

Airport Service Vehicle Scheduling

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Outline

Why Service Vehicle Scheduling

The CARMA Project

Scheduling Algorithms

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Conclusion



Why Service Vehicle Scheduling

"For most airports there is a dominance of delays due to gate congestion" (Idris *et al*., ATM 1998)

Interdependence of gates, airports

Very little service vehicle research to date, none from the perspective of a service provider

Available research has focused on describing the turnaround process



The CARMA Project (Car Management on Aprons)

Cost-efficient vehicle detection and communication on the apron

Applications to show vehicle information, and to manage vehicles from stakeholder control centers

Investigate the safety case and business case for vehicle management at Hamburg Airport

Proof of the technical and economical feasibility of a vehicle management system at Hamburg Airport



The CARMA Project

Hamburg Airport

DFS Deutsche Flugsicherung

TUHH
Technische Universität Hamburg-Harburg

AIRBUS

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr

AIRSYS
Airport Business Information Systems GmbH

Universität Hamburg

Technische Universität Carolo-Wilhelmina zu Braunschweig

Luftfahrtstandort Hamburg
Hamburg – The place for aviation



Scheduling Algorithms

Decisions

- assign service vehicles aircraft to service
- assign times when service is to begin

Objectives

- minimize delay aircraft absorb
- minimize distance service vehicles travel
- minimize number of service vehicles required

Difficulties

- aircraft assignment has exponential possibilities
- aircraft sequencing has factorial possibilities



Scheduling Algorithms

Current

periodically see if aircraft is about to require service
use vehicles that have been idle the longest

Greedy

use vehicles that are closest to aircraft

Moving time window

periodically solve static scheduling problem
assign service vehicles according to results



Scheduling Algorithms: Moving Time Window

Planning horizon need not equal assignment horizon (examine schedule over next hour, every ten minutes)

Assignment horizon should depend on extent of uncertainty

Planning horizon should depend on computational power

In cases where planning horizon is unreasonably short, test heuristic approaches like genetic algorithms

“Clever optimization algorithms are best”



Scheduling Algorithms: Clever Optimization

Modify constraints to discourage fractional variables

Constraints on service times sum across binary sequencing variables

$$b_j \geq (F_x + \frac{D_{x,j}}{V}) a^x_{0,j} \qquad \forall j \in I,\ x \in X$$

becomes

$$b_j \geq \sum_{x \in X} \left[(F_x + \frac{D_{x,j}}{V}) a^x_{0,j} + \sum_{i \in I} (T_i + S_i + \frac{D_{i,j}}{V}) a^x_{i,j} \right] \qquad \forall j \in I$$

Add constraints to penalize cyclic flow

$$\sum_{x \in X} (a^x_{i,j} + a^x_{j,i}) \leq 1 \quad \forall i,j \in I$$



Scheduling Algorithms: Clever Optimization

Branch based on vehicle assignment and task sequencing, never on individual variables

(Somewhat) more detailed explanation in paper

Methods applicable to other vehicle routing problems, including arrival scheduling



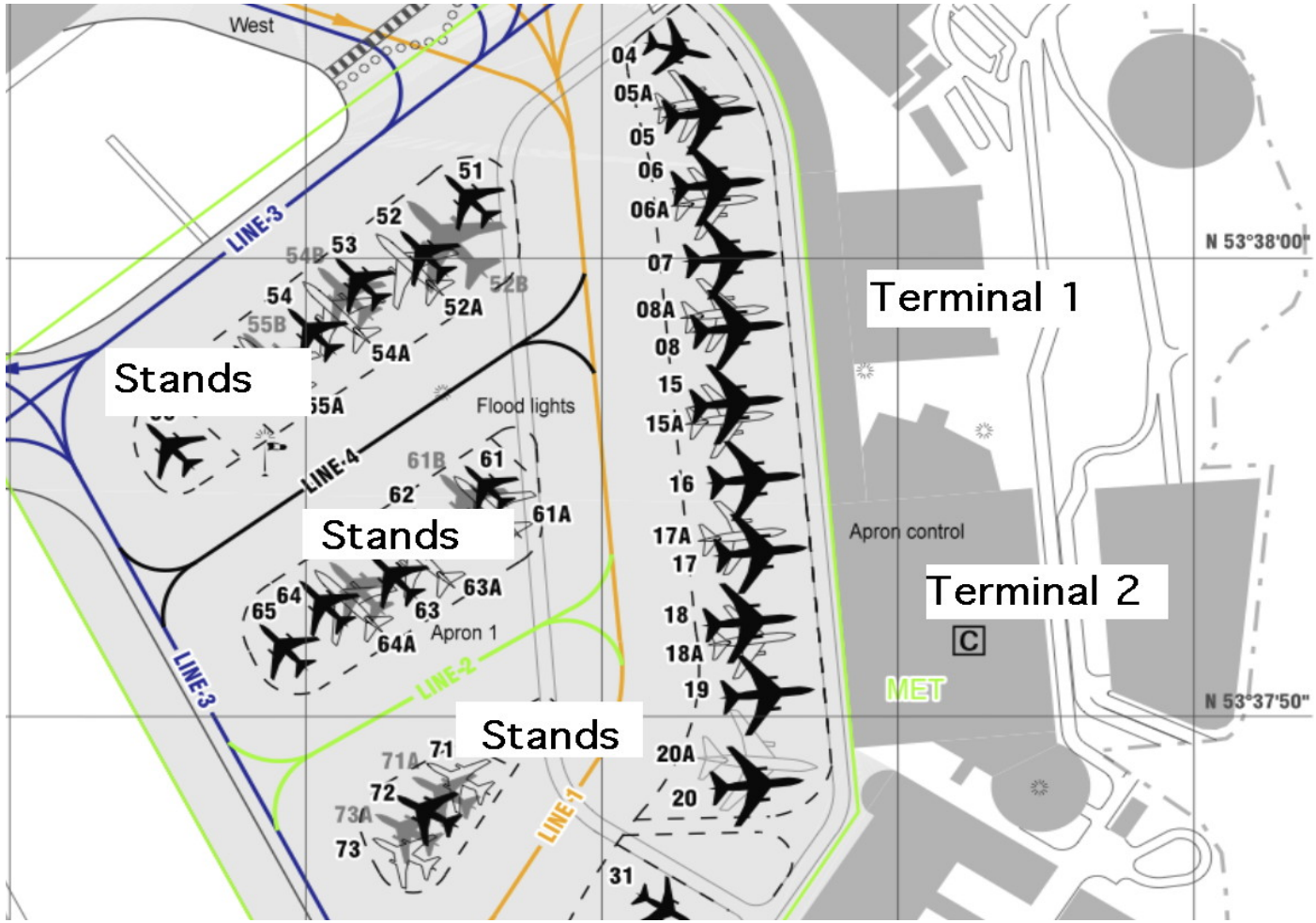
Scheduling Algorithms: Genetic Algorithm

Technique borrowed from arrival scheduling

- assign aircraft to runways / vehicles
- sequence aircraft
- schedule based on sequence (trivial)

Aircraft	1	2	3	4
Individual	**0.45**	**1.63**	**1.48**	**1.31**
Vehicle Assignment	Vehicle 1	Veh 2	Veh 2	Veh 2
Ordering Instructions	1st Task	3rd	2nd	1st

Simulation Studies: HAM





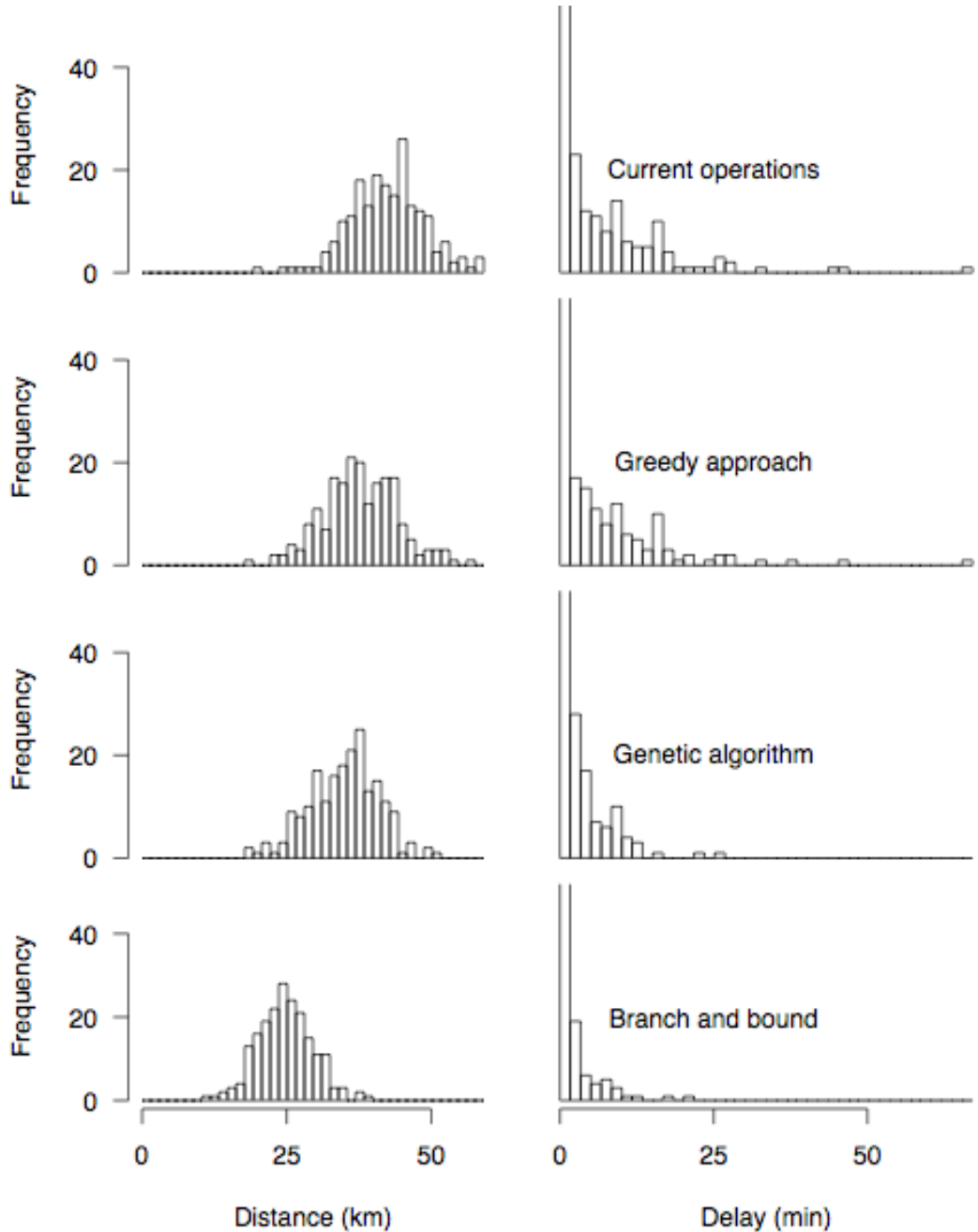
Simulation Studies: HAM

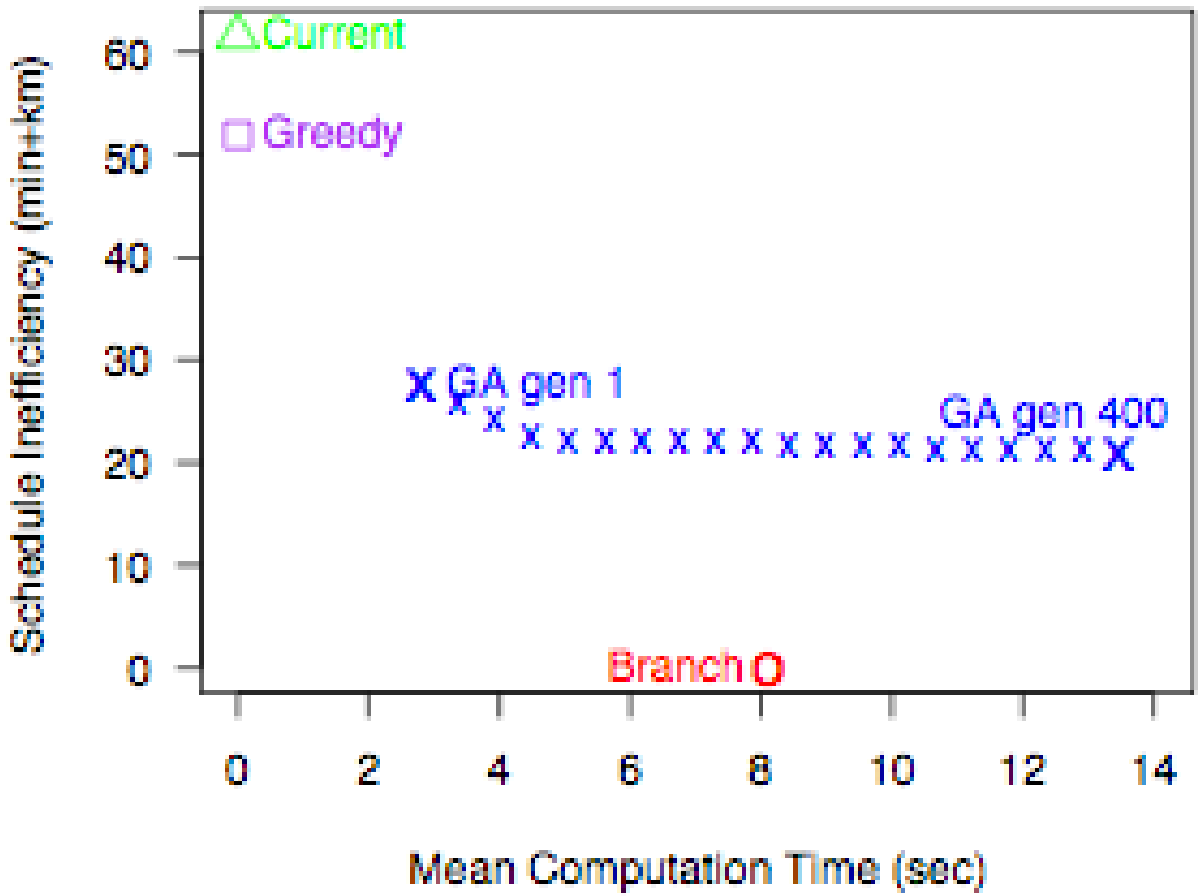
200 scenarios given to various scheduling algorithms

17 aircraft requesting service from 6 service vehicles in each scenario (a busy hour or two at HAM)

Over 10^{13} ways to assign aircraft

For each assignment, as many as 10^{14} ways to sequence tasks


Frequency
40
20
0
Current operations
Greedy approach
Genetic algorithm
Branch and bound
0
25
50
Distance (km)
Delay (min)

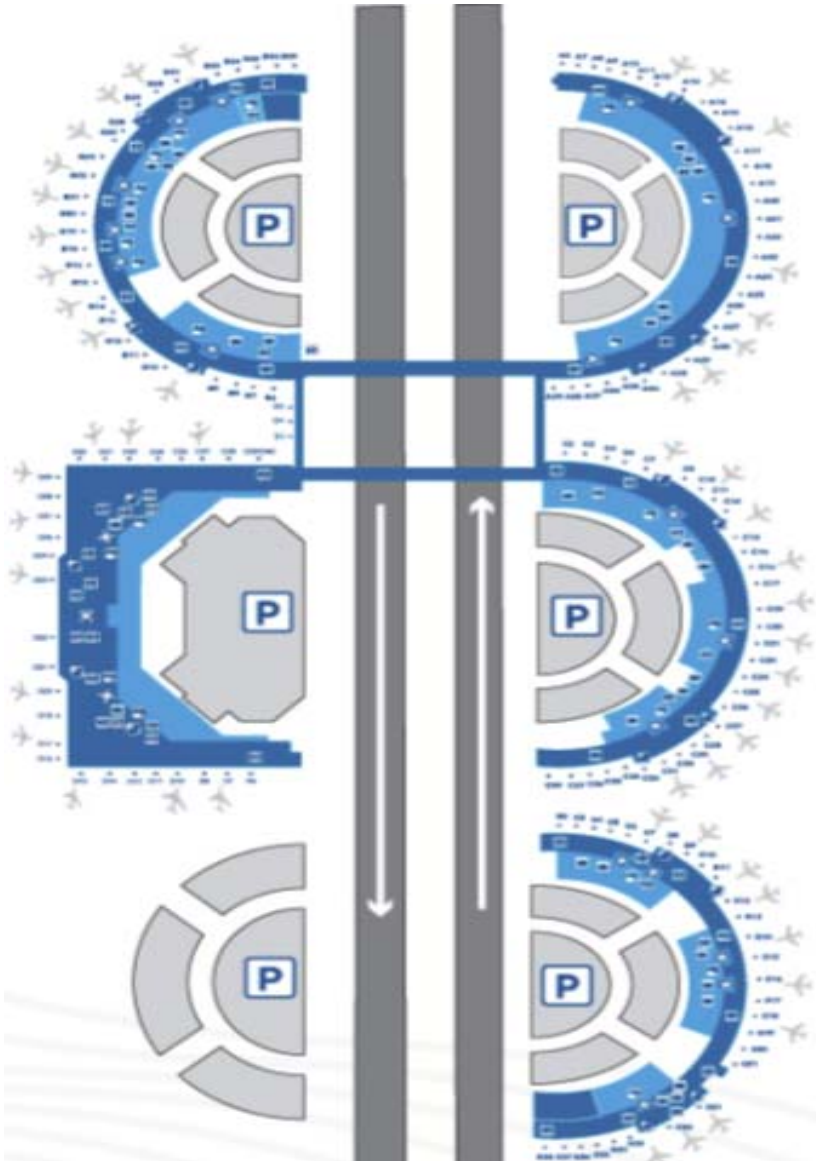


Simulation used glpk solver (open source) called from C++

Computation time of optimization highly variable



Simulation Studies: DFW



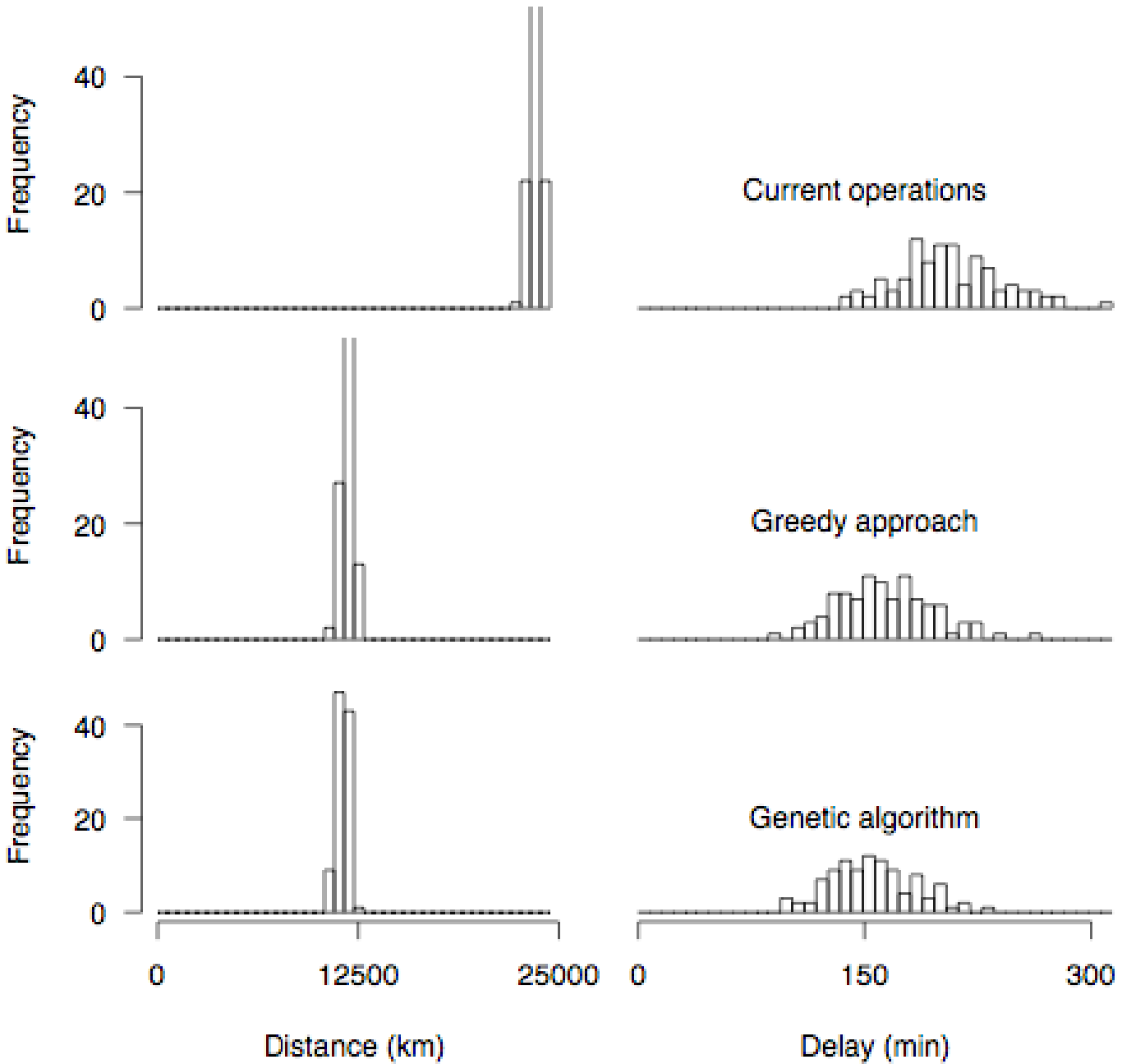


Simulation Studies: DFW

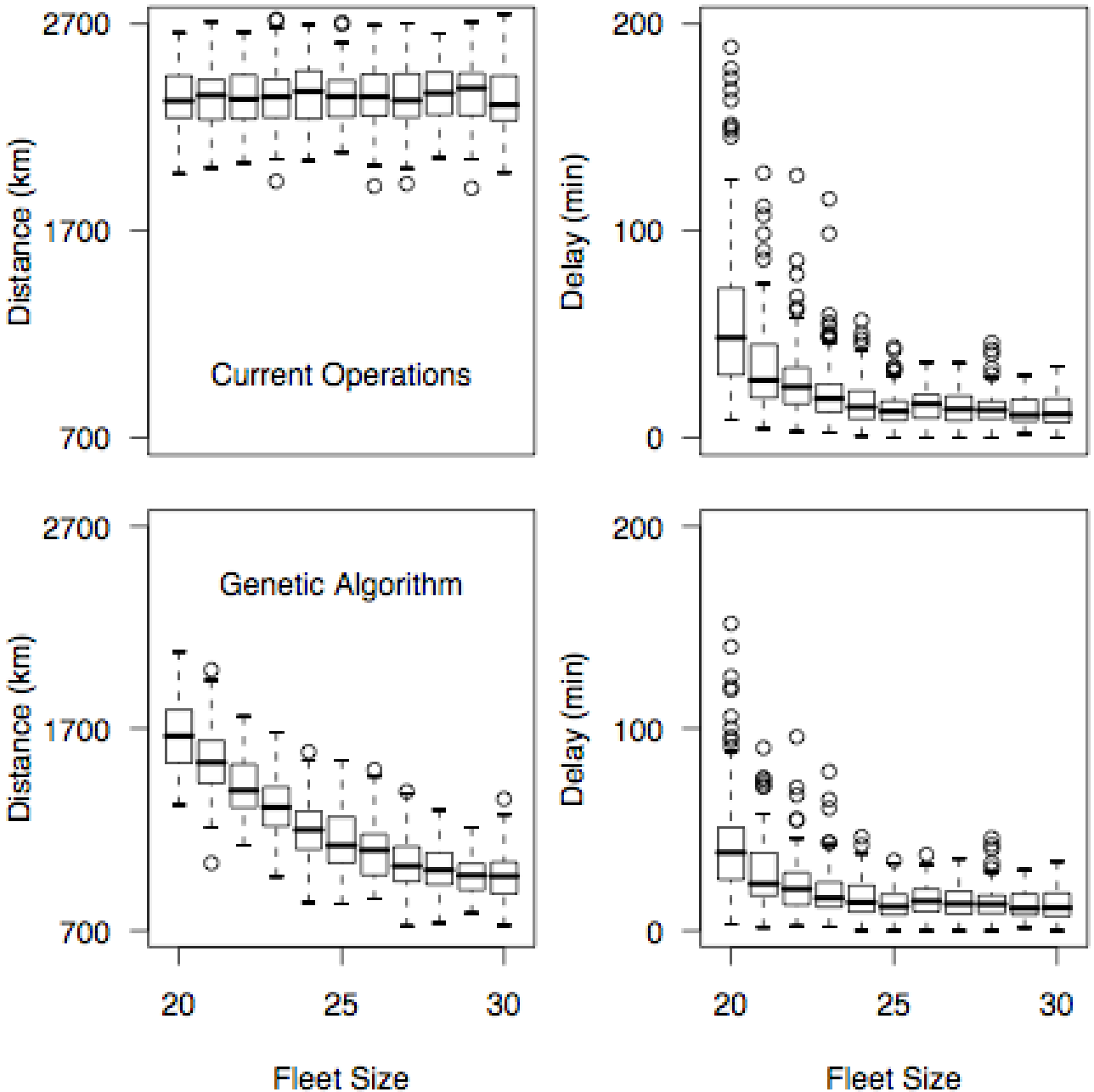
200 scenarios given to scheduling algorithms

1,000 aircraft requesting service from 20 - 30 service vehicles in each scenario

Optimization impossible given any reasonable planning horizon


Frequency
40
20
0
Current operations
Frequency
40
20
0
Greedy approach
Frequency
40
20
0
Genetic algorithm
0
12500
25000
Distance (km)
0
150
300
Delay (min)




2700
1700
700
Distance (km)
Current Operations
200
100
0
Delay (min)
Genetic Algorithm
20
25
30
Fleet Size
Fleet Size



Conclusion

Vehicle management systems have significant potential at both small and large airports

- reducing delay aircraft absorb
- reducing distance service vehicles travel
- reducing service vehicle fleet size

Delay aircraft absorb waiting for service vehicles also a function of arrival and departure time distributions

Established clever optimization and genetic algorithms for scheduling