SARDA HITL Simulations: System Performance Results

Gautam Gupta

Agenda

- SARDA concept introduction
- HITL description
- System performance results

Motivation and Concept

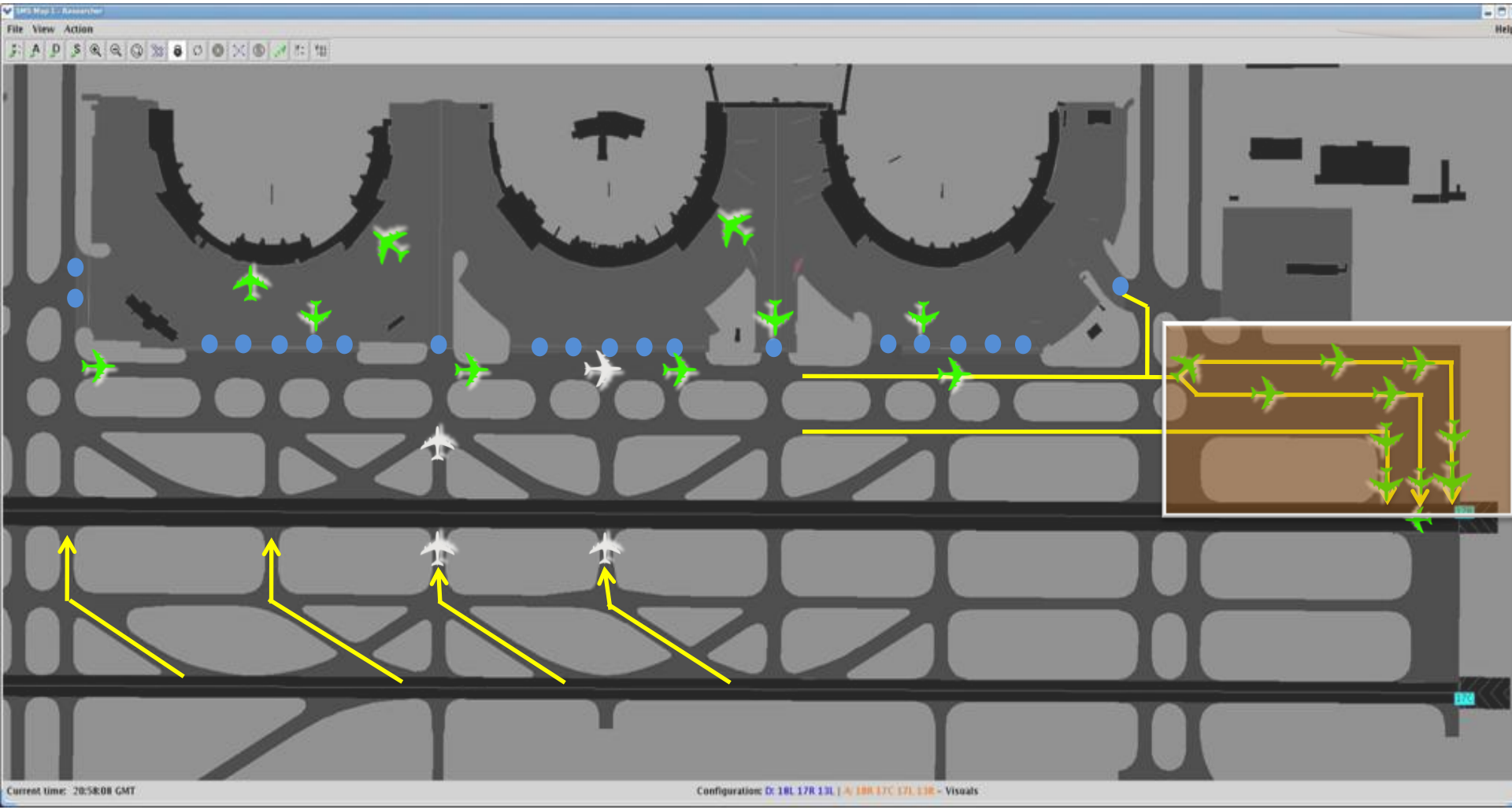
- Motivation
  - Currently, departure delay at runway queues
  - Leads to inefficient fuel consumption and higher emissions (at queues and taxiway)
- Operational Concept
  - Hold aircraft back at gates/holding areas in collaboration with airlines
  - Provide “advisories” to Ground and Local Controllers, incorporating future traffic (through airline collaboration)
  - Increased efficiency and predictability in surface operations
  - Reduced fuel consumption and emissions
  - No concession in runway throughput

Spot And Runway Departure Advisor (SARDA)

- **Goal:** An integrated decision support tool for airlines and tower controllers to enhance the efficiency of surface traffic

- Airline Operator Advisory – Surface CDM
  - Aim: Provide gate push-back times to airlines
- Ground Controller Advisory
  - Aim: Provide spot/ramp release schedule to reduce taxi delay while maintaining maximum runway throughput
- Local Controller Advisory
  - Aim: Provide take-off and crossing sequence for maximum runway usage while addressing all criteria

Current Operations



Improvements over SARDA 2010

- Traffic management initiatives (TMI)
- Out of the window view
- Gate holding (instead of spot holding)
- Uncertainty in aircraft taxi speed (12 to 17 knots)
- Electronic Flight Strips (EFS)
- Single scheduler

Simulation Details (1)

- Surface Collaborative Decision Making (CDM)
  - Gate push-back readiness communicated by airline
  - Actual gate push-back times based on SARDA spot release
  - Idealized
    - Airline inputs accurate
    - No re-negotiation
    - Airlines meet SARDA gate push back

Simulation Details (1)

- Surface Collaborative Decision Making (CDM)
  - Gate push-back time readiness communicated by airline
  - Actual gate push-back times based on SARDA spot release
  - Idealized
- Ground and local controller advisory – through EFS
- Run traffic with SARDA advisories, and without SARDA (aka “Baseline”)
- Traffic Management Initiatives (TMI) in all runs
- Full out-of-the-window tower simulation

Simulation Details (2)

- East side DFW (17R departures and 17C arrivals)
- No perimeter taxiway
- 3 weeks, 6 controllers, 2 controllers per week
- 2 traffic levels - medium and heavy, 2 scenarios each
  - M1, M2, H3 and H4
  - 16 runs per week, 48 total
  - 6 runs for each scenario for advisory and baseline (with different controllers)
- 5 Pseudo-pilots

Simulation Caveats

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

Some Pictures

Data Collected

- SMS data
  - Positioning
  - Scheduler inputs and outputs
- Electronic flight strip logs
- Voice recordings
- Video recordings
- Workload (Workload Assessment Keypad)
- Predictability
- Surveys

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- Did SARDA reduce taxiing aircraft through gate holding?
- Was there any loss in runway usage due to holding?
- What are the benefits?

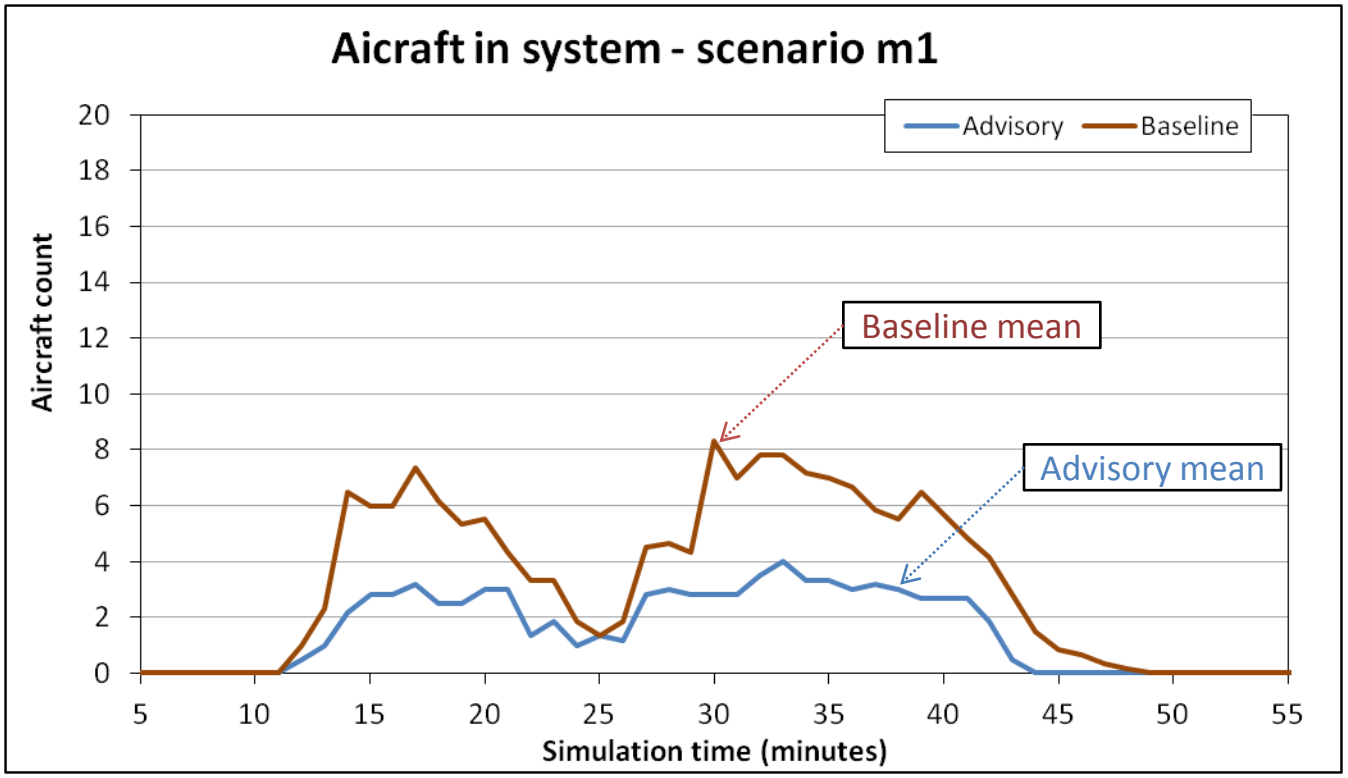
Gate Holding Effect

- 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

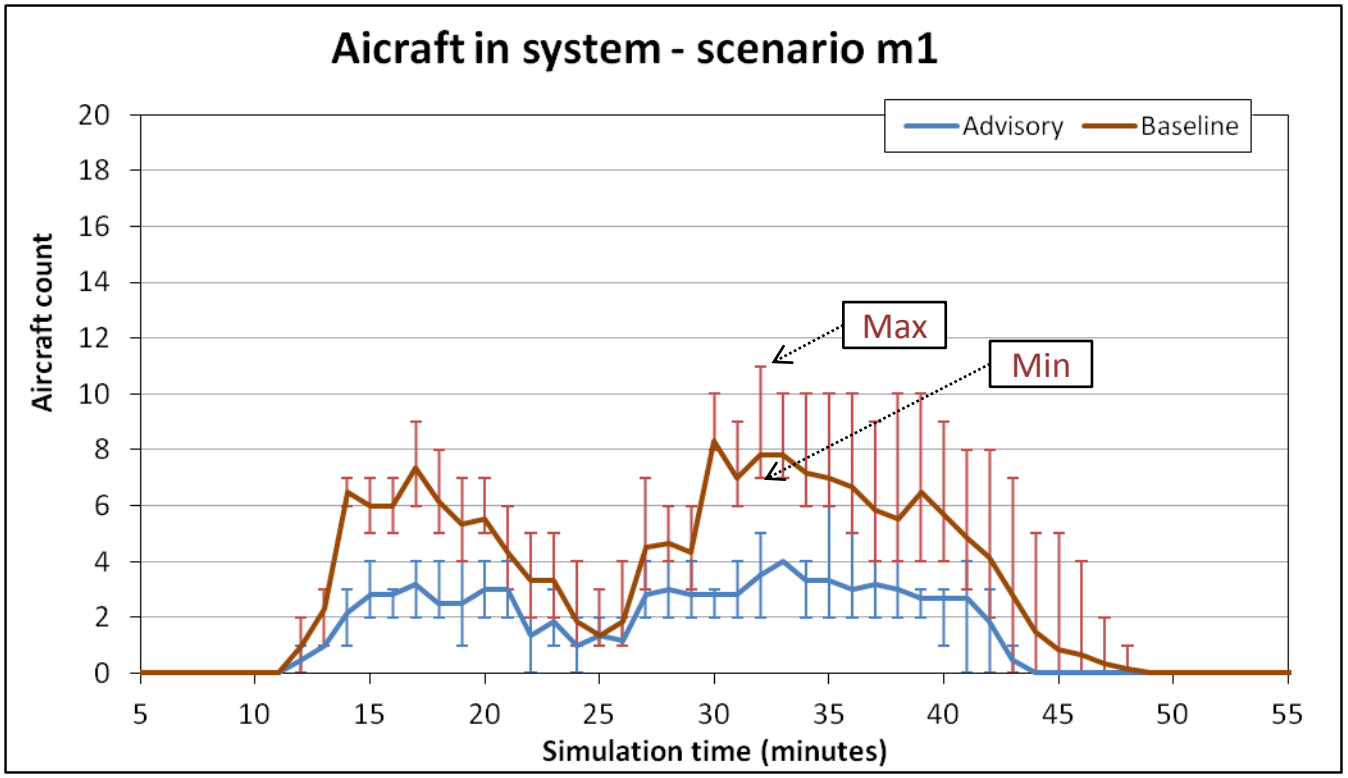
- Expectation: lower for advisory

Gate Holding Effect



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

Gate Holding Effect



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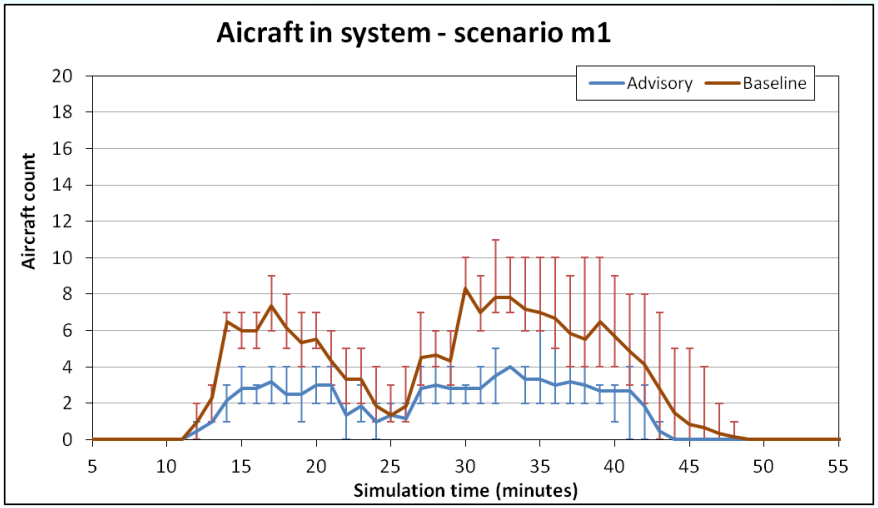

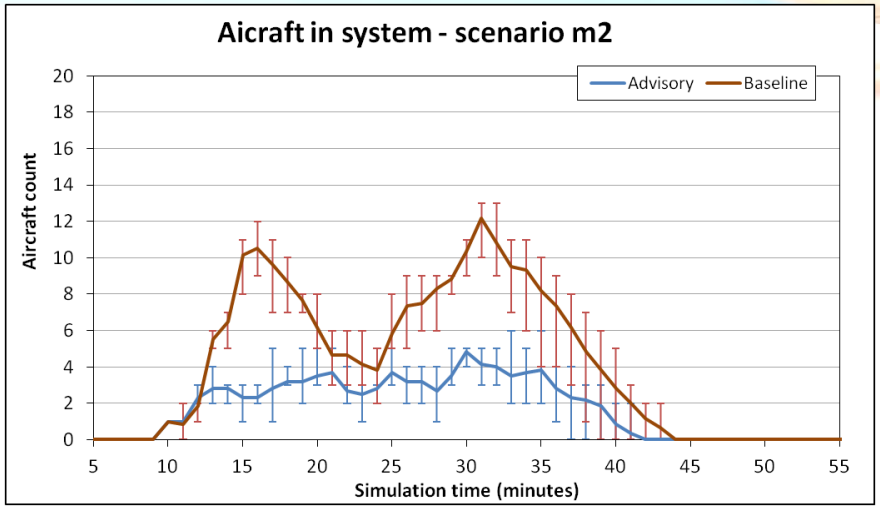

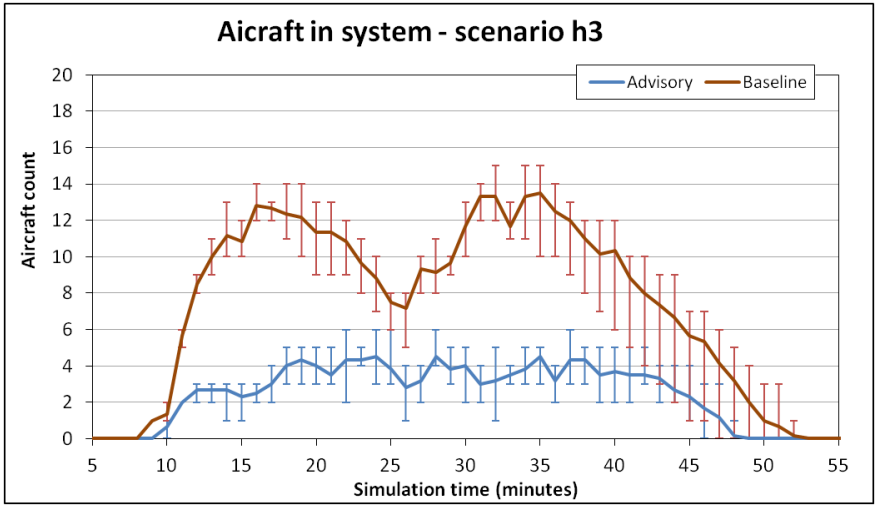

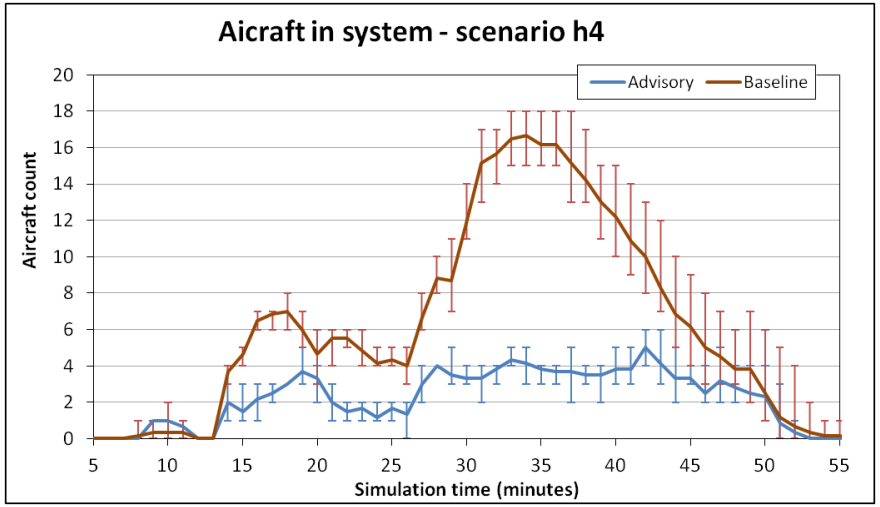

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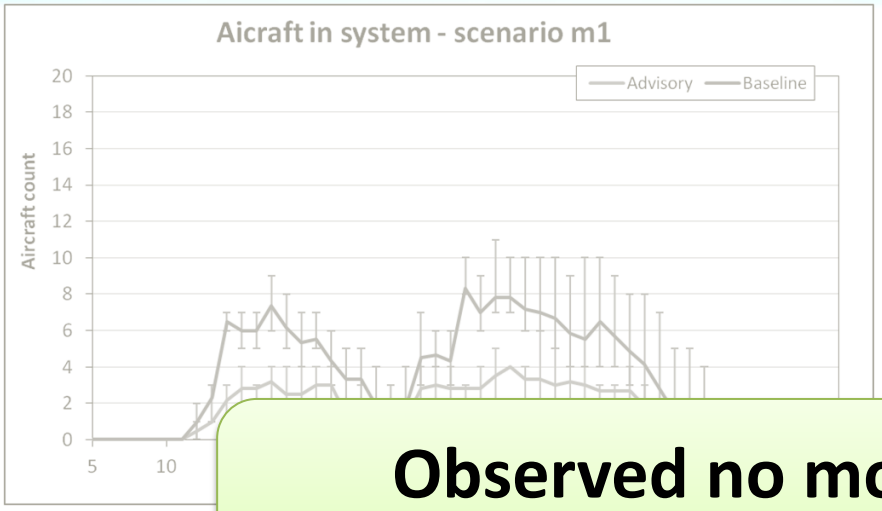
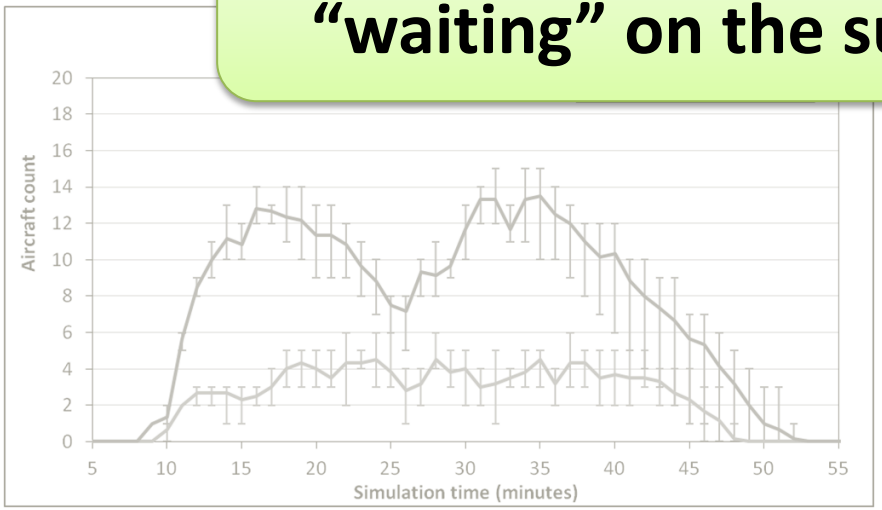
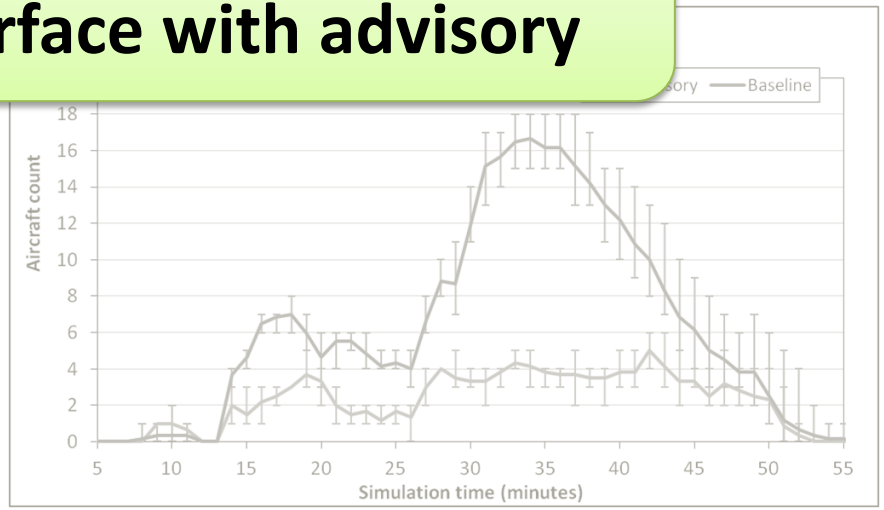
Gate Holding Effect



Observed no more than 6 aircraft "waiting" on the surface with advisory





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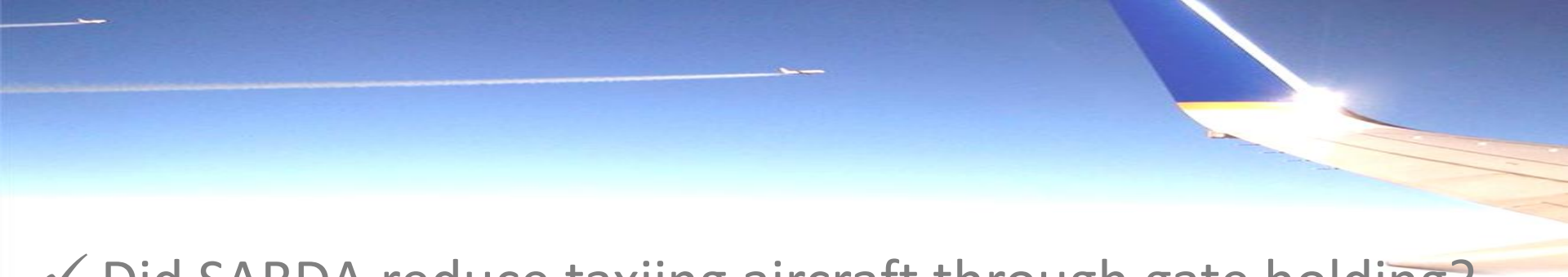


✓ Did SARDA reduce taxiing aircraft through gate holding?

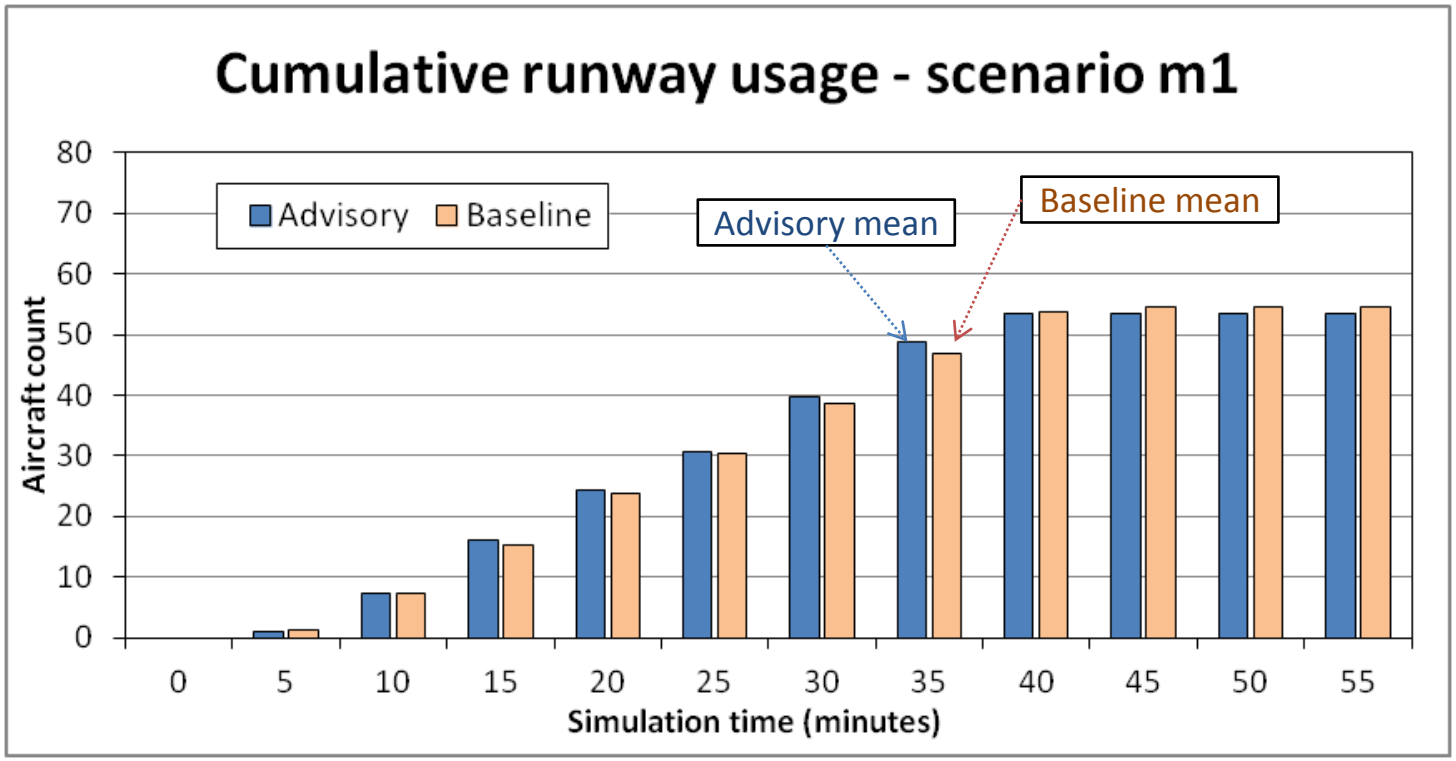
- Was there any loss in runway usage due to holding?
- What are the benefits?

Runway Usage Comparison

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

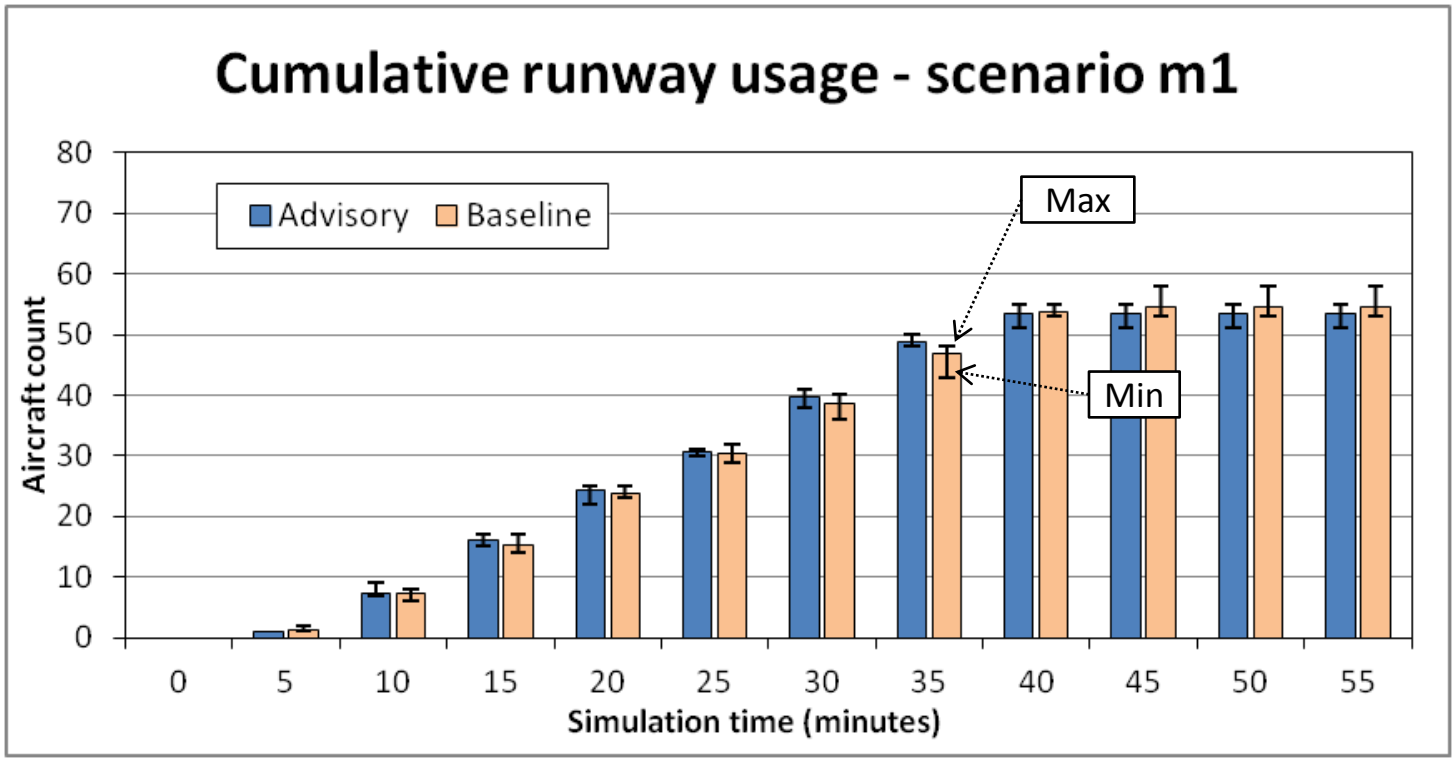
- Expectation: No reduction in runway usage with advisory

Runway Usage Comparison



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

Runway Usage Comparison



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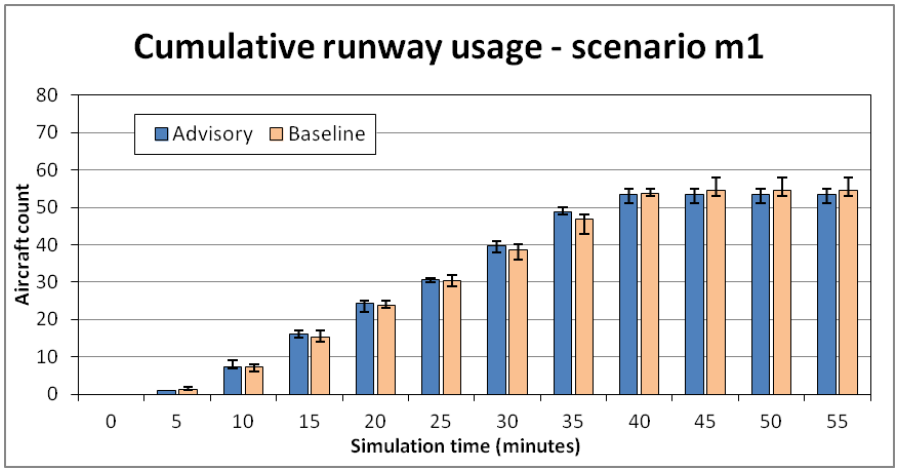

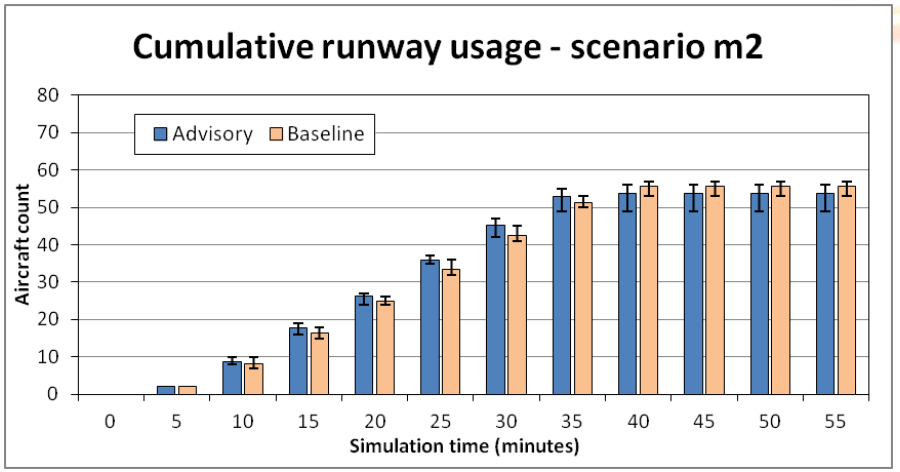

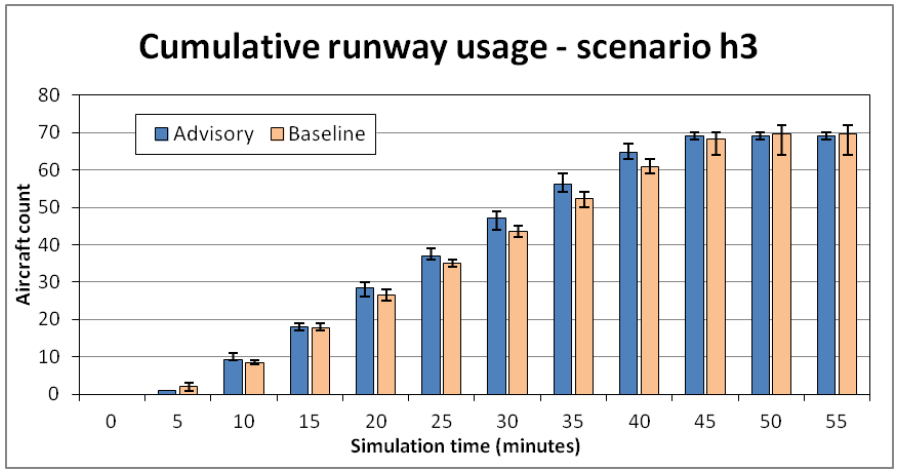

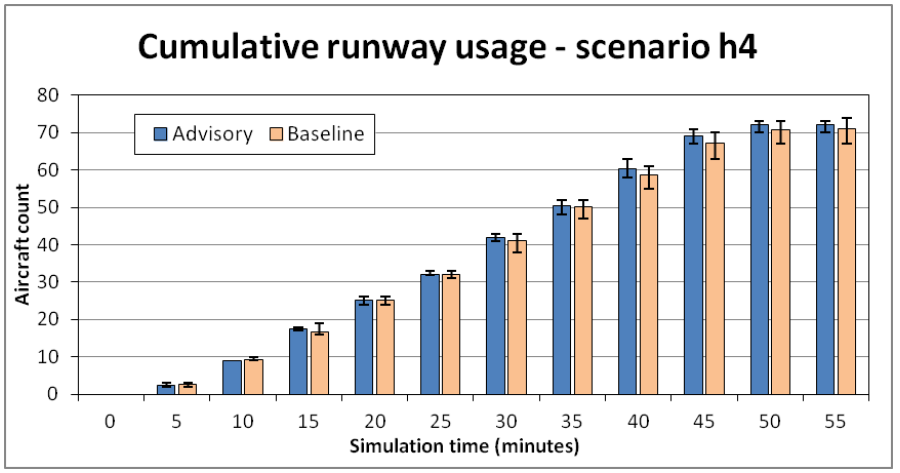

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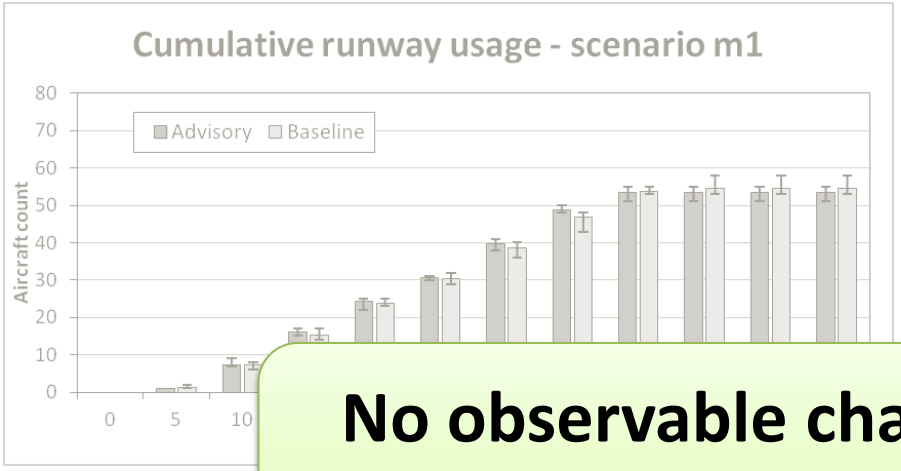
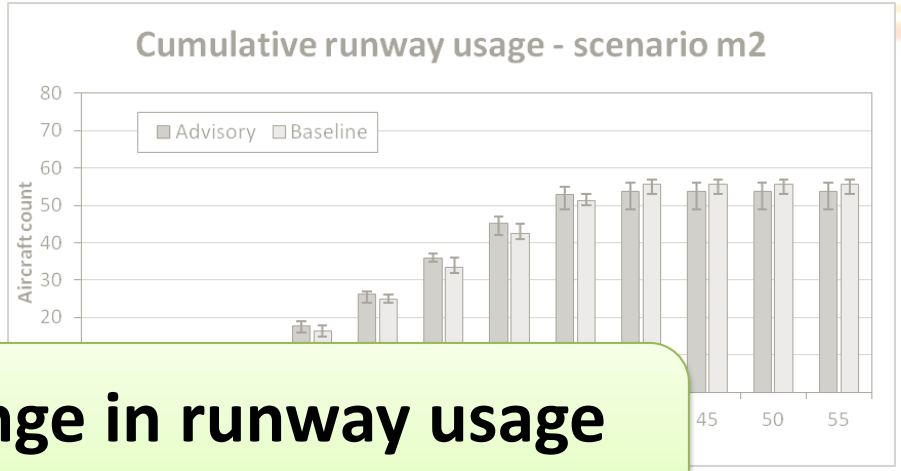
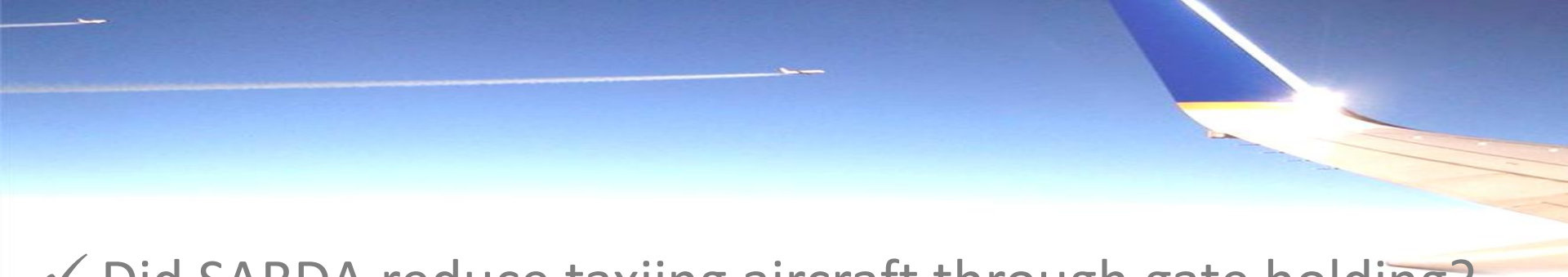




No observable change in runway usage with SARDA advisory

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



✓ Did SARDA reduce taxiing aircraft through gate holding?

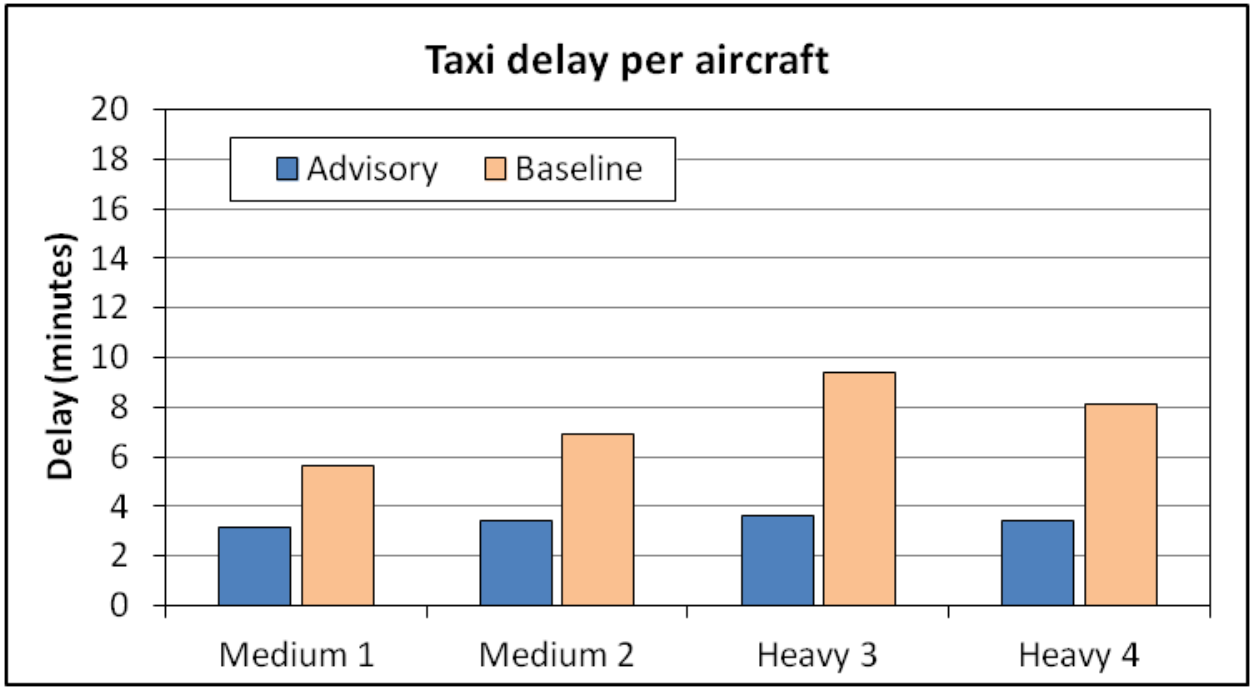
✓ Was there any loss in runway usage due to holding?

- What are the benefits?
  - Taxiing delay reduction
  - Potential fuel savings

Delay

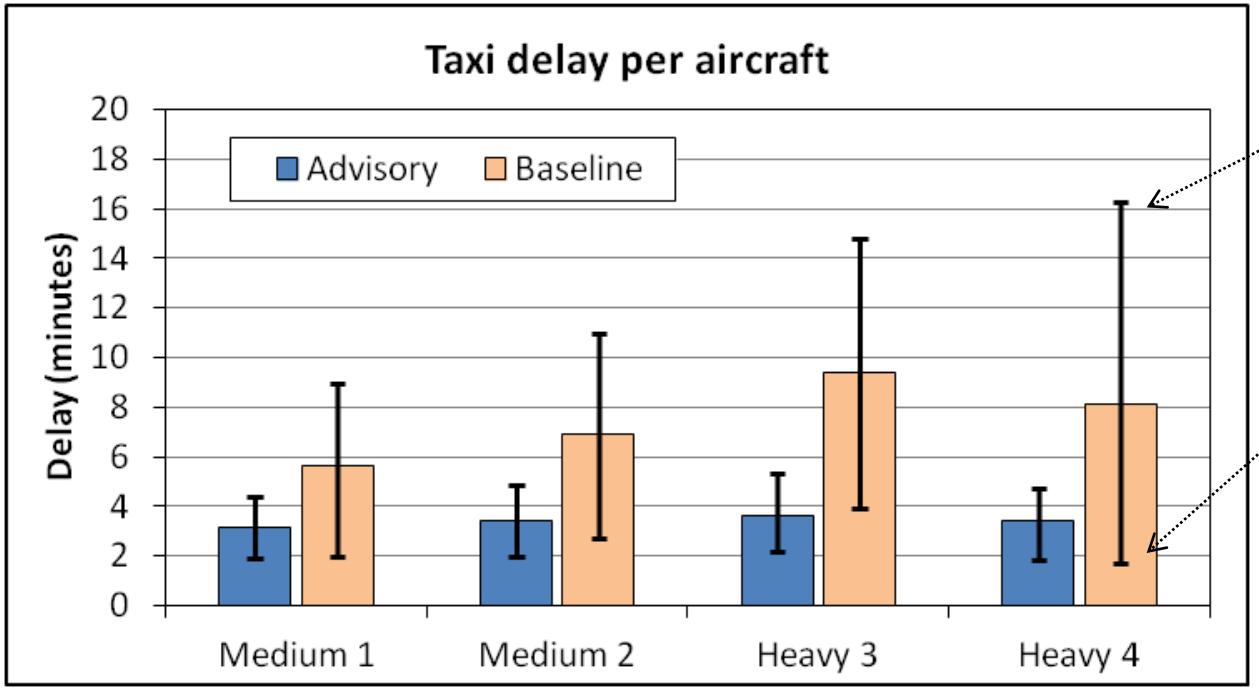
- Delay definition
  - (Observed time – unimpeded time)
  - Unimpeded taxi time: time to travel on that route (gate-spot-queue combination) at 17 knots without stops
  - Unimpeded definition different from ASPM
- Taxiing delay: Delay in ramp, taxiways, queues and runway

Taxiing Delay for Departures (ramp, taxiway, queue)



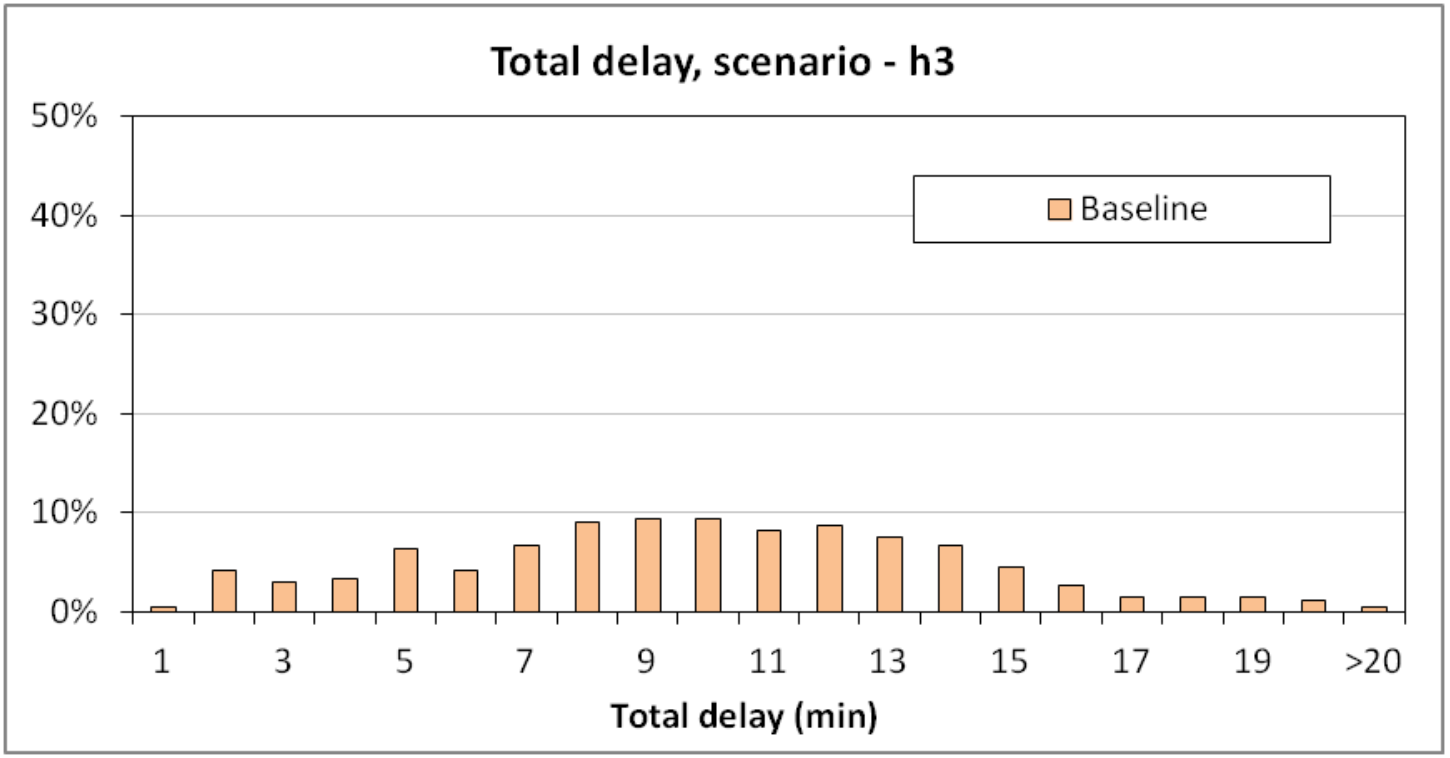
3 min reduction in medium (45%)
5.5 min reduction in heavy (60%)

Taxiing Delay for Departures (ramp, taxiway, queue)



Mean and percentile over all aircraft for that scenario

Taxi Delay - Distribution



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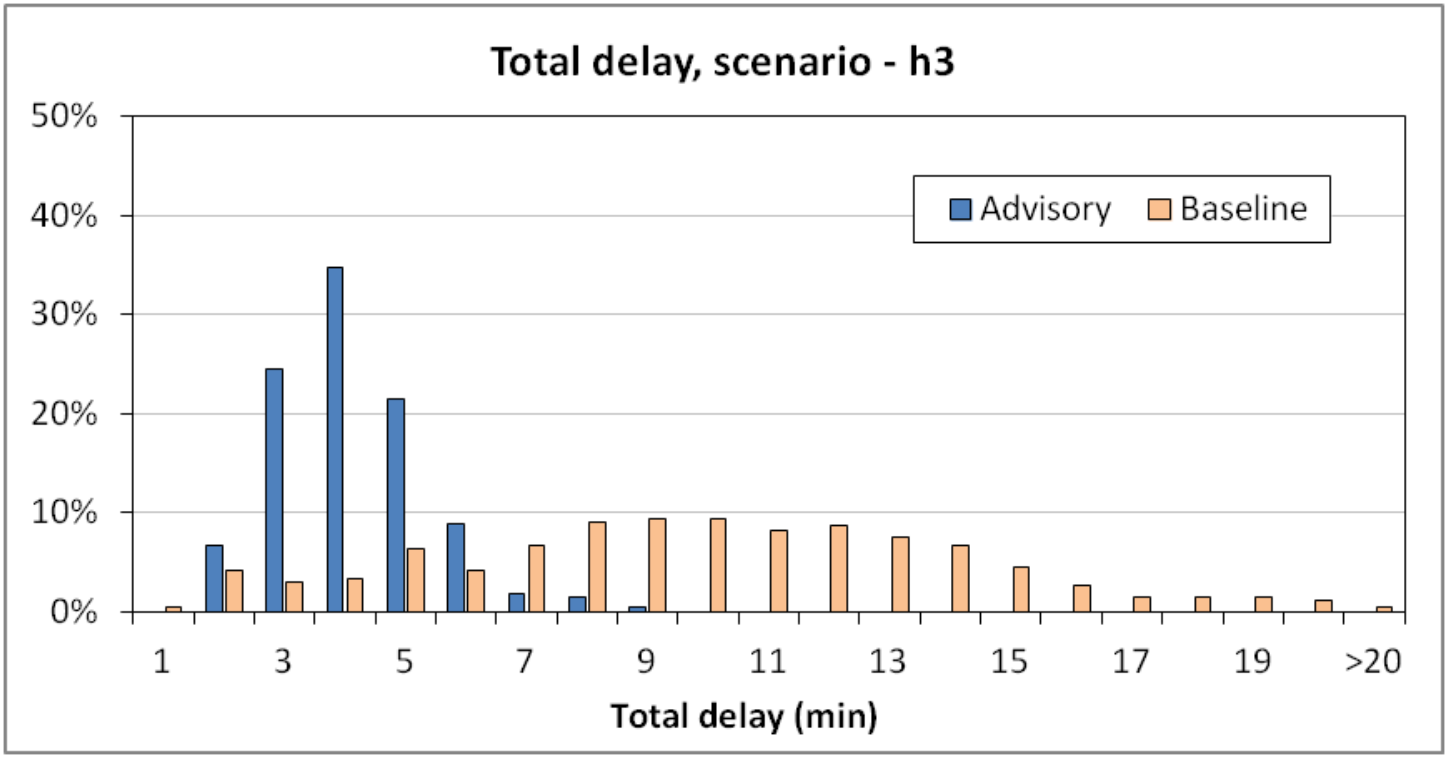
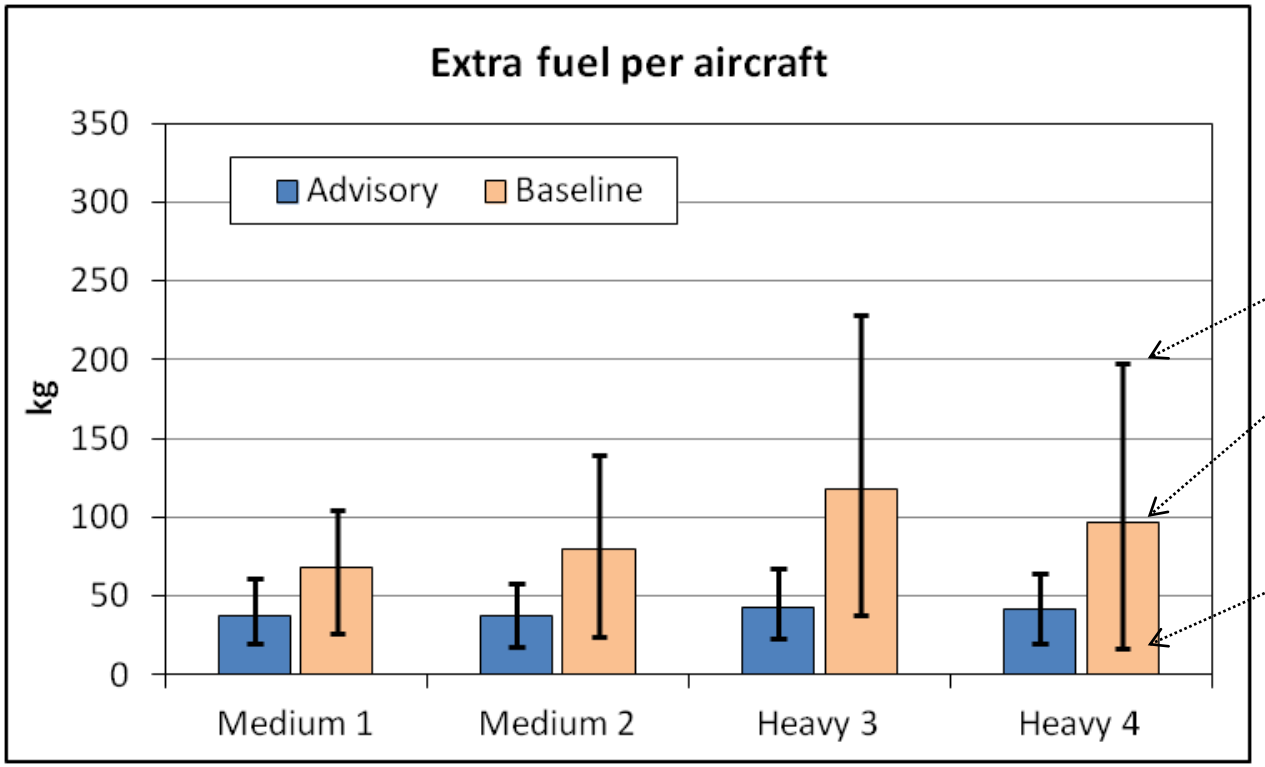


Large variation in delay in baseline

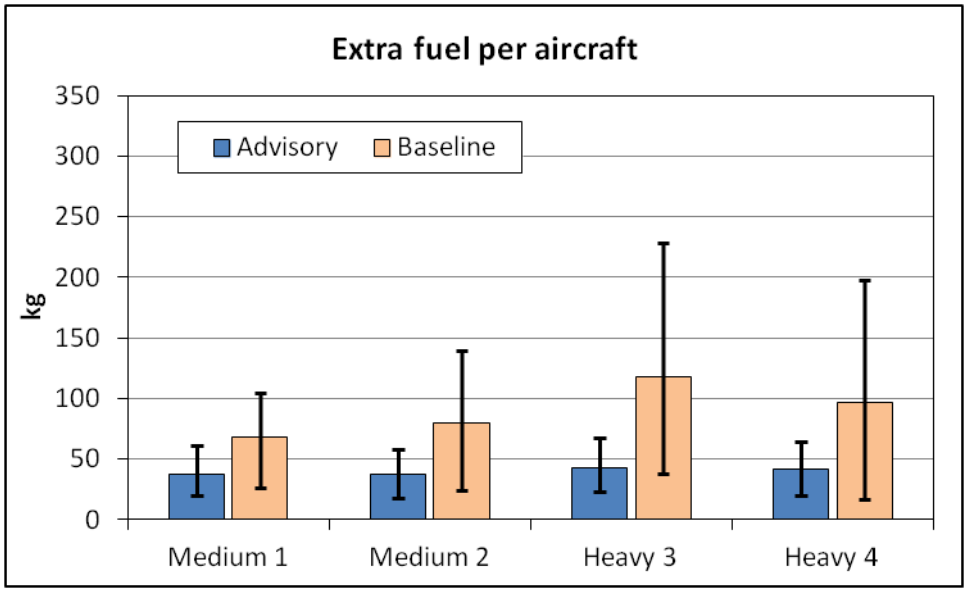
Fuel Consumption



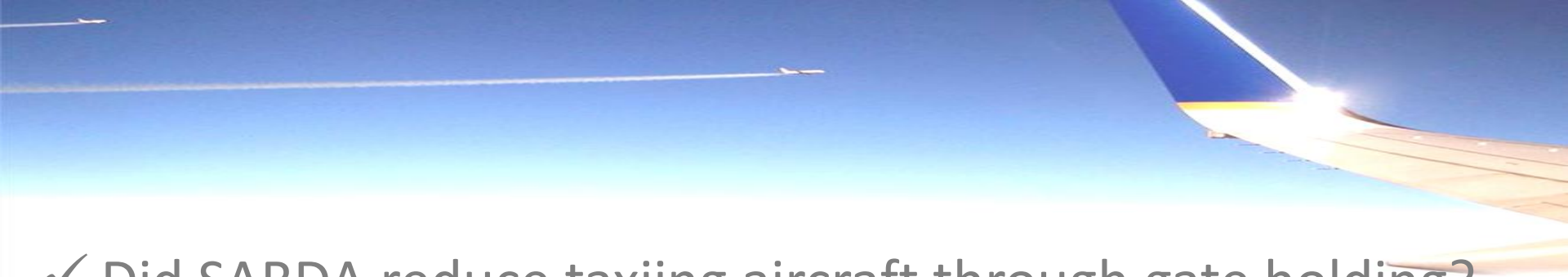
22% reduction in medium

34% reduction in heavy

Fuel Consumption



- 34% fuel savings = 70kg fuel per aircraft
- Daily operations: 6 peak periods of 50 aircraft each
- At $3/gallon, annual savings: 6 million USD



✓ Did SARDA reduce taxiing aircraft through gate holding?

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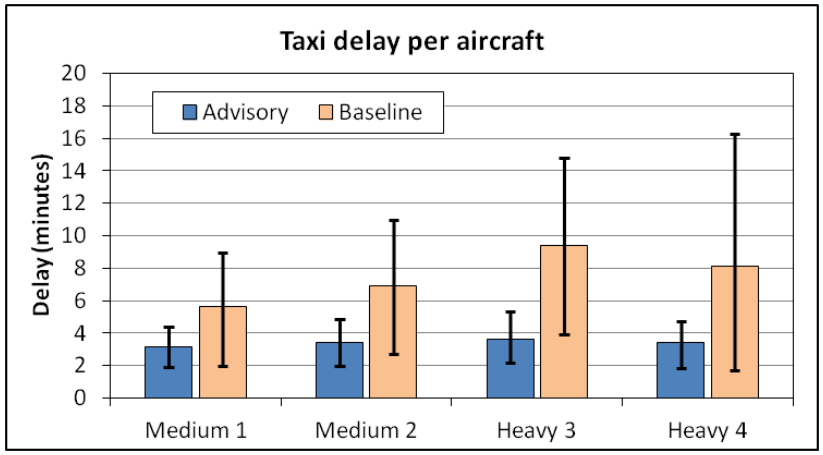
- What are the benefits?
  - Taxiing delay reduction
  - Potential fuel savings
  - TMI (Traffic Management Initiatives)

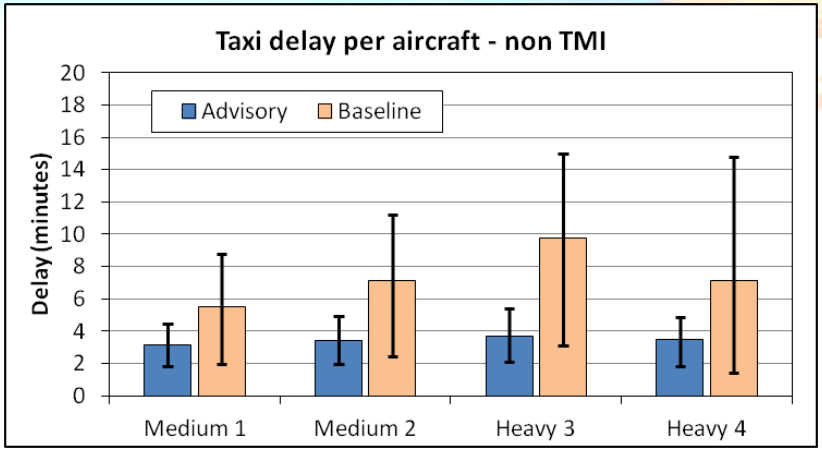
TMI

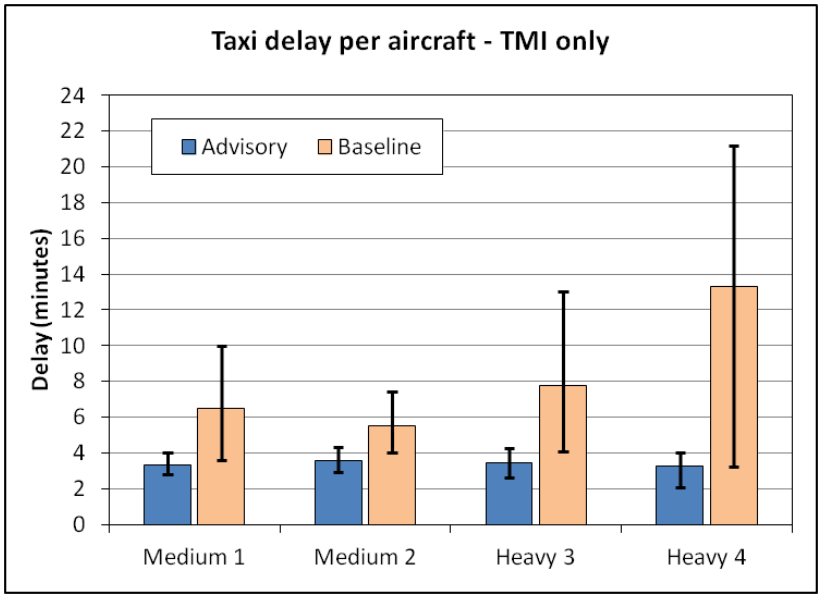
- Details
  - Each TMI aircraft has a scheduled take-off time (displayed in Electronic Flight Strips)
  - Aircraft should take off within 1 minute before or 1 minute after this time
  - If cannot be done, release as close to time as possible (no new TMI time issued)
- Compliance?

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

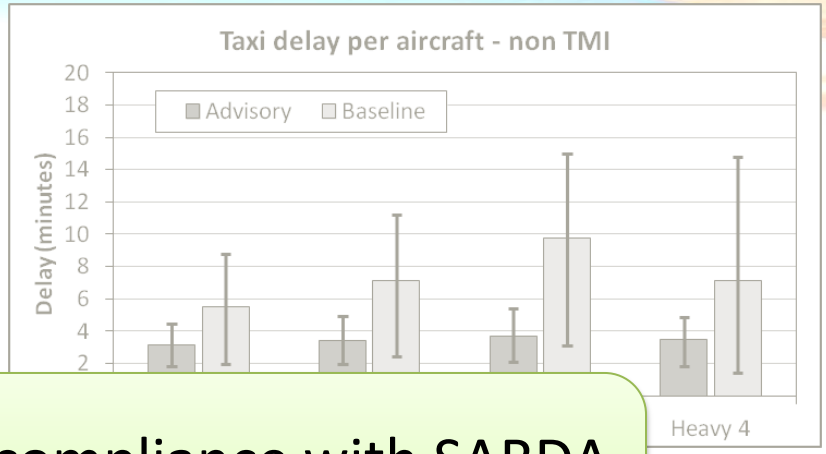
TMI


Taxi delay per aircraft
Delay (minutes)
0
2
4
6
8
10
12
14
16
18
20
Advisory
Baseline
Medium 1
Medium 2
Heavy 3
Heavy 4

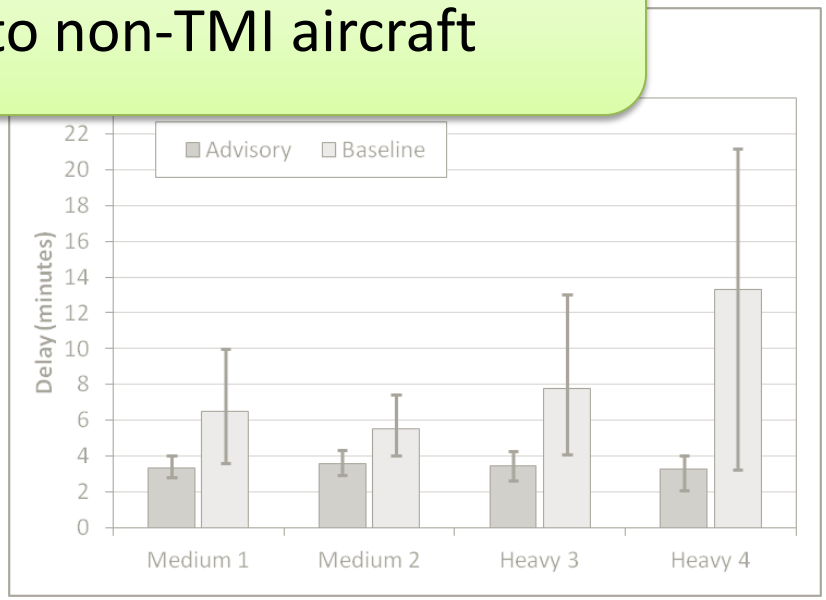

Taxi delay per aircraft - non TMI
Delay (minutes)
0
2
4
6
8
10
12
14
16
18
20
Advisory
Baseline
Medium 1
Medium 2
Heavy 3
Heavy 4

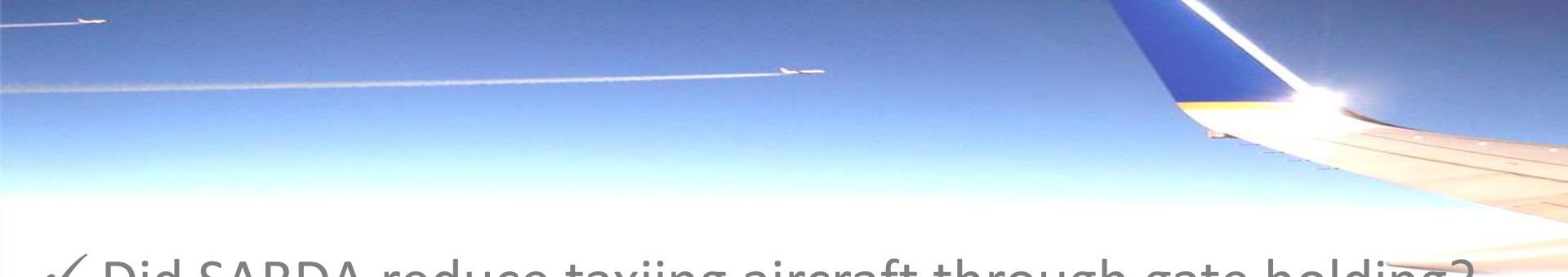

Taxi delay per aircraft - TMI only
Delay (minutes)
0
2
4
6
8
10
12
14
16
18
20
22
24
Advisory
Baseline
Medium 1
Medium 2
Heavy 3
Heavy 4

TMI



No observed change in TMI compliance with SARDA but TMI delays similar to non-TMI aircraft





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- What are the benefits?
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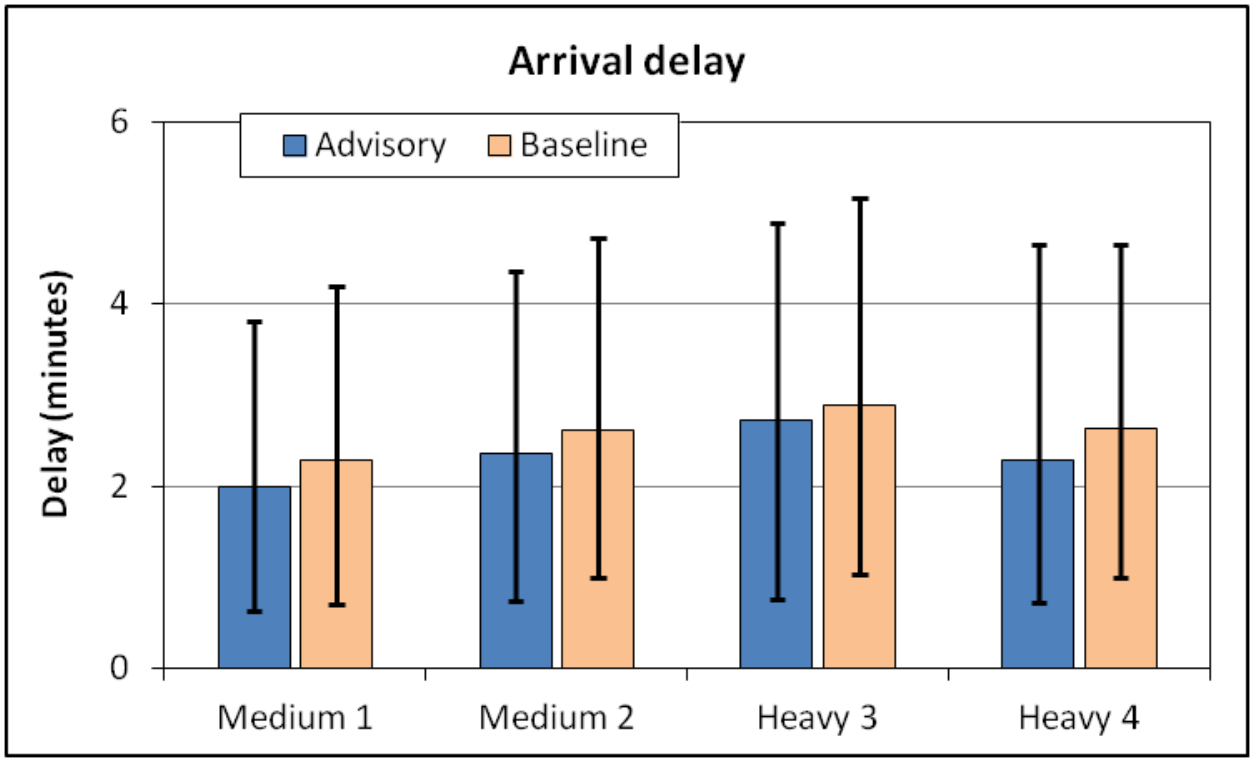
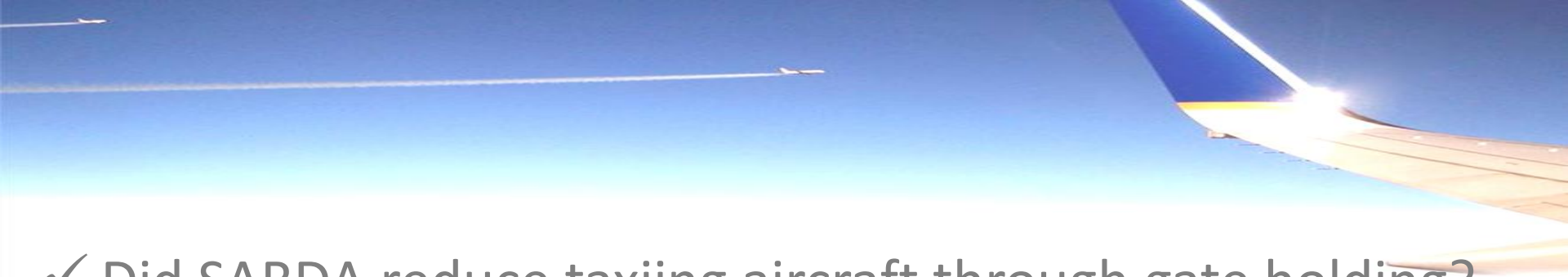
  - Potential fuel savings
  - TMI (Traffic Management Initiatives)
  - Effect on arrivals

Arrival Delay



No observed effect on arrival aircraft



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  - TMI (Traffic Management Initiatives)
  - Effect on arrivals
  - Uniform system performance

Uniform System Performance

- SARDA advisories seem to make system performance
  - Uniform across different traffic levels

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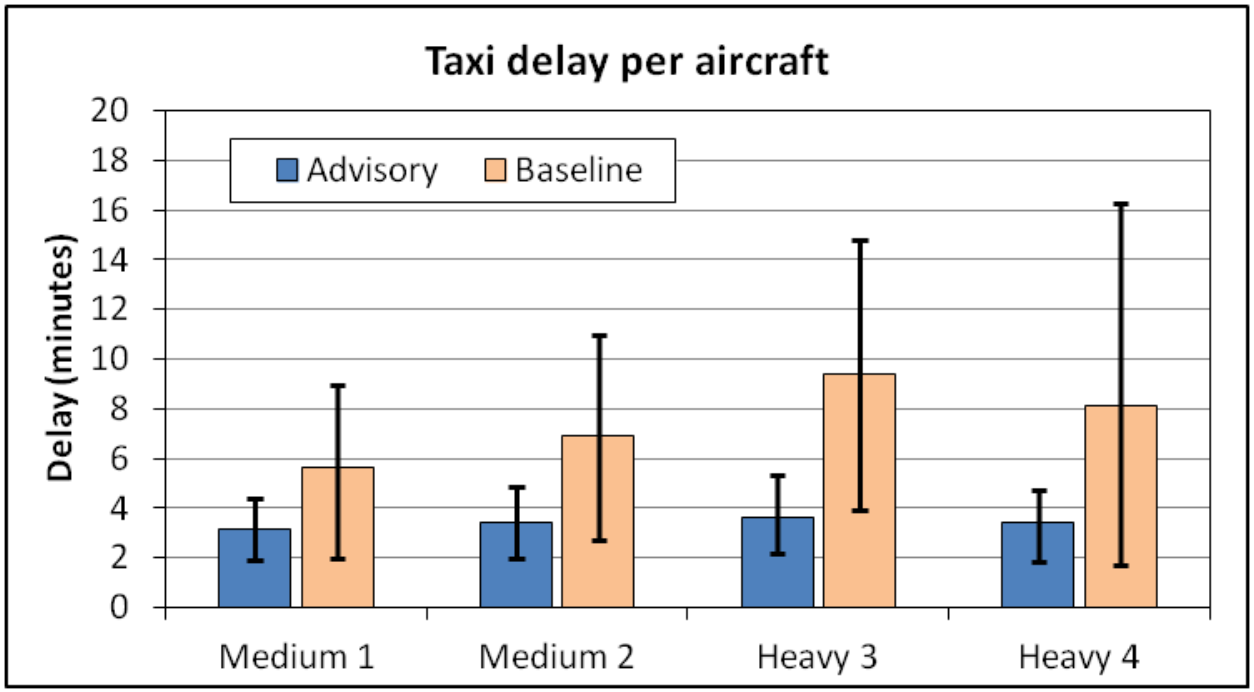

Uniform System Performance

- SARDA advisories seem to make system performance
  - Uniform across different traffic levels
  - Uniform across different controllers

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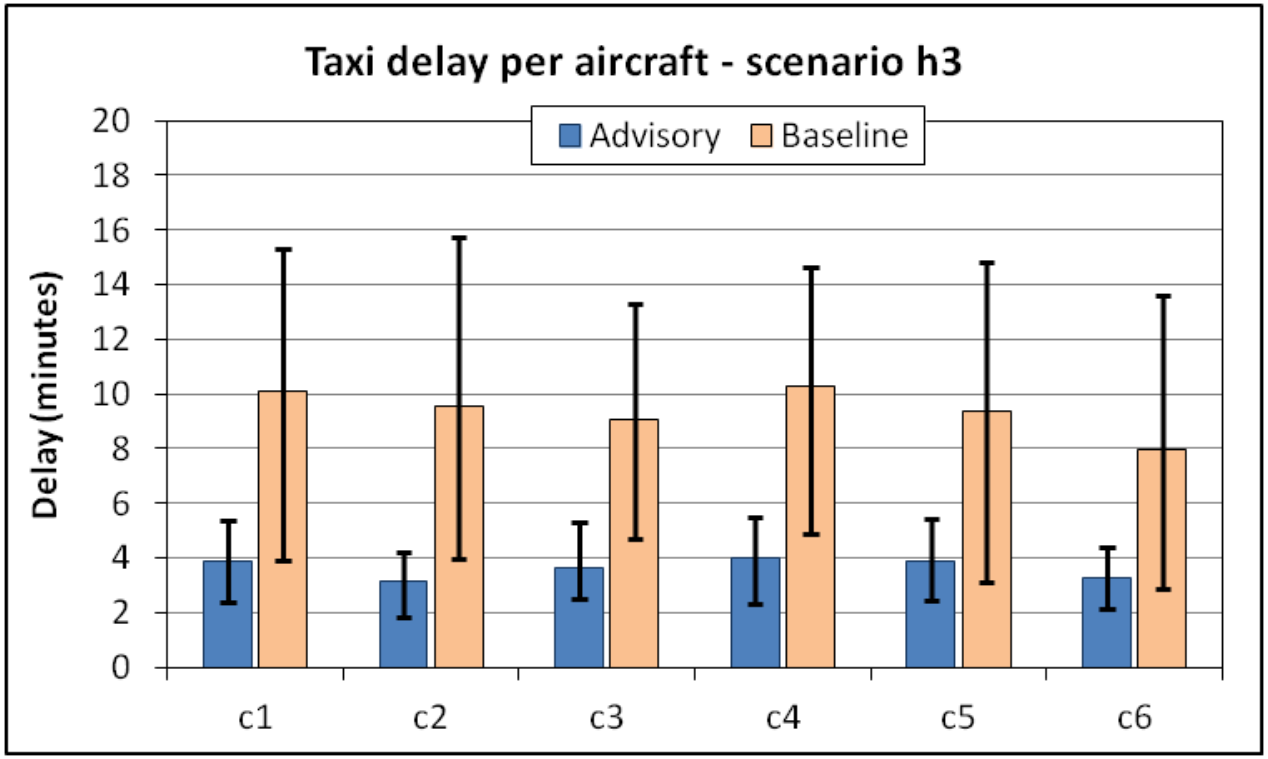
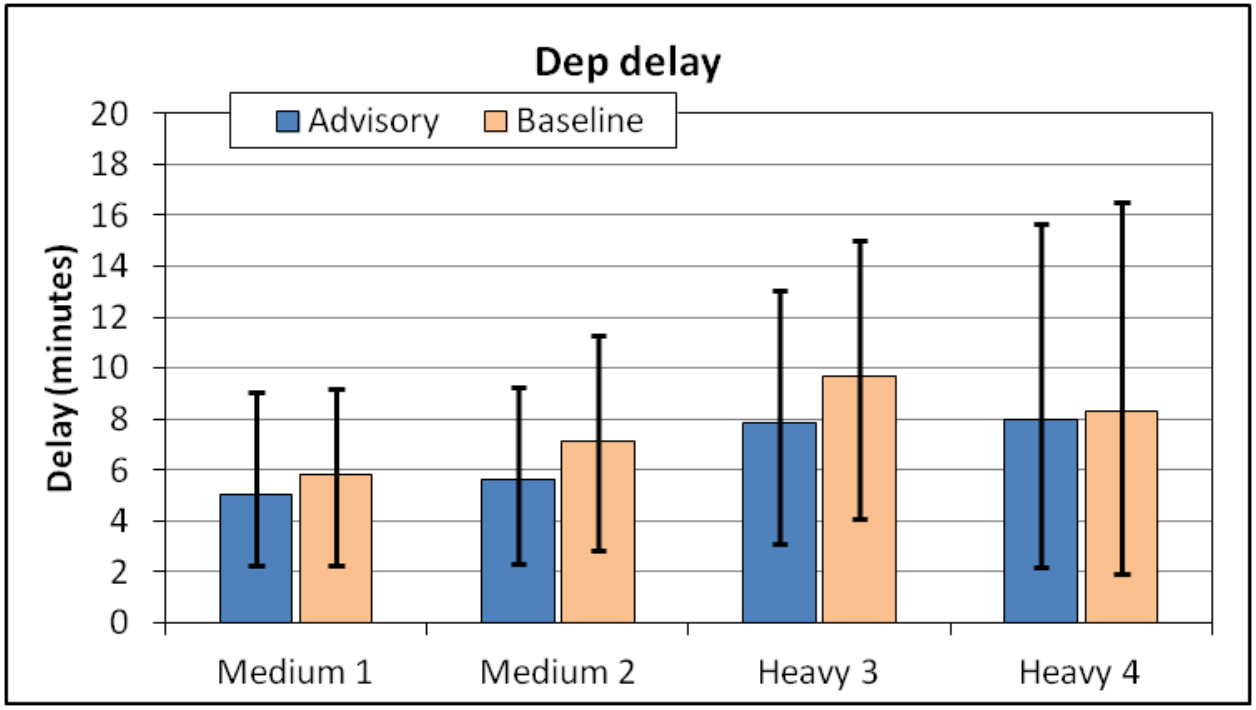


Summary

- Observations from SARDA experiment
  - Reduced delays (60%)
  - Reduced fuel (34%)
  - No observed change in runway usage
  - Reduced variation in system performance
- Lastly……

Effect on Individual Aircraft

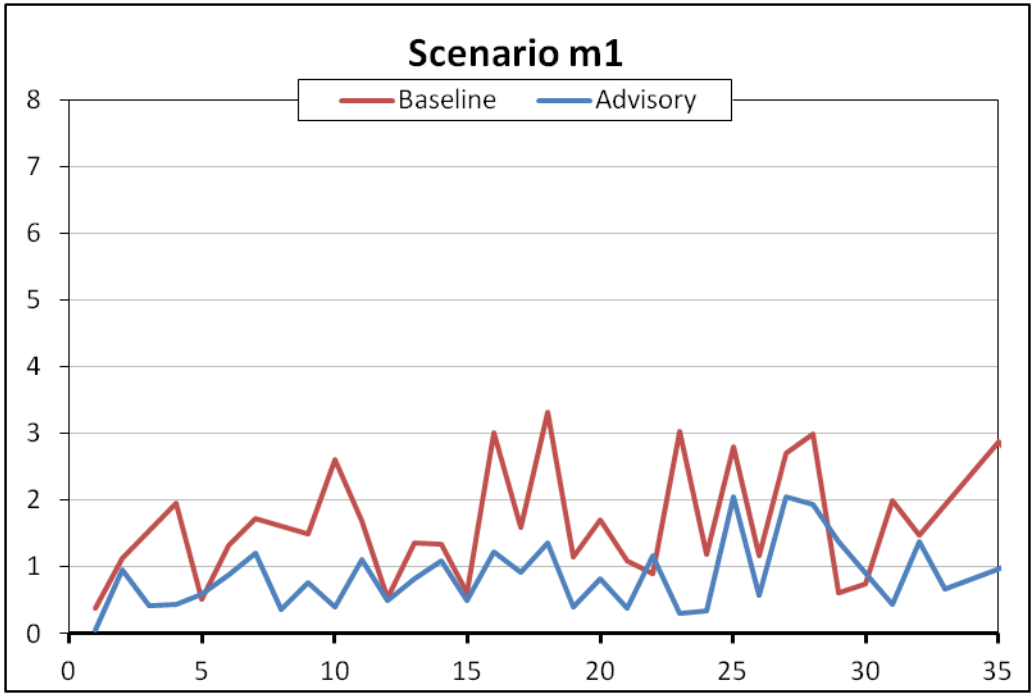
- SARDA gate holding: moves delay from runway to gate
  - Departure delay: Delay from scheduled wheels-off time



Effect on Individual Aircraft

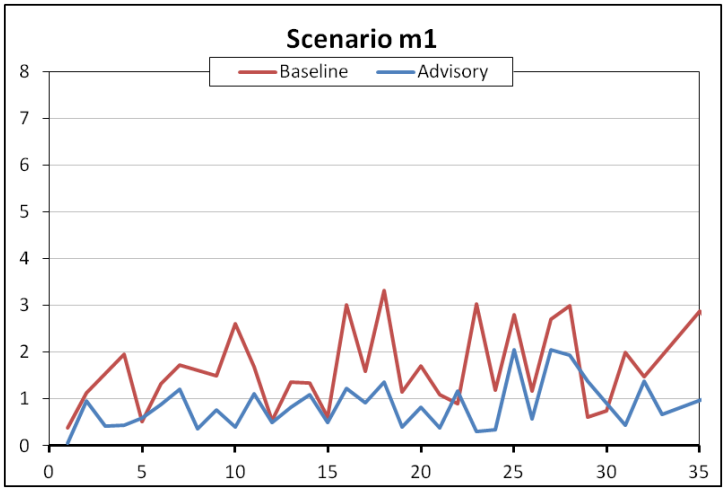
- SARDA gate holding: moves delay from runway to gate
- Effect on individual aircraft take off time?
  - 6 runs per scenario in baseline and advisory
  - Std deviation of aircraft take off times over 6 points

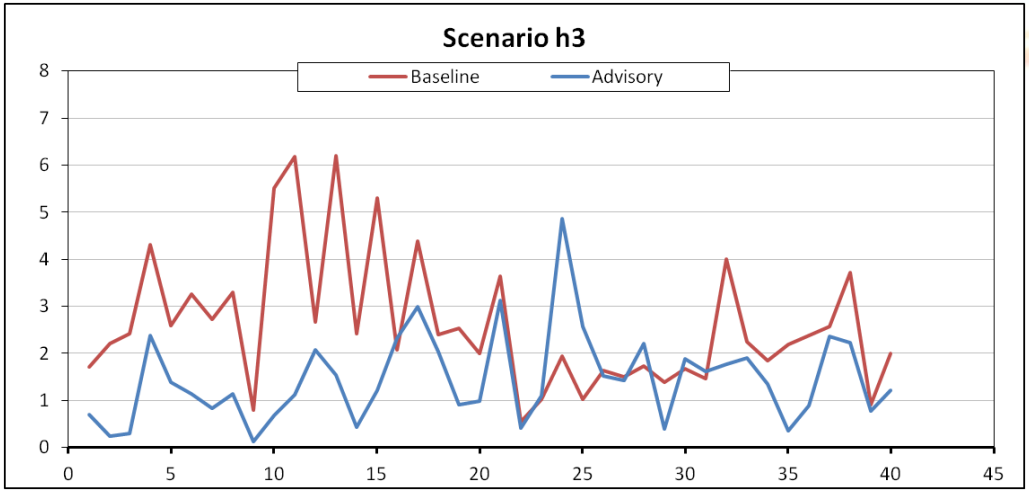
Std Dev in aircraft take-off times (min)

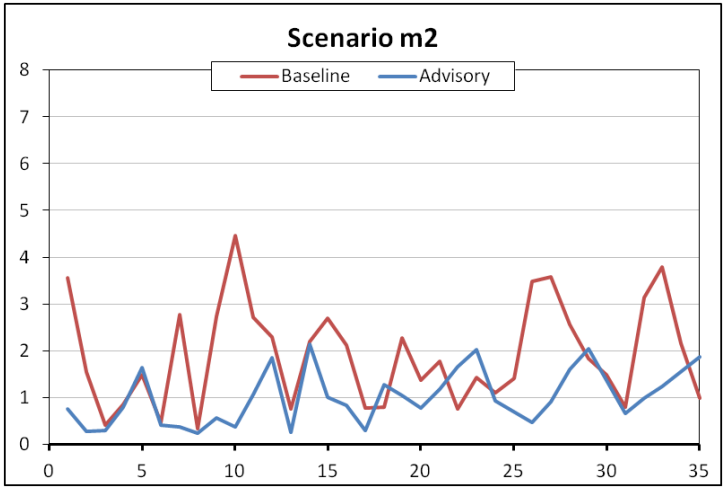


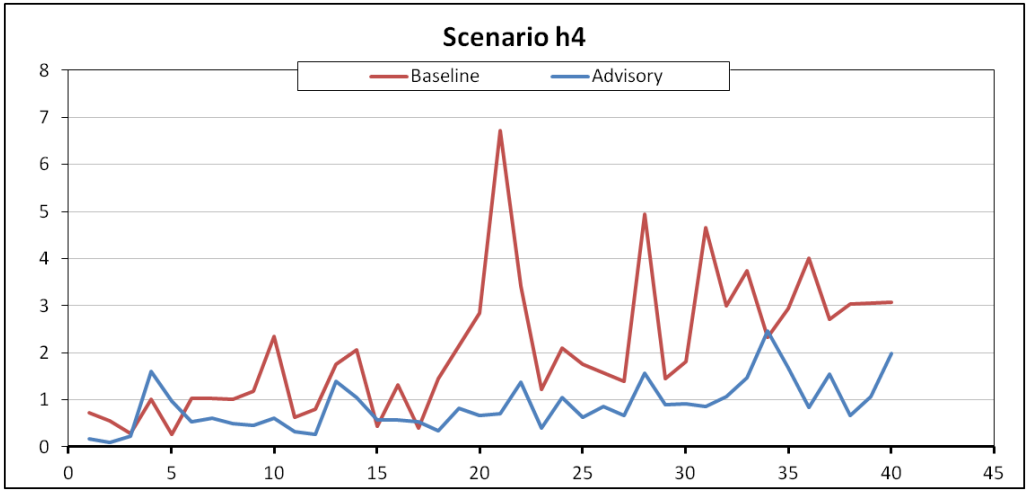
Numeric Aircraft ID

Effect on Individual Aircraft

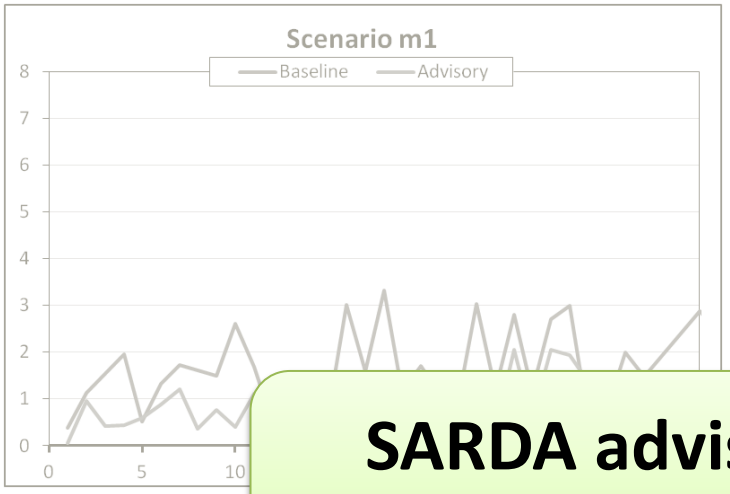


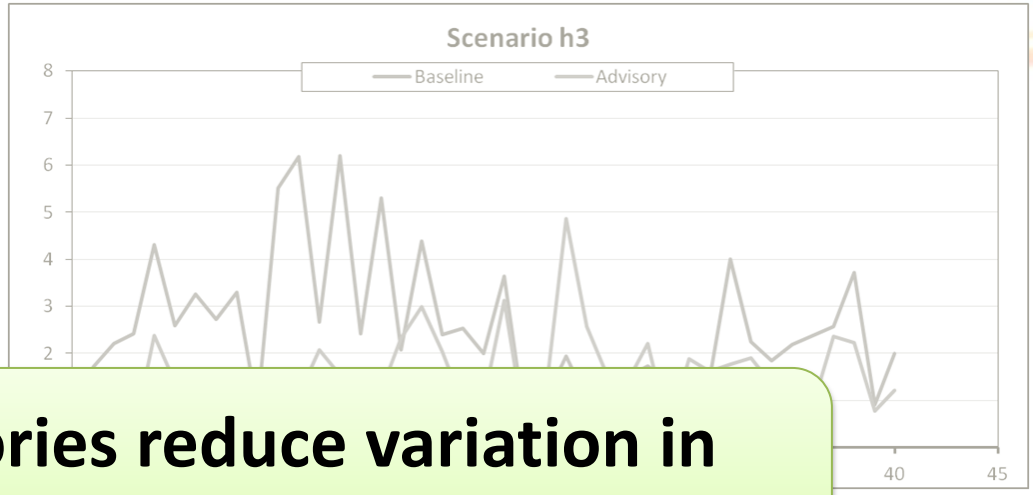






Effect on Individual Aircraft





SARDA advisories reduce variation in individual aircraft take off times