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Airline aircraft maintenance requirements, development of flight planning and maintenance planning models

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Abstract

Abstract: Aircraft maintenance planning is one of the main decisions an airline has to make during its flight operations. Although maintenance planning is an easy-to-understand but difficult-to-solve problem when flying an assigned aircraft, it is necessary to plan the maintenance of the aircraft that should fly, which segments, when, and where each aircraft should go through the various levels of maintenance. The goal is to minimize maintenance costs and costs incurred during reassign the nment of aircraft to flight segments.

Keywords, maintenance, planning, check

1. Introduction

Optimizing aircraft maintenance has long been considered a cornerstone of European air transport planning. The development of maintenance planning is a complicated task of synthesizing a range of economic, political, legal and technical factors. Demand for services, aircraft utilization and aircraft operating costs are their main drivers.

The goal is to achieve a balanced flight model, the output of which is a time schedule in accordance with regulations and aviation policy.

Major airlines have seen significant changes in their operations following the deregulation of the Aviation Act of 1978. As a result of fierce competition, airlines have lowered their prices, resulting in more passengers than ever before.

More than 80% of passengers nowadays travel for less than the base price. This situation puts downward pressure on revenue and has led many airlines to focus on controlling maintenance and maintenance costs.

From the point of view of air traffic, the demand for the service determines the daily flight schedule, which determines which type of aircraft will fly on a given route. This is the main limitation that maintenance planners face. They must schedule a compliance inspection of each aircraft in the fleet. The ability to assign individual aircraft to different routes throughout the day offers the necessary flexibility to meet this requirement.

Aircraft maintenance checks are planned based on the given flight schedule. A flight plan consists of a series of flight arms to be executed by an aircraft. So maintaining the aircraft maintenance problem is solved after the aircraft is assigned to the flight.

Solving maintenance issues, scheduling issues to optimize maintenance can cause aircraft to be reassigned to a flight. Different aircraft assignments lead to different costs and revenues for the airline. For example, two aircraft of different capacities may fly the same flight, which may lead to a loss of revenue if the smaller aircraft is selected for a flight with a higher capacity.

In contrast, a flight that may be operated by two aircraft of different capacity may result in higher operating costs if the larger aircraft is selected, if the capacity is lower than that of large aircraft. Relocating the aircraft would result in a loss of revenue or an increase in operating costs. These costs are taken into account by penalizing the entry of unsuitable aircraft into flight.

Since most maintenance checks are performed at night, the problem arises as to where the aircraft spend each night on a 7-day cycle schedule. The sequence of flight arms to which an aircraft is assigned on a given day may be considered as one trip. During reassignment, the aircraft is assigned to a trip rather than a single flight. Penalty costs for the trip are the sum of penalties for all flights that make up the trip. The following sequence of flight arms making the trip will be identified as the destination.

2. Airlines maintenance requirements

Aircraft maintenance is performed through a series of high-care checks, with the exception of unscheduled repairs. The frequency of these checks depends on a combination of flight hours and the number of take-off and landing cycles and can be carried out at any place equipped in a suitable manner. Given that each type of aircraft has a different inventory requirement, savings can be achieved by combining equipment for different fleets. To comply with Federal Aviation Administration restrictions, some companies have adopted maintenance policies that require routine inspections at least every four days. There are four main types of FAA inspections that every aircraft is subject to. These vary in extent, duration and frequency (Clarke et al., 1997).

2.1 Type A check

The first major inspection (designated Type A) actually mandated by the FAA occurs every 400 – 600 flight hours or every 200 to 300 flights, or about every 8 to 10 weeks. Type A inspections include inspection of all major systems, such as chassis, engines and control surfaces. As well they give a detailed inspection of all the emergency equipment. It takes between 6 – 24 hours on a narrowbody aircraft.

2.2 Type B check

The second major check (designated Type B) is performed every six to eight months and includes a thorough visual inspection and lubrication of all moving parts such as horizontal stabilizers and wings.

2.3 Type C check and type D inspection

The heavy maintenance is much more extensive than a A and B checks. For several weeks check take out the aircraft from commercial services. Type C check happens every 18 months to 2 years. Over 6000 maintenance hours takes the C check. Technicians perform specific tasks such as in-depth lubrication of fitting and cables and examination of structures.

Very important inspections, designated as type D, is carried out every 4 yearsand require the aircraft to be out of service for up to one month at a time. If once it is done, the plane seems and looks like a brand new aircraft. However, when an aircraft gets two or three D checks, it may become more costly than the plane´s actual value. Then it comes time to resell aircraft or to retire the aircraft.Everything fittings in the cabin is taken out (seats, galleys, overhead bins, toilets) so engineers can inspect the metal skin od the aircraft, inside out. All the engines are taken off. They remove aircraft systems and the landing gear, which are checked, repaired or replaced and reinstalled.

Because type C and D controls are spacedat relatively large intervals and due to dynamicsdue to the nature of the market, these two checks may not be considered in maintenance planning.

Picture 1: D check control – source: https://www.aircraftengineer.info/aircraft-maintenance-checks/

The main concern of the airlines is to meet the A and B inspection requirements through their own 4-day inspection and maintenance. Unless there are extraordinary circumstances, inspections and repairs take place at night. Given the flight schedule, the problem is with aircraft rescheduling and maintenance - maintenance planning determines which aircraft should fly, which pairs, and when and where each aircraft should undergo Type A and B maintenance checks. The goal is to minimize maintenance costs and penalties that they arose when the aircraft was reassigned to a pair.

Fixture 1Check type schedule table

CHECK TYPE SCHEDDULE TABLE		
CHECK TYPE	FREQUENCY	MAINTENANCE HOURS
A	FROM 8 TO 10 WEEKS	FROM 6 TO 24
B	FROM 6 TO 8 MONTHS	UP TO 180
C	EVERY 18 MONTH TO 2 YEARS	UP TO 6000
D	EVERY 6 TO 10 YEARS	OVER 10000

3. Development of flight models, airline crews and maintenance planning

In this section, we present a brief overview of some existing airline flight and crew models, fleet allocation and maintenance planning.

By 1970, the focus of researchers was on demand forecasting, fleet planning, and flight scheduling. The work done on these topics during this period was limited due to the computationally intensive nature ofthe problem when optimal solutions were sought.

The main method of attack was dynamic programming, which usually involves a very large space for any real-life traffic system. The fleet scheduling and routing problem was formulated as an integer linear program by Levin (1971). It was the first stage of improving the formulation from the dynamic programming model to the integer programming model. No heuristic or approximation methods were used in this formulation to solve the large problem. The goal of the model was to formulate and obtain an optimal solution to a real-world problem. The methods used in this formulation to solve the problem are branch and bound methods (Levin, 1971).

Desaulniers (1997) presented two models for the problem of aircraft routing and planning. The first is a set distribution-type formulation and the second is a time-bound multi-combination network flow formulation. The column generation technique - 1st model is used to solve the linear relaxation. The Dantzig-Wolfe decomposition approach is used to solve the linear relaxation of the second model.

Due to the flight schedule, the problem in airline flight crew planning is to optimally assign flight crews to the flight schedule while meeting the restrictions resulting from employment contracts. In most cases, the problem is modeled as a distribution of circumstances problem.

The goal of the crew scheduling problem is to find the minimum assigned crew wage for a given flight schedule. Since in most cases the crews are differentiated based on which aircraft they can fly, as a rule the scheduled flight schedule only includes flights that have been assigned to a single type of aircraft. So crew allocation is solved for each type of aircraft separately. The crews to be assigned are all qualified to fly that particular type of aircraft and are thus treated equally. Assignment of aircraft types to flight arms or fleet assignment is completed before crew scheduling decisions are made. Models and an algorithm for fleet allocation are presented in Abara (1989), Hane et al. (1995) and Subramanian et al. (1994).

Flight scheduling is also a problem similar to flight crew scheduling, but tends to be much larger because a pilot may be deployed in more than one type of aircraft. They are usually qualified to fly almost all types of aircraft.

Recent approaches to crew scheduling have focused on the setup-allocation problem presented in Vance et al. (1997). The large number of variables in the model presented in Vance et al. (1997) leads to billions of pairs even for a problem with a few hundred flights. Because of this explosive nature of the problem, a local optimization approach, as discussed by Anbil (1991) and Gershkoff 32 C. Sriram, A. Haghani / Transportation Research A 37 (2003) 29-48 (1989). Graves et al. (1993) describes a crew scheduling optimization system by United Airlines. Other approaches have used specially constrained shortest path methods of structured networks to value attractive pairings. Examples are given in Lavoie et al. (1988). Hoffman and Padberg (1993) found optimal solutions to integer problems with a maximum value of 300,000 pairings using a branch and cut algorithm.

The limitations of the base crew were explicitly considered in their approach. Clarke et al. (1996) considered crew constraints in a fleet allocation form.

Considering the flight schedule and set of aircraft, it is necessary to determine the problem of assigning the fleet, which type of aircraft should fly in each flight segment. Mostly, this problem is formulated as a large multi-commodity flow problem with lateral constraints defined in a time-evolved network. These problems are often highly degenerate, leading to poor performance of the normal linear. Also, a large number of integer variables can make optimal lifetime solutions difficult and time-consuming. Methods used to solve this problem include the interior point algorithm, simplex, cost perturbation, model aggregation, branching on partition constraints, and branch ordering.

The fleet allocation solution must satisfy balanced constraints that force the aircraft to circulate through the flight network. Aircraft balance is enforced by the flow conservation equation for a time-advanced multicommodity network. To minimize maintenance costs, aircraft must be assigned to the appropriate maintenance base. This may involve changing the flight schedule. A change in the flight schedule may cause a loss of revenue or an increase in operating costs.

Therefore, changes occur between the assignment of the aircraft to the respective maintenance base and the maintenance of the flight schedule.

Several people have addressed this problem in the past, but most of them have focused on solving the problem without considering cycle constraints, heterogeneity in the fleet, and B-type maintenance constraints. The first attempt was made to consider two important

maintenance requirements with cyclic constraints and a heterogeneous fleet. Most flights have weekly schedules, cyclical restrictions and are one of the most important restrictions.

From the above list, we can see that there is not much change between maintenance formulation - maintenance planning.

Most researchers have formulated the problem as a multi-commodity network flow model. However, there is a huge difference in the computational approach. Each article differs from the others only in the approach to solving the problem. From the above list, it is very clear that the challenge facing researchers in aircraft planning, routing and maintenance; planning is not about formulating problems, but rather about solving formulated models. It was also found that the important control of type B maintenance was not considered in any of their problem formulations.

4. Conclusion

The aim of our work was to introduce the issue of airline companies' requirements for proper, efficientand economical maintenance of their aircraft. We have characterized the basic types of aircraft maintenance that must be performed on any aircraft that is and should remain in service. Shows how important aircraft maintenance is and how much time and money airlines needs. We also presented the issue and development of flight planning and aircraft maintenance models.

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