

Model approach to keeping track of trains

The Netherlands' new rail timetable was designed by a team of academics and logistics experts using sophisticated computer wizardry, writes Ben Schiller

Professor Leo Kroon, professor of quantitative logistics at RSM Erasmus University in Rotterdam, describes the task of redesigning the Dutch railway timetable as "rather complex". That is probably an understatement.

Imagine trying to create a system detailing the precise movements of 5,500 daily train services, thousands of pieces of rolling stock and all the personnel needed to run a railway network (a typical day on the Dutch railway involves 15,000 driver journeys). Then figure that, as with a Rubik's Cube, moving any piece of the puzzle could have knock-on effects on another part – meaning that the problem always has to be tackled as a whole, rather than in its component pieces.

Imagine, also, that the timetable must be flexible enough to withstand everyday disturbances and that it needs to strike a balance between operating costs and service quality. Quite complex.

That was the problem facing a team of mathematicians and logistics experts at Erasmus University and Netherlands Railways, who in 2002 were charged with coming up with the country's first new train timetable since 1970. What they produced – a new timetable introduced in late 2006 – has been a success, improving punctuality, making more efficient use of rail resources and winning the team behind the project an important award.

Prof Kroon and the team approached the problem by developing a series of mathematical models and algorithms that describe the variables of the train system as well as the relationships between them. These models and algorithms allowed the design team to come up with 10 different timetables, each with its own balance of cost and service. Netherlands Railways, the biggest Dutch passenger operator, and Pro-Rail, the Dutch rail infrastructure body, then chose the one that best suited their objectives.

The methods that Prof Kroon employed are known collectively as operational research (OR) – a form of applied mathematics that uses algorithms and models to reach decisions that either optimise the "maxima" (for example, profit) or the "minima" (eg cost), and that can make a trade-off between these objectives.

The team began work on the new timetable in 2002, when the operators and Pro-Rail realised that the old system was no longer fit for purpose. Passenger and freight volume had roughly doubled in 30 years, leading to increased delays and declining satisfaction among passengers.

The year before, the entire board of Netherlands Railways had been forced to resign following falling punctuality rates and disputes over working practices.

"The old timetable had grown larger and larger as new trains were added," says Prof Kroon. "In the end, it was better to do a complete redesign, rather than try to add even more trains to the system. That was not really going to be possible in the future anyway."

The new timetable, introduced in December 2006, has been a success by a number of measures. Passenger demand has increased by 15 per cent on some lines. Passenger satisfaction, measured in surveys, has gone up. More trains arrive on time. And Netherlands Railways makes better use of its resources. Its profits rose by €40m (\$61.8m) in the first year of the timetable, with more profit growth expected down the line.

"The cost reductions come mainly from more efficient rolling stock circulation and crew scheduling," Prof Kroon explains

"Until recently, these were both created manually and the whole process was down to the planners. Now we can create rolling-stock circulations and crew schedules based more on computer models. This also reduces the throughput time of the process."

Prof Kroon and his colleagues from Netherlands Railways, Erasmus University, the Dutch Centre for Mathematics and Computer Science and Double Click, were recently awarded the Franz Edelman prize, the highest accolade in the world of OR.

However, in spite of the mathematical beauty of the new timetable, its introduction did not all go smoothly. For one thing, some politicians in the north of the Netherlands complained that their journeys were now longer than before (the timetable had to be modified). More seriously, new train lines due to be completed in December 2006 were delayed by four months, so a temporary timetable had to be used instead.

The hold-ups created serious problems for timetablers. "The moment you change the timetable, you get consequences for the rolling stock circulation and the crew schedules. Everything is affected," Prof Kroon says.

The new timetable is in full operation and Prof Kroon and colleagues are looking forward to new challenges. Among these is a system allowing managers to make better decisions in the event of network disturbances.

"What one would like to know as quickly as possible is: which are the most appropriate measures to take in order to uphold as much of the service as possible?" says Prof Kroon.

"One has to decide quickly how to react. Model-based decision support is badly needed, but currently nonexistent. That's our next challenge and we hope that our work will also have a positive effect on the quality of the system."