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## The use of auctions for allocating airport access rights

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## A B S T R A C T

This paper considers the challenge of managing congestion at an airport by restricting the total number of flight operations at that airport. It reviews historical evidence, economic theory and data analysis related to the challenge of airport congestion management. It argues that this evidence presents a strong case for the use of a market mechanism to control access and more specifically for the use of periodic auctions to allocate limited term slot leases. It then shows that the existing body of knowledge and practical experience with the use of combinatorial auctions lead naturally to highly viable auction designs for the airport slot context. It further provides analysis of a variety of specific issues related to the use of auctions in the context of airport slots.

## 1. Introduction

International air transportation demand continues to grow at a strong rate, with total revenue passenger-kilometers (RPK) expected to roughly double between 2014 and 2029 (Boeing 2015; Airbus 2015). While this growth is led by developing countries, e.g. China, even developed regions with historically high demand continue to see growth, especially of long-haul, international traffic. For example, Boeing (2015) forecasts annual RPK growth through 2034 of 2.4 percent for markets within North America, 3 percent for North America to Europe markets, 4.4 percent for North America to Asia, and 5 percent for North America to Latin America. Airport runway capacity remains a (and in many cases THE) constraining factor limiting growth in flight operations. Because of this, entities with oversight for airport access or performance very often employ mechanisms to restrict airport access in order to limit congestion. The most predominant mechanism used is the IATA Slot Allocation System (Ulrich, 2007). This system involves defining a set of airport “slots” and allocating those slots to flight operators through a system of administrative controls. This system is used at virtually all large airports within Europe. In the U.S., as discussed in Section 2.2, the federal government has imposed a similar set of administrative slot controls at four airports.

Over the years market-based approaches have also been proposed to limit access to airports in order to control congestion. Such approaches can broadly be classified into two categories: congestion pricing and slot auctions. A slot auction approach starts by defining a system of slots as is done under the IATA rules, but rather than allocating the slots by administrative rule the slots are allocated via auction. Congestion pricing does not require a system of slots; rather fees on flight operations, which vary during the course of the day, are set. By charging higher prices during congested periods, flight operators are encouraged to move their flights to less congested periods or to reduce their overall number of flights. While congestion pricing and slot auctions have been discussed, proposed and analyzed at various times over the years, their use has been very limited. As we will discuss a key element to successful use of slot auctions is that the product sold should be a slot lease and not outright slot ownership.

The premise of this paper is that analysis of historical data, basic economic theory and anecdotal evidence show very clear

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deficiencies in the existing systems of administrative slot controls used throughout the world. Further, this same evidence strongly indicates that a properly defined slot auction system would provide superior overall system performance. How one defines performance is itself a difficult question but certainly it should include consideration of the extent of service options between city pair markets, the daily flight delays and financial/cost considerations both from the passenger and air carrier perspectives. We describe auction mechanisms appropriate for the airport slot context and also answer many of the application-specific design questions that arise when creating a practical system.

Many of the initial concepts presented in this paper were developed under a project sponsored by the U.S. Federal Aviation Administration (FAA), in anticipation of the expiration of administrative slot control at New York LaGuardia Airport (LGA). Ball et al. (2007, 2013) describe many of the ideas developed and give historical background. See also (Ball et al., 2005). Over time we have refined some of these concepts based on recent developments and research. It is also the case that the general state of knowledge on combinatorial auctions has advanced since that time. The recommendations provided in this paper represent an integration of those advances and developments. Much of the extensive recent work on combinatorial auction has been motivated by their increasing use in other domains such as spectrum allocation, energy markets, pollution credit allocation as well as others. This research and application experience provides much of the basis and motivation for our recommendations.

In Section 2, we review current practice in limiting airport access and provide evidence that will support both the use of auctions and our recommended auction-based approach. Section 3 defines basic quantities and properties upon which the auction mechanism will operate. These include such topics as the definition of the product to be sold, who may bid, distribution and use of auctions revenues as well as others. Section 4 defines recommended auction mechanism alternatives. As will be discussed, the airport slot context calls for a combinatorial auction: specific combinatorial auction mechanisms are recommended depending on the particulars of the application setting. Section 5 includes a discussion of certain auxiliary topics. Section 6 provides summary and conclusions.

## 2. Motivation and justification

### 2.1. Current practice

The world-wide air transportation system has evolved over time as aircraft technology has improved and demand for air transportation services has grown. This evolution has been greatly influenced by political and social factors that, at times, have led the system to develop in a suboptimal manner. As evidence of the influence of such “external” factors, it is noteworthy that virtually all major European airports operate under slot control regimes but only four U.S. airports have slot controls. It would be difficult (and controversial) to try to explain the basis for this difference. Arguments could be made for differences in climate/weather but differences in attitudes toward regulation and the role of government are also likely relevant.

A slot conveys to its owner the right to conduct an arrival or departure flight operation during a certain time window. A slot control system starts by partitioning the day into a series of time windows, whose width typically would be set between 15 min and 1 h. For each time window a certain slot limitation is set. For example, if an airport’s runway structure and other constraints limited the number of flight operations to 80 per hour, then a time window of 30 min would have a slot limitation of 40. The IATA Worldwide Scheduling Guidelines and the rules governing slot use at U.S. airports share two fundamental features:

- (1) **Grandfather rights**, that initially assign slot rights to flight operators in order to accommodate historical scheduling practices;
- (2) **Use-it-or-lose-it rules**, that allow existing slot holders to maintain rights to a slot so long as they “use” the slot by consistently scheduling flights in that slot’s time window over a period of time.

In both the U.S. and Europe slot rules are only imposed on airports that achieve a certain congestion level. There are differences in slot limitations, use-it-or-lose-it rules and congestion thresholds both between Europe and the U.S. and even within each region. Generally, in both cases, slot ownership rights are permanent assuming required rules are followed. Another important feature of a slot system is the ability to buy and sell slots in a type of secondary market. The U.S. adopted a buy-sell rule fairly early, although this rule has evolved over times, and, in fact, is currently not in place. Slot leasing is currently permitted; new buy-sell rules were considered but have not yet been put in place. In Europe, certain transactions were executed and challenged in court leading to the 1999 English High Court judgement in *R v Airport Coordination*, which held that airlines have the authority under Regulation 95/93 of the European Union to exchange slots, and such exchange may include financial consideration. This interpretation applies only in England and Great Britain; there is generally a narrower view that prohibits outright sales of slots on the Continent except as part of the sale of all, or a substantial part, of an airline. Some high value transactions have been executed for slots at London Heathrow Airport. However, for both the U.S. and Europe, such transactions are fairly rare.

As discussed in the previous section, market-based approaches to control airport access have been investigated and analyzed over the years but their use in practice is relatively rare. What is arguably the first serious research paper on combinatorial auctions used airport slots as a motivating example (Rassenti et al., 1982). The FAA funded a project that investigated both congestion pricing and slot auctions and resulted in a slot auction design with associated rulemaking (Ball et al., 2007). As discussed below, the final implementation of the auction mechanism was blocked in the courts (Ball et al., 2013). There have been some cases of the use of auctions within limited contexts. For example, in November 2011, when US Airways and Delta Air Lines were required by the US Department of Treasury to divest a total of 48 slots, or 24 slot pairs, at Ronald Reagan Washington National Airport (DCA) and LGA (DOT, 2011; 76 FR 205), the FAA employed simple auction mechanisms to execute these transactions, for which the buyers and sellers were airlines, i.e. they should be classified as secondary market transactions, albeit ones in which the government played a

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