

# Case – 2017 A New Departure Hall

## Planning security Marshalls at an airport

### *Problem description*

Personnel planning is a well-known problem in logistics which arises in many applications. In this case, we will look at a major airport. Different types of personnel are necessary to keep such an airport running. For instance, bus crew is needed to transport travelers from the various parking areas to the departure halls, while fuel- and baggage handling crew is needed to service airplanes at the gates. Another problem is the scheduling of air traffic control personnel. In many cases, personnel may be deployed flexibly, i.e. various services start at different times and their shifts may have different lengths. Breaks can be scheduled flexibly.

In this case, we look at the Security Personnel planning for a major Dutch airport.

This airport has recently opened a new departure hall, which a part of the airport's travelers need to use to check-in and drop off their cabin baggage. The departure hall also contains a Security Check area, in which the travelers and their handbags are checked for forbidden items. This area is controlled by Security Marshalls of the Royal Marechaussee (Dutch Military Police).

Due to recent budget-cuts of the Dutch Government, the number of Security Marshalls on the whole airport is limited. Therefore, the airport needs to efficiently plan the Security Marshalls to safely cover the Security Check of the new departure hall. Depending on the time of day, on the number of departing flights and expected number of travelers in the departure hall, a certain number of Security Marshalls should be present in the Security Check area.

The departure hall is closed at night (between 00:00 and 06:00). The Flight schedule at this airport repeats itself every week. Therefore, 7 separate planning problems have to be solved for each day of the week. Single Marshalls may only work a limited number of hours per day due to labor rules set by the Military and the European legislative. A shift may last between 6 and 8.5 hours. A break of one hour has to be scheduled. This break has to be cohesive and shall not be at the beginning or the end of shift. Furthermore, the working time before and after a break may not be longer than 5 hours each.

A single normal Security Marshall costs 40 euros per hour. Breaks are not paid. A single specialized Security Marshall costs 60 euros per hour. The goal is to minimize the total security personnel cost. The required numbers of security Marshalls per half hour are given. For the data, we refer to the Excel sheet "Data 1".

### *Mathematical formulations*

The type of personnel planning that we see in this case can be formulated in various ways as an integer linear programming problem. In this case you analyze two different formulations for the basic problem.

The first formulation is known as the implicit formulation. This formulation has the following types of decision variables:

- $s_{tp}$ : number of shifts of type  $t$  starting in period  $p$
- $f_{tp}$ : number of shifts of type  $t$  ending in period  $p$

- $m_{tp}$ : number of breaks in shifts of type  $t$  starting in period  $p$

For an example, we refer to Thompson (1995).

The second formulation is known as a (generalized) set covering formulation. This formulation was introduced by Dantzig (1954). Herein all shifts are explicitly displayed, and the decision variable  $x_j$  shows the number of times that a shift  $j$  is performed.

### *Assignments*

1. Formulate the basic problem as integer linear programming problem. Disregard specialized Marshall shifts, i.e. assume that only normal shifts exist. Make use of the implicit formulation.
2. Formulate the basic problem as integer linear programming problem. Disregard specialized Marshall shifts, i.e. assume that only normal shifts exist. Make use of the set covering formulation.
3. Solve the formulations of assignments 1 and 2 by using AIMMS for the 7 different datasets. Compare the computation times of the different formulations, and mention in the final report why one formulation performs better than the other.
4. Suppose that a single break of 1 hour may also be split into two smaller breaks of half an hour each. Working time between such two small breaks may not be longer than 4 hour. Formulate this modified problem as integer linear programming problem, and solve it for the seven different datasets. You can use either the implicit or the set covering formulation, but explain your choice in the final report. Compare the new solutions with the solutions from assignment 3. How does the objective value improve? Why?

The airport plans to use the new departure hall to handle a number of so-called 'Risk flights'. These flights tend to attract smugglers who try to use these flights to smuggle illegal substances such as drugs in or out of the country. To catch these smugglers, the Marshalls need to employ Sniffer Dogs, which are trained to detect illegal drugs hidden for instances in bags or smugglers' clothing. The use of a single Sniffer Dog costs 10 euros per hour and the dog cannot work longer than 4 hours, but it requires no break. There are in total 5 Sniffer Dogs available. Only specialized Security Marshalls may handle the dogs, and they costs 60 euros per hour. For each dog active at a certain moment in time, one specialized Security Marshall must be present to handle that dog. A specialized Security Marshall having a break cannot be used to handle a dog, but the Marshalls can exchange dogs at any moment (each dog is not assigned to a single Marshall). Specialized Security Marshalls not busy handling dogs can be used for regular tasks. Also, specialized Security Marshalls follow the same rules for shift duration and break duration. For the dog demand data, we refer to the Excel sheet "Data 2".

5. Formulate this variant of the problem and solve it for the 7 datasets. You can use either the implicit or the set covering formulation, but explain your choice in the final report. Compare the new solutions with the solutions of assignment 3. Which impact does the airport plans have on the personnel cost? What happens to the total number of Marshalls needed? Why?

**Assignments 1 and 2 have to be included in the proposal on May 3, 2017, 15:00 (max. 2 A4 pages).**

**In the final report, all assignments must be answered. Furthermore, we appreciate (and reward) additional sensitivity analysis as well as other extensions of the basic problem (as in assignments 4 and 5).**