Overview - Spot and Runway Departure Advisor (SARDA)

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Topography of Airport and Surface Management

Consequences:
- Excessive taxi delay
- Excessive fuel consumption and emissions
- Missed opportunities in merging departures into overhead traffic flow

Today’s Airport Surface Operations:
- Uncertainties (e.g., flight readiness)
- Lack of common situational awareness and coordination
- Lack of predictability
- First-come, first served operations
Intelligent Scheduling is the Key to Efficient Surface Management

SARDA is the NASA’s approach for solving this problem.

- Optimizes at a system level by minimizing overall delay
- Plans at a detailed trajectory level for aircraft movement (gate, ramp, taxiways, and runways)
- Uses a fast algorithm suited to real-time operations
- Accounts for departures and arrivals
- Connects airport tower, en route facility, and airlines
- Adaptable to other airports with different configurations
SARDA Concept

Through collaboration between ATC and airlines, SARDA
- Builds an optimal runway schedule
- Generates spot release sequence and timing
- Determines when to push back departures from gates

Each departure aircraft pushes back from its gate at the **RIGHT TIME**.
Surface Performance Metrics

• Efficiency
  – Taxi time: $\Delta$(OFF, OUT), $\Delta$(ON, IN)
  – Taxi delay: $\Delta$(Actual, Unimpeded)
  – Runway queue length
  – Fuel burn

• Predictability
  – Variance in efficiency metrics
  – Accuracy in OFF time prediction

• Throughput
  – Schedule delay: $\Delta$(Actual OFF - Scheduled OFF)
  – Number of runway operations
**Option 1: SARDA as Surface CDM Tool**

- Develop a runway schedule and generate spot/gate pushback times through CDM process
- Communicate spot/gate pushback times with airlines
- Refine schedule as traffic situation changes dynamically and provide tactical advisories to ATCT controllers

- Ideally for hub airports with multiple carriers
- Data exchange is required (e.g., pushback ready times, TMIs, runway configuration)

8/14/14
ATCT Controller Tool
Dallas/Ft. Worth Airport (2012)

DFW Simulation Setup (FutureFlight Central)

Taxiing delay for departures

Takeoff Time Prediction Error

Var. of Remaining Taxi Time

Scheduled PB
Actual PB
Taxiway entry
Queue entry
Rwy entry

High (w/ SARDA)
Med (w/ SARDA)
Med (w/o SARDA)
High (w/o SARDA)

8/14/14
SARDA Implementation (2)

Option 2: SARDA as Airline Ramp Management Tool

– Develop a runway schedule and generate spot times
– Provide gate pushback advisories to ramp controllers to meet runway/spot schedule

• Ideally for hub airports with a single dominant carrier
• ATCT can have a repeater or employ a SARDA controller advisory tool in parallel
• Data exchange is required
NASA-US Airways Collaboration
• Goal: Develop and test a Prototype DST for US Airways Charlotte Airport Ramp Operators
• Conduct a series of HITLs throughout FY14 & 15
• Conduct Field Evaluations in FY15
Ramp Sector Controller Workstation (Illustration Purpose Only)

Surface Map

Ramp Traffic Console (RTC)

Gate Manager

(Touch screen)
Ramp Traffic Console (RTC)

- 27” touchscreen
- Virtual strips
- Surface surveillance
- Dynamic pushback advisories
CLT SARDA Project Timeline

06/2013
Concept of Operations

10/2013 – 9/2014
HITL Simulations (baseline core)

Simulator development
SARDA core functions development
GUI development

10/2014
Install SARDA at CLT Ramp Tower

5/2014 – 1/2015
HITL Simulations (follow-on)

3/2015 – 9/2015
Field Evaluations
# CLT SARDA HITL Schedule

<table>
<thead>
<tr>
<th>No.</th>
<th>Objective</th>
<th>Target</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
<td>#1</td>
<td>Baseline System</td>
<td>12/13</td>
<td>Completed</td>
</tr>
<tr>
<td>#2</td>
<td>User Interface and Procedures</td>
<td>2/14</td>
<td>Completed</td>
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<tr>
<td>#3</td>
<td>Scheduler Function</td>
<td>4/14</td>
<td>Completed</td>
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<td>#4</td>
<td>Ramp Operational Constraints</td>
<td>7/14</td>
<td>Completed</td>
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<tr>
<td>#5</td>
<td>TMI's and Uncertainties</td>
<td>8/14</td>
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<tr>
<td>#6</td>
<td>Benchmark Test</td>
<td>9/14</td>
<td></td>
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<tr>
<td>#7</td>
<td>Runway Configuration Change</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>#8</td>
<td>Off-nominal Situations</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>#9</td>
<td>ATC Integration</td>
<td>TBD</td>
<td></td>
</tr>
</tbody>
</table>

**Phase 1**
- #1 Baseline System: Completed
- #2 User Interface and Procedures: Completed
- #3 Scheduler Function: Completed
- #4 Ramp Operational Constraints: Completed

**Phase 2**
- #5 TMI's and Uncertainties
- #6 Benchmark Test: 9/14
- #7 Runway Configuration Change: TBD

**Phase 3**
- #8 Off-nominal Situations: TBD
- #9 ATC Integration: TBD
On-going/Future Surface Research

• SARDA
  – Conduct field test at CLT
  – Conduct follow-on HITLs
  – Develop simulation for integrated ATC-Airlines surface concept validation
  – Integrate SARDA with flight deck for trajectory-based surface operations

• Expand SOSS modeling capability for IADS research

• Characterize benefits of surface CDM at JFK

• Continue to collaborate with international partners on surface concepts
Partnerships

• Airlines
  – US Airways for SARDA HITLs and field test at CLT

• Airports
  – PANYNJ for surface CDM collaborative research

• FAA
  – Surface Operations Office (AJR-E)
    • Technical Interchange
  – Technology Dev and Prototyping Div (ANG-C5)
    • IADS RTT
    • ASDE-X data feed to ARC (work-in-progress)
  – Operational Concepts, Validation & Requirements (AJV-7)

• International
  – DLR: ConOps, Surface modeling and simulation
  – NLR: Surface Conflict Detection
Questions?

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Backup slides
SARDA - 2014

Waqar Malik
UARC Research Scientist
Motivation

• Inefficiencies in current operations:
  – Aircraft are delayed in departure queues
  – Excess taxi-out times, fuel consumption and emissions

• Departure metering: limiting aircraft queues near runway and taxiways by modulating aircraft pushback
SARDA Concept

Goal: A collaborative decision support tool for airlines and tower controllers to enhance the efficiency of surface traffic.

• **Airline Operator Advisory**
  - Provide gate push-back times to airlines

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

• **Local Controller Advisory**
  - Provide take-off and crossing sequence for efficient and safe runway usage
SARDA History

• SARDA - Spot and Runway Departure Advisory
  – Initial proof of concept (as a tower tool) was developed for DFW airport and tested at the FutureFlights Central (FFC)
    • Reduction in AMA taxiing delay for departures (45% in medium, 60% in heavy), and reduced variation
    • Take-off time was predicted reliably under advisory condition
Taxi Predictor

- Simple kinematic model used.
- Analyzed unimpeded aircraft movement at CLT
- A single value from the speed distribution is chosen as the unimpeded speed for all aircraft

Nominal speed used for taxi estimation

Unimpeded speed
Taxi Prediction Module (TPM)

Scheduler → TPM Config.txt → TPM.sh

TPM Client → setETAs → TPM Server

CAI → input

Server option & Ops parameters

Run one server among options below:
- Dead Reckoning
- LINOS
- Linear Regression
- Support Vector Machines
- k-Nearest Neighbors
- Random Forest
Runway Scheduler

- Estimated runway queue entry times (for departures).
- Estimated runway time (for arrivals).
- Spot, runway and fix/exit for each aircraft.
- Type (weight class) of each aircraft
- Wake vortex separation criteria for take-off/crossing
- Separation criteria for particular aircraft pairs (MIT)
- Individual time-windows of intended take-off times for departing aircraft (EDCT, CFR)
Runway Scheduler

• Mixed Integer Linear Program
Gate Release Time =

(Calculated Take Off Time) - (Estimated Taxi Time)
Single Lane Advisory

• Provide advisories for single lane use.
Single Lane Advisory
Scheduled Departure Demand vs. Departure Capacity

(Source: ASQP Data from year 2010)

35 OEP Airports

- **Movement area and non-movement area data**
- **Movement area data only**
- **No data**
Taxi Out Delay for OEP airports
(Source: ASQP Data from year 2009; all times are in minutes)

High Taxi Out Delay Proportion

Mean Taxi Out Time

Mean Taxi Out Delay

Taxi Out Delay / Total Taxi Out Time (%)
Missed Opportunities for Tactical Departure Scheduling

<table>
<thead>
<tr>
<th>System</th>
<th>Hit Scheduled Slot %</th>
<th>Hit First Surveillance Slot %</th>
<th>Estimated Number of Aircraft that missed slot due to departure time uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival TMA</td>
<td>26.9</td>
<td>39.3</td>
<td>6,792</td>
</tr>
<tr>
<td>EDC</td>
<td>39.4</td>
<td>57.1</td>
<td>1911</td>
</tr>
</tbody>
</table>

Monthly Mean Taxi Time (2013)