Surface Traffic Management Research

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Goal

To manage traffic on the airport surface (gates, taxiways, and runways) safely and efficiently to enable maximum throughput with consideration of environmental impacts

Surface Research Products

• Concept of operations for surface DSTs
• Algorithmic research for surface schedulers
• Modeling and simulation, fast- and real-time
• Prototype surface DSTs for ATC and airlines
• Benefits assessment of surface concepts
• Tower human-in-the-loop simulation
Surface Management System (SMS)
- Traffic Management Tool (ATC & Airlines)
- Controller Tool (Tower & Ramp)
- NAS Information Tool
- Current Users:
  - FedEx at MEM
  - UPS at SDF
  - NASA/FAA prototype DSTs (e.g., SARDA, PDRC, RCM, TFDM)
Surface Management System (SMS) System Architecture
Real-time HITL Simulation Systems

- **Surface Decision Support System (SMS/SDSS)**
  - Scheduling and prediction engine
  - Traffic visualization displays
  - Hosting of controllers stations (Tower/ramp)
  - Airport models (e.g., DFW, CLT, MEM, SDF, MCO, etc.)

- **Airspace Traffic Generator (ATG)**
  - Target generator
  - Hosting of pseudo-pilot stations
  - Airport model

- **FutureFlight Central (FFC) — Tower simulator**
  - 360-deg Out-the-Window view of airport surface
  - Reconfigurable controllers workstations
  - Communication with pseudo-pilots through voice channels
Fast-time Simulation System

Surface Operations Simulator and Scheduler (SOSS) - A fast-time surface simulation for efficient development and analysis of algorithms that control optimal surface movement

Capabilities:
- Models any airport surface
- Simulates aircraft surface movement
- Enforces runway separation constraints
- Prevents collisions
- Connects with any scheduler through a standardized interface
- Executes up to 100 times faster than real-time

Existing Airport Models: DFW, CLT, JFK
Airport Models in Development: BOS, LGA
Spot And Runway Departure Advisor (SARDA)

• **Goal:** An integrated decision support tool for airlines and tower controllers to enhance the efficiency of surface traffic

• **Ground Controller Advisory**
  – Provide spot/ramp release schedule to reduce taxi delay while maintaining maximum runway throughput

• **Local Controller Advisory**
  – Provide take-off and crossing **sequence** for maximum runway usage while addressing all criteria

• **Airline Operator Advisory**
  – Provide gate push-back times to airlines
SARDA Scheduler Concept

**Stage 1: Runway scheduling**
- Surface Surveillance
- Rwy ETAs of arrivals
- TMI
- Runway assignments

**Stage 2: Spot release scheduling**
- Scheduled push back times
- Scheduled spot times

**Ramp Taxi Estimator**
- Estimated push back times
- Estimated spot times

**Push Back Control Logic**
- Scheduled push back times
- Scheduled spot times

**Spot Release Planner (SRP)**
Taxi Time Prediction

• Taxi prediction:
  – Ramp model for predicting spot enter time
  – Spot to queue model for predicting queue enter time
  – Queue to start roll for predicting start roll time

• Available models:
  – Kinematic Model
    • Unimpeded taxi prediction for both long- and short-term
    • Speed profile from historical database
  – Other models under consideration
    • Linear regression
    • Neural network
    • Random Forest
• East side DFW (17R departures and 17C arrivals)
• No perimeter taxiway
• 3 weeks or runs
  – 1st day training day
  – 16 data runs per week
  – 48 total
  – 16 end-of-week exploratory runs
• 6 controllers (2 controllers per week)
• 5 pseudo-pilots
Test Variables

• 2 traffic levels - Medium and Heavy (with 2 scenarios per level)
  – M1, M2, H3 and H4
  – 6 runs for each scenario for advisory and baseline (with different controllers)

• 2 test conditions
  – Baseline - use current day strategy
  – Advisory - utilize SARDA advisory
SARDA Concept
SARDA HITL Simulation 2012
Dependent Variables

• System Performance
  – Taxi Out/In delay
  – Fuel consumption and emissions
  – Taxi stop
  – TMI adherence accuracy
  – Throughput

• Human Factors
  – Situational awareness
  – Workload
  – Usability
Taxiing Delay for Departures (ramp, taxiway, queue)

Mean and percentile over all aircraft for that scenario

- 3 min reduction in medium (45%)
- 5.5 min reduction in heavy (60%)
Taxi Delay - Distribution

Taxi delay, scenario – h3

Large variation in delay in baseline
Fuel Consumption

Extra fuel used beyond unimpeded travel

Fuel Consumption

22% reduction in medium
34% reduction in heavy
Fuel Consumption

34% fuel savings = 70 kg fuel per aircraft

Daily operations: 6 peak periods of 50 aircraft each

At $3/gallon, annual savings: $6 million USD
Summary of System Performance

• Fuel Savings (kg): 22% (medium), 34% (heavy)
• Delay reduction (ramp, taxiway, queue): 3 min (medium 45%), 5.5 min (heavy 60%)
• Reduces variation in taxi delay distribution
• Gate holding does not diminish runway usage
• Advisories reduce variation in system performance
• No net effect on arrival taxi delay
Partial Results - Human Factors

• Controllers’ subjective workload ratings were lower in advisory runs than in baseline runs
• Ground and Local reported that it was easy to use SARDA advisories
• Over half of participants found advisory helpful with managing TMI aircraft in heavy traffic
• Half of participants would prefer to use the tool than not
• Other analysis are on-going
Questions?