Case Study of Adverse Weather Avoidance Modelling

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4th SESAR Innovation Days
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Case Study of Adverse Weather Avoidance Modelling

Outline

• Motivation and Objectives

• The weather diversion model DIVMET

• The air traffic simulation model NAVSIM

• Case Study: Air traffic over Austria during a squall-line passage

• Summary and Outlook
Motivation and Objectives

17th July 2010: Squall line over Austria and Czech Republic
  extension: >500 km, durability: ~6 hrs

  → Impact on air traffic
  → Austro Control: Additional workload for air traffic controllers

Can we predict the sector occupancy for various time scales by forecasting weather impacted flight trajectories?

Basic question: How accurately and realistically can we simulate trajectories in adverse weather situations?
  Case study: thunderstorms, 1 hr time horizon (over Austria), based on observations, but not yet on forecasts
THE WEATHER DIVERSION MODEL
DIVMET
DIVMET

Input:
- Flight trajectories
- Weather situation

Parameters:
- Distance to CBs
- Field of view
How much weather information is considered?

**Limited view (business case: on-board radar at night)**

**Full view (unlimited weather information in the cockpit)**
How much weather information is considered?

Limited view (business case: on-board radar at night)  Full view (unlimited weather information in the cockpit)
DIVMET

Input:
- Flight trajectories
- Weather situation

Parameters:
- Distance to CBs
- Field of view

→ Realistic representation of diversion routes

→ Diagnostics: Punctuality, distance, fuel consumption

Limitations:
- 2-dimensional
- Single AC with constant speed
- Without AC performance data
THE AIR TRAFFIC SIMULATION MODEL
NAVSIM

C.-H. Rokitansky
NAVSIM: Global air traffic simulation tool

Up to 300,000 aircraft per day

Simulation: real time and fast time (up to 60x)

4D trajectories

Input:
- Traffic Demand
- Base-of-Aircraft-Data (BADA)
- Navigation data
NAVSIM

Output:
• Position recording

Display (radar-like screen):
• Weather polygons
• FPL route (planned)
• CPR route (actually flown)
• POS route (NAVSIM simulated)

AC-AC conflict detection

Realistic representation of the entire air traffic from gate to gate!
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CASE STUDY: AIR TRAFFIC OVER AUSTRIA DURING A SQUALL LINE PASSAGE
17th July 2010, 12:30 UTC – 18:00 UTC

>26,000 flights over Europe (Traffic Demand)

Weather radar data: CERAD
- Threshold for polygons: 37 dBZ ↔ 8 mm/h
- Time interval: 15 min

„Area of relevance“

![Map showing the area of relevance](image_url)
Scenario: 8 flights in the area of relevance
Scenario: 8 flights in the area of relevance

<table>
<thead>
<tr>
<th>AC-Type</th>
<th>Start (UTC)</th>
<th>Departure</th>
<th>Destination</th>
<th>Detour in % of FPL route</th>
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</thead>
<tbody>
<tr>
<td>B737</td>
<td>13:53</td>
<td>Graz</td>
<td>Berlin-Tegel</td>
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<tr>
<td>F100</td>
<td>14:34</td>
<td>Vienna</td>
<td>Frankfurt/M</td>
<td>-2</td>
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<td>Split</td>
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<td>CRJ9</td>
<td>16:58</td>
<td>Düsseldorf</td>
<td>Vienna</td>
<td>0</td>
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</table>

Weather update (interval: 15 min)  
New route calculation  
Residual route is deconflicted
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Flight from Vienna to Frankfurt

- Distance to CBs: 5 NM
- Distance to CBs: 10 NM
Flight from Vienna to Frankfurt

Flight from Vienna to Frankfurt, simulated with varied parameters (distance to CBs, field of view)

Conclusions:
- Actual flight can partly be represented
- Smallest deviation from FPL with $d = 5$ NM
- Largest detours with limited view and $d > 5$ NM
- Optimized trajectories for $d > 5$ NM with full view
- All simulated trajectories are shorter than actually flown route (up to 6%)

TABLE I

<table>
<thead>
<tr>
<th>route parameters</th>
<th>track length (NM)</th>
<th>deviation from FPL route (NM)</th>
<th>deviation from CPR route (NM)</th>
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<tbody>
<tr>
<td>FPL</td>
<td>358.0</td>
<td>0.0</td>
<td>-14.0</td>
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<tr>
<td>5 NM full view</td>
<td>351.0</td>
<td>-7.0</td>
<td>-21.0</td>
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<tr>
<td>10 NM</td>
<td>353.6</td>
<td>-4.4</td>
<td>-18.4</td>
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<tr>
<td>15 NM</td>
<td>357.9</td>
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<tr>
<td>5 NM limited view</td>
<td>350.0</td>
<td>-8.0</td>
<td>-22.0</td>
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<tr>
<td>10 NM</td>
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<tr>
<td>15 NM</td>
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<tr>
<td>CPR</td>
<td>372.0</td>
<td>+14.0</td>
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SUMMARY AND OUTLOOK
Summary

17th July 2010: Squall line over Austria and Czech Republic
          Austro Control: Additional workload for air traffic controllers

How accurately and realistically can we simulate trajectories in thunderstorm situations?

- Comparison of simulated trajectories with planned and actually flown routes
- Deconflicted realistic routes using DIVMET and NAVSIM
- More efficient routes in case of an increased field of view
- Limitation: Special flight manoeuvres (e.g. directs)

- Decision support for pilots in case of adverse weather
Outlook

Key question: Can we predict the sector occupancy for various time scales by forecasting weather impacted flight trajectories?

Prediction of sector occupancies will be possible at least for up to 1 hr!
Thank you!

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