EN-024

A Simulation Study on a Method of Departure Taxi Scheduling at Haneda Airport

Izumi YAMADA,

Hisae AOYAMA, Mark BROWN,

Midori SUMIYA and Ryota MORI

ATM Department,ENRI

i-yamada@enri.go.jp

Outlines

- Background and objectives
  - Characteristics of Haneda airport
- Traffic management algorithm
- Results of fast-time simulation experiment
  - Reduction of taxiing and queuing time
  - Guarantee of takeoff time
- Discussion
- Conclusion

Backgrounds

- Corresponding R&D vision
  - ICAO ASBU(Aviation Systems Block Upgrades)
    - Module 80: Airport CDM (Collaborative Decision Making)
    - Module 15: AMAN/DMAN (Arrival/Departure Manager)
  - Corresponding R&D reports in Europe and the United States says…
    - Airport CDM is effective for improving efficiency and punctuality of airport operation
  - CARATS (JAPAN: Collaborative Actions for Renovation of Air Traffic Systems)
    - Bottlenecks at congested airports and airspaces in the Greater Tokyo Metropolitan area, etc. must be eliminated

Aims of the study

■ To examine a traffic management method suitable for Haneda airport

   – Departure taxi scheduling

■ Expected performance

  1. Reduction of taxiing time

     ■ Especially for departure

  2. Transparency in takeoff time planning and execution (guarantee of takeoff time)

About Haneda airport (1/2)

- The most congested airport in Japan
  - Over 1,000 movements per day
  - Origin and destination of major air traffic flow in Japan
    - Mainly used for domestic airways

Sapporo

Osaka

Fukuoka

Tokyo
(Haneda)

Naha

About Haneda airport (2/2)

B-RWY 2,500m

Int'l terminal

Cargo

Domestic terminal

A-RWY 3,000m

Hangar

C-RWY 3,000m

Photo: MLITT

D-RWY 2,500m

Complex layout and operation
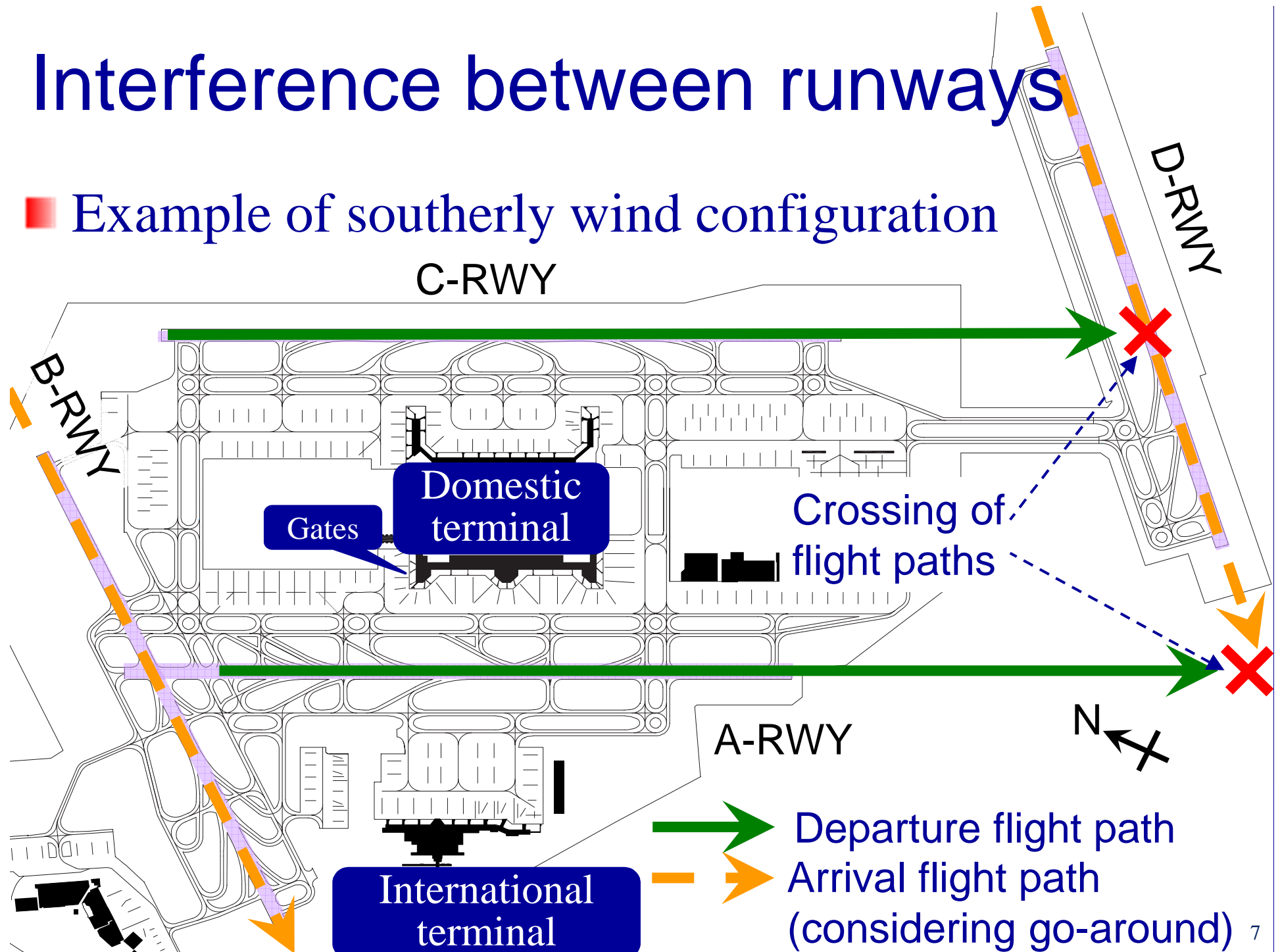- 4 runways (2 pairs of parallel runways)
  - 3 or 4 runways constantly active
  - Interference between runways occurs frequently
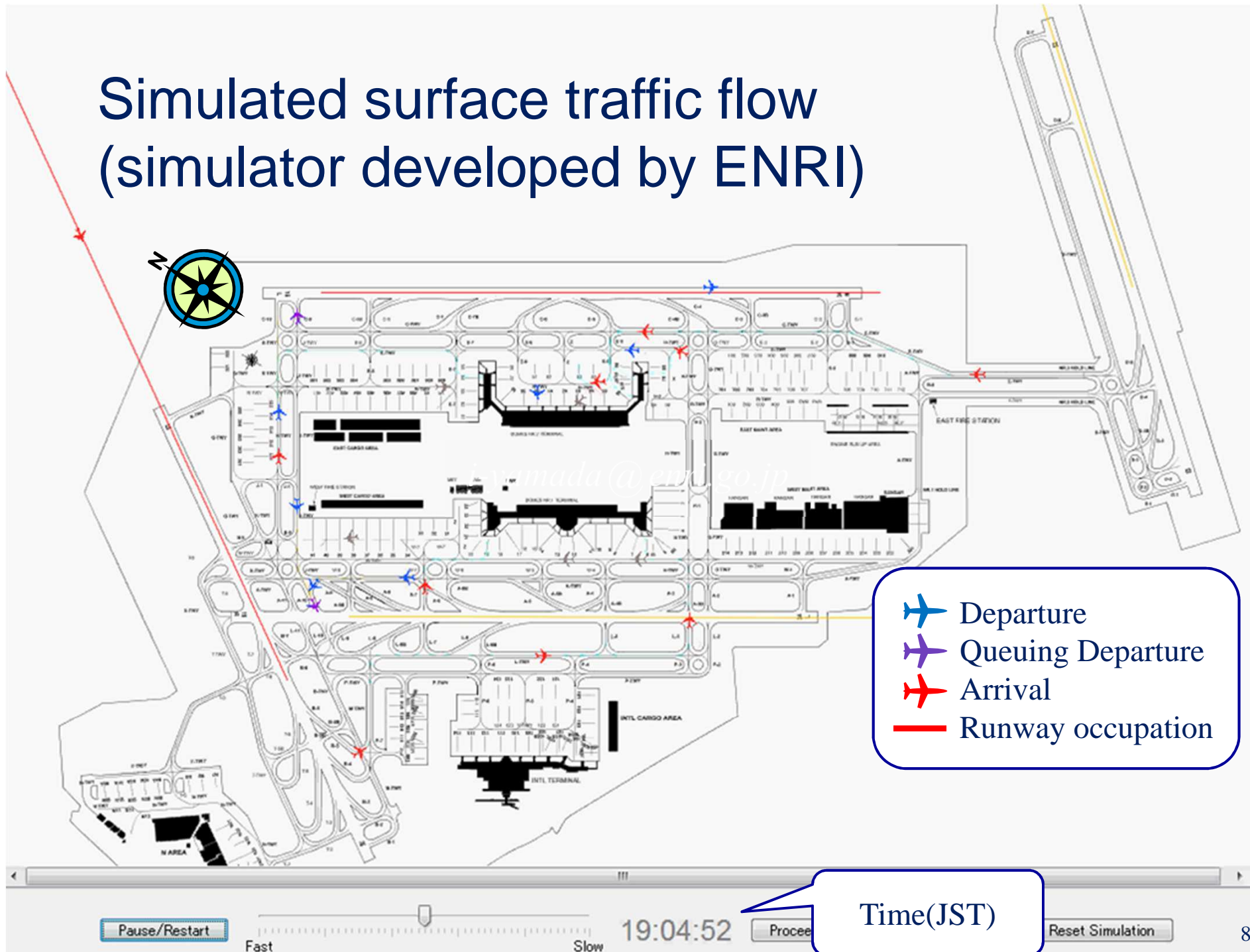- Gates: densely located around terminal buildings

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Interference between runways

■ Example of southerly wind configuration

C-RWY

D-RWY

B-RWY

Domestic terminal

Gates

Crossing of flight paths

A-RWY

N

Departure flight path

Arrival flight path (considering go-around)

International terminal

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Simulated surface traffic flow (simulator developed by ENRI)

Departure
Queuing Departure
Arrival
Runway occupation

Time(JST)

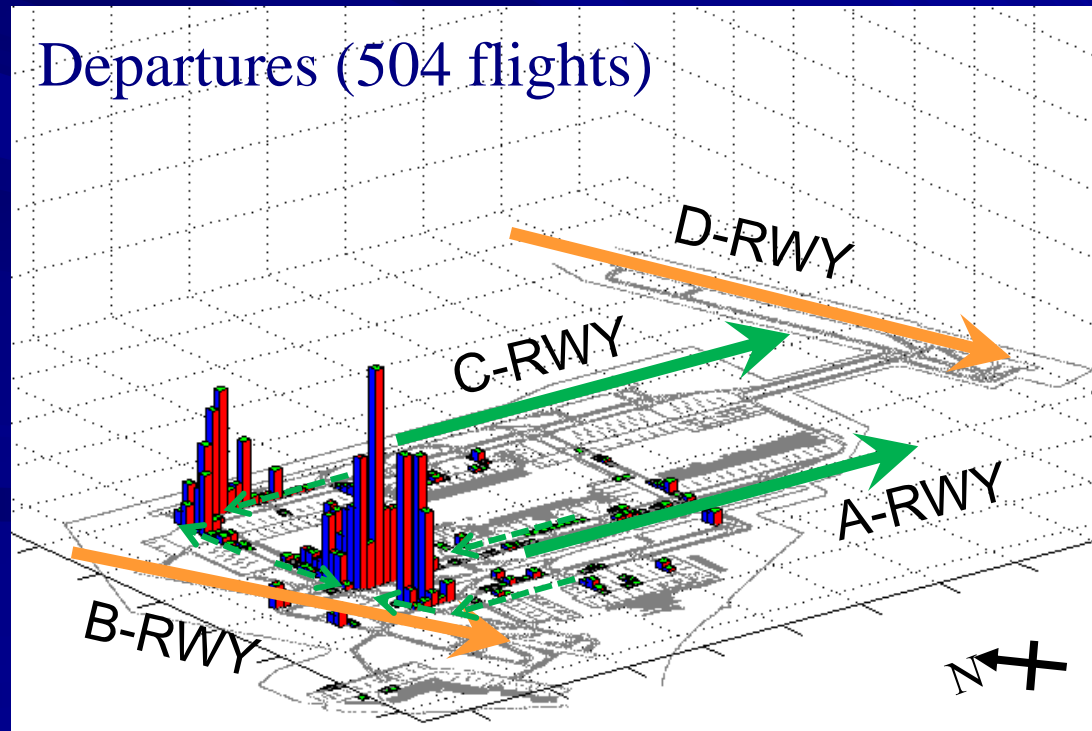Pause/Restart   Fast   Slow   19:04:52   Procee   Reset Simulation   8

Location of congestion at Haneda

- Almost limited in the area before departure runway
  - Relevant to apply taxi scheduling (queue management)
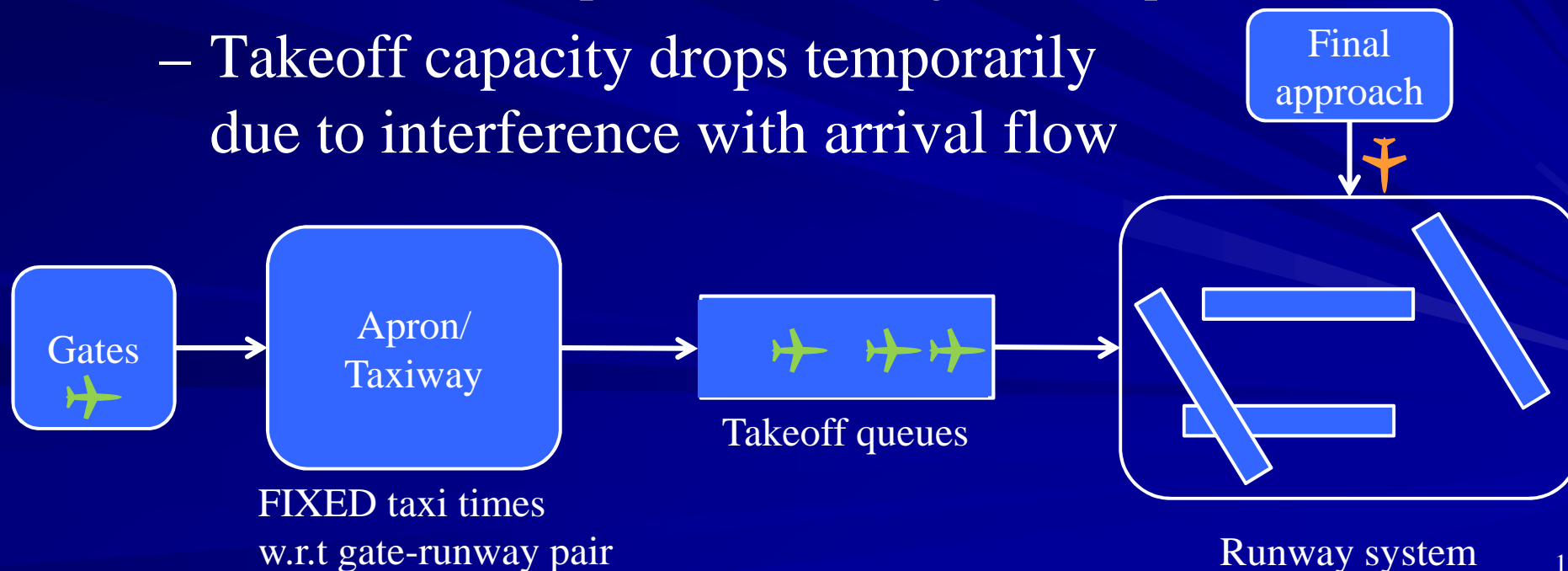
Mapping of taxiing time with speed less than 10 [km/h] (excl. pushback)

Departures (504 flights)

D-RWY

C-RWY

A-RWY

B-RWY

N

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Simplified congestion model

- Focusing on takeoff queues
  - Dynamics of congestion will be determined by…
    - Takeoff capacity of runway system
    - Number of departures reaching takeoff queue
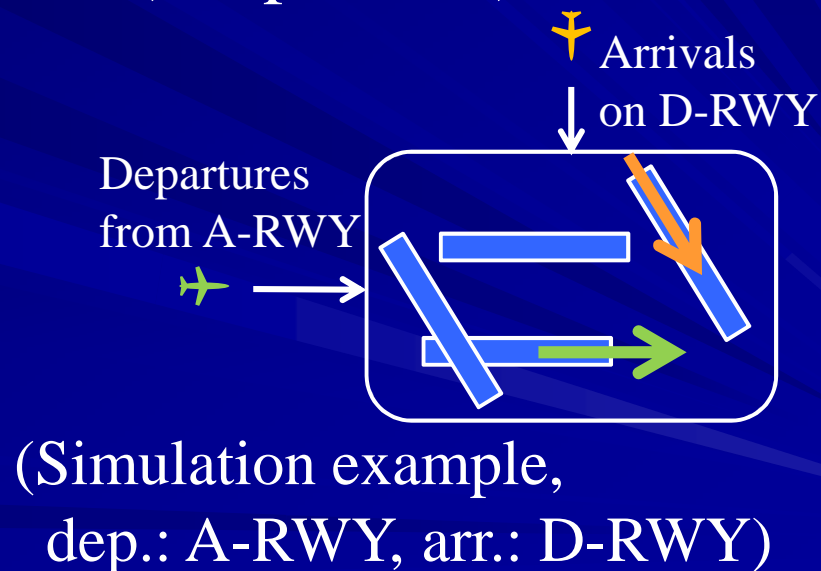 - Takeoff capacity drops temporarily due to interference with arrival flow

Final approach

Gates

Apron/ Taxiway

Takeoff queues

FIXED taxi times
w.r.t gate-runway pair

Runway system

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Runway capacity constraint model

- Based on Gilbo's capacity model
  - Count (#dep., #arr.) observations in 5 minute time window, rejecting (0,0) as exception
  - Evaluate the proportion of each (#dep., #arr.) in total observations
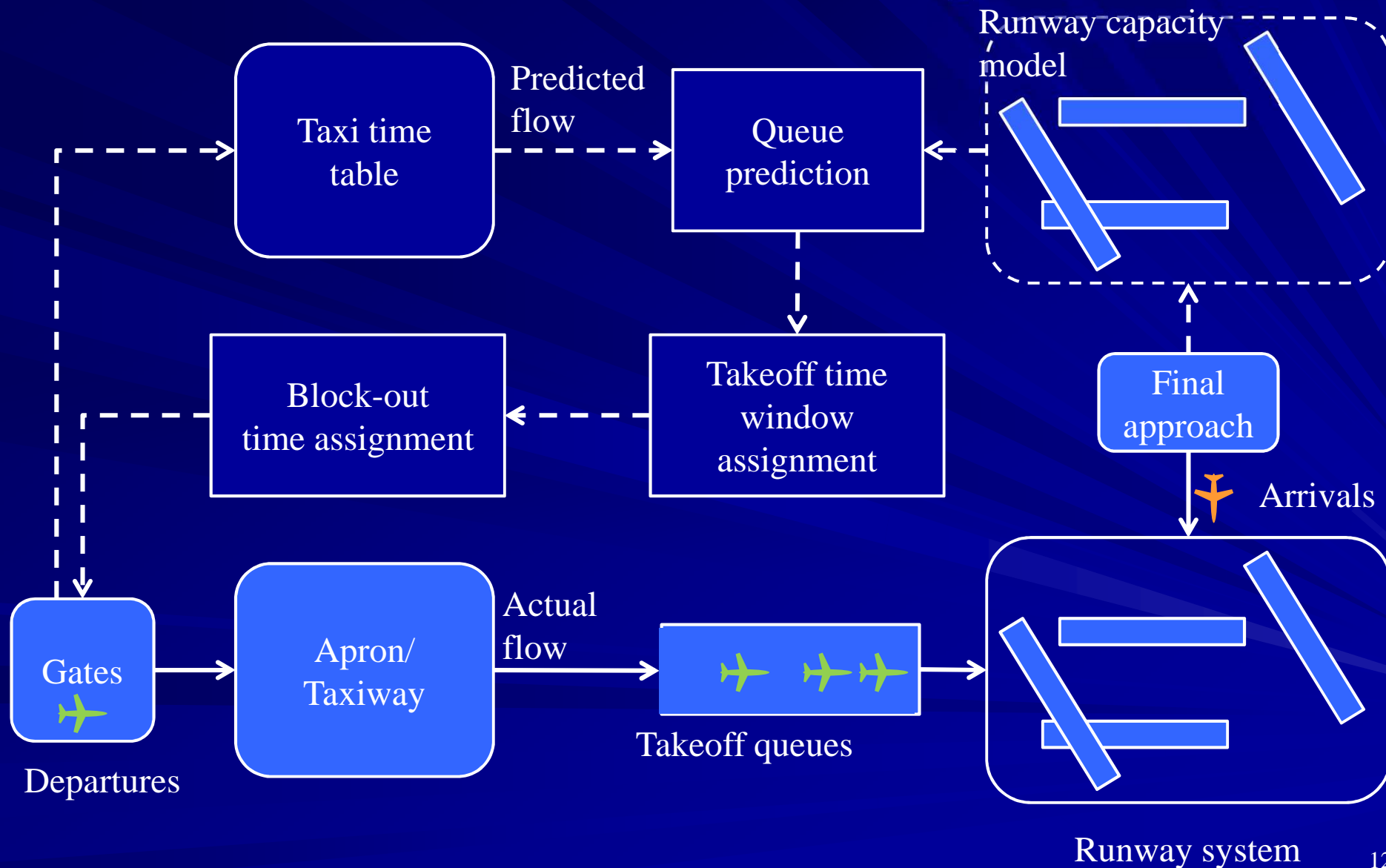
#dep. #arr.	0	1	2	3	4
0		21.0%	11.6%	5.7%	1.2%
1	18.3%	17.1%	13.0%	5.4%	0
2	3.9%	1.5%	1.0%	0	0
3	0	0	0	0	0

Departures from A-RWY

Arrivals on D-RWY

(Simulation example, dep.: A-RWY, arr.: D-RWY)

- Capacity constraint assumption

$$\#dep[/5min] \leq 3 - \#arr[/5min]$$

Departure scheduling algorithm 1/2

Runway capacity model

Taxi time table

Predicted flow

Queue prediction

Block-out time assignment

Takeoff time window assignment

Final approach

Arrivals

Gates

Departures

Apron/ Taxiway

Actual flow

Takeoff queues

Runway system

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Departure scheduling algorithm 2/2

a) Predicted interfering landing number per 5 minutes

One arrival within 5-minute window

… 18:45   19:00   19:15   19:30 … time

Queue prediction

b) Predicted takeoff demand per 5 minutes

One departure within 5-minute window

… 18:45   19:00   19:15   19:30 … time

Takeoff time window assignment

c) Takeoff time window assignment

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… 18:45   19:00   19:15   19:30 … time

Block-out time assignment

Baseline scenario

- Derived from observation of actual operation
  - Block-out/ -in time and gate
  - Takeoff / landing time and runway
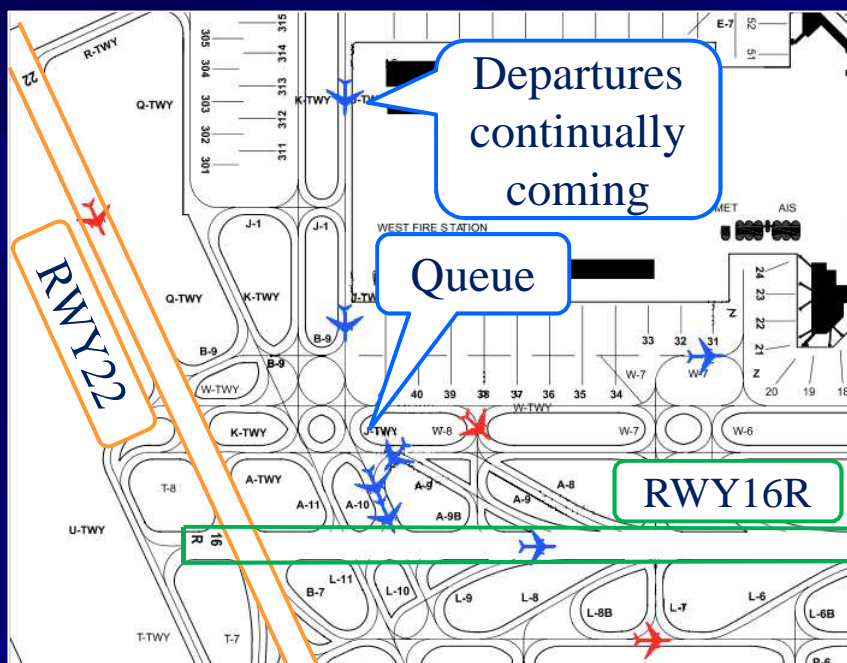
Hourly traffic volume
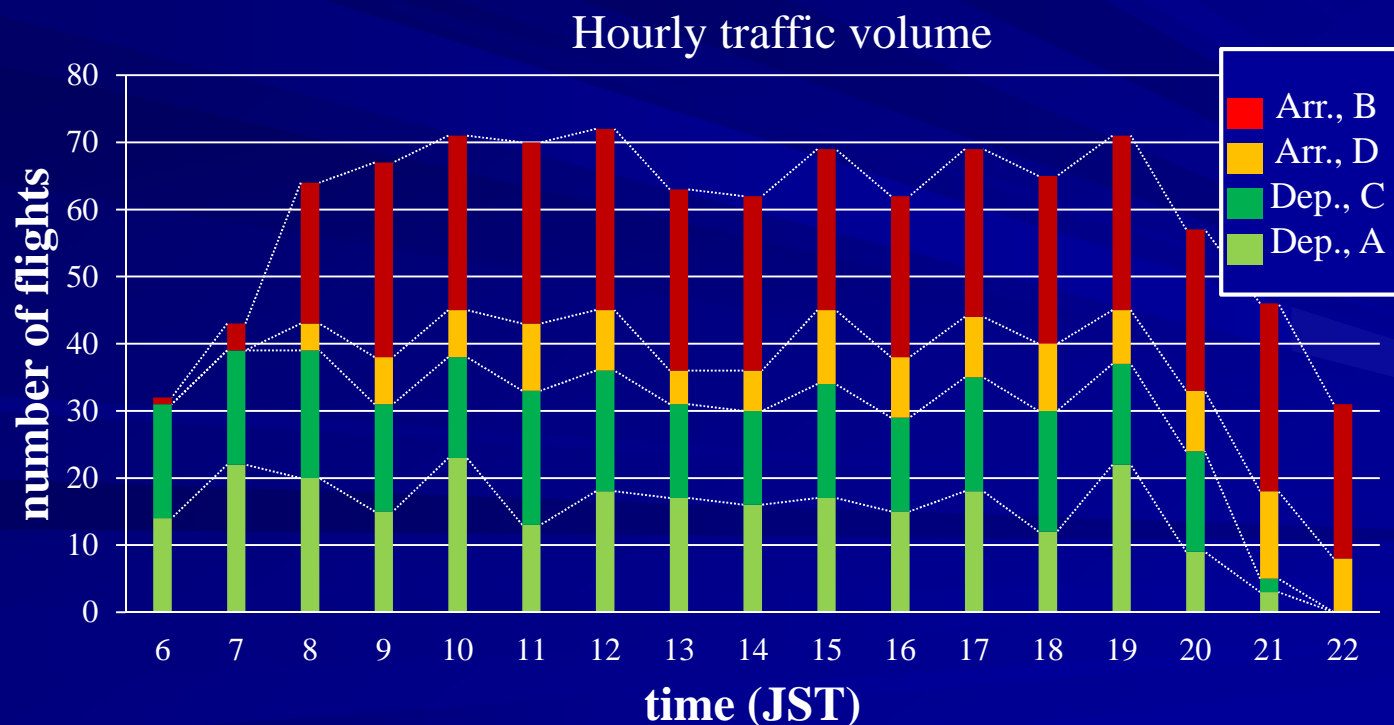
Through the day
Dep.: 504 flights
Arr.: 525 flights
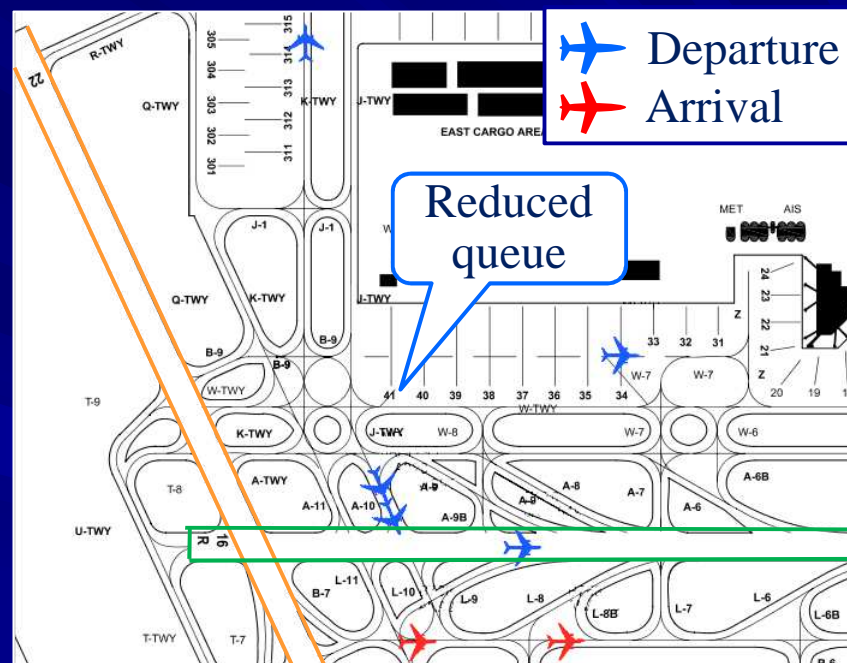
14

Modified scenario

- 94 departures were assigned block-out delay
  - Sum of delay: 249 min.
  - Many for congested period in the evening
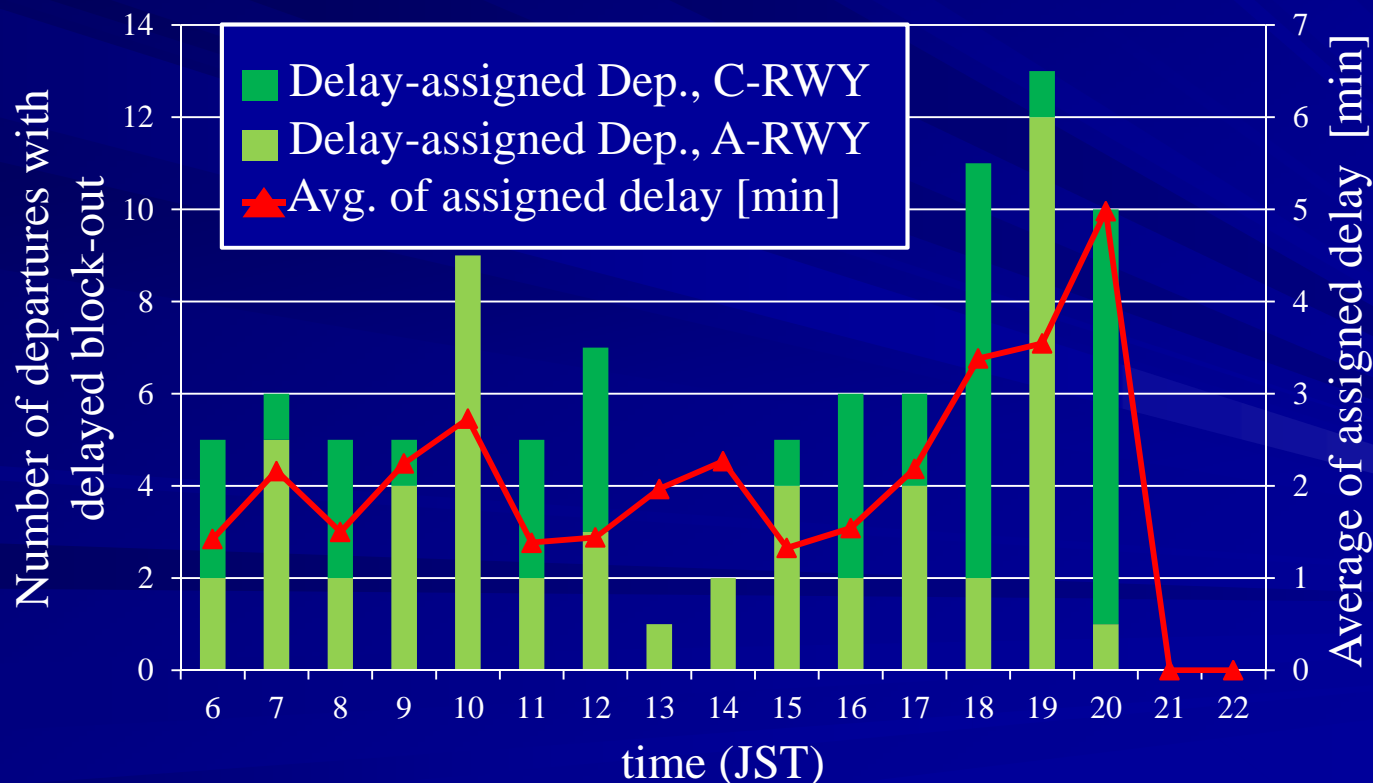
Simulation result
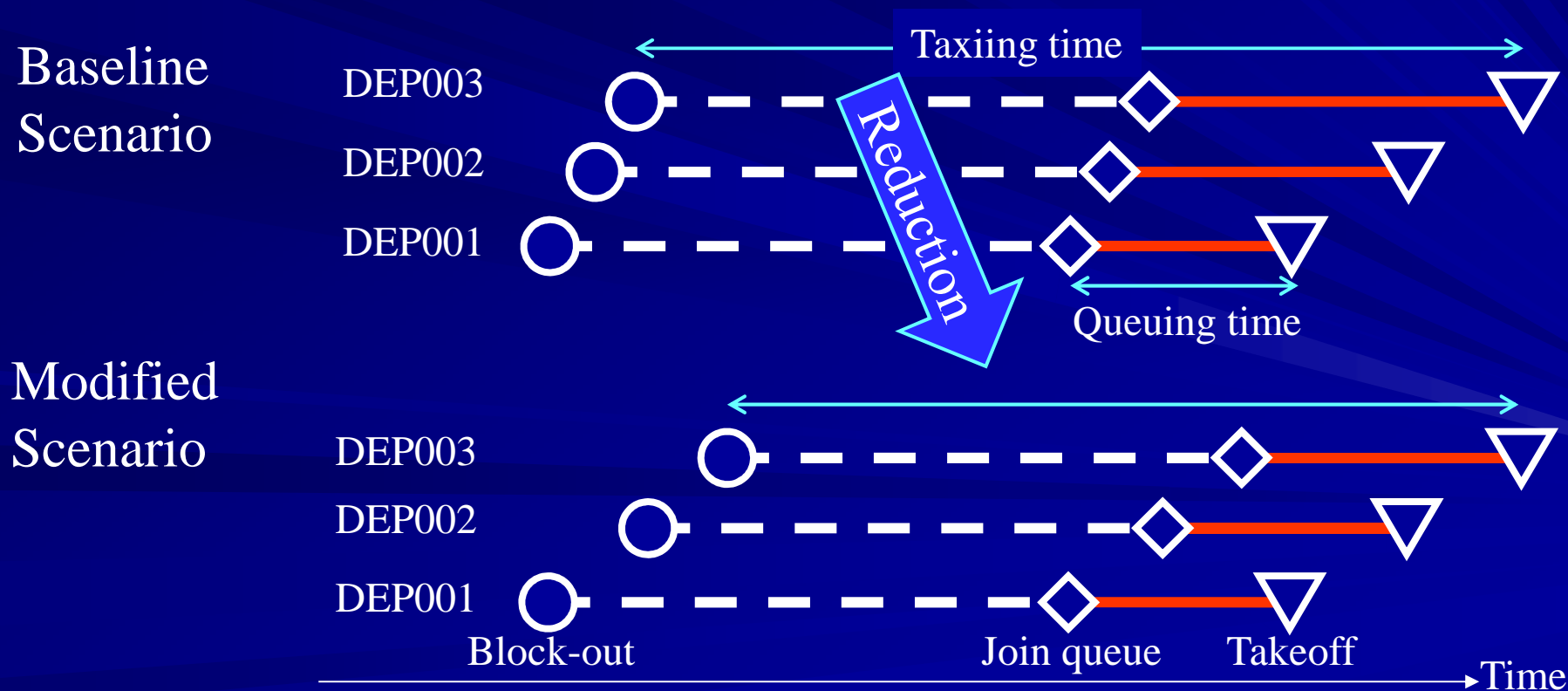

Baseline scenario

Modified scenario

Queue reduction in congested period (19:30 JST)

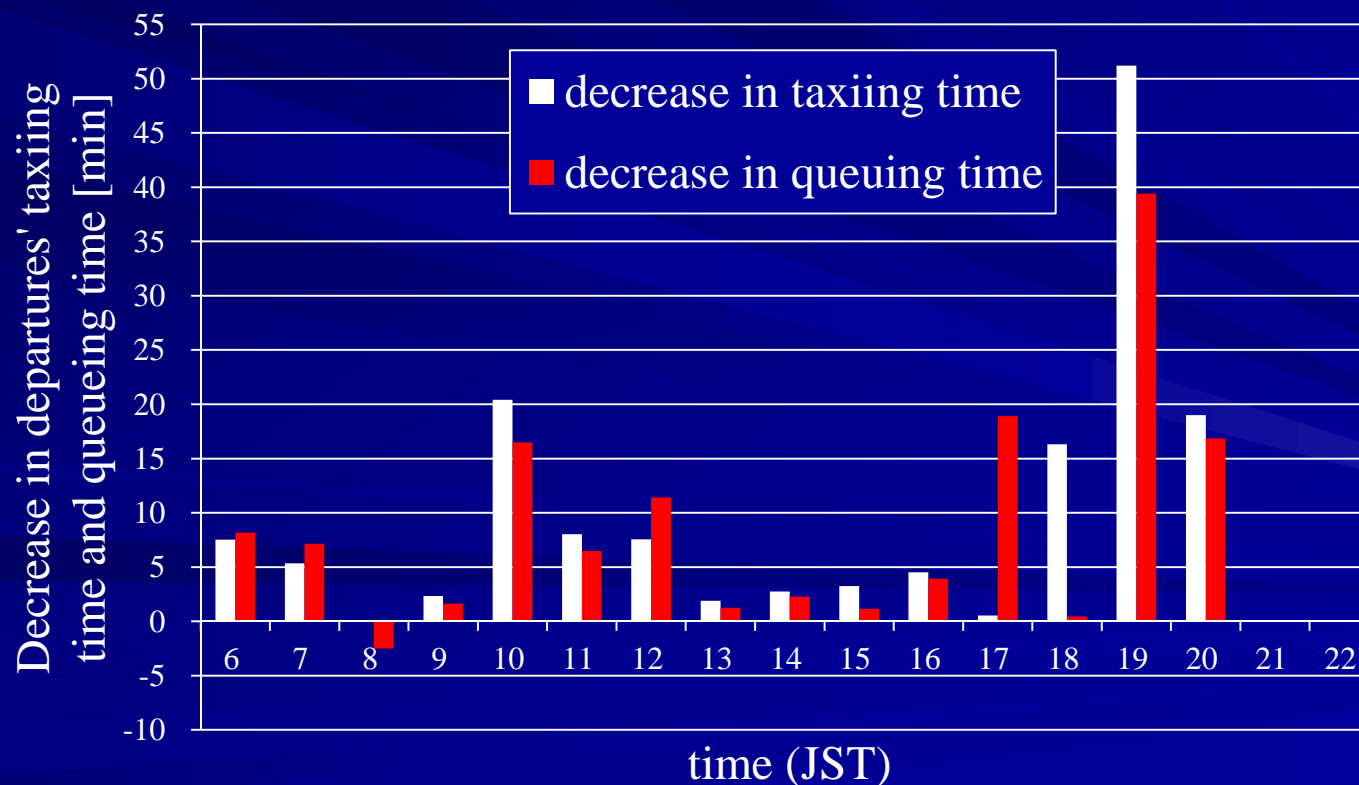Performance index 1.

Reduction of taxiing time

How to measure

– Comparing taxiing/queuing time between the simulation result of baseline and modified scenario

Baseline Scenario

Taxiing time

DEP003

DEP002

DEP001

Reduction

Queuing time

Modified Scenario

DEP003

DEP002

DEP001

Block-out   Join queue   Takeoff
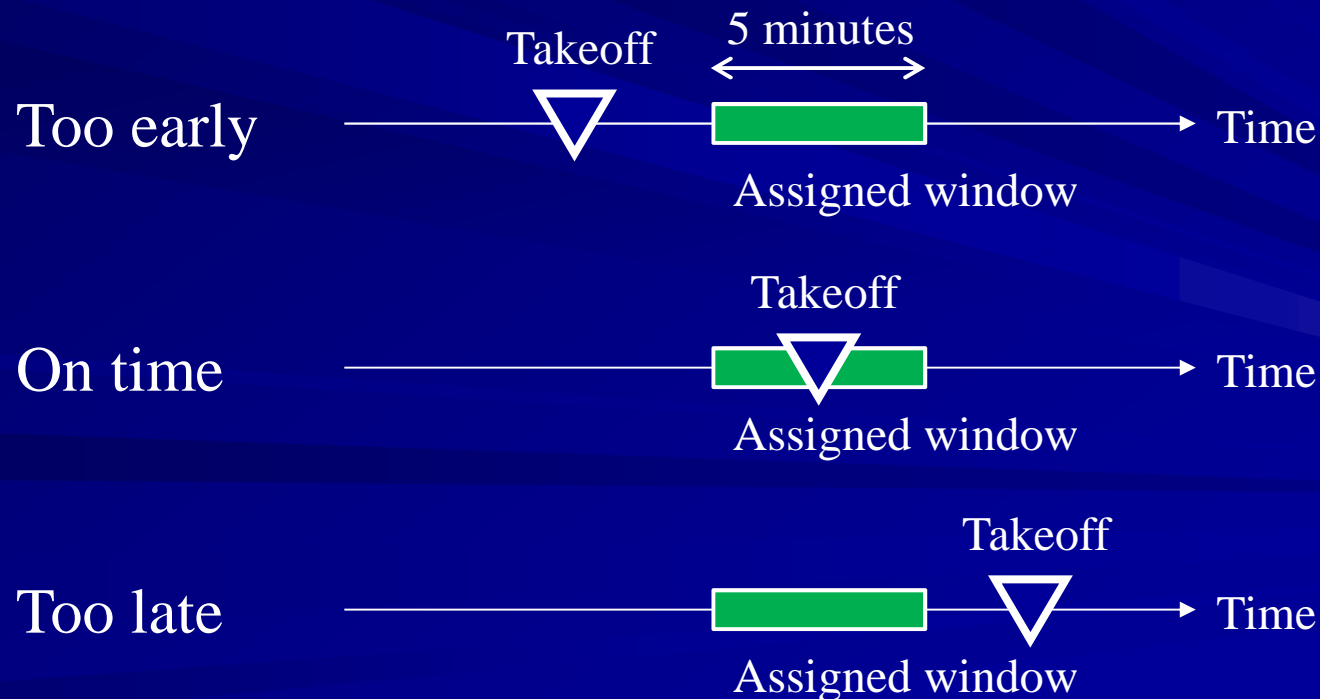
Time

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Performance index 1.

Reduction of taxiing time

- ■ Significant reduction in the evening
  - – Through the day: total 2.12% (133 min.) reduction for departure taxiing time

Performance index 2.

Guarantee of takeoff time

■ **How to measure**

– Punctuality: takeoff within the assigned takeoff time window

Too early

Takeoff

5 minutes

Time

Assigned window

On time

Takeoff

Time

Assigned window

Too late
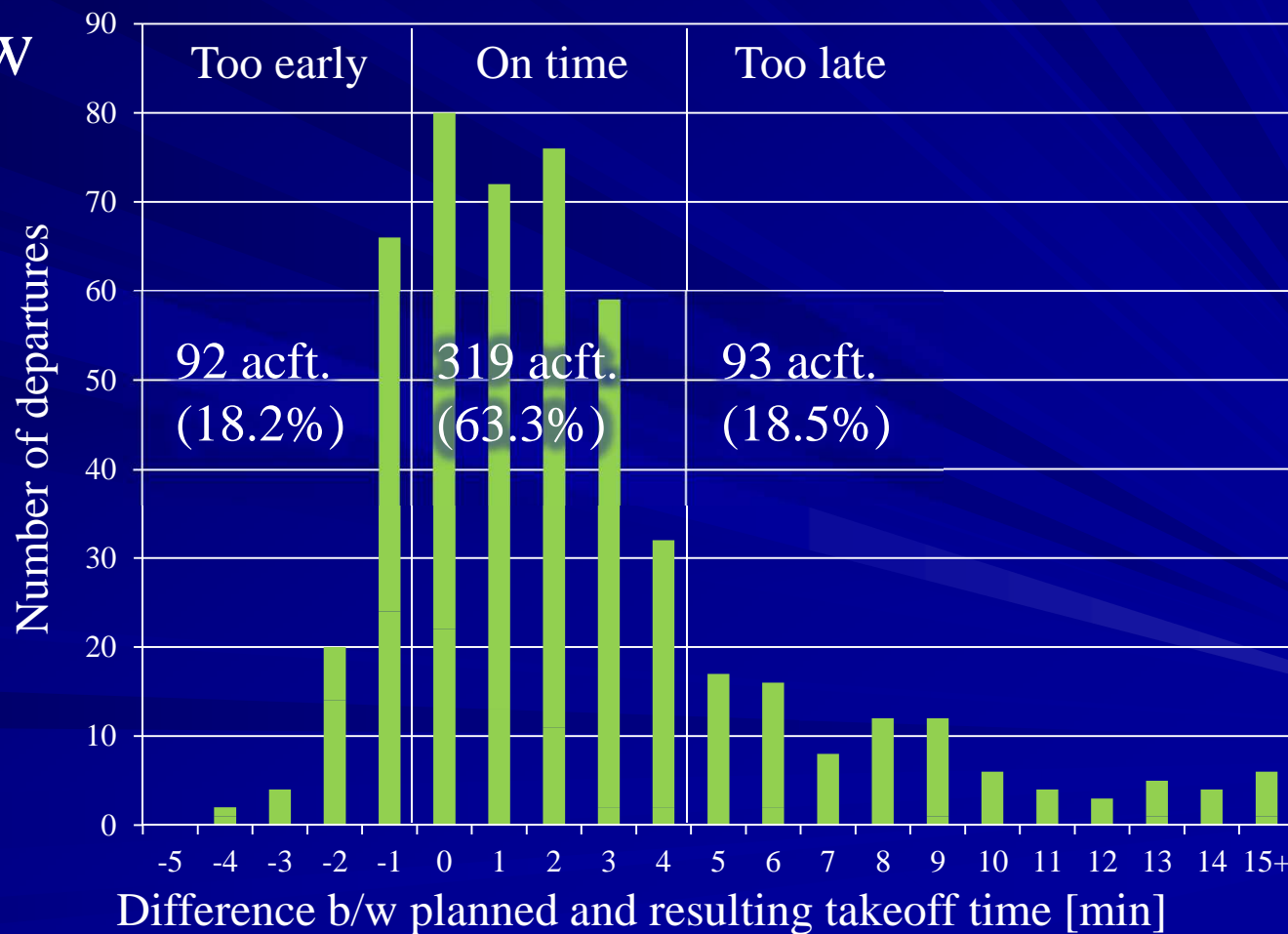
Takeoff

Time

Assigned window

Performance index 2.

Guarantee of takeoff time

- 63.3% of departures took off within assigned time window

Discussion

- 18.2% took off slightly earlier than assigned window (up to 4 min., mostly within 2 minutes)
  - Due to rough assumption on runway capacity
    - Sometimes #dep. + #arr. > 3
- 18.5% took off later than assigned window
  - In some cases, large deviation from assigned window
    - Though, takeoff times are same as baseline results
  - Due to unmodeled congestion factor
    - Congestion at aprons
- These may be solved by detailed modeling

Conclusions

- **Traffic management method suitable for Haneda airport**
  - Departure taxi scheduling
- **Good performance obtained**
  - Reduction in departure taxi time : 2.12%
  - Guarantee on takeoff time : 63.3%
- **Problems to be solved**
  - More precise forecast of runway capacity
  - Taxi time prediction method considering apron congestion

Acknowledgement

The authors express special thanks to
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and especially…

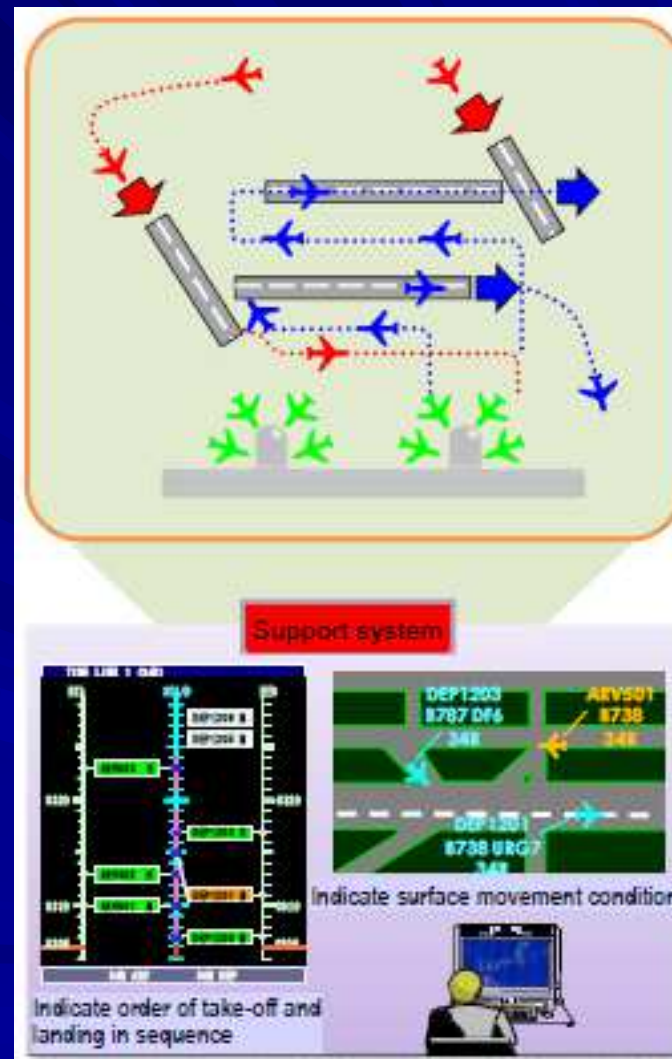# Thank you for your attention!

i-yamada @ enri.go.jp

BACKUP SLIDES

Motivation

- **CARATS says…**
  - "Bottlenecks at congested airports and airspaces in the Greater Tokyo Metropolitan area, etc. must be eliminated"

- **Many literatures report effectiveness of Airport CDM**
  - How will Airport CDM work at Haneda airport?

Reference: JCAB, "Long-term Vision for the Future Air Traffic Systems", 2010.
http://www.mlit.go.jp/common/000128185.pdf

Our research topics

- **Technical arguments on traffic management at Haneda airport**
  - Post-operation data processing
  - Surface traffic flow analysis
    - Identification of congested area
    - Queue analysis
  - Airport surface movement simulator
  - Traffic management methods
  - Evaluation methods for traffic management

Traffic management algorithm 1/2

- **Arrivals assumed as independent movement**
  - Landing time assumed as fixed
    → enabling takeoff capacity prospect
- **Time management for departures**
  - Predict takeoff demand at runway from initial planning of departing gate
  - Detect excess demand compared to the prospect of takeoff capacity
  - Assign wait at gate for excess demand

Congestion at apron

- Departure's taxiing route is blocked by arrivals