Ph.D. Dissertation Defense
Engineering Management and Systems Engineering
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A HYBRID TABU/SCATTER SEARCH ALGORITHM FOR SIMULATION-BASED OPTIMIZATION OF MULTI-OBJECTIVE RUNWAY OPERATIONS SCHEDULING

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As air traffic continues to increase, air traffic flow management is becoming more challenging to effectively and efficiently utilize airport capacity without compromising safety, environmental and economic requirements. Since runways are often the primary limiting factor in airport capacity, runway operations scheduling emerges as an important problem to be solved to alleviate flight delays and air traffic congestion while reducing unnecessary fuel consumption and negative environmental impacts. However, even a moderately sized real-life runway operations scheduling problem tends to be too complex to be solved using analytical methods, where all mathematical models for this problem belong to the complexity class of *NP*-Hard in a strong sense due to the combinatorial nature of the problem. Therefore, it is only possible to solve practical runway operations scheduling problem by making a large number of simplifications and assumptions in a deterministic context. As a result, most analytical models proposed in the literature suffer from too much abstraction, avoid uncertainties and, in turn, have little applicability in practice. On the other hand, simulation-based methods have the capability to characterize complex and stochastic real-life runway operations in detail, and to cope with several constraints and stakeholders' preferences, which are commonly considered as important factors in practice.

This research proposes a simulation-based optimization (SbO) approach for multi-objective runway operations scheduling problem. The SbO approach utilizes a discrete-event simulation model for accounting for uncertain conditions, and an optimization component for finding the best known Pareto set of solutions. This approach explicitly considers uncertainty as well as fairness among aircraft as part of the optimization process. Due to the problem's large, complex and unstructured search space, a hybrid Tabu/Scatter Search algorithm is developed to find solutions by using an elitist strategy to preserve non-dominated solutions, a dynamic update mechanism to produce high-quality solutions and a rebuilding strategy to promote solution diversity. The proposed algorithm simultaneously maximizes runway utilization and fairness among aircraft. To the best of our knowledge, this is the first SbO approach that explicitly considers the stochastic version of the multi-runway operation scheduling problem with multi objectives. The framework has been validated against real life data and its performance has been thoroughly evaluated.