Surface Traffic Management Research

Yoon Jung
NASA Ames Research Center

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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

TFMS/TMA

Air Carrier Data

Future Airport Situation & Advisories

TFMS/TMA

ASDE-X

SMS

NAS TFM Systems

Tower, TRACON, & ARTCC Traffic Managers

Local & Ground Controllers

Air Carriers Ramp Tower & AOC
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
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

Ramp Management

Spot Release Planner (SRP)

Estimated push back times
Ramp Taxi Estimator

Estimated spot times

Scheduled push back times
Push Back Control Logic

Scheduled spot times
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
Simulation Details

• 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

Gate Pushback Schedule
Spot Release Schedule
Runway Sequence
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)

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 per aircraft

- 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?