A Statistical Approach for Taxi Time Estimation at London Heathrow Airport

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1 Introduction and Problem Description

With a predicted year on year increase in the number of flights [5], increasing attention will need to be paid to the environmental effects of air transportation, in addition to an increasing focus upon maintaining and improving on-time performance at airports [3]. These challenges will face both airlines and airports in the near future and improved taxi time predictions (which is the aim of the model discussed here) will be an important tool for handling them.

The purpose of the ground movement problem is to guide aircraft around the surface of the airport to arrive at their destinations in a timely (and potentially more environmentally friendly) manner. From an optimisation point of view, the ground movement problem can be considered to be one of the most important airside operations at an airport [2], since it links together several other important problems, such as runway sequencing (for arrivals and/or departures) and gate assignment. The aims of this combined routing and scheduling problem are usually to reduce the overall taxi time, reduce the fuel burn, arrive at the destination by a target time, and/or to absorb any necessary waiting time or delays in preferred positions (e.g. before the engines are started). It has to guarantee conflict-free routes for each aircraft throughout the movement and, therefore, usually has to coordinate the movement of multiple aircraft around the surface at once. A comprehensive review of the problem can be found in [2].

In previous research, it has been difficult to quantify the benefits of new ground movement approaches compared with the status quo at airports, since it can be hard to distinguish between the effects of the variability in taxi times and the benefits of the improved routing and sequencing. Research is badly needed to understand and quantify the variability in taxi times, and moreover, to develop models which accurately predict taxi times from more measurable but influential factors. In particular, if predicted taxi times are to be used in a decision support tool for the ground movement problem, which itself incorporates the effects of re-routing and queuing delays, the predicted taxi times must not already include the effects of these. The production of a model to quantify and eliminate these delays has not, however, been simple.

London Heathrow Airport is one of the busiest international airports in the world, despite the fact that it operates with only two runways and (for noise control reasons) is restricted to using only a single runway at a time for departures. There has been

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considerable research and innovation of late into automated support for the various operations at the airport, in terms of both information sharing and advisory tools.

The aim of this research is to consider the variability in taxi times, both including and excluding the runway queue times, to determine the degree to which they can be predicted and to develop functions to predict them, where possible, by utilising information which will be available in advance.

2 Ground Movement Model and Statistical Analysis

Our research consists of an innovative combination of a ground movement model and a statistical multiple linear regression approach, to improve the predictability of taxi times. Advance predictions for departure taxi times have long been known to be useful and Idris et al. [4] performed a statistical analysis of departing aircraft at a North American airport. More recent research by Atkin et al. [1] used the model which we will present to show the benefits from considering both departures and arrivals at the same time, due to their interactions, and of including more accurate models of the airport layout and current mode of operations. The work analysed the effects of a number of potential taxi-time-influencing factors at two European hub airports: Stockholm-Arlanda Airport in Sweden and Zurich Airport in Switzerland. We now extend this research to consider the applicability to London Heathrow, where departure queue delays are relatively unpredictable for individual aircraft. We compare and contrast both the generated models and the accuracy of the predictions at the different airports.

We will discuss the model which has been developed for this work, explaining both the ground movement model which has been used and the statistical analysis which uses it. We will then present and discuss the potential influencing factors for taxi speeds and the importance which was determined for each, utilising real recorded data from London Heathrow Airport, supplied by NATS Ltd. The goal has been to present a model which is as practical (requiring the least information) and easy to interpret (so that the effects of influencing factors can be understood and validated by the problem domain experts) as possible, while maintaining a high level of accuracy.

We will not only discuss and highlight the significant factors and the way in which they have been identified, but will also consider the ways in which the model has been verified, such as the results from leave-one-out cross validation, which shows not only the quality of the model as a whole, but also the variability in predicting new observations.

3 Applicability and Importance

Advance taxi time predictions are important for a number of reasons. Better taxi time predictions can be used to improve take-off time predictions (by considering the push back times plus taxi times) or on-stand time predictions (for arrivals, where the landing time has already been predicted), both of which are of increasing importance at airports, [3]. They can also be used to enable engine start-up to be delayed (moving waiting time back from the runway queues, with engines running, to the stands, before they are started) to reduce fuel burn and pollution.

Moreover, the developed model links the ground movement paths which are taken, to the ground movement speeds. This enables the results to be fed into any ground movement decision support tool to improve the reliability of the taxi speed/time predictions.

Such decision support tools, which aim to optimise the ground movement problem, need taxi time predictions for isolated aircraft (since the algorithms usually explicitly consider the interactions of aircraft, introducing delays or re-routing as appropriate) along specific routes, and sufficient examples are not usually directly available in historic data. The utilised statistical approach provides the opportunity to disregard the effects of other aircraft on the airport surface, meeting this objective.

Of course, improved predictions mean that less slack will be needed to allow for taxi time uncertainty, allowing more efficient movement prediction or planning.

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