On the Optimization of Aircraft Maintenance Management

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Abstract. Task scheduling and resource allocation problems have been the subject of intense research over the past decades, particularly within Operations Research. However, seldom optimization models have been proposed to address the aircraft maintenance management process in an integrated manner. Besides eliciting the problems of capacity planning, parts forecasting and inventory management, and task scheduling and resource allocation faced by aircraft MRO companies, this paper presents a short review on models that address each of the problems and discusses research opportunities within this field.

Keywords: aircraft maintenance, capacity planning, spare parts forecasting, inventory management, task scheduling, resource allocation.

1 Introduction

Maintenance is formally defined as the "combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it, or restore it to, a state in which it can perform the required function" (CEN 2001). The activity has evolved from a support activity that was seen as an inevitable part of production, to an essential strategic element needed for the accomplishment of business goals (Pintelon and Parodi-Herz 2008). Aircraft maintenance services provided by independent *Maintenance, Repair and Overhaul* (MRO) companies share many of the actions, policies, and concepts employed by traditional industrial maintenance, however some differences are to be mentioned. Most literature on maintenance address the subject from the perspective of the owner/operator of a complex system that needs maintenance (Mobley 2004), but to whom *maintenance* is not the core business (Marquez and Gupta 2006). This is not the case of independent aircraft MRO companies. Such companies *produce* maintenance services and in that sense their motivations and goals are different from those of the owner/operator of the aircraft (Kobbacy and Murthy 2008). The goal of the owner/operator is to retain or restore the reliability levels of an aircraft at a minimum cost, while the goal of an independent MRO is to achieve high service levels and to maximize profits. The motivations and goals of independent MROs are even different from those of airlines' subsidiary MROs,

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so are the difficulties faced. Traditionally, airlines' subsidiary MROs have been concerned with the availability of their own fleets, while independent MROs provide maintenance services to any operator in the market through outsourcing. Aircraft are for the former type of MROs what Fortuin and Martin (1999) categorize as "technical systems under client control". For these authors, there is usually a dedicated maintenance department providing maintenance services and managing spare parts inventories within the client organization in this case. As a result, a significant amount of information is available for the maintenance provider such as scheduled maintenance activities, times between failures, usage rates, and condition of the equipment. On the contrary, for independent MROs, aircraft resemble what Fortuin and Martin (1999) refer to as "end products being used by customers". In this latter case, much less information is available and such lack of information may result in occasional spikes of demand, both in manpower and spare parts.

The first source of information for the production planning of an aircraft MRO company must be the existence of reliable business forecasts regarding the number and type of products that are to be intervened in a given period of time. These forecasts allow the company to set the required manpower to meet the expected workload and to order the necessary materials in time. However, as aforementioned, the information that independent MROs possess on this matter is often scarce or unreliable. In addition to an estimate on the number and type of products expected to be intervened, a prediction regarding the scale of such interventions is also desirable. Any maintenance program contains periodic tasks that must be performed to keep the equipment in perfect working order. For aeronautical products, besides the replenishment of consumable materials and the replacement of spare parts and components that have reached their potential, the large majority of maintenance tasks include some kind of inspection. If in the course of these inspections an item is found damaged or below admissible tolerances, it must be repaired, or replaced altogether.

The set of tasks included in the maintenance program make up the *preventive maintenance* (also known as scheduled maintenance) (CEN 2001), while the repair or replacement tasks that result from inspections make up the *corrective maintenance* (also known as unscheduled maintenance) (CEN 2001). The duration of maintenance tasks is easily estimated since the maintenance programs from the *Original Equipment Manufacturers* (OEMs) set execution times for the tasks. Also the consumable materials, spare parts, and components are listed in the maintenance programs and can easily be purchased and stocked prior to the beginning of the intervention. However, this is not the case for the unexpected repair work. The required working time to fulfill the repair tasks and the need of parts that are found damaged or operating below functional limits cannot be easily predicted and is subject to a high degree of uncertainty. Materials that result from unexpected repair work often show a lumpy demand pattern (Ghobbar and Friend 2002), and their lead times can be higher than the immobilization periods of the aircraft themselves. Other factors that contribute to the increased complexity of