenger and crew access to/from airport
* Hangar space and shelter available
ATC Delays

* Often initiated after gate push, since ATC resources “claimed” for a flight when ready to depart

* Airport-specific factors – ramp congestion, long departure queues, inbound arrivals, etc.

* Ground stops and taxiway holds for flights inbound to problem airports – get in the penalty box and wait!
What causes ramp congestion?

Assuming the schedule is balanced to begin with...

- Inbound flights already coming
- Flights at gate ready to depart
- Constrained departure capacity

Distills to three key factors:

1. Ramp and taxiway space available
2. Simultaneous arrivals and departures
3. Unconstrained regional airspace capacity
Examples: JFK vs. DEN
Facility Congestion

- Causes long tarmac delays (taxi-out and taxi-in)
- Creates schedule disruption
- Impacts crew duty timing

**ATC can respond by:**
- Blocking inbound flights at their origin airports
- Airborne holds for inbound aircraft
- Prioritizing departure capacity
- Operating simultaneous arrivals and departures
When Long Taxi Times Occur

Long (3hr) Tarmac Times by Time of Day

During the summer, severe weather causes long afternoon taxi delays
Tarmac delays and ramp congestion coincide with pop-up weather conditions during the summer.
For the reasons discussed, airlines strongly prefer to cancel before gate departure rather than risk interminable tarmac delays and/or gate returns.

Now we are going to discuss the four types of cancellations, and how facility congestion and weather factors influence those decisions (and network recovery).
Cancellations – 4 Types

Before Gate Departure
* Advance (8+ hours before departure)
* Short notice (2-8 hours before gate departure)
* Last minute (0-2 hours before gate departure)

After Gate Departure
Airborne Return (to origin airport)
En-Route Diversion Airport
Frequency of Cancellations

Flight Cancellations by Phase (2010)

- Pre-Gate Departure: 168 per 10,000 departures (108,777 cancellations)
- After Gate Departure: 5 per 10,000 departures (3,172 cancellations)
- Airborne Return: 2 per 10,000 departures (1,306 cancellations)
- Diversion Cancellation: 4 per 10,000 departures (2,805 cancellations)

6.45 million total flights during 2010 (BTS)
Particularly popular when any of the following probable:

- Long-term weather disruption
- Departures or arrivals blocked (by ramp, runway, or airspace)
- Regional diversion airports unavailable
- Ground access to airport difficult or impossible
- Crew flight time does not start
- Pre-cancel away from the impacted area
* Cancellations 2-8 hours before event
* Crew swaps difficult without compromising duty time
* Passenger notification more difficult
* Catering and airport services in process
* Aircraft likely en route to problem area
Aircraft, crew, passengers and resources in place to operate the flight

Why cancel at the last minute?

- Non-deferrable maintenance required
- Probability of successful departure is low
- Delay time indefinite or recovery option compelling
- Tarmac rule fine exposure
Cancellations after Gate Departure

* Aircraft departs the gate – then returns and cancels
* Why does this happen?
  * Non-deferrable maintenance problem found on startup
  * Weather suddenly worsens
  * Airspace closes
  * Expected ground hold exceeds crew duty limits
  * Long de-icing queues – can’t de-ice and depart in time
  * Risk of 3-hour tarmac hold
Airborne Returns

* Equipment failure in flight – aircraft “dead” on landing
  * Critical event after takeoff – requires immediate landing
  * Non-critical event – airline maintenance and parts at the origin airport to fix, but not at the spoke city
* Destination airport and filed alternates close
* Ugly result for the airline – passenger, crew and aircraft disruption. Fuel expense and loss of revenue
En-Route Diversions

* **Safety** diversions vs. **tactical** diversions
* Safety diversion – unable to land at destination airport or hold due to fuel or mechanical emergency
  * Pilot in command selects closest available airport suitable for *landing* the aircraft
* Tactical diversions – en-route to avoid tarmac delay at destination, or await better weather conditions
  * Both destination and diversion airports unavailable
  * Divert into online station capable of *deplaning* aircraft
Safety Diversions

* Significant recovery issues
* Strongly correlated with long tarmac delays
* Crew can time out on landing – but always need to:
  * Deplane the aircraft within three hours (not so easy with B757/B767 and larger aircraft)
  * Choose whether to complete the flight (next day?) or ferry
  * Maintain the aircraft (daily check, sign-off, ETOPS etc.)
  * Service the aircraft (lavatories, water, etc.)
Tactical Diversions

* Divert aircraft en-route into facility with runway and ramp capability to handle the aircraft
* Online personnel ready to assist passengers
* Hold at tactical diversion point for weather to clear, or cancel and re-book passengers onto other flights
* Not surprisingly, most tactical diversions are into major airline hubs (DFW, ATL, etc.) where aircraft, crew and passenger repositioning options greatest
Planes Divert En-Route to Hubs

Diversion Airports (2010) (En-Route Diversions)

1. Denver (413)
2. Atlanta (387)
3. BWI (302)
4. Los Angeles LAX (280)
5. Austin (277)
6. Indianapolis (269)
7. Colorado Springs (266)
8. Phoenix (264)
9. O’Hare (249)
10. Salt Lake City (243)
So:

- Delays before departure are relatively low-cost... until the delay impacts follow-on flights or connections
- Cancellations before departure can be the lowest cost option for dealing with *probable* severe weather
- Airlines get caught with pop-up summer weather – which often causes last-minute cancellations, diversions and expensive recovery
Schedule Recovery

* Operations support software is critical in optimizing the recovery of the flight network
* Key factors to consider:
  * Crew pairings and available duty time
  * Aircraft location and maintenance requirements
  * Passenger loads – both disrupted and planned
* Often crew and aircraft will be paired during disruptions in order to increase flexibility in off-plan operations
Other Noteworthy Items

* Tarmac delay rule
* Passenger responsibilities
* Possible crew duty time changes
• Effective April 29, 2010, DOT policy restricted taxi time before takeoff or deboarding to 3 hours
• DOT threatens punitive fines ($27,500 per passenger)
• Tarmac delays stopped and cancellations have spiked
• DOT projected 41 incremental cancellations per year
• Thousands of cancellations already due to the rule
### Distribution of Long Taxi Times by Phase
(Full Year 2009; 6,450,285 total flights scheduled)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Taxi-Out (no Gate Ret.)</th>
<th>Taxi-Out (Gate Return)</th>
<th>All Taxi-Out</th>
<th>Diversion Airport</th>
<th>Taxi-In (Destination)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3 Hours</td>
<td>3,967</td>
<td>789</td>
<td>4,922</td>
<td>363</td>
<td>118</td>
</tr>
<tr>
<td>3-4 Hours</td>
<td>506</td>
<td>166</td>
<td>672</td>
<td>63</td>
<td>2</td>
</tr>
<tr>
<td>4-5 Hours</td>
<td>69</td>
<td>39</td>
<td>108</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>5-6 Hours</td>
<td>8</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>6+ Hours</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Tarmac Fines vs. Revenue On Board

Potential revenue based on airline year-end reports. Revenue on a flight segment (not round-trip) basis. Regional Jet based on SkyWest reported revenue per passenger for FY2009. A320/B737 based on Southwest Airlines revenue per passenger for FY2009.

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Potential Revenue</th>
<th>Potential Fine</th>
<th>Fine to Revenue Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Jet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70 seats</td>
<td>$75 per passenger</td>
<td>$1.56 million</td>
<td>366:1</td>
</tr>
<tr>
<td></td>
<td>$4,253 per flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(81% load factor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A320/B737</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>144 seats</td>
<td>$119 per passenger</td>
<td>$3.21 million</td>
<td>231:1</td>
</tr>
<tr>
<td></td>
<td>$13,880 per flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(81% load factor)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Airline Response: Proactive Steps

Tarmac Delay Procedures

<table>
<thead>
<tr>
<th>Time from Push-Back</th>
<th>Checkpoint</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:00 after gate push-back</td>
<td>Food and water</td>
<td>Pilots confirm that food and water has been distributed. Pilots and cabin crew inform passengers of the DOT rule and Delta’s compliance strategy.</td>
</tr>
<tr>
<td>2:00</td>
<td>Flight return assessment</td>
<td>Delta’s operations center conducts a review of the delayed flight and flags the operation for further action.</td>
</tr>
<tr>
<td>2:15</td>
<td>Flight return decision</td>
<td>Unless takeoff is certain within 30 minutes, the flight returns to gate.</td>
</tr>
<tr>
<td>2:30</td>
<td>Mandatory return</td>
<td>The aircraft returns to the gate even if departure is imminent (few exceptions permitted)</td>
</tr>
</tbody>
</table>

* Formal approach (DL, UA): specific time checkpoints established with rare exceptions

* Informal approach (AA, WN): case by case basis, with flights flagged for action at 2 hours

* Result of all approaches: High increase in cancellation decisions made prior to departure, or before two hours of taxi time.

Based on interviews with airline operations teams
Part 240 Rule

- Today – very few carriers honor Part 240 obligations to re-accommodate passengers on other airlines
- Result: longer re-booking times

EU Passenger Compensation – Coming to the US?

- Regulation (EC) 261/2004 – always meals, transport, hotels
- EUR 250/400/600 for short/med/long flights for delays not due to extraordinary circumstances out of airline control
Pending Notice of Proposed Rulemaking would significantly overhaul crew duty regulations.

Key changes include:

- Allowing two-pilot crews to operate certain transcontinental flights back-to-back, and more Europe-US flights without relief pilots; and
- Introducing a two hour duty “buffer” for IRROPS

Likely that the two hour buffer will have significant impact on reducing cancellations.
Conclusions

* Objectives (besides safety) always:
  * Minimize cost to the airline
  * Maximize revenue retained from passengers
  * Return operations to schedule as quickly as possible
* Delay vs. cancel – tradeoffs always at play
* External factors (i.e. tarmac regulations) have significant impact on how airlines manage IRROPS