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An Overview on Aviation Management

Puneet Raheja

Assistant Professor, Department of Finance, Dhanalakshmi Srinivasan College of Arts and Science for Women, Perambalur, Tamil Nadu

research@dscollege.ac.in

ABSTRACT

Aviation or air travel relates to the operations of the airlines and aircraft industries related to mechanical flights. We are presenting a recent literature survey on aviation management in this article. Airline Capability Analysis; Air Traffic Flow Management; Airline Fleet Assignment; Tail Assignment with Aircraft Maintenance Routing; Airline Crew Pairing; Airline Recovery and Rescheduling; Airline Revenue Management; Joint Decision Making; Aircraft Scheduling. The literature review is grouped into the following key categories: This classification seeks to inspire aviation management researchers and practitioners to establish more important, practical and wider-ranging optimization methodologies to address the current needs of the aviation industry.

Keywords — *Aviation Management; Airline Industry; Aircraft*

INTRODUCTION

Over the past 100 years, the air transportation industry has grown rapidly and has become an important global economic field. The Operations Research (OR) discipline has played a key role since the 1950s in helping the airline industry and its infrastructure to function efficiently and maintain a high rate of growth. While there is a great deal of aviation management research production, there is a lack of reliable and convenient classification of the papers recently published in leading OR journals. In this article, by presenting a recent detailed literature survey on aviation preparation and scheduling, we attempt to fill this void. We further group them into the following nine key categories in order to better coordinate and evaluate these research ideas, namely, Aviation Capability Analysis; Air Traffic Flow Management; Tail Assignment with Aircraft Maintenance Routing; Crew Pairing; Airline Recovery and Rescheduling; Airline Revenue Management; Collective Decision Making; Aircraft Scheduling. The key contribution of such a literature survey and classification is to enable aviation management researchers and practitioners to establish OR methodologies that are more applicable, practical and detailed and directly linked to the aviation industry.

A. Aviation Capacity Analysis

The main purpose of the study of airline capability is to evaluate the capacity of airline facilities for the arrival and departure of aircraft. The following leading papers discussed the problems of

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airline capability research (Barnhart et al., 2012; Dalmau and Prats, 2017; Derigs and Illing, 2013; Flores-Fillol, 2010; Kim, 2016; Lapp and Cohn, 2012; Lonzius and Lange, 2017). An optimal control problem for evaluating the effects of continuous descent operations with arrival time windows was investigated by Dalmau and Prats (2017). In order to analyse the real-world effect of two robust scheduling approaches, i.e., hub connectivity and swap possibilities, Lonzius and Lange (2017) studied an econometric model. To evaluate the impacts of changing flight demands and throughput efficiency on airport delays in the recession, Kim (2016) applied a probabilistic simulation method. In various European emissions trading systems, Derigs and Illing (2013) implemented a model-based assessment of network design and optimization at cargo airlines. Lapp and Cohn (2012) proposed a new usability model for metric maintenance that tests the capabilities and robustness of a planned set of flight lines. Barnhart et al. (2012) concluded research patterns and opportunities in the field of demand and capacity management in air transport; then outlined a systematic approach to better demand and capacity management in terms of specifying, allocating, and leveraging capacity in air transport. To explain the interplay between flight frequency and aircraft size, FloresFillol (2010) suggested a congestion-pricing model and extensively analysed the effects of airport hub congestion.

B. Air Traffic Flow Management

The key goal of Air Traffic Flow Management (ATFM) is to control airspace en route traffic flow and to reduce the cost of ground keeping (Bertsimas et al., 2014; Bertsimas and Gupta, 2016; Ivanov et al., 2017; Kim and Hansen, 2015; Koepke et al., 2008; Lulli and Odoni, 2007; Zhang et al., 2017). A two-level mixed integer optimization model was proposed by Ivanov et al. (2017) to solve the problem of on-road demand-capacity imbalance, reduce the ATFM delay and improve adherence to the airport slot. The MIP models and a two-stage hybrid algorithm were developed by Zhang et al. (2017) to solve the problems of hub position and plane assignment for the air-cargo delivery service. Bertsimas and Gupta (2016) suggested a two-stage strategy that involves fairness and coordination in the management of air traffic flows. In a congestible transport system, Kim and Hansen (2015) presented a game theoretical model of a sequential capacity allocation mechanism and analyzed the concepts at work in how airlines can fulfil their demands for en-route capital under capacity shortages and unpredictable circumstances. For modeling complex resource allocation issues, Bertsimas et al. (2014) implemented a binary optimization framework. Three commonly discussed issues, namely Air Traffic Flow Control, Aircraft Maintenance Problems and Job Shop Scheduling, were added to the system.

C. Airline Fleet Assignment

The primary objective of the Airline Fleet Assignment is to determine the size of aircraft to be assigned to each flight, as demonstrated in the following important literature papers (Andreatta et al., 2011; Barnhart et al., 2012, 2009; Bélanger et al., 2006; Benlic, 2018; Bertsimas et al., 2011; Haddad et al., 2008; Haouari et al., 2009; Liang et al., 2014; Pilla et al., 2012; Rey et al., 2016; Safa et al., 2016; With the consideration of flight timing, passenger demand and fuel consumption costs related to cruise speed control, Safak, Gurel and Akturk (2017) created an integrated aircraft path assignment and scheduling challenge. A deterministic conflict resolution model adapted to subliminal speed regulation was proposed by Rey et al. (2016). The proposed models are formulated as nonlinear problems of optimization that aim to reduce indicators relevant to the workload of air traffic controls. A flight sequence assignment model (FSAM) was

developed by Liang et al. (2014) that selects an optimal set of flight sequences to minimise the total cost of the penalty. The weight restricted shortest path problem with replenishment was investigated by Smith et al. (2012) and a new algorithm was developed that exploits the structure of the inter-replenishment path. An aggregate stochastic programming model for airline fleet management was developed by Andreatta et al. (2011) with three important aspects, namely uncertainties in airport capacity; trade-offs between arrivals and departures of aircraft; and interactions between different airport hubs.

D. Tail Assignment with Aircraft Maintenance Routing

Most of the Tail Assignment and Aircraft Maintenance Routing papers seek to decide how aircraft can be allocated to fly legs and route aircraft to minimise the overall operating and maintenance costs of flights (Ben Ahmed et al., 2017; Faust et al., 2017; Grönkvist, 2006; Khaled et al., 2018; Liang et al., 2015; Maher et al., 2014; Marla et al., 2018; Quan et al., 2007; Reményi and Staudacher, 2014). From a data-driven viewpoint, Marla et al. (2018) addressed various classes of robust aircraft routing models. A compact mathematical formulation model was developed by Khaled et al. (2018) to solve the tail assignment problem of aeroplanes (i.e. assigning aeroplanes to flight legs) with the goal of reducing the overall operational and maintenance cost of the flight. Ben Ahmed et al. (2017) present a technique for hybrid optimization-simulation aircraft scheduling, in which a nonlinear mixed integer programming model is built to optimise aircraft maintenance routing and a Monte-Carlobased approach is used to modify flight departure times sequentially. A new integrated scheduling problem was created by Faust, Gönsch and Klein (2017) to optimise the option of flights and aircraft maintenance routing on the basis of real-world data provided by a provider of airline information technology called Lufthansa Systems. In order to reduce the overall anticipated propagated delay of the aircraft routes, Liang et al. (2015) solved two closely related airline planning issues, i.e. the robust weekly aircraft maintenance routing issue and the tail assignment issue. Via a database for airport surface movement, Weiszer et al. (2015) developed a real-time active routing approach. By applying the recoverable robustness paradigm and the Pareto-optimal method, Maher et al. (2014) investigated the single day aircraft maintenance routing problem. A systematic-simulation-based approach to the identification and application of a scheduling law for aircraft engine maintenance was suggested by Reményi and Staudacher (2014).

E. Airline Crew Pairing

In aviation management, the Airline Crew Pairing issue aims to allocate the required workers to each flight to reduce the overall cost of the crew (Beliën et al., 2013; De Bruecker et al., 2018, 2015; Ho and Leung, 2010; Maher et al., 2018; Quan et al., 2007). In order to optimise the skill mix and training schedule of aircraft maintenance staff, De Bruecker et al. (2018) developed a three-stage mixed integer programming system. A new mixed integer linear programming model was developed by De Bruecker et al. (2015) to obtain robust aircraft maintenance workers rosters in order to reduce the overall cost of labour. In the event of flight cancellations, Maher (2015) applied the column-and-row generation solution method to solve a passenger recovery problem through a unique definition of the cancellation variables. A mixed integer linear programming model for constructing an aircraft maintenance company's staff schedules was proposed by Beliën et al. (2013). Ho and Leung (2010) explored the issue of manpower scheduling for airline catering by providing airline meals and other supplies to aircraft on the tarmac just before take-

off. To solve this manpower scheduling problem, taboo quest and simulated annealing met heuristics are developed.

F. Airline Recovery and Rescheduling

Most airline recovery and rescheduling studies are aimed at coping with unforeseen disturbances (e.g., floods, frogs or haze) and preventing them from regularly operating to reduce delay propagation (Aktürk et al., 2014; Arıkan et al., 2017; Atkinson et al., 2016; Burke et al., 2010; Cadarso and de Celis, 2017; Clausen et al., 2010; Eggenberg et al., 2010; Kohl et al., 2007; Maher, 2015; Manley and Sherry et al., 2010; To minimise the delay accumulation of the entire traffic stream, Takeichi (2017) developed a nominal flight time optimization technique. In order to reduce aircraft recovery and operational costs, passenger itinerary delay costs, and passenger itinerary cancellation costs, Zhang et al. (2016) explored an integrated airline service recovery problem in which aircraft and passenger schedule recovery issues are simultaneously taken into account. A three stage sequential math-heuristic technique is developed to solve the flight schedules and aircraft rotations in the first stage to solve this complicated problem. Then, in the next two stages, a flight rescheduling issue and passenger schedule recovery issues are iteratively overcome. Atkinson et al. (2016) studied how three standard practises (i.e. aircraft swap flexibility, gate reassignment flexibility, and planned aircraft downtime) were used to reduce the impact on the earnings of airlines of unanticipated disruptions. It is found that "the return per dollar from gate spending, or more efficient management of existing gate capacity, is three times greater than the returns per dollar from other inputs." In order to achieve a reasonable balance between fuel consumption and cruise speed due to flight rescheduling scenarios, Akturk et al. (2014) suggested an airline recovery optimization model.

G. Airline Revenue Management

The aim of Airline Revenue Management is to fill each flight with the highest revenue possible to maximise the overall profit (Abdelghany et al., 2017; Bollapragada et al., 2007; Czerny et al., 2017;Yan et al. 2019; Ge et al., 2010). Abdelghany et al. (2017) developed a modelling system for flight timetabling to optimise the revenue of the airline by meeting the limitations of the airline's resources (e.g. aircraft and crew) as well as the change in customer demand due to competition at the network level. Czerny et al. (2017) compared the ideal combination of airport charges based on per-passenger and per-flight from the carriers' and social perspectives when carrier markets became oligopolistic. The proposed approach is capable of minimizing airport aeronautical charges that are historically related to aircraft weight and of rising the share of airport aeronautical revenues generated from passenger charges. Ge et al. (2010) suggested an overbooking model to manage the optimum amount of transfers between flights with different departure times and each flight's overbooking cap. To minimize the overall portfolio cost of long-term service agreements for the maintenance of capital-intensive equipment, Bollapragada et al. (2007) developed an integer programming model.

H. Collaborative Decision Making

Collaborative Decision Making's key concept is to create a decentralization structure through the use of a dedicated communication network and a common collection of database systems . In both academic literature and practice, benchmarking airports is currently common, but due to the

heterogeneity inherent in any reasonably sized dataset, it has proven quite troublesome. Most studies either treat airport manufacturing technology as a black box, or separate terminal and airside operations, individually analyzing them. Adler et al. (2013) used a Data Envelopment Analysis (DEA) approach to explain the individual reference set of each airport, and the specific impact of outliers for benchmarking airports, to resolve this issue. In the background of weather-related disturbances, Sherali et al. (2011) investigated an airspace flow programmer by increasing the airspace preparation and collective decision-making model. Some strategic planning concerns such as aircraft servicing, crew swapping, market rise and distinction in fractional aircraft ownership programmers were discussed by Yao et al. (2008). An integrated decision-making strategy was developed by Grushka-Cockayne et al. (2008) to define a desired range of changes in aircraft arrival and departure procedures. Sherali et al. (2006) further discussed the parameter estimations and implementation test results of the airspace planning and collective decision-making model. A large-scale airspace preparation and shared decision-making model was developed by Sherali et al. (2003) to strengthen U.S. management. With the consideration of probabilistic disputes, workload, and equity, National Airspace Scheme.

Aircraft Scheduling Problems

The goal of the Aircraft Scheduling Problems (ASPs) is to evaluate the precise timing details (timetable/schedule) of each aircraft on airport terminal resources (e.g. taxiways, air segments, runways) in such a way that any possible conflicts between aircraft are resolved at a microscopic level. In reality, however, air traffic control operations and related issues are still scheduled by human controllers who, on the basis of their previous knowledge, intuition and clear scheduling rules without using performance metrics, create feasible aircraft schedules in the airport terminal control area. The recent publications include a detailed overview and literature review on the ASPs. In reality, the theoretical footstone of the ASPs approach is based on the extensions of models of work shop planning . In terms of this key concept, in another journal paper that is under preparation, we will report a comprehensive literature review.

CONCLUSION

This paper presents, in conclusion, a recent literature review on aviation management. Airline Capability Analysis; Air Traffic Flow Management; Airline Fleet Assignment; Tail Assignment with Aircraft Maintenance Routing; Airline Crew Pairing; Airline Recovery and Rescheduling; Airline Revenue Management; Joint Decision Making; Aircraft Scheduling. The literature review is categorized into nine major categories. Based on this literature review and classification, we discover that more and more attention is being paid to research on aircraft scheduling problems at the operational level, as aviation authorities are pursuing advanced scheduling optimization tools to better manage the infrastructure and resources available.

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