Reduced Surface Emissions through Airport Surface Movement Optimization

Prof. Hamsa Balakrishnan
Prof. R. John Hansman
Aeronautics & Astronautics and Engineering Systems
MIT
Motivation

- Opportunities to improve the environmental and economic performance and efficiency of airports and airlines
- Increased Congressional/public pressure to improve environmental performance
- In 2006, aircraft in the U.S. spent over 20 million minutes taxiing in to their gates, and over 49 million minutes taxiing out for departure
- Taxiing aircraft burn fuel, and contribute to surface emissions of CO$_2$, hydrocarbons, NO$_x$, SO$_x$ and particulate matter
- Taxi times are typically much larger than the unimpeded taxi times

[FAA ASPM data]
Objectives

• Reduction of surface emissions through improved surface movement optimization

• Investigate promising near-term opportunities for surface optimization
  - Limiting build up of queues on the airport surface
  - Gate-hold strategies
  - Taxi route planning

• Assess challenges to implementation, and develop strategies to overcome them
  - Gate usage
  - ATC procedures

• Ensure equitable treatment of airlines
What is the “right” number of aircraft on the surface?

- There is a critical number of aircraft on the surface in order to achieve efficient surface operations

[N. Pujet, 1999]
Surface congestion increases taxi times

- Taxi times are closely correlated with the number of aircraft on the airport surface

[N. Pujet, 1999]
Queuing network model of surface operations

- For example, BOS in the 27/22L-22R/22L configuration

[H. Idris, 2001]
Operational challenges: First-Come-First-Served departure queues

- Pushback order can make a significant difference to the departure time
- Suppose the red aircraft pushes back just before the blue aircraft
- Final departure sequence is:
Operational challenges: Gate usage

- Gate assignments affect ability to delay pushback
- Gate leases may make gate-swaps infeasible

Terminal E
Aer Lingus, Air France, Alitalia, American (Int'l), British Airways, Finnair, flyGlobespan, Iberia, Icelandair, JetBlue Airways (Int'l), KLM, Lufthansa, Northwest, SATA, Swiss, Virgin Atlantic Airways

Terminal C
AirTran Airways
Cape Air
Continental
JetBlue Airways
Midwest
United
United Express

Terminal A
Delta
Delta Connection/
Comair
Delta Shuttle

Terminal B
Air Canada
Alaska Airlines
America West
American/American Eagle
Spirit Airlines
US Air/US Air Express/
US Airways Shuttle
Airports for a pilot study

- We would like to engage with airports for a pilot study

For example, the ten major airports with the largest taxi times?

[FAA ASPM data]
Approach

1. Identification of inefficiencies/opportunities for improvement in current surface operations

   We would really welcome and appreciate your ideas and input!

2. Analysis of different surface movement optimization strategies, and their potential benefits

3. Identification of potential barriers to the adoption of promising surface movement optimization strategies

4. Development of a plan for the field trials of promising concepts

5. Determination of factors influencing candidate airports for field trials

6. Description of an initial plan for a pilot airport study on reducing emissions through improved surface traffic management
Summary

- Optimized surface movement planning is a promising approach to decreasing surface emissions
  - Early studies seem to suggest that controlling pushback ("gate-holding strategies") can help reduce taxi times
  - Other approaches?
  - Plan to introduce environmental factors into objective function

- Implementation barriers need to be identified and addressed
  - Gate usage and ownership
  - Infrastructure issues: taxiway layout, availability of tugs
  - Interactions between surface and airspace operations
  - Airline concerns

- Factors influencing candidate airports for field tests
  - Taxi times
  - Gate ownership/lease procedures
  - Ramp control by airlines
  - Stakeholder interest
  - Non-attainment areas
  - Availability of surface surveillance