Copenhagen Airport
“An Operations Analyst in an Airport is like a kid in a candy store”
Agenda

- Introduction to Copenhagen Airports A/S
- OR Optimization Methods in CPH
- Flow in the Airport
  - Passenger Flow in the Airport
    - Check-in Optimization
    - Manning Security
    - Manning the passport control
    - Baggage handling
    - Customs
  - Aircraft Flow in the Airport
    - Air Traffic Controllers
    - Ground Handling
    - Stands and Gate Optimization
Introduction to Copenhagen Airports A/S

• Copenhagen Airports A/S
  - Owns and operates the airports at Kastrup (CPH) and Roskilde (RKE)
  - Approximately 1900 employees
  - Makes its infrastructure, buildings and service facilities available to the many companies that have business operations at the airport.

• Mission
  - “Connect passengers and airlines — and bring Scandinavia and the world together”

• Vision
  - “Be the best airport in the world for passengers and airlines”

• Goals
  - Satisfaction: Top 3 in Europe by 2010
  - Growth: 30 million passengers in 2015
  - Competitiveness: Total operating costs for airlines: “Best in class”, 2012
Introduction to Copenhagen Airports A/S

• Facts
  - Founded in 1925
    • One of the first civil airports in the world
  - 39.2 % of the share capital held by the Danish State
  - 53.7% of the share capital held by Macquarie Airports Copenhagen ApS
  - 2 groups of customers: airlines and passengers
  - Main airport / hub of Scandinavia
  - Main airport / hub of SAS
  - Scandinavian hub for DHL
  - Largest workplace in Denmark - approximately 22,000
  - Direct connections to a total of 140 destinations (July 2010) worldwide
  - **Number of operations in 2009 (take-offs and landings):** 236,172
  - **Number of passengers in 2009:** 19.7 million
  - **Cargo volumes in 2009:** 312,179 tonnes
OR Optimization Methods in CPH

• CPH is in operation 24/7/365
  - Primary focus is on ensuring a reliable and well driven airport
  - The operation has first priority no matter what (!)
• Historically CPH has had sufficient capacity in all areas
  - Motivation for optimization not present
• Airport = An OR candy store...BUT
  - OR optimization methods are still only applied to a small fraction of its potential areas.
  - If OR optimization methods are used, it is within externally delivered software products, i.e. development is not conducted/decided upon by CPH.
  - OR competences not present in-house (...)
• Next step
  - Is optimization needed?
  - What is optimization?
  - What defines an optimal solution?
OR Optimization Methods in CPH

• Is optimization needed?
  - Can we accommodate today's traffic without optimization?
    • Check-in?
    • Stand and gates?
    • Baggage?
  - Can we go from 19,7 to 30 mio pax in 5 years without investing?
    • Buildings?
    • Employees?
    • Equipment?
  - Can we utilize our facilities better than we do today?
OR Optimization Methods in CPH

• What is optimization?
  – That you have made all of your calculations / planning in Excel?
  – That you are doing things in the same way as always?
  – That you find a feasible solution?
  – That you intelligently use statistical data and apply known OR optimization methods?

• Definition of “optimality” differs a lot within the company
  – Investors define optimality from a purely cost driven perspective.
  – For some departments optimality is when all tasks are covered, regardless of the number of people used.
  – For some departments optimality is when all employees have their wishes fulfilled.
  – For some departments optimality is when things are done in the way they have always been done.
OR Optimization Methods in CPH

• So what are we doing?
  - Establishment of a centralized **Planning and Analysis** department (November 1st, 2010)
    • All analysts in the Operations Department (Passenger Service, Traffic Handling, Baggage Handling, Security, Environment, Quality, Roskilde Airport and Lean) gathered in one place.
    • All analyses relating to the Operations Department.
  - Projects:
    • Check-in optimization
    • Security / Police manning
    • Stand and Gate optimization
    • Baggage Sorting
    • Baggage Racetrack Allocation
    • Capacity Analyses of all of the above
    • “One Set of Numbers”
    • ?
Passenger / Aircraft Flow in the Airport

Figure 1: The Airport Boundary

Key:
- Orange: ATC
- Blue: Airline
- Gray: Handling Agent
- Airport
- Choke points
Passenger / Aircraft Flow in the Airport

Figure 1: The Airport Boundary

Airport = OR Candy Store!
Passenger Flow in the Airport
Passenger Flow in the Airport

- All passengers are on an inbound or outbound flight.
- We know about all flights in advance.
  - Hence, we have a pretty good idea about passenger appearance.
Passenger Flow in the Airport

• For each flight, we have forecasts on:
  - Load factor
  - Appearance pattern
  - Bag factor
  - Passenger types (e.g. leisure / business)
• Forecast is based on historic data and differentiated on:
  - Airline
  - Destination
  - Aircraft type
  - Seat capacity
  - Flight type
  - Time of day
  - Handler
Appearance at Check-in

Arrivals, forecasted vs. realized - Tuesday September 1
Appearance at Check-in
Arrivals, forecasted vs. realized - Saturday September
Appearance at Check-in
Arrivals, forecasted vs. realized - Sunday September 6
Check-in Optimization

• What is the problem?
  - Opening patterns not optimized to match appearance patterns
    • Driven strictly by SLAs between airlines and handlers
    • CPH: “Only open counters when there are passengers”
  - Allocation of check-in areas
    • Previously handled entirely by the handlers
    • CPH: “Allocation of check-in areas should take baggage belt direction, baggage belt take-away capacity, queue lengths, CUSS kiosk demand and flow into consideration”
• What have we done?
  - Observation of appearance patterns
  - Dialog with airlines and handlers about opening patterns with CPH suggesting new and optimized opening patterns
  - As of May 3, 2010, CPH controls allocation of check-in areas to counters
    • Mathematical Modeling and Optimization
Check-in Optimization

![Check-in Optimization Chart]
Manning security

• Aggregate passenger appearance for all flights.
  - Incorporate the waiting time and processing time for check-in.
• Remove passengers that go through SAS Fast Track.
  - All other international passengers go through CSC.
• We assume that all passengers are identical.
  - However, we differentiate between summer / winter.
    • More clothes means longer processing time.
Manning security
Manning security

• Converting a passenger forecast to a plan:
  - SLA’s (Service Level Agreements) define constraints for the acceptable quality level.
  - Robustness considerations add to the demands.
  - Optimization objectives:
    • Minimize manpower allocation (minimize cost).
    • Maximize employee satisfaction.
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- Currently, we use a greedy heuristic:
  - Initialize cover with large values.
    - All demand is covered. Solution is very expensive.
  - Lower cover as much as possible, while respecting SLA’s.
    - Solution value drops to an acceptable level.
    - The quality of the service is still acceptable.

- Next step, enhance algorithm:
  - The problem is an optimization problem with:
    - A “nice” structure
    - “Simple” rules
    - Well defined objectives.
  - Solving the problem to optimality using mathematical programming should be possible.
    - Could make the basis of Master’s Thesis!
Manning security: Forecasting and Planning
Manning security: Forecasting and Planning

Antal åbne spor / Antal hold på arbejde - Mandag 22-11-2010 -
Forventet passanttal: 17816

Plan fra prognose
Manning security: Forecasting and Planning

• We need more employees than that.
  - Breaks
  - Lunch breaks
  - Special tasks
  - Buffer
Manning security: Forecasting and Planning

Antal åbne spor / Antal hold på arbejde - Mandag 22-11-2010 -
Forventet passanttal: 17816
Manning security: Forecasting and Planning

• With a demand per time interval, the demand must be covered by employees on shifts.
• From a “demand per time interval” the “demand per shift” is found.
• The employee shift plans are created to cover the “demand per shift”.

<table>
<thead>
<tr>
<th>Shift Name</th>
<th>Time</th>
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<tr>
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<tr>
<td>A1</td>
<td>05:00-14:00</td>
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<tr>
<td>C</td>
<td>06:00-18:00</td>
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<td>D</td>
<td>10:00-20:00</td>
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<tr>
<td>F0</td>
<td>13:00-21:00</td>
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<td>F1</td>
<td>14:00-23:00</td>
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<td>H3</td>
<td>20:30-06:30</td>
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<td>H4</td>
<td>18:00-04:00</td>
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<td>K2</td>
<td>08:00-16:00</td>
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### Manning security: Forecasting and Planning

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|       |       | 4-4     | 4-4     | 4-4     | 4-4     | 4-4     | 4-4     | 4-4     |

- Tj.nr.: Tjernummer
- Nøgle: Nøgle
- TIMER: Timer
- Vfri: Vfredag
- Kfri: Kfredag
- C: Cede
- Lfri: Lfredag
- A1: 5-14
- C = 6-18

**Norm:** 592,00  **Diff:** -4,00
Manning security: Forecasting and Planning

• Currently, most of this is a manual process.
  - We are currently in the process of buying a Resource Management System to optimize plans.

• Possible Master’s Thesis projects:
  - Find optimal “demand per shift”.
    • A (much) extended version of the assignment that I gave you at the previous lecture.
  - Generate optimal rosters.
Manning security: Evaluating

- Performance is evaluated.
  - Was performance acceptable?
  - If not, what are the causes.
    - The only way to improve is to find the origin of the causes.
- Passenger forecast is evaluated.
  - Even small variations can lead to queues.
    - Hence, the forecast must be very accurate.
    - We are constantly working to improve this.
- Plan is compared to realized opening of lanes.
  - If there are deviations, there should be a good reason.
- Productivity is compared to expected productivity.
Manning security: Evaluating

- Bad performance:
  - Find cause.
  - We know what the causes could be.
  - If we find consistencies over several days, the forecast and planning must be revised.
Manning security: Evaluating
Manning security: Evaluating

Open lanes, realized vs. forecast, Monday, 22-11-2010

Waiting time, in mins,

Lanes open

Waiting time

Lanes, realized

Lanes, forecasted

KPI
Manning security: Evaluating
Manning security: Evaluating
Passenger Flow in the Airport

• Other planning problems:
  - Manning the passport control
    • We are cooperating with the Danish Police.
  - Baggage handling
    • We are currently developing models and planning tools in the Baggage Department.
  - Customs
    • We are not looking at this problem, at the moment.
Aircraft Flow in the Airport
Aircraft Flow in the Airport

• The airlines are in control of their own schedules.
  - We have limited influence.
  - Usually, we consider them to be fixed.

• Optimization Tasks in the Aircraft Flow:
  - Air Traffic Controllers
    • Rostering
    • Task Scheduling
  - Ground Handling
    • Rostering
    • Task Scheduling
  - Stands and Gate Optimization
Stands and Gate Optimization

- A **stand** is an area on the apron where aircraft are parked
- A stand is (primarily) characterized by the following properties
  - Remote / gate
  - Size / physical conditions
    - What aircraft can / may at a given stand?
  - Passenger Status (Schengen, non-Schengen, non-EU, domestic)
    - Regulatory requirements
- CPH
  - **108 stands (including cargo and GA)**
    - 9 domestic
    - 43 gate stands
    - 54 remote stands
    - 2 helicopter stands
Stands and Gate Optimization

- Aircraft Types on B17
Stands and Gate Optimization

- Schengen
- Non-Schengen
- Schengen / Non-Schengen
- Non-Schengen / Non-EU inbound + outbound
- Schengen / Non-Schengen / Non-EU inbound + outbound
- Non-Schengen / Non-EU outbound

Terminal 1 / Domestic

Numre med "a" eftir nummeret er et ankomstområde/ankomst busgate

T-hus = Trappehus
And then things don’t go as planned, anyway
And then things don’t go as planned, anyway
And then things don’t go as planned, anyway
Merry Christmas!