

Runway Pressure Research

*The effect of en-route delay absorption
on the runway throughput*

by

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Agenda

- Introduction and background
- Goals of the research
- Simulation set-up
- Results
- Conclusions & recommendations

Introduction

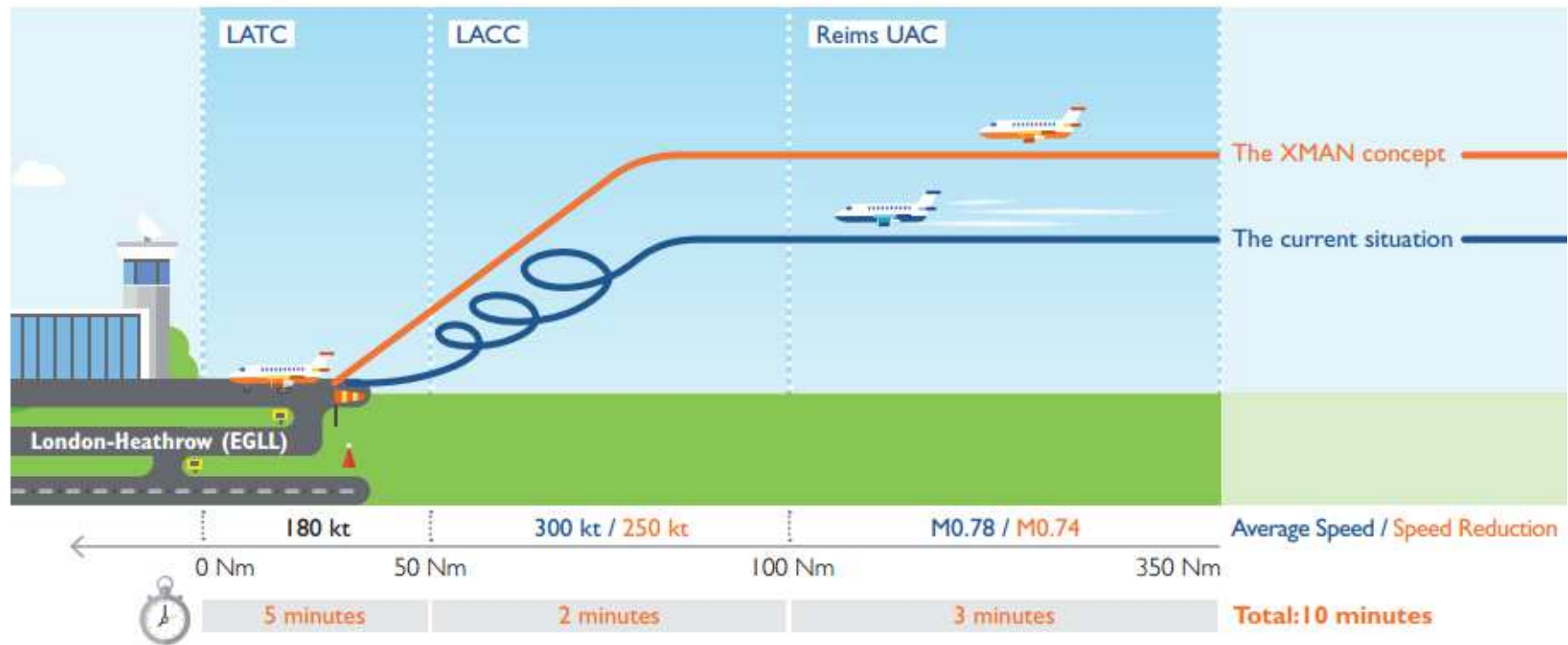
Cross Border Arrival Management (XMAN)

- Trials started in 2014 for London Heathrow
- Deployment expected for Paris Charles de Gaulle, Frankfurt, Munich and Amsterdam Schiphol airport
- Shift delay absorption from approach to cruise phase
- Reduce waiting time in holding and lower airspace
- Benefits: decreased fuel consumption and lower emissions



Introduction

The XMAN Heathrow trials: the delay sharing strategy between London Terminal (LATC), London ACC (LACC) and Reims UAC (En-route)



Delays generated to slow down aircraft are not counted as ATFCM delays.

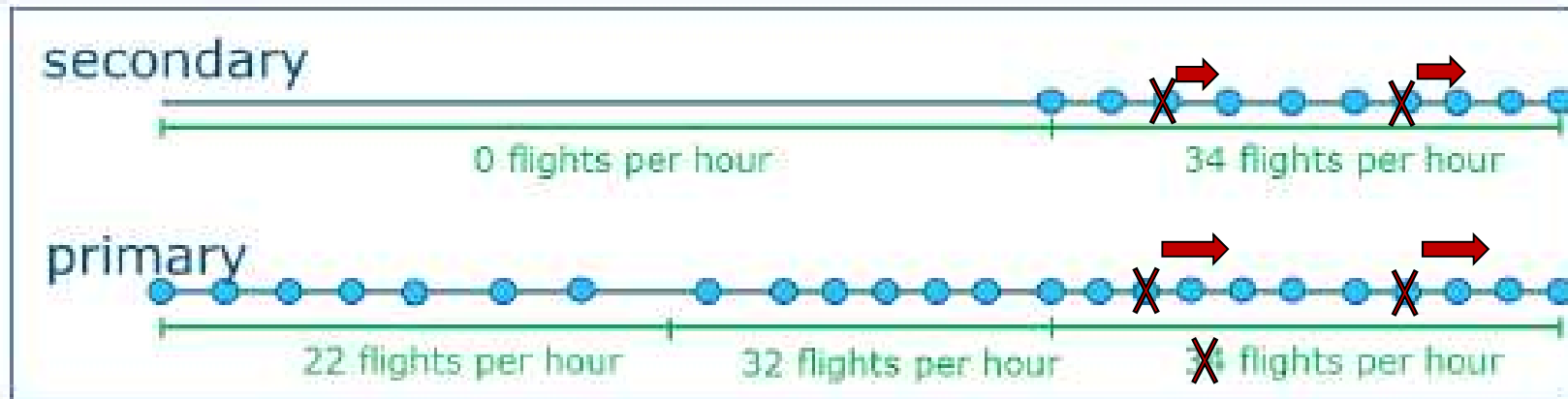
Source: DSNA/NATS XMAN folder – March 2015

Introduction

What if aircraft arrive too late at the Initial Approach Fix (IAF)?

- Gaps in the landing interval
- Less landings per hour
- Decreased runway efficiency

Flights are delayed such that they match current landing capacity.



Source: AIRE trial document

Introduction

Solution:

Maintain a minimum amount of delay for APP controller to absorb

➡ **Runway Pressure**

“The Runway Pressure is defined by the amount of delay that shall be left for the approach controller to be absorbed.”

This is to guarantee an optimum use of the runway and avoiding ‘holes’ in the sequence. This value may vary with *physical* parameters such as IAF, Runways in use, Type of Aircraft, Wind, etc.

However: No research performed on this topic

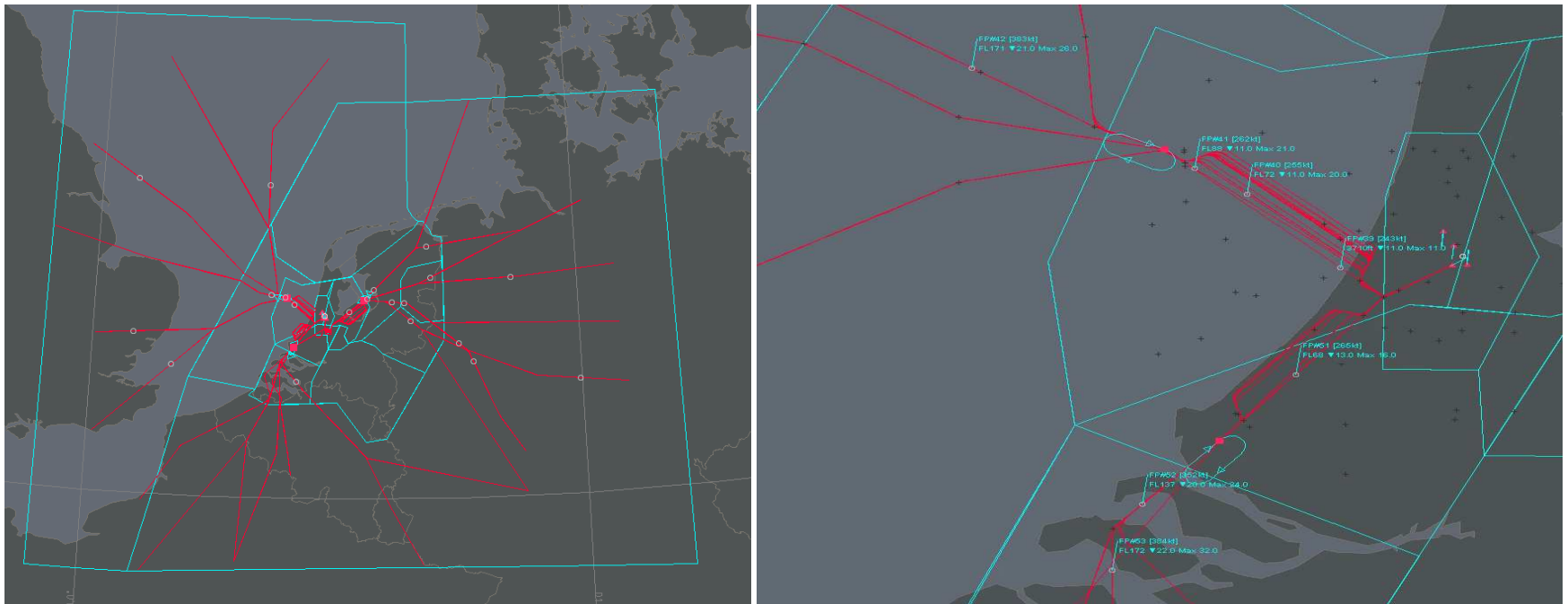
Goals of the Research

Main research question:

"What is the effect on the actual runway throughput of an airport if the delay in the TMA is shifted towards the en-route phase?"

Simulation set-up

AirTOp software: license provided by To70



Simulation set-up

1. Design simulation environment
2. Verification/validation of the model with actual flight data
3. Create simulation scenarios to answer research question(s)
4. En-Route Delay Absorption (ERDA) algorithm

Simulation set-up

Design simulation environment

Implement significant rules and approach procedures

- Approach paths, altitude and speed ranges
- Time based separation matrix
- Runway maximum arrival rate (34 landings per hour)

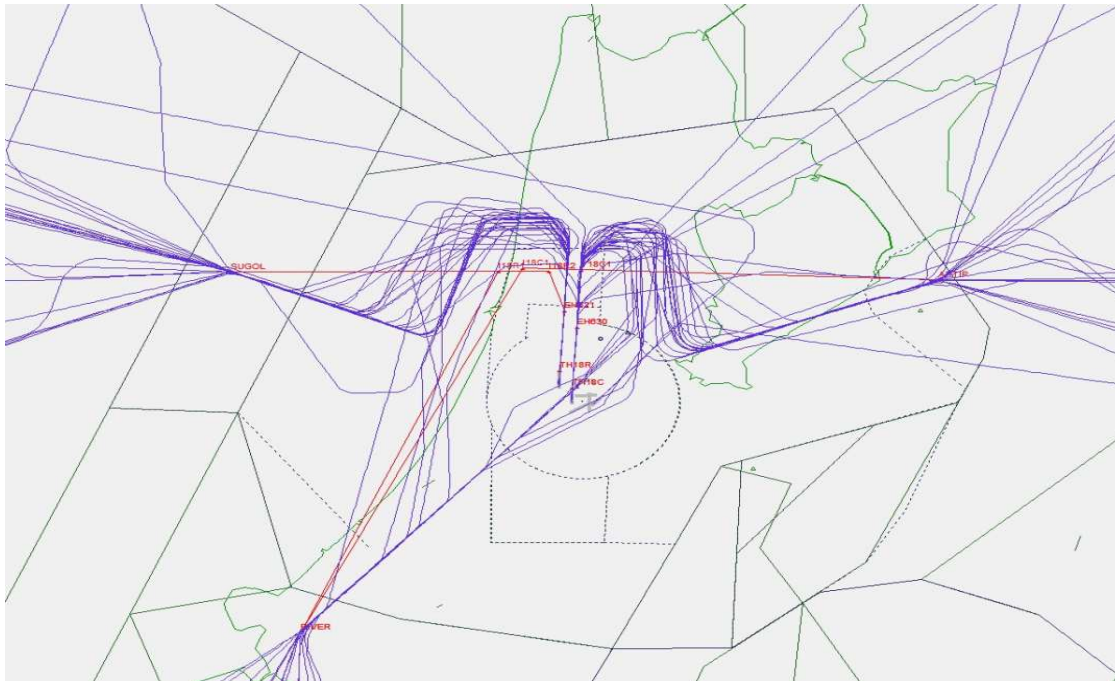
Create traffic flight plans

- Various aircraft types and fleet mix (Medium, Heavy, Super)
- Aircraft perf: BADA files
- Reference time at the IAF (± 30 s)

Simulation set-up

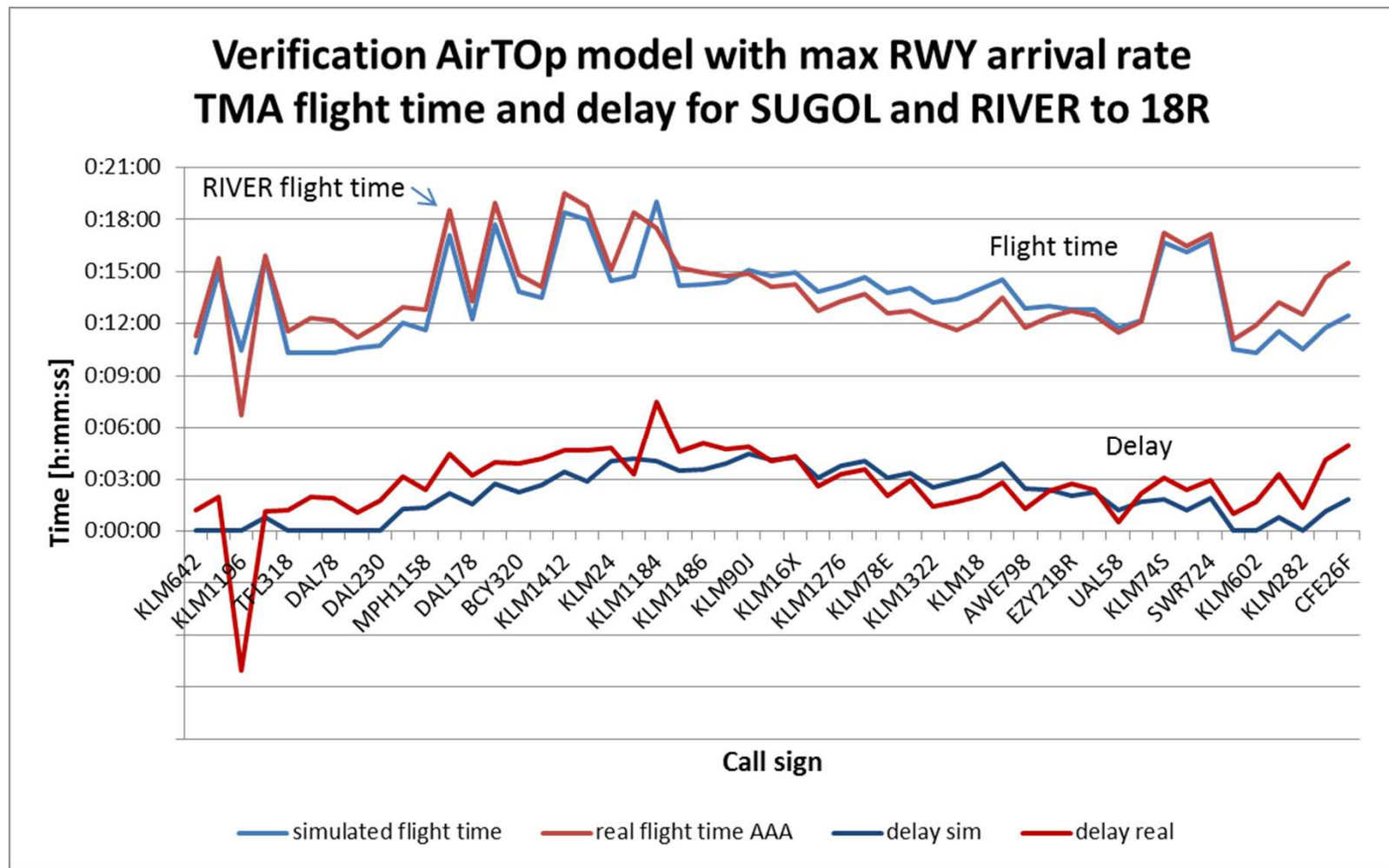
Verification of the model

- Data from actual traffic radar tracks (28-05-2014)
- Used ATO @ IAF as reference time flight plan
- Compare TMA flight time and delay



Simulation set-up

Verification of the model



Simulation set-up

Variables for scenarios

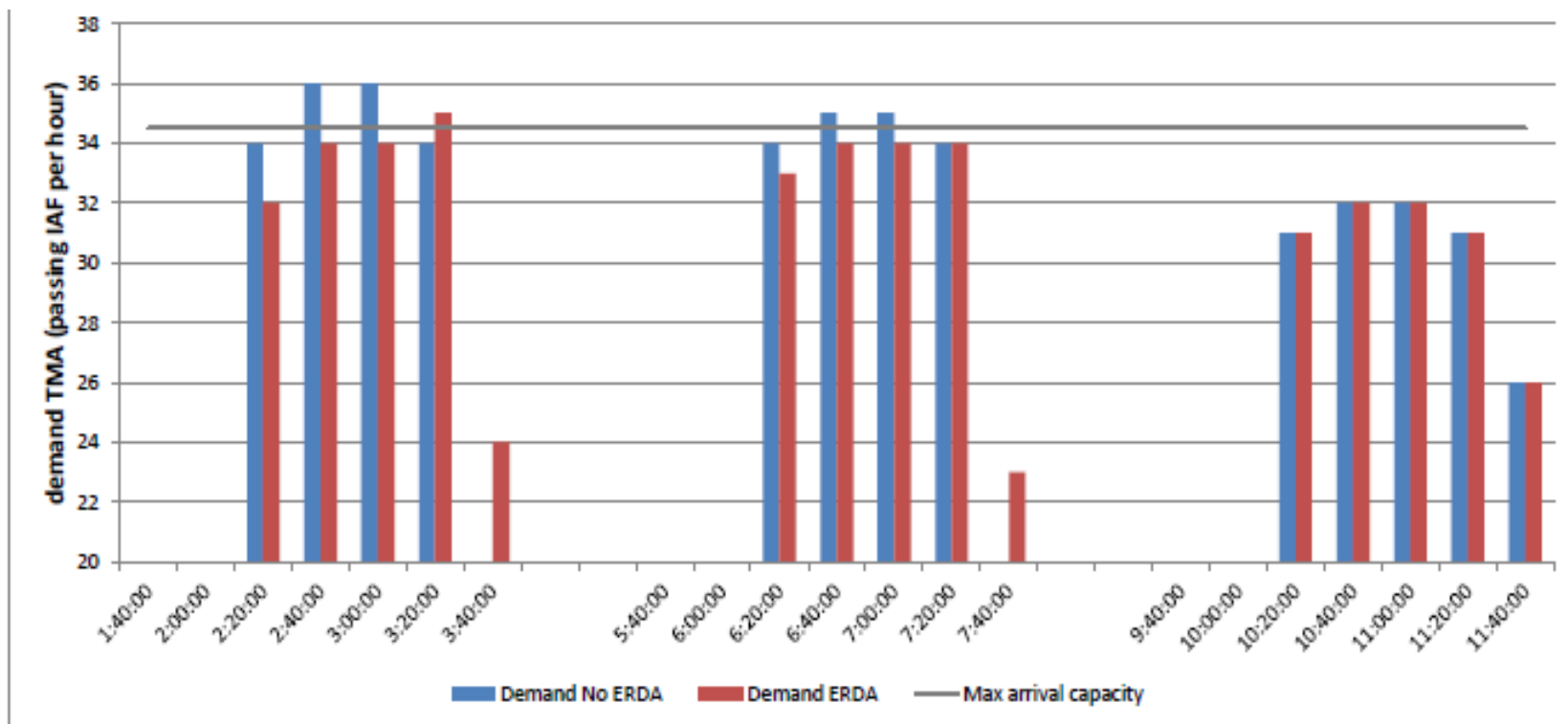
- Fleet mix based on actual inbound peaks
 - Morning peak: 7 heavy, 25 medium jet and 2 turboprop per hour
 - Evening peak: only medium jets + 2 turboprop per hour
 - Future: 1 super (A380) per hour, no turboprop
- 2 approach scenarios in TMA
 - 1 IAF to 1 runway
 - 2 IAFs merge to 1 runway
- 3 demand profiles : 68 aircraft per inbound peak of 2 hours

Time period [H:MM]	0:20	0:40	1:00	1:20	1:40	2:00	2:20
High demand	10	11	13	12	11	11	
Medium demand	11	11	12	12	11	11	
Low demand	10	10	11	11	10	10	6

Simulation set-up

Variables for scenarios

Demand for landing for future inbound peak fleet mix





Simulation set-up

En-route delay absorption

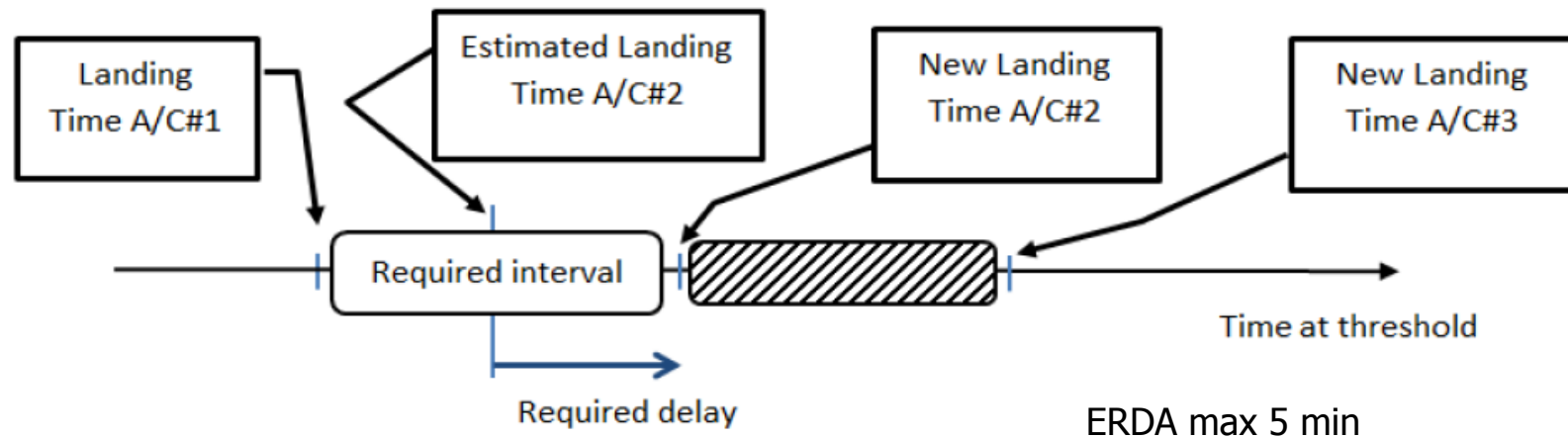
Simulate En-route delay absorption

How?

Modify the reference time at the IAF (CTO) to get the required interval at the IAF that matches runway capacity

Simulation set-up

En-route delay absorption



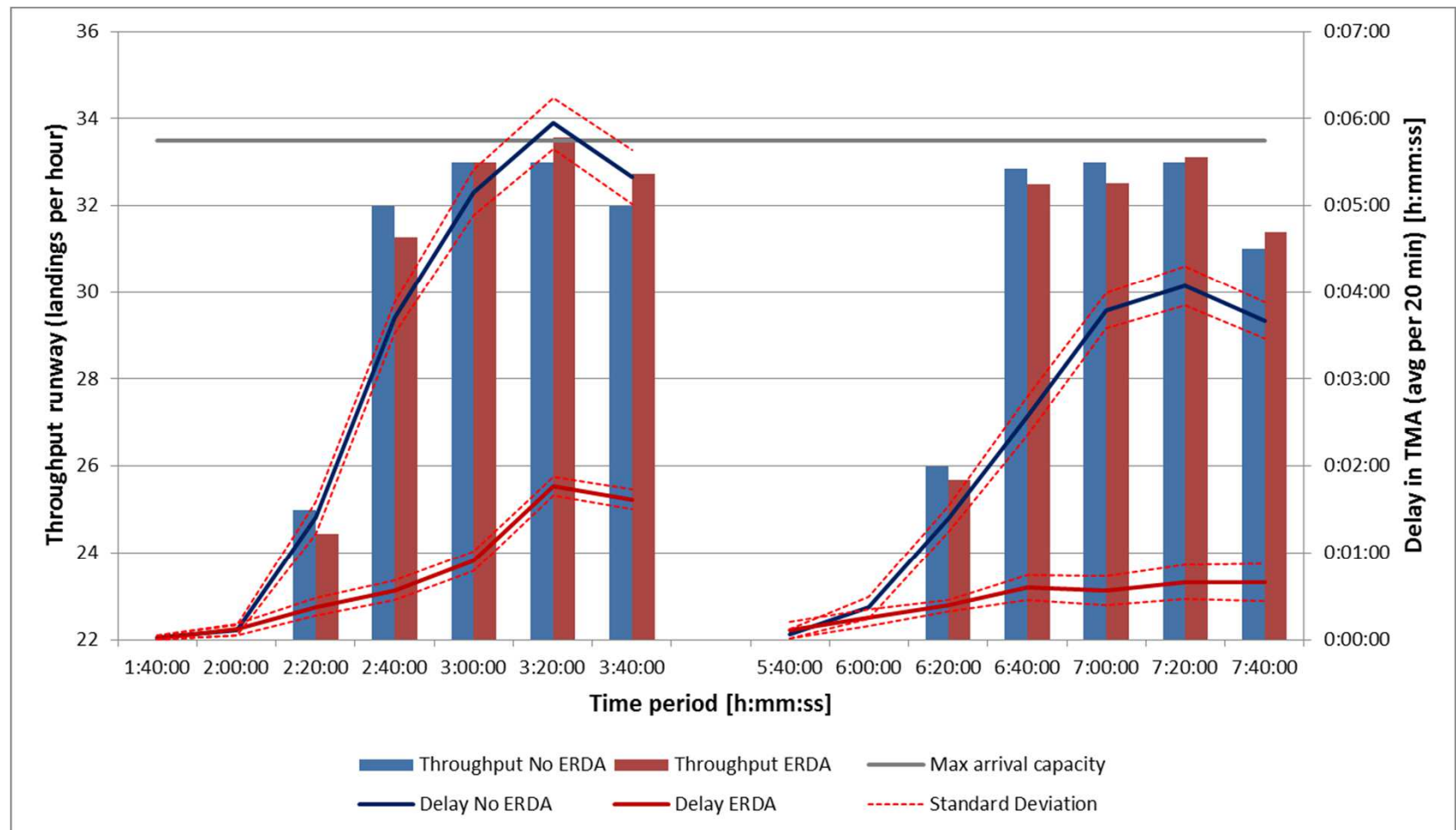
Sequence nr.	WTC	IAF	Initial ETA	Separation	Required separation	Difference	New ETA	New CTO IAF
14	SuperHeavy	SUGOL	10:17:43				10:17:43	10:07:10
15	Medium	SUGOL	10:19:43	0:02:00	0:03:00	-0:01:00	10:20:43	10:10:10
16	Heavy	RIVER	10:21:43	0:01:00	0:01:45	-0:00:45	10:22:28	10:07:42
17	Medium	SUGOL	10:23:43	0:01:15	0:02:00	-0:00:45	10:24:28	10:13:55
18	Medium	SUGOL	10:25:43	0:01:15	0:01:45	-0:00:30	10:26:13	10:15:40
19	Medium	SUGOL	10:27:43	0:01:30	0:01:45	-0:00:15	10:27:58	10:17:25
20	Heavy	RIVER	10:29:43	0:01:45	0:01:45	-0:00:00	10:29:43	10:14:57
21	Heavy	RIVER	10:31:43	0:02:00	0:01:40	0:00:20	10:31:43	10:16:57

100



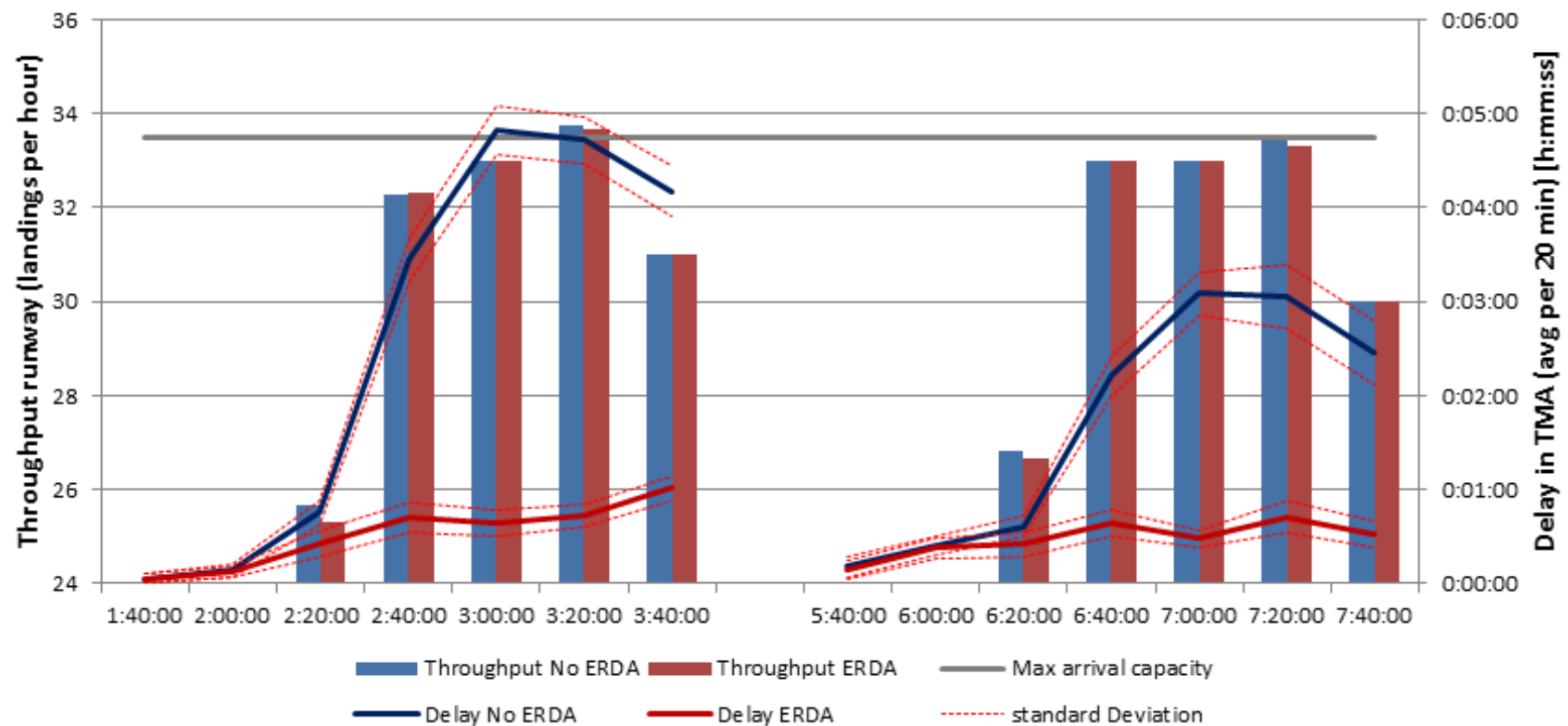
Results

1 IAF to 1 runway

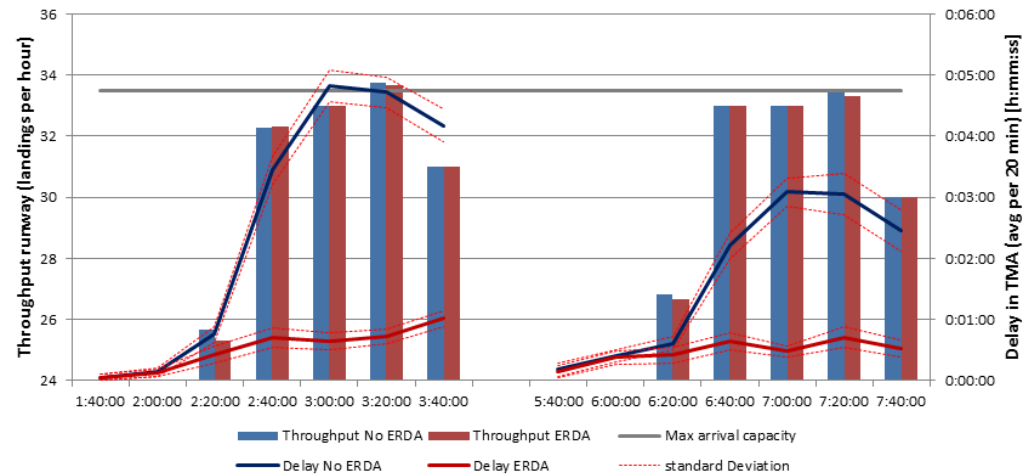


Results

2 IAFs merging 1 runway



Results



Throughput \Time	1:40:00	2:00:00	2:20:00	2:40:00	3:00:00	3:20:00	3:40:00
20 min: No ERDA	4,0	10,0	11,0	11,0	11,0	11,0	10,0
20 min: ERDA	4,0	10,0	10,4	10,8	11,7	11,0	10,0
Rolling hour: No ERDA			25,0	32,0	33,0	33,0	32,0
Rolling hour: ERDA			24,4	31,3	33,0	33,6	32,7
Throughput \Time	5:40:00	6:00:00	6:20:00	6:40:00	7:00:00	7:20:00	7:40:00
20 min: No ERDA	4,2	10,8	11,0	11,0	11,0	11,0	9,0
20 min: ERDA	4,1	10,9	10,7	10,9	10,9	11,3	9,2
Rolling hour: No ERDA			26,0	32,8	33,0	33,0	31,0
Rolling hour: ERDA			25,7	32,5	32,5	33,1	31,4

Conclusions

- ERDA can sometimes cause a small decrease in runway throughput.
- TMA delay decreases significantly
- Inbound peak is extended in time by 30 to 90 seconds (1 arrival)
- A correct time based separation at the IAF is important:
 - Same required time interval at the threshold can be used
 - Difference in TMA flight time between aircraft can be important if long fixed approach paths are in use

Conclusions

Runway Pressure?

Always minimum delay remaining in TMA

- Caused by accuracy of ATO IAF => +/- 30 seconds
- Caused by difference in flight time (aircraft performance)

Benefit of decreased delay in TMA are clear,
so should we absorb all expected delay en-route?

No, some factors not investigated:

- Workload of en-route airspace and ACC controllers
- Absorption capacity in those airspaces can be limited

Recommendations

For further research

- Simulate with a dynamic AMAN/flow control module
 - Time based separation with strong head wind at threshold
 - Missed approaches, pop-up flights, runway change, etc.
- Investigate effect on workload ATCOs (APP, ACC, MUAC)
- Investigate delay sharing strategy
- Effect of ERDA in continuous hub operations

For other students/researchers

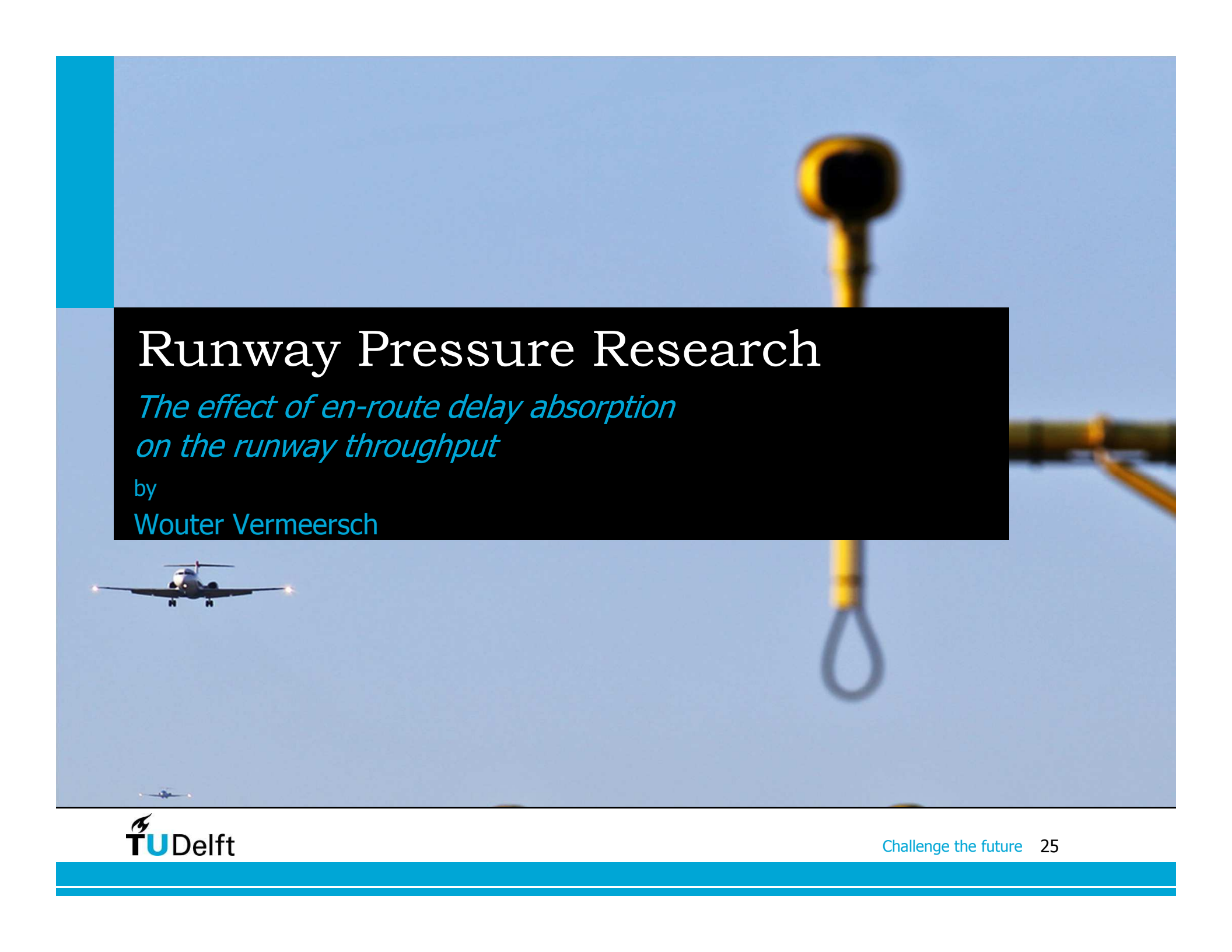
- Perform good analysis of the ATM system before modeling

Thank you!



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