Ground Crew Rostering with Work Patterns at a Major European Airline

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Abstract Staff Rostering is a well known optimization problem in the Operations Research literature. People are one of the most important resources, and the construction of efficient rosters using tailored optimization algorithms can lead to significant potential savings for the employer. In this paper we address one such problem arising in the ground operations at a major European airline. This problem, termed the Ground Crew Rostering Problem with Work Patterns (GCRPWP), entails assigning a set of employees to a set of shifts, which are spaced over a given daily time horizon, in such a way that the required employee demand on each shift is satisfied as closely as possible. Having too few staff on a given shift results in undercoverage, which is undesirable. When assigning a sequence of shifts to a particular employee one must respect several practical constraints. In particular, unlike traditional rostering problems, one must satisfy a so called work pattern of length l days. A work pattern specifies both the number of consecutive days of work (on-stretch) as well as the number of consecutive days of rest (off-stretch) an employee must have and is repeated over the rostering horizon.

We present a cutting stock based formulation and propose a column generation solution approach to find an efficient set of roster lines, where a roster line is a legal sequence of on and off-stretches that one or more employees can work. While the use of a repeating work pattern limits the number of feasible roster lines, the work pattern can be staggered across the employees to ensure all employees are not off on the same day. This staggering results in l independent subproblems, each of which entails solving a resource constrained shortest path in an appropriate acyclic network. To solve the model, we decompose the six month time horizon into smaller, computationally tractable blocks. The column generation procedure is combined with a variable fixing routine to find a roster for each block. The blocks are solved sequentially and consistency between the rosters of successive blocks is enforced through shift fixing in a prespecified overlapping duration between two consecutive blocks.

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In addition, we describe an alternative time-based model that constructs roster lines simply using the forecast workload. Like the first model, this assumes the shifts have been predetermined; however, it does not assume that the required employee demand for each shift is known. The number of employees working any shift is determined by the optimization as part of the solution. By doing this we are able to circumvent one step of the conventional roster planning process. This second model is very similar in structure to that of the first and can be solved using the same methodology. With the second model, one attempts to cover, as well as possible, the workload rather than the required employee demand on each shift. We demonstrate that this second model is more flexible from a modelling perspective in that one can more easily include robustness factors. Robustness factors of interest for the airline in question include being able to cover a higher workload than anticipated as well as a workload that has been delayed by a prespecified number of minutes.

Encouraging numerical results are reported using real-life data supplied by a major European Airline. We also stress test the approach on 10 artificially constructed instances. All instances have a time horizon of 189 days and contain as many as 139 employees. The proposed methodology is shown to produce high quality rosters that outperform what is currently done in practice. In particular, from a robustness perspective, we show that more robust solutions can be obtained even with a 10-12% reduction in current staffing levels.

Keywords Staff Rostering · Decomposition · Robustness

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