The New Dutch Timetable: The OR Revolution

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Abstract. On April 14, 2008, INFORMS (The Institute for Operations Research and Management Sciences) announced Netherlands Railways to be the winner of the 2008 Franz Edelman Award. In this extended abstract, we give a short summary of both the paper [1] and the presentation of the winning team.

1 Introduction

On December 10, 2006, Netherlands Railways (in Dutch: Nederlandse Spoorwegen, or shortly NS) introduced a completely new timetable. The new timetable was constructed with the help of several Operations Research tools:

- CADANS creates a 1-hour cyclic timetable on the routes between the stations,
- STATIONS creates a 1-hour cyclic platform assignment and routing through the stations,
- ROSA creates a rolling stock allocation and circulation,
- TURNI creates the crew schedules for train drivers and conductors.

These four tools were developed in close cooperation with partners in the scientific community: the Centre for Mathematics and Computer Science, or CWI; Erasmus University and the company DoubleClick S.A.S., related to the University of Padua. The first work to construct an Operations Research model for cyclic timetabling started already in the early 90s. Afterwards, the other tools were developed, where the last one ROSA has been in full operation since 2005. In the remainder of this paper, we discuss why it was necessary to introduce a new timetable and the process how the timetable was generated.

2 Why a new timetable?

The last major change in the Dutch timetable took place in 1970. Since then, the number of passengers using the Dutch railway network has doubled. During the same period, freight transport increased significantly as well. To accommodate this growth, more and larger trains were scheduled, in particular many double-deck trains, but the basic structure of the timetable was not changed. Likewise, the rail infrastructure remained nearly the same, even though the Dutch rail

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network was becoming the most heavily used in Europe. Inevitably, the systems reliability came under pressure, resulting in delays for passengers. Therefore, the key question, NS was faced with, can be summarized as:

How can we transport many more passengers, and at the same time offer a more reliable service?

One obvious answer would be to significantly expand the railway infrastructure. Unfortunately, such expansion projects are extremely expensive and time consuming. Moreover, the government, being responsible for the rail infrastructure, was unwilling to pour many additional billions of Euros into new rail infrastructure. In 2002, all parties involved in the Dutch railway sector concluded that they had to come up with a different solution. That is, to develop a better timetable. Combining the need for a better timetable and the availability of advanced Operations Research tools, the railway sector launched the project to construct a new timetable from scratch.

3 Timetable project

The start of the timetable project was in June 2003. Since several operators use the same network, one timetable for all operators was constructed. In 2003, it was decided that the new timetable should start in December 2006. The main input to generate a timetable is the line system. Here a line is described by its start and end station, and all intermediate station it stops. Moreover, every line has a certain frequency, e.g. 1 or 2 trains per hour. All the individual lines together are called a line system. During the project, we generated and evaluated 10 different timetables based on 10 different line systems. For each line system, the following process was executed. First, we constructed a one-hour timetable with the DONS system. DONS consists of two Operations Research solvers: CADANS for constructing the timetable on the routes between the stations, and STATIONS for the detailed routing through the stations. Once each timetable was generated, we wanted to have an estimation of its expected profit. To estimate revenues, we first calculated the travel times and transfers for all passengers. Moreover, the punctuality of the system was simulated. The punctuality is measured as the percentage of trains that arrive within 3 minutes of the scheduled arrival time. The number of passengers depends on the timetable: shorter or longer travel times, more or fewer transfers, and higher or lower punctuality all influence the number of passengers. Based on this number, the revenues were estimated. Then, we estimated the match between the required and available amounts of rolling stock and crew. Since these are NS two main resources, we could also estimate the costs of the timetable. Finally, we calculated the expected profit as the revenue minus the costs. In March 2005, the key resulting figures from all 10 timetables were considered by the board. Their preference was a combination of two of the generated timetables, resulting in an 11th and final one, which is the one currently in operation. The board chose a timetable that is very attractive for passengers and increases the profitability of the company at the same time. The benefit for the passengers was achieved by choosing a line system with 15 minute

frequencies for fast and slow trains on the most important corridors. During the year 2006, we completed the details of the new timetable. First, we expanded the 1-hour timetable to seven times twenty four hours. Here, we chose the starting times of the first and last trains, and made decisions concerning exceptions during the off-peak hours. Afterwards, we constructed the rolling stock and crew schedules with advanced Operations Research tools: ROSA and TURNI.

4 Impact and success

Finally, we would like to discuss the impact of the use of Operations Research on NS and the society as a whole. In 2007, the first year of full operation of the new timetable, an all-time high number of passengers were transported. A detailed analysis of all individual routes showed that on the routes where we put more trains into service, the increase in passengers is much higher than the average. On these routes the increase is as high as 15%. The financial benefits for NS are the result of two factors. The first is the new timetable itself, which is more profitable than its predecessor. The second is the use of more efficient resource schedules. For instance, the use of ROSA led to a reduction of 6% in rolling-stock-kilometers. The total annual financial benefit of the more profitable timetable and the more efficient resource schedules amounts to 50 million Euros. The new timetable has also led to an all-time high in punctuality. Several years ago, NS made an agreement with consumer organizations that would allow the company a bonus fare increase of 2% if an all-time high punctuality level would be achieved. As NS achieved the record in 2007, fares were increased in February 2008. This leads to an additional annual profit of 20 million Euros. In addition, the higher punctuality has also led to the highest-ever level of customer satisfaction. More importantly than all these records, due to the new timetable a further increase in railway transport is possible without further significant infrastructure extensions. Since in the future additional railway transport can be accommodated by the new timetable, the growing demand for transportation to the main cities in the rush hours can be facilitated by railway transport. This helps reducing the pressure on the roads into and inside these cities, as well as pollution from greenhouse gases.

References

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