

Air Traffic Planning in an Uncertain World

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MITRE Sponsored Research

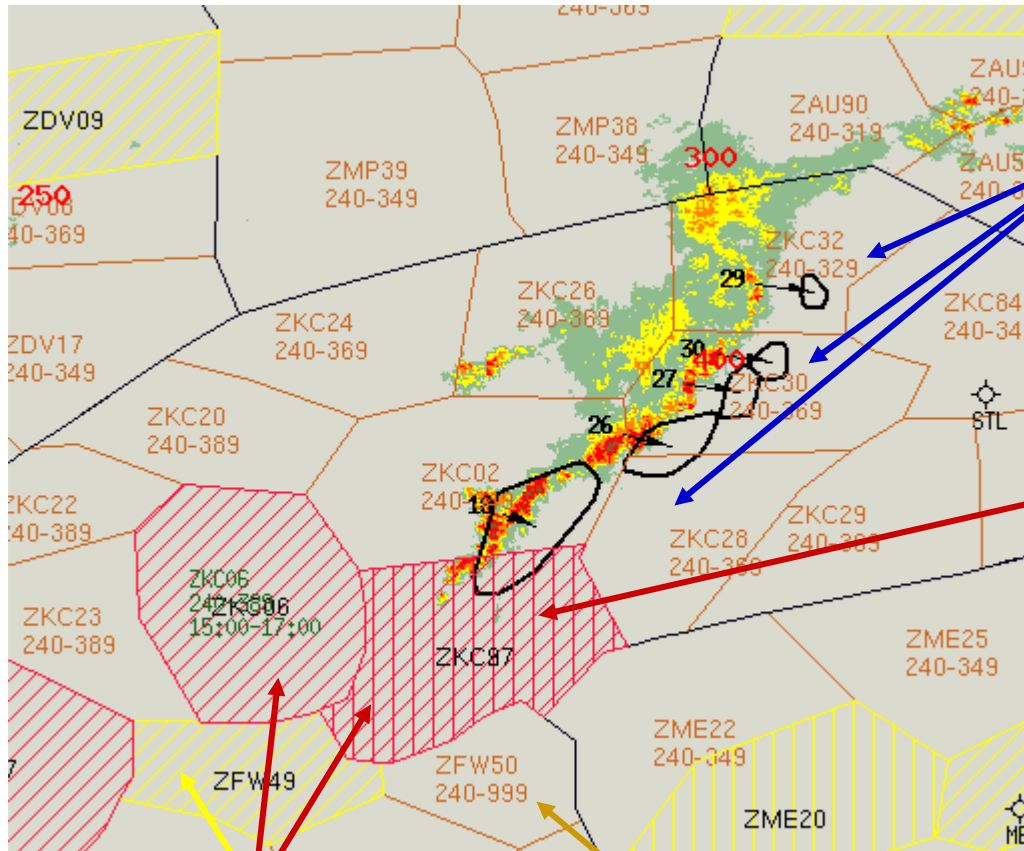


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Problem

- **Air traffic planning decisions are based on imperfect predictions of traffic demand and capacity, but uncertainties are not known.**
 - This produces conservative decisions and unnecessary actions...
 - ...leading to excess delays and unused capacity.
- **By taking uncertainty explicitly into account, can we improve decision-making?**

Background



Uncertain weather forecasts indicate future loss of airspace capacity...

Uncertain traffic forecasts indicate airspace demand...

If demand exceeds capacity, delays will occur and safety may be compromised.

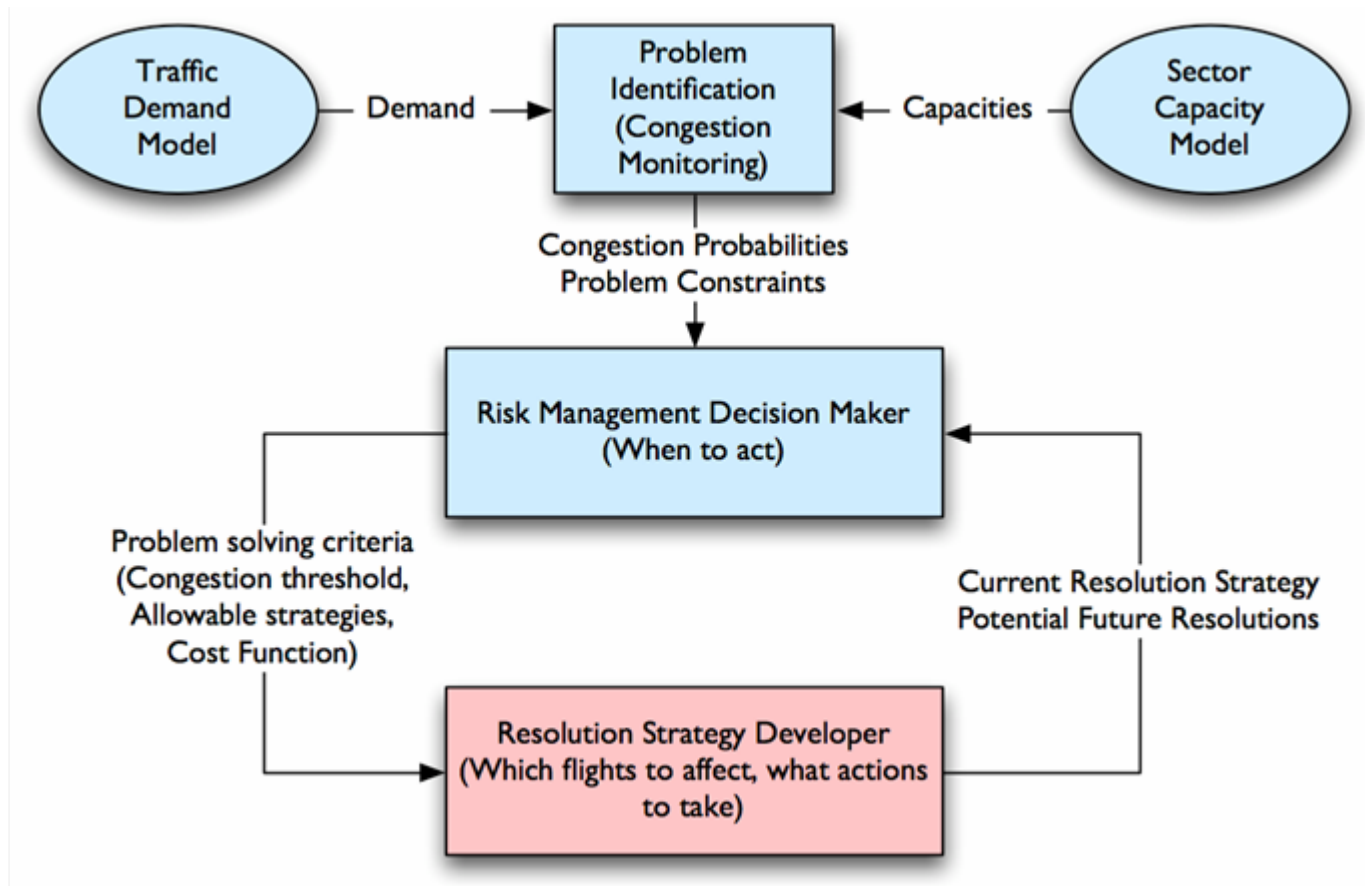
Given the uncertainty:
When should air traffic be restricted, and which flights should be affected?

Congestion Alerts

Air traffic control sector

Objective

- Develop practical, effective methods for solving air traffic congestion probabilistically



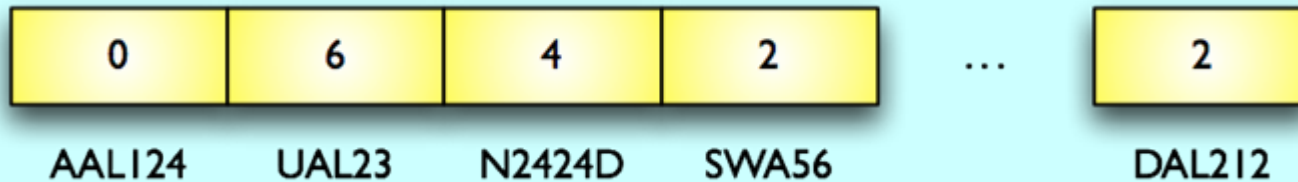
Activities

- Refine probabilistic prediction methods for traffic demand and airspace capacity
- Develop optimal, incremental decision algorithms for congestion resolution
- Estimate operational benefits
- Address key human factors issues

Highlight

Congestion Resolution Using a Genetic Algorithm

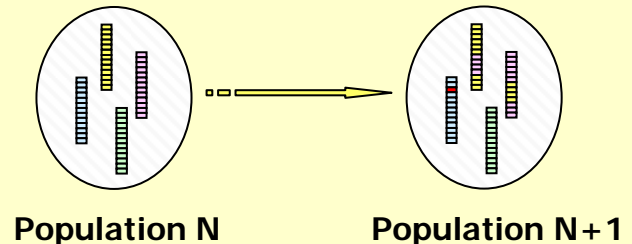
Chromosome: each flight entering congested area is a gene, valued by resolution option (reroute, ground delay, combination)



Cost Function: a sum of unresolved congestion and incurred delays (on-ground and airborne)

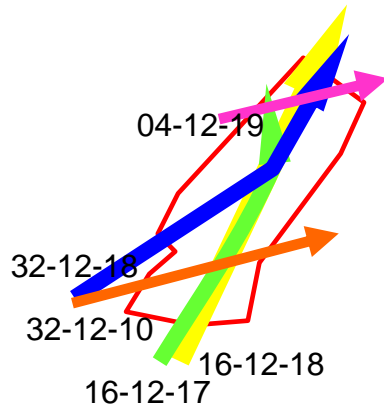
$$J = J_{congestion} + J_{delay}$$
$$J_{delay} = \sum_{i=1}^{N_F} (J_{d_1} G_i + J_{d_2} A_i)$$

Result: a set of flight-specific resolution maneuvers to minimize the cost function

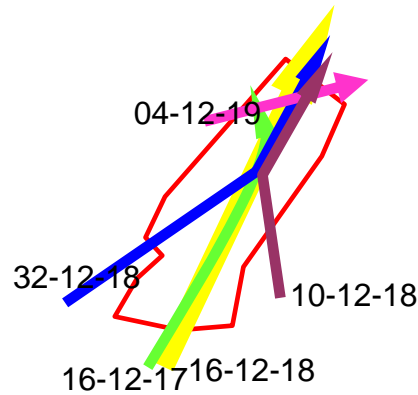


Highlight

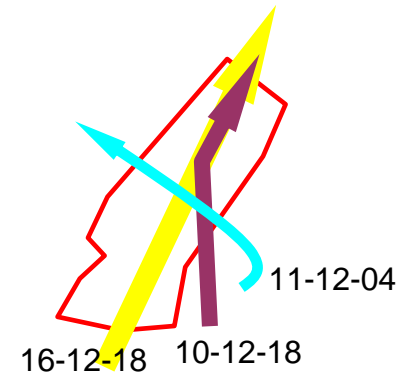
Predicting Sector Capacity as a Function of Traffic Flow Pattern



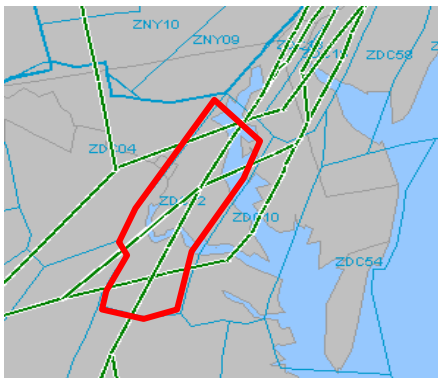
Capacity: 18



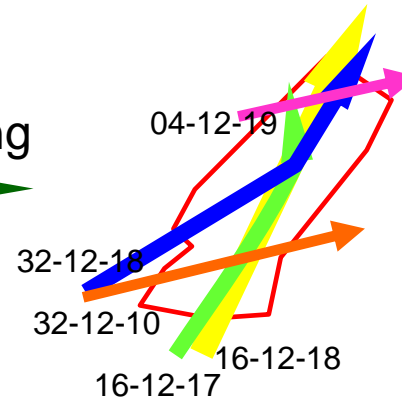
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Pattern Matching



Impacts

- **Develops fundamental technologies for dynamic air traffic planning in the future**
 - Air traffic demand is increasing rapidly!
 - Incremental, probabilistic, well-tailored solutions improve efficiency, helping to accommodate increased demand
- **Leads to discoveries about traffic dynamics that can be applied today**
- **Provides new, general-purpose tools for traffic simulation and airspace analysis**

Future Plans

