LAGUARDIA SLOT ALLOCATION:
A Clock-Proxy Auction Approach

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1 INTRODUCTION

While overcrowding at U.S. airports has been an issue for decades, appropriate treatments to the problem have remained unrealized. Since 1968, several of the busiest US airports have been subject to "High Density Rules" limiting the number of take-offs and landings per hour. Airports under HDR distribute 'slots' defined as, "a reservation for an instrument flight rule takeoff or landing by an air carrier or an aircraft in air transportation."[1] With HDRs in place, these slots have effectively become a scarce resource, and the FAA predicts that demand at the busiest airports will quickly pull ahead of supply. Even without federal limits on airport slots, any given airport has operational constraints determined by runway size, number of terminals, and air traffic control facilities. As demand for an airport approaches and in some cases exceeds capacity, flight delays increase and safety is jeopardized. Having identified slots at congested airports as a scarce resource, it is imperative to assure they are efficiently allocated among airlines. The purpose of this paper is to analyze possible demand management mechanisms for one of the most congested US airports—LaGuardia.

Historically, LGA has been home to some of the worst delays in the US, and due to the hub and spoke nature of US airports, these delays typically propagate throughout the entire airspace network[2]. Demand for slots at LaGuardia has been ever increasing, and when a reform allowing HDR slot exemptions was enacted in 2000, the jump in airport operations nearly crippled the airport. To recover, the FAA quickly capped the number of slot exemptions and allocated the exemptions to airlines using a lottery.

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[1] US Code. Legal Information Institute. http://www4.law.cornell.edu/uscode/. 2004.

[2] Federal Register, 2001, Department of Transportation, Federal Aviation Administration, "Notice of Alternative Policy Options for Managing Capacity at LaGuardia Airport and Proposed Extension of the Lottery Allocation", Docket Numbers [FAA2001-9852], [FAA2001-9854] vol. 66, no. 113.

LaGuardia's poor performance under these conditions illustrates the rampant inefficiencies of the current slot system.

The critical failure of the current system is that slots at crowded airports like LGA *have* value, but are not treated as such. The existence of some slot trading between airlines indicates that airlines can assign value to slots, and reveals the potential for a formal slot market. Slots are currently assigned under administrative methods including 'grandfathering' and lotteries, which fail to reflect the slots' true value. These current methods often result in slots not going to the airlines that value them most, and forgo potential revenue. In addition, the number of slots allowed at LGA continues to exceed optimum performance levels resulting in a 'tragedy of the commons' outcome. The FAA must implement a demand management mechanism in order to extract the full potential of this scarce resource.

Several new ideas have been suggested to alleviate the current problems at LaGuardia, including expansion of airport infrastructure, confiscating a percentage of each airline's slots, mandatory use of larger aircraft, a 'congestion fee' for arrivals or departures during high traffic times, and slot auctions. Looking at the recent success of FCC spectrum assignment methods, auctioning slots at LaGuardia appears the most appropriate action. Due to the presence of strong complements and substitutes among slots, this paper recommends the implementation of a clock-proxy auction to assign slots to airlines, resulting in increased airline competition, reduced delays, safer conditions, and increased revenue generation at LaGuardia airport.

2 METHODS

The sources for data can be broken into three main categories--online resources, journals/articles, and scholarly papers. Online resources included, the Federal Aviation Administration website (www.faa.gov), Bureau of Transportation Statistics website (www.bts.gov), PANYNJ website (www.panynj.gov), and the Legal Information Institute website (www.law.cornell.edu/lii.html). These sites contained a plethora of data in the form of searchable databases, benchmark reports, and other publications regarding air traffic statistics, FAA policy, and federal code. Accessed journals included, The Economist, Economic Review, Airfinance Journal, and Aviation Week & Space Technology. These provided an overview of responses to FAA policies regarding slots and suggested slot allocation methods. Several papers regarding slot auctions, auctions with package bidding, and clock-proxy auctions were also used to assess appropriateness, feasibility, and effectiveness of various auction methods.

3 DATA

3.1 LAGUARDIA OPERATION STASTICS

LaGuardia, like all airports, has several factors that constrain its total number of flights per hour. These include limited runway and taxi space, number of gates and control towers, and air traffic control technology. In 2001, the FAA released a report indicating the benchmark capacity of 31 U.S. airports including LaGuardia. Capacity at LaGuardia was reported to be 80-81 operations per hour in optimal conditions and 62-64 ops/hr in reduced conditions. By 2010, planned technology improvements put the numbers at 88-89 ops/hr and 64-66 ops/hr, an increase of 10% and 3% respectively[3].

[3] Federal Register, 2001, FAA.

Unfortunately, the report predicts operations at LGA to increase 17% by 2010 leading to demand far exceeding capacity. In 2000, during poor weather conditions, scheduled operations exceeded capacity approximately 12 hours/day, and 15% of all flights at LGA were delayed 15 minutes or more exceeding all other U.S. airports delay rates. In 2001, delays at LaGuardia accounted for 10% of delays in the US. A steady increase in demand at LaGuardia can be seen by viewing its operations over time. Figure 1 shows the steady increase in LGA use over the past five decades[4]. As a result of the September 11th attacks, the demand at LaGuardia and other airports was reduced significantly.

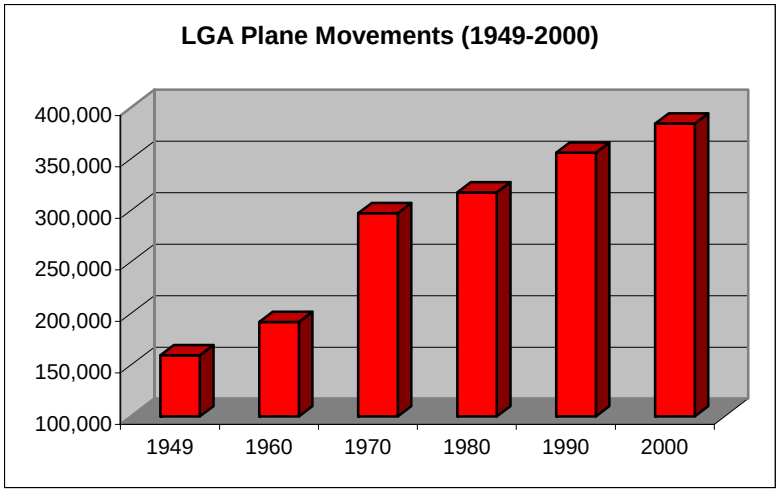

Figure 1

The initial drop can be seen in figure 2, but note the steady increase since then and Feb 2004 totals. Though temporarily reduced, the total number of operations at LaGuardia is already approaching pre September 11th levels. Figure 2 displays the total arrivals per month to LaGuardia from January 2001 to February 2004[5].

[4] Source data: http://www.laguardiaairport.com/aviation/lhisfram.htm
[5] Source data: http://www.bts.gov/programs/oai/airline_ontime_statistics/SummaryStatistics/

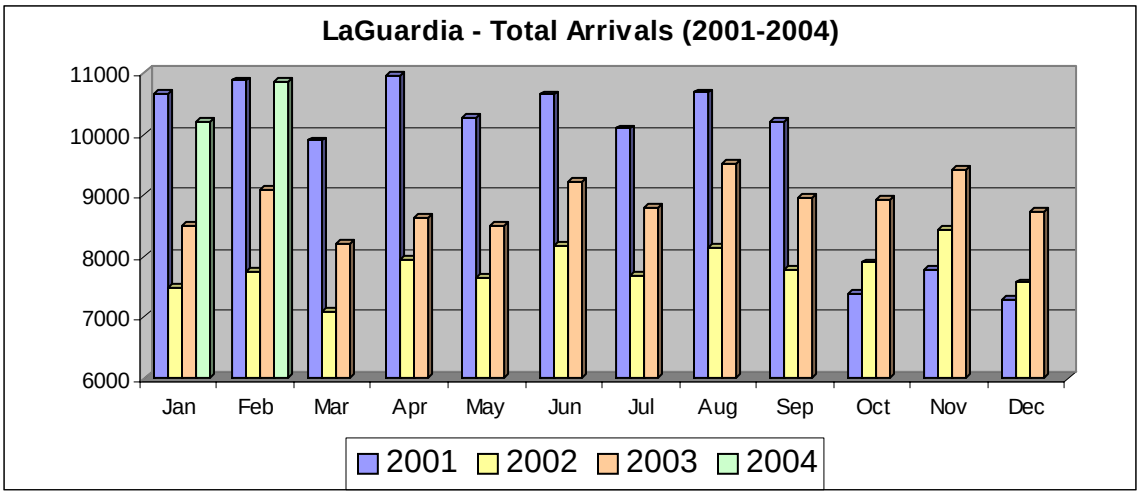

Figure 2

Figure 3 shows the late arrivals to LaGuardia as a percentage of total arrivals from month to month for 2001, 2002, and 2003[6]. Delay rates at LGA also appear to be climbing back to pre September 11th levels.

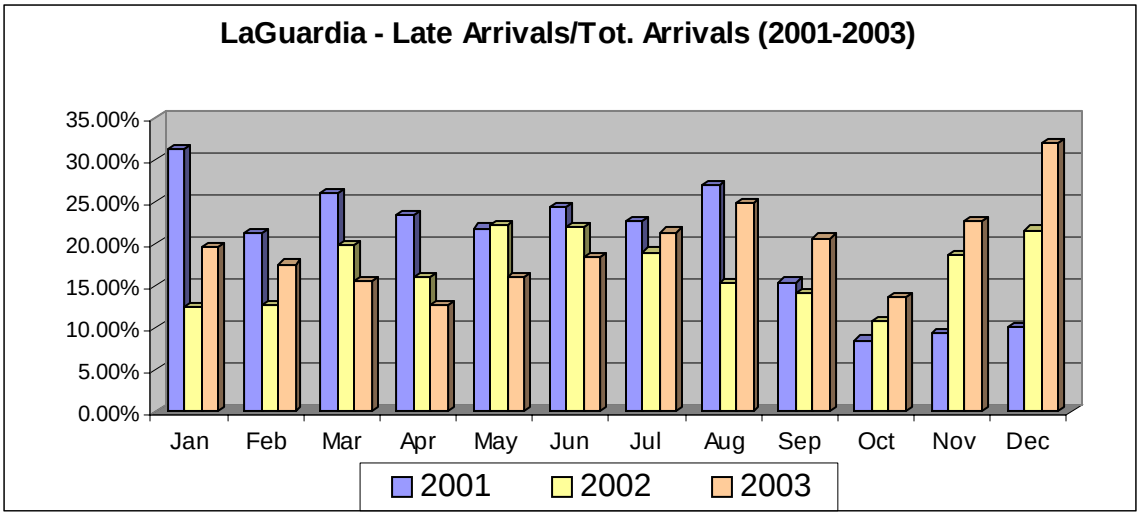

Figure 3

As would be expected, data for departures from LaGuardia show similarities to the data for arrivals. Notable differences occur in the percentage of flights delayed. Arrivals appear to experience higher rates of delay, but the overall delay rate trends remain the

[6] Source data: http://www.bts.gov/programs/oai/airline_ontime_statistics/SummaryStatistics/

same. Figure 4 and 5 show total departures and departure delay rates from month to month for LaGuardia[7].

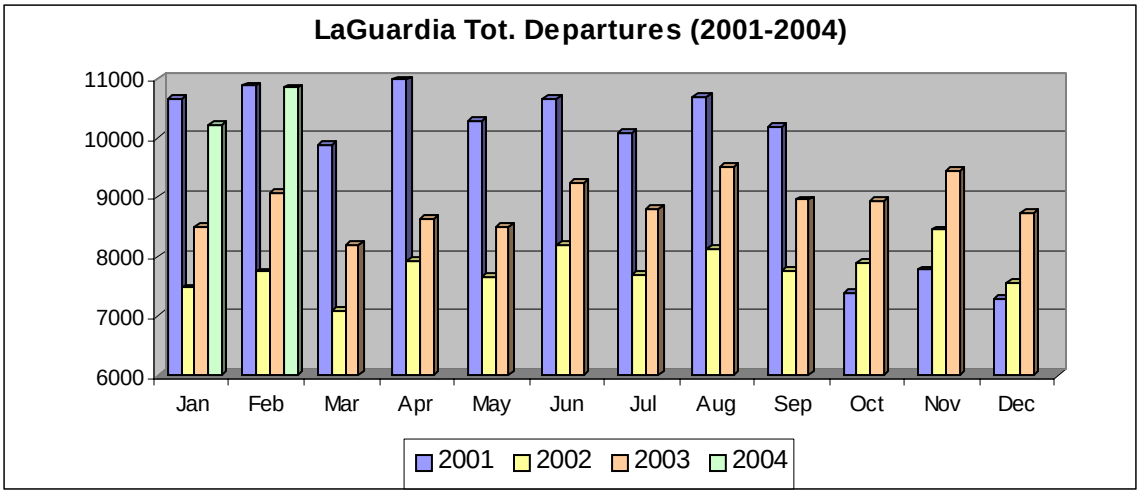

Figure 4

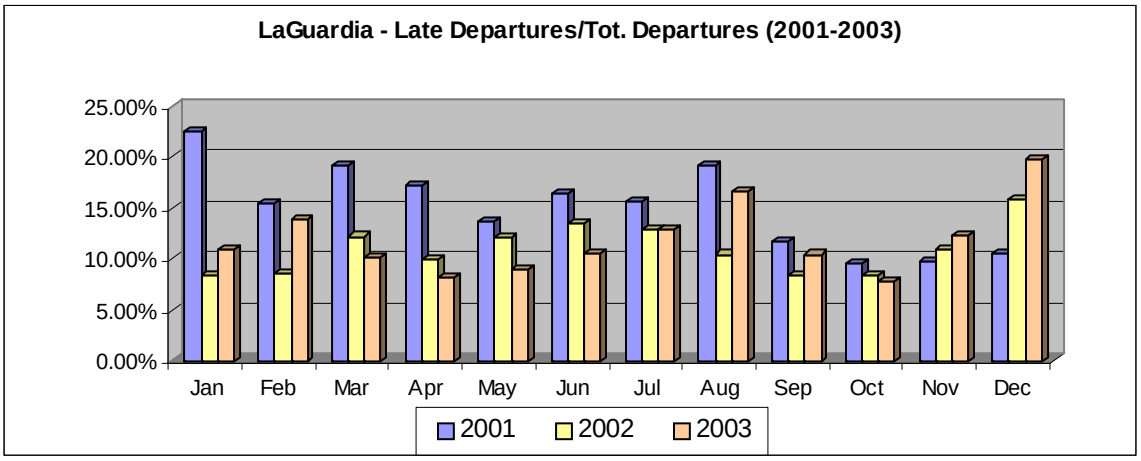

Figure 5

3.2 REGULATION OF LGA OPERATIONS

Due to its close proximity to downtown New York City, LaGuardia airport has historically been one of the busiest airports in the US. In 1968 LGA became classified as a 'high density airport' defined as, "an airport at which the Administrator limits the

[7] Source data: http://www.bts.gov/programs/oai/airline_ontime_statistics/SummaryStatistics/

number of instrument flight rule takeoffs and landings of aircraft"[8]. Under High Density Rules (HDR), LaGuardia had a limited number of take-off and landing slots to distribute to airlines. The number of slots allocated was determined according to safety constraints at the airport. As demand for the slots grew over time, complaints regarding the exclusion of short-haul flights began to surface eventually resulting in the enactment of AIR-21 in April of 2000.

The Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21) allowed for airlines to request slot exemptions, effectively increasing the ceiling on slots indicated by HDR at LaGuardia. In addition to allowing slot exemptions, AIR-21 called for the phase-out of limits on slots altogether by 2007. Within five months of the enactment of AIR-21, total operations at LaGuardia had skyrocketed as airlines added approximately 200 daily flights to an already overburdened schedule. By the end of 2000, slot exemptions were expected to hit 300. The crippling delays at LaGuardia caused by AIR-21 resulted in the FAA capping the total number of slot exemptions to 159, and allocating these exemptions via a lottery. The cap and lottery system managed to bring LGA back to within reasonable limits, and delay rates decreased. However, demand and operations at LaGuardia continued to remain well above efficient levels.

3.3 DEMAND MANAGEMENT PROPOSALS (FAA FEDERAL REGISTER)

Realizing the issue of demand imbalance at LaGuardia, in early 2001, the FAA released several proposals to manage demand, and invited comments and solutions to the problem[9]. The methods discussed can be separated into two main categories; administrative, and market-based. Administrative methods include among others,

[8] U.S. Code. Legal Information Institute.
[9] Federal Register, 2001, FAA.

requirements for increase use of larger aircraft, reducing each airline's current slots by a percentage, and withdrawing slots reserved for GA (general aviation). Encouraging or forcing airlines to fill slots with larger aircraft has the hopes of alleviating excess passenger demand and capturing the lost efficiency created by smaller planes. A plane carrying 50 passengers and a plane carrying 150 passengers both only require one slot to land, but the latter uses that slot more efficiently. Slot withdrawal methods simply attempt to reduce the total of number of operations at LGA, while maintaining the current allocations.

Market-based schemes included congestion pricing for slots, and slot auctions. Congestion pricing involves charging airlines a fee for using a slot during the most congested periods of the day. The aim of congestion pricing is to reduce airline incentive to use the airport during the busiest hours of the day, and thereby alleviate congestion and delays. Slot auctions would attempt to manage demand and extract efficiency by giving (leasing) limited numbers of slots to the airlines that value them most. The FAA auction proposal has a particular formula outlined as follows. Each airline is given a baseline of up to 20 slots per day. 80 slots would be reserved for carriers serving small communities, and would be assigned through either lottery or auction methods. 70 percent of the remaining slots would be assigned to carriers based on their enplaned market share. Any remaining slots would then be auctioned among competing carriers[10].

[10] Federal Register, 2001, FAA.

4 ANALYSIS

4.1 LAGUARDIA SLOTS AS A SCARCE RESOURCE

The first step towards realizing a solution to LaGuardia's demand/capacity problem is to appropriately identify the slots as a scarce resource. Due to its geographic location, LaGuardia cannot expand its infrastructure to accommodate more slots. The addition of runways has helped congested airports increase capacity in the past, but the Flushing and Bowrey bays make this option infeasible at LGA. While advances in air traffic control technology can also increase operations per hour, the growth rate of ATC technology is considerably lower than the projected growth rates of demand at LaGuardia. In 2001, the FAA predicted that by 2010 technology improvements could increase capacity at LGA by about 10% (3% in adverse conditions), but predicted operations at LGA to increase by approximately 17% by that time. Thus, the total number of daily slots at LaGuardia is essentially bounded, and with the demand well exceeding that bound, LGA slots can indeed be identified as a scarce resource.

4.2 PROBLEMS WITH ADMINSTRATIVE ASSIGNMENT

The critical failure of the FAA's attempts to regulate demand at LaGuardia stems from the fact that slots at LGA have value but are not treated as such. By not treating slots as a scarce resource with real value, the FAA has subjected LaGuardia to delays and unsafe conditions, and stifled airline competition. The majority of slots are assigned through grandfather rights where incumbent airlines automatically maintain any slots they've used in the past. A small portion of slots is set aside for GA (general aviation) and miscellaneous use, and any unused slots are typically put into a pool for new entrant airlines. The use of grandfather rights at LaGuardia stifles competition by allowing

inefficient airlines to access a highly valuable resource simply because they have in the past. Even when a new entrant airline could use a given slot more efficiently (i.e. uses larger aircraft), it is blocked from competing for that slot by current administrative rules. Slots that are not grandfathered (including slot exemptions) are typically assigned by a scheduling committee, but as with most administrative methods, this lacks transparency. It is not always clear ex post why certain airlines received slots and others did not. In addition, slots assigned by a committee or lottery will not always go to airlines best suited to provide service.

4.3 WHY USE AN AUCTION?

Once we realize that slots at LaGuardia are limited (or at least should be limited), and that they indeed have value, the question arises, 'Which airlines should receive slots and what should they pay for the slots?' Fortunately an auction can answer this question in a timely, transparent, and profitable process[11].

The primary motivation in using an auction as a method of slot assignment is its competitive nature. Currently, the majority of slots at LGA are assigned through non-competitive methods (grandfathering). By introducing a competitive assignment mechanism, slots will tend to go to the airlines best able to use them. This increase in competition also has the likely benefit of reducing the price to consumers over time, and stimulating innovation within airline industry.

Modern auctions also have the benefit of being a relatively quick process. Administrative processes often suffer from being extremely slow to produce results. As

[11] Cramton, Peter. 2002. "Spectrum Auctions," in Martin Cave, Sumit Majumdar, and Ingo Vogelsang, eds., *Handbook of Telecommunications Economics*, Amsterdam: Elsevier Science B.V., Chapter 14, 605-639, 2002. pg 3.

an example, using administrative methods, "it took the Federal Communications Commission an average of two years to award thirty cellular licenses"[12]. Since then, the FCC has removed the administrative process and turned to auctions to assign licenses.

Another benefit of using slot auctions is that an auction will generate substantial revenues that can be used for upkeep of airport facilities or to stimulate ATC research and development. Previously unrealized revenues are generated as a direct result of the introduction of competition into the assignment method[13]. Even the FAA's auction proposal where only a fraction of the slots are auctioned was estimating additional revenues of approximately $60-$90 million a year[14].

The other market-based option proposed by the FAA was congestion pricing. This method does have the desirable characteristics of most market-based schemes, however, it does have drawbacks that make an auction more desirable. Congestion pricing relies on the FAA to control prices of slots to manage demand. Controlling demand through price setting can be very difficult, and requires continual adjustments to keep demand in check. Because the FAA knows the optimal level of operations at LGA, it would be safer and more efficient to control the quantity, and let the market reveal the price. With an auction format, they can do just that.

4.4 POSSIBLE PROBLEMS

Before implementing an auction in any format, it is imperative to understand the characteristics of the industry at hand in an effort to foresee possible pitfalls. One of the necessary steps before auctioning any item is to properly define it. In the case of slots at LaGuardia, the items up for auction would be slot licenses. A slot license would give the

[12] Cramton. "Spectrum" pg. 3
[13] *ibid.* pg 4
[14] Federal Register, 2001, FAA.

owner the right to take-off or land at LaGuardia within a particular time window. Licenses would be active for a time period set by the FAA. In the FAA's proposed auction, licenses would expire after two years whereupon they would be auctioned again. With this definition in place, the FAA can determine what the safe level of operations is within each time window. As an example, the time window might be 15 minutes. If the safe number of operations per hour at LGA is bounded to 80, then there would be 20 licenses available for each 15- minute block in the day.

One of the biggest problems that would arise with this implementation is the exposure problem. Because of the nature of the industry, there would be strong compliments between the slot licenses. An airline, in scheduling a flight will naturally need one slot for the plane to land, and then another later slot so the flight can take off to its next destination. In this case, the two slots are strong compliments, and in an auction, the airline is exposed to the risk that it might win one but not the other. In cases where bidders are exposed to this risk, efficiency of the auction is reduced along with revenues. With proper auction design, this exposure can be avoided.

Another problem is possible demand reduction, which comes about due to the presence of substitutes between slots. Bidders reduce their individual demand in an attempt to split the items among themselves at prices well below market value[15]. The existence of substitutes in this case arises from the fact that an airline can usually switch between slots that are relatively close together (i.e. 1200-1215 and 1230-1245), without incurring any adverse effects. Demand reduction in auctions can also be avoided with proper auction design.

[15] Cramton. "Spectrum" pg. 14

A common complaint against using auctions to assign slots at LaGuardia is that general aviation and new entrants would not be able to compete against the incumbent airlines. This is clear example of an externality in the slot market. There is some socio-political benefit associated with letting GA and new entrants enter LaGuardia that an auction would overlook. Cramton states, "standard auctions at best ensure that the bidder with the highest private value wins, rather than the bidder with the highest social value."[16] We might want to allow general aviation access to LGA despite their budget constraints, and we definitely want to give new entrants the chance to enter the market despite being a weak bidder. These concerns can also be addressed with appropriate auction design.

One last problem worth mentioning is the fact that LGA, like any airport, has a variable capacity due mostly to weather. In reduced capacity conditions, airlines will sometimes have paid for a slot that they can no longer use. This is not a particular downfall auctions, but rather of any market based solution. However, the use of auctions in slot assignment could lessen the blow to airlines in this case. Because well-designed auctions tend to generate substantial revenues for the sellers, portions of the revenues from slot auctions could be used to offset effects of variable airport capacity. Airlines could be refunded to some extent using money from the prior auctions.

4.5 A CLOCK-PROXY SLOT AUCTION

The choice to use a clock-proxy auction to assign slots at LaGuardia is based upon its ability to handle the problems that would arise in the auction of airport slots, its simplicity, and its efficiency. The problems include the bidder exposure due to compliments among slots, demand reduction due to substitutes among slots, and the gap

[16] Cramton. "Spectrum" pg. 4

between private and social value. While the details of a clock-proxy auction are lengthy, a brief overview of a potential process for airport slot licenses is outlined below[17].

4.6.1 The Clock Phase

In the clock phase, the auctioneer would announce the prices for licenses within each time window. The airlines would respond with the number of licenses they want in each time window. The prices on licenses for time windows where licenses demanded exceed supply of licenses are then raised, and a new round begins. The clock phase ends when there is no excess demand for any time window. The main purpose of the clock phase is for price discovery, and to remove the exposure problem. By the end of the clock phase, airlines would learn a rough idea of the value for each particular license.

4.5.2 The Proxy Phase

In the proxy phase, each airline would determine its value for packages of slot licenses its interested in and then report these values to a proxy agent. The proxy would bid for the airline in an ascending package auction as follows. The proxy determines in round X the potential profit for every possible bid using the reported values. The proxy then submits the bid corresponding to the maximum potential profit[18]. This phase ends when no new bids are submitted. The main purpose of the proxy phase is to remedy any demand reduction that may have taken place in the clock phase, and to promote efficient final assignment.

4.5.3 Avoiding Exposure and Demand Reduction

[17] For the details of the clock-proxy auction see: Ausubel, Lawrence M. Peter Cramton, and Paul Milgrom. 2004. "A Practical Combinatorial Auction: The Clock-Proxy Auction," Working Paper, University of Maryland.

[18] Ausubel, Lawrence M. Peter Cramton, and Paul Milgrom. 2004. "A Practical Combinatorial Auction: The Clock-Proxy Auction," Working Paper, University of Maryland. pg. 10

In the context of slots at LaGuardia, the clock phase is essential. Because landing and take-off slots are compliments, exposure is a concern. Utilizing a clock phase removes the exposure problem, allowing bidders to bid for synergistic gains without fear[19]. On top of this, bidding in the clock phase would be very easy for the airlines, since they only have to decide how much of each license they want given the prices shown. Finally, the price discovery that occurs over the clock phase would allow airlines to get an idea about what packages of licenses to focus on for the proxy phase.

The proxy phase is also an essential component of the slot auction. Airlines can substitute between slot licenses to some degree, making collusion in a slot auction possible. The proxy phase can eliminate any demand reduction or collusion that may have occurred in the clock phase, and pushes the outcome toward an efficient allocation[20]. This in turn can mean increased revenues for the FAA.

4.5.4 General Aviation, New Entrants, and Increased Competition

There have been complaints in the past that auctioning slots at LaGuardia would shut out general aviation and non-incumbent airlines. Again, with proper auction design these issues can be addressed. The FAA could set aside slot licenses specifically for general aviation, and hold a separate auction just for those. Similarly, there could be a certain percentage of slot licenses reserved for new entrants as well. New entrants would have an auction among each other bidding for 'new entrant' slots. For example, if there are 20 total licenses per 15-minute window, the FAA could set one slot aside for GA, and two slots designated for new entrants. Three auctions would then take place--a GA auction, a new-entrant-only auction, and a large airline auction. Other methods include

[19] Ausubel. "Clock-Proxy" pg. 13
[20] *ibid*. pg. 14 -15

giving bidding credits to small bidders (GA and new entrant airlines in this case) to encourage competition. Similar methods have been used in FCC spectrum auctions, where women, minorities, and small businesses were given preference to help broaden participation and increase competition[21]. In addition to helping the little guys, the auction rules can and should limit the total amount of slots that any one airline can win. This slot cap would prevent a large airline from being able to gain market power from buying up huge shares of slot licenses, and is just another measure to help ensure a competitive airline industry. Again, this technique of 'caps' has been used already in treasury auctions and spectrum auctions to help maintain competitive markets[22].

5 CONCLUSIONS

LaGuardia airport suffers from massive delays and unsafe conditions due to overcrowding. In 2001, The FAA reported that operations at LaGuardia often exceeded capacity resulting in the highest delay rates in the US. While operations and delay rates subsided following the September 11th attacks, the numbers are rising again, and are approaching pre-Sept 11th levels. Projected growth puts demand on LGA slots well above capacity by 2010, and something must be done to manage demand.

Slots at LaGuardia airport should be limited and assigned to airlines using a clock-proxy auction. The clock-proxy auction will allow the FAA to distribute slot licenses to competing airlines in a simple and transparent way, while ensuring slot licenses go to the airlines that value them most. The clock-proxy auction is ideal in this setting, because of the presence of compliments and substitutes among slot licenses. The

[21] Cramton. "Spectrum" pg. 10
[22] *ibid*

clock phase removes exposure, and the proxy phase mitigates collusion while increasing the efficiency of the outcome.

In addition to reducing delays and increasing safety at the airport, the auction will increase competition and stimulate innovation within the airline industry and raise substantial revenues.

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