Chapter 5  
Summary, Conclusions, and Future Work

Abstract. In this study, two airline scheduling approaches were developed that integrate the flight schedule generation and aircraft scheduling phase into a single scheduling approach. One of the two approaches for airline schedule optimization follows the traditional planning paradigm of iteratively and sequentially solving subproblems of the overall airline scheduling problem. The other airline scheduling approach is based on self-adaptive metaheuristic optimization in which complete airline schedules are processed at once. Applying both approaches to the same scenarios results in the simultaneous approach being the more efficient planning technique. The capability of the simultaneous approach is further demonstrated by verifying its results for systematically modified planning scenarios. The simultaneous planning approach of this study optimizes a large portion of the overall airline scheduling problem in an integrated procedure while minimizing simplifying assumptions. Thus, many of the requirements formulated in airline operations research literature are fulfilled. However, further challenges exist that future work should focus on: incorporating the complete crew planning into this scheduling approach, including stochastic elements in the schedule evaluation to minimize the effects of disruptions, further increasing the level of detail in which airline operations are represented and considering more practical requirements, and finally – since this study represents a theoretic framework – assessing the applicability of the integrated approach in real-world airline scheduling.

5.1 Summary

Since its beginning as exclusive adventure airline travel has become a mass travel system representing one of the most valuable assets for economic growth. In the past, a constant increase of the total passenger kilometers of scheduled passenger airlines could be observed that is expected to continue in future years. However, despite this positive trend, the airlines profit margins are considerably small and strongly depend on overall passenger demand. As a result, the airlines’ profitability is cyclical, following economic upturns and downturns. For each airline, the challenge is to match its resources like personnel and aircraft to the demand given by the market. The instrument to accomplish this task is the airline’s schedule, containing all flights of
the airline and the assignment of the resources. Hence, an optimal schedule represents the most efficient and effective deployment of an airline’s resources while best satisfying potential passenger demand. It is the central element within an airline’s corporate planning system, because it affects almost every operational decision and has the largest impact on profitability.

As a consequence, the construction of an airline schedule is one of the most important but also most complex planning tasks of each airline. Many factors such as demands in various markets, competition, and available resources have to be taken into account. Unfortunately, a single optimization model for the complete airline scheduling problem is intractable when using exact optimization techniques. Instead, this problem is solved in a sequential approach. The overall problem is decomposed into subproblems of less complexity; these subproblems are solved in a sequence, and the solution of one problem serves as input for the next problem. Some subproblems are grouped together to form airline scheduling phases. One possible decomposition of the overall problem and aggregation of the subproblem to scheduling phases is proposed on page 10. Many different solution approaches were developed for individual planning steps. An extensive presentation of these models and the underlying problems including their objectives and constraints are given in Sect. 2. Since in general a decomposition of a problem cuts interdependencies between decision variables, and a solution sequence limits flexibility of later planning steps, only suboptimal or even infeasible solutions of the problem can be achieved. To reduce these disadvantages for the airline scheduling problem, airlines usually implement iterations in the planning process where solutions or details of later planning steps are processed to earlier steps. However, since it is impossible that a sequential solution approach can achieve better or equal solutions than a simultaneous approach, research focuses on the integration of different subproblems into a single optimization model. Models that aim at integrating selected subproblems are presented in Sect. 2.5.

The objective of this study is to fill a large gap between the status quo in airline scheduling and the optimal scheduling using a fully integrated optimization model that includes all subproblems and represents airline operations on a sufficient level of detail. For this purpose, two airline scheduling approaches were developed that integrate the flight schedule generation and aircraft scheduling phase into a single scheduling approach. Their only requirement is to receive a quality measure for each schedule processed. As schedule evaluation applications used by airlines and their required parameters and data are not available for this study, a custom evaluation procedure was developed that estimates the operating profit for any given airline schedule (Sect. 4.2). One of the two approaches for airline schedule optimization (presented in Sect. 4.3) follows the traditional planning paradigm of iteratively and sequentially solving subproblems of the overall airline scheduling problem. For the individual solution steps, existing models from literature were used, which are then integrated in a complete planning procedure. The other airline scheduling approach (presented in Sect. 4.4) is based on self-adaptive metaheuristic optimization in which complete airline schedules are processed at once. Because in each schedule the subproblems and interdependencies are included implicitly, the optimization results in a truly simultaneous airline scheduling approach.