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

(Airspace Systems Program, Next Generation Air Transportation System Concepts and Technology Development Project FY2011-2015 Project Plan, Version 3.0, April 2011)

Surface Research Products

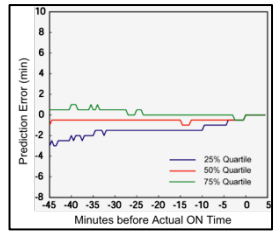
- Concept of operations for surface DSTs
- Algorithmic research for surface schedulers
- Modeling and simulation, fast- and real-time
- Prototype surface DSTs for ATC and airlines
- Benefits assessment of surface concepts
- Tower human-in-the-loop simulation

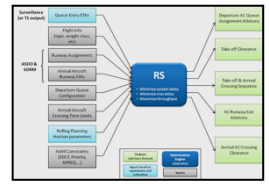
NASA Surface Research

CY01	CY02	CY03	CY04	CY05	CY06	CY07	CY08	CY09	CY10	CY11	CY12

SMS Field Trials at MEM

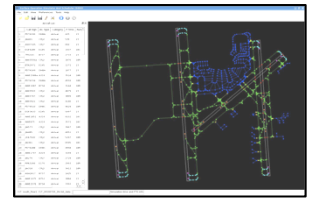
SMS-TMA Integration



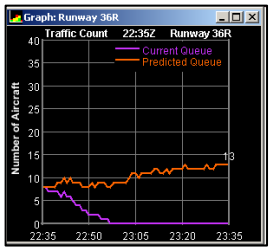


SARDA Concept

SOSS released to an NRA partner



SMS HITL Simulation

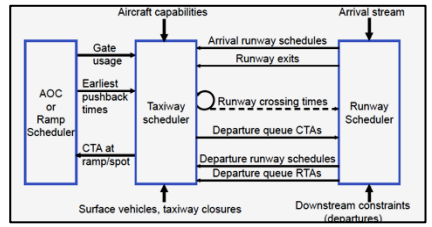


SMS Tech Transferred to the FAA

Start Exploring a New Framework for Surface Traffic Mgmt.

1st SARDA HITL Sim

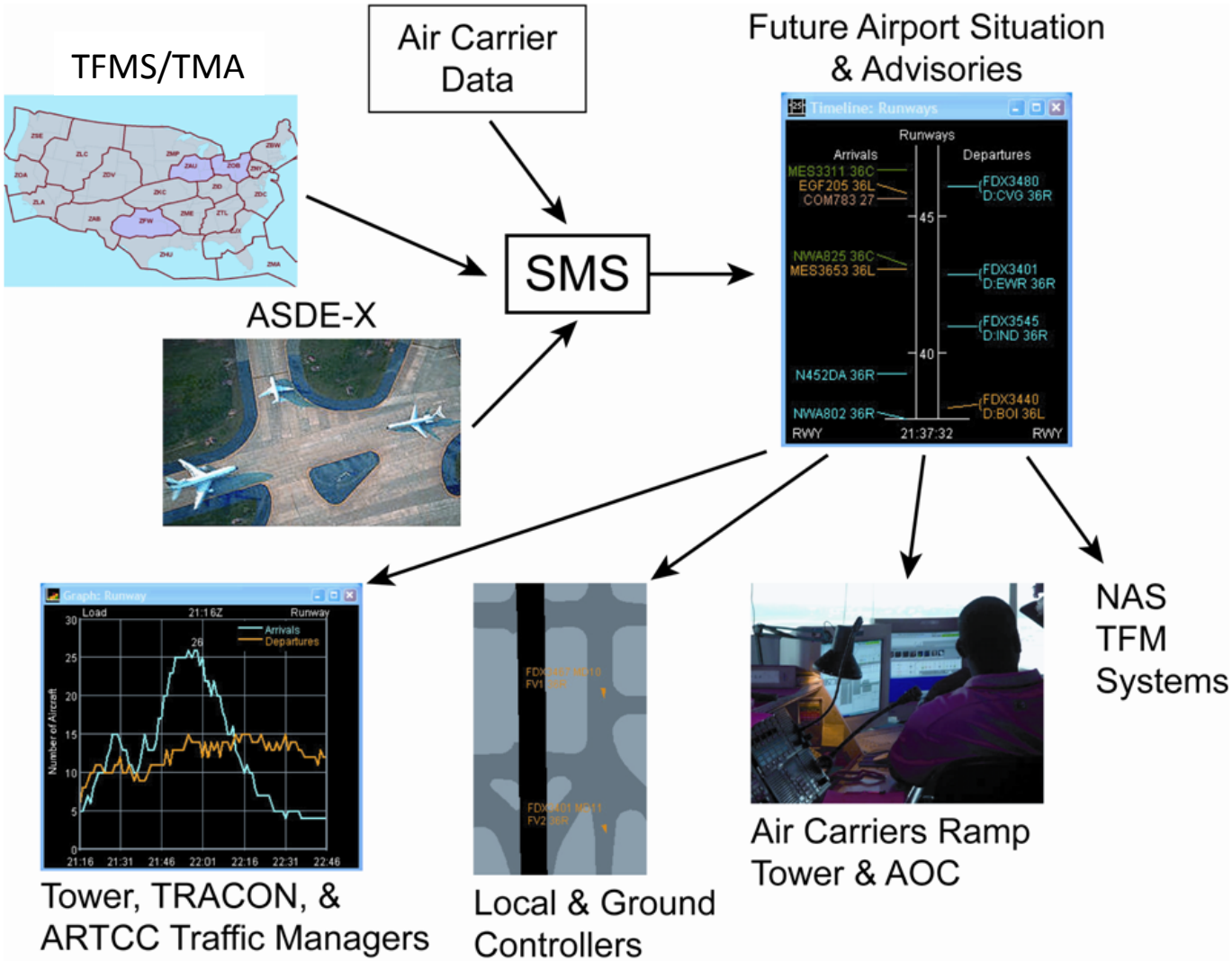
2nd SARDA HITL Sim



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

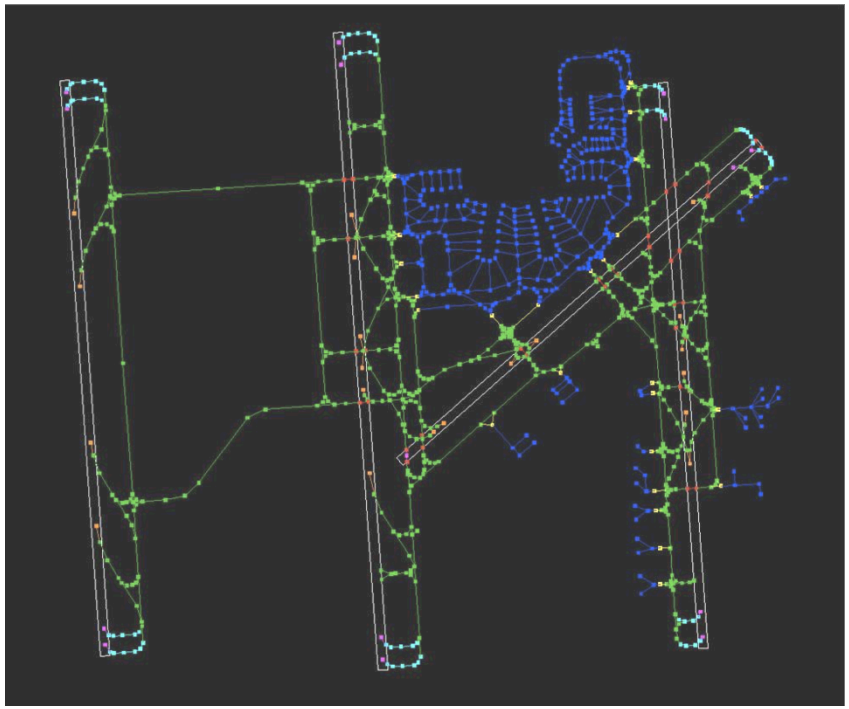
Fast-time Simulation System

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

Screenshot of SOSS with CLT Node/Link Model



Existing Airport Models: DFW, CLT, JFK

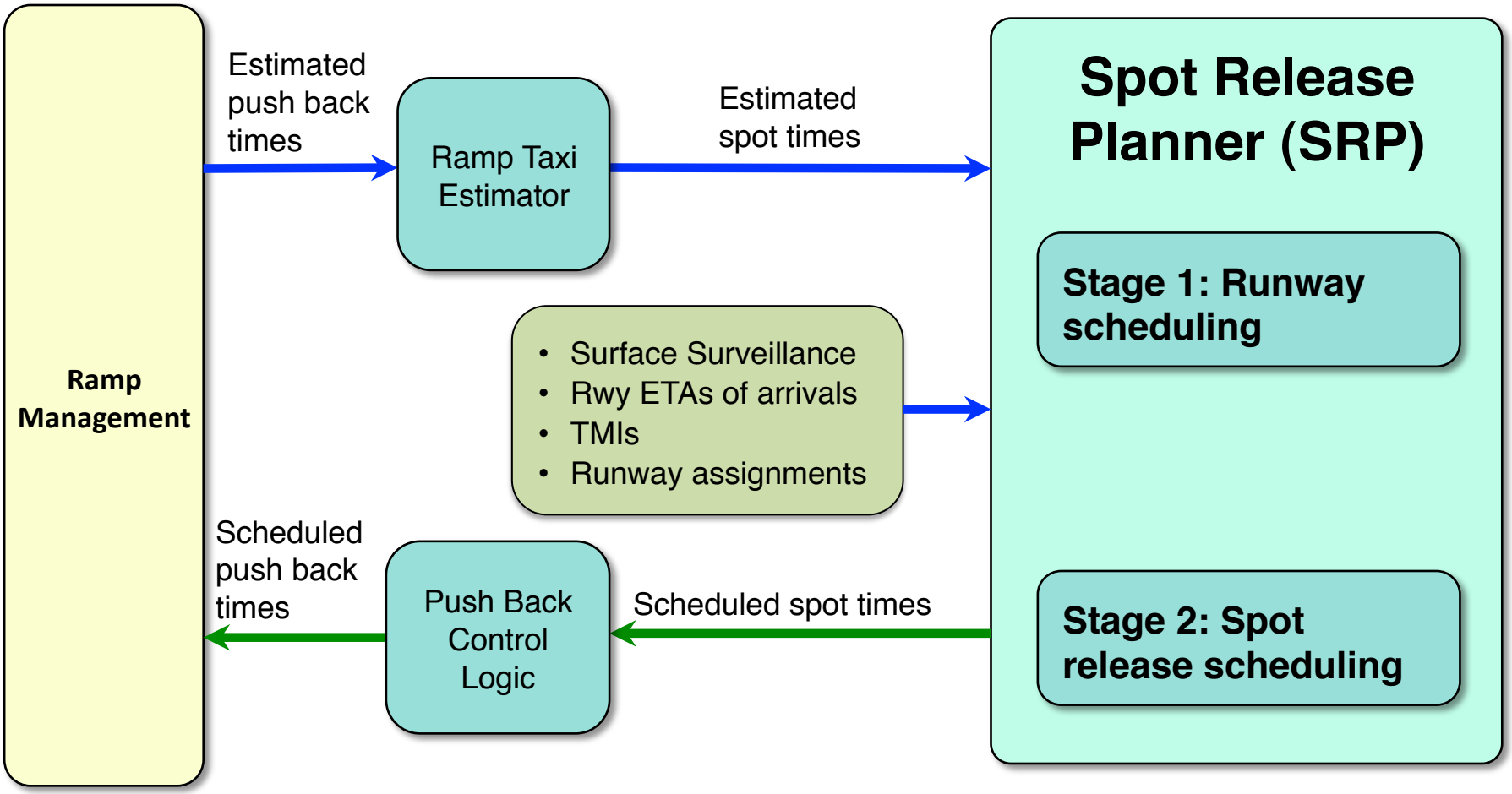
Airport Models in Development: BOS, LGA

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



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

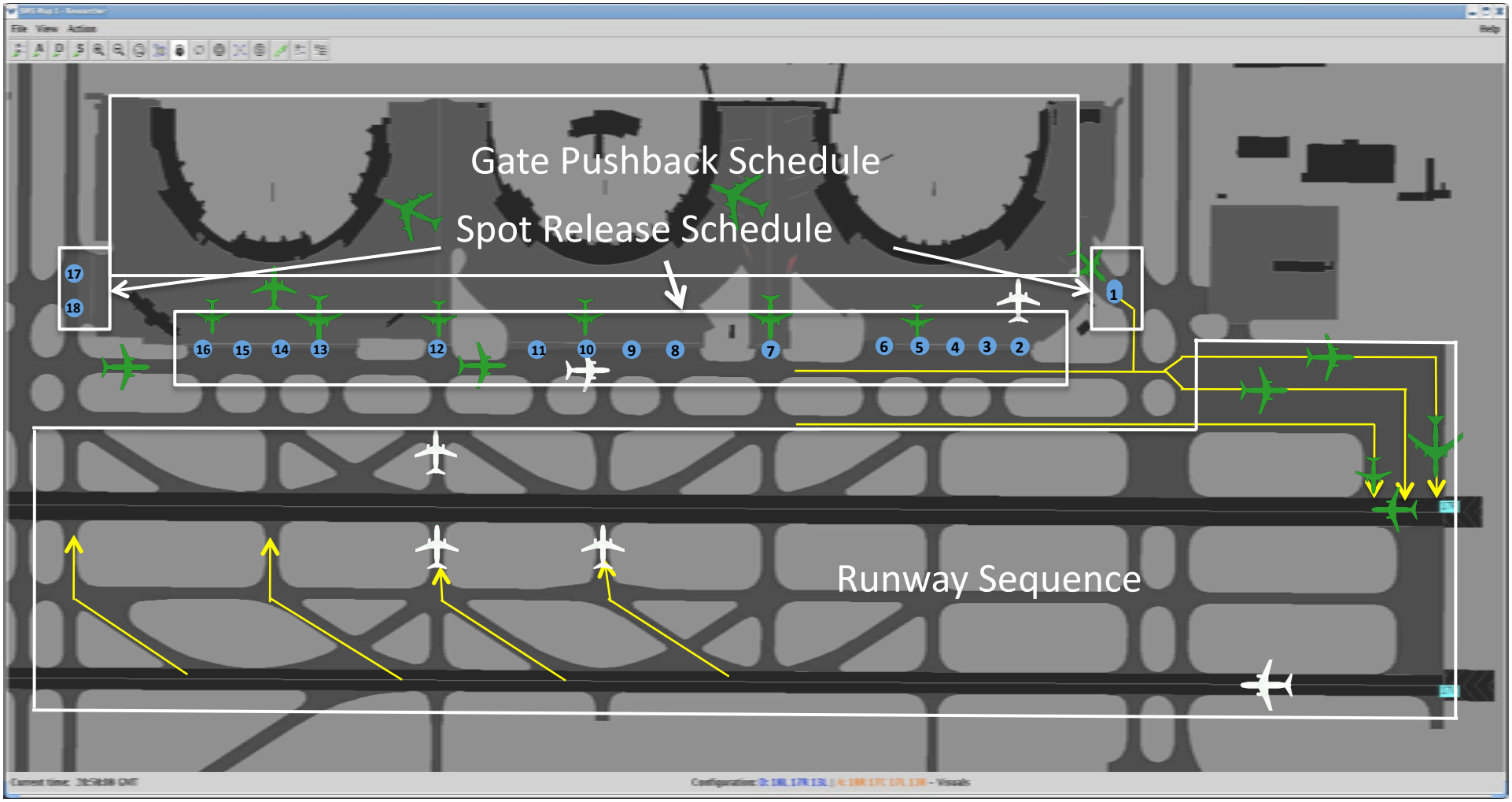
Simulation Details

- 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

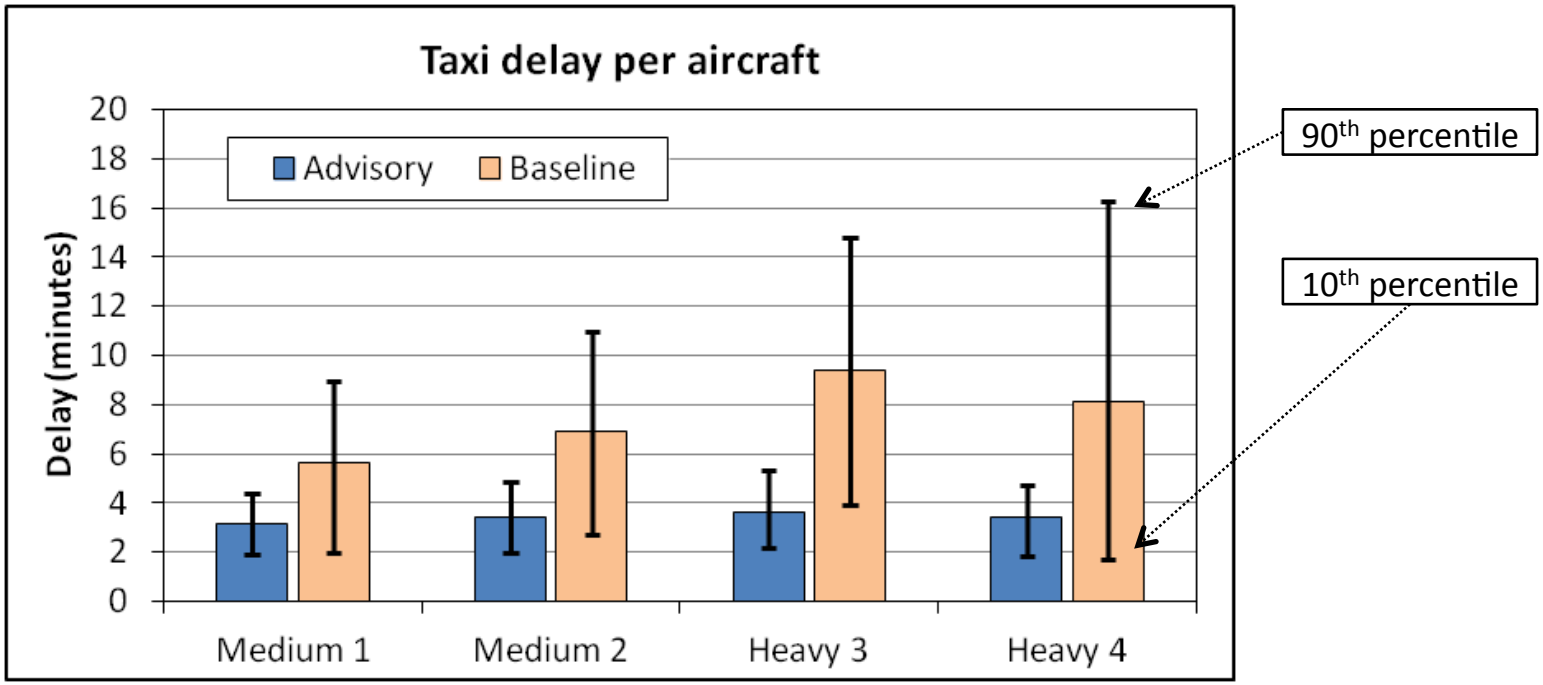


SARDA HITL Simulation 2012

Dependent Variables

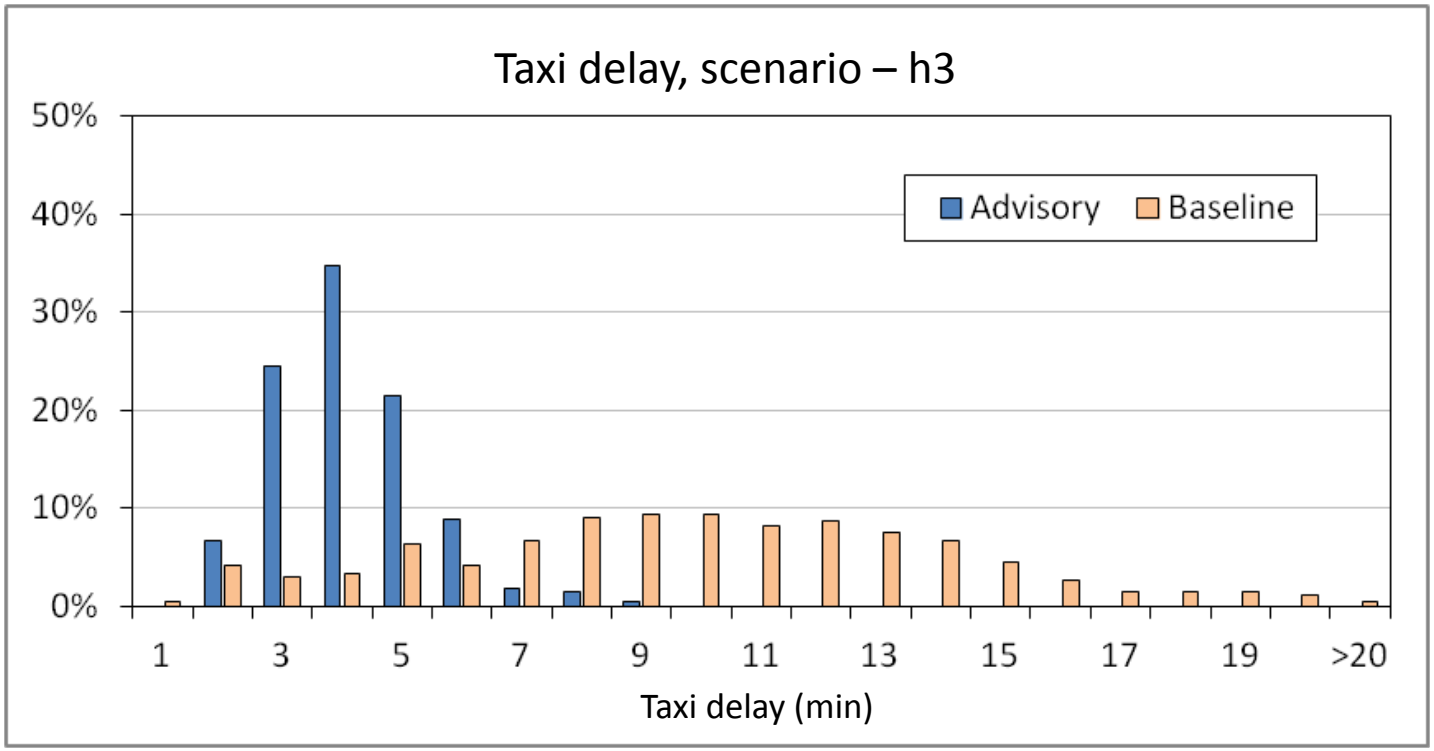
- System Performance
  - Taxi Out/In delay
  - Fuel consumption and emissions
  - Taxi stop
  - TMI adherence accuracy
  - Throughput
- Human Factors
  - Situational awareness
  - Workload
  - Usability

Taxiing Delay for Departures (ramp, taxiway, queue)



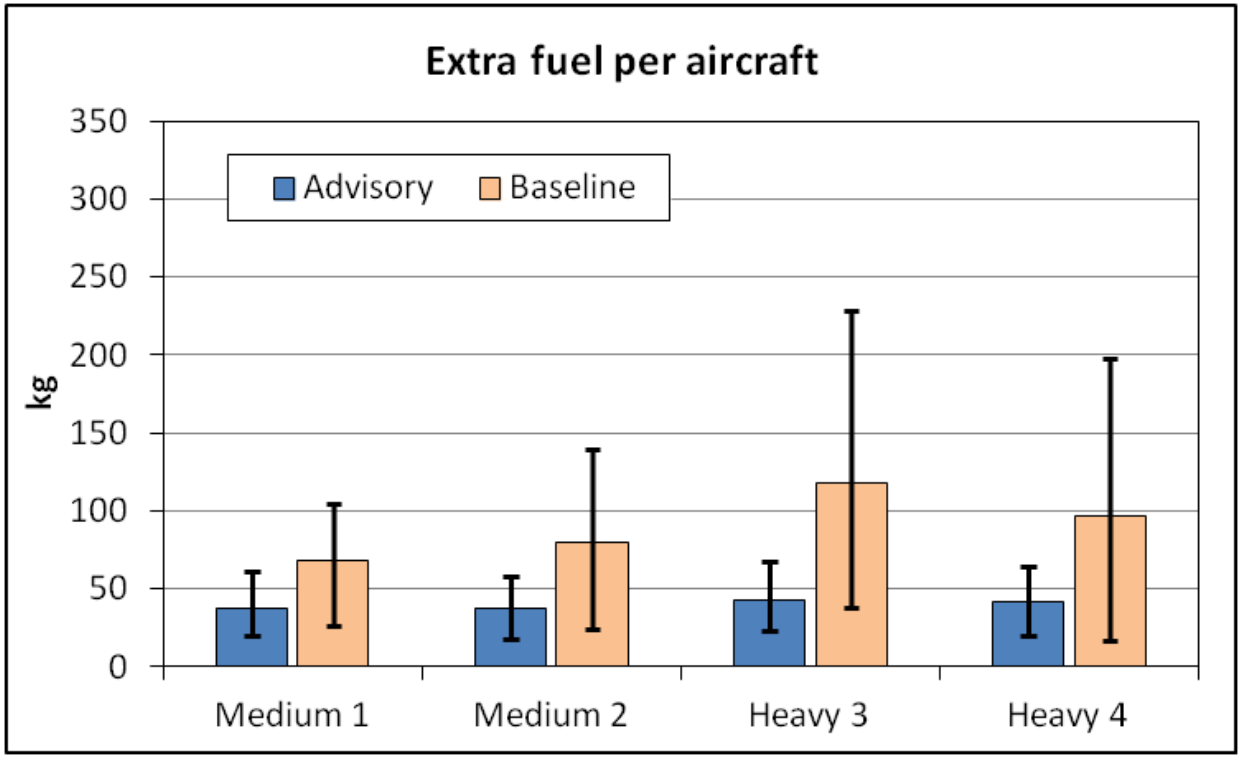
<u>3 min</u> reduction in medium (45%)
<u>5.5 min</u> reduction in heavy (60%)

Taxi Delay - Distribution



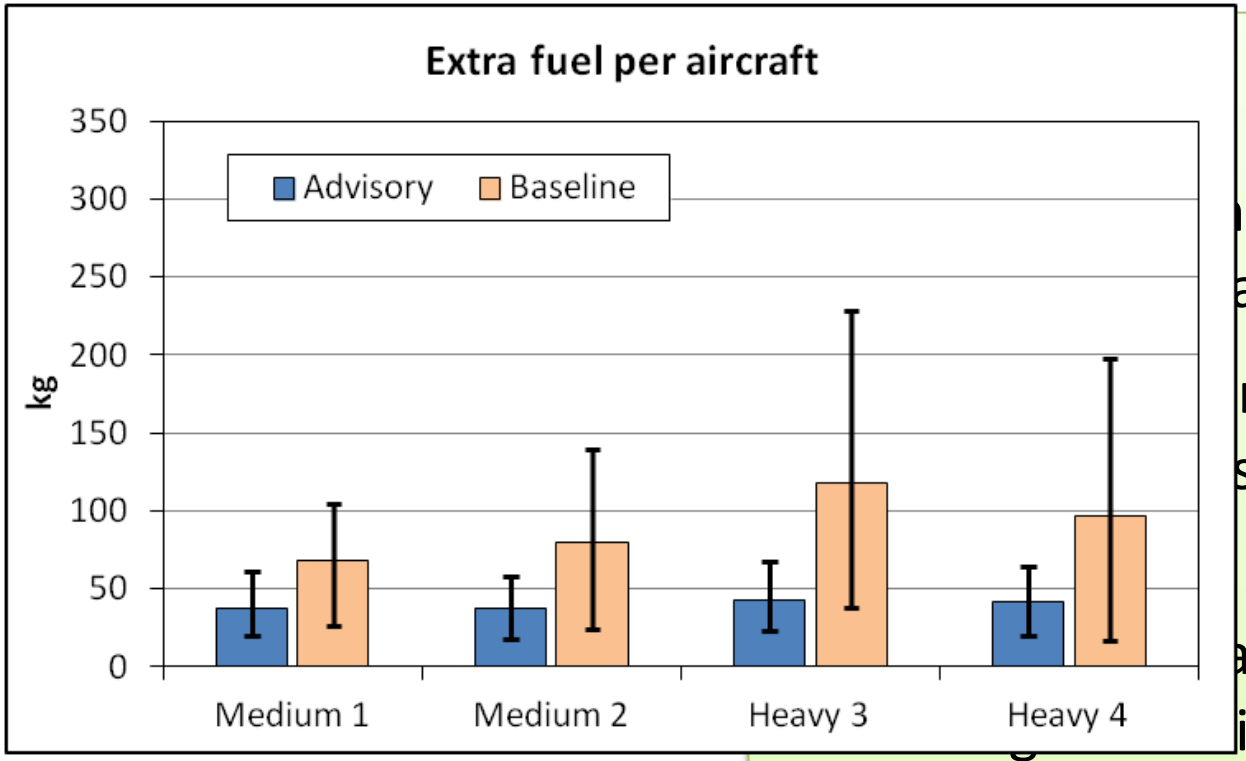
Large variation in delay in baseline

Fuel Consumption



22% reduction in medium
34% reduction in heavy

Fuel Consumption



ngs =
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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?