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Maximizing operational readiness in military aviation by optimizing flight and maintenance planning

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Abstract

The primary objective in military aviation is to optimize operational readiness: the capability to perform assigned flight missions. In terms of a flight planning process, operational readiness has three primary components: availability, serviceability and sustainability. Furthermore, it is influenced by aircraft downtime due to preventive maintenance at prescribed flight time interval. In practice, aircraft flight scheduling (including maintenance constraints) tends to be managed manually and on a day-to-day basis, leading to a reactive approach to aircraft flight hour allocation in which problems with respect to availability, serviceability and sustainability can easily develop. Optimization models have been developed to address this issue, but none of them cover the full scope of operational readiness. This work introduces a flight and maintenance planning optimization model that simultaneously addresses the aspects of availability, serviceability and sustainability, leading to a pro-active, efficient and more robust scheduling effort. The proposed model is tested, verified and validated using Royal Netherlands Air Force data and infrastructure related to the CH47D Chinook helicopter fleet.

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1. Introduction

The primary objective of a military aviation operator or air force is to optimize its readiness to respond to external threats, take part in peace supporting missions and provide humanitarian aid, wherever and whenever the home state

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or international community calls for it. This is embodied in the concept of continuous operational readiness: the capability to perform all assigned present and future flight operations. In order to maintain a minimum readiness level, air forces need to ensure that sufficient aircraft are mission capable and continue in this state for an adequate period of time. Furthermore, a sufficient amount of training flight hours need to be produced to keep aircrew in mission capable condition. These requirements must be fulfilled at all times, which requires an involved planning process. Within the context of this flight planning process, operational readiness is depicted by the following primary components:

- **Availability:** the total duration in which subject aircraft are mission capable, which influences the capacity of the military organization to meet its flight hour requirement. This requirement is derived from the necessity to meet air crew training hour requirements and perform predetermined operational assignments. Availability is an overall measure, considering the full planning horizon;
- **Serviceability:** the number of mission capable aircraft at a specific instant of time. This is therefore an instantaneous measure describing the capability to perform flight missions at any specific point in time. However, this number alone gives no information of how long the serviceable aircraft remain available for flight operations in the future. In other words, although serviceability might be sufficient, it is unknown if the subject aircraft have sufficient residual flight time left to fulfill a mission requirement;
- **Sustainability:** the total residual flight time of the entire fleet at a specific instant of time. This is also an instantaneous measure, which solves the shortcoming of serviceability. Together, serviceability and sustainability determine how long a tactical unit will remain capable of sustaining a flight mission, starting at an immediate point in time, when no maintenance resources are accessible.

Since aircraft are subject to strict safety requirements, preventive maintenance must be performed at prescribed flight time intervals, which causes downtime. This directly affects operational readiness as any downtime restricts opportunity for flight operations. As a result, all preventive maintenance efforts as well as the mission assignments must be planned and scheduled adequately for the entire aircraft fleet. The process is highly complex and time consuming due to numerous constraints (operational demand, maintenance resources, facilities, locations) and uncertainties (unpredictable operational assignments, unscheduled maintenance, changing weather conditions). As a result, the flight and maintenance plan requires to be adjusted frequently. It follows that the generation must be flexible, fast and efficient. However, in practice, aircraft utilization tends to be managed manually and on a day-to-day basis, leading to a reactive approach to aircraft flight hour allocation in which problems with respect to operational readiness can easily develop.

Several optimization models have been developed to address this specific problem, as discussed further in the next section. However, none of these models take into account the full scope of operational readiness as introduced above. It is the aim of this work to introduce a flight and maintenance planning (FMP) optimization model that can simultaneously address the three primary components, leading to a pro-active, efficient and more robust scheduling effort.

The structure of this paper reflects this aim. First, the theoretical context of the flight and maintenance planning optimization problem is discussed in more detail. Subsequently, an FMP optimization model is proposed in Section 3, followed by its application on Royal Netherlands Air Force data and infrastructure related to the CH47 Chinook helicopter fleet. The findings are given and discussed in Section 4: Results. Finally, conclusions are presented in Section 5.

2. Theoretical context

Existing work in the FMP field primarily focuses on civil aviation within the context of complex airline networks (Feo & Bard, 1989) and fleet assignment for flight schedules incorporating maintenance constraints at different levels of complexity and planning horizons (Hane et al., 1995; Clarke et al., 1996; Sriram & Haghani, 2003). These efforts however concern commercial aviation maintenance, which is different from the scope of this contribution, being military aviation. A major difference is that commercial airlines have to deal with routes in a (often complex) network, where the military flight scheme is generally concentrated around a central base. In terms of optimization,