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Derivation of representative air traffic peaks as standard input for airport related simulation

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A B S T R A C T

The high diversity in air traffic situations at airports worldwide complicates the selection of an appropriate set of operational cases for a general technology and procedure evaluation in airport related simulation. In this research, representative airport peak hour traffic situations are determined. Flight data from multiple airports is analyzed and traffic peaks are automatically detected and parameterized, taking into account arrival and departure movement shares for ten aircraft weight groups. A subsequent clustering process results in an optimal number of 16 characteristic peak types. These are representative peaks that provide a limited set of typical peak traffic situations of relevance for a large number of airports worldwide, which can be directly used as input for air traffic simulation, providing standardized traffic situations to ensure comparability and clarity.

1. Introduction

Current plans for airport infrastructure expansion do not keep pace with the projected air traffic growth (Graham and Guyer, 1999) which, combined with air traffic restrictions related to environmental aspects (ACARE, 2002), qualifies airport capacity as one of the major challenges for future air traffic development. Consequently, any new aircraft design or technology will have to be evaluated according to its airport capacity impact along with other operational aspects in order to identify system-wide optimal solutions.

Computer simulations provide a suitable tool for airport capacity assessments being able to handle the highly complex and dynamic system interrelations involved (Wenzel et al., 2008) and are thus widely used. The definition of simulation model input parameters to generate meaningful results, however, is highly demanding and crucial for their validity. To assess new technologies independent from a specific airport setting (unlike many existing case studies), the main challenge is to produce results that are not only valid for one airport's operational case, but have sufficient relevance for all important operational cases regarding the technology that is being investigated.

As shown in Fig. 1, the air traffic mix representative for the airport air traffic demand characteristics is among the main determinants of an airport's capacity and delay situation and thus one of the crucial input parameters for airport simulation studies (Cateloy and Rodriguez, 2005). Analyzing the arrival–departure ratio, which is another important variable of an airport's demand situation, results in a corresponding achievable aircraft throughput as can be graphically represented by an arrival/departure capacity curve diagram (Gilbo, 1993). To cover a range of different operating conditions of airport systems it is important to not only simulate an average daily traffic mix or total peak situations, but also to look at traffic peaks dominated by either arrival or departure traffic.

Looking at air traffic patterns worldwide or even regionally, a high diversity can be found resulting in a high number of different operational cases that are to be considered. To limit simulation effort by reducing the number of simulation models required, careful selection of simulated air traffic patterns can help to achieve applicability of simulation results to more than one relevant operational case for the technology studied. One first step to achieve this is to limit the analysis to traffic peak situations only, since these are most critical for airport related simulation. Kazda and Caves (2007) described the significance of peak hour traffic schedules for airport design as an alternative approach.

Although every peak situation contains very specific peculiarities of an airport, establishing a set of traffic peaks that is representative for a multitude of airports, and not specific to only a particular one, could provide a possible solution. The use of specific airport traffic data is common practice for case studies in capacity analysis. These case studies evaluate a certain traffic situation at a selected airport of interest and enable understanding of processes and influences on the capacity of the specific airport system. However, for a capacity analysis on a more general technological

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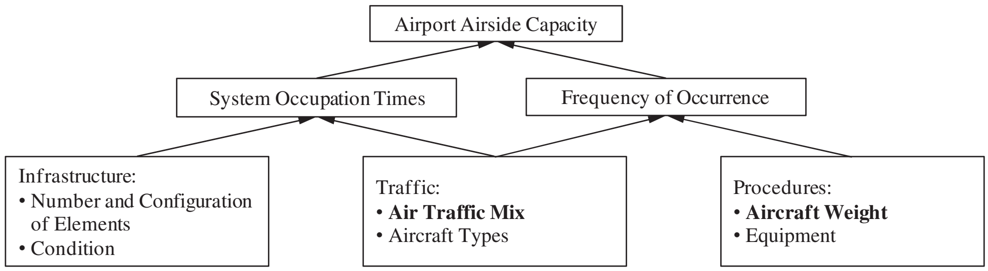


Notes: adapted from Cateloy and Rodriguez (2005). Drivers addressed in the proposed approach are marked in bold.

Fig. 1. Airport demand characteristics: drivers for an airport's capacity and delay situation.

influence level, it is inevitable to cover a multitude of different operational cases. In order to reduce the analysis effort, representative traffic situations of worldwide relevance can be used instead of taking into account specific case examples only. Addressing the overall influence of aircraft take-off and landing performance on runway capacity is only one example where a generally applicable result cannot be drawn from a few specific case studies. Hence, taking into account a limited number of representative peaks would cover a wide range of typical worldwide traffic situations. Combined with the common runway system layout, their use would ensure improved technology evaluation results.

The importance of such standardized data input was highlighted by Dorado-Usero et al. (2004): "ATM analysts would benefit greatly from having a given standard set of data." and "For example, the analysts would be certain that when choosing an "average day," it would be similar to one used by any other analyst, whatever the tool they use. Results would then be based on the same input parameters." Thus, a standardization of input data (i.e. traffic situations) would increase comparability of results.

In this paper a possible approach to determine representative peak situations is presented. Section 2 describes the process of identifying peaks in airport traffic data, while section 3 concentrates on the determination of representative traffic situations.

2. Proposed methodology to derive representative peak traffic

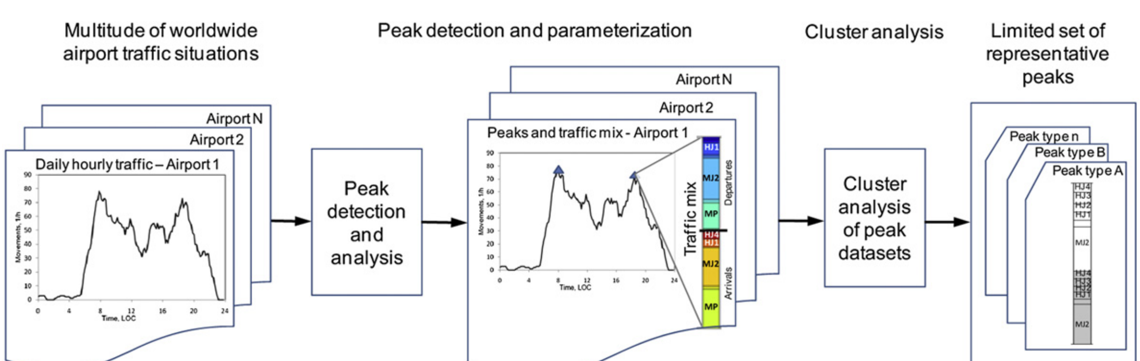
An outline of the overall process of determining representative traffic peaks is depicted in Fig. 2. There is a manifold of traffic situations at airports worldwide. These are taken into account as the basic input for this analysis. Each airport has a specific daily demand profile typically showing traffic peaks. The detection of these peaks is one of the methodological steps presented in the following section.

The proposed approach uses parameters given by the traffic mix for all peaks detected to identify similarities among them in a subsequent cluster analysis. This results in a limited set of representative traffic situations. The cluster analysis process and its application are discussed in Section 3.

3. Detection and parameterization of traffic peaks

In order to find a representative set of peak traffic situations it is necessary to detect different traffic peaks in the flight data of a large number of airports. Worldwide OAG flight data of one selected day (13th of June 2008, OAG, 2008) was used as the data source. In the following, the peak detection algorithm is described for a single airport example.

First, the daily distributions of total movements, arrivals and departures for a selected airport at a certain day can be determined from the OAG flight data. For sufficient accuracy, rolling hour data for 10 min intervals was selected to process movement data. As an example, movement data for Munich Airport is shown as solid graphs in Fig. 3a) for total movements and in figure b) for arrivals (upper part) and departures (lower part). These movement distributions are analyzed regarding traffic peaks. By application of a 7th order rolling average, which was identified to be most suitable, the movement graphs are smoothed. This facilitates peak detection. The smoothed graphs for Munich Airport are shown in Fig. 3 as dashed lines. The resulting graphs are then subject to a rise/fall



Notes: Starting from a variety of daily movement distributions at airports worldwide, peak situations are detected and parameterized by the traffic mix. Cluster analysis of the peak data results in a limited set of representative peaks.

Fig. 2. Methodology to derive representative airport traffic peaks.