Surface Operations Simulator and Scheduler (SOSS) Presentation

Zhifan Zhu
Stinger Ghaffarian Technology
NASA Ames Research Center

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Outline

• What is SOSS?
• SOSS Architecture
• How SOSS Models Airport Surface Traffic
• Build a SOSS ICN model
What is SOSS?

- Fast time simulation tool running on desktop/laptop computers
What is SOSS: Domain

• Fast time simulation tool running on desktop/laptop computer

• Manage surface and runway traffic
What is SOSS: Domain

- Fast simulation tool running on desktop/laptop computer
- Manage surface and runway traffic

Flight from gate to gate:
- Taxi out
- Take off and climb out
- En route
- Descent and landing
- Taxi in

SOSS
- Departure runway threshold
- Terminal & En Route
- Final approach Fix (4-5nmi)

4/6/2016
What is SOSS: Airport Models

• Fast time simulation tool running on desktop/laptop computer
• Manage surface and runway traffic
• Airport model independent
What is SOSS: Airport Models

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- Manage surface and runway traffic
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What is SOSS: CAI Support

- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation

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What is SOSS: CAI Support

- Fast simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation

SOSS Engine

- Scheduler Manager
- Optimization Scheduler
- Common Algorithm Interface
- SDSS/HITL

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What is SOSS: Output

- Fast time simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database
What is SOSS: Output

- Fast simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database
What is SOSS: Playback

• Fast time simulation tool running on desktop/laptop computer
• Manage surface and runway traffic
• Airport model independent
• Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
• Post data analysis on database
• DVR type playback
What is SOSS: Playback

- Fast simulation tool running on desktop/laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database
- DVR type playback
What is SOSS: vs HITL

- Different from HITL environment
  - No human interaction
  - Follow traffic scheduling advisories (best effort)
  - Can run various simulations in a short time
  - Useful for early prototype and adaptation for HITL modeling
How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler
- Walk through example
How SOSS Models Airport Surface Traffic

• Airport adaptation
  – Surface node-link graph
  – Runway configuration
  – Taxiing routes
  – Weather condition
How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Surface node-link graph

Node-link graph representation of CLT
How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Runway configuration
    - Runway geometry, length, heading
    - Takeoff, exit and crossings
    - Traffic flow direction
    - Runway separation rules
How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Taxiing routes
    - Based on surface operation configurations
    - Static taxiing routes between runways and gates
    - Multiple routes between runway and gate possible
How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Weather condition
    - Currently only static wind (speed and direction) impacting on landing and takeoff

![Weather Controls](image.png)
How SOSS Models Airport Surface Traffic

• Airport adaptation

• Surface traffic movement
  – Built-in aircraft dynamics database
  – Aircraft taxiing mobility model
  – Separation criteria and surface conflict detection & resolution (CD&R)
  – Uncertainty model for taxi speed and flight readiness (i.e., pushback)
How SOSS Models Airport Surface Traffic

- Surface traffic movement
  - Built-in aircraft dynamics database
    - 459 aircraft types – extensible and substitution-able
    - Each type has 36 aircraft dynamic parameters
    - Weight class: small, large, heavy (super heavy)

Aircraft performance parameters
How SOSS Models Airport Surface Traffic

• Surface traffic movement
  – Aircraft taxiing mobility model
    • Aircraft type dependent mobility characteristics – speeds, accel/decel
    • ‘open-loop’ movement with linear accel/decel and nominal speed
    • No turn/curve model yet
    • Taxi movement follows node-link along assigned route
How SOSS Models Airport Surface Traffic

• Surface traffic movement
  – Separation criteria and surface CD&R
    • Aircraft to aircraft safety separation
    • Conflict detection and FCFS resolution (localized)

Example of taxi separation and surface CD&R in the ramp area

Aircraft movement demonstrating surface CD&R capability
How SOSS Models Airport Surface Traffic

• Surface traffic movement
  – Uncertainty in speed and flight-readiness
    • Individual taxiing speed variation uncertainty
    • Individual flight readiness uncertainty

No uncertainty in taxi speed

With uncertainty in taxi speed

Uncertainty in flight readiness
• Airport adaptation
• Surface traffic movement

• Traffic scenarios
  – Static flight schedule scenario – surface only modeling
  – Dynamic flight schedule – terminal space integration
How SOSS Models Airport Surface Traffic

- Traffic scenarios
  - Static flight schedule scenario – surface only modeling
    - Flight ID, aircraft callsign, and aircraft type
    - Runway and gate assignment
    - Gate pushback time (or off block time)
    - Final approach start time
    - Destination airport
    - Tail number

Data elements in traffic scenario

<table>
<thead>
<tr>
<th>Column</th>
<th>Owner</th>
<th>Comment</th>
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<tbody>
<tr>
<td>flight_id</td>
<td>unique flight id</td>
<td></td>
</tr>
<tr>
<td>flight_type</td>
<td>inbound or outbound flight</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>aircraft type that helps determine aircraft characteristics</td>
<td></td>
</tr>
<tr>
<td>destination</td>
<td>destination airport for outbound flight</td>
<td></td>
</tr>
<tr>
<td>runway</td>
<td>runway assignment</td>
<td></td>
</tr>
<tr>
<td>position</td>
<td>usually the gate or stand position</td>
<td></td>
</tr>
<tr>
<td>fix</td>
<td>metering fix</td>
<td></td>
</tr>
<tr>
<td>tail</td>
<td>turnaround tail number</td>
<td></td>
</tr>
<tr>
<td>time</td>
<td>flight schedule time may be wheel on, wheel off, gate off block or in block time</td>
<td></td>
</tr>
</tbody>
</table>
How SOSS Models Airport Surface Traffic

- Traffic scenarios
  - Dynamic flight schedule – terminal airspace integration
    - Allows runtime flight schedule passing to SOSS
    - SOSS handles inbound traffic to gate and handover outbound traffic to a terminal space flight manager
    - Support metroplex simulations
How SOSS Models Airport Surface Traffic

• Airport adaptation
• Surface traffic movement
• Traffic scenarios

• Model integration
  – Landing and takeoff models
  – Gate management model (a case study in 2015)
  – Other potentials (e.g., de-icing, fuel/emission model)
How SOSS Models Airport Surface Traffic

• Model integration
  – Landing and takeoff models – using aircraft dynamics, winds and runway configurations

Landing: runway threshold – wheels on – runway exit

Takeoff: take off accel – wheels off – runway threshold
How SOSS Models Airport Surface Traffic

• Model integration
  – Landing and takeoff models
  – Gate management model (a case study tested in 2015)
How SOSS Models Airport Surface Traffic

• Airport adaptation
• Surface traffic movement
• Traffic scenarios
• Model integration

• Connection to scheduler (e.g., SARDA scheduler)
How SOSS Models Airport Surface Traffic

• Connection to scheduler
  – Communication between SOSS and a scheduling algorithm uses a Common Algorithm Interface (CAI) protocol
  – Scheduler call can be synchronized or a-synchronized
  – Multiple schedulers can be connected, e.g., one for each side runways
How SOSS Models Airport Surface Traffic

• SOSS to scheduler
  – Runway information: most recent operations (take off, landing, crossing)
  – Departure fix information: most recent fix usage (time, aircraft type, weight class)
  – List of aircraft in planning horizon: current states, predicted times, runway/gate, taxi routes
How SOSS Models Airport Surface Traffic

• Scheduler to SOSS
  
  – List of aircraft and STRs (scheduled time of release)
  
  – STRs can be provided at all nodes, but typically at control locations such as gate, spot, etc.
  
  – A branch of source code in SOSS distribution dedicated to building scheduler with the CAI is available
How SOSS Models Airport Surface Traffic

• Airport adaptation
• Surface traffic movement
• Traffic scenarios
• Model integration
• Connection to scheduler (e.g., SARDA scheduler)
• Walk through example
How SOSS Models Airport Surface Traffic

• Walk through example: departure without a scheduler
  – Initiate departure flights at assigned gates
  – Start push back at scheduled time
  – Follow the default taxi route to assigned runway
  – Aircraft joins traffic to runway queue
  – Enter runway queue in the order of arrival
  – Ready to take off and meet separation rules
  – Takeoff model takes over
  – Runway events (start acceleration, wheels off, threshold crossing) are registered
Build SOSS ICN model

• Build a SOSS ICN model, step by step

Operation Info & historical data
Build SOSS ICN model

• Build a SOSS ICN model, step by step

Operation Info & historical data
• Build a SOSS ICN model, step by step

- Operation Info & historical data
- Runway configuration
• Build a SOSS ICN model, step by step
Build SOSS ICN model

- Build a SOSS ICN model, step by step

Operation Info & historical data

Runway configuration

Taxi routes

Test scenarios
• Build a SOSS ICN model, step by step

- Operation Info & historical data
- Runway configuration
- Taxi routes
- Test scenarios
- Model validation
• SOSS is a fast-time surface traffic modeling and simulation tool for desktop/laptop computer
• Allow building of airport adaptation model, shared with HITL simulation environment
• Use the same interface (i.e., CAI) to surface scheduling algorithm as the real-time environment
• Help build early prototype decision support tools and evaluation of scheduling algorithms
• Has a modular architecture for model/component integration
• Provide a complement surface modeling and simulation capability to HITL simulation