Modeling Deicing Operations in Departure Scheduling using Fast Time Simulation

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38th Digital Avionics Systems Conference

San Diego, California, USA, Sep 8-12, 2019

Introduction

Deicing operation is a procedure to remove frost, ice, slush, or snow from aircraft, and to apply anti-icing fluid to aircraft surface if needed

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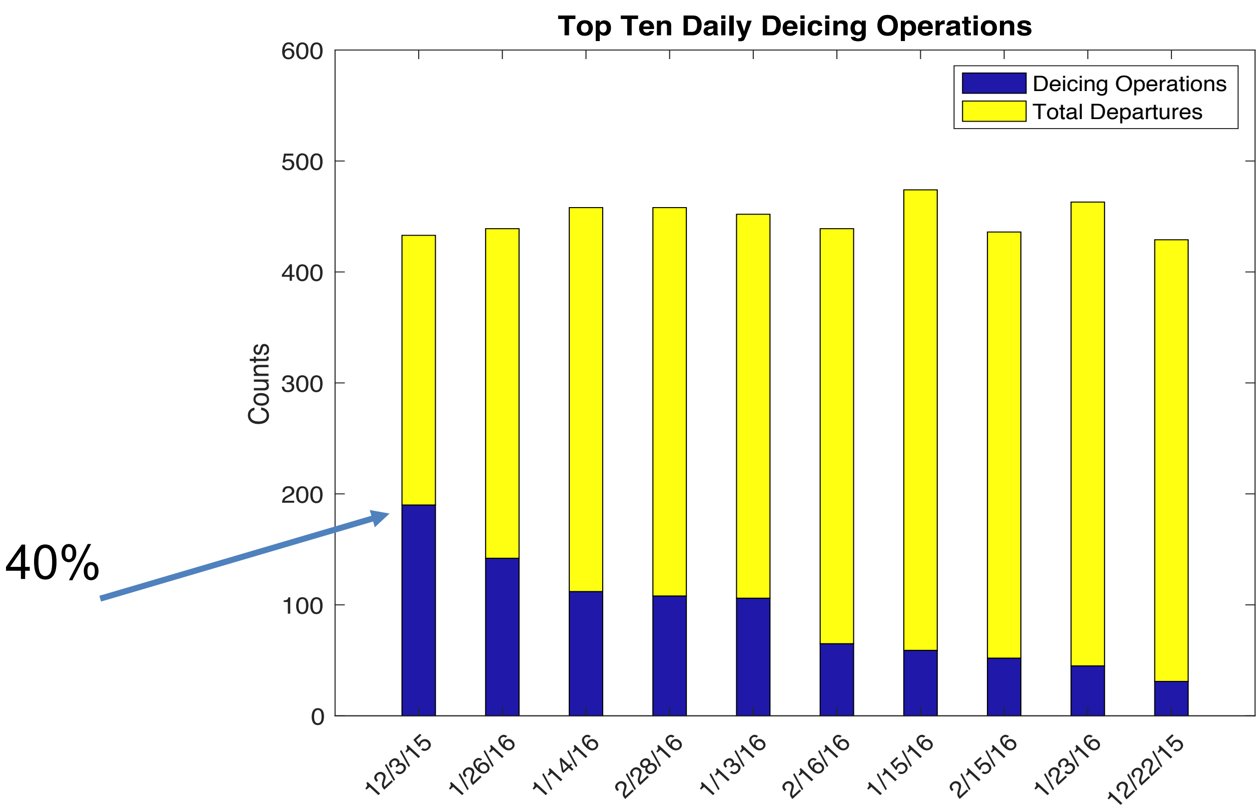
Introduction

Incheon International Airport requires deicing operations in winter season

- 2015-16 winter season analysis showed multiple deicing days
- Dec 3rd, 2015 had 190 deicing operations, ~**40%** of departures



Motivation

- Deicing operations impact on airport operations
  - Extra workload to controllers
  - Extra aircraft time on ground
  - Extra uncertainty to surface traffic management
- Insufficient study in managing deicing operations as off-nominal use case
  - Not considered as part of departure scheduling problem
  - No individual aircraft based decision support tool existing today

Research Objectives

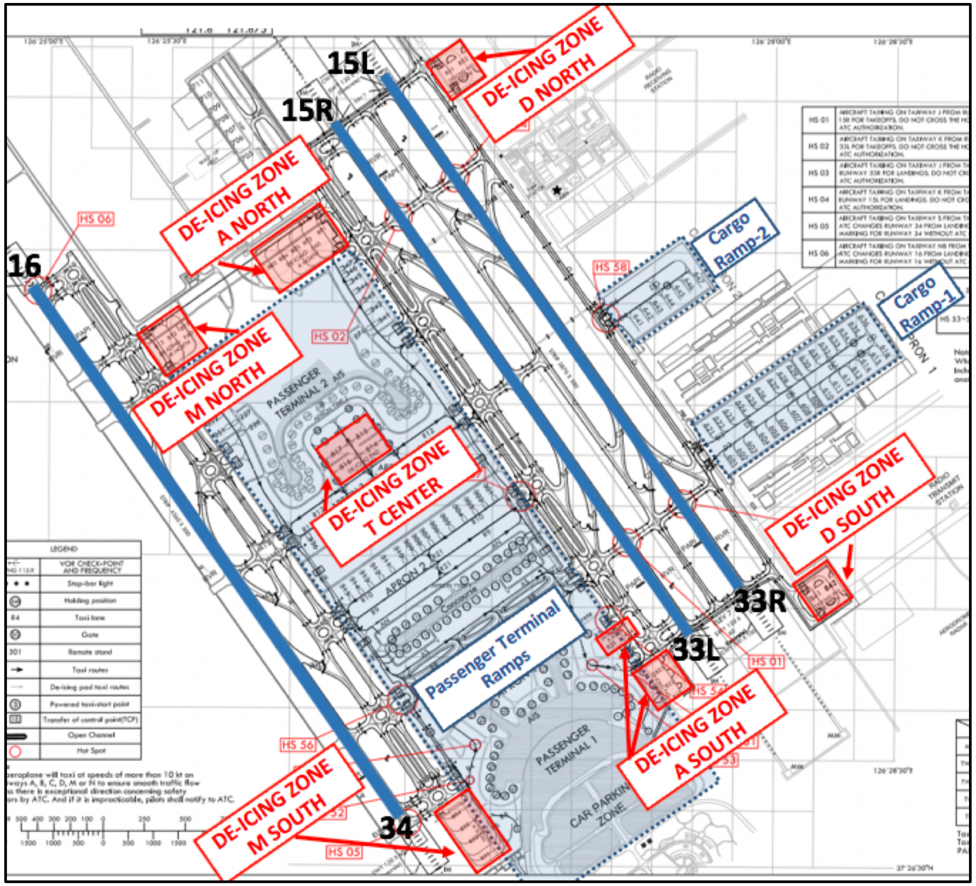
- Understand how deicing operations affect surface traffic movement
- Evaluate deicing service resource management strategies
- Investigate scheduling of deicing aircraft to improve efficiency of surface operations

Outline

- Deicing Operations at Incheon International Airport (ICN)
- Approach
- Deicing Model and Departure Scheduler
- Simulation Environment
- Results and Analysis
- Summary and Future Work

ICN Deicing Operations

ICN layout



Runways

	Arrival	Departure
North flow	33R, 34, (33L)	33L, 34
South flow	15L, 16, (15R)	15R, 16

Deicing zones

Wingspan Category	B	C	D	E	F
A South	2			3	2
A North	10			4	1
M South			2	3	1
M North				2	1
D South	4			1	1
D North	4			1	1
T Center		4		4	

ICN Deicing Control Procedure

Pilot contacts Deicing Position (DP) at Ramp for deicing request ← Request

DP assigns a deicing zone to the aircraft ← Resource management decision

Pilot calls when ready and obtains pushback clearance

Aircraft leaves gate and taxies to the assigned zone

Aircraft arrives at the Zone and gets a pad assignment from DP

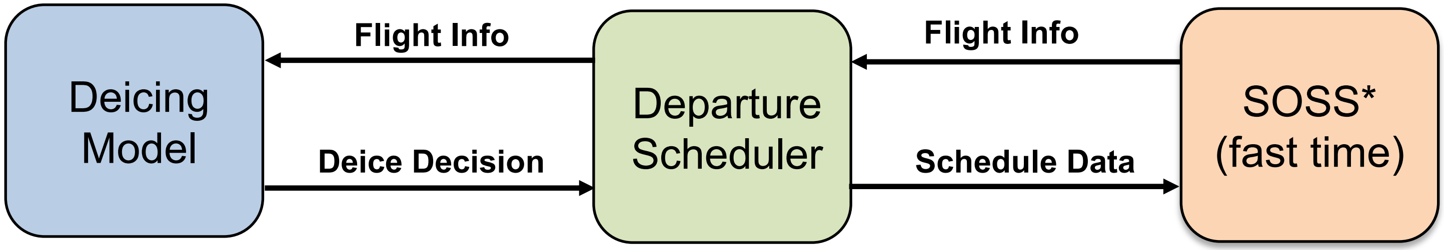
Aircraft taxies to the pad and deicing service starts

Pilot contacts ATC for pre-departure clearance during deicing

Pilot contacts Ramp to taxi out of deicing zone after deicing

Zone time

Approach



- Develop a deicing model at ICN and integrate it with a departure runway scheduler
- Create a deicing day traffic scenario
- Conduct fast time simulations and analyze the results

* SOSS: Surface Operations Simulation and Scheduler

Deicing Model

- Deicing request decision (for simulation only)
- Deicing zone assignment
- Deicing zone time

Deicing Request

- Deicing request decision – at gate when aircraft ready to pushback
- Use a uniform distribution sampling
- A single parameter -- deicing request rate, e.g. 40%

Deicing Zone Assignment Heuristic

- A priority zone list based on departure **gate**, **runway** and **ac type**

Zone List: First → Second - - - → Last → Gate Hold

Overflow

- Zone **load condition** = assignment / capacity

  example: 4 assignments to a zone of having two wingspan category E pads → load condition = 200% for E

- **Overflow**: if the front zone's loading condition >= a prescribed threshold, move onto the next zone on the list
- **Gate hold**: if all zones are overloaded, hold aircraft at gate

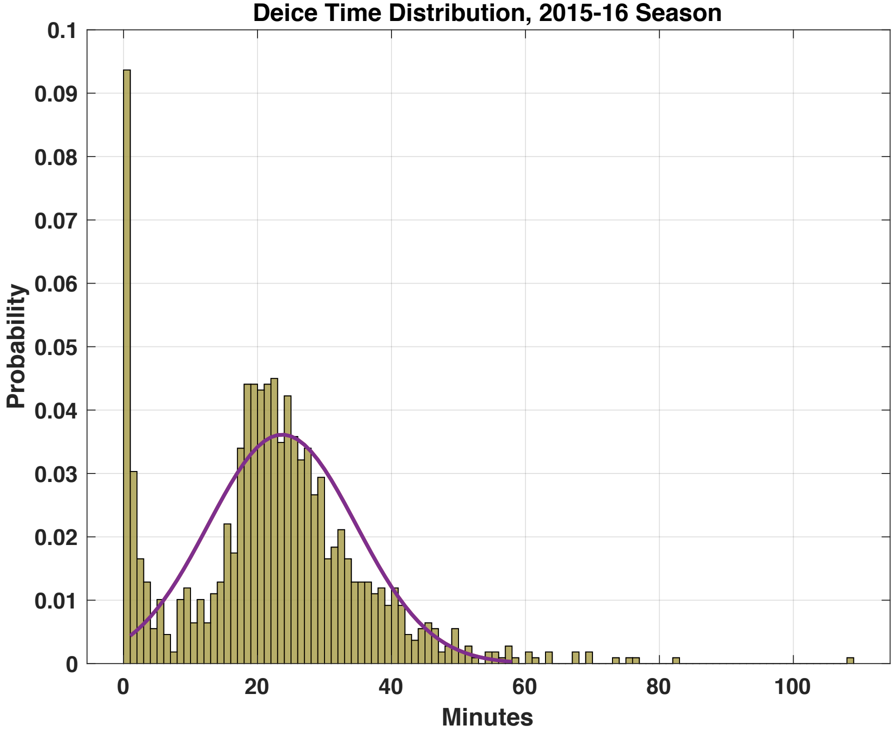
- Example: from a terminal gate to runway 33L

A South → A North → Gate Hold

Zone Time

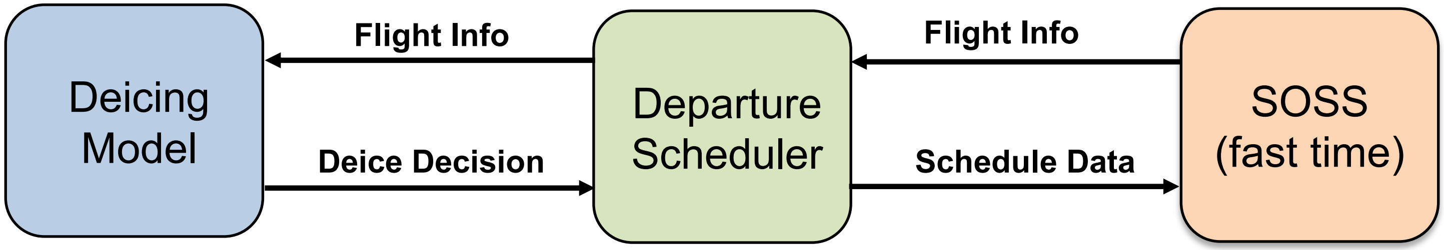
Normal distribution based on 2015-16 winter data

- zone in and zone out (grouped by aircraft wingspan categories)
- bad data points filtered out



Category	Samples (%)	μ (min)
C	29.8%	21.01
D	5.3%	20.58
E	56.6%	25.19
F	8.2%	24.98
All	100%	23.67 (σ =11.0)

Departure Scheduler Heuristic



- Schedules runway time using aircraft group priorities and unimpeded surface transit time
- Groups aircraft in priorities
  - Arrival
  - Departure in taxiing
  - Departure ready at deicing zone to runway
  - Departure ready at gate to runway
- Schedules departure gate pushback and zone exit time
  - Gate/zone to runway: target off time – unimpeded transit time
  - Gate to deicing zone: once zone assignment made

Traffic Scenarios

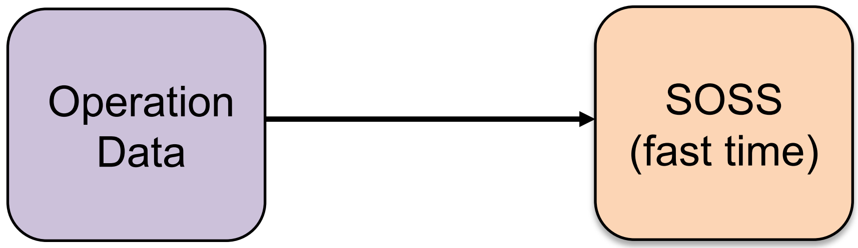
- Data source from the Dec 3, 2015 operations

Departures			
	33L	34	All
Non-Deicing	171	69	240
Deicing	118	67	185
Total	289	136	425

Arrivals			
33L	33R	34	All
34	286	110	430

- Two simulation scenarios were created:
  – The 24-hour scenario was used for simulation validation
  – The 5-hour scenario from 08:00 to 13:00 local time was used for the study in Monte Carlo runs

Simulation Validation



- Validation scenario: the 24-hour from Dec 3rd, 2015 (north flow)
- Departures push @AOBT (actual off-block time) of the operations
- Arrivals land @ON_Time (actual wheels on time) of the operations
- Deicing zone/pad assignments and deice times match the actual operations
- SOSS configuration adjusted for best possible match up to actual operations

Simulation Setup

- Traffic scenario: the 5-hour traffic scenario from Dec 3rd 2015 operations

	33L	34	33R	All
Arrival		21	68	89
Departure	73	65		138

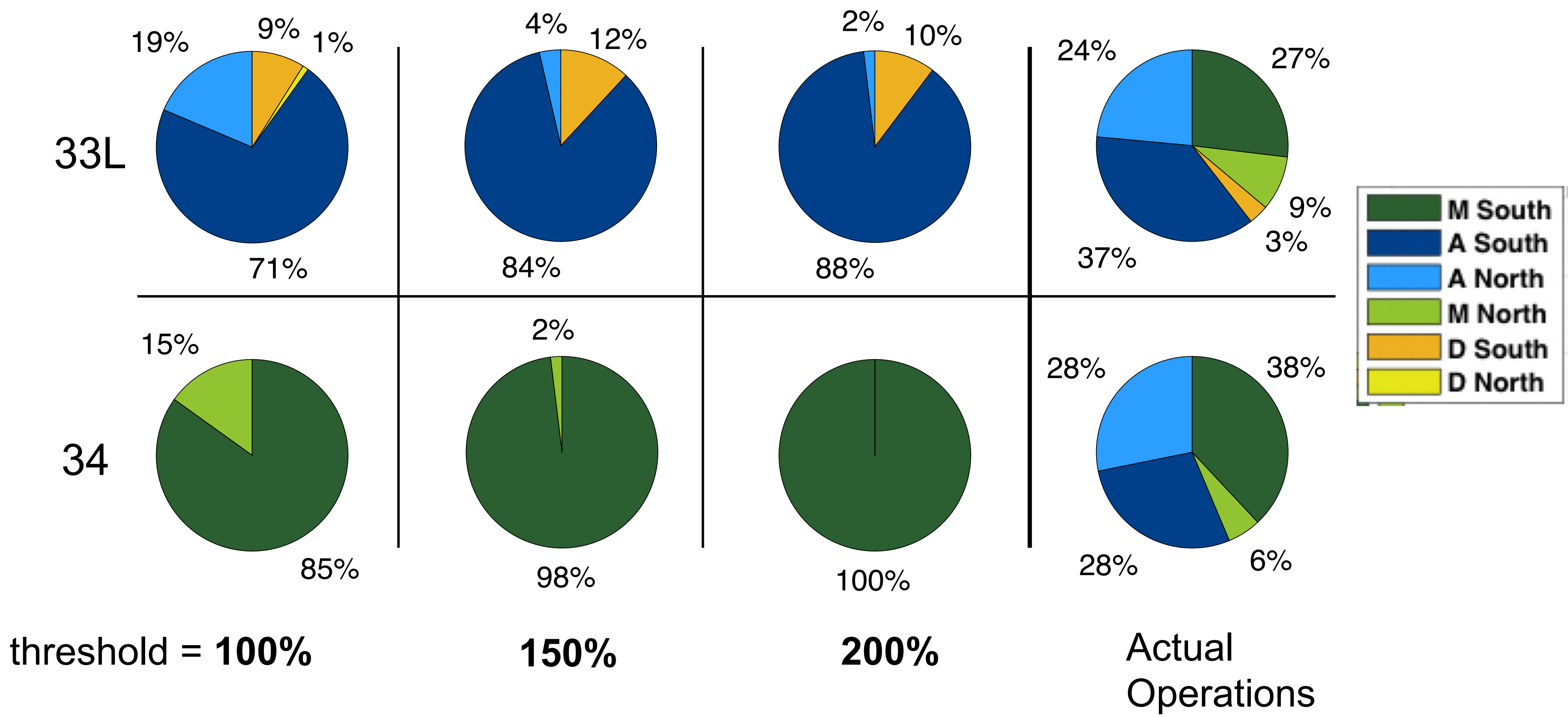
- Deicing model configurations
  - Deicing rate – **40%**
  - Deicing zone assignment heuristic (three zone lists)
    - Terminal to 33L : [A South, A North]
    - Cargo to 33L : [D South, D North, A South]
    - Terminal and Cargo to 34 : [M South, M North]
  - **Three** deicing zone load thresholds: [**100%, 150%, 200%**]

Analysis Metrics

- Zone assignment
- Zone queue size
- Deicing aircraft taxi out times
- Deicing gate hold *
- Runway and zone throughputs *

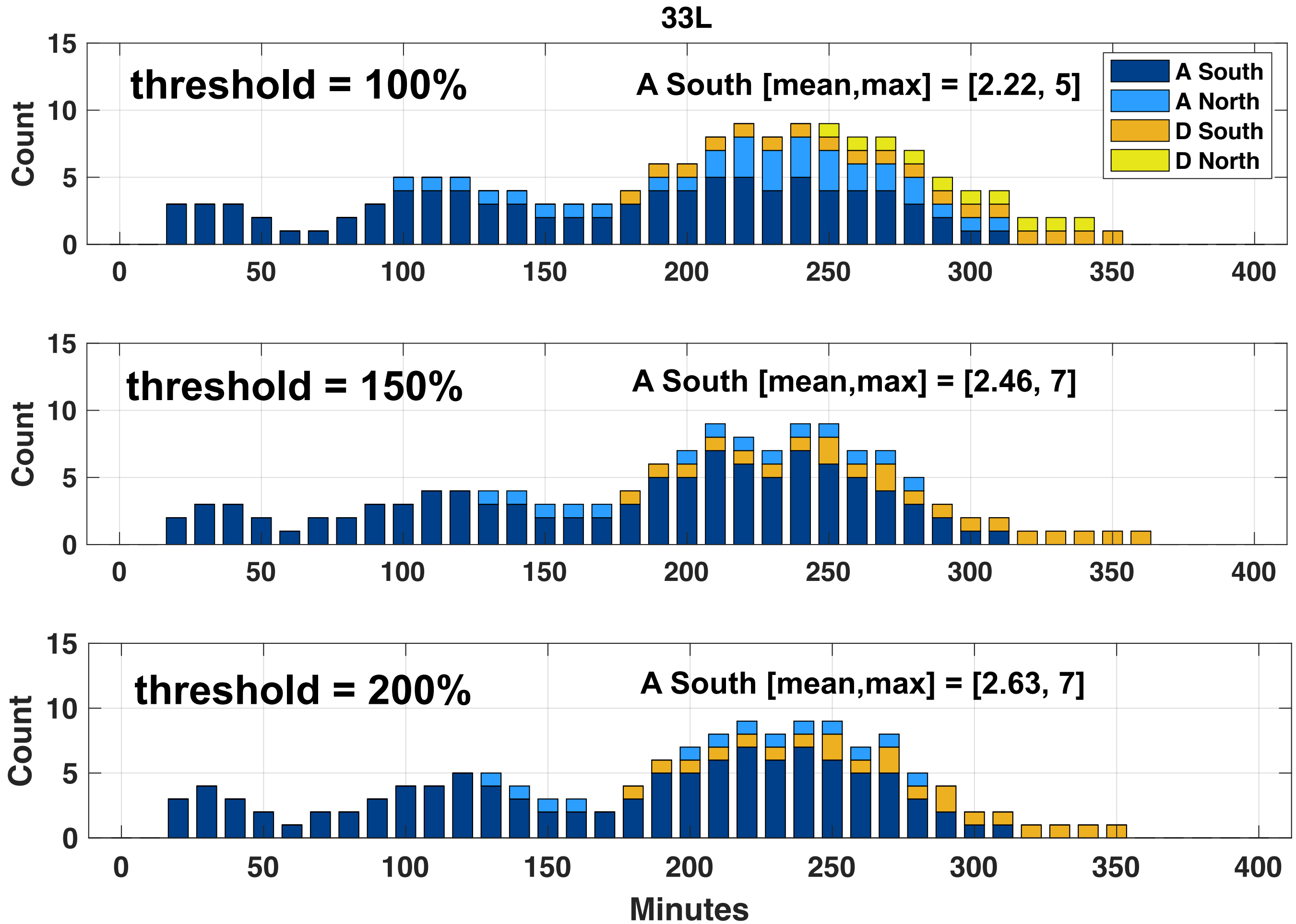
* Analysis can be found in paper

Zone Assignment



- The model used the first-choice zones for majority of the requests
- At 100% threshold, the first-choice zone capacity meets the 80-85% deicing request
- In actual operations, zone assignments are spread out

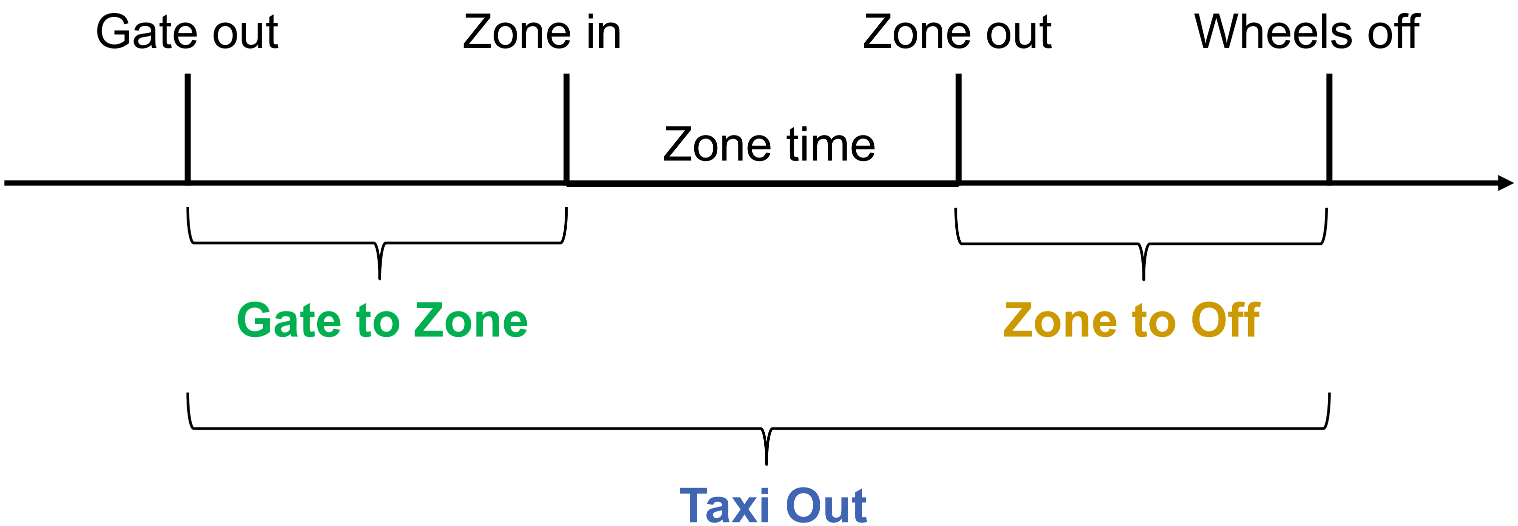
Deicing Zone Queue Size for 33L



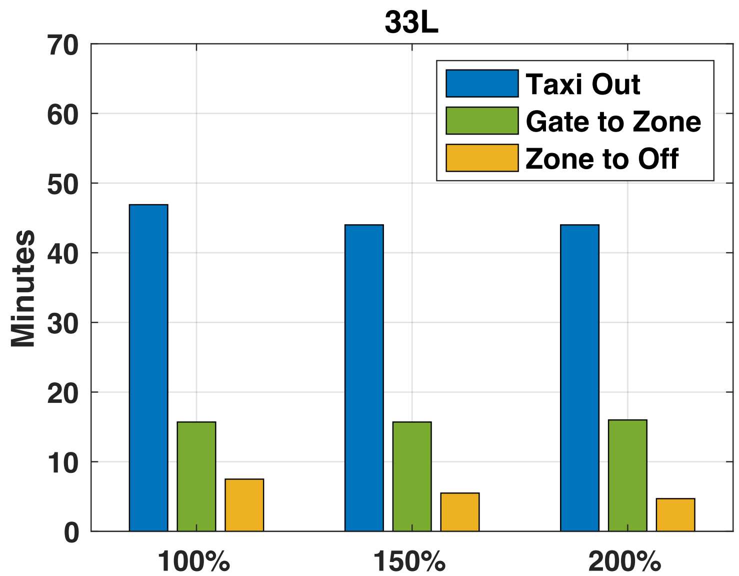
Overloading the deicing zones increases the queue sizes → potentially add extra waiting time in the queues

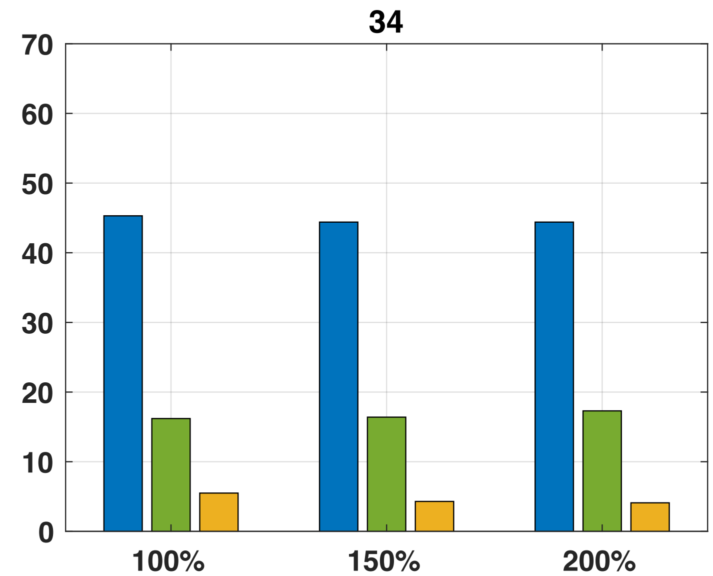
Taxi Out Times of Deicing Aircraft

Measurements:



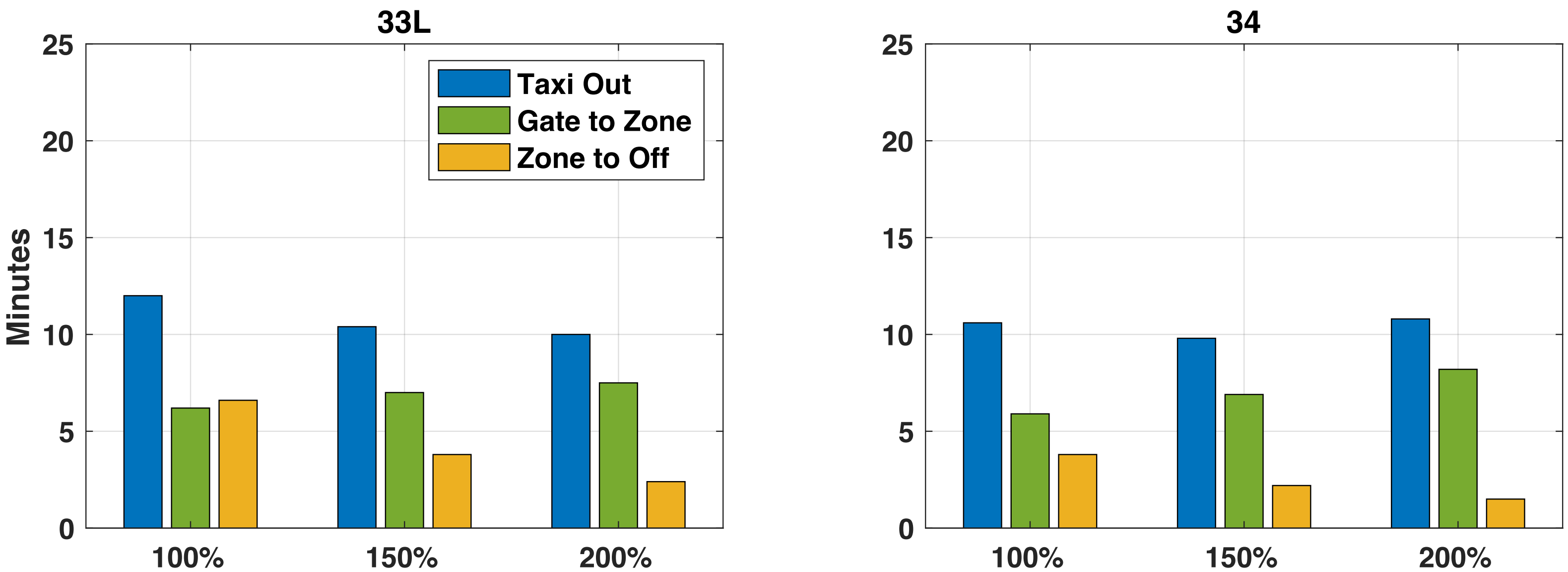
Mean Taxi Out Times of Deicing Aircraft





- Comparable gate to zone times among simulations
- Shorter zone to wheels-off times when more first-choice zones were used

Taxi Out Time STD of Deicing Aircraft



- No clear trend of overall taxi out time predictablity change
- Gate to zone and zone to wheels-off predictabilities went in opposite directions as more first-choice zones assigned
- Better zone to wheels-off predictabilities suggest runway schedule of deicing aircraft from zone

Summary

A deicing model was developed for ICN and integrated with departure scheduling in fast time simulations

- Heuristic zone assignment to balance the deicing zone load and taxi and waiting times
- Traffic scenario and deicing demand derived from a heavy deicing day operation
- Monte Carlo simulations conducted using three zone load conditions

Summary

The simulations showed

- Increasing deicing zone load resulted in
  - reduced zone to runway taxi time and improved predictability
  - decreased gate to zone taxi time predictability
- Comparable overall taxi out times in different zone load conditions
- Potential benefit to have deicing support in departure scheduling for the off-nominal operation condition

Future Work

- Improve the deicing model to include dynamic zone capacity
  - Number of deicing trucks
  - Fatigue factor over time
- Include airline deicing operator contract constraint in zone assignment algorithm (ICN specific)
- Consider runway capacity reduction in deicing days
- Evaluate the benefit of integrating the deicing model in ICN departure management system

The End

Questions

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