Modeling Convective Weather Avoidance of Arrivals in Terminal Airspace

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Goal

Adapt the Convective Weather Avoidance Model (CWAM) for the terminal airspace with a focus on arrival decision making

Motivation

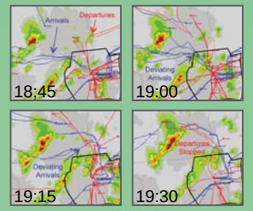
Arrival Management

Operational impact planning of weather avoidance in terminal

Case id: 328567 B772 DEN ⇒ ORD

Departure Management

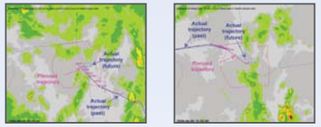
Arrivals deviating into departure airspace



June 8, 2009 ORD

Challenges

- Flexibility in arrival airspace makes it difficult to identify planned trajectory

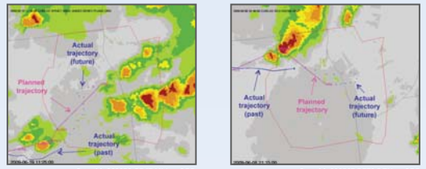


Case id: 299529 CRJ7 RDU ⇒ ORD

- Trajectory from cornerpost dependent on many factors
  - Runway configuration
  - Extension of downwind leg due to winds, traffic volume, etc.
  - Potential interactions with operations of nearby airports

Typical Cornerpost Impacts

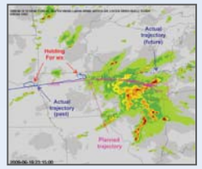
"Classic" Deviations



Case id: 863258 CRJ7 MLI ⇒ ORD — Case id: 328567 B772 DEN ⇒ ORD

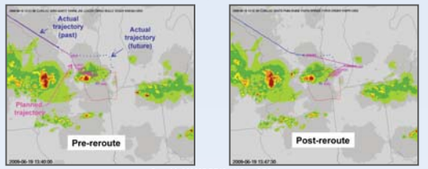
Arriving aircraft deviating to avoid a storm near the arrival cornerpost
No flight plan changes made

Airborne Holding



Airborne holding assumed in response to weather at cornerpost

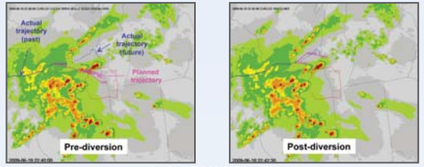
Airborne Reroute



Case id: 862605 B742 ANC ⇒ ORD

Airborne reroute to alternate cornerpost to avoid weather

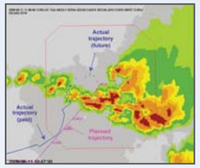
Diversion



Case id: 899095 DC10 MEM ⇒ ORD

Diversion to avoid cornerpost weather

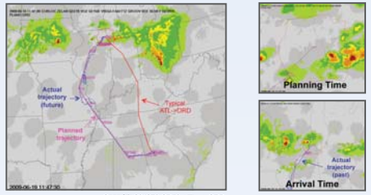
Pathfind



Case id: 450693 B738 LAX ⇒ DFW

Aircraft maneuvers to avoid weather inside terminal

Planning

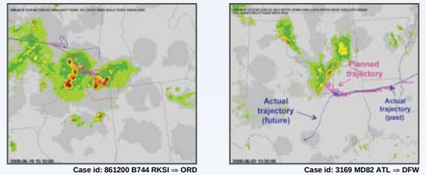


Case id: 864870 CRJ9 ATL ⇒ ORD

Pilot plans atypical route to avoid weather impacting cornerpost at departure time

Typical Airport Impacts

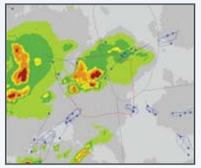
Diversion



Case id: 861200 B744 RKSI ⇒ ORD — Case id: 3169 MD82 ATL ⇒ DFW

Airport closed – diversion after holding

Holding



Airport closed – aircraft enter holding patterns to wait out storms

Analysis Database

- Analyzed five days from 2009 for four metro regions
  - ORD, DFW, CLT, and DEN
  - ~11,000 trajectories
  - ~4,000 weather impact decisions

Weather Impact Decision Type

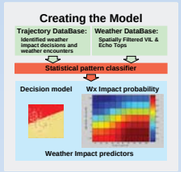
Weather Impact Location	Planning	Reroute	Deviation	Holding	Slowdown	Pathfind	Missed	Diversion	TOTALS
Cornerpost	286	435	221	108	39	71	0	33	1193
Airport	0	7	0	394	35	0	10	226	662

- Cornerpost: Most common weather impact decisions are planning, rerouting, and deviation
- Airport: Most common weather impact decision is to hold

CWAM Modeling

Modify enroute CWAM for terminal applications

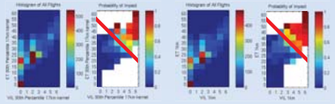
- Identify impacts that are specific to terminal operations (manually)
  - 'Classic' Deviation
  - Holding
  - Reroutes
  - Avoidance planning
  - Diversions
  - Slowdowns
  - Pathfinding



- Identify nonimpacted flights (automated)
- Create Terminal Weather Avoidance Field (TWAF) from probability of weather impact decisions

Cornerpost Impacts

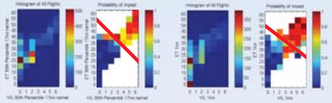
Spatial Filter: 90th Percentile over 17 km kernel — Spatial Filter: None



A correlation exists between pilot behavior and the storm intensity and echo top height. Pilots are likely to avoid storms with tops greater than 40 kft and VIL greater than level three. However, pilots will penetrate storms with level four intensity if the tops are below 35 kft.

Airport Impacts

Spatial Filter: 90th Percentile over 17 km kernel — Spatial Filter: None



Airport closures are likely to occur when precipitation with intensity greater than level three and/or echo tops are greater than 40 kft.

Conclusions

- Terminal weather avoidance is highly correlated with precipitation intensity (VIL) and the storm vertical extent (echo top)
- Pilots will fly in close proximity to storms within the terminal airspace suggesting that large spatial filters are not appropriate

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