Air Transportation System Architecture Analysis

Project Phase I

Advanced System Architecture

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Motivation

• The air transportation system is facing and will continue to face significant challenges in terms of meeting demand for mobility

• Current multi-agency effort to establish a roadmap for the “Next Generation of Air Transportation System”

• Navigation in current system under most conditions requires use of fixed-location of current infrastructure to facilitate mobility

• Future (evolved) architecture of the system require understanding of the structure of the current system

• Lack of integrated quantitative analysis of structure of the current system
Objective of the project

- Better understand the architecture of the current system through network analyzes
- Understand
  - the network characteristics of individual system layers
  - Influence of constraints, desired properties (i.e. safety, capacity, etc.) in explanation of network characteristics
  - comparison of network characteristics across different layers, through coupling of infrastructure or comparison of different network characteristics across layers
Overview of the System

<table>
<thead>
<tr>
<th>System layer</th>
<th>Layer attributes</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand layer</td>
<td>Population, income, location of businesses</td>
<td>ArcGIS, Census</td>
</tr>
<tr>
<td>Mobility layer</td>
<td>Movements of People and goods</td>
<td>DB1B database</td>
</tr>
<tr>
<td>Transport layer</td>
<td>Aircraft routes</td>
<td>ETMS, OAG</td>
</tr>
<tr>
<td>Operator layer</td>
<td>Operators Part 121, 135, 91</td>
<td>OAG</td>
</tr>
<tr>
<td>Infrastructure layer</td>
<td>National Airspace System (airports layout and airspace structure)</td>
<td>FAA Form 5010 airport database, airway</td>
</tr>
</tbody>
</table>
Current Progress (examples in next slides)

• Infrastructure Layer:
  – Airspace Structure (Navaids) Analysis
    • Low Altitude routes (Victor Airways)
    • High Altitude routes (Jet routes)

• Transport Layer:
  – Traffic Data (ETMS) Analysis
Preliminary Analysis of the High Altitude (Jet) Route Network

Chart of Jet Routes

Degree Distribution

“Pseudo” Poisson distribution

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Preliminary Analysis of the Wide-Body/Narrow Body & Regional Jet Flight Network

Wide Body Jets

Narrow Body Jets

(Degree Distribution)

Scale free with exponential cut-off

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Preliminary Analysis of the Light Jet Flight Network

Image removed for copyright reasons.

Light Jets

Degree Distribution

Scale free with a slow exponential cut-off
Potential Additional Data Acquisition

- 10% Ticket Sample – DB1B Database
- Ground Delay Program Data
- Additional ETMS Days
- Air Traffic Control Sectors And Interfaces
- Additional Schedule Data (OAG)
Potential Future Areas of Investigation

- **Cross-Layer Comparisons**
  - Infrastructure, transport, and mobility layers
  - Domain expertise input on processes at work to create network structure
- **Intra-Layer Comparisons (Transport Layer)**
  - Network differences by aircraft type, or by air carrier
- **Influence of nodal constraints**
  - Airport and airspace capacity as nodal constraints on network growth
- **Maximum Route Efficiency Achievable**
  - Merging of airport and airway data
- **Motifs/Substructure**
  - Application of motif/coarse-graining analysis to identify common patterns in network