2013-gupta-Presentation-tn8782

The Spot and Runway Departure Advisor (SARDA) is an integrated decision support tool for aurlines and air traffic control tower enabling surface collaborative decision making (CDM) and departure metering in order to enhance efficiency of surface operations at congested airports. The presentation describes the concept and architecture of the SARDA as a CDM tool, and the results from a human-in-the-loop simulation of the tool conducted in 2012 at the FutureFlight Central, the tower simulation facility. Also, presented is the current activities and future plan for SARDA development. The presentation was given at the meeting with the FAA senior advisor of the Surface Operations Office.

SARDA: An Integrated Concept for Airport Surface Operations Management

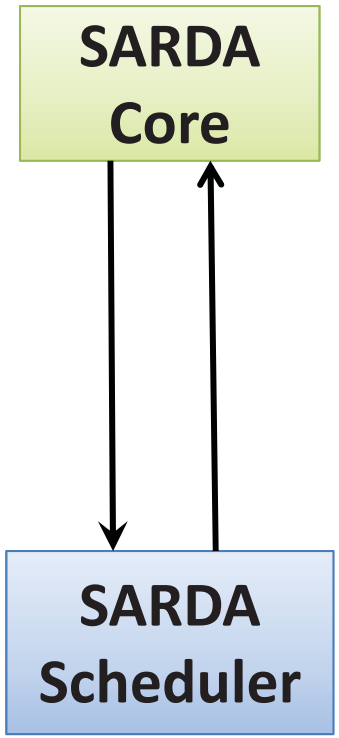
SARDA Team

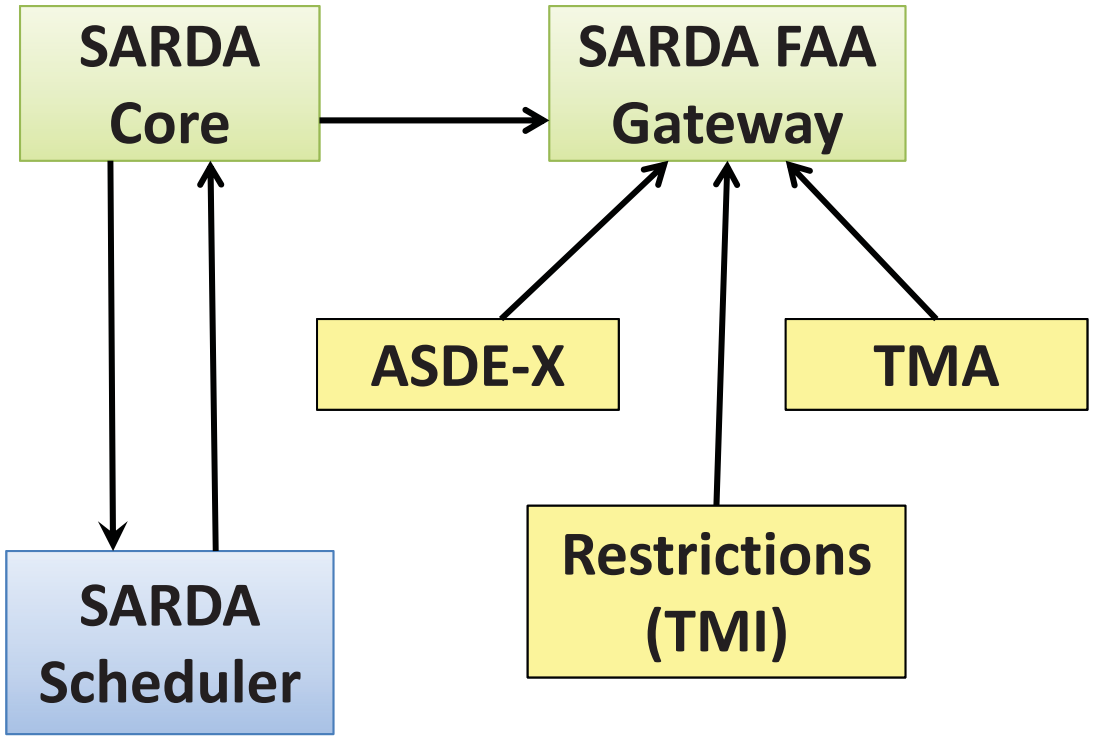
NASA Ames Research Center

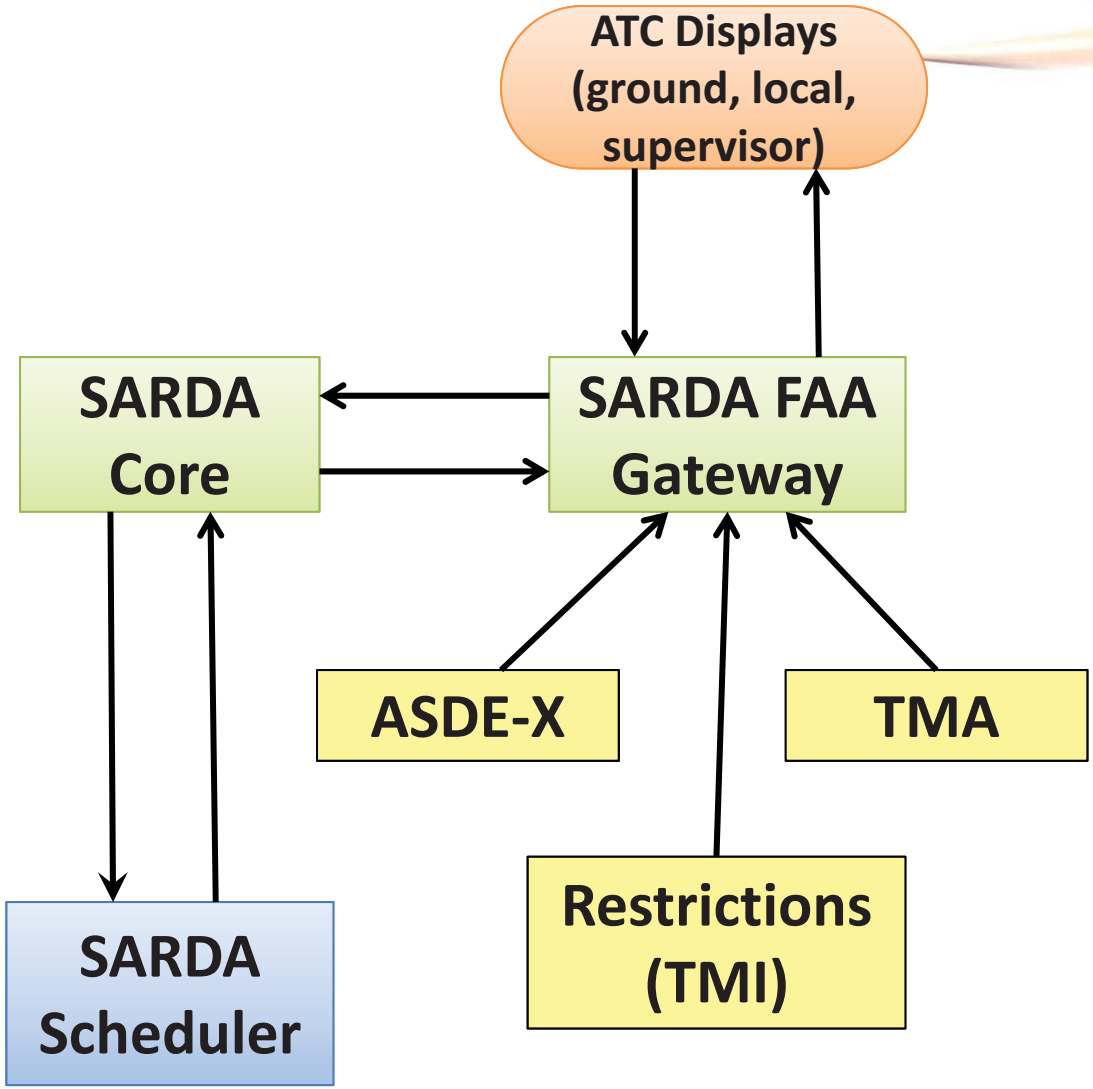
March 7, 2013

Spot And Runway Departure Advisor (SARDA)

- Integrated tool for airlines and Air Traffic Control Tower enabling CDM and departure metering


SARDA
Core
SARDA
Scheduler


SARDA Core
SARDA FAA Gateway
ASDE-X
TMA
Restrictions (TMI)
SARDA Scheduler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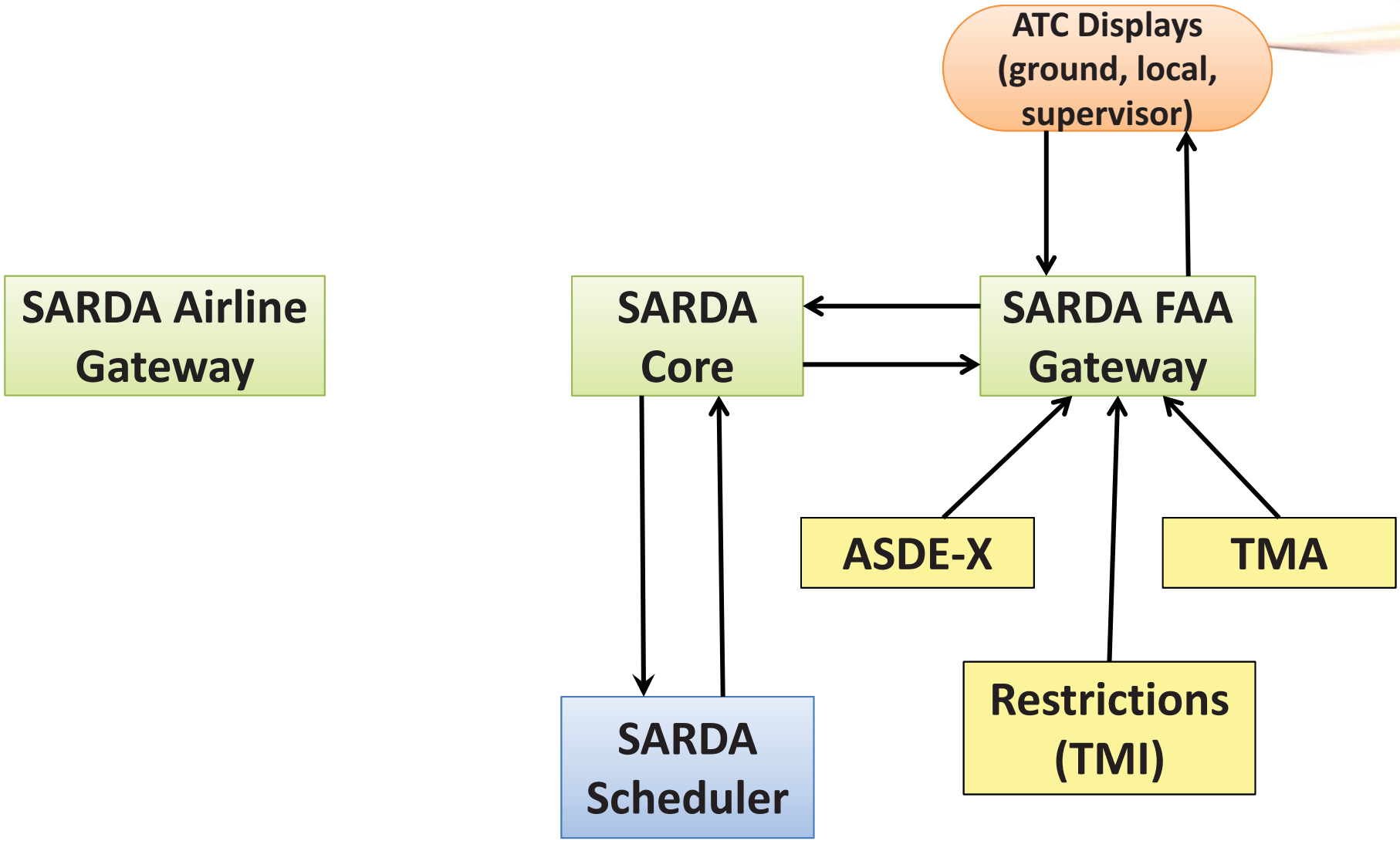
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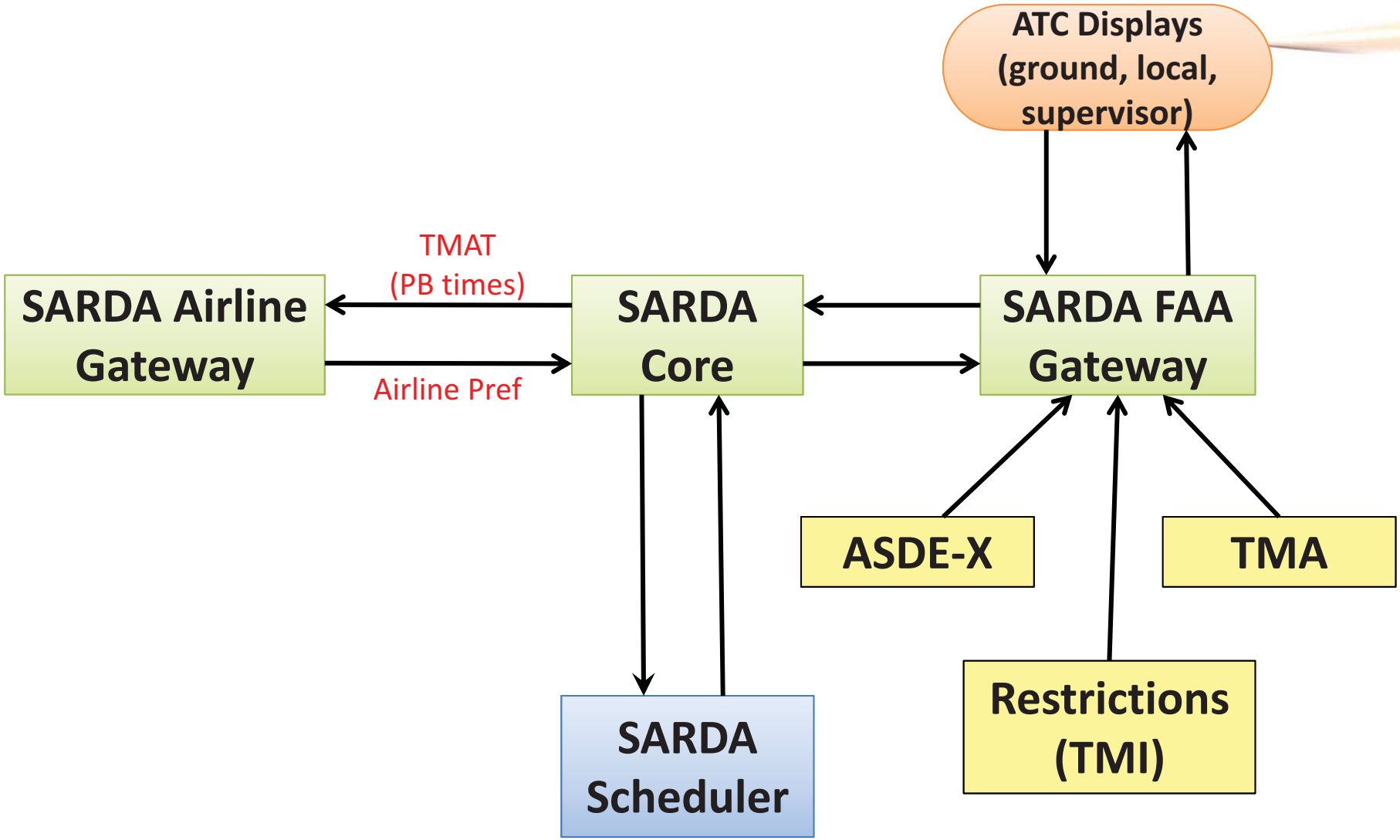
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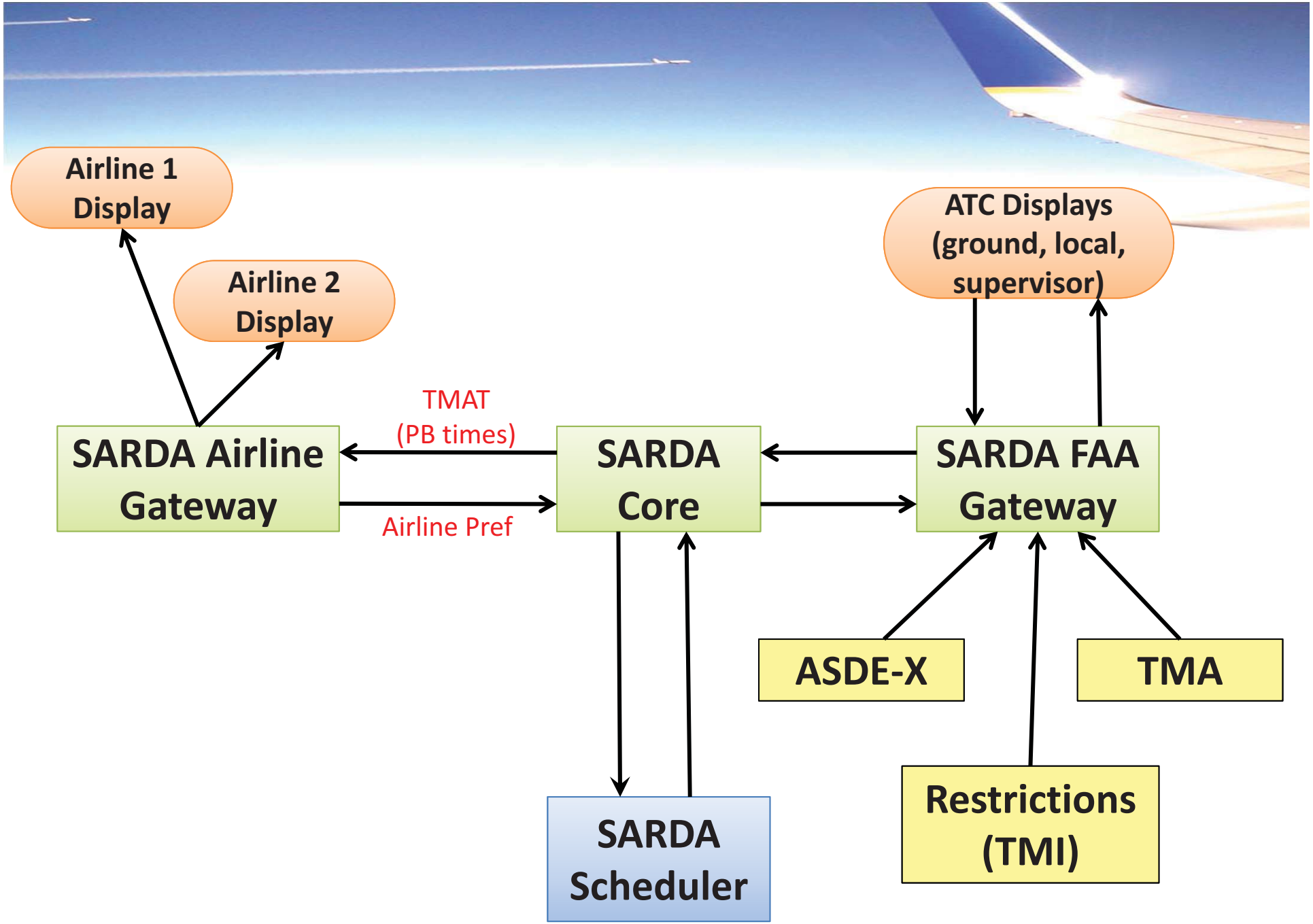
Airline 1 Display
Airline 2 Display
ATC Displays (ground, local, supervisor)
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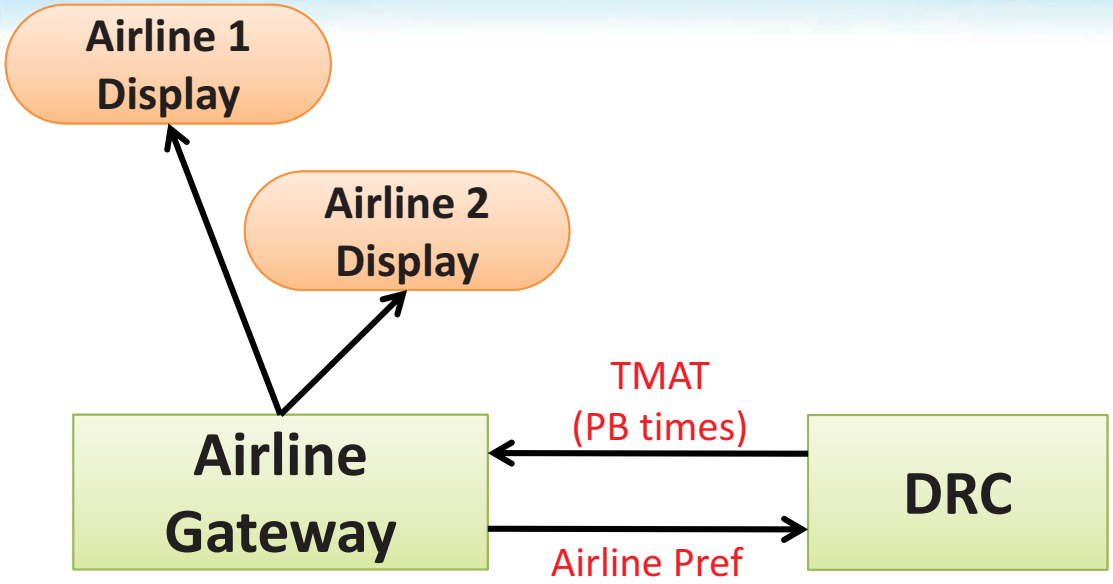


Nominal JFK System

Spot And Runway Departure Advisor (SARDA)

- Integrated tool for airlines and Air Traffic Control Tower enabling CDM and departure metering
- Based on managing scarce resource: Runway
- Strategic or tactical departure metering

Spot And Runway Departure Advisor (SARDA)

- Integrated tool for airlines and Air Traffic Control Tower enabling CDM and departure metering
- Based on managing scarce resource: Runway
- Strategic or tactical departure metering
  - Strategic: gate/ramp hold fixed 30 or 60 mins before scheduled push-back
  - Tactical: gate/ramp hold assigned after pilot communicates push-back readiness
  - Both have tactical ATCT advisories

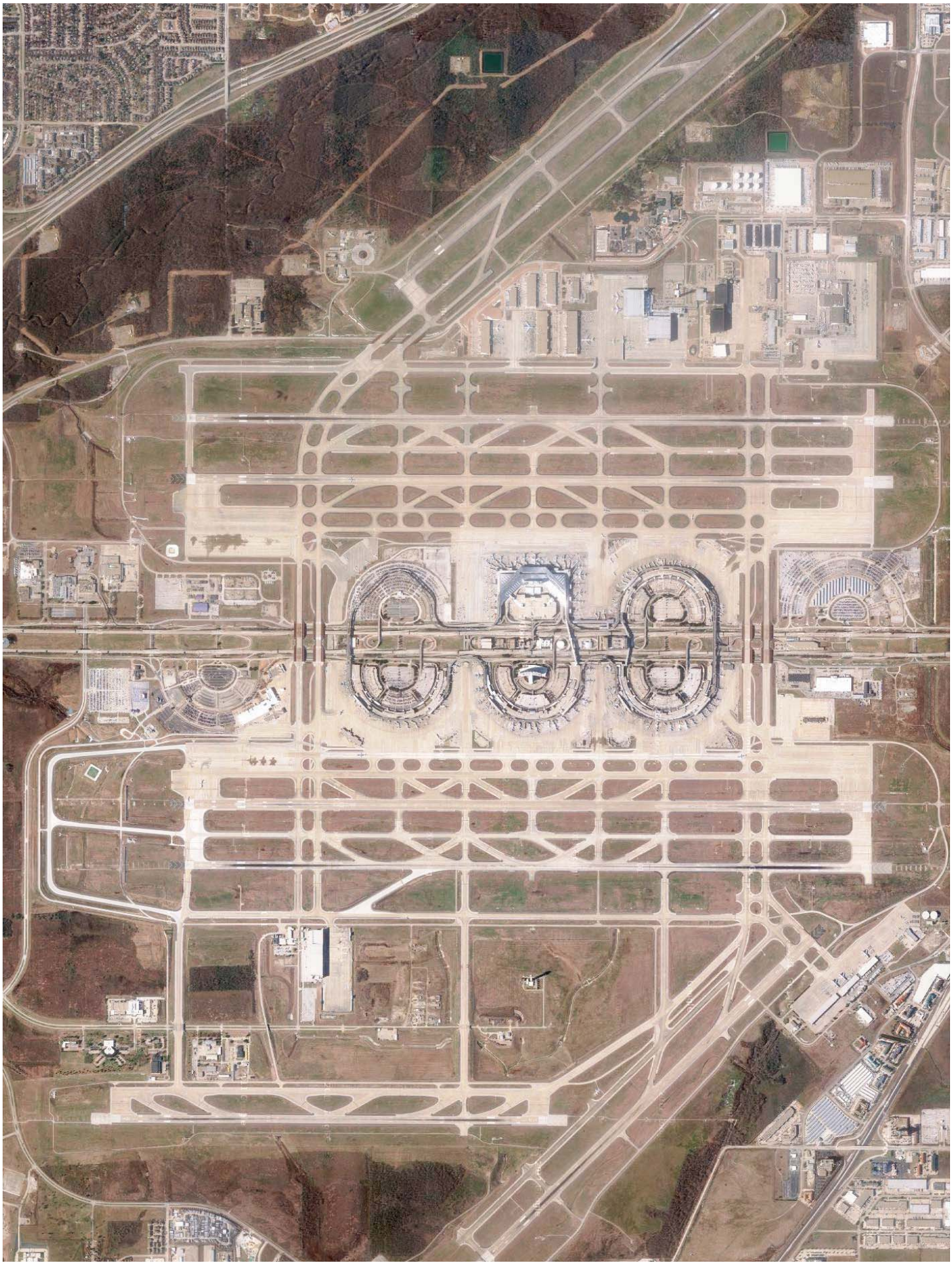
Spot And Runway Departure Advisor (SARDA)

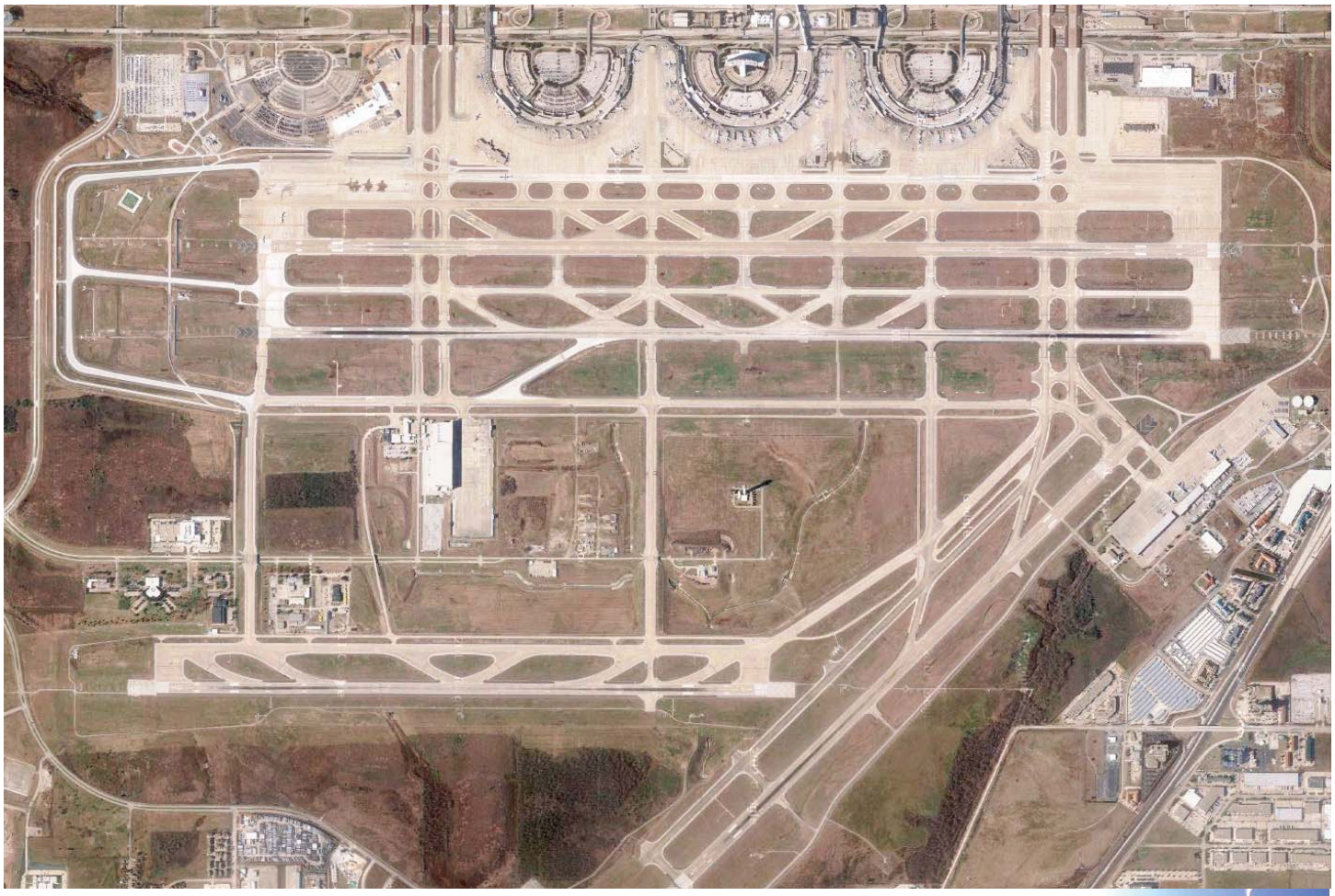
- Integrated tool for airlines and Air Traffic Control Tower enabling CDM and departure metering
- Based on managing scarce resource: Runway
- Strategic or tactical departure metering
- 4-D trajectory enabler

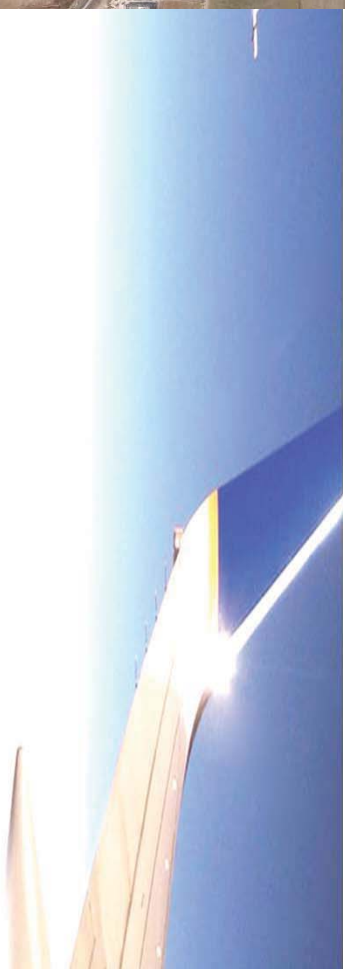
SARDA Strategic Gate Hold

Planning Definition

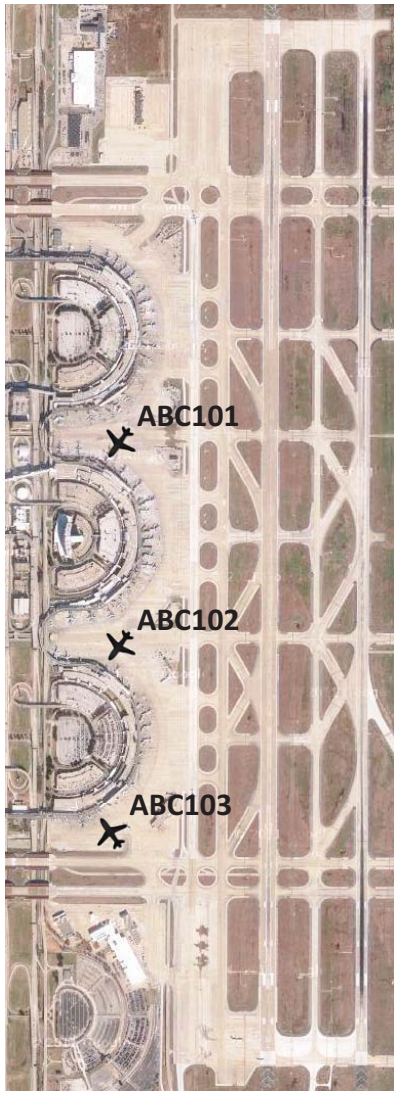
- Planning horizon (PH): how soon is planning done. E.g. 30 minutes





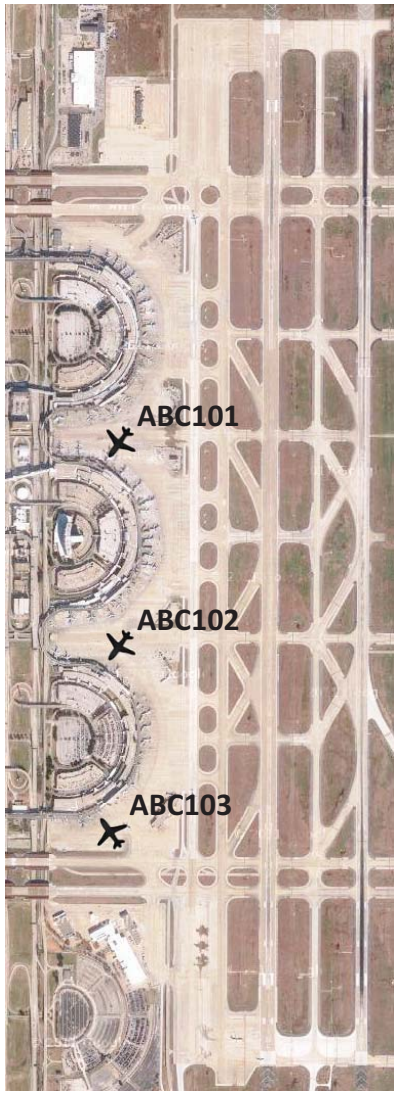


Strategic SARDA Walkthrough



Scheduled push-back
ABC101: 1502
ABC102: 1504
ABC103: 1507

Strategic SARDA Walkthrough



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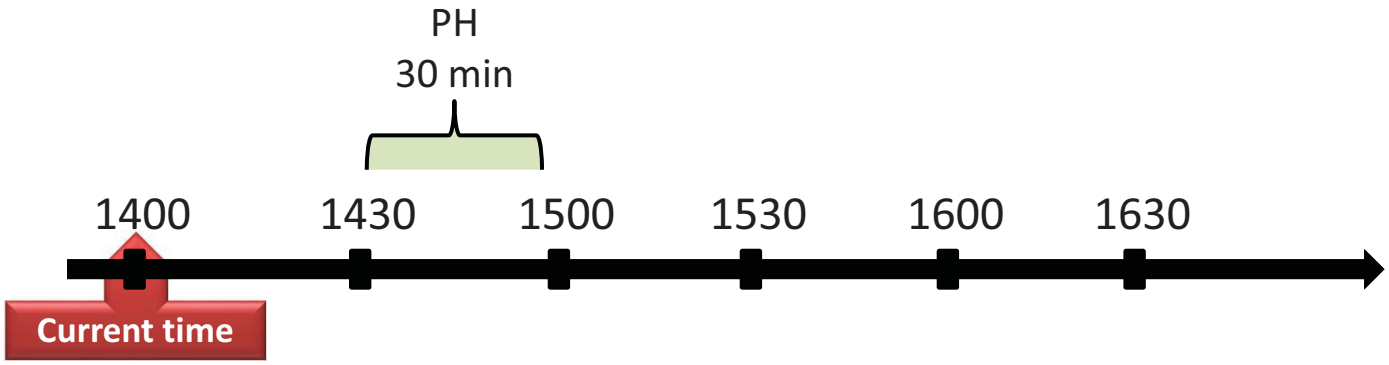

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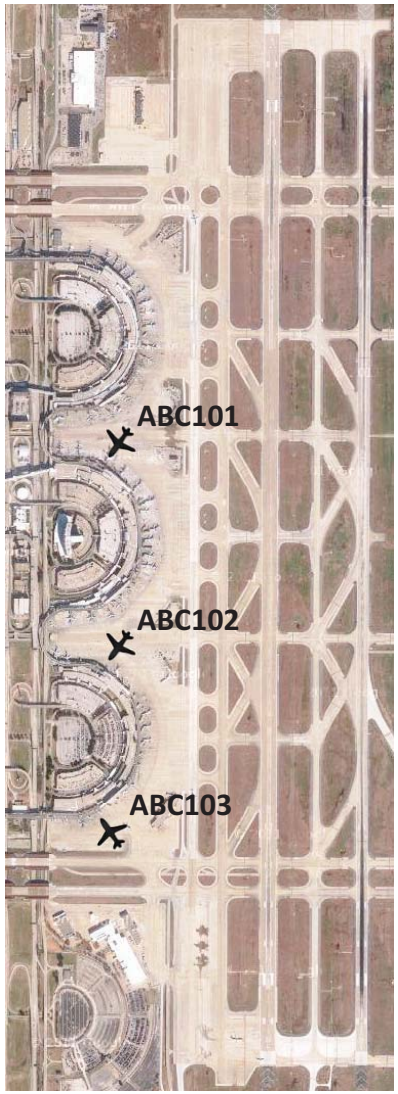


Strategic Planning Component (SPC)

Strategic SARDA Scheduler

Scheduled push-back
ABC101: 1502
ABC102: 1504
ABC103: 1507

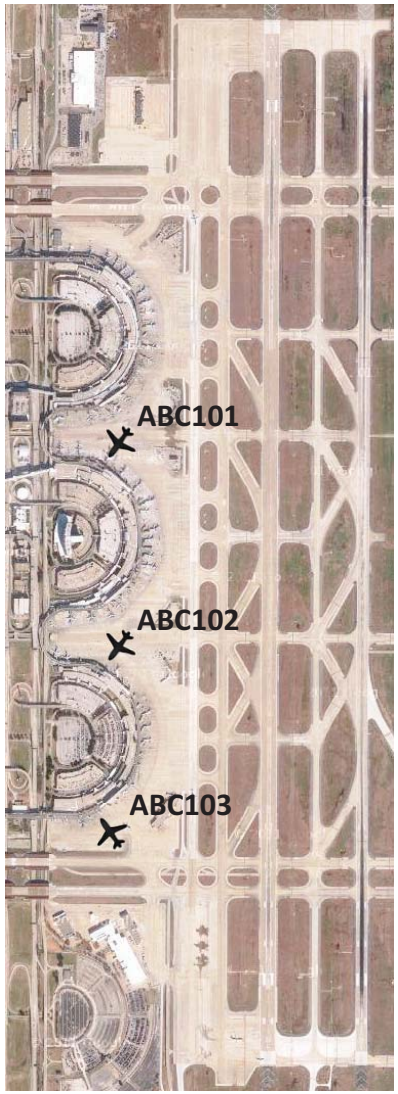
- **Flight restrictions (TMI)**
- **Flight details**
- **Airport config**

PH
30 min

1400 1430 1500 1530 1600 1630

Current time

Strategic SARDA Walkthrough



Stage 1
Updated push-back
ABC101: 1504 (1502)
ABC102: 1510 (1504)
ABC103: 1508 (1507)

Strategic Planning Component (SPC)

Strategic SARDA Scheduler

Airline

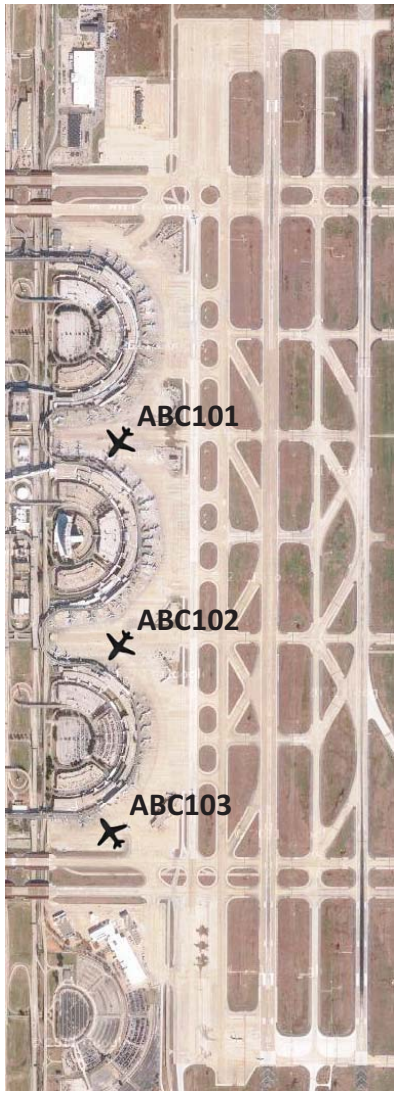
Preferences
- Later push-back
- Swaps

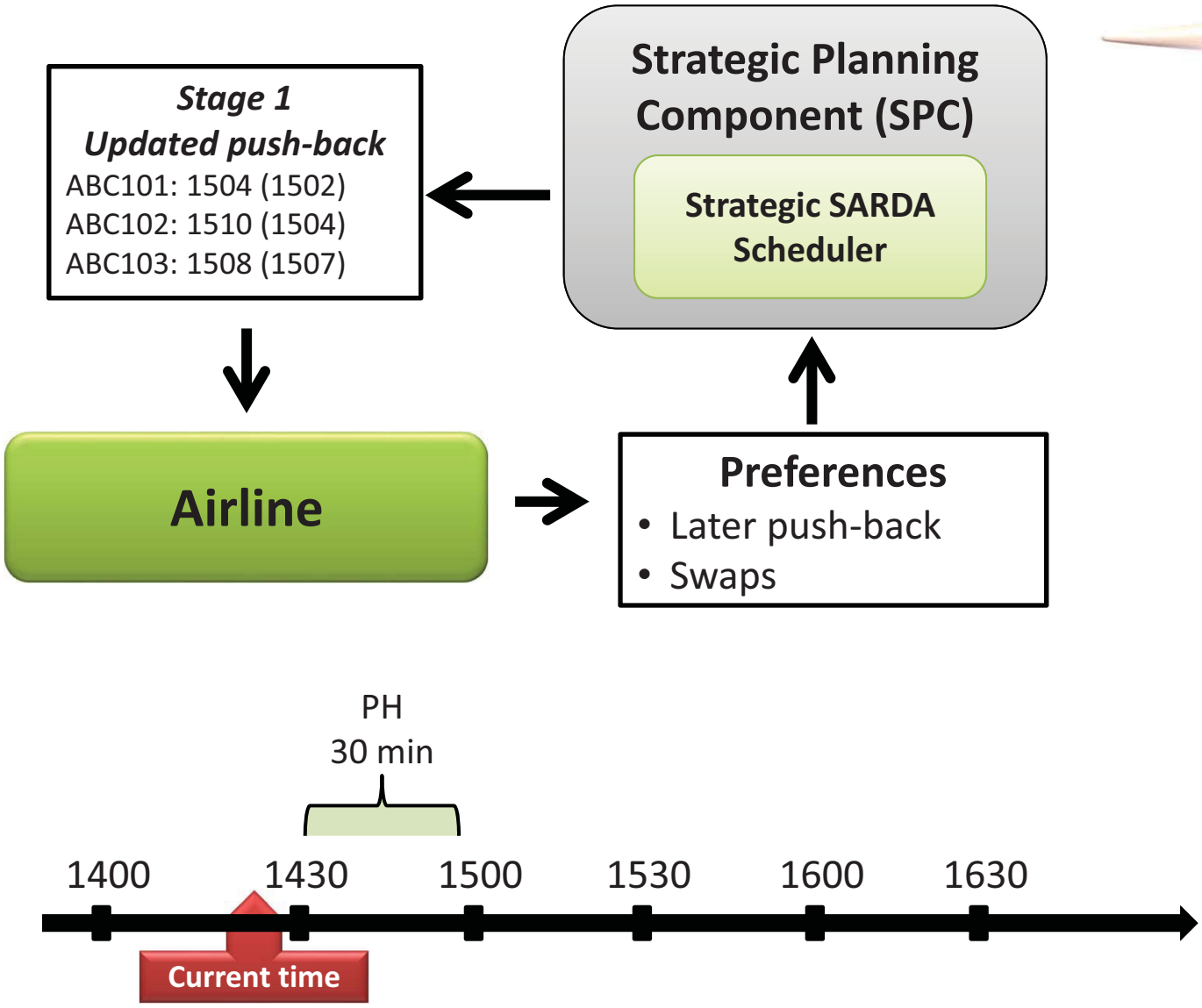
PH
30 min

1400 1430 1500 1530 1600 1630

Current time

Strategic SARDA Walkthrough





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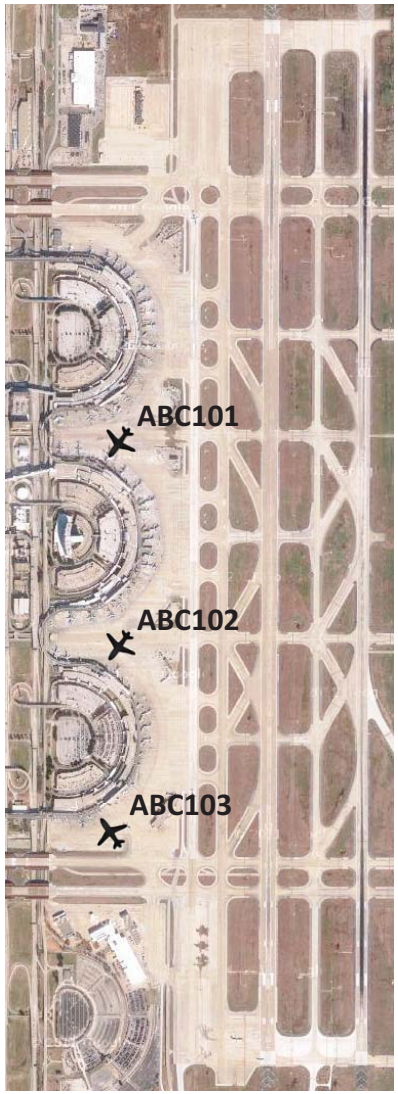
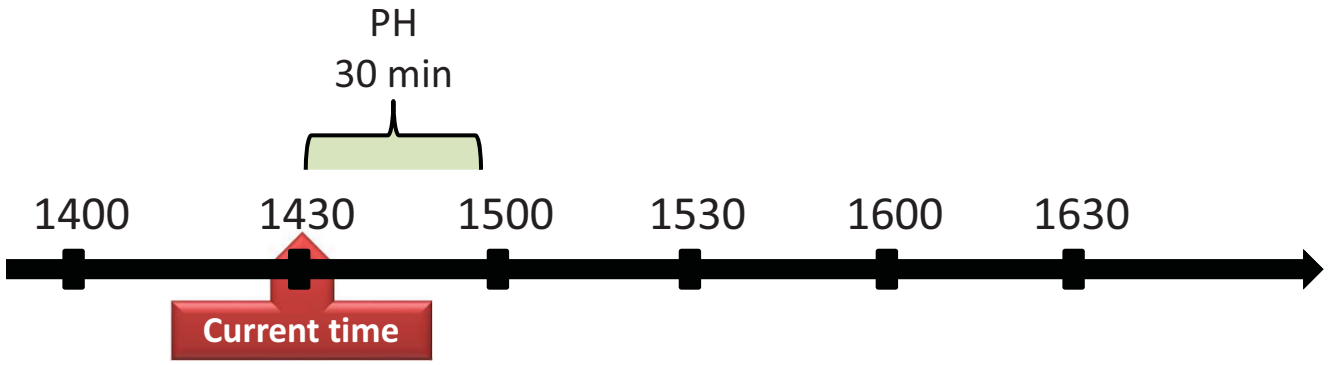


Stage 2
Updated push-back
ABC101: 1504 (no change)
ABC102: 1510 (no change)
ABC103: 1508 (no change)

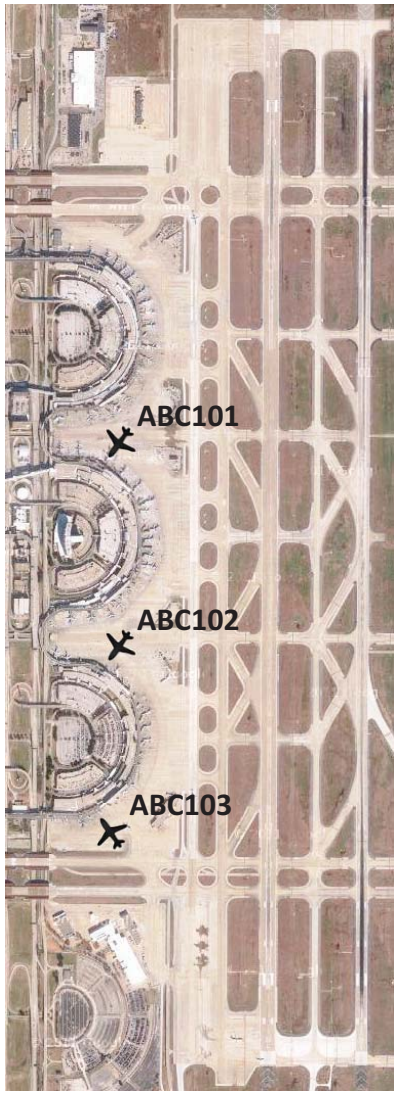
Strategic Planning Component (SPC)

Strategic SARDA Scheduler

Airline



Strategic SARDA Walkthrough



Stage 2
Updated push-back
ABC101: 1504 (no change)
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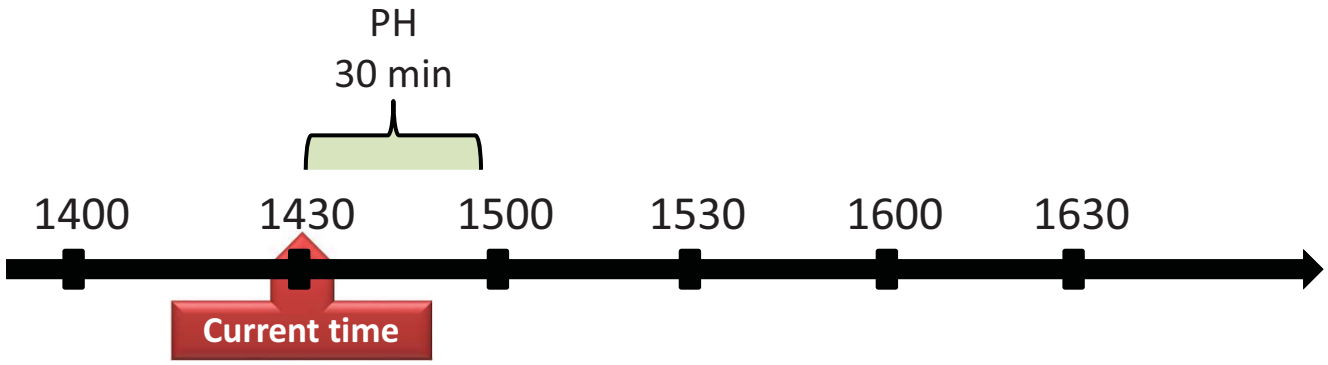
ABC103: 1508 (no change)

Strategic Planning Component (SPC)

Tactical Advisory Component (TAC)

Tactical SARDA Scheduler



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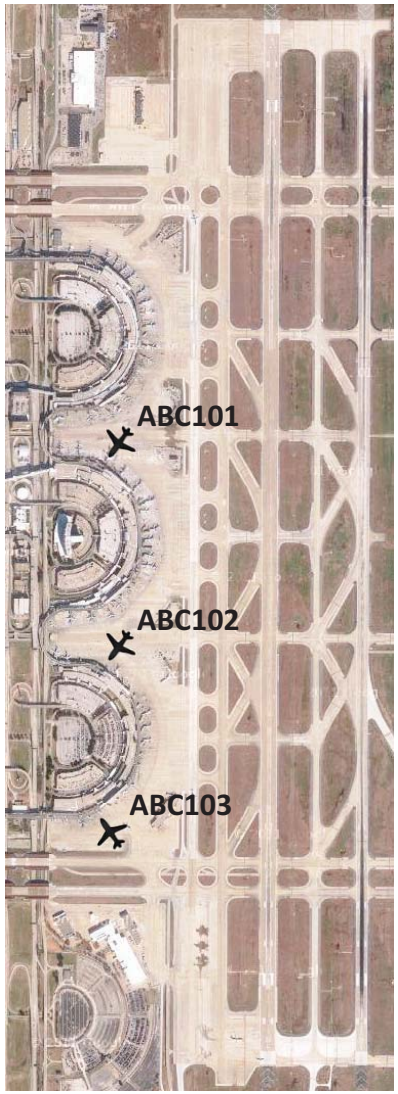

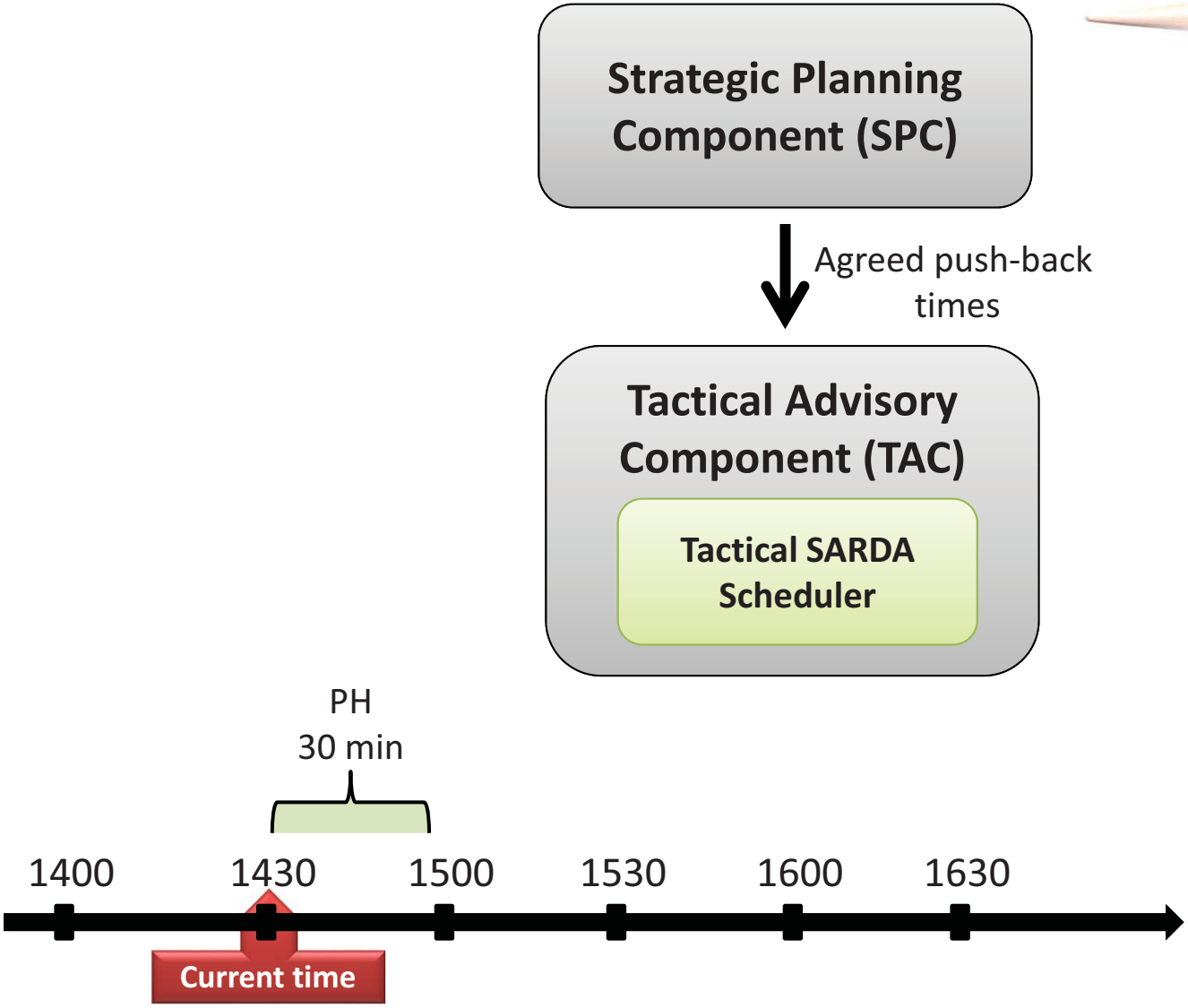

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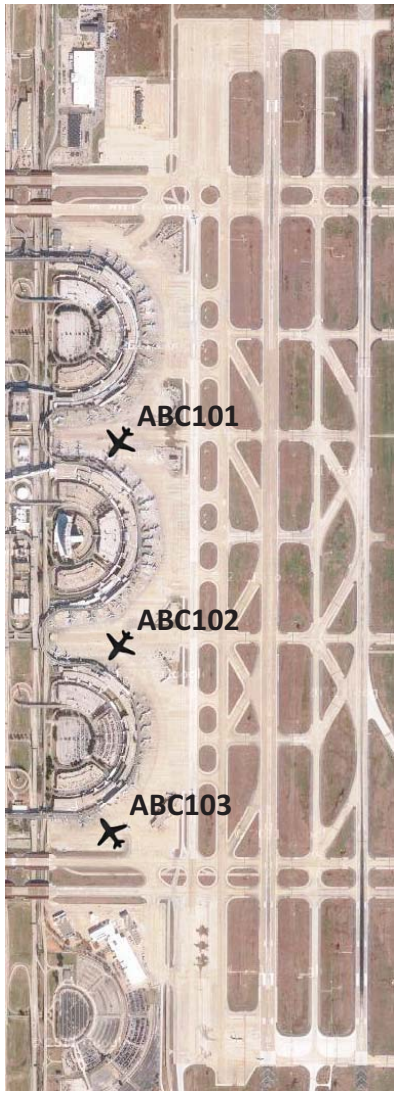


Actual push-back
ABC101: 1507 (1504) late
ABC102: 1500 (1510) early
ABC103: 1508 (1508) on-time

10 sec update of all aircraft positions

Strategic Planning Component (SPC)

Agreed push-back times

Tactical Advisory Component (TAC)

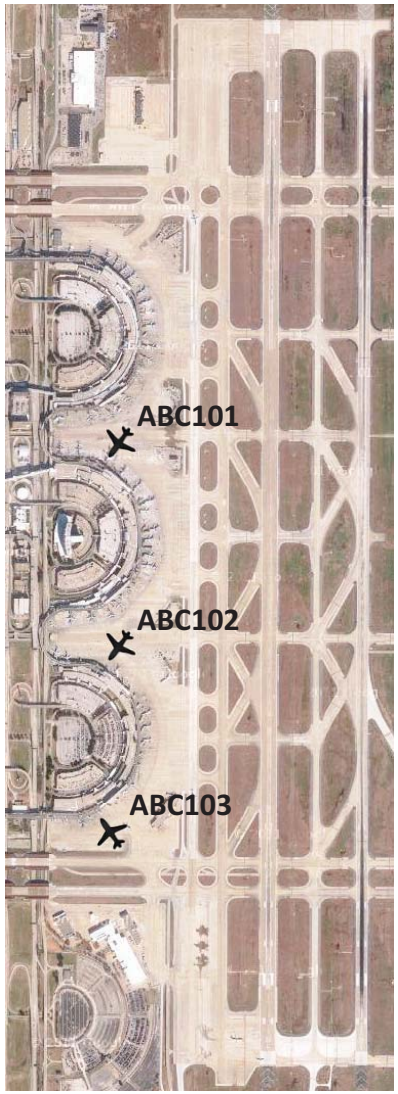
Tactical SARDA Scheduler

PH
30 min

1400 1430 1500 1530 1600 1630

Current time

Strategic SARDA Walkthrough



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Strategic Planning Component (SPC)

Agreed push-back times

Tactical Advisory Component (TAC)

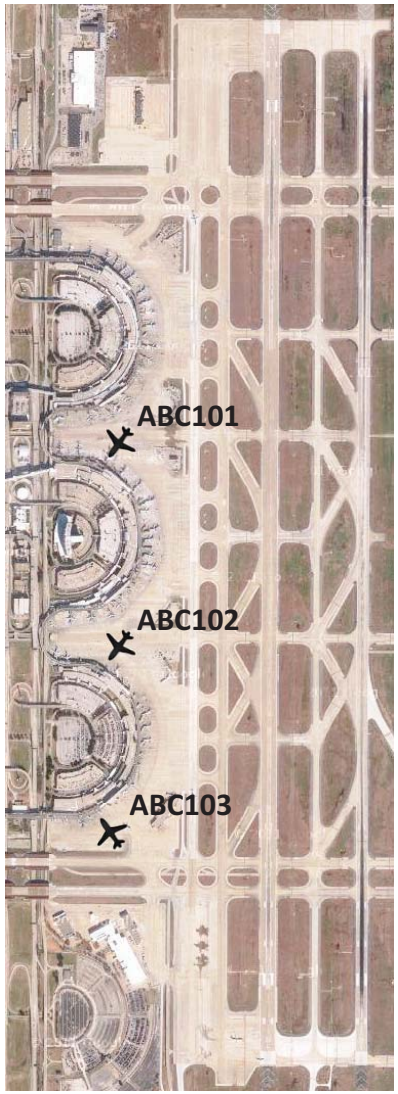
Tactical SARDA Scheduler

ATCT Advisories

1400 1430 1500 1530 1600 1630

Current time

Strategic SARDA Walkthrough



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1400 1430 1500 1530 1600 1630

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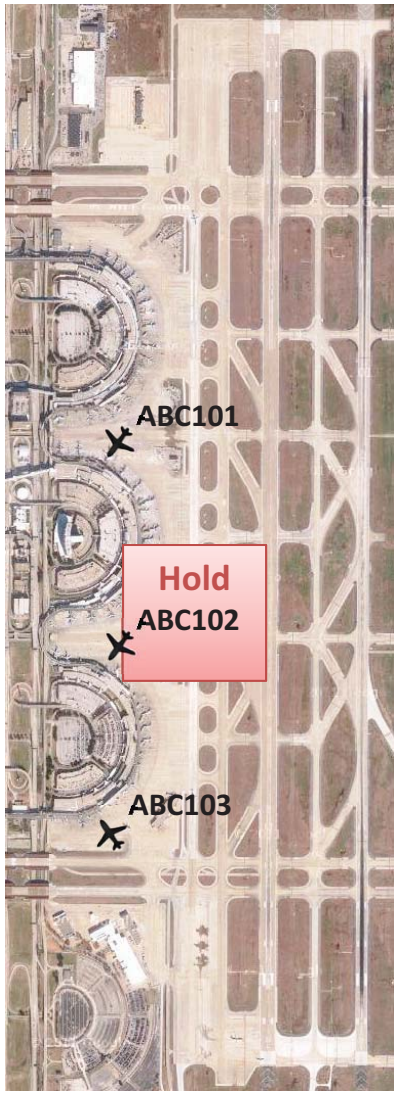

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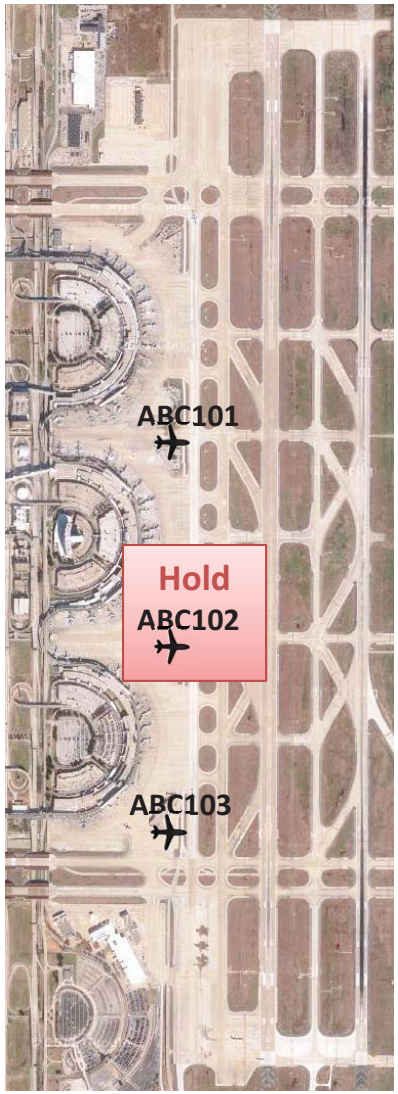

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Strategic Planning Component (SPC)

Agreed push-back times

Tactical Advisory Component (TAC)

Tactical SARDA Scheduler

ATCT Advisories

1400 1430 1500 1530 1600 1630

Current time

Strategic SARDA Compliance

- After gate push-back agreement, three potential outcomes:
  - On-time push-back
  - Early push-back: ground controller holds till allotted time
  - Late push-back
    - Compliance encouraged by public performance metrics based on agreed push-back times
    - If late, spot release by ground controller as early as possible, **without affecting complying aircraft**

Tactical SARDA Walkthrough

- Intended for airports with single majority carrier (CLT)
- Can work with airline or ramp control
- SARDA has flight plan
- Push-back time continuously updated based on current airport situation and airline input
- CLT version: When pilot calls “ready for push back”
  - Ramp Controller inputs in SARDA display, SARDA gives hold or release. If hold, gives hold time
  - Advisories for ATCT

SARDA Components and Uses

- Airline (and/or ramp) collaboration
  - Move delays from runway queue to gate
  - Fuel and emission reductions
  - Potentially better connections
- Ground controller advisory
  - Compliance to SARDA for early push-back
- Local controller advisory
  - Improve predictability for downstream (TRACON) integration of departure aircraft
  - Improve predictability of arrival aircraft movement on taxiways

Tactical SARDA HITL tests

- Conducted in May-June 2012
- SARDA implemented in SDSS
- East side DFW (17R departures and 17C arrivals)
- 2 controllers (Ground and Local)
- Pseudo-pilots
- Tactical gate hold through CDM (Idealized to reduce delays)
- No perimeter taxiway
- Ground Controller and Local Controller advisory – through EFS

Tactical SARDA HITL

- Run traffic with SARDA advisories, and without SARDA (aka “Baseline”)
- 2 traffic levels - medium (1.2x) and heavy (1.5x)
- 3 weeks, 2 controllers per week, 48 runs
- Departure peaks in some scenarios
- Separation requirements for RNAV
- Traffic Management Initiatives (TMI) in all runs

Simulation Caveats

- “Advisories” had to be followed
- Ramp area
  - Gate management not implemented
  - De-conflicted ramp movement under development

SARDA Controller Display

Ground Controller Display

AAL454	MD82	7	04:00	S22/EK...EH	17R/SOL/ATL		TX-D
DAL849	B737	6	02:22	S47/K...EH	17R/DAR/IAH		TX-D
DAL281	B737	5	00:59	S37/K.EG	17R/TRI/TYS		TX-D
DAL274	B737	4	00:38	S33/K.EG	17R/AKU/STL		TX-D
AAL827	MD82	3	00:22	S11/K...EH	17R/SOL/ATL		TX-D
AAL1539	MD83	2	00:04	S11/K...EF	17R/SOL/ATL	1850	TX-D
AWE998	B737	1	-00:13	S33/K...EF	17R/AKU/BOS	1845	TX-D

Local Controller Display

AAL948	B772	9	EF	AKU/PIA	1835	LUAW	CFTO
AAL768	MD82	8	EG	NOB/LGA		LUAW	CFTO
UAL51	B763	6	S36	E GND			
AWE458	B737	6	S46	E GND			
UAL90	B763	5	EG	NOB/DTW		LUAW	CFTO
AAL394	B772	4	S13	E GND			
AAL6715	MD83	4	S13	E GND			
UAL395	B772	3	EG	TRI/ORF		LUAW	CFTO
AAL318	MD82	2	EG	AKU/BOS		LUAW	CFTO
AAL648	MD82	1	EF	SOL/ATL		LUAW	CFTO

Results

- Did we succeed in gate holding?
- Was there any loss in runway usage due to holding?
- What are the benefits?

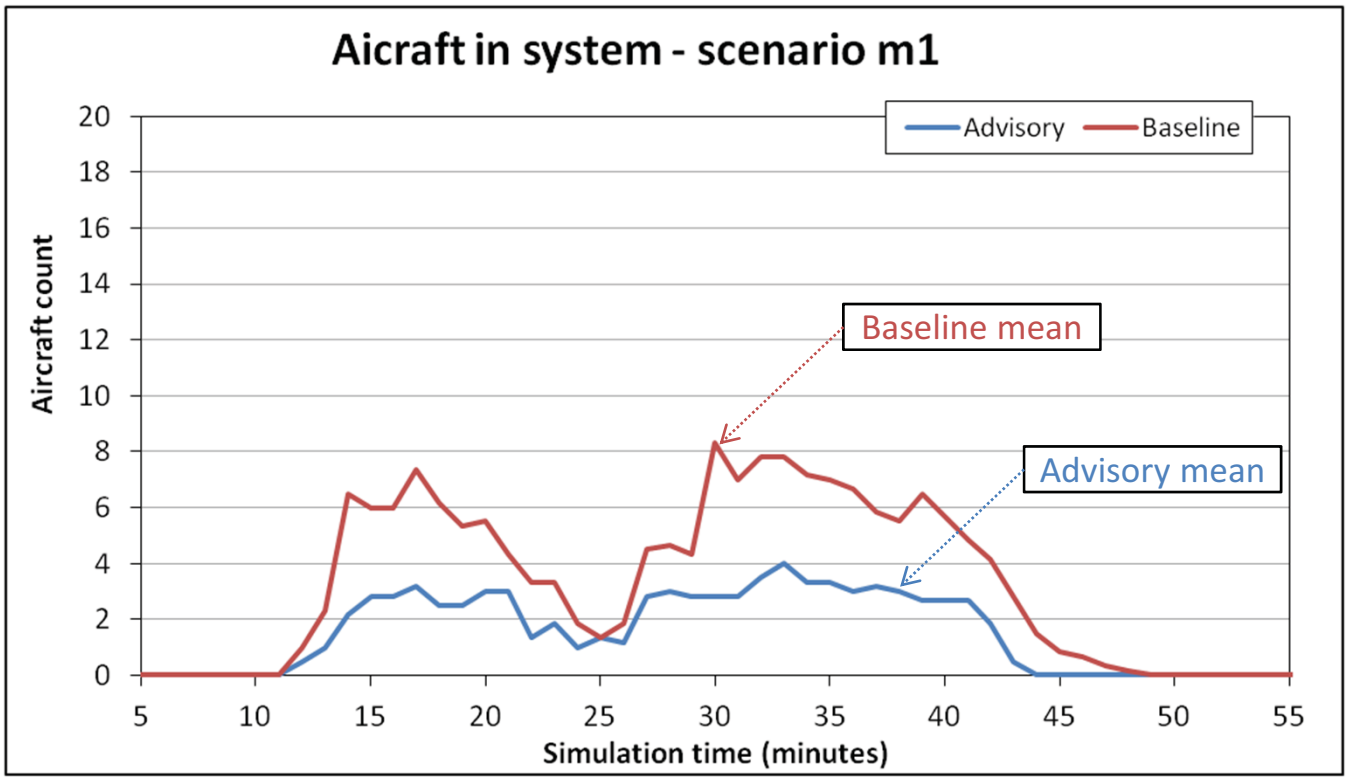
Gate Holding

- Aircraft "**waiting**" in the system:

  At every 1 minute, number of departure aircraft that
  - Have pushed back and
  - Have not taken off within unimpeded taxi time

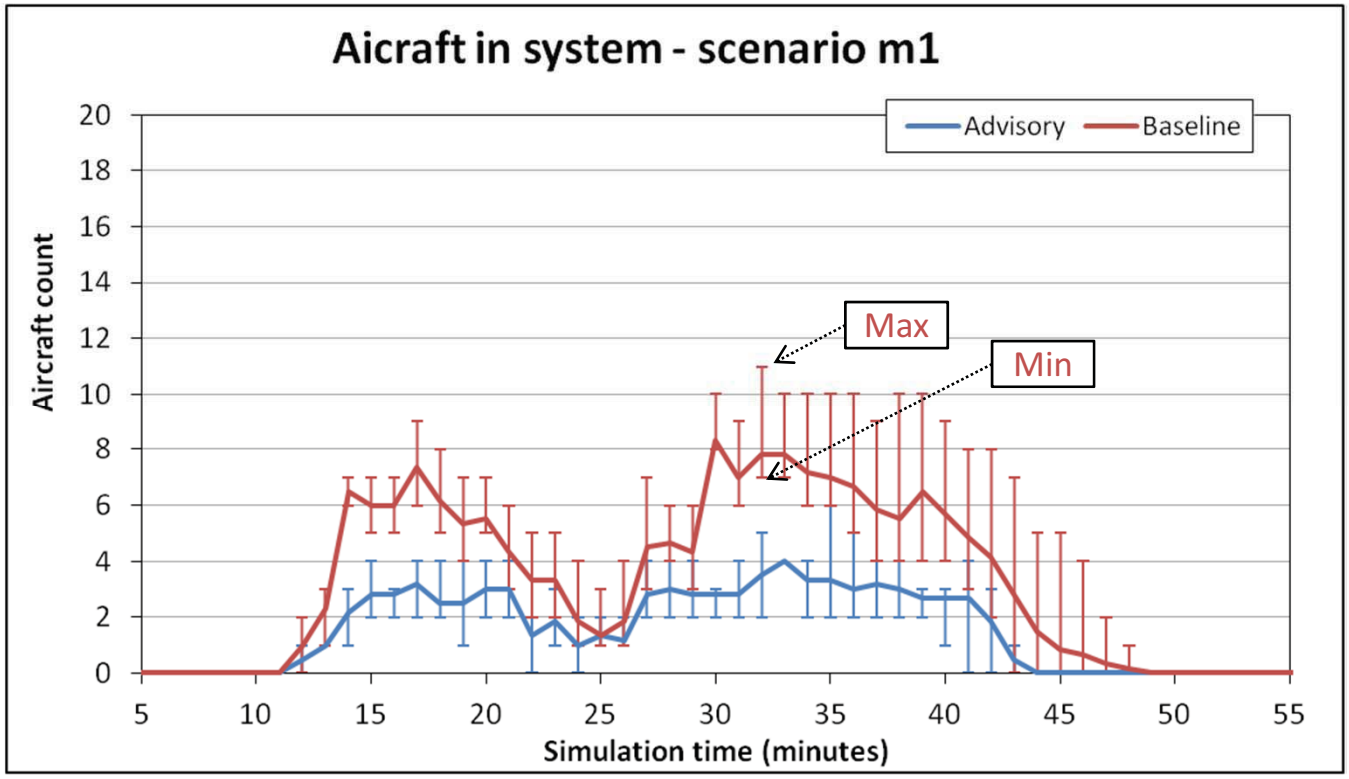
- Expectation: lower for advisory

Gate Holding



At every 1 minute, number of departure aircraft that have pushed back but not have not taken off

Gate Holding



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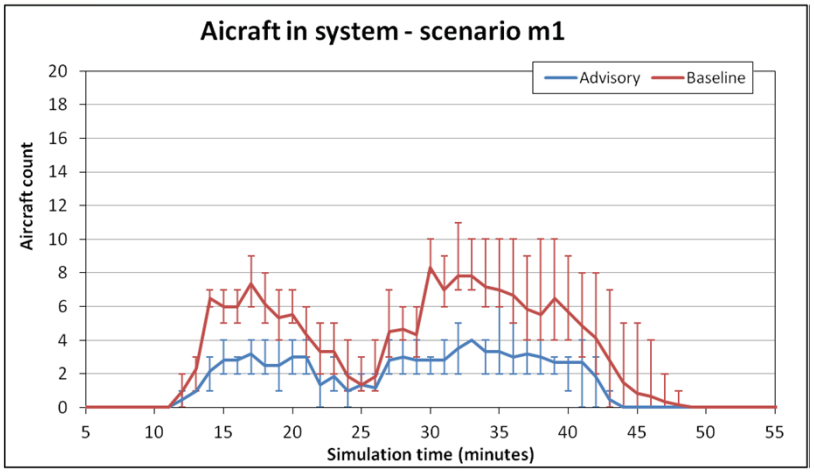

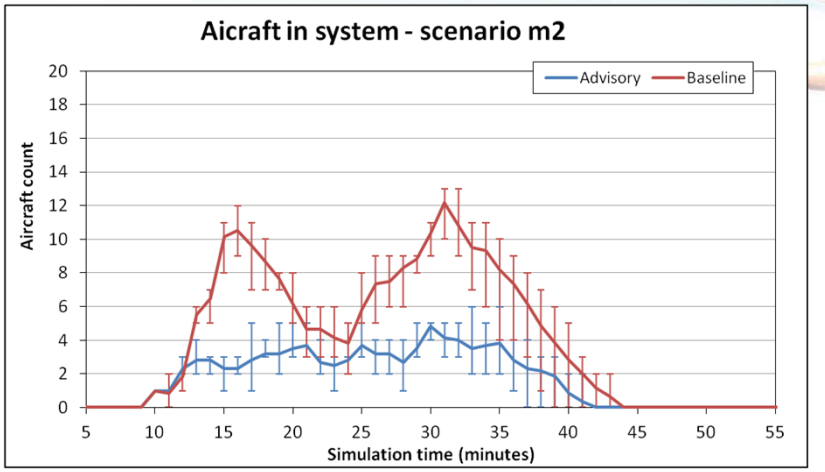

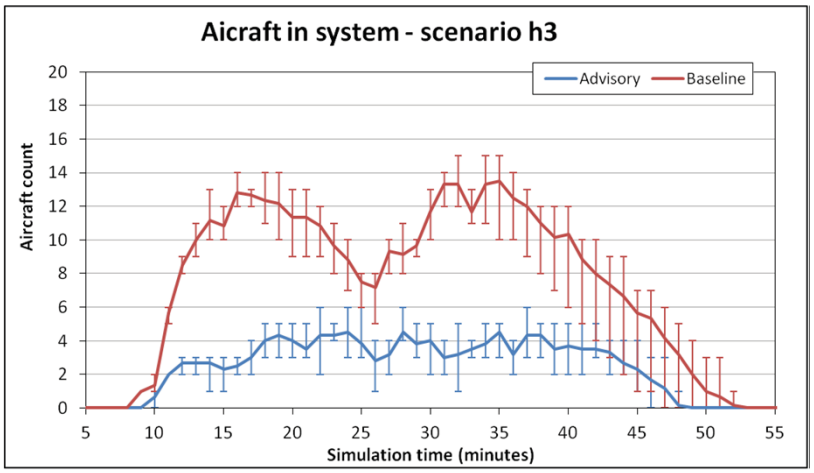

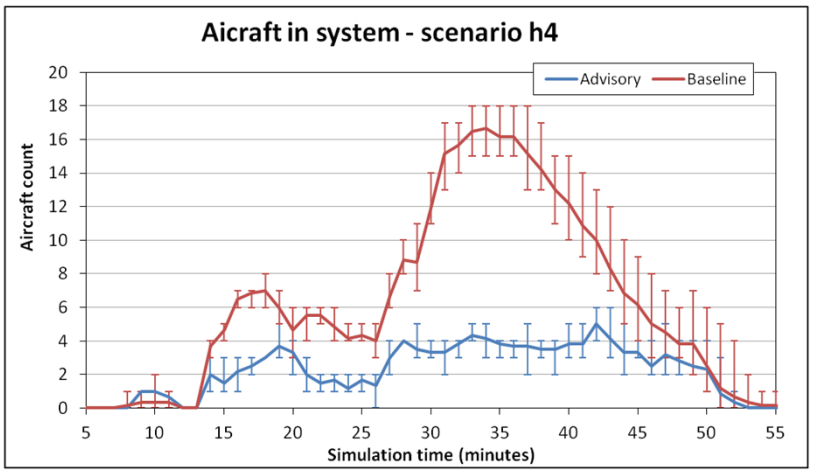

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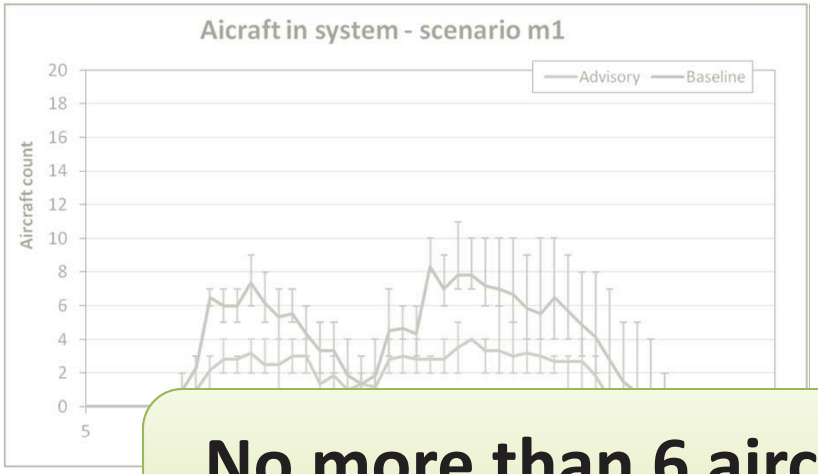
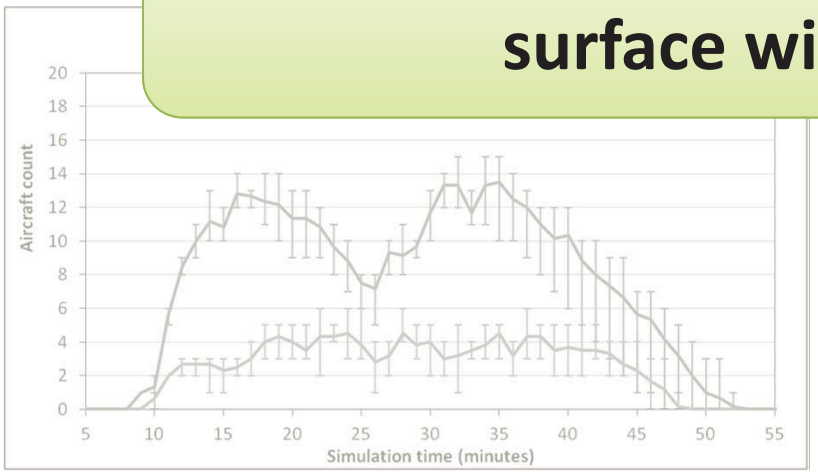
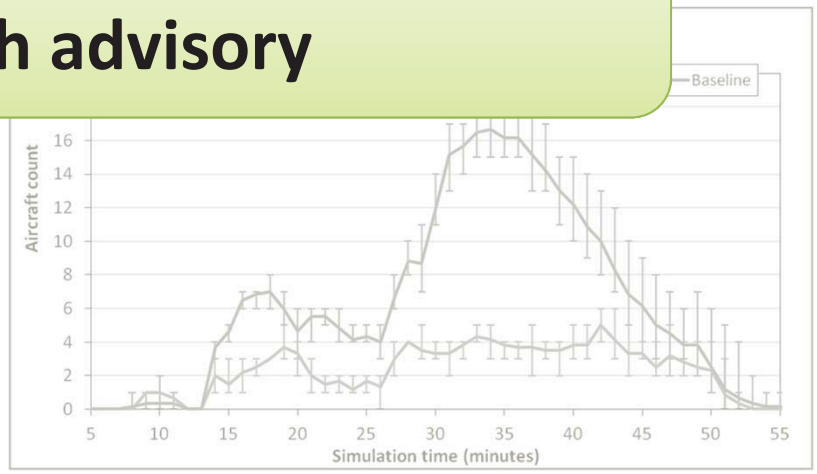
Gate Holding



No more than 6 aircraft "waiting" on the surface with advisory





At every 1 minute, number of departure aircraft that have pushed back but not have not taken off

Results

- ✓ Did we succeed in gate holding?
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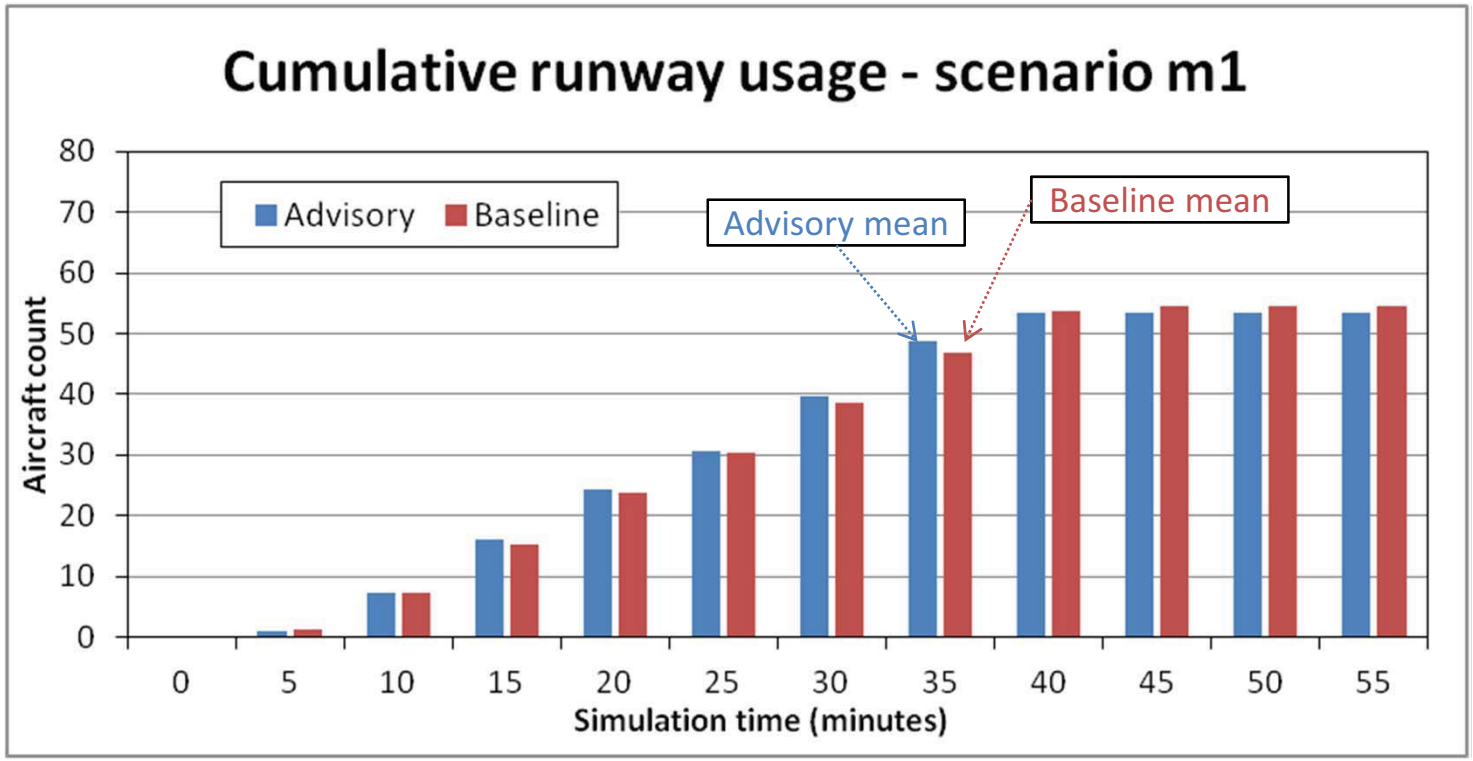
- What are the benefits?

Runway Usage Comparison

- Cumulative runway usage
  - Number of departure take-offs and arrival crossings **till** a particular time
  - Calculated every 5 minutes

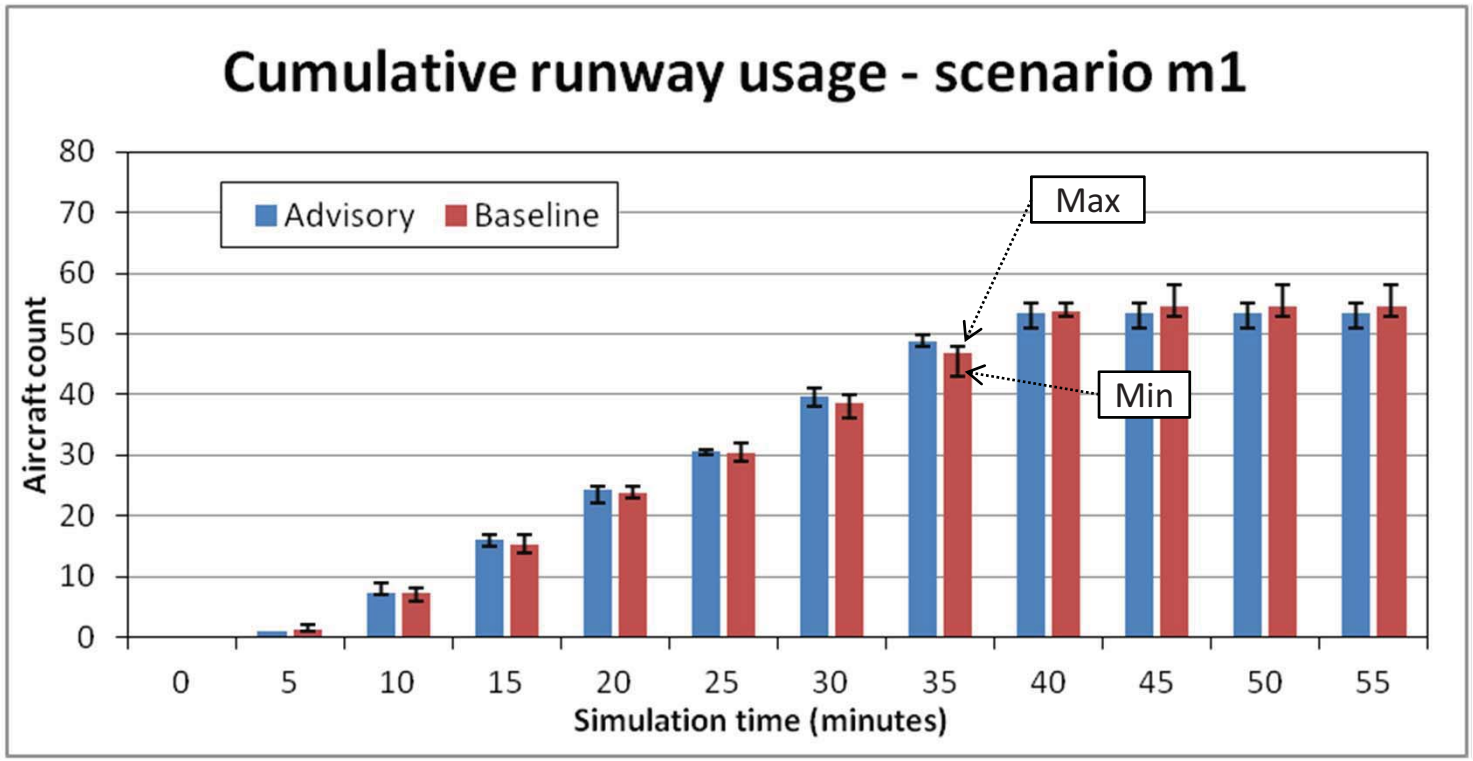
- Expectation: No reduction in runway usage with advisory

Runway Usage Comparison



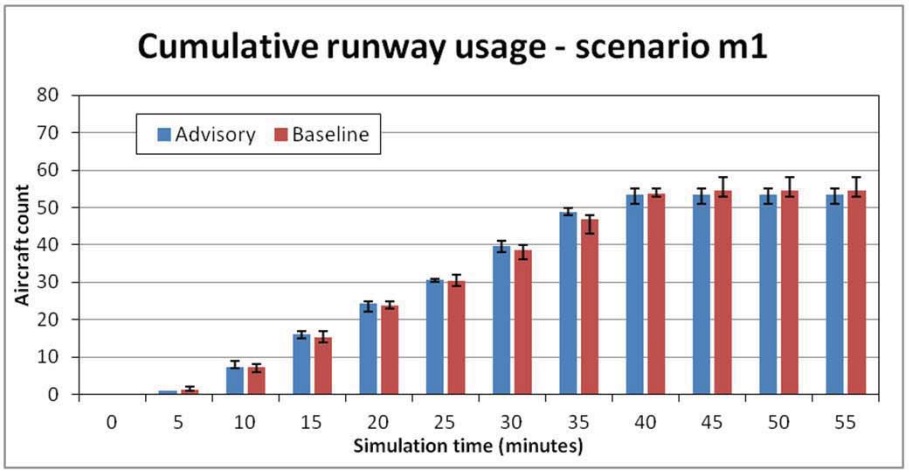
Number of departure take-offs and arrival crossings **till** a particular time

Runway Usage Comparison



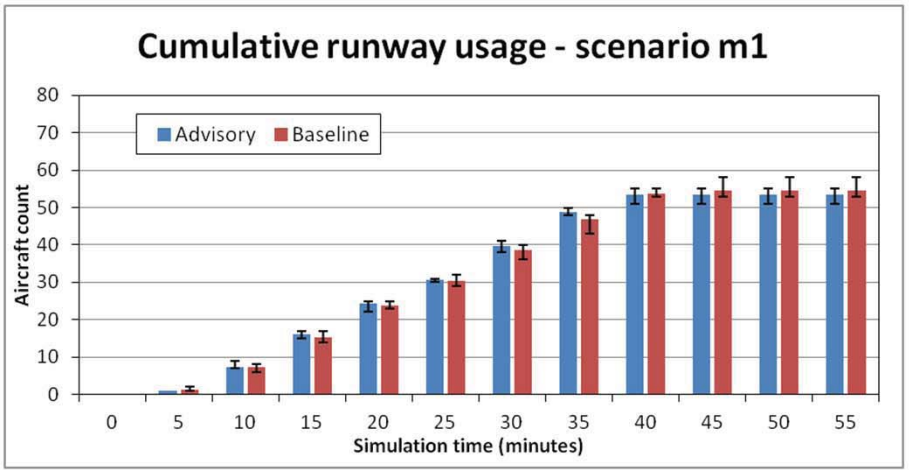
Number of departure take-offs and arrival crossings **till** a particular time

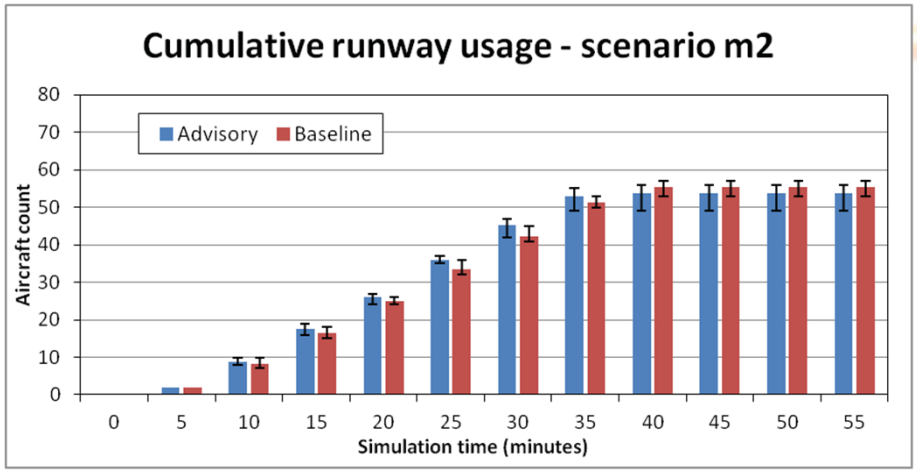
Runway Usage Comparison

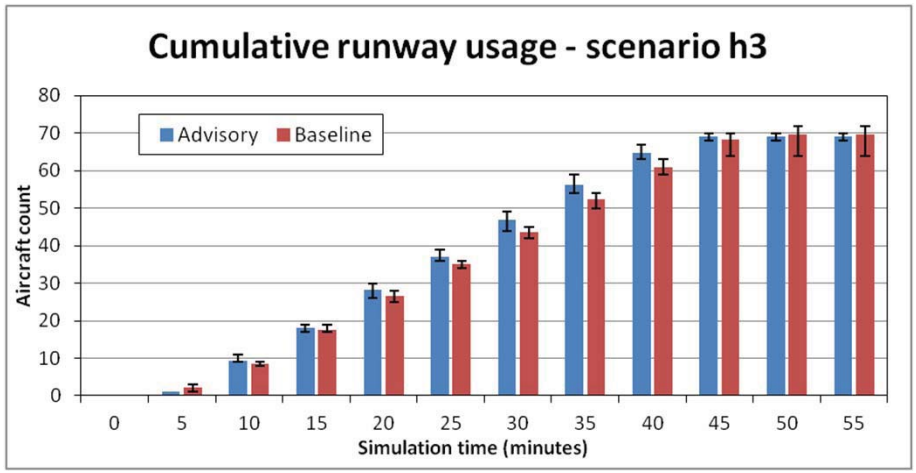


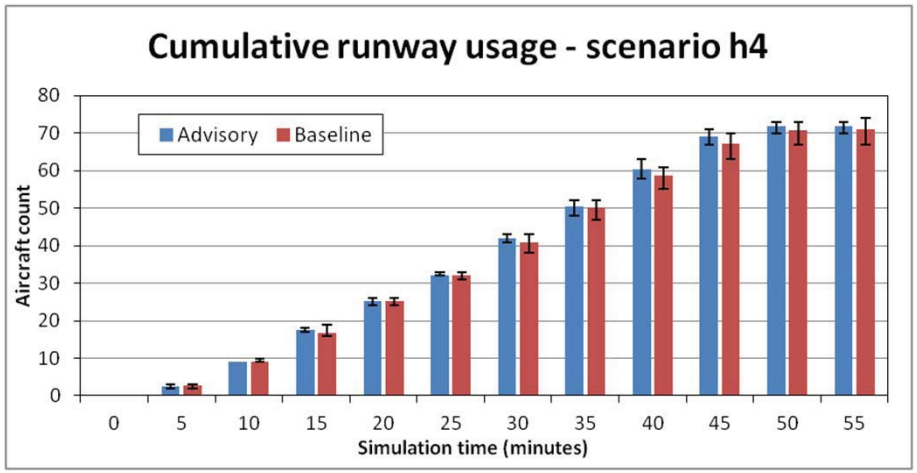
Number of departure take-offs and arrival crossings **till** a particular time

Runway Usage Comparison



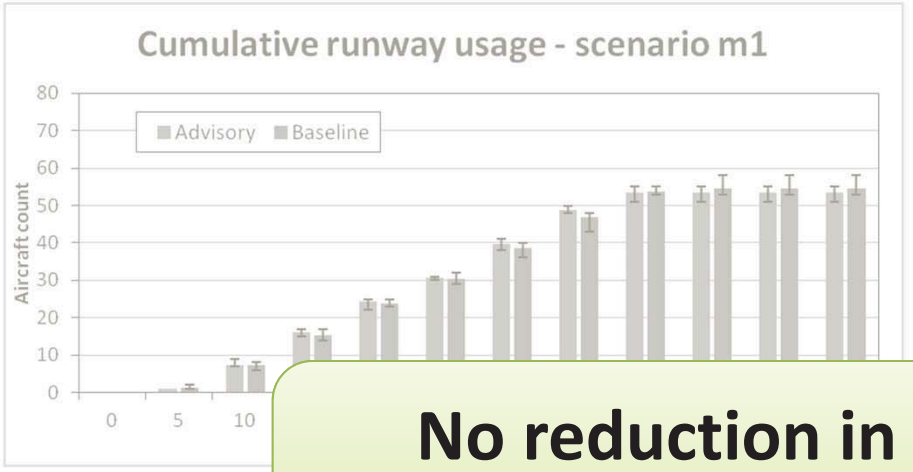


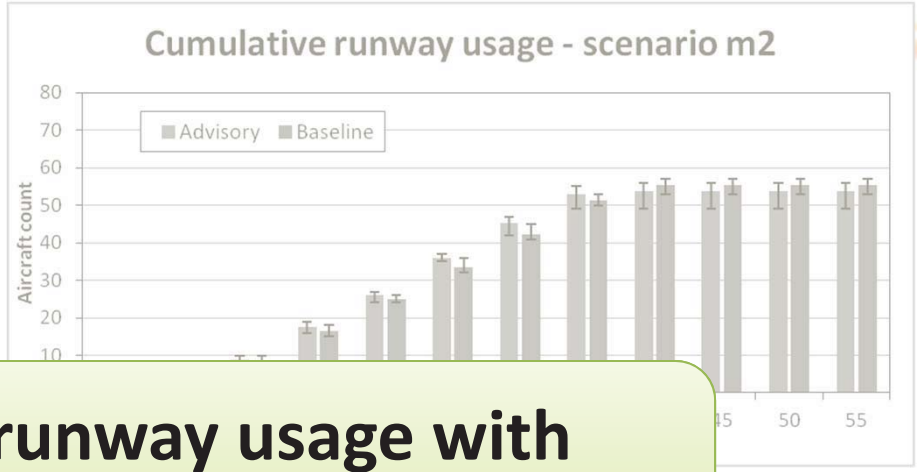




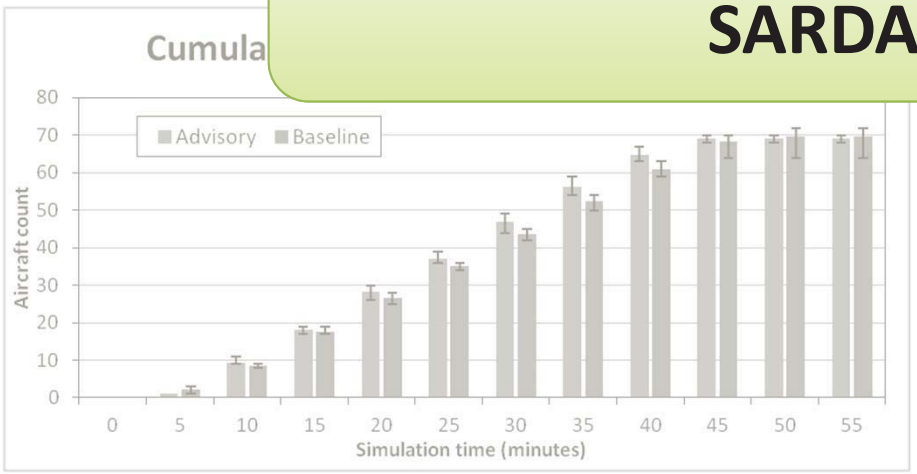
Number of departure take-offs and arrival crossings **till** a particular time

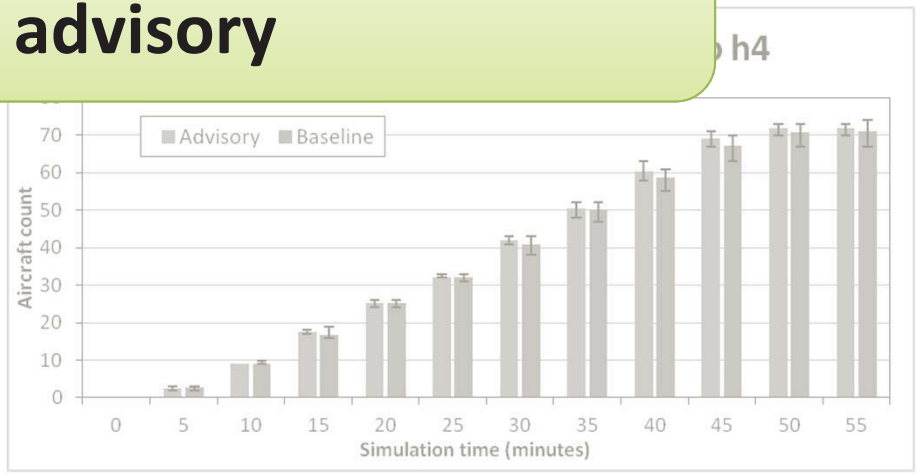
Runway Usage Comparison





No reduction in runway usage with SARDA advisory





Number of departure take-offs and arrival crossings **till** a particular time

Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?

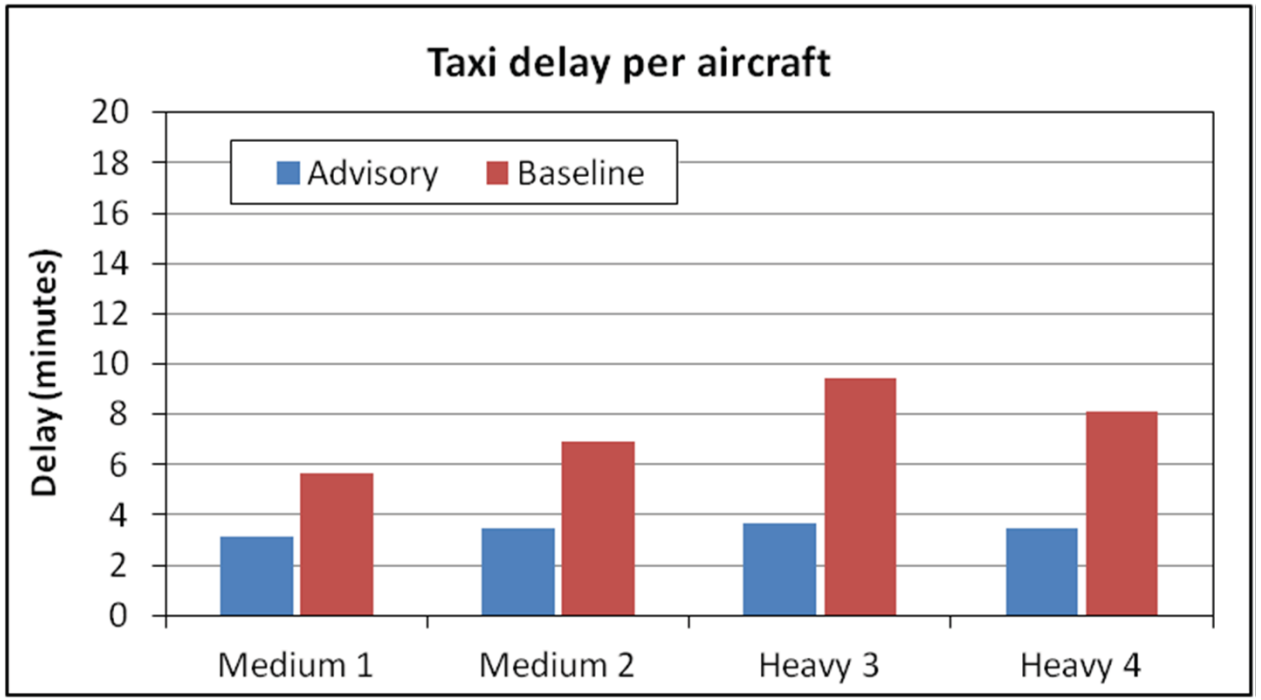
Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?
  - Delay
  - Fuel

Delay

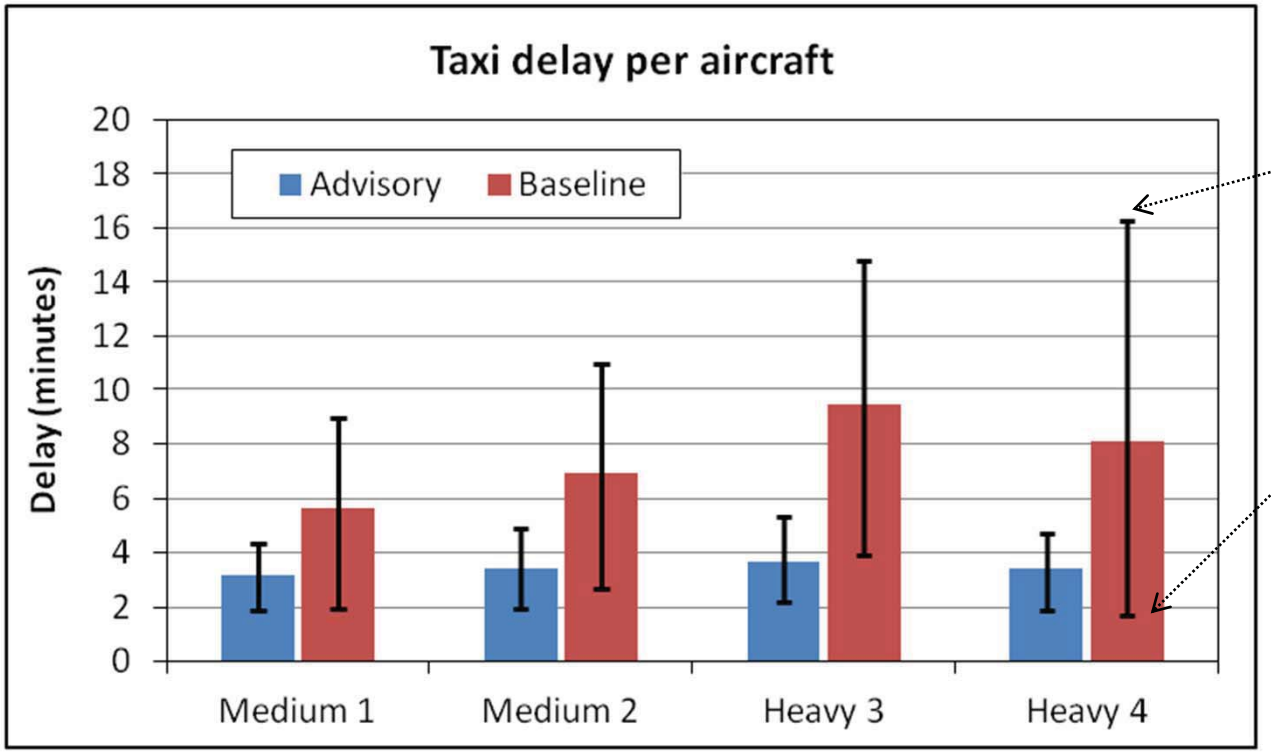
- Delay definition
  - (Observed time – unimpeded time)
  - Unimpeded taxi time: time to travel on that route (gate-spot-queue combination) at 17 knots without stops
  - Unimpeded definition different from ASPM
- Taxiing delay: Delay in ramp, taxiways, queues and runway

Taxiing Delay for Departures (ramp, taxiway, queue)



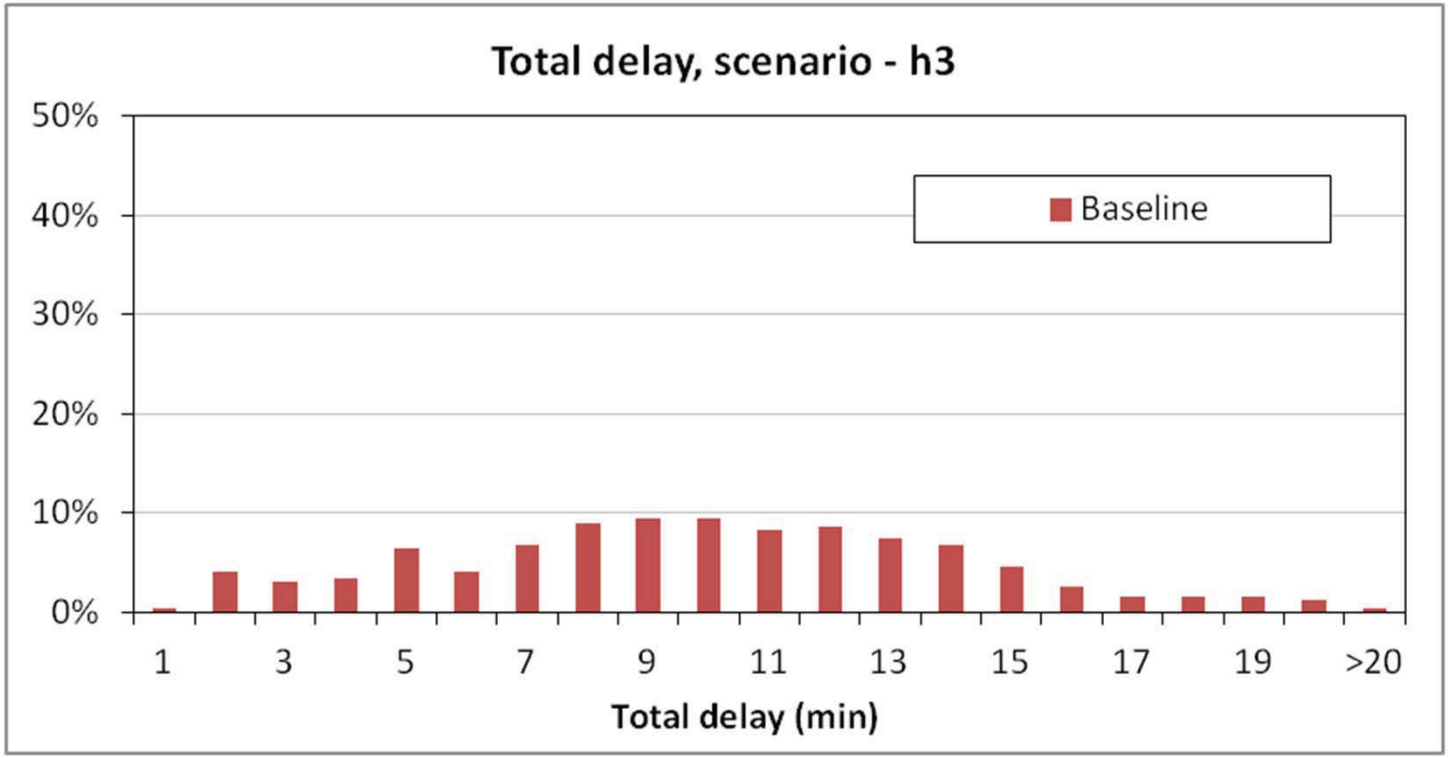
3 min reduction in medium (45%)
5.5 min reduction in heavy (60%)

Taxiing Delay for Departures (ramp, taxiway, queue)

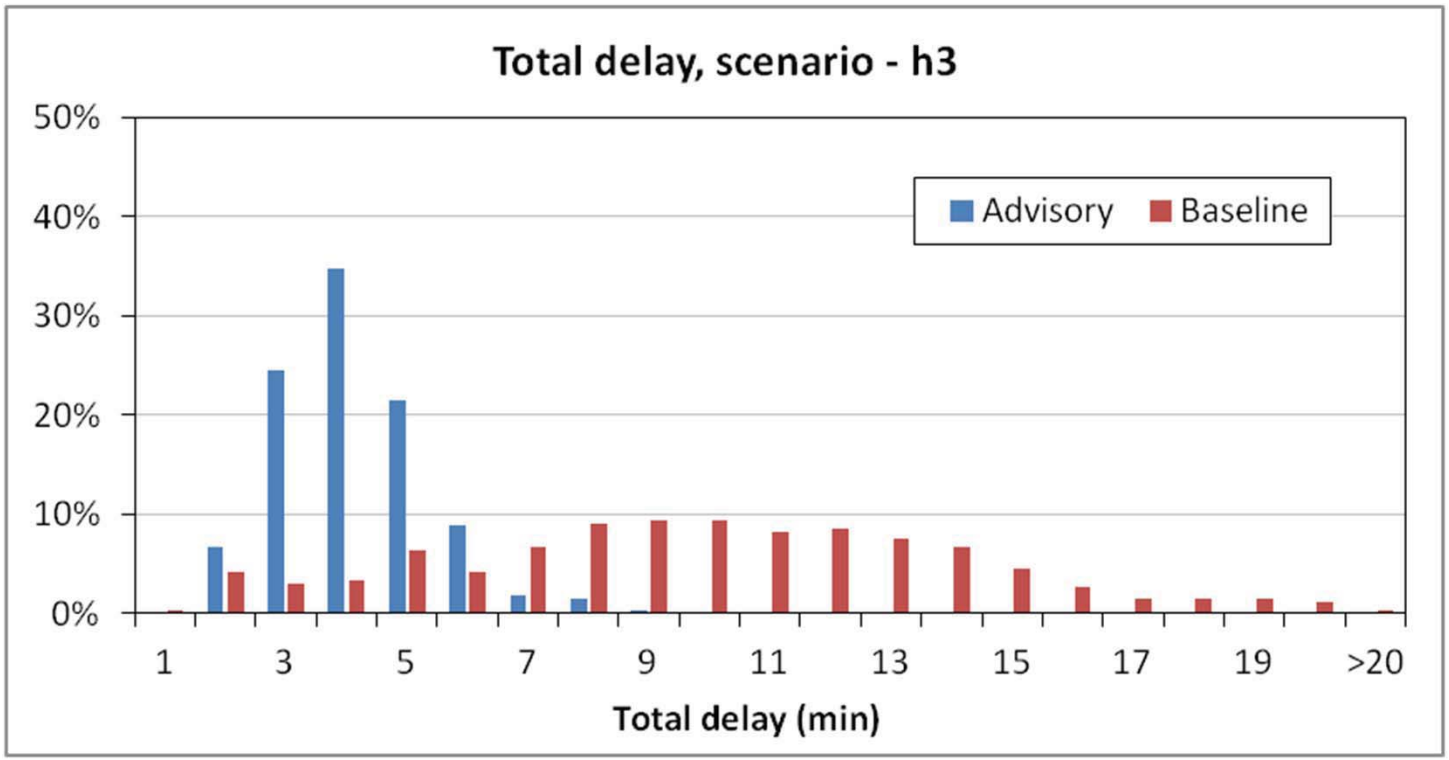


Mean and percentile over all aircraft for that scenario

Taxi Delay - Distribution

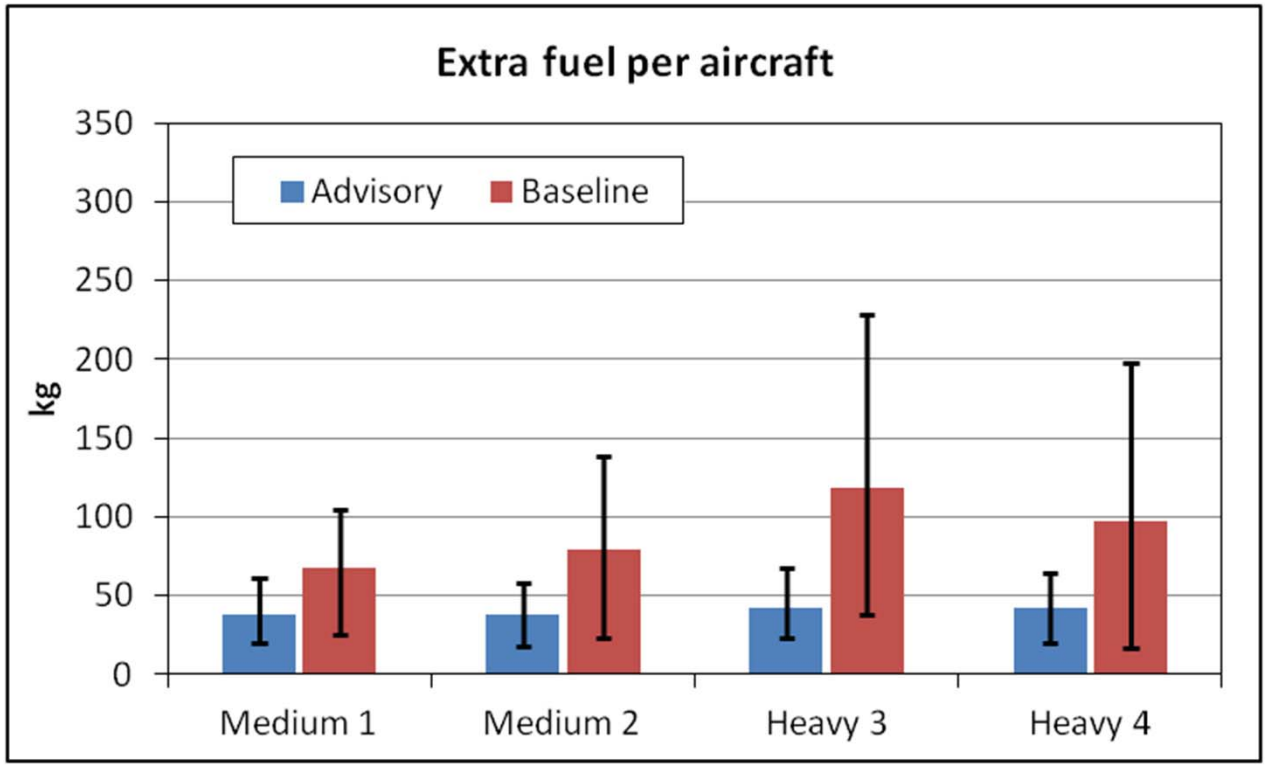


Taxi Delay - Distribution



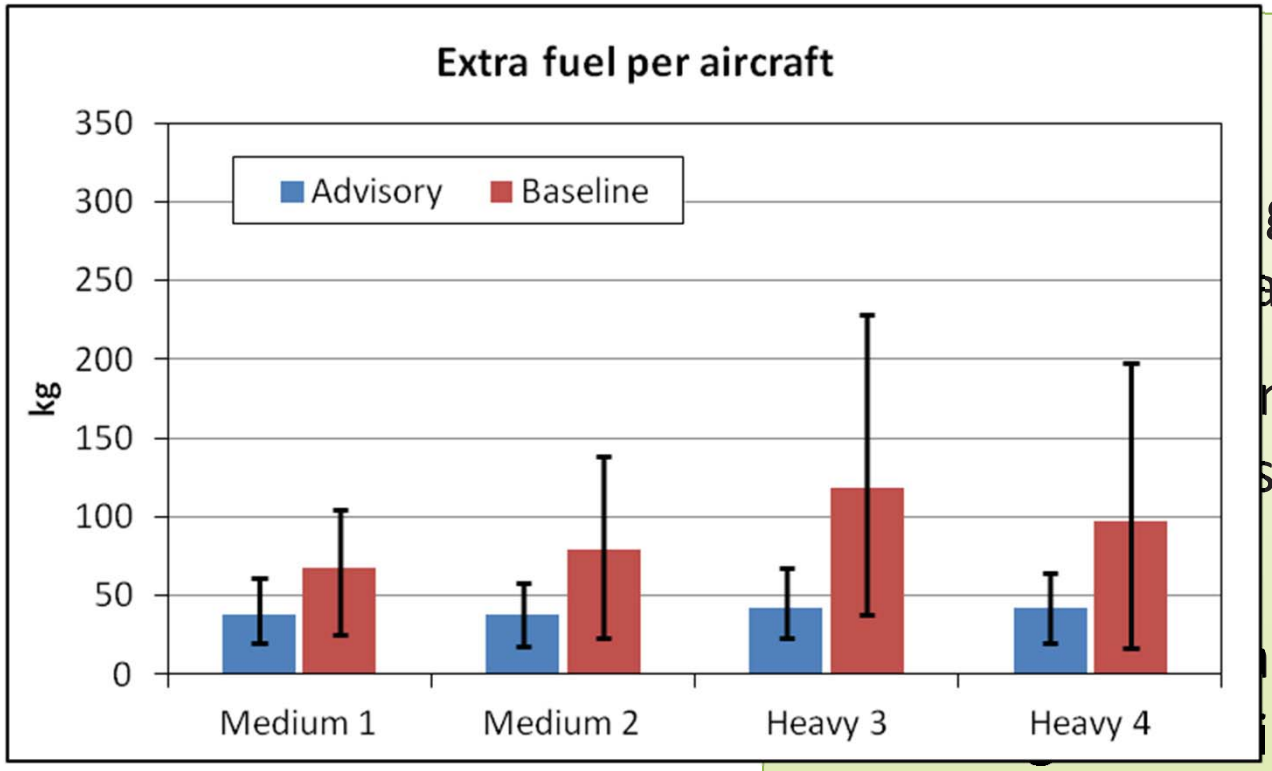
Large variation in delay in baseline

Fuel Consumption



22% reduction in medium
34% reduction in heavy

Fuel Consumption



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Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?
  - Delay
  - Fuel
  - TMI (Traffic Management Initiatives)

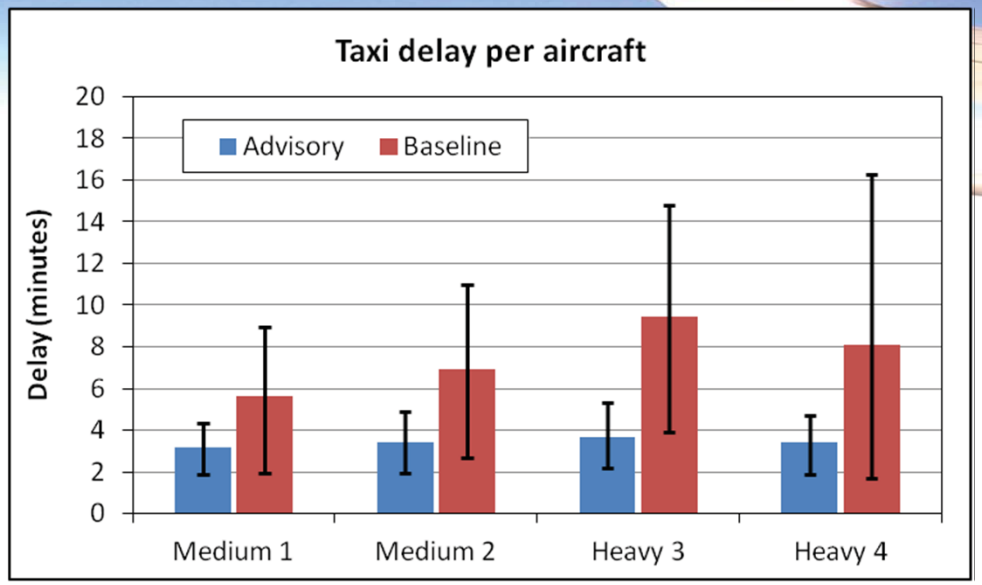
TMI

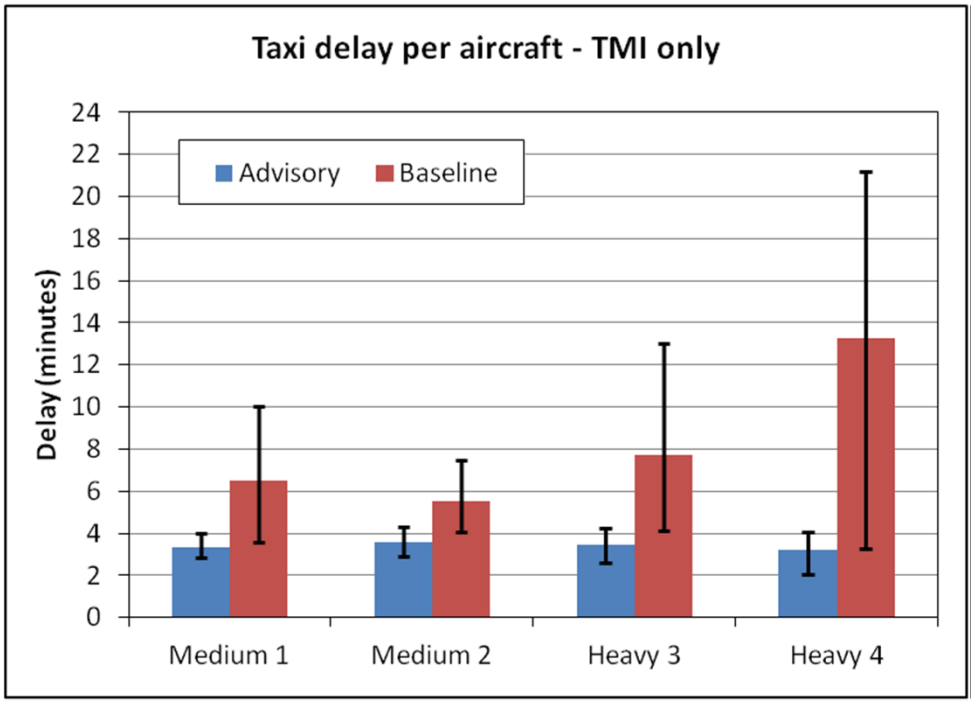
- Details
  - Each TMI aircraft has a scheduled take-off time (displayed in Electronic Flight Strips)
  - Aircraft should take off within 1 minute before or 1 minute after this time
  - If cannot be done, release as close to time as possible (no new TMI time issued)
- Compliance?

Scenario	Baseline	Advisory
m1	93%	100%
m2	100%	100%
h3	86%	100%
h4	93%	100%

TMI

Less variation in TMI aircrafts' delays in advisory

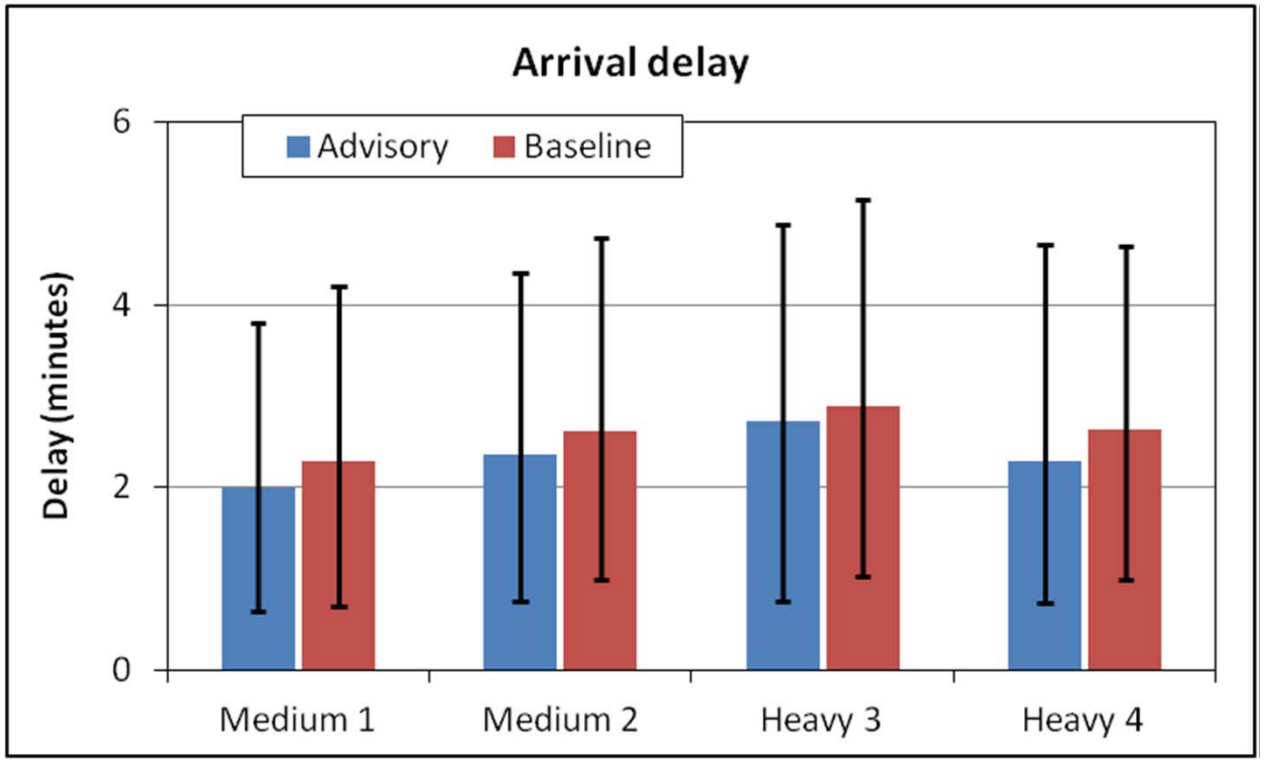




Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?
  - Delay
  - Fuel
  - TMI (Traffic Management Initiatives)
- Effect on arrivals

Arrival Delay

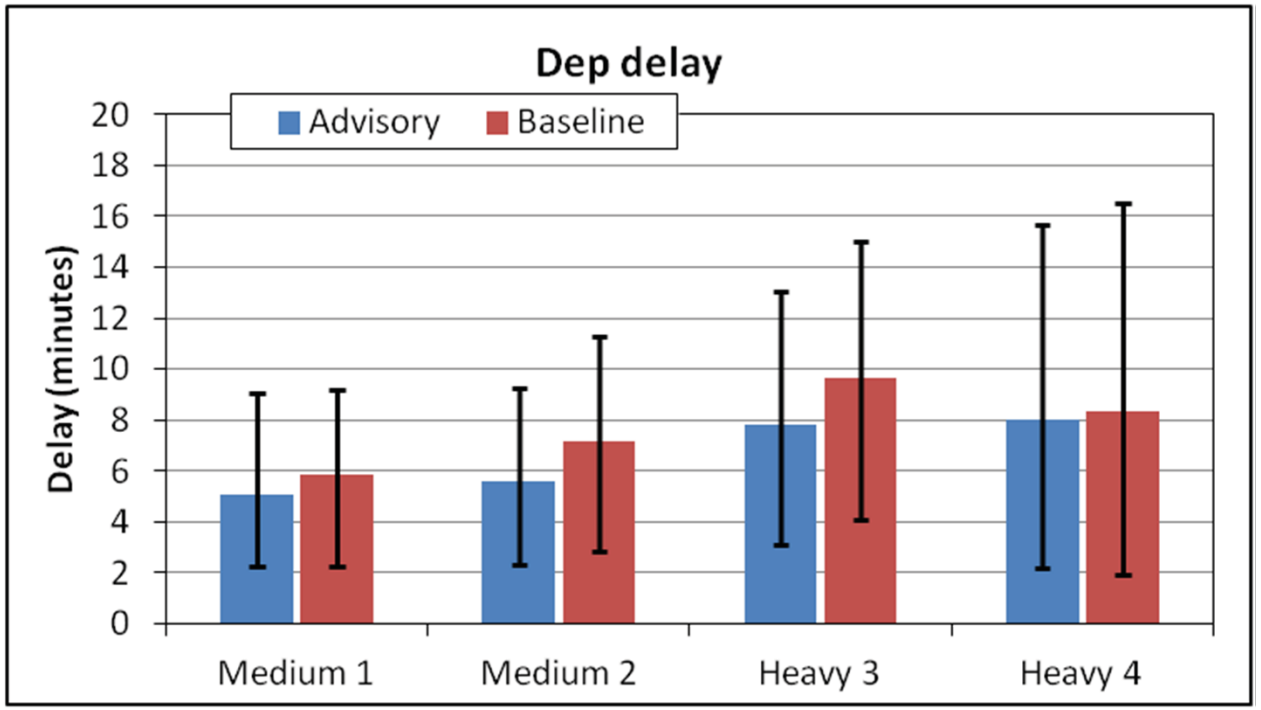


No effect on arrival aircraft

Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?
  - Delay
  - Fuel
  - TMI (Traffic Management Initiatives)
- Effect on arrivals
- Reduction in overall delay

Departure Delay



Statistically significant effect of advisory on **departure delay**

Results

- ✓ Did we succeed in gate holding?
- ✓ Was there any loss in runway usage due to holding?
- What are the benefits?
  - Delay
  - Fuel
  - TMI (Traffic Management Initiatives)
- Effect on arrivals
- Reduction in overall delay
- Increased predictability

Beyond 2012 HITL

- Idealized push back holds – what happens under push back uncertainty
  - Real-time automated simulations
  - Even with increasing uncertainty in gate push-back (± 3 mins), there is little increase in taxiing delay
  - For the 2 scenarios tested, loss in runway usage with ± 3 mins push-back uncertainty not substantial

Spot And Runway Departure Advisor (SARDA)

- Integrated tool for airlines and Air Traffic Control Tower enabling CDM and departure metering
- Based on managing scarce resource: Runway
- Strategic or tactical departure metering
- 4-D trajectory enabler
  - Currently 3 advisories: gate/ramp, spot and runway
  - SARDA can provide times for more “nodes” – full datalink based movements

Current Activities

- NRA teams are wrapping up studies of implementing SARDA concepts at airports: PHL, LAX, CLT, JFK, and BOS
- Preparation for the next HITL in 2014
  - Developing a second airport model (adaptation), Charlotte
  - Expanding SARDA scheduler to provide full airport scheduling
  - Developing ramp controller interface (GUIs)
  - Enhancing simulation facility to host multiple & concurrent participants (ramp and tower controllers)

Upcoming Activities

- 2014 Charlotte ramp control HITL
  - Simulation characteristics
    - Two hour long scenario, to capture arrival-departure push
    - Includes turnaround traffic
  - Ramp side
    - Staffing: 4-ramp controllers + 1-supervisor
    - Participants: airline operator personnel
    - Using Electronic Flight Strips (EFS) and other GUI to interact with SARDA and manage traffic
  - Tower side
    - Staffing: 1-ground + 1-local controller
    - Participants: 1-ground controller + 1-local controller (pool of participant is TBD)
    - Using Electronic Flight Strips (EFS) and other GUI to interact with SARDA and control traffic

- Future Work
  - Strategic SARDA with airline interface
  - Accepts changes to miles-in-trail restrictions in real-time.