Airport Operations Benefits Research

Tom G. Reynolds

December 12, 2012

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

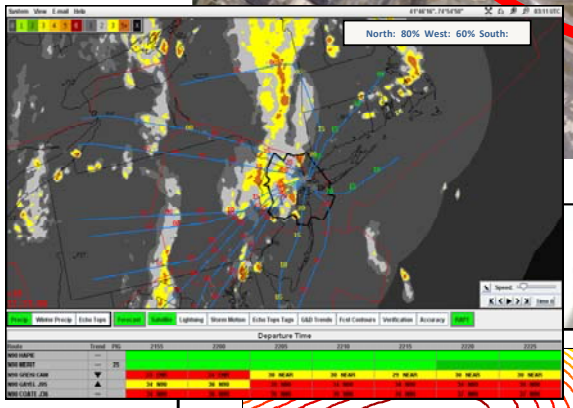
This work is sponsored by the Federal Aviation Administration under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, recommendations and conclusions are those of the author and are not necessarily endorsed by the United States Government.

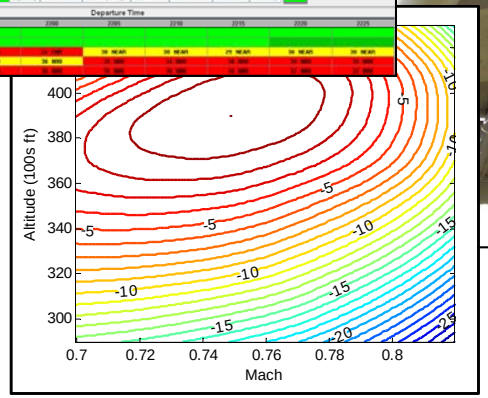
Outline

- **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

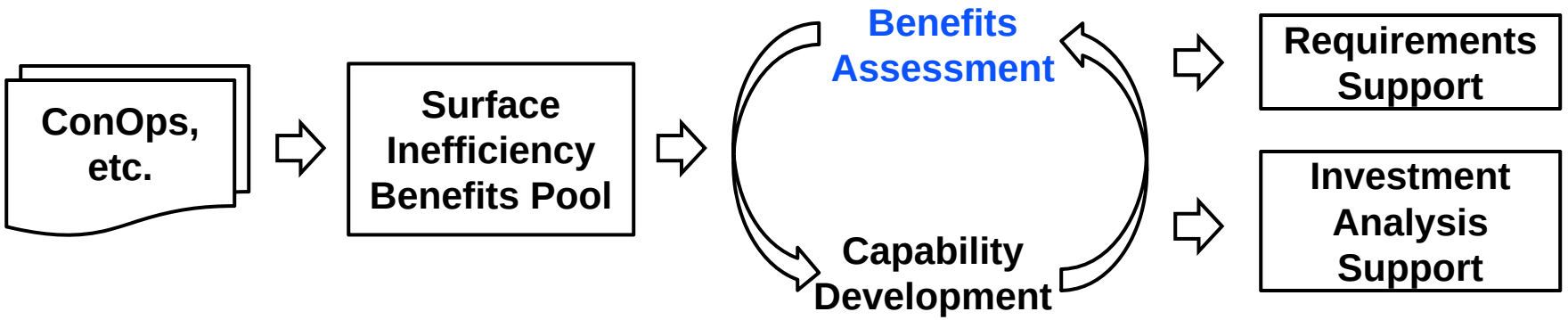
- **MIT/LL developing new capabilities to support FAA efficiency and performance objectives across all flight phases**
  - **Improved Decision Support Tools (DSTs) & operations**
- **Surface**
  - **Congestion management**
  - **Sequencing/scheduling**
  - **Airport configuration**
- **Departure**
 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





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**

Outline

- MIT/LL capability development areas and role of benefits assessment
- Traditional benefits assessment case study
  - Departure metering
- Environmental impacts in benefits assessment

Terminal Flight Data Manager (TFDM) Benefits Assessment Example

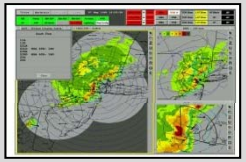
External Sources

Terminal and Surface Surveillance

Flight Plan Data

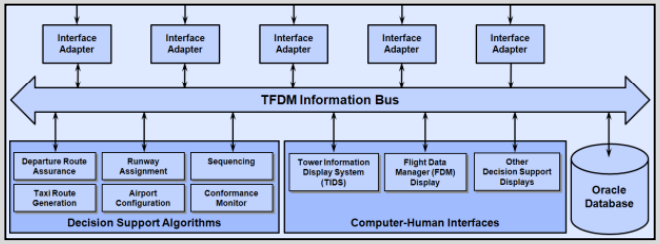
Traffic Flow Constraints

Flight Operations Data

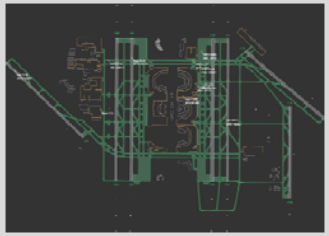


Weather / Hazards

Terminal Flight Data Manager

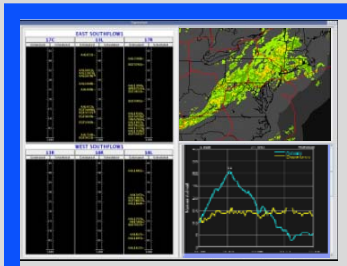


Net-centric infrastructure



Enhanced surveillance display

Electronic flight data manager



Decision Support Tools (DSTs)

- Departure metering
- Sequencing & scheduling
- Runway assignment
- Airport configuration manager
- Departure route assurance

Operational Users

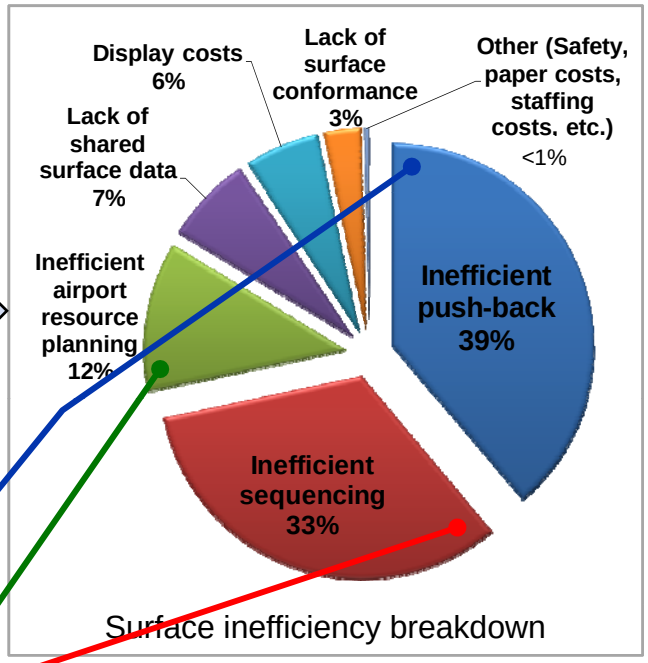
- Tower controllers
- Terminal ATC (TRACON)
- En Route ATC
- Flight Operations Centers
- Ramp Tower
- Airport Authority

Anticipated Benefits

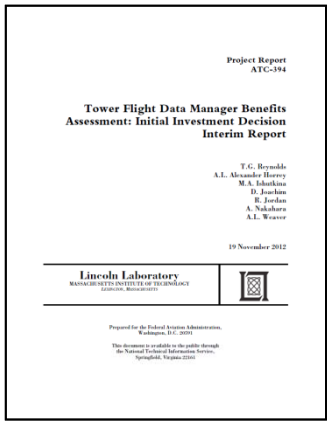
- Operational & Environmental Performance Improvement
  - Reduced delay
  - Reduced fuel burn
- Workload Reduction
- Safety Improvements
- Cost Avoidance

TFDM Benefits Assessment Modeling

- **Needed to identify potential benefits across key NAS-wide airports out 20 years**
- **Initially indentified 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**



Surface inefficiency breakdown


Project Report ATC-394

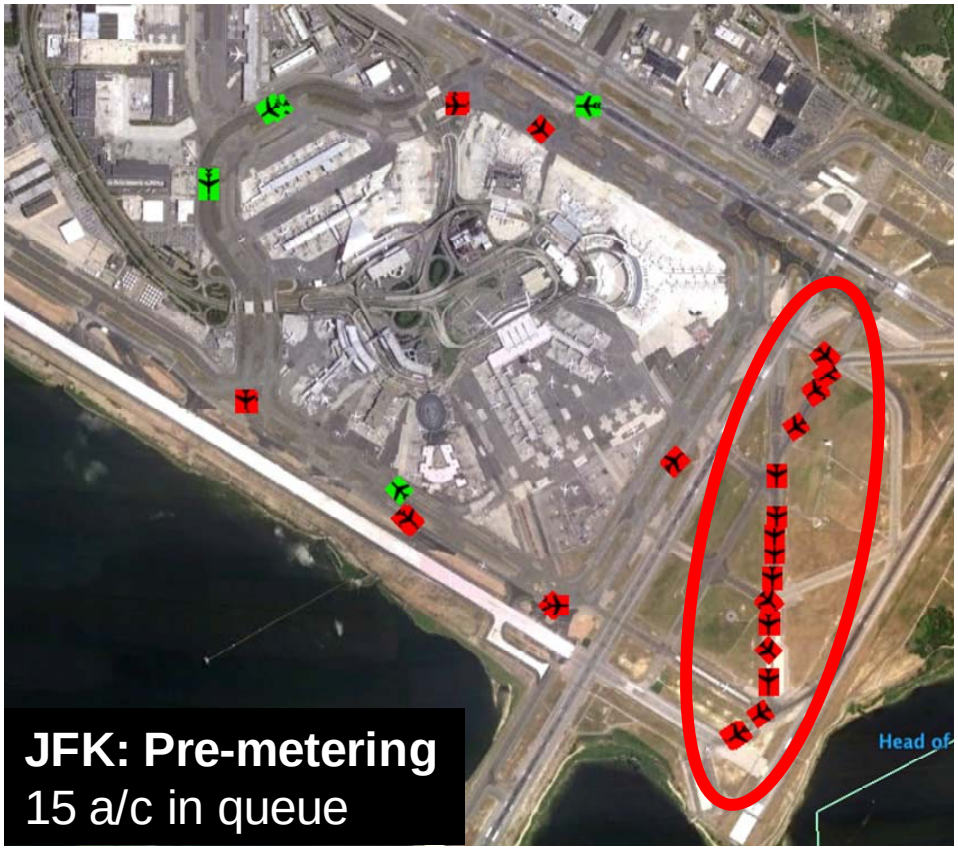
Tower Flight Data Manager Benefits Assessment: Initial Investment Decision Interim Report

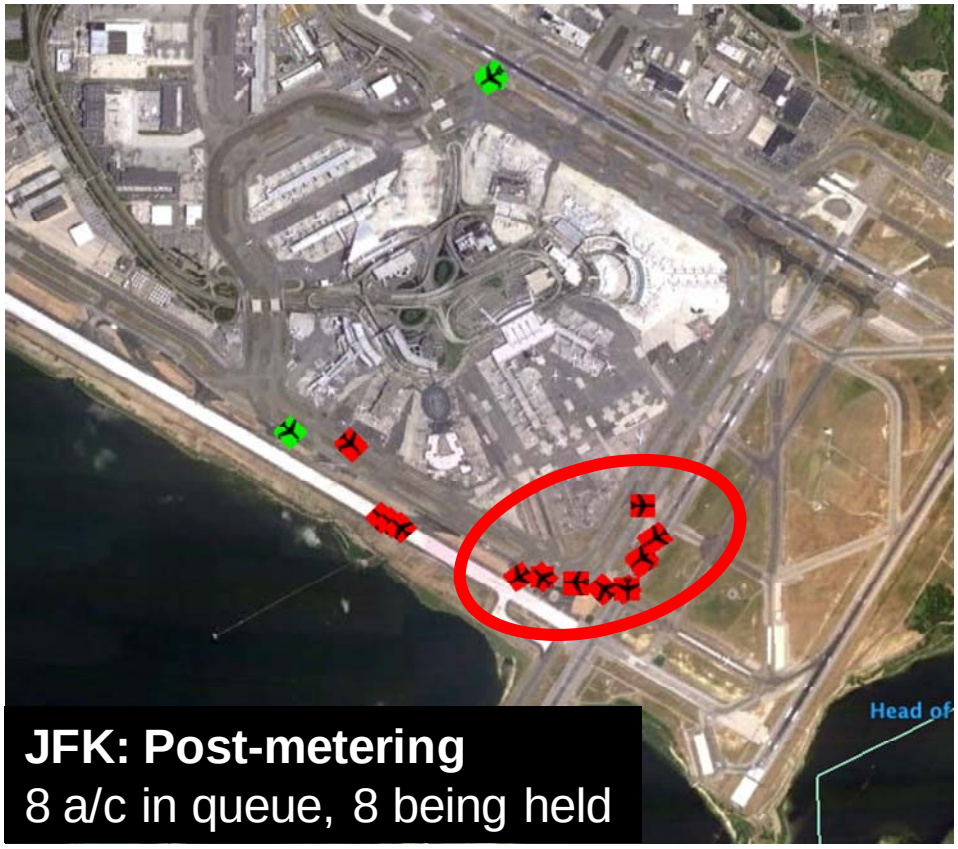
19 November 2012

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Departure Metering Concept

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

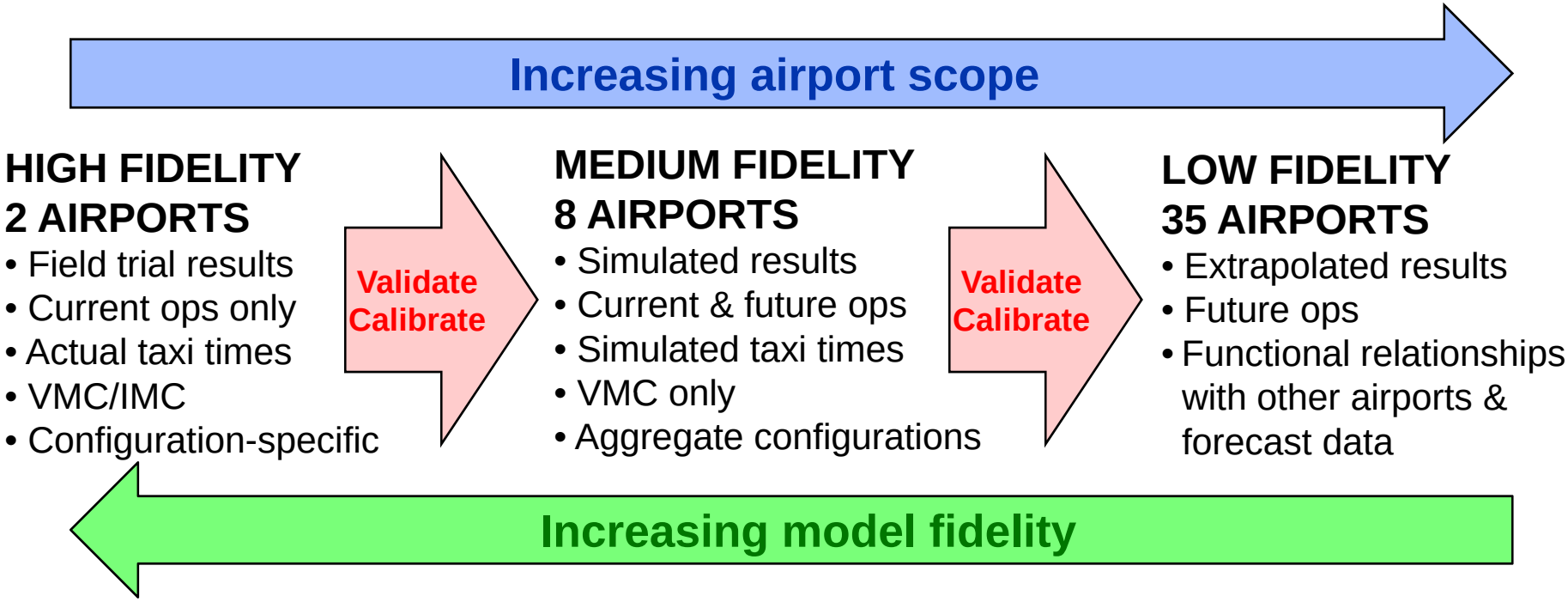




Departure Metering Benefits Assessment Methodology

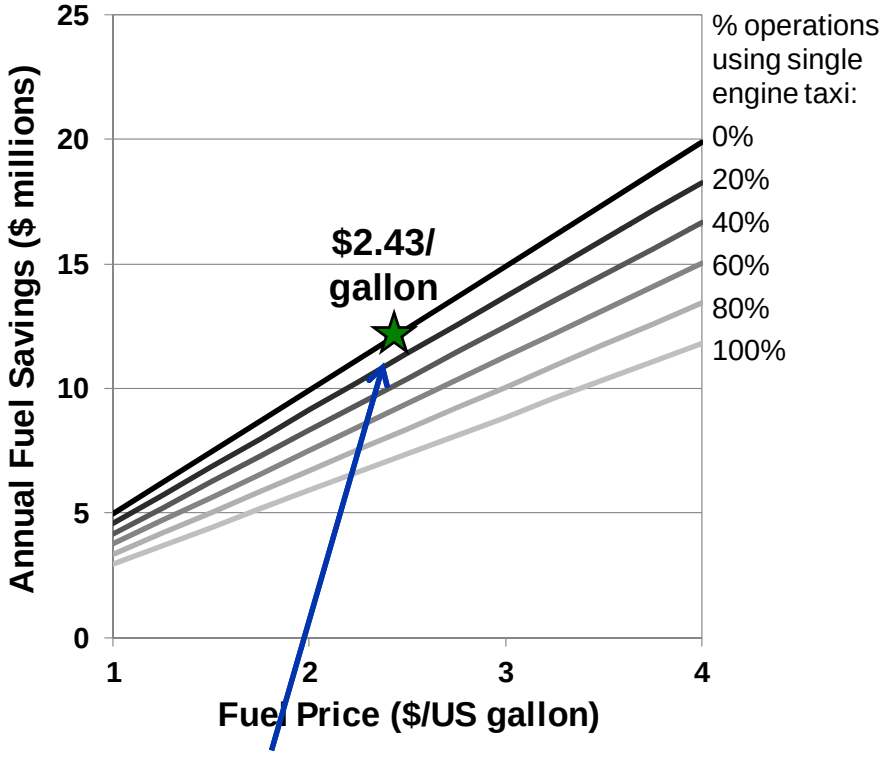
- **CHALLENGE: appropriate modeling fidelity given wide airport and temporal scope (OEP35 airports, out 20 years)**

- **Multi-scope/Multi-fidelity modeling approach adopted**



High Fidelity Benefits Assessment
JFK Implementation: 2010-2011

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

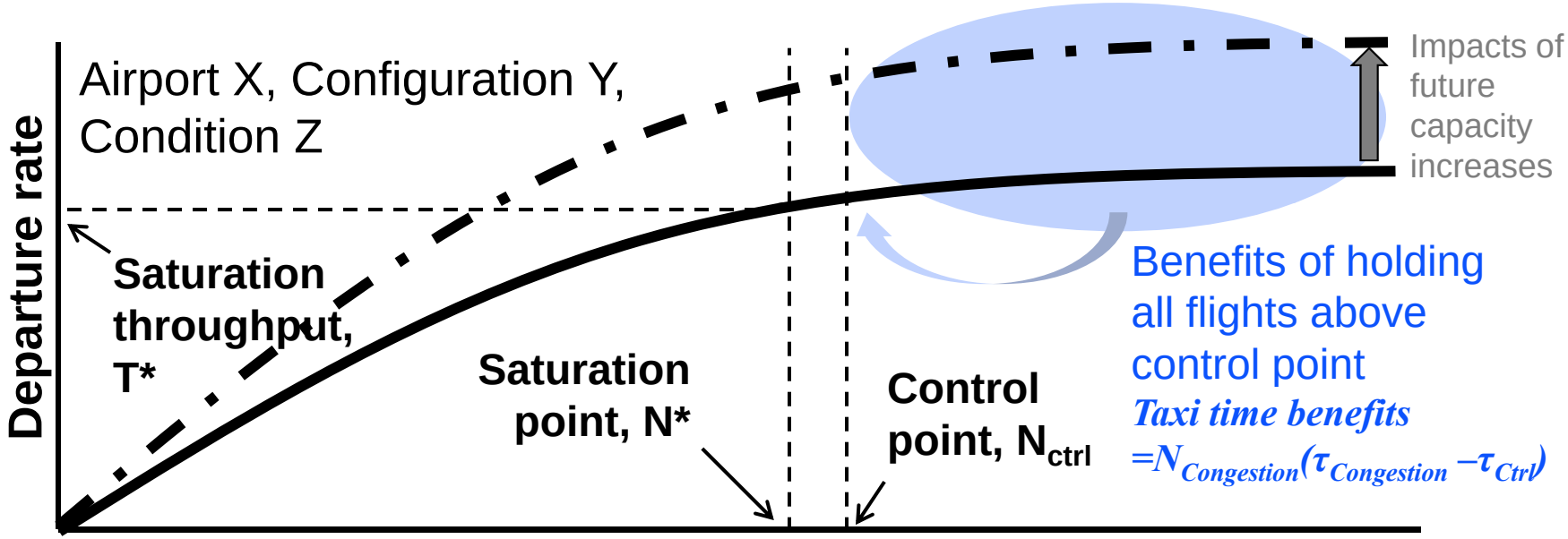


- **Over 2010, estimated 5.0 million gallons/$12.2 million fuel saving**
  - **Published as AIAA ATIO2011 conference paper***

*Nakahara, A., T. G. Reynolds, T. White, C. Maccarone & R. Dunsky, "Analysis of a Surface Congestion Management Technique at New York JFK Airport", 11th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Virginia Beach, VA, 2011.

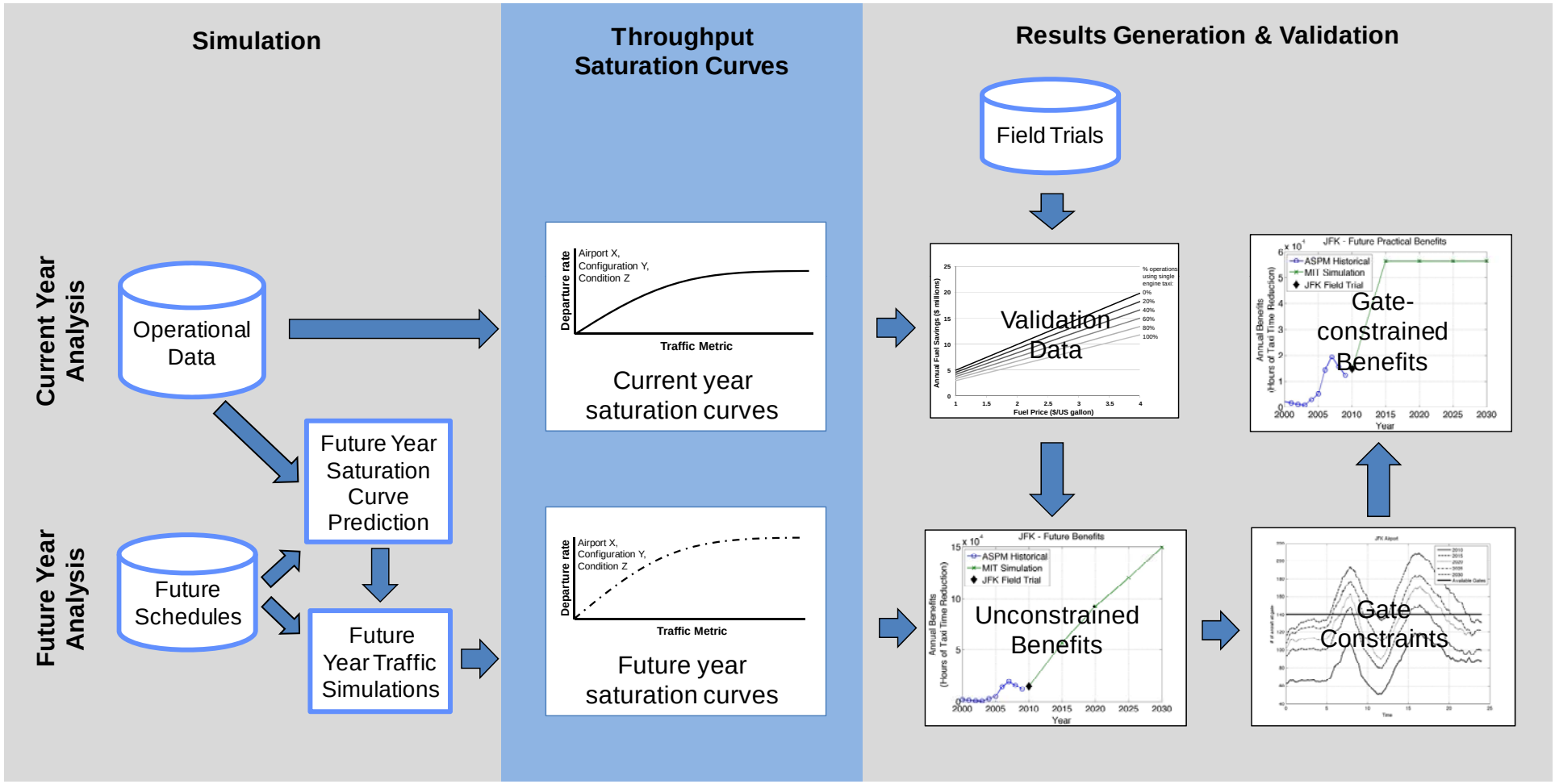
Medium Fidelity Assessment: 8 Study Airports Benefits Modeling

- **Throughput saturation curves at core of methodology**



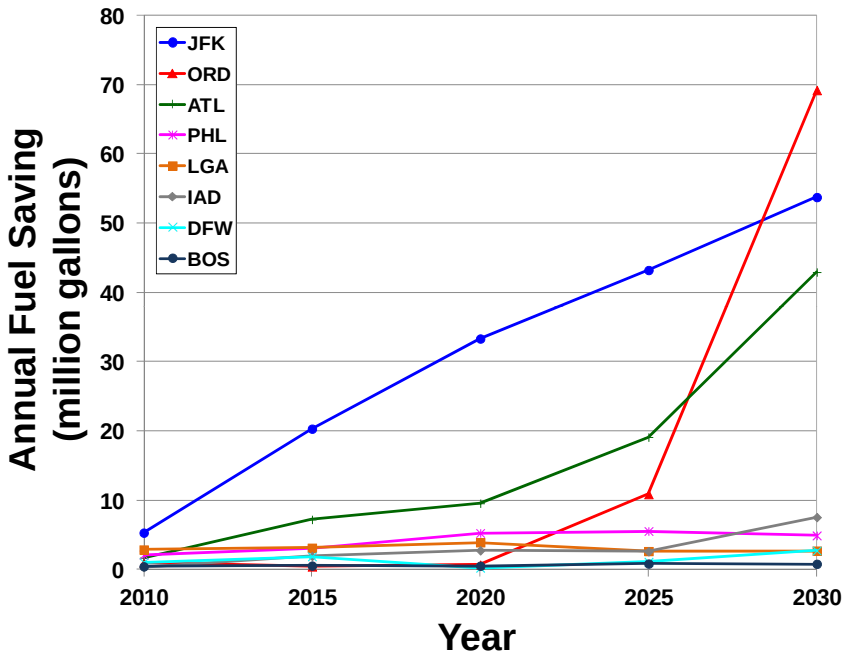
- **Current year: curves can be established from operational data**
- **Future years: curves estimated from demand/capacity forecasts**

Medium Fidelity Assessment: 8 Study Airports Benefits Modeling

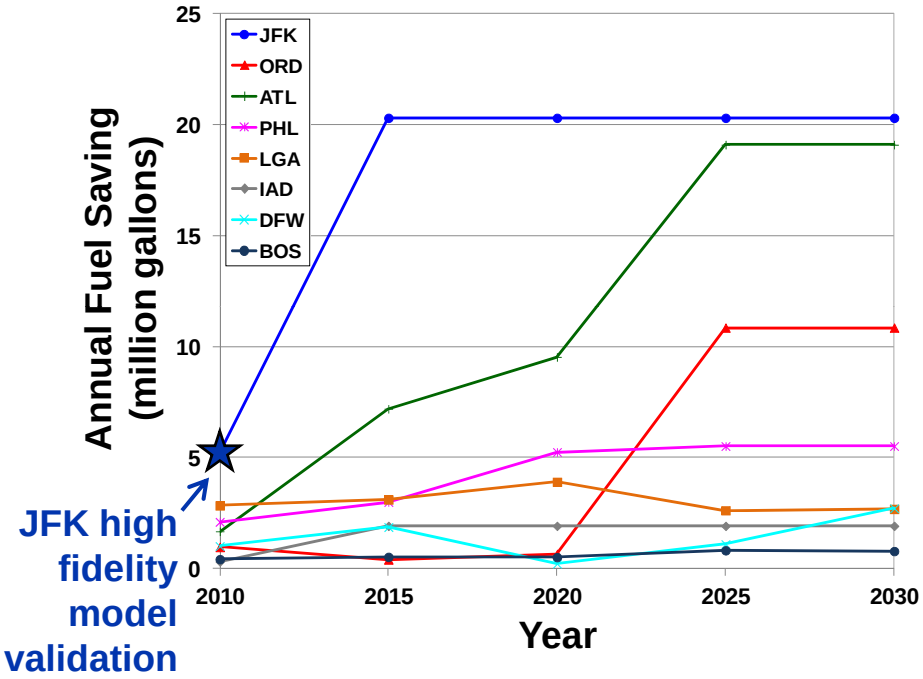


Medium Fidelity Assessment: 8 Study Airports Fuel Savings Estimates

Unconstrained Fuel Benefits



Gate-constrained Fuel Benefits



- **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***

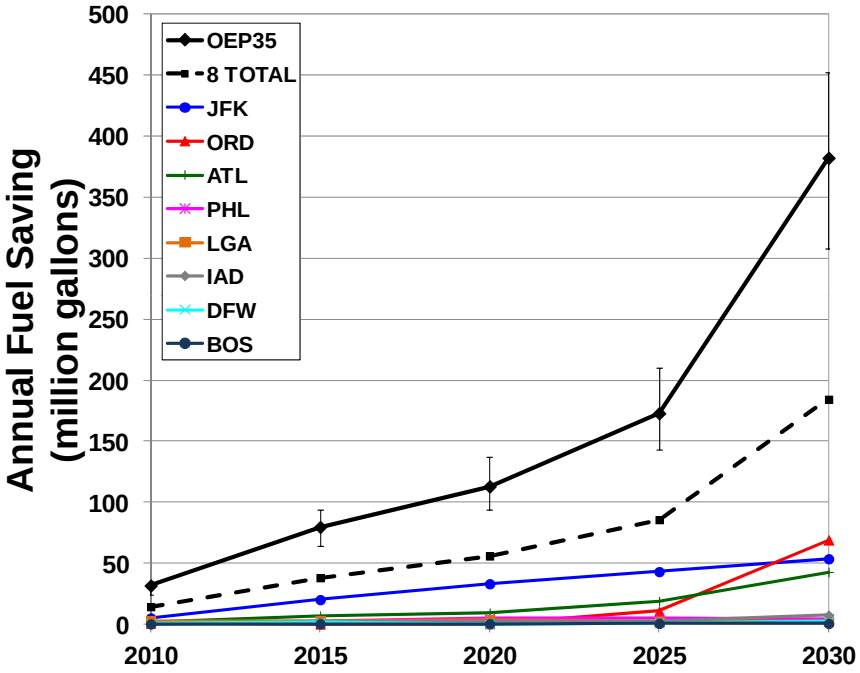
*Nakahara, A. & T. G. Reynolds, "An Approach for Estimating Current and Future Benefits of Airport Surface Congestion Management Techniques", 12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Indianapolis, IN, 2012.

Low Fidelity Assessment: OEP35 Fuel Savings Estimates

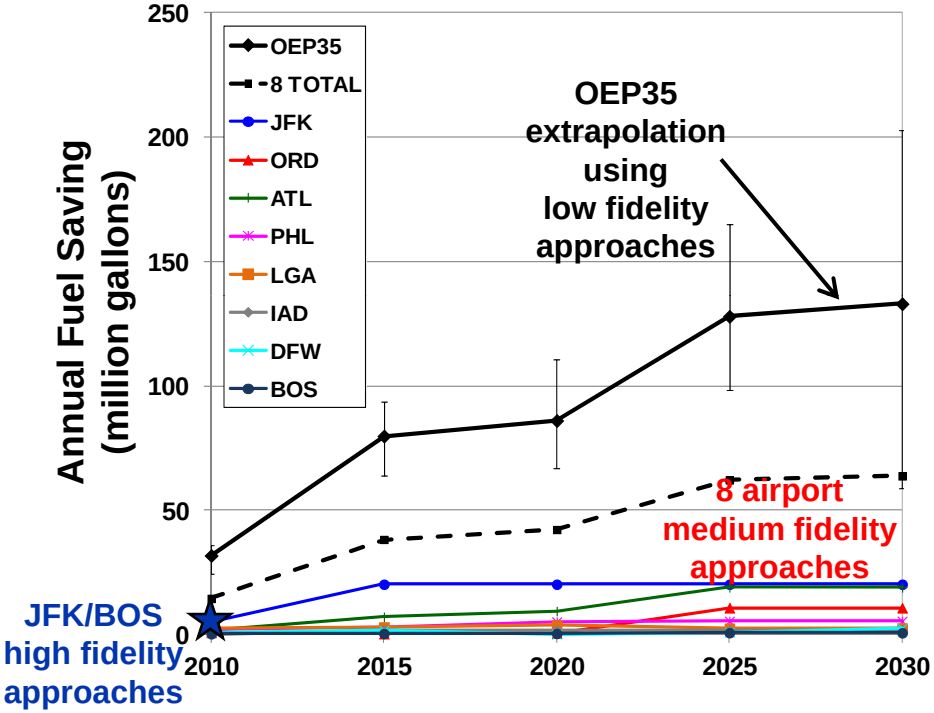
- **Multiple approaches employed to extrapolate medium fidelity results to OEP35 airports to bound benefit estimates**
  - **Scaling factors to apply to medium fidelity studies**
- **Taxi delay scaling factor**
  - **Scale medium fidelity benefits to OEP35 benefits in proportion to amount of total taxi 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**

Departure Metering Benefits Roll-Up

Unconstrained Fuel Benefits



Gate-constrained Fuel Benefits



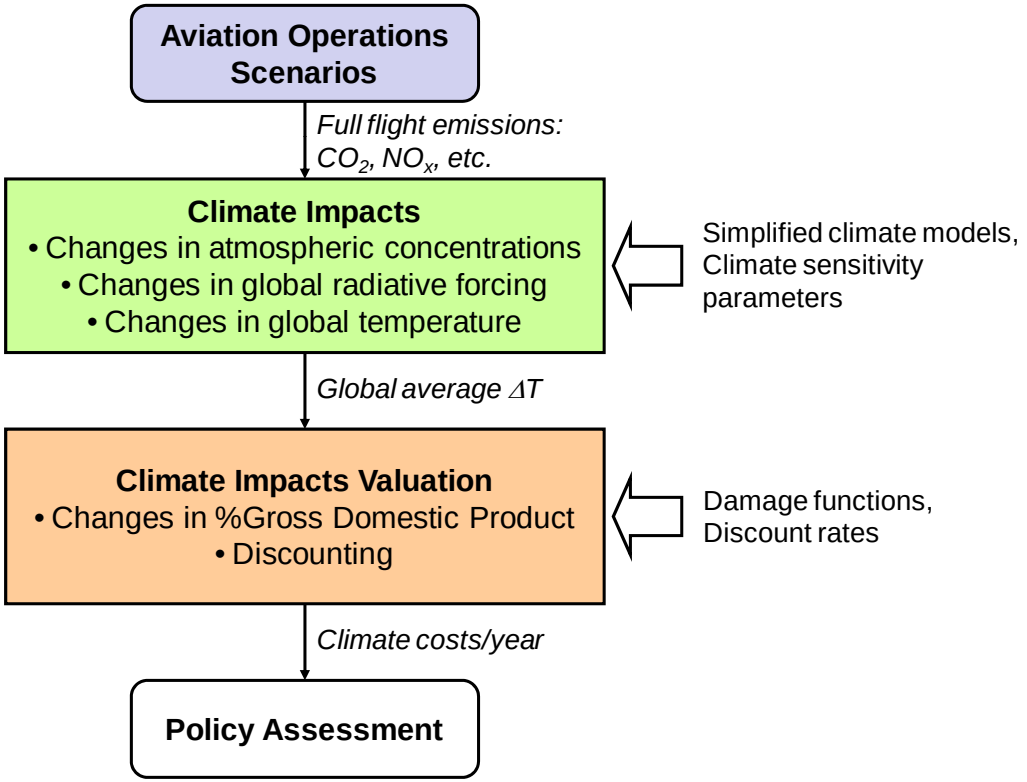
- **Gate-constrained fuel saving estimate at OEP35 airports over 20 yrs: 1.8-2.7 billion gallons, $4.4-6.6 billion (@$2.43/gallon)**
- **Also equates to 18-26 million metric tons CO_2 emissions saved**

Outline

- **MIT/LL capability development areas and role of benefits assessment**
- **Traditional benefits assessment case study**
  - **Departure metering**
- **Environmental impacts in benefits assessment**

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**



Environmental Impacts in Benefits Assessment

	Departure Metering	Sequencing and Scheduling	Airport Configuration Management
Primary Effects	Reduced engine-on time	Increased throughput	Change in flight patterns Increased throughput
Noise Impacts	Reduced noise ↓ Property value and health benefits	Reduced noise ↓ Property value and health benefits	Modified noise locations ↓ Property value and health impacts
Air Quality Impacts	Reduced emissions ↓ Health benefits *First order estimate:* *$0.2-8.8 billion* *@ $29-1226/tonne fuel**	Reduced taxi time ↓ Reduced emissions Health benefits	Reduced taxi time ↓ Reduced emissions Health benefits
Climate Impacts	Reduced emissions ↓ Climate benefits *First order estimate:* *$0.1-1.4 billion* *@ $5-65/tonne CO_2**	Reduced taxi time ↓ Reduced emissions Health benefits	Reduced taxi time ↓ Reduced emissions Health benefits

*Dorbian, C., P. Wolfe & I. Waitz, "Estimating the Climate and Air Quality Benefits of Aviation Fuel and Emissions Reductions", Atmospheric Environment ,Vol. 45, pp. 2750-2759, 2011.

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**