Probabilistic TFM Decision Support

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Problem

- **Significant uncertainty is present in traffic flow management (TFM) predictions of demand and capacity.**
  - **This produces highly conservative decisions.**
- **Can we improve the effectiveness of TFM decision making by taking uncertainty into account via probabilistic**
  - **decision analysis methods,**
  - **visualization and alerting techniques,**
  - **automated decision support aids?**

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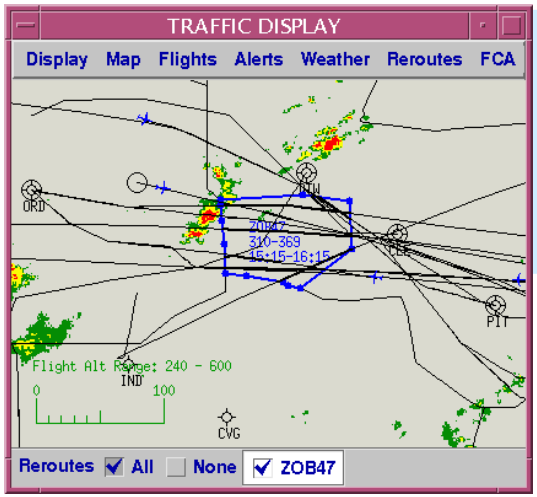
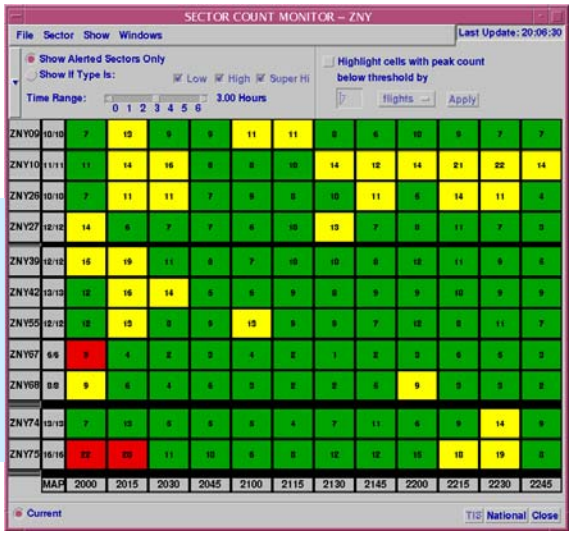
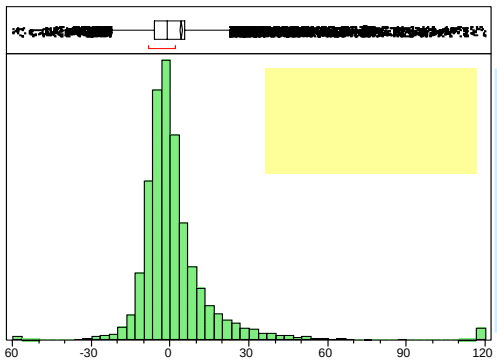
Background







However, predictions are subject to several types of uncertainty, which increase in magnitude as the prediction look-ahead time increases.

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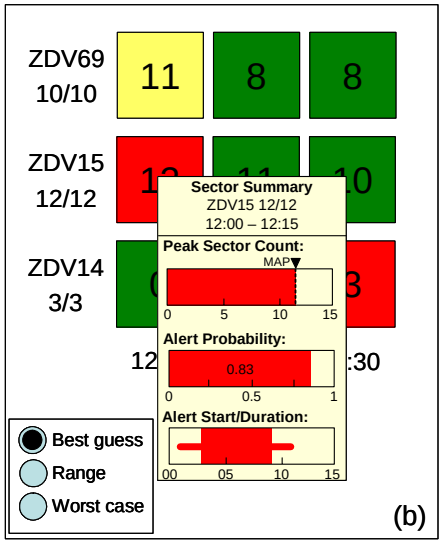
Objective

- **Quantify uncertainty in TFM predictions**
  - **Measure accuracy of present-day predictions**
  - **Identify primary components of uncertainty**
  - **Develop prediction uncertainty simulation tools for HITL experiments and analytical work**
- **Develop probabilistic TFM decision support techniques**
  - **Develop visualizations for uncertain predictive information**
  - **Develop decision rules and automation aids**



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Activities

- **Perform in-depth statistical analysis of operational TFM predictions**
- **Construct a *Stochastic TFM Analysis Capability* (STAC) to support research**
- **Conduct a human-in-the-loop experiment to refine concepts for probabilistic displays**
- **Apply formal decision analysis to develop rules and guidelines for probabilistic TFM**

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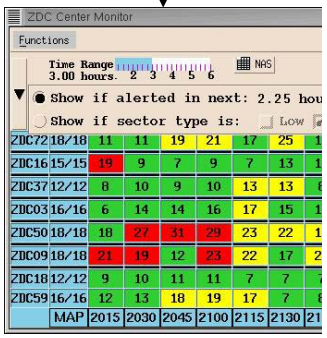
Highlight

Stochastic TFM Analysis Capability: Simulating Prediction Errors



Deterministic Sector Demand Predictions

Baseline Trajectory Predictions

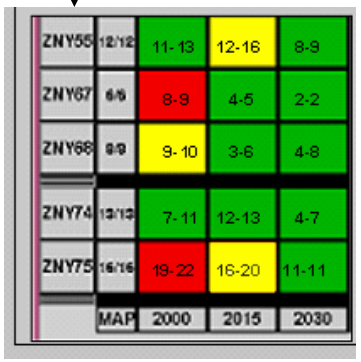
One Monte-Carlo Simulation Trial:

- Remove "no-shows"
- Apply unanticipated routing and altitude changes
- Apply departure prediction errors
- Apply sector transit prediction errors
- Add "pop-ups"
- New set of predicted trajectories, with uncertainties applied

"N" simulation trials…

Calculate Statistics

Probabilistic Sector Demand Predictions



Probabilistic Displays, Decision Analysis, Real-Time DS Automation, …

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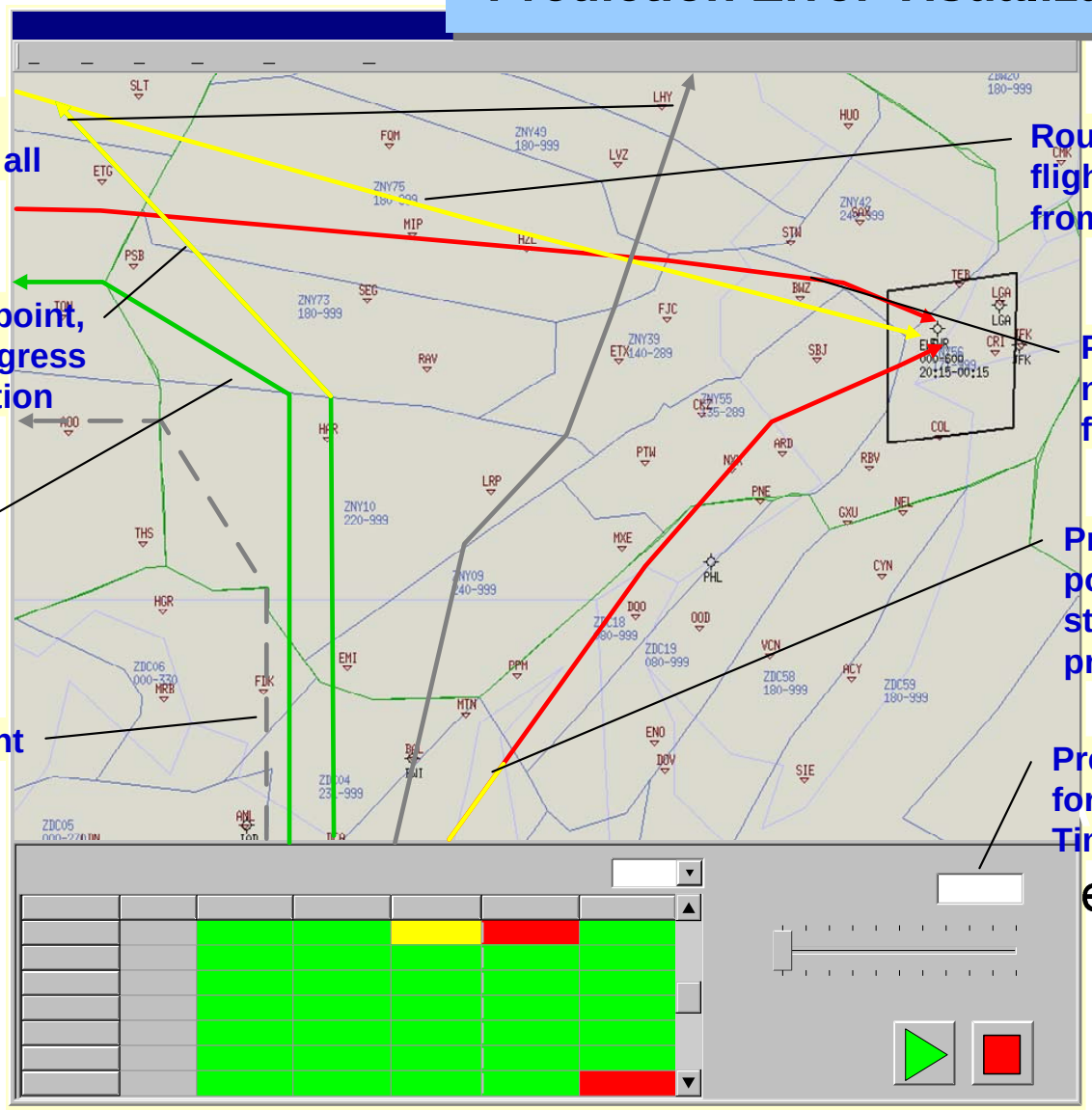
Demonstration

Prediction Error Visualization Tool



“Pop-up” flight, not predicted to exist at all

Route string correct, but flight progress deviates from prediction

Prediction valid to a point, then actual flight progress deviates from prediction

Predicted route does not match actually-flown route

Accurate prediction

Prediction is valid to a point, then actual route string deviates from prediction

“No-show” flight

Prediction time: 07:00 for a Look-Ahead Time (LAT) of 5 hours

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Impacts

- Addresses a vital decision support need recognized by the FAA and industry
- Provides foundation for changing TFM decision making from “best guess” to a more effective risk management approach
- Resulting decision guidelines are applicable to all automation levels, from manual to automation-initiated problem resolution
- Potentially large economic benefits

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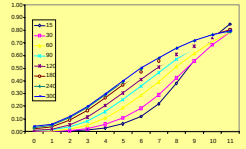
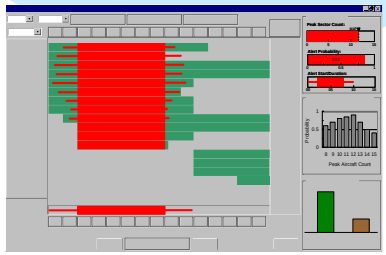
Future Plans

Core Research: **Quantify, visualize, understand uncertainty in airspace demand predictions and the impact on human TFM decision-making**

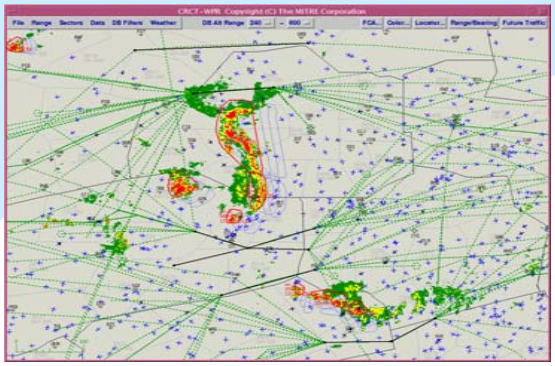


Operational Applications

Improved situation awareness for traffic managers and airspace users



Improved decision heuristics for airspace demand management



Improved decision-support automation

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