Assessing the impact of tactical airport surface operations on airline schedule block time setting

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ABSTRACT

With the growth of air traffic, airport surfaces are congested and air traffic operations are disrupted by the formation of bottlenecks on the surface. Hence, improving the efficiency and predictability of airport surface operations is not only a key goal of NASA’s initiatives in Integrated Arrival/Departure/Surface (IADS) operations, but also has been recognized as a critical aspect of the FAA NextGen implementation plan. While a number of tactical initiatives have been shown to be effective in improving airport surface operations from a service provider’s perspective, their impacts on airlines’ scheduled block time (SBT) setting, which has been found to have direct impact on airlines’ on-time performance and operating cost, have received little attention. In this paper, we assess this impact using an econometric model of airline SBT combined with a before/after analysis of the implementation of surface congestion management (SCM) at John F. Kennedy International Airport (JFK) in 2010. Since airlines do not consider gate delay in setting SBT, we find that reduction in taxi-out time variability resulting from SCM leads to more predictable taxi-out times and thus decreases in SBT. The JFK SCM implementation is used as a case study to validate model prediction performance. The observed SBT decrease between 2009 and 2011 at JFK is 4.8 min and our model predicts a 4.2 min decrease. In addition, Charlotte Douglas International Airport (CLT) is used as an example to demonstrate how different surface operations improvements scenarios can be evaluated in terms of SBT reduction.

1. Introduction

With the growth of air traffic in the United States, airport surfaces are congested and the performance of air traffic operations are disrupted by the formation of bottlenecks on the surface (Bosson et al., 2015). At major airports in the U.S. in 2009, there was over 32 million minutes of taxi-out delay, translating to over 130 million gallons of excess taxi fuel burn (Nakahara et al., 2011). Skaltsas et al. (2010) and Hao and Hansen (2013) also find that the taxi-out time for the departure phase of a flight is the most variable in U.S. domestic operations comparing to other flight phases, and is, therefore, the most difficult to estimate. An aviation community stakeholder survey\textsuperscript{1} (Aponso et al., 2015) confirms this finding and the survey results suggest that air traffic controllers’ (ATC) first-

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\textsuperscript{1} Survey respondents include major US commercial passenger and cargo carriers; airport authorities of major US airports; groups within the FAA with responsibility for surface and terminal operations, operational infrastructure planning, and NextGen implementation; and industry providers of aircraft, avionics, and software/hardware tools that support airport surface and terminal area traffic management.

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come, first-served operating principle for departures is a primary factor in this uncertainty. Hence, improving the predictability of airport surface operations so as to reduce the cost and environmental impacts of taxi delay and fuel consumption is not only a key goal of NASA’s initiatives in Integrated Arrival/Departure/Surface (IADS) operations (Aponso et al., 2015), but also has been recognized as a critical aspect in Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGEN) implementation plan (FAA, 2016a) as well as its Destination 2025 plan (FAA, 2012).

One effective approach is to employ surface congestion management (SCM) techniques which aim to ensure efficient surface operations when demand exceeds capacity. The key idea of SCM is to meter departures (whether at the gate or at the entrance point to the movement area or on taxiway) so that a part of taxi-out delay could be shifted to the gate or some designed area, where the aircraft can wait with its engines turned off resulting in less fuel consumption. This also helps reduce the number of flights queueing on the airport surface, thus, help relieve the ramp and tower controllers’ workload as well as allow more predictable departure operations (Hayashi et al., 2015).

In this vein, various tactical SCM initiatives have been proposed and implemented. For example, a SCM initiative (later renamed as Ground Management Program (GMP)) was implemented at New York John F. Kennedy International Airport (JFK). During airport peak hours when flights wanting to push back couldn’t be handled efficiently, the excess flights are held at gate and receive assigned departure slots according to ration-by-schedule (Nakahara et al., 2011; Stroiney et al., 2013). On the other hand, an aggregate-level pushback rate control strategy has been tested at Boston Logan International Airport (BOS) which regulates the rate at which aircraft pushback from their gates during high departure demand periods so that the airport does not reach undesirably high congested states (Simaiakis et al., 2014). Another initiative, Collaborative Departure Queue Management (CDQM), tested at Memphis International Airport (MEM), allocates departure slots to different airlines at peak times to manage average departure delay to below a control value, and then the airlines determine which flights go into which allocated slot (Brinton et al., 2011). A similar concept in Surface Collaborative Decision Making (S-CDM) Metering has been proposed by the FAA (2013) on the premise of sharing airport aircraft surface surveillance data and operational data among different stakeholders. Some European airports also have collaborative pre-departure sequencing procedures which allow ATC to employ target pushback times so that flights can depart from their stands in a more efficient and optimal order (EUROCONTROL, 2012).

Instead of focusing on metering flights specifically at gates or at the entrance point to the movement area, NASA has conducted research on the Spot and Runway Departure Advisor (SARDA) concepts (Jung et al., 2010), which provides optimized sequences and times for entry into the movement area and take-off for departure flights. Specifically, SARDA provides advisories on actual pushback time, sequence and timing for spot release, sequence for take-offs, and sequence for active runway crossings. Variants of SARDA concepts have also been tested in Dallas/Fort Worth International Airport (DFW) (Jung et al., 2011; Gupta et al., 2012) and Charlotte Douglas International Airport (CLT) (Hayashi et al., 2015) using the ideas of strategic target pushback time pre-assignment and tactical ramp area pushback (gate-hold) advisories, respectively. Besides practical applications of SCM, airport surface operations management has also received considerable attention from the academic community with the focus on developing optimal departure scheduling algorithms minimizing taxi time, fuel consumption, and other operational objectives while maintain separation requirements (Marín, 2006; Deau et al., 2009; Zografos et al., 2012; Ravizza et al., 2014; Weiszer et al., 2015). These algorithms include use of the stochastic branch and bound method (Söveling and Clarke, 2014), mixed integer programming (Beasley et al., 2000; Bosson et al., 2015), constrained dynamic programming (Balakrishan and Chandran, 2010), and graph-based searching approach (Lesire, 2010), to name a few.

When it comes to evaluating the benefit and performance of the above-mentioned initiatives or algorithms, existing literature typically focuses on throughput increases, delay reduction, fuel burn and carbon dioxide ($CO_2$) emissions reductions (Nakahara et al., 2011; Hao et al. 2017; Gou et al., 2014; Kang and Hansen, 2017a). A recent study by Liu et al. (2014) recognizes that another benefit of SCM is surface operations predictability as measured, for example, by the variability of taxi time. Reducing the variability in taxi time can lead to reductions in communication and controller workload; allow more accurate prediction on flight arrival time; and yield direct financial and environmental benefits by enabling greater use of single engine taxiing (Liu et al., 2014). Following this line of research, the contribution of this paper is to assess the impact of SCM on airline scheduled block times (SBTs). Specifically, we provide evidence that, because airlines base SBTs on historical block times, which do not include gate delay, SCM may result in reduced SBTs. Since SBTs are costly (Zou and Hansen, 2012) this is likely to translate into a cost saving for airlines. On the other hand, reducing SBTs may also reduce on-time arrival performance. Whatever the pros and cons of SBT reductions that may result from SCM, it important to determine whether this impact exists, if so, to quantify magnitude of the impact. This is the first paper to consider this particular impact of SCM.

The remainder of this paper is organized in the following way. In the next section, we illustrate the significance of connecting airport surface operations performance with SBT by providing a general review of airline SBT setting process and discuss why it is of great interest to both airlines and air navigation service providers (ANSPs). Data collection and metrics definition will be described in Section 3. In Section 4, we use the SCM/GMP initiative at JFK (Nakahara et al., 2011; Stroiney et al., 2013) as a case study and perform a post-implementation analysis to investigate the impacts of SCM/GMP on the surface operations performance. After that, in Section 5, SBT prediction models are developed to link airlines’ SBT settings with historical flight performance including airport surface operations performance. Model validation is discussed in Section 6. To demonstrate the usage of proposed SBT models, a prediction analysis for CLT is presented in Section 7 which predicts the impacts of different hypothetical scenarios of airport surface operations improvement. Key findings and implications of our analysis are discussed Section 8.
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