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Prescriptive analytics in airline operations: Arrival time prediction and cost index optimization for short-haul flights

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ABSTRACT

In this paper, we provide arrival time prediction combined with a cost index optimization model for short haul flights. Our work is based on flight data of a European network carrier. We focus on predicting the arrival time for incoming flights at two hub locations. Airlines focus on two aspects in their operations: Minimizing cost while ensuring on-time arrivals. Especially network carriers with hub connections need to ensure that incoming flights are on time for passenger, crew and aircraft transfer. The cost index is a tool for optimizing the aircraft's speed. A high cost index implies a faster flight. The cost of time is set in relation to the cost of fuel. Today there is no model for arrival time prediction and integrated cost index optimization. We consider three different flight distances to model the impact of cost index changes on gate arrival time. With our model airlines are able to reduce the cost index without any tangible impact on their overall schedule. We conclude that the optimal cost index level heavily depends on a flight's distance, fuel costs and delay costs. Especially for short haul flights we recommend lowering the cost index as a high cost index has limited impact on gate arrival time.

1. Introduction

Considering that reactionary delays made up more than 40% of all delays in 2015 ensuring on time arrivals is a critical operational problem for airlines [33]. Operations control can implement several measures during the flight and on the ground to ensure punctual arrivals. The cost index (CI) is a tool to influence arrival time. It basically describes the speed of the aircraft. The CI defines the trade off between time and fuel cost. An increased CI results in decreasing flight time and increasing fuel cost and vice versa. According to [27] airlines can save several millions a year by optimizing their cost index without impairing their schedules. Today operations control are not able to accurately integrate cost index models with their arrival time predictions. This is due to the fact that time related costs are hard to quantify and short term arrival time forecasting is lacking accuracy [21,30]. Oftentimes delayed flights are flying with a high CI to recover time, even on such short flight routes, where an increase in CI has very limited impact. En-route flight phases are too short to tangibly reduce flight time by flying faster. Time savings are often small and easily lost in the landing and taxiing process.

Significant effort has been made by industry and researchers to ensure the minimization of delays through strategic planning and robust scheduling [4]. Due to unforeseeable events and tight schedules delays cannot be eliminated. In recent years, predictions focusing on network wide delay propagation as well as on delay predictions for single aircrafts were published [1,26]. Their work is closely connected to the research field of arrival time prediction, which has entered the focus of researchers and industry in the past years [20,21,30]. Especially the use of machine learning algorithms, for example the ones used by the top five contestants of the GE-Flight Quest Kaggle competition, have shown to outperform linear models [30]. They were able to increase the prediction accuracy of a flight's runway and gate arrival time by up to 40%. Similar results were achieved in other studies [17]. The accurate assessment of the most economic cost index represents a crucial operational problem for airlines. The cost index optimizes the speed of an aircraft to ensure minimum costs of fuel and time. Not only the correct estimation of those different cost blocks is highly dependent on the airline and its aircraft fleet, but even more critical is the correct estimation of change in arrival time considering different cost indices. Work on cost index optimization is rather limited. Cook et al. [10] provide a generic tool for dynamic cost indexing (DCI). DCI is defined as managing flight delay costs dynamically through trading fuel burn against cost of time. Airline manufacturer maintain cost index guidelines for their fleets [12,27]. Especially network carriers have a strong interest in improving their arrival time predictions and lower their fleet wide cost index. At their hub locations, long distance flights are fed by a

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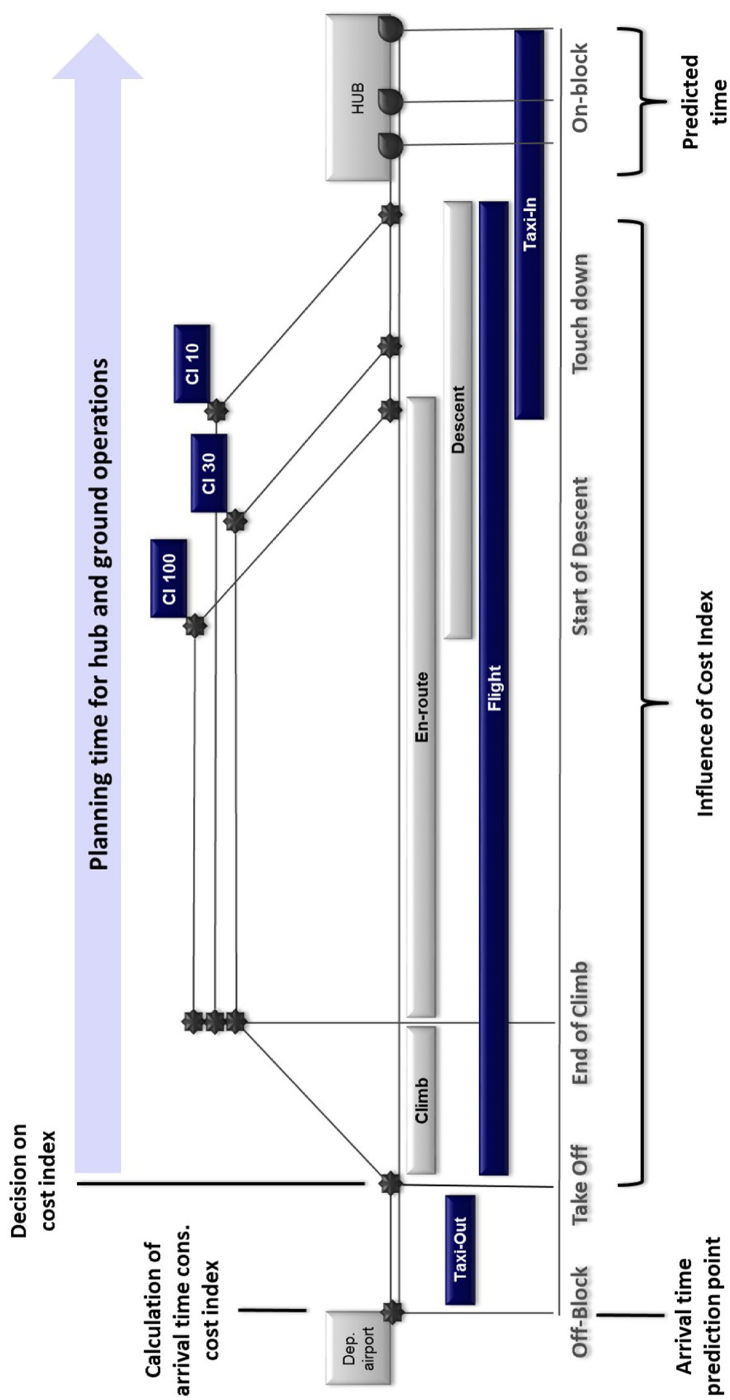

Fig. 1. Overview of cost index and arrival time prediction model. We adopt five flight phases for our model: Taxi out, Climb, En-route, Descent and Taxi in. The en-route flight phase can vary according to distance. Very short flights start the descent right after the climb phase. On average the en-route phase lasts for 31 min and an average flight for 100 min. The cost index only influences the flight time.