Spot and Runway Departure Advisor (SARDA) Technical Overview

Yoon Jung
NASA Ames Research Center

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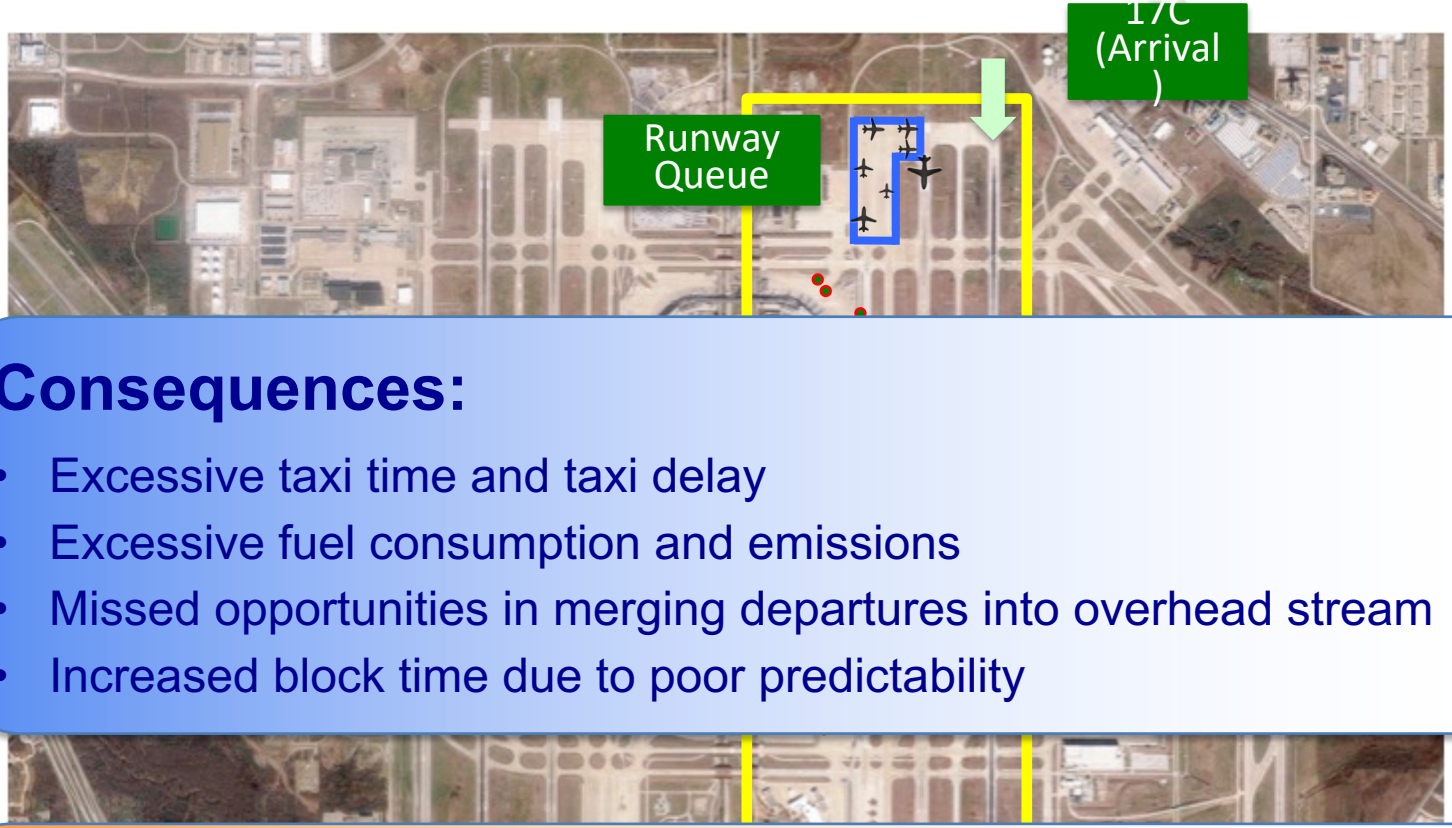
Contents

- Research Background
- Technical Approach
- Concept
- Research Results
- Current Research
- Summary and Next Step

Topography of Airport and Surface Management



Consequences:

- Excessive taxi time and taxi delay
- Excessive fuel consumption and emissions
- Missed opportunities in merging departures into overhead stream
- Increased block time due to poor predictability

Today's Airport Surface Operations:

- Demand-Capacity imbalance
- Huge uncertainties in surface events
- Lack of common situational awareness and coordination

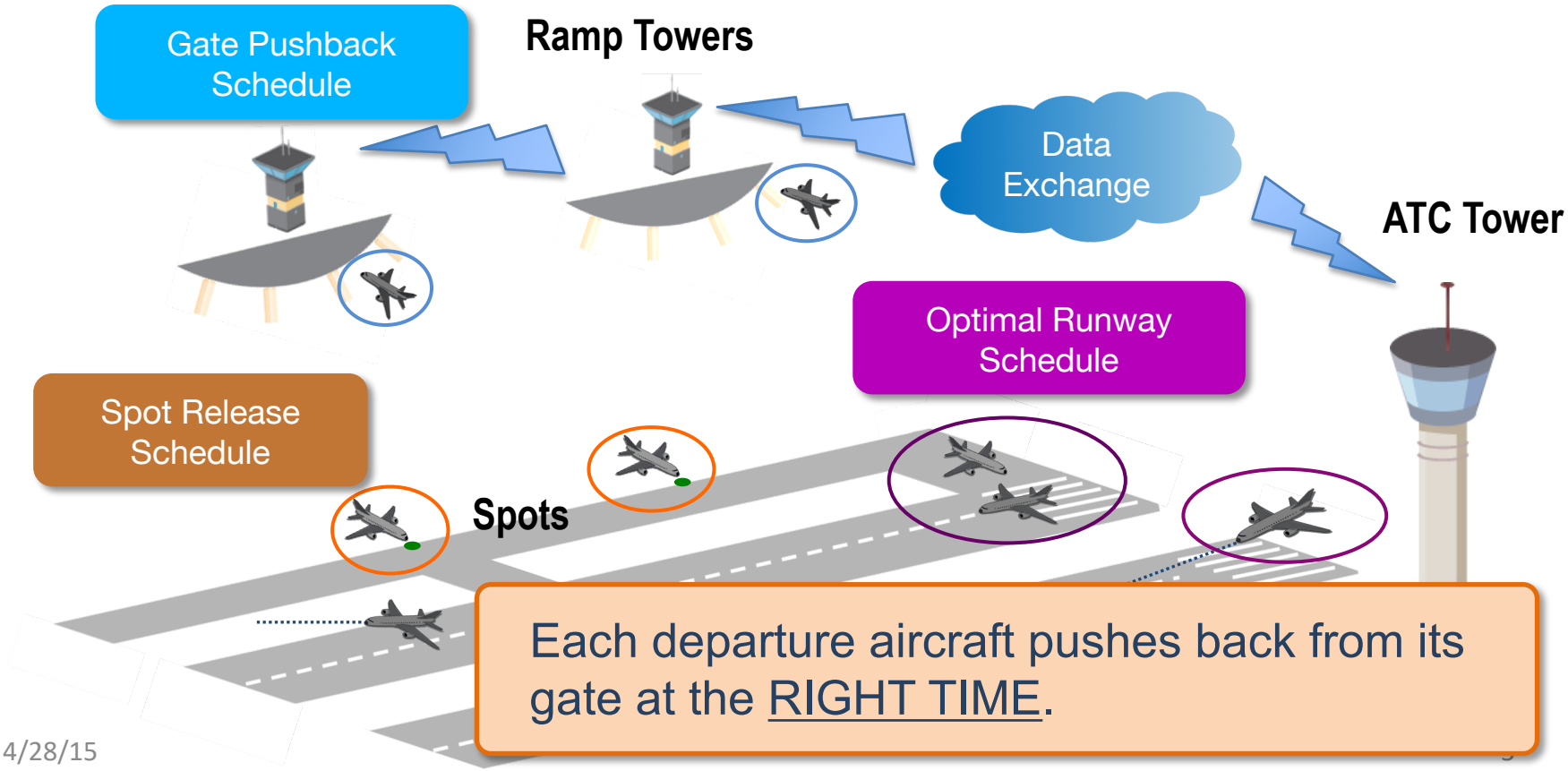
Intelligent Scheduling is the Key to Efficient Surface Management

SARDA is NASA's approach for solving this problem.

- Optimizes at a system level by minimizing overall delay
- Plans for aircraft movement at various flow control points (gates, spots, and runways)
- Accounts for departures and arrivals
- Incorporates constraints at individual aircraft level
- Provides connectivity with airport tower, airlines, and en route facility
- Adaptable to other airports with different configurations and operating procedures

SARDA Concept

- **Builds an optimal runway schedule**
- **Generates spot release sequence and timing**
- **Determines when to push back from gates**

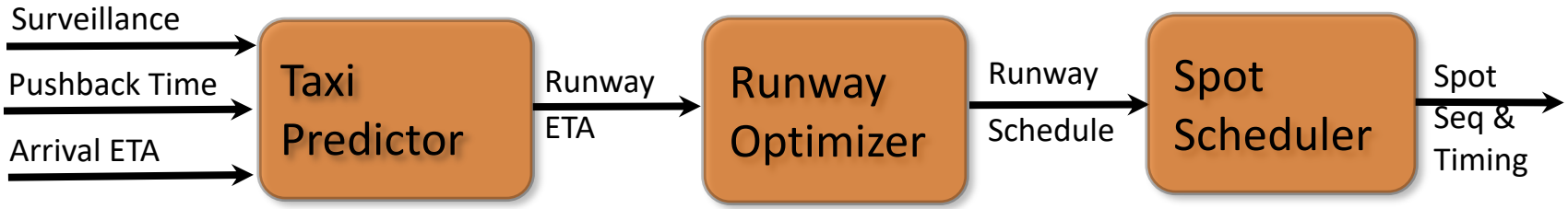


Anticipated Benefits

- **Increased Efficiency**
  - Reduced taxi time and taxi delay
  - Reduced runway queue length
  - Reduced fuel burn
- **Improved Predictability**
  - Reduced variation in efficiency metrics
  - Accurate OFF time prediction
- **Maintain Throughput**
  - Number of runway operations

SARDA as ATC Tower Tool

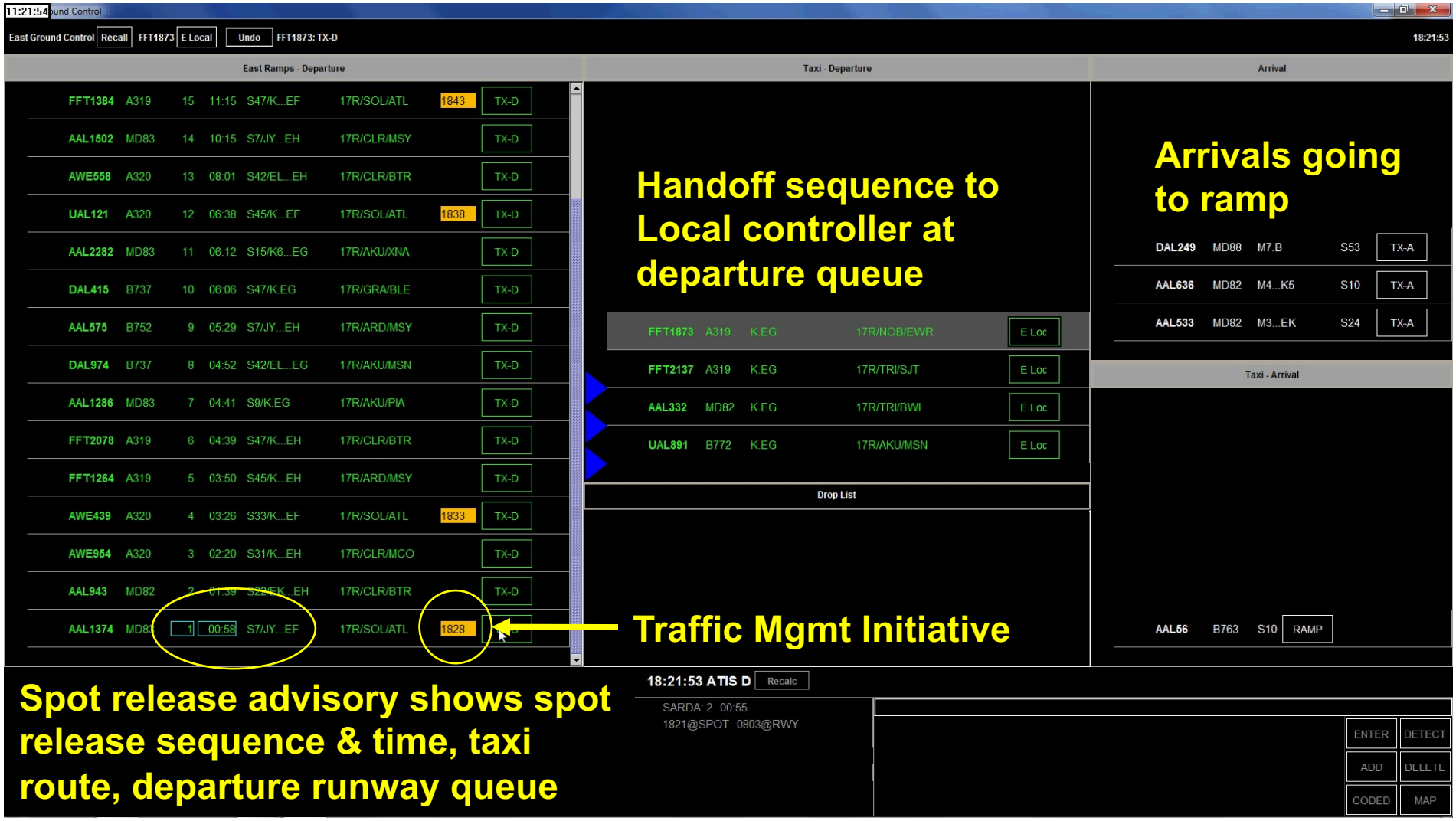
SARDA takes inputs from multiple sources and computes advisories for runway usage and spot release



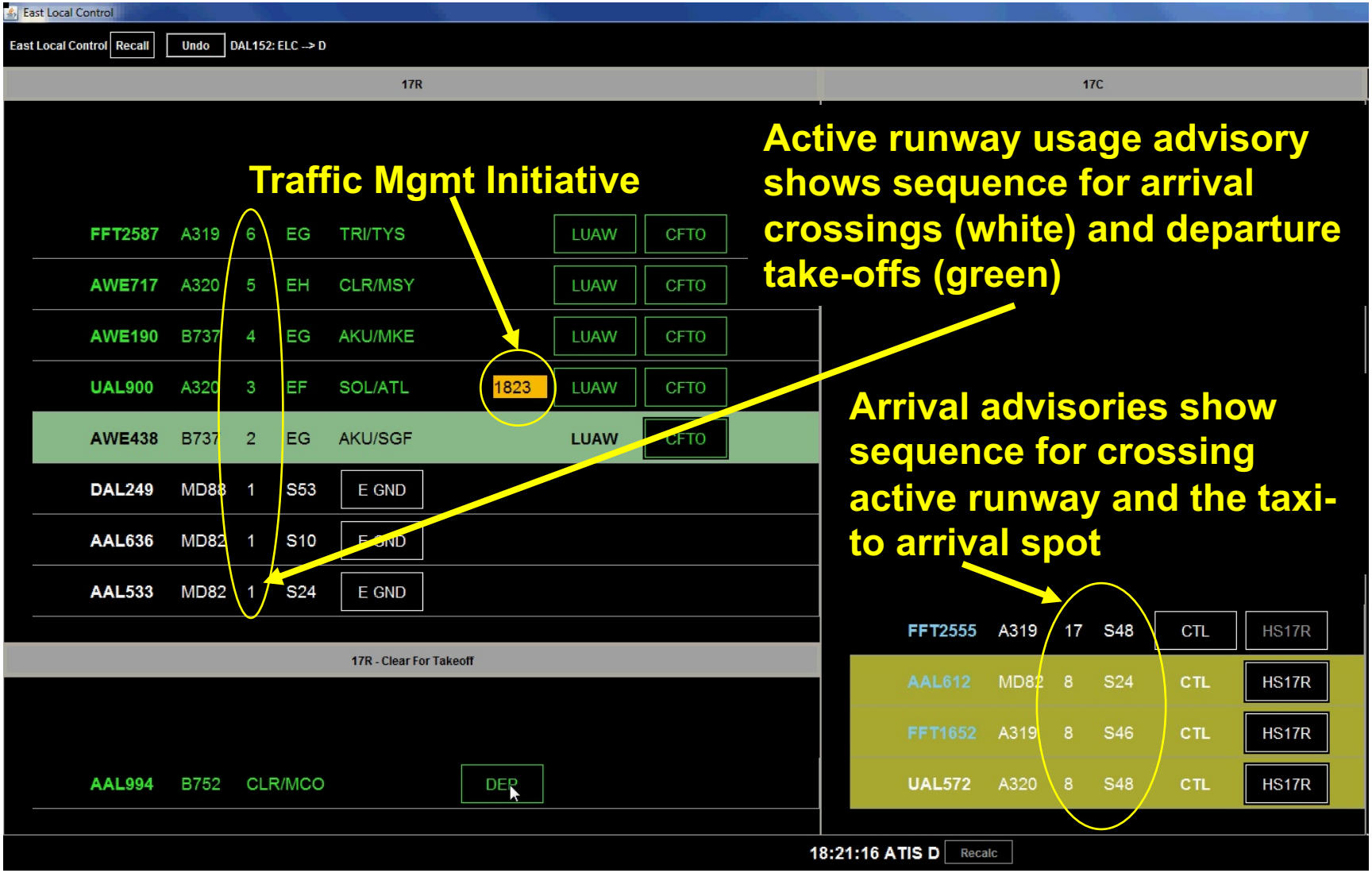
Local - Runway Sequence

Ground - Spot Release

SARDA Ground Controller Advisories



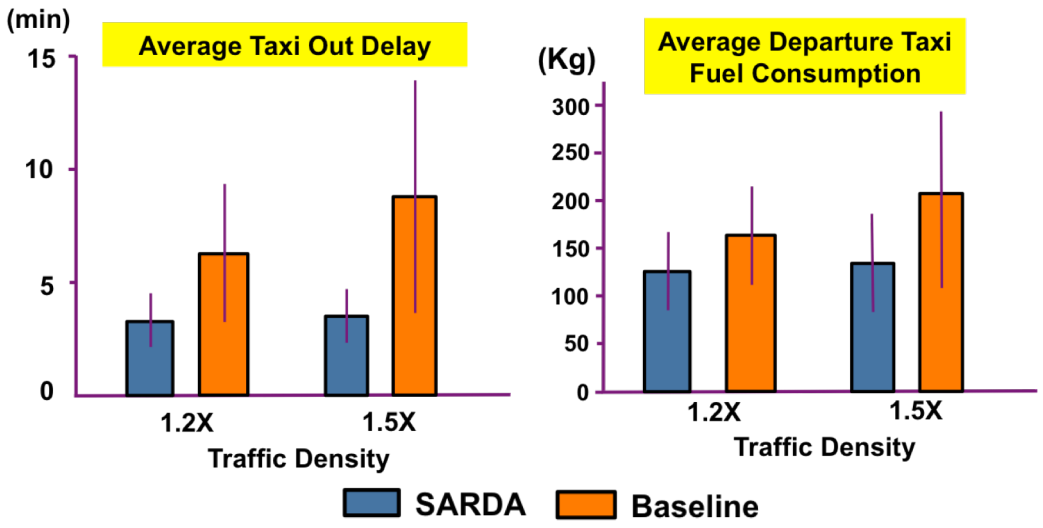
SARDA Local Controller Advisories



SARDA Benefits – DFW ATC Tower Tool

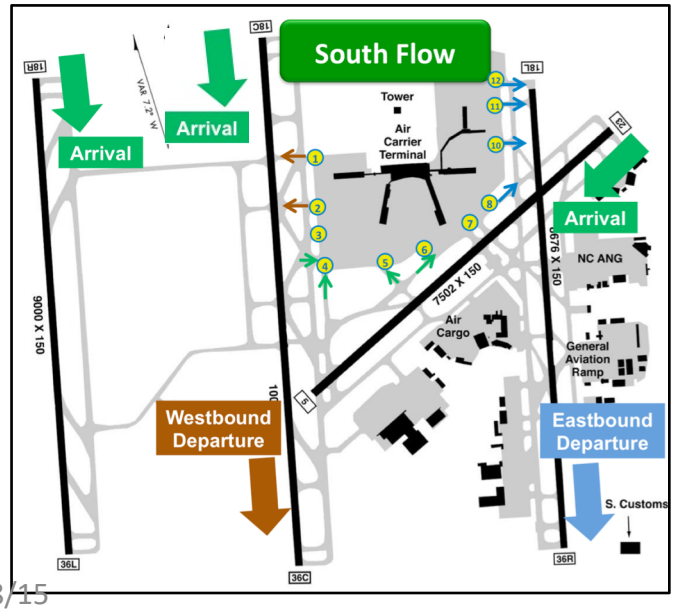
- Reductions in departure taxiing delay (45% - 60%) and variability
- Reductions in fuel consumption (23 - 33%) and variability
- Consistent and accurate prediction of takeoff time
- Decreased controllers workload, less sensitive to the traffic load

Human-in-the-loop Simulation for Dallas-Ft. Worth Airport (2012)



Ramp Management Tool

- NASA-US Airways Collaboration (Space Act Agreement, 2013)
- Goal: Develop and test a prototype decision support tool for Charlotte International Airport (CLT) ramp operators
- Conduct a series of human-in-the-loop (HITL) simulations in 2014 & 2015
- Conduct field evaluations in 2016

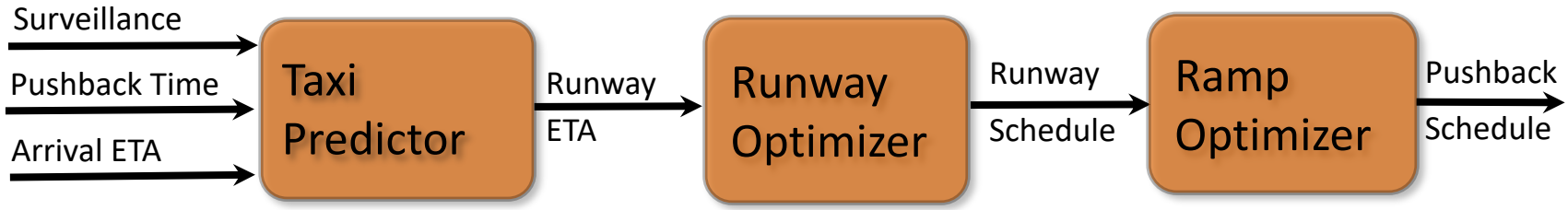


CLT Operations - Challenges

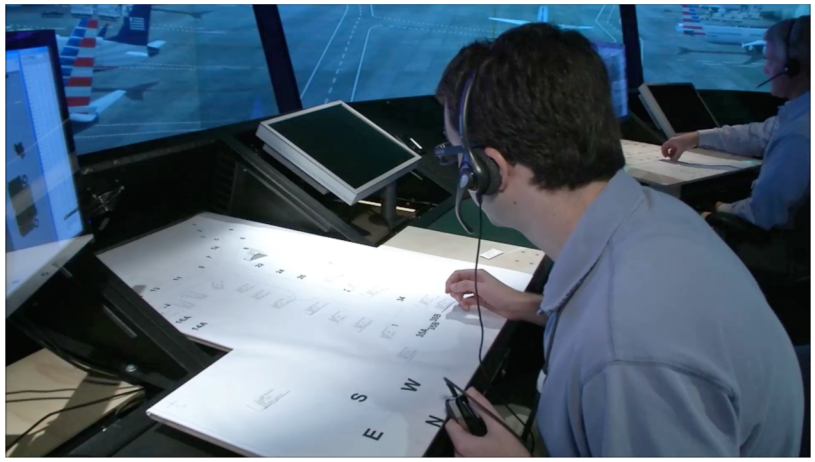
- Over 20% of time departure demand exceeds airport capacity
- Over 80% of passengers are connecting flight passengers
- Multiple banks of arrivals and departures with overlaps
- Over 35% of departures are destined to airports in north east
- Complexity in ramp area geometry (gates, taxiways)

SARDA as Ramp Tool

SARDA takes input from multiple sources and computes advisories for gate pushback



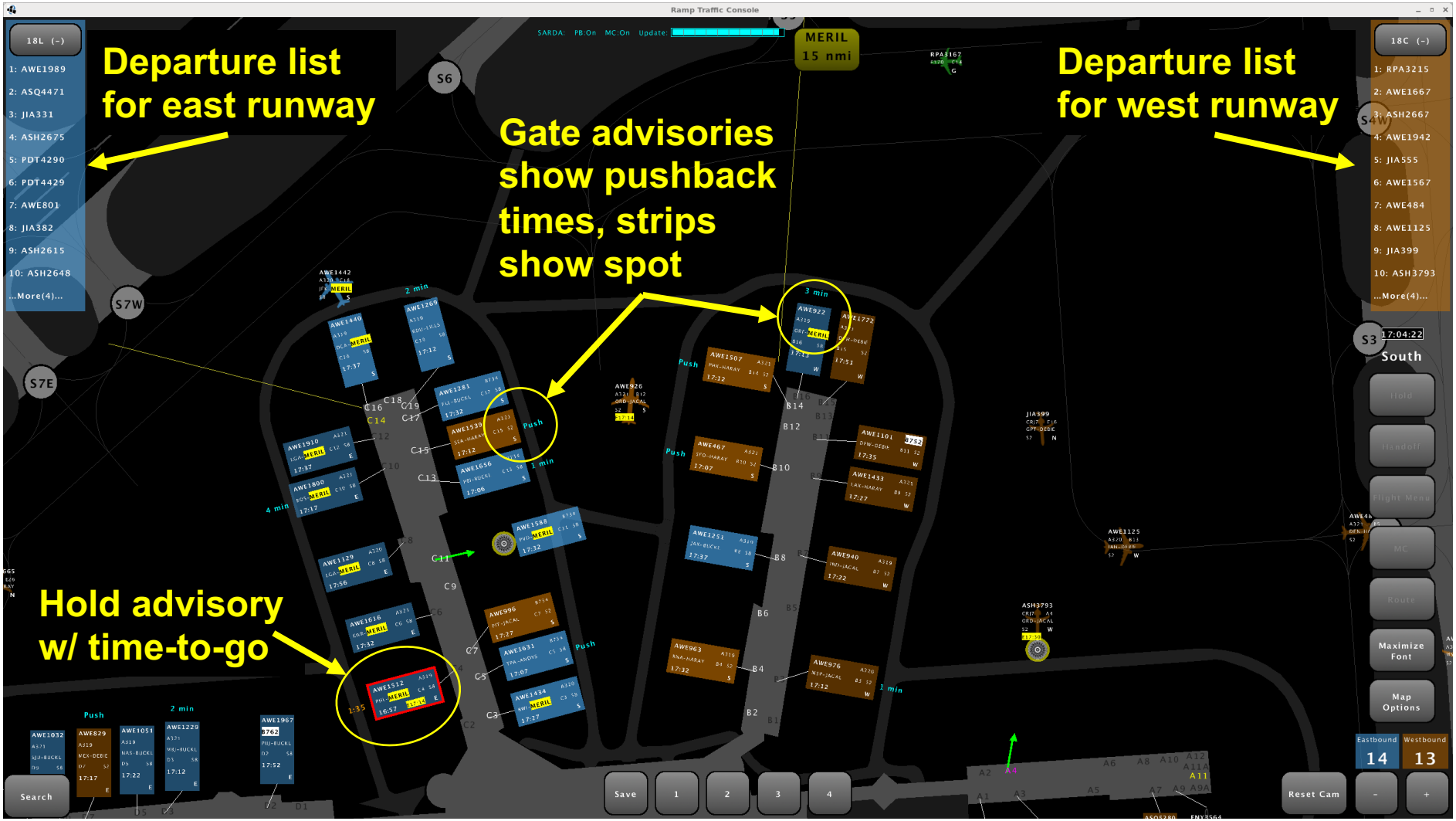
Today's Operation:
- **Paper ramp area map**
- **Paper flight strips**



SARDA Ramp Tool:
- **Electronic Flight strips**
- **Surface map & surveillance**
- **Pushback advisories**

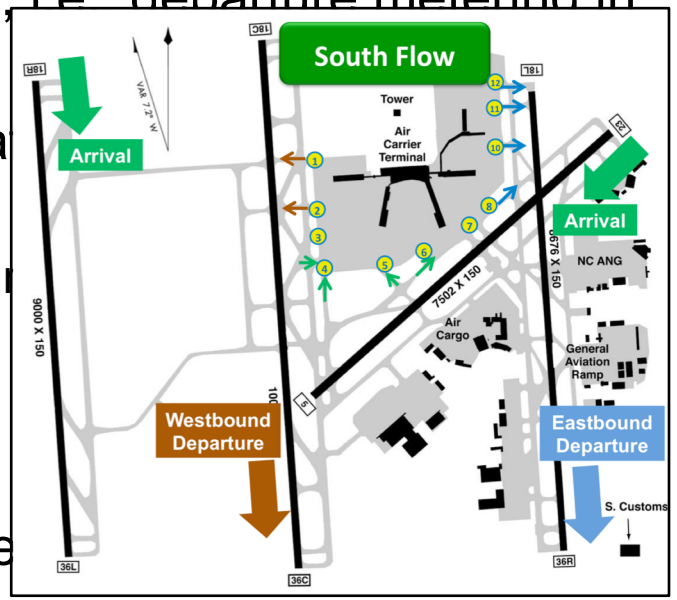
SARDA Ramp Controller Advisories

Ramp Traffic Console (RTC) displays SARDA advisories on ramp surface map



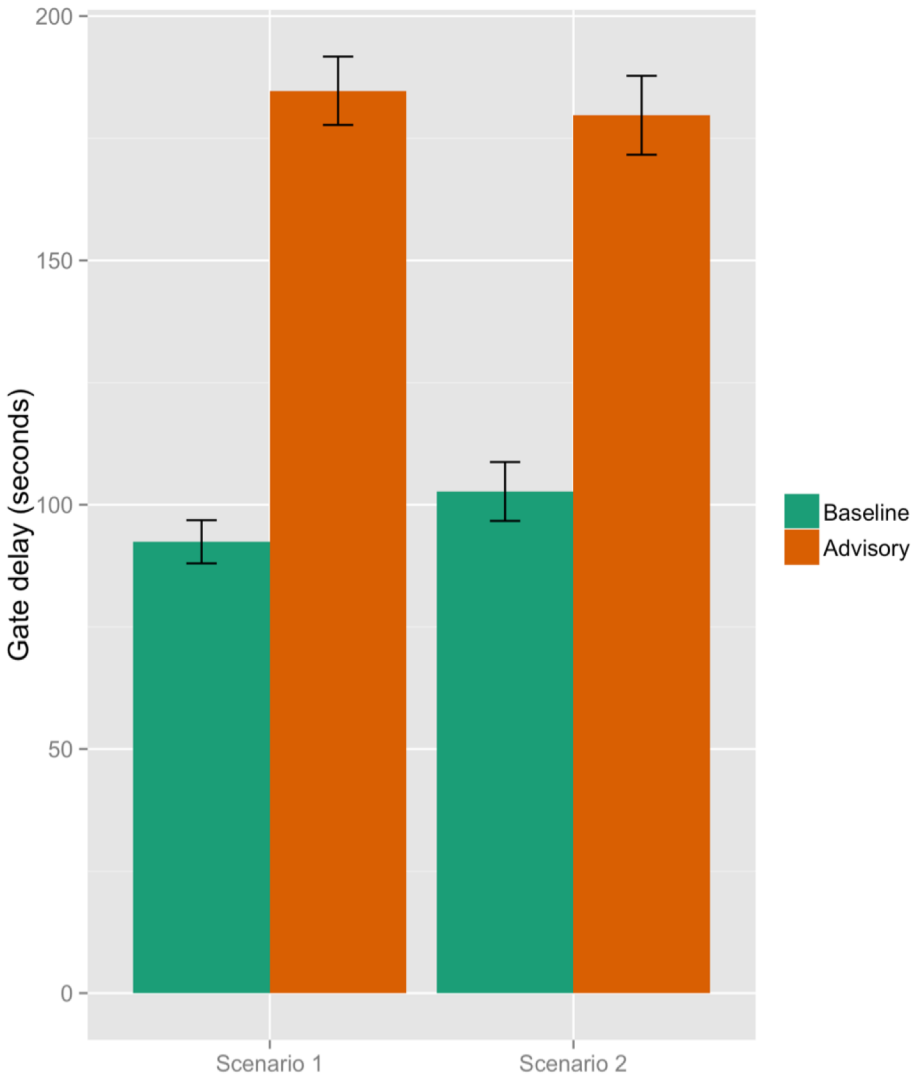
HITL Simulation Details (Oct 2014)

- Advisory runs – Ramp controllers were asked to follow pushback advisory as much as possible
- Baseline runs – Current day operations, i.e., departure metering in place (queue size < 15)
- 2 scenarios created based on actual tra
  compressed in time
  - Departure push with the first part of the
  - Each scenario is about 1 hour long
- Clear weather - VFR
- TMIs (MIT @ MERIL 20 nm, EDCT) in e
- Four-sector configuration for ramp area
- South-flow configuration (Departing: 18L, 18C; arriving: 23, 18R) with the Arrival-Departure Window (ADW) rule enforced



Gate Hold

gate_delay = actual_out_time – pushback_ready_time

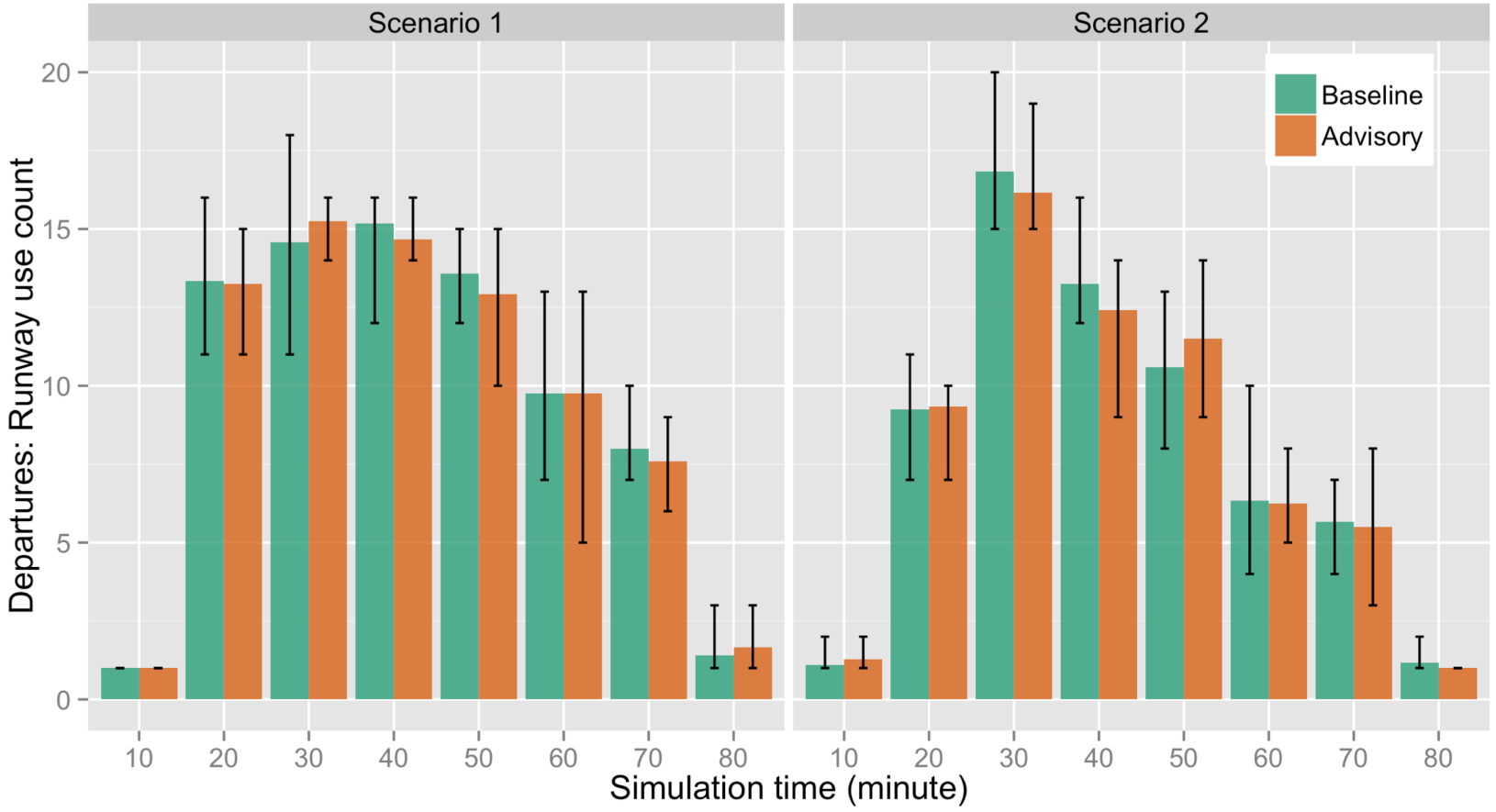


Departures are held at gates longer in Advisory runs

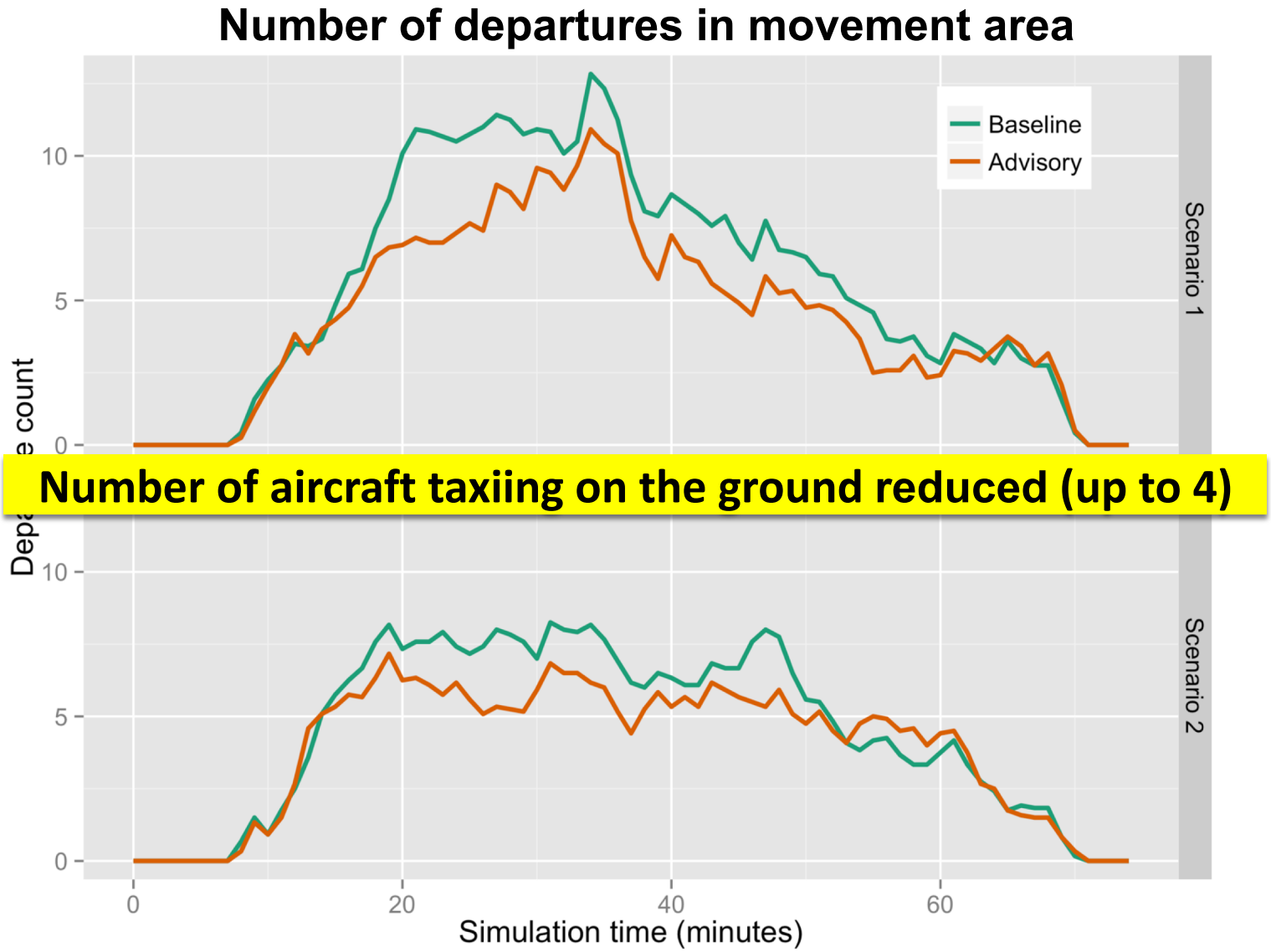
1.53 min increase in Scenario 1 (99.7%)
1.29 min increase in Scenario 2 (75.4%)

Runway Usage

No observable reduction in runway usage with advisory



Surface Congestion



Number of aircraft taxiing on the ground reduced (up to 4)

Taxi Times

taxi-out_time = actual_off_time - actual_out_time

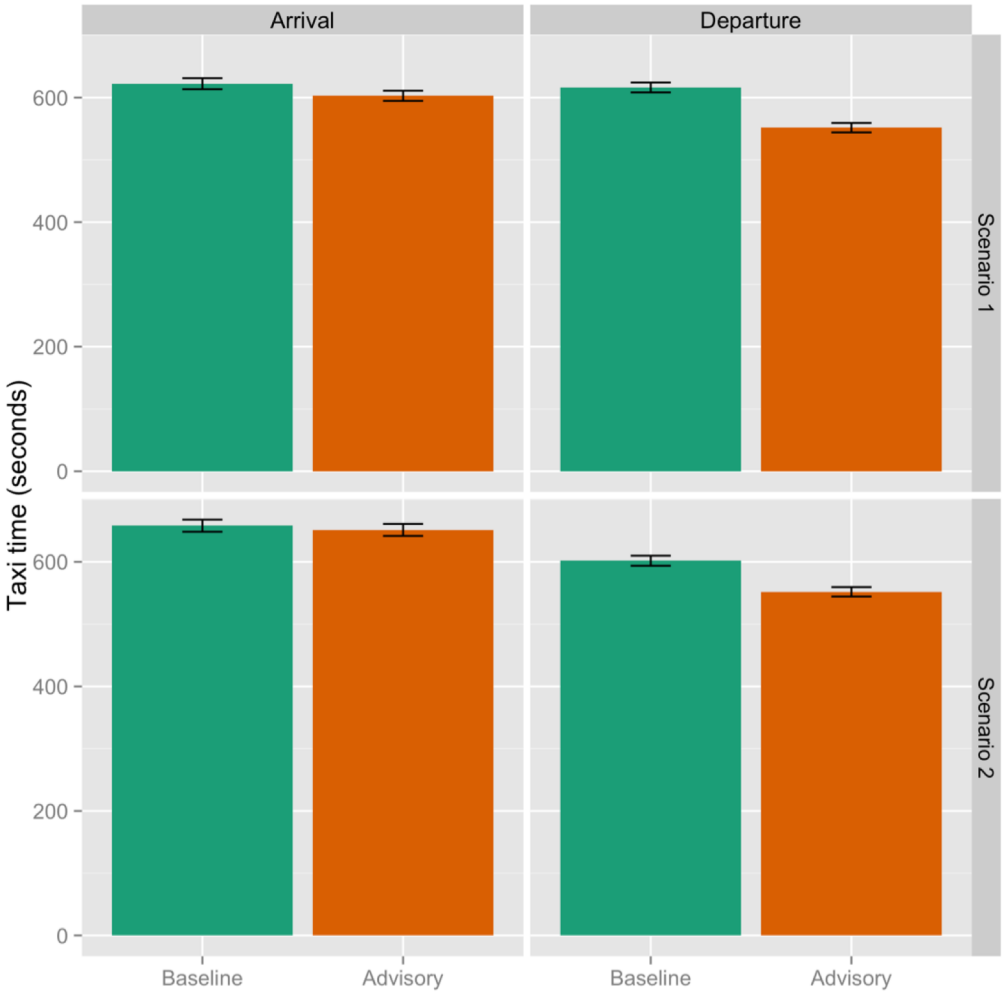
taxi-in_time = actual_in_time - actual_on_time

Arrivals

0.3 min reduction in Scenario 1 (3.1%)
0.1 min reduction in Scenario 2 (1.0%)

Departures

1.1 min reduction in Scenario 1 (10.5%)
0.8 min reduction in Scenario 2 (8.3%)



Fuel & Emissions Calculation

Assumptions:

- Engines are off if aircraft is held at the gate
- Engine thrust level: 7% during the entire taxi phase
- Both engines are running while taxiing

AC Type	Assumed AC Model	Assumed Engine Type	EI HC (g/kg)	EI CO (g/kg)	EI NOx (g/kg)	Fuel Flow (kg/sec)
Heavy	B772	Trent 892	1.59	29.62	8.88	0.57
B757	B752	RB211-535E4	0.56	19.40	7.33	0.34
Large	A319	CFM56-5A5	3.47	41.92	7.15	0.19

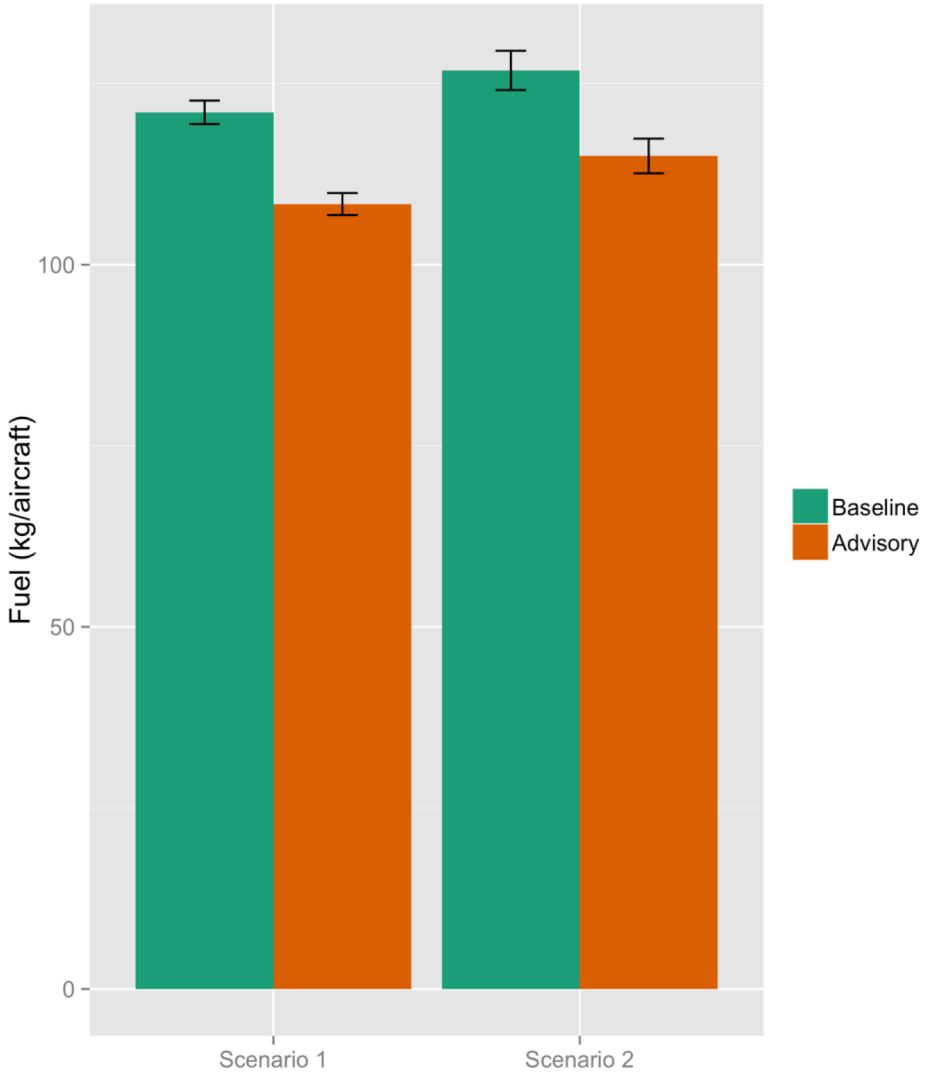
Fuel Savings

Average Fuel Savings:

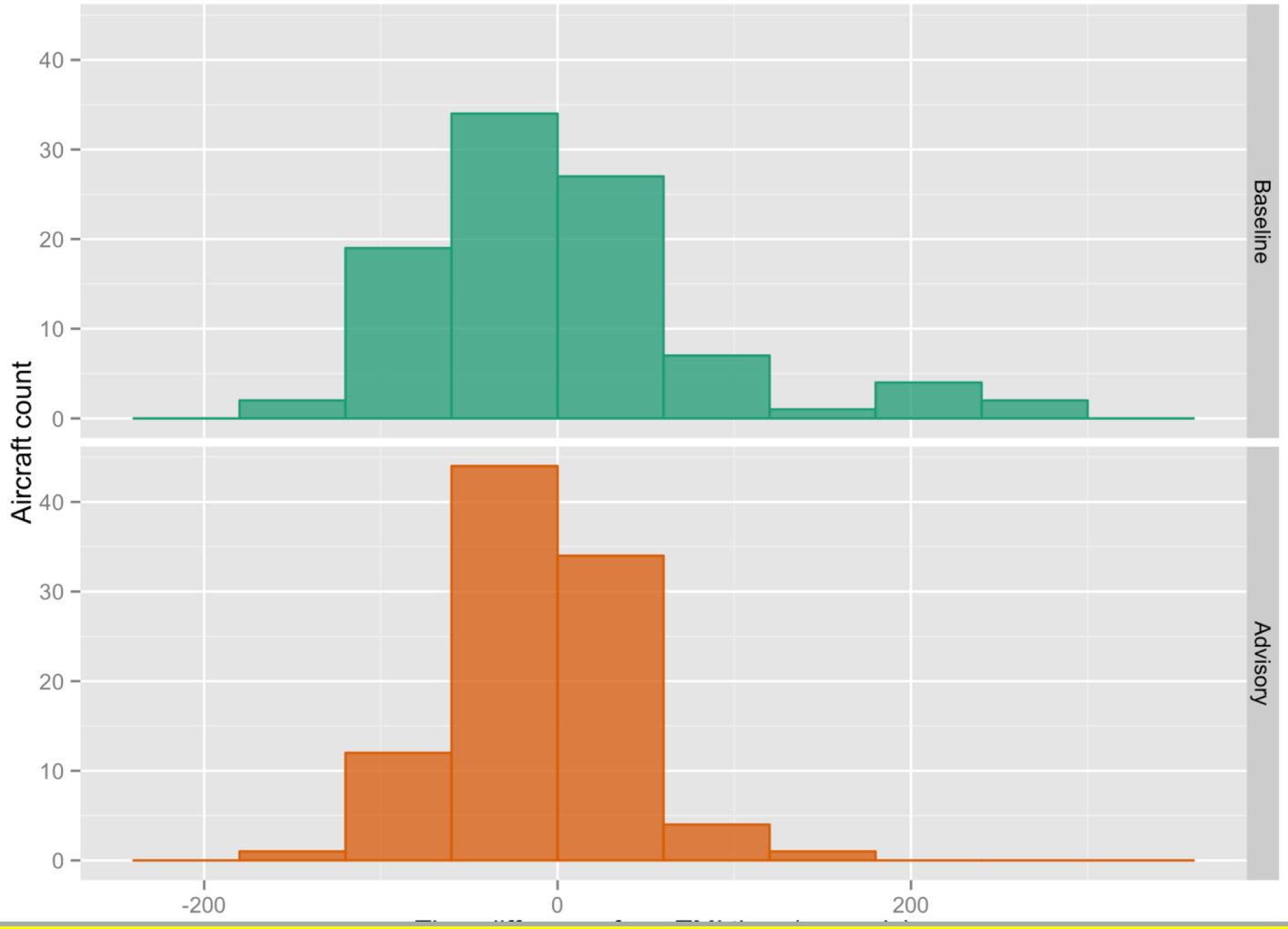
12.7 kg/flight saved in Scenario 1 (10.5%)
11.8 kg/flight saved in Scenario 2 (9.3%)

Total Fuel Savings:

1.3 tonnes saved in Scenario 1 (12%)
1.1 tonnes saved in Scenario 2 (10.4%)



TMI Conformance



Advisory runs resulted in smaller variances in the TMI deviations than Baseline runs

Summary – Ramp Tool HITL Performance

- Aircraft were held at the gate longer with advisories.
- No significant differences in runway usage.
- Number of aircraft taxiing on the ground was reduced (up to 4).
- Taxi-out times were reduced (8-10%).
- Fuel savings for departures:
  - 1.3 tonnes in Scenario 1,
  - 1.1 tonnes in Scenario 2
- Better TMI conformance with advisories.

Summary and Next Step

- SARDA provides an optimal schedule of departure aircraft for efficient surface operations.
- A prototype tower controller tool evaluated via HITL simulations showed promising results in taxi delay reduction and fuel saving for DFW.
- SARDA was applied to airline ramp operations to provide pushback advisories.
- HITL results of CLT ramp tower tool showed reduction in taxi time, queue size, and fuel savings.
- Currently, collaborating with American Airlines for field testing.

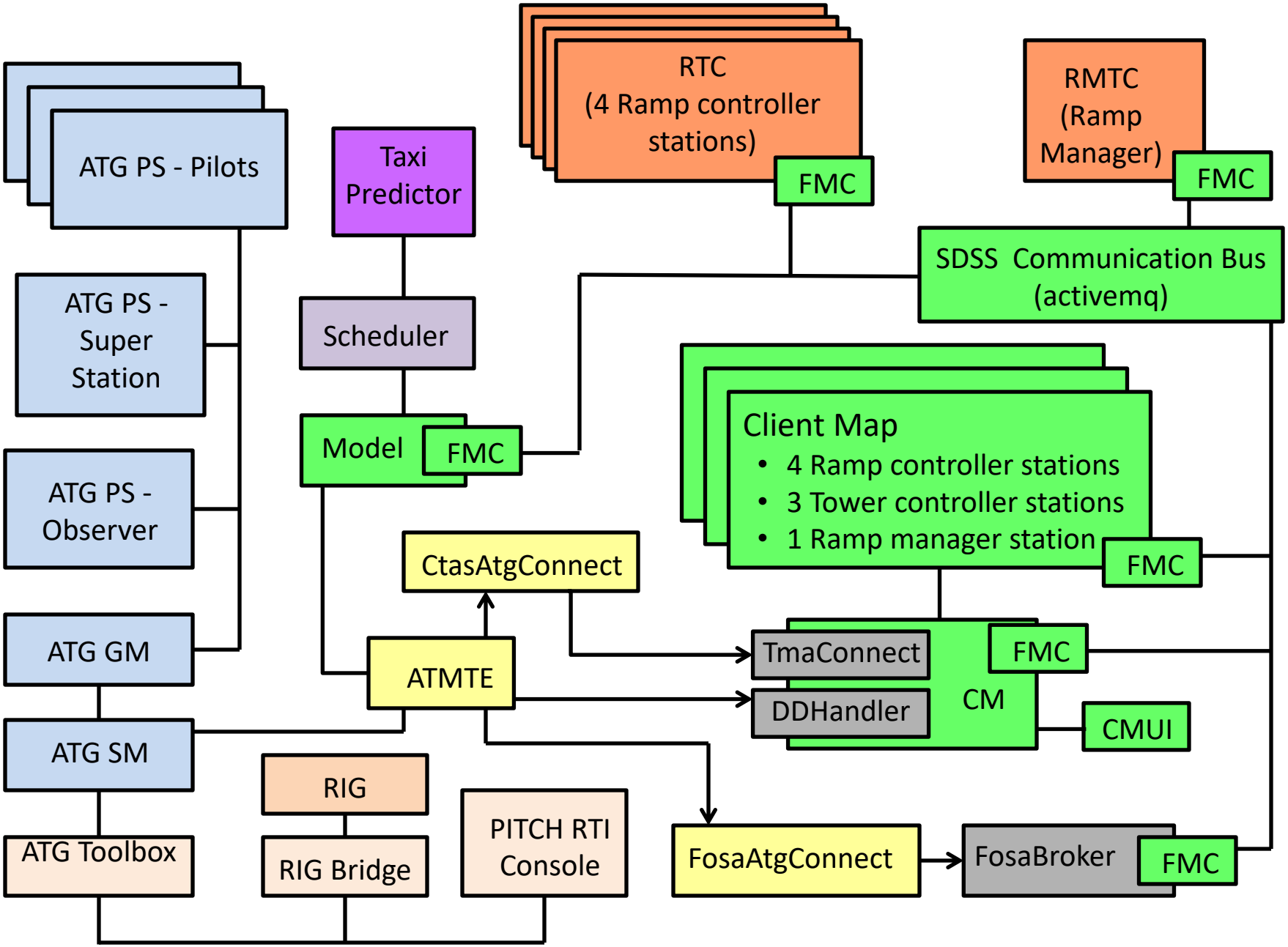
Thank you!

For more information go to:

www.aiviationsystems.arc.nasa.gov

Backup Slides

SARDA Ramp Tool System Architecture


ATG PS - Pilots
Taxi Predictor
RTC (4 Ramp controller stations)
FMC
RMTC (Ramp Manager)
FMC
SDSS Communication Bus (activemq)
ATG PS - Super Station
Scheduler
Model
FMC
Client Map
• 4 Ramp controller stations
• 3 Tower controller stations
• 1 Ramp manager station
FMC
ATG PS - Observer
CtasAtgConnect
ATG GM
ATMTE
TmaConnect
DDHandler
CM
FMC
CMUI
ATG SM
RIG
PITCH RTI Console
FosaAtgConnect
FosaBroker
FMC
ATG Toolbox
RIG Bridge
HLA Network