Airport Operations
Benefits Research

Tom G. Reynolds

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Lincoln Laboratory
Massachusetts Institute of Technology

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Outline

• MIT/LL capability development areas and role of benefits assessment

• Traditional benefits assessment case study
  – Departure metering

• Environmental impacts in benefits assessment
MIT/LL Capability Development Areas

- MIT/LL developing new capabilities to support FAA efficiency and performance objectives across all flight phases
  - Improved Decision Support Tools (DSTs) & operations
- Surface
  - Congestion management
  - Sequencing/scheduling
  - Airport configuration
- Departure
  - Route availability
- Cruise
  - Altitude & speed optimization
- Approach
  - Delayed deceleration approaches

Lincoln Laboratory Air Traffic Control Workshop 2012
Airport Operations Benefits- 3
TGR 12/12/12
Benefits Assessment Role in Capability Development

- Benefits assessment process helps identify inefficiencies =>
  - DST & operational needs
  - Iterative development
  - Adaptation challenges

- Helps identify requirements to address key inefficiencies
- Provides business case for development and deployment
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Terminal Flight Data Manager (TFDM) Benefits Assessment Example

**External Sources**
- Terminal and Surface Surveillance
- Flight Plan Data
- Traffic Flow Constraints
- Flight Operations Data
- Weather / Hazards

**Terminal Flight Data Manager**

**Terminal Flight Data Manager (TFDM)**

**Operational Users**
- Tower controllers
- Terminal ATC (TRACON)
- En Route ATC
- Flight Operations Centers
- Ramp Tower
- Airport Authority

**Anticipated Benefits**
- Operational & Environmental Performance Improvement
  - Reduced delay
  - Reduced fuel burn
- Workload Reduction
- Safety Improvements
- Cost Avoidance

**Net-centric infrastructure**

Enhanced surveillance display

Electronic flight data manager

Decision Support Tools (DSTs)

- Departure metering
- Sequencing & scheduling
- Runway assignment
- Airport configuration manager
- Departure route assurance
TFDM Benefits Assessment Modeling

• Needed to identify potential benefits across key NAS-wide airports out 20 years

• Initially identified surface inefficiencies

• Computer modeling of DST capabilities which address key surface inefficiencies
  - Departure metering
  - Airport configuration optimization DST
  - Sequence optimization DST

• Results summarized in TFDM benefits assessment report
  - MIT/LL Project Report ATC-394
Departure Metering Concept

- Holding aircraft at gate or ramp (with engines off) to reduce surface congestion & fuel burn while not adversely affecting throughput

JFK: Pre-metering
15 a/c in queue

JFK: Post-metering
8 a/c in queue, 8 being held
Departure Metering Benefits Assessment Methodology

• CHALLENGE: appropriate modeling fidelity given wide airport and temporal scope (OEP35 airports, out 20 years)

• Multi-scope/Multi-fidelity modeling approach adopted

Increasing airport scope

HIGH FIDELITY
2 AIRPORTS
• Field trial results
• Current ops only
• Actual taxi times
• VMC/IMC
• Configuration-specific

MEDIUM FIDELITY
8 AIRPORTS
• Simulated results
• Current & future ops
• Simulated taxi times
• VMC only
• Aggregate configurations

LOW FIDELITY
35 AIRPORTS
• Extrapolated results
• Future ops
• Functional relationships with other airports & forecast data

Increasing model fidelity

Validate Calibrate

Validate Calibrate
High Fidelity Benefits Assessment
JFK Implementation: 2010-2011

• PASSUR live trials at JFK throughout 2010/11, MIT analysis

• Over 2010, estimated 5.0 million gallons/$12.2 million fuel saving
  – Published as AIAA ATIO2011 conference paper*

Medium Fidelity Assessment:
8 Study Airports Benefits Modeling

- Throughput saturation curves at core of methodology

Airport X, Configuration Y, Condition Z

Saturation throughput, $T^*$

Saturation point, $N^*$

Traffic Metric, e.g. No. of aircraft on surface, Dep queue length, etc.

Control point, $N_{ctrl}$

Impacts of future capacity increases

Benefits of holding all flights above control point

$\text{Taxi time benefits } = N_{\text{Congestion}}(\tau_{\text{Congestion}} - \tau_{\text{Ctrl}})$

- Current year: curves can be established from operational data

- Future years: curves estimated from demand/capacity forecasts
Medium Fidelity Assessment: 8 Study Airports Benefits Modeling

Simulation

Current Year Analysis
- Operational Data

Future Year Analysis
- Future Schedules
- Future Year Saturation Curve Prediction
- Future Year Traffic Simulations

Throughput Saturation Curves

Results Generation & Validation

Field Trials

Current year saturation curves

Future Year saturation curves

Gate-constrained Benefits

Unconstrained Benefits

Gate Constraints
Medium Fidelity Assessment: 8 Study Airports Fuel Savings Estimates

- Gate-constrained fuel saving estimate at 8 study airports over 20 yrs: 950 million gallons/$2.4 billion (@ $2.43/gallon)
  - Approx. 18% taxi-out and 1% block fuel burn
  - Results published as AIAA ATIO2012 conference paper*

Low Fidelity Assessment: OEP35 Fuel Savings Estimates

- Multiple approaches employed to extrapolate medium fidelity results to OEP35 airports to bound benefit estimates
  - Scaling factors to apply to medium fidelity studies

- Taxi delay scaling factor
  - Scale medium fidelity benefits to OEP35 benefits in proportion to amount of total taxi delay in each set

- Linear regression
  - Relationship between medium fidelity benefits and key indicator variables which can be forecast for all OEP35 airports

- Clustering
  - Assign OEP35 airports to clusters based on operating characteristics
  - Benefit level set by medium-fidelity study airports in each cluster
• Gate-constrained fuel saving estimate at OEP35 airports over 20 yrs: 1.8-2.7 billion gallons, $4.4-6.6 billion (@$2.43/gallon)

• Also equates to 18-26 million metric tons CO₂ emissions saved
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Environmental Impacts in Benefits Assessment

- Ability to characterize environmental impacts/benefits now possible using FAA Aviation Environmental Tool Suite

- Allows assessment of physical and monetizable impacts

- Climate
  - Greenhouse gas concentrations
  - Temperature changes
  - GDP impacts

- Air quality
  - Pollutant concentrations
  - Health impacts

- Noise
  - Noise contours
  - Property value & health impacts

Aviation Operations Scenarios
  - Full flight emissions: CO₂, NOₓ, etc.

Climate Impacts
  - Changes in atmospheric concentrations
  - Changes in global radiative forcing
  - Changes in global temperature

Climate Impacts Valuation
  - Changes in %Gross Domestic Product
  - Discounting

Policy Assessment
  - Climate costs/year

Simplified climate models, Climate sensitivity parameters

Damage functions, Discount rates
### Environmental Impacts in Benefits Assessment

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<th>Departure Metering</th>
<th>Sequencing and Scheduling</th>
<th>Airport Configuration Management</th>
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<td>Reduced engine-on time</td>
<td>Increased throughput</td>
<td>Change in flight patterns</td>
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<td><strong>Noise Impacts</strong></td>
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<td><em>First order estimate:</em></td>
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<td>$0.2-8.8 billion @ $29-1226/tonne fuel*</td>
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<td>$0.1-1.4 billion @ $5-65/tonne CO₂*</td>
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*Combines benefits from noise and health impacts；Reduced emissions includes air quality benefits．The climate benefits are given as a first order estimate, and the cost is calculated at $29-1226/tonne fuel, and $5-65/tonne CO₂ for aviation fuel and emissions reductions."

**Notes:**
Summary

• Benefits assessment activities assist with research/prototyping priorities and investment analysis processes

• MIT/LL involved in multiple aviation decision support tool and operations research areas
  – Presented traditional benefits assessment of departure metering capability

• Approaches are now available to include environmental impacts in benefits assessment
  – First order estimates suggest climate and air quality monetized benefits are of similar order of magnitude to fuel cost savings