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Sequencing landing aircraft process to minimize schedule length

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Abstract

The increasing number of air operations is a challenge for air traffic controllers. The organization of air traffic can be achieved by better aligning the planes for landing or sequencing. Sequencing problem is commonly found in many areas of science, industry and economics. The schedule of tasks in air transport is also important in the integration of traffic, as it allows passengers, not only direct flights, but also efficient interchanges.

Generally, the problem of sequencing tasks is to determine the order of execution of tasks on machines (CPUs) so as to minimize (or maximize) the value of a given criterion. The problem of optimally determining the order of landing operations is noticeable both in official regulations and scientific publications. Aiming to develop the optimum sequencing of aircraft landing process, support procedures implemented at airports. In the early stages of air traffic sequencing, extended arrival management (AMAN) and feature-based navigation (PBN) are used to extend the planning horizon. It is possible to sequence traffic both during the flight and early descent. However, there are no universal sequencing methods. Research is still needed in this area.

The article discusses the process of sequencing landing aircraft, taking into account the minimization of the schedule length. It represents the desired number of landing operations in the shortest possible time. The application of theoretical algorithms has been verified and a methodology has been developed for determining the order of landing operations, providing the shortest possible execution of all operations. On the basis of the computerized algorithm of sequencing landing aircraft with regard to the minimization of the ranking, calculations were made to check the validity of the algorithm. The results were compared with the times achieved using probabilistic sequencing problems.

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Keywords: sequencing of aircraft; schedule length; air traffic; flight operations management

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1. Literature review

Methods are described in the literature that rely on an appropriate sequencing of aircraft landing (Dear & Sherif, 1991), (Kwasiborska & Skorupski, 2014) and the planes taking off. The popularity of these methods stems from expectations of a significant improvement of airport capacity (Diallo et al. 2012), with minimal financial and organizational but also can be useful for the organization of air traffic in terms of noise restrictions (Kwasiborska & Skorupski, 2017). Proposed models and algorithms can be used for control in the TMA region (Dell'Olmo et al., 1996). The problem of optimal sequencing of airplanes at an aerodrome with one runway for takeoffs and landings is described in the paper (Bianco et al., 1978). This problem was compared with the problem of sequencing n tasks (plane takeoffs and landing) on one machine (runway).

Among the studies on air traffic but not using formal sequencing algorithms, eg work (Andreussi et al., 1981) can be mentioned. It presents a model for evaluating traffic control strategies in the TMA that includes several inbound points to the area and several routes to selected landing approach endpoints. The implementation of the model to assist air traffic management in the area of Rome-Fiumicino Airport was finalized. A similar issue in more contemporary realities is discussed in (Boursier et al., 2007).

The Just-In-Time Idea was the basis of a concept that could represent work (Boysen & Fliedner, 2011), where the basic criterion for assessing the effectiveness of sequencing was the workload of ground personnel. As a solution to this problem is shown sequencing algorithms take into account the number of landing an even distribution of passengers, the number of aircraft and the number of individual carriers landing passengers on airplanes each carrier.

A similar approach to landing aircraft sequencing is presented in the paper (Soomer & Franx, 2008), where an algorithm is proposed, where the key role is to reconcile landing time with air carrier preferences. The question of the proper (desirable) time of landing is discussed at work (Smedt at al., 2013). The availability of the required arrival time (RTA - Required Time of Arrival) and, in principle, the arrival of controlled arrival times (CTA - Controlled Time of Arrival) are considered. Although many papers discussing the issue of sequencing landing aircraft still have the potential to look for opportunities to use a task scheduler using the Petri network (Skorupski & Florowski, 2016). An important direction of research is to create sequencing algorithms that use more than one criterion (Skorupski, 2015). Most benefits should provide a solution to minimize the length of the rank and at the same time characterized by the best compatibility with the desired end time of each operation.

2. Wake turbulence aspects of aircraft

Aircraft approaching airport may not always start the approach to landing and landing. When at a given time report more than one aircraft, which reports desire the landing, the aircraft may be grouped in the waiting area from which each take an approach. This provides a safe way for the expectation of landing. An analysis of the aircraft landing sequencing, priority must be given separation procedure. This is a fundamental way to prevent conflicts. The article did not consider the vertical separation as the aircraft were reported to the system at a fixed altitude.

Table 1. The minima between preceding and following aircraft.

Following aircraft Preceding aircraft	Heavy	Medium	Light
HEAVY (H) — all aircraft types of 136 000 kg or more	1 minute	2 minutes	3 minutes
MEDIUM (M) — aircraft types less than 136 000 kg but more than 7 000 kg	1 minute	1 minute	3 minutes
LIGHT (L) — aircraft types of 7 000 kg or less	1 minute	1 minute	1 minute
SUPER HEAVY (SH) — aircraft A-380 with a maximum take-off mass in the order of 560 000 kg*	2 minutes	3 minutes	4 minutes

Source: Procedures for Navigation Services – Air Traffic Management, 16th Edition 2016: ICAO Doc 4444, 4-12, 5-44.

*https://www.eurocontrol.int/sites/default/files/field_tabs/content/documents/nm/airports/airports-wake-vortex-aspects-letter-a380-aircraft1.pdf