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OR Impact

Articles demonstrating direct benefits from implementing OR studies

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Automated Airport Staff Scheduling at Swissport International Ltd.

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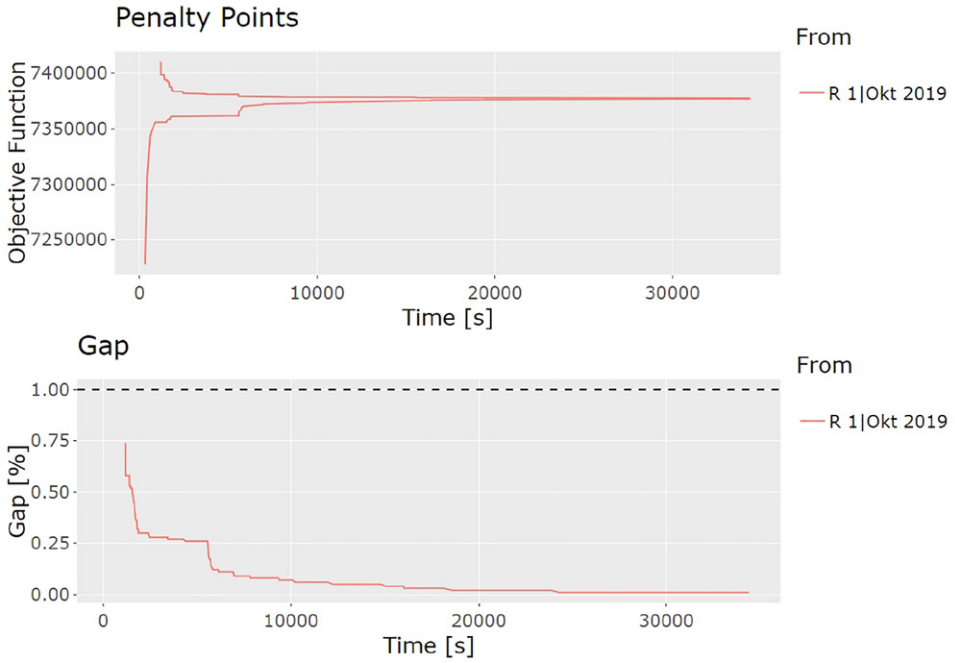
Project Overview

Swissport International Ltd. is the world's leading provider of airport ground services and air cargo handling, with 66,000 employees and a consolidated operating revenue of 2.99 billion euros in 2018. Swissport provided ground services for some 282 million passengers in 2018, and handled roughly 4.8 million tons of air freight in 115 cargo warehouses worldwide. At the end of June 2019, Swissport was active at 310 airports in 49 countries, on behalf of some 850 aviation customers.

Airport ground handling involves a broad range of tasks, including passenger services like check-in, gate handling and transfer, and ramp services like baggage management, aircraft handling, and aircraft servicing and cleaning. Swissport employs at its main airports up to 2500 people with hundreds of different work skills and shift duties, and a multitude of contract types. Monthly staff planning is highly complex and expensive, and usually requires extensive manual work by specially trained personnel.

Swissport decided more than 10 years ago to start to try to optimize these sophisticated planning processes with the help of an appropriate software solution. Evaluation of the commercially available staff rostering tools showed that no software was able to satisfactorily solve the complex large-scale planning problems at Swissport.



In 2007, Swissport launched a strategic R&D cooperation with the Zurich University of Applied Sciences Institute of Data Analysis and Process Design (IDP), with the aim of developing innovative high-performance software for automated staff rostering that is capable of solving Swissport's challenging planning problems. In addition, the tool needed to be sufficiently general and flexible to be usable in other companies and industries with complex rostering problems.

This collaboration, called Auto-Roster, started as a Swiss national research project and has continued as a strategic long-term cooperation between ZHAW and Swissport, with an aim to continually adapt, extend, improve and deploy the developed optimization tool.

Employee Scheduling

This generally comprises three main phases: (1) task generation and shift construction, (2) rostering, (3) real-time dispatching. Phase 1 includes demand modeling, task generation, shift design, and demand covering. Phase 2 is the main rostering phase where daily shifts are assigned to individual employees. It consists of the days-off planning and shift assignment tasks, and generates a detailed monthly staff schedule which is communicated to the employees several days before execution. Phase 3 deals with the real-time planning and control tasks on the day of operational execution.

The Auto-Roster project mainly focuses on Phase 2 which represents the most complex, expensive and sensitive planning task at Swissport. The amount of work involved in rostering at Swissport can be illustrated with reference to the initial situation at Zurich Airport, the pilot site for the project. At project start, the rostering department comprised 20 planners who worked almost exclusively on rostering the over 2000 employees at Zurich Airport which corresponds to around 400 working days per monthly plan.

Major innovations and challenges for the Auto-Roster software came from a dynamic, demand-driven planning policy which does not rely on repetitive shift patterns rolled out over a long-term horizon, and from a rostering approach which attributes high importance to individual employee preferences. Human planners typically achieved a 95% wish fulfillment rate, and it was imperative that an automated solution also met this rate.

Methodology

In contrast to most commercial rostering tools, which are generally based on stochastic search metaheuristics, Auto-Roster relies significantly on Mixed Integer Linear Programming (MIP), combined with various other optimization techniques, including decomposition and relaxation, pre- and post-processing, and a variety of heuristic procedures.

Approaching large-scale real-world rostering problems by MIP techniques is innovative and challenging, since computation times are typically far beyond any acceptable limits. Developing "good" MIP formulations to reduce solver computation times was one of the most important and challenging parts of the Auto-Roster project, and required deep knowledge in combinatorial optimization, polyhedral combinatorics, and graph theory. The project was several times close to failing due to intractable MIP models and could only be continued thanks to mathematical breakthroughs leading to powerful new MIP formulations

Other major challenges came from feasibility issues, since most real-world planning instances at Swissport are infeasible at first. Finding and explaining infeasibilities is intrinsically complex, and a variety of algorithmic approaches had to be developed to master these issues.

The current Auto-Roster optimization engine (without front- and back-end) comprises some 25,000 lines of MIP code and 30,000 lines of Java code. The largest MIP instances contain around 1 million integer variables and 0.5 million constraints, and can typically be solved within 20 - 70 hours with relative MIP optimality gap << 0.5%. The relative MIP optimality gap corresponds to the percentage deviation of the best objective function value found so far from the best objective bound resulting from the Branch-and-Cut MIP solver process. For an illustration, see Fig.1, which shows the convergence of the decreasing objective function curve (measured in penalty points associated to the current solution) and the increasing objective lower bound, together with the associated MIP gap.

Implementation

The Auto-Roster software is fully implemented and in operational use at all three major airports in Switzerland, namely Zurich, Geneva and Basel. Other airports in Europe are currently preparing for deployment, and the roll-out is being continuously expanded. Zurich Airport is one of Swissport's most complex airports in terms of staff rostering, and operational implementation of the software in the various planning units took several years.

Currently, a total of 57 internal customers are using Auto-Roster. Since planning units often have different policies regarding their rostering processes, software roll-out is generally challenging and laborious. A detailed understanding of the business needs and a close cooperation with the involved planners and employees is indispensable.

The preparatory work for the introduction of the Auto-Roster software generally includes a comprehensive analysis and cleanup of the existing planning processes and data situation. Along with the implementation, all associated business processes must be thoroughly redesigned or adapted, and the personnel involved must be carefully re-trained.

Years of experience with the Auto-Roster deployment have shown that, after a demanding transition period of a few months, customers generally express great satisfaction and trust in the software, fully align their planning processes with it, and report on substantial operational and financial benefits.

Business Impact

Auto-Roster has become one of Swissport's most important operational planning instruments. At the strategic level, top management decided that the software should be rolled out further to other stations within Europe. In addition, the process optimizations developed in connection with Auto-Roster should be transferred to other stations as best practices.

A recent comprehensive study of the personnel planning processes at all Swissport stations in Switzerland, carried out by an external consulting company, concluded that Auto-Roster is of central importance for Swissport and has a significant business impact. The study also emphasized that the tool is indispensable in the current planning environment, and there are hardly any alternative tools with similar functionality, performance, and flexibility.

The Auto-Roster software generates considerable financial savings for Swissport. Part of the financial impact can be quantified by comparing the rostering department's post-implementation workload with the original workload.>> Planning effort can often be reduced by up to half, and associated personnel costs are reduced accordingly. At the three Swissport stations in Switzerland, the annual savings from rostering effort reduction alone amount to around $1 million.

Besides reduced planning expenses, Auto-Roster has numerous other impacts that also bring substantial operational and financial benefits, including the following:

- Shift scheme optimization (phase 1), based on Auto-Roster's sophisticated rough-cut planning capabilities, eliminates wasted shift times and reduces operational personnel costs.
- New employment contract models can be evaluated and optimized by means of rough-cut algorithms.
- Proactive optimization of employee and contract mix improves alignment of demand and supply.
- Improved roster quality, fairness, and robustness.
- A broad range of options for defining personal preferences, wishes, and lifestyles allows employees to design their individual work plans in great detail.
- A very high and stable wish fulfillment rate of 95 - 100% leads to high employee satisfaction.
- Shorter planning processes allow roster releases closer to execution, reducing time and cost effort for intermediate adaptations.
- Standardization and maintenance of informal planner know-how reduces dependence from individual planners.
- Possibility to implement innovative rostering approaches such as shift bidding.

Challenges

Various managerial, technical and operational challenges had to be overcome during the 12-year cooperation. We mention the following:

- As a non-standard, long-term, costly, complex, and risky R&D project, this collaboration required strong commitment, confidence, courage, patience and personal trust from all stakeholders including Swissport's top management.
- A multitude of constraints from industrial regulations, labor contracts and workplace agreements had to be implemented, taking into account regional and group specific differences and ever-changing operational conditions and requirements specifications.
- Detailed modelling of employee preferences was difficult and required the study of hundreds of informal employee files and notes to understand and formalize individual wishes.
- Computational performance is an ongoing challenge, since current computation times are at the limit of the strictly defined operational deadlines. Improvements typically require deep mathematical and algorithmic research.

Further Business Opportunities

The Auto-Roster software can easily be transferred to other customers and industries, since business rules, mathematical models, and algorithms are designed on a generic abstraction level. This opens up a variety of new business opportunities for the profitable application of the Auto-Roster tool.