Practical Applications of Probability in Aviation Decision Making

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Portfolio of TFM Decisions

Playbook Reroutes

Ground Delay Programs

Ground Stops

Airspace Flow Programs

Arrival & Departure Fix Metering

<table>
<thead>
<tr>
<th>National</th>
<th>Regional</th>
<th>Local</th>
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<td>9+</td>
<td>6</td>
<td>3</td>
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Planning Horizon (Scale & Hours)
TFM decisions require high-fidelity forecasts of storm structure and characteristics.
Approaches to Probabilistic Forecasts for Aviation

Model Ensemble

Historical Data

Translate to probability

Thunderstorm Probability

Translate to decision

No

Don’t Know

50%

Yes

Take Action

Ensemble Airspace Classification

Translate to probability

Translate to decision

Low Impact

Medium Impact

High Impact

Probability of Impact

0

0.2

0.4

0.6

0.8

Low Impact

Medium Impact

High Impact

Take Action

Model Ensemble

Historical Data

Thunderstorm Probability

Translate to decision

Take Action

Low Impact

Medium Impact

High Impact

Probability of Impact

0

0.2

0.4

0.6

0.8

Low Impact

Medium Impact

High Impact

Translate to probability
Decision-based Uncertainty

Define Resources → Define Decisions → Provide Uncertainty

**Define Resources**

- NY Metro FCA
- FCAOB1

**Define Decisions**

- FCA Airspace Availability
  - Table showing time blocks and impact levels for FCAOB1, FCABW1, and FCAA01.

**Provide Uncertainty**

- Most Likely Availability & Range
  - Graph showing time blocks and impact levels for FCAOB1 with high, medium, and low impacts.

**Enroute**

- NY Metro Gates

**Terminal**

- Terminal Gate Availability
  - Table showing gate availability for different time blocks and impact levels for North (N), East (E), South (S), and West (W) gates.

- West Gates
  - Graph showing time blocks and impact levels for West Gates with high, medium, and low impacts.
FCA Blockage and Uncertainty

Blockage forecast and uncertainty based on:
- Model to translate storm intensity and height to blockage
- Time-lagged ensemble of CoSPA forecasts
- Historical forecast performance given scale, orientation, intensity of weather
- Location, issue time, valid time

Forecast Issued 12 UTC

Ensemble of CoSPA Forecasts Valid 8 Hours in the Future (20Z)
FCA Blockage and Uncertainty

Forecast Issued 12 UTC

- Low Impact
- Medium Impact
- High Impact

Time (UTC)
13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00

Forecast Issued 15 UTC

- Low Impact
- Medium Impact
- High Impact

Time (UTC)
16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00

Ensemble of CoSPA Forecasts
Valid 8 Hours in the Future (20Z)

Ensemble of CoSPA Forecasts
Valid 5 Hours in the Future (20Z)

Regular forecast updates needed to revisit decisions
Forecast Event Start, Duration and Recovery

Forecast Issued 15 UTC

- **Low Impact**
- **Medium Impact**
- **High Impact**

FCA Blockage vs. Time (UTC)

Forecast Issued 22 UTC

- **Ongoing event**
- **Event recovery**

Time (UTC)

Event Start

Ongoing Event

Event Recovery
• Traffic Flow Management decisions encompass a portfolio of time and space scales in the NAS

• Probabilistic forecasts cast in TFM decision space could yield considerable operational benefit for strategic planning
  – Convert high-fidelity weather forecasts to aviation impact, then provide probability of impact
  – Provide event start, severity, and duration
  – Focus here on enroute airspace, but similar approach could be used for other airspace and time horizons

• Probabilistic forecasts need to update regularly so that TFM decisions can be revisited and revised
Future Work

- Map FCA blockage to flow rate
- Consider uncertainty for broader portfolio of decisions
- Incorporate other models in decision-based uncertainty (SREF, LAMP)