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# An optimization approach for airport slot allocation under IATA guidelines

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ABSTRACT

Air traffic demand has grown to exceed available capacity during extended parts of each day at many of the busiest airports worldwide. Absent opportunities for capacity expansion, this may require the use of demand management measures to restore the balance between scheduled traffic and available capacity. The main demand management mechanism in use today is the administrative schedule coordination process operated by the International Air Transport Association (IATA), which is in place at the great majority of busy airports outside the United States. This paper proposes a novel multi-objective Priority-based Slot Allocation Model (PSAM) that optimizes slot allocation, while complying with the complex set of priorities and requirements specified by the IATA guidelines, as well as with the declared capacity constraints at the airports. It presents an efficient computational approach that provides optimal slot allocation solutions at airports significantly larger than has been possible to date. The model is applied to two Portuguese airports, a small one (Madeira) and a mid-size one (Porto) using highly detailed data on airline slot requests and airport capacity constraints. Results suggest that PSAM can improve the efficiency of current practice by providing slot allocations that match better the slot requests of airlines. Equally important, PSAM can also quantify the sensitivity of slot allocation decisions to the various priorities and requirements specified in the IATA guidelines.


## 1. Introduction

Air traffic growth coupled with limitations in available infrastructure and air traffic management operations have created severe imbalances between demand and capacity at the world's busiest airports. Limited capacity at busy airports can result in congestion and schedule unreliability. In 2015, 19% and 18% of commercial flights experienced an arrival delay of 15 minutes or more in the United States and in Europe, respectively (FAA, 2016), with the trend pointing upward in both cases. Moreover, these constraints can impose long-term economic impacts due to lost demand, higher airfares, and limitations in airlines' route development.

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In the absence of supply-side interventions aimed to increase system capacity through infrastructure expansion and/or operational improvements, airport congestion mitigation may require the use of demand management mechanisms. Demand management consists of interventions that limit the number of flights scheduled at busy airports at peak hours. These interventions fall conceptually into two categories: (i) economic approaches, which involve market-based mechanisms such as congestion pricing and slot auctions, and (ii) administrative approaches, which involve non-monetary adjustments to airport flight schedules imposed by a designated schedule coordination entity. The former has received significant attention in the economics and operations research literature (see, e.g., Ball et al., 2006, and Gillen et al., 2016, for reviews). On the economics side, much research has aimed to design optimal congestion pricing schemes (Brueckner, 2002; Pels and Verhoef, 2004; Czerny and Zhang, 2011; Czerny and Zhang, 2014) and to compare price-based vs. quantity-based auction mechanisms (Brueckner, 2009; Czerny, 2010; Basso and Zhang, 2010; Verhoef, 2010). On the operations research side, Ball et al. (2006) and Harsha (2009) developed optimization models to support auctioning of airport slots. In practice, however, existing demand management practices are almost exclusively based on administrative approaches.

The foremost demand management mechanism currently in use is the schedule coordination process developed by the International Air Transport Association (IATA). With minor variations depending on geographic location and local or regional regulations (e.g., in Europe), this process, with essentially identical guidelines and priority rules, is currently applied at 175 "schedule coordinated" ("Level 3") airports worldwide, including the great majority of the busiest ones outside the United States (IATA, 2017). In Europe, for instance, the process is mandatory for coordinated airports and driven by the EU regulation (EC, 2002). Despite a few differences, the IATA guidelines and the EU regulation are, in general, very similar.

This paper proposes a novel model, the Priority-based Slot Allocation Model (PSAM), to optimize slot allocation decisions based on slot availability and airline slot requests. The model minimizes the costs of schedule coordination to the airlines and other airport stakeholders, as measured by the *displacement* from airline requests, while accounting for the many priorities and requirements included in the IATA guidelines. It develops an efficient computational approach that makes it possible to apply the model at even medium-size airports, with up to 100,000 aircraft movements per year, for an entire season of operations. The paper then presents detailed applications at the Cristiano Ronaldo International Airport of Madeira and the Francisco Sá Carneiro International Airport of Porto, both located in Portugal, using fine-grain data on airline slot requests. The computational results suggest that such applications may offer important benefits by accepting all slot requests, while significantly reducing the largest flight displacement, the total schedule displacement, and the number of flights displaced that are necessary to accommodate all requests. Before summarizing the paper's contributions in more detail in Section 1.2, we provide additional information on current schedule coordination processes and procedures.

### *1.1. IATA slot allocation process*

This section provides some background on the slot allocation process endorsed by IATA, including: (i) an overview of its different stages and the scope of this paper; (ii) some important definitions and concepts; (iii) its priorities and requirements; and (iv) the main sources of complexity of the problem considered.

The IATA schedule coordination process is carried out bi-annually to provide airlines with access to schedule coordinated airports. This access is granted in the form of a landing or takeoff "slot", defined as the permission to use the full range of an airport's infrastructure to perform aircraft arrivals or departures on a specific day and at a specific time. For each season ("Summer" or "Winter"), the IATA slot allocation process involves five main steps:

(1) *Setting of Declared Capacity*: Each airport provides the values of its "declared capacity", which specifies the number of slots made available in each time interval of a day. Declared capacities are commonly specified as hourly limits on the number of flight movements (landings and takeoffs) that may be scheduled, but may also be specified at a finer level of granularity for (i) different elements of the airport (e.g., runway capacity, apron capacity and terminal capacity), (ii) different types of movements (e.g., arrivals, departures and total), and (iii) different "block" durations (e.g., capacities per hour, per 15-minute period, per 5-minute period, as well as per day, per week, per month, or per year), etc. The declared capacities of each schedule coordinated airport are announced about one year before the start of each season.

(2) *Slot Requests*: The airlines submit their desired schedule of flights at each airport to the schedule coordinator for the upcoming season. Flight scheduling requests are submitted in one of two forms. If a flight is to take place at least five times over a season on the same day of the week and at the same time of the day, the corresponding request must be submitted in the form of a "series of slots" (e.g. a flight that takes place every Monday in July and August at 10:15). If the flight does not satisfy these criteria, the request is provided as an "individual slot". Requests for series of slots are submitted approximately five months in advance of each season. Individual slots may be requested up to the actual day of operations and may be awarded depending on availability of slots at the requested time.

(3) *Initial Slot Allocation*: At each airport, the schedule coordinator is tasked to perform the initial slot allocation in an "unbiased, transparent and non-discriminatory" way. No contact is allowed between the slot coordinator and the airlines. The allocation of slots is performed solely on the basis of the priorities and requirements specified by the IATA guidelines. The coordinator provides the resulting initial schedule to the airlines about four months before the start of each season. Only *series of slots* are allocated at this stage.