Metrics/Weather/Environment

Rapporteur's Report
Tom Edwards

Opening remarks

- Sessions contained consistently well prepared papers and generated lively discussion - the track was quite successful

- Even so, there was not a consistent theme to the track (hence all the /'s in the title)

- Sessions are therefore encapsulated as "mini-tracks" and evaluated as such

Capacity Estimation Metrics

- #54: Mondoloni and Liang - Preliminary application of fractal dimensions to measure complexity in the NAS
  - Demonstrates inverse relationship between dimensionality and conflict rate
  - Reaffirms earlier results that conflict rate increases linearly with traffic density
- #108: Hansman et al. - Structural considerations in complexity metrics
  - Establishes a topological approach to defining complexity using features in the airspace, traffic, and operations
  - Explains how controllers simplify their work through these abstractions
  - Introduced concept of applying Kolmogorov entropy to assessing complexity
- #171: Hudgell and Gingell - Capacity of novel systems
  - Assessed information processing limitations of actors (controllers, automation and communication systems, etc.) in a system framework
  - Identified capacity-limiting resource in the system

Observations

- Results are preliminary, but methods are maturing a variety of approaches to understand airborne capacity limits

- A "fundamental" approach to performance analysis

Delay Correlation Analysis

- #94: Callaham et al. - two approaches to model aggregate delay in NAS based on traffic and weather: cellular statistics and qualitative characterization
  - Both show promise in explaining average delay
  - Predictive capability erodes at high levels of delay
- #133: Hansen and Bolic - delay correlation at LAX
  - Demonstrated good explanatory capability using decomposed delay statistics and weather characteristics
  - Delay at origin is a significant component of total delay
  - Demonstrated a statistically significant benefit of a DST (pFAST)
- #186: Welch and Lloyd - airport delay performance
  - Developed metrics that begin to explain delay in terms of airport vs. airspace capacity limits
  - Developing estimated benefit of adding runways at impacted airports

Observations

- Promising progress in decomposing a highly interdependent system

- But, models do not address some other significant factors, such as TFM actions and AOC responses

- A "phenomenological" approach to delay analysis

Noise and Emissions Modeling

- #72: Hullah and Cavadini - ENHANCE noise modeling tool
  - Incorporated recorded flight tracks and engine parameters as input to INM for improved noise predictions
  - Preliminary results - insufficient for comparison and validation
  - Future work in error analysis and improved modeling holds promise
- #187: Celikel and Jelenik - Preliminary model for emissions forecasting for Europe
  - When validated, model will be useful for international environmental policy formulation
  - Significant increase in emissions forecast (50% - 57%)
  - CNS/ATM advancements offer small but measurable benefit (~7%)
  - Points to the need for an environmental objective for aviation that supports policy

Observations

- Models need further development before they will be useful for practical applications
- Validation data are needed in order to identify shortcomings in model fidelity
- Where are the US papers?

Weather in the NAS

- #147: Allan et al. - weather delay analysis at EWR
  - Convective weather and reduced ceiling visibility were the leading contributors to delay
  - Departure delays were much larger than arrival delays
  - The data strongly suggests that the strategy for implementing GDP has a dramatic affect on the delays and warrants additional study

- #182: Nilim et al. - TFM with weather uncertainty
  - An innovative method for optimal route planning in the presence of weather uncertainties has been developed
    - Based on a Markov chain for weather modeling and a dynamic programming algorithm for optimization
    - Allows for contingency planning
  - Method has been tested in hypothetical environment
  - Although not ready for operational use, represents a reasonable framework on which to build

- #148: Evans - tactical measures for TFM in convective weather
  - Strategic approach to traffic flow management is fundamentally limited due to the inability to forecast weather that far in advance
  - The development of a tactical capability to route traffic through weather can complement traffic flow management for reduced delays
  - Weather products are rapidly evolving to support this goal, integration with en route support tools is required for success

Observations

- Experience and observations at Newark and the New York Area have resulted in a comprehensive data set that has allowed dissection of arrival delays in terms of type and cause.
  - Results can assist in focusing air traffic research at the tactical, local flow control, and strategic levels of command
- Convective storms are as significant as ceiling and visibility in accounting for system delays
- Strategic traffic management must be complemented with improved products for tactical control of traffic in order to account for uncertainty in long-range weather forecasts.
  - Weather products are evolving for use in tactical control
  - Near-term focus needs to be on integration with decision support tools
- In the long-term we need to develop:
  - Physics based weather models for improved forecasting .
  - Algorithms for dynamically rerouting in the presence of uncertainty.
  - Algorithms for integration of traffic flow management decisions at the tactical, regional and system levels
- This is an excellent application for improved system modeling techniques

Overall Remarks

- Would like to see more revolutionary research
  - increases opportunities for US/Europe collaboration
- Would like to see follow-through on many of these preliminary concept papers
- Need to do a better job of setting research in context of prior work, and where it is going if successful
- Identification of research issues in this forum is highly relevant and valuable to formulating NASA's research agenda